National Inventory Report

Emissions of greenhouse gases in Iceland from 1990 to 2020

Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

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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 the years 1990-2020. 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, and under its bilateral agreement with the EU regarding the second commitment period of the Kyoto Protocol.

The NIR is written by the Environment Agency of Iceland (EA - Umhverfisstofnun), the Soil Conservation Service of Iceland (SCSI – Landgræðslan) and the Icelandic Forest Service (IFS - Skógræktin). The EA is responsible for all chapters apart from those concerning Land-Use, Land-Use Change and Forestry (LULUCF and KP-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 Agricultural University is acknowledged for his extensive contribution to the LULUCF chapters.

This NIR, together with the associated CRF tables and MMR templates, is submitted in accordance with Art. 7.1 of the Monitoring Mechanism Regulation (MMR, Regulation No 525/2013) and relevant articles and annexes in the implementing Regulation No 749/2014, as stipulated by the transitional provisions stated in Art. 58 of Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action.

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Note: This report was resubmitted to the UNFCCC 23 september 2022 as requested by the UNFCCC Expert Review Team during the UNFCCC inventory review. Changes were made to chapter 11.5.3, Table 12.4 and chapter 15, and correspond to Iceland's submission 2022 v4.

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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
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
EA	The Environment Agency of Iceland
EF	Emission Factor
ERT	Expert Review Team
ERU	Emission Reduction Unit
EU	European Union
EU ETS	European Union Greenhouse Gas Emission Trading System
FAI	Farmers Association of Iceland
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
IEF	Implied Emission Factor
IFR	Icelandic Forest Research
IFS	Iceland Forest Service
IFVA	Icelandic Food and Veterinary Association

IPCC	Intergovernmental Panel on Climate Change
ITL	International Transaction Log
IW	Industrial Waste
Kha	Kilohectare
KP	Kyoto Protocol
LULUCF	Land Use, Land-Use Change and Forestry
MAC	Mobile Air Conditioning
MAC	Mobile Air-Conditioning Systems
MCF	Methane Correction Factor
MMR	Monitoring Mechanism Regulation
MSW	Municipal Solid Waste
N_2O	Nitrous Oxide
NEA	National Energy Authority
HA-1	Nitrogen Trifluoride
NFI	National Forest Inventory
NIR	National Inventory Report
NIRA	The National Inventory on Revegetation Area
NMVOC	Non-Methane Volatile Organic Compounds
NO_X	Nitrogen Oxides
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
RMU	Removal Unit
SCSI	Soil Conservation Service of Iceland
SEF	Standard Electronic Format
SF_6	Sulphur Hexafluoride
Si	Silicon
SiO	Silicon Monoxide
SiO2	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	2006 IPCC GWP
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298
Sulphur hexafluoride	SF_6	22,800
Perfluorocarbons (PFCs):		
Tetrafluoromethane (PFC 14)	CF_4	7,390
Hexafluoroethane (PFC 116)	C_2F_6	12,200
Octafluoropropane (PFC 218)	C_3F_8	8,830
Hydrofluorocarbons (HFCs):		
HFC-23	CHF_3	14,800
HFC-32	CH_2F_2	675
HFC-125	C_2HF_5	3,500
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1,430
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	4,470
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	124
HFC-227ea	C_3HF_7	3,220

Source: Table 2.14 of the Fourth Assessment report (AR4 - WGI), 100-yr time horizon.

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

Executive Summary

ES.1 Background

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol requires that the Parties report annually on their greenhouse gas (GHG) emissions by sources and removals by sinks. In response to these requirements, Iceland has prepared the present National Inventory Report (NIR). This NIR together with the associated Common Reporting Format (CRF) tables and Monitoring Mechanism Regulation (MMR) templates is submitted in accordance with Article 7.1 of the MMR (Regulation No 525/2013) and relevant articles and annexes in the Implementing Regulation No 749/2014.

The responsibility of producing the emissions data lies with the Environment Agency of Iceland (EA), 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 the year 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 to 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

[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

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.

- 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.
- 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.

The distribution of reported greenhouse gas emissions over the UNFCCC sectors (excluding LULUCF) 1990 to 2020 is shown in Figure ES. 1. Emissions from the Energy sector and Industrial Processes 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 between 1990 and 2020 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)

[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)

increased by 23% from 1990 to 2020. 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.

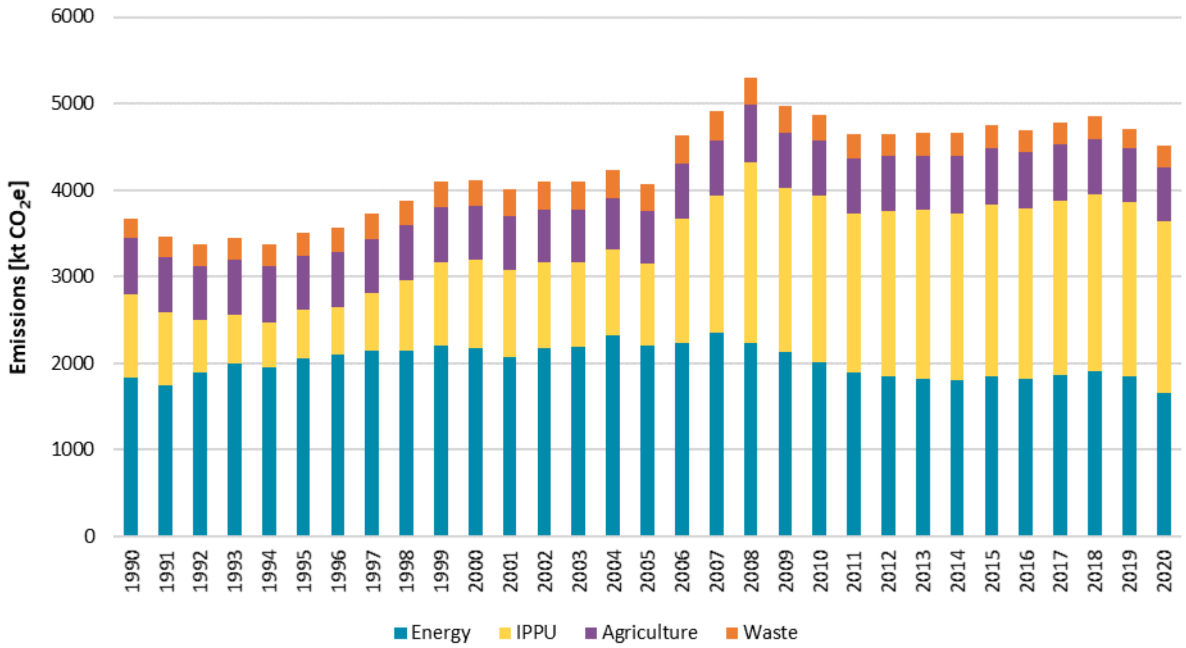


Figure ES.1 Emissions of GHG by sector, without LULUCF, from 1990 to 2020, [kt CO_2e]

Table ES. 1 Emissions of GHG by sector, without LULUCF, from 1990 to 2020, [kt CO_2e]

	1990	1995	2000	2005	2010	2015	2019	2020	Change ’90-´20	Change ´19-´20
1 Energy	1,836	2,053	2,181	2,155	2,020	1,848	1,849	1,659	-10%	-10%
2 Industrial Processes	958	565	1,010	955	1,917	1,983	2,020	1,986	107%	-1.7%
3 Agriculture	662	618	627	605	631	655	621	618	-6.5%	-0.5%
4 Land Use, Land Use Change and Forestry	9,199	9,175	9,194	9,232	9,196	9,107	9,020	9,010	-2.1%	-0.1%
5 Waste	219	270	302	304	296	261	223	247	12%	10%
Total without LULUCF	**3,674**	**3,506**	**4,119**	**4,019**	**4,865**	**4,746**	**4,713**	**4,510**	**23%**	**-4.3%**
Total with LULUCF	**12,873**	**12,681**	**13,314**	**13,251**	**14,061**	**13,853**	**13,733**	**13,519**	**5.0%**	**-1.6%**

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

XXX

- 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 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 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 and not include 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 2021 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. The NIR, together with the associated Common Reporting Format (CRF) tables and Monitoring Mechanism Regulation (MMR) templates is submitted in accordance with article 7.1 of the MMR (Regulation 512/2013) and relevant articles and annexes in the Implementing Regulation 749/2014, as per Art. 58 of Regulation 2018/1999 on transitional provisions as regards the second commitment period of the Kyoto Protocol.

In 1995 the Government of Iceland adopted an implementation strategy based on the commitments of the Framework Convention. The domestic implementation strategy was revised in 2002, based on the commitments of the Kyoto Protocol and the provisions in the Marrakech Accords. Iceland acceded to the Kyoto Protocol on 23 May 2002. The Kyoto Protocol commits Annex I Parties to individual, legally binding targets for their GHG emissions. A brief overview of Iceland's international obligations with regards to its GHG emissions can be found here:

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.

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 concerning Iceland´s participation in the joint fulfilment of commitments of the Union, the Member States and Iceland 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 ("MMR") and current and future Delegated and Implementing Acts based on Regulation (EU) No

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

525/2013 shall be binding upon Iceland. This includes for instance Commission Implementing Regulation (EU) No 749/2014, which further details 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.

1.1.3 Paris Agreement period (2021-2030)

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 (**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).

1.1.4 Climate change strategies

A climate change 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 Change Action Plan in order to execute the strategy.

In September 2018 the Icelandic government published a Climate Change Action Plan[7] for the years 2018-2030; an updated version of the action plan was released in June 2020[8] 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.

[6] Decision of the EEA Joint Committee No 269/2019
[7] Aðgerðaáætlun í loftslagsmálum 2018-2030: Climate Action plan 2018-2030, in Icelandic
[8] Aðgerðaáætlun í loftslagsmálum til 2030: Climate Action plan, updated second edition, in Icelandic

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, Energy and Climate, 2021[9]) 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.

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 (EA), an agency under the auspices of the Ministry of the Environment, Energy and Climate, carries the overall responsibility for the national inventory. EA compiles and maintains the GHG emission inventory, except for the LULUCF sector which is compiled by the Soil Conservation Service of Iceland and the Icelandic Forest Service in collaboration with the Agricultural University of Iceland (AUI). The EA reports to the Convention and to the EU. The Act specifies that the EA 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 (see also Chapter 13). 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 Ministry of the Environment, Energy and Climate (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.

[9]2021 Progress report on the Climate Action Plan, published September 2021 (in icelandic)

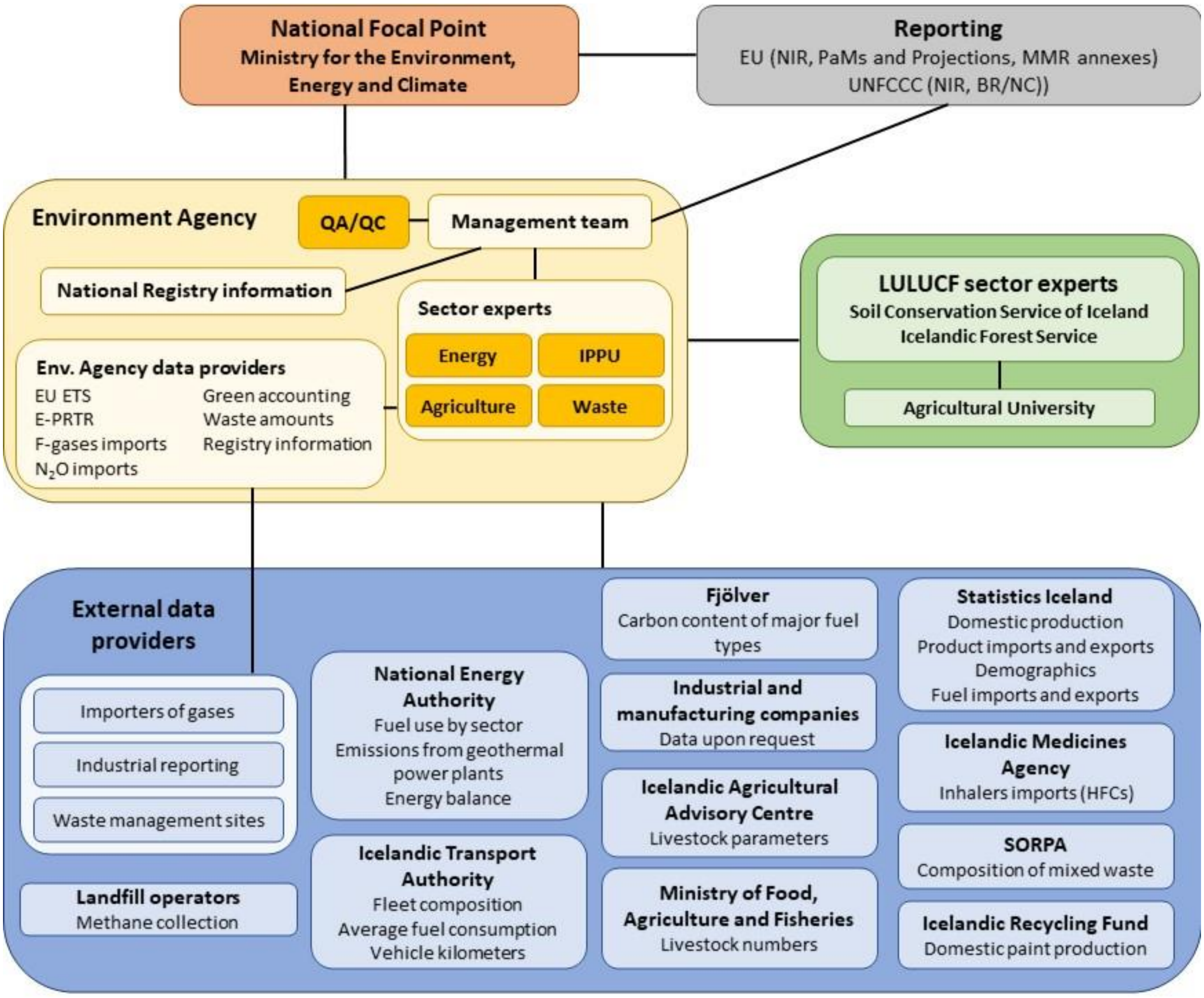


Figure 1.1 Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the UNFCCC.

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 mitigation to the consequences of climate change, and
- To create a framework for the government to fulfil its international obligations regarding climate change.

Act No 70/2012 supersedes Act No 65/2007 on which basis the EA 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 EA is the responsible entity for the national accounting 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 (EA) compiles Iceland’s GHG inventory in accordance with Iceland´s international obligations. Act No 70/2012 established the form of relations between the EA and other bodies concerning data handling. Responsibilities from the various bodies are further specified in Regulation No 520/2017, as described below.

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[10] was adopted in June 2017. This regulation establishes formally the data provision modalities, such as content, format and deadlines for data submission to the EA; furthermore, it implements 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. Further details on the Regulation can be found in Chapter 13 of Iceland’s NIR 2021.

Regulation No 520/2017 has proved difficult to implement fully (see Chapter 13 in Iceland’s NIR 2021) and is being revised now. A final draft of the revised regulation is expected to be accepted within the next few months and the updated regulation published in 2022. Main changes will be highlighted in next year’s NIR, as this submission was still done following Regulation No 520/2017. Main changes 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.

Furthermore, Commission Implementing Regulation (EU) 2020/1208 establishes stricter rules on the establishment, operation and functioning of the National inventory system[11], reference to which will be included in the updated regulation.

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 EA and be composed of representatives from the Soil Conservation Service, the Forestry Service, the Ministry of the Environment, Energy and Climate 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

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

[11] Art. 26-29 of Regulation (EU) 2020/1208

between experts in the inventory team, various ministries as well as experts from other institutions, companies, universities and research centers.

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 EA collects the bulk of data necessary to run the general emission model, i.e. activity data and emission factors, for all sectors apart from LULUCF. Activity data is collected from various institutions and companies, as well as by EA 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 EA.
- The National Energy Authority collects fuel sales data by sector; however, the sectoral split of the NEA does not entirely match that of the IPCC, thus the EA processes the data in order to ensure correct attribution to the IPCC codes as per the CRF.
- The Soil Conservation Service of Iceland 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 Icelandic Forest Service 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, the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands and the 2013 Revised supplementary methods and good practice guidance arising from the Kyoto Protocol. When available, country specific emission factors are used.

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

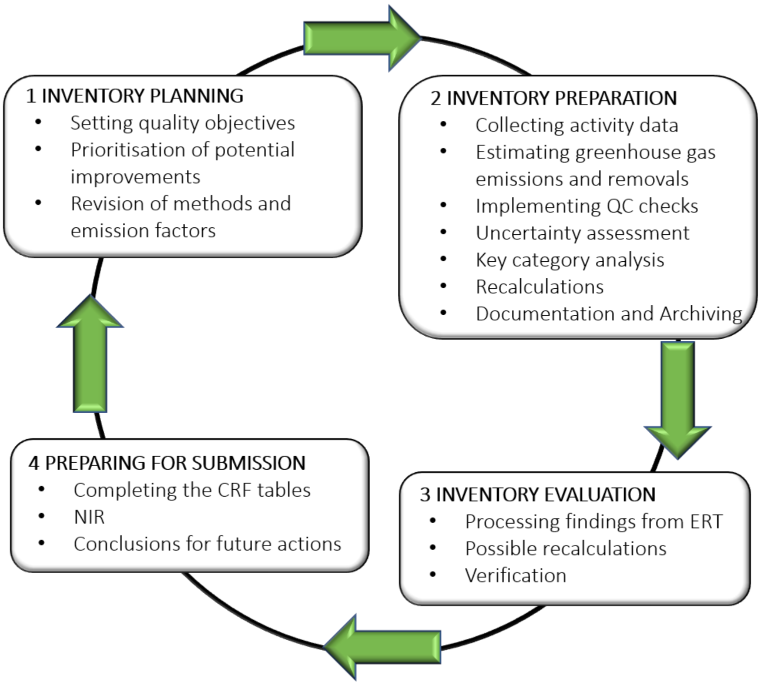


Figure 1.2 Iceland's annual inventory cycle.

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 harmonized 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 source categories and for those categories where data and methodological changes have recently occurred.

After an approval by the Ministry of the Environment, Energy and Climate, the GHG inventory is submitted to the UNFCCC by the EA.

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 EA'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 EA 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 200 km straight line.

Backups are taken daily, a subset of those is regularly set for at least 15 months storage. The exact backup schedule is currently under evaluation.

The land use database IGLUD is stored on a server of the Soil Conservation Service of Iceland (SCSI) as well as spreadsheets containing calculations regarding other land use classes than forest land. Data regarding forest land, forestry and harvested wood products are stored on servers of the Icelandic Forest Service.

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 as part of a staff development plan. In addition, more general training has been received at the institutional level including the improvement to inventory systems and transparency. This is important in terms of business continuity, for example when key individuals leave the Agency, or change roles, leaving knowledge gaps that may require filling at short notice. The main recent activities are outlined below.

- Training by the consulting company which has been helping staff at the Environment Agency 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 EA 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 EA 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 EA 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. Organized 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 organized by Aether for European Commission.
  - **All sectors:** Capacity-building webinars organised by DG Climate action on ESD review 2021 and LULUCF trial review
- Participation in a Nordic inventory experts' workgroup, where inventory compilers from Norway, Sweden, Finland, Denmark and Iceland meet once a year (separate meetings for LULUCF and for the other sectors (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 to the annual training session for the COPERT model, organized 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

Additional funding was allocated by the Icelandic government to the Environment Agency in recent years, in recognition of the fact that the existing staff did not have the capacity to fully adhere to all reporting obligation, including (but not limited to) the work associated with the new EU regulations pertaining to the commitment period under the Paris Agreement (2021-2030 - for instance, the Effort Sharing Regulation (EU) 2018/842, the Governance Regulation (EU) 2018/1999 and the Commission Implementing Regulation (EU) 2020/1208). A new staff member was hired early 2020 to work on the inventories early February 2020. Another new position was filled in January 2021. At the time of this writing, two new positions were filled earlier this year. This brings the capacity of the inventory team to a total of 7.5 positions for the sectors covered by the EA (all except LULUCF) and for the overall project management; in addition to this, the inventory team also includes a 50% lawyer position, and a position specialising in communication. This will ensure more time allocated to each sector, which is expected to allow for more time for QA/QC activities. It is though 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).

Two full-time persons were added to the SCSI LULUCF inventory team in 2021. The LULUCF inventory team now consists of 13 persons, 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. The NFI/LULUCF team of the Icelandic Forest Service consist of six fulltime employees and two summer workers yielding 3.5 person years in NFI/LULUCF projects in 2021.

1.4 Key Category Analysis

According to the IPCC definition, a key category is one that is prioritized 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. The Key Category Analysis for the KP-LULUCF emissions/removals can be found in Section 11.7.1.

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 2020	Trend
Energy (CRF sector 1)					
1A2	Fuel combustion - Manufacturing Industries and Construction	CO_2	✓		✓
1A3b	Road Transportation	CO_2	✓	✓	✓
1A3e	Other Mobile Machinery	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 2020	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	Fertilizer 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 Horses	Enteric Fermentation - Horses	CH_4	✓	✓	
3B11	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

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

The Hub is focused around three interconnecting elements:

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

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

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

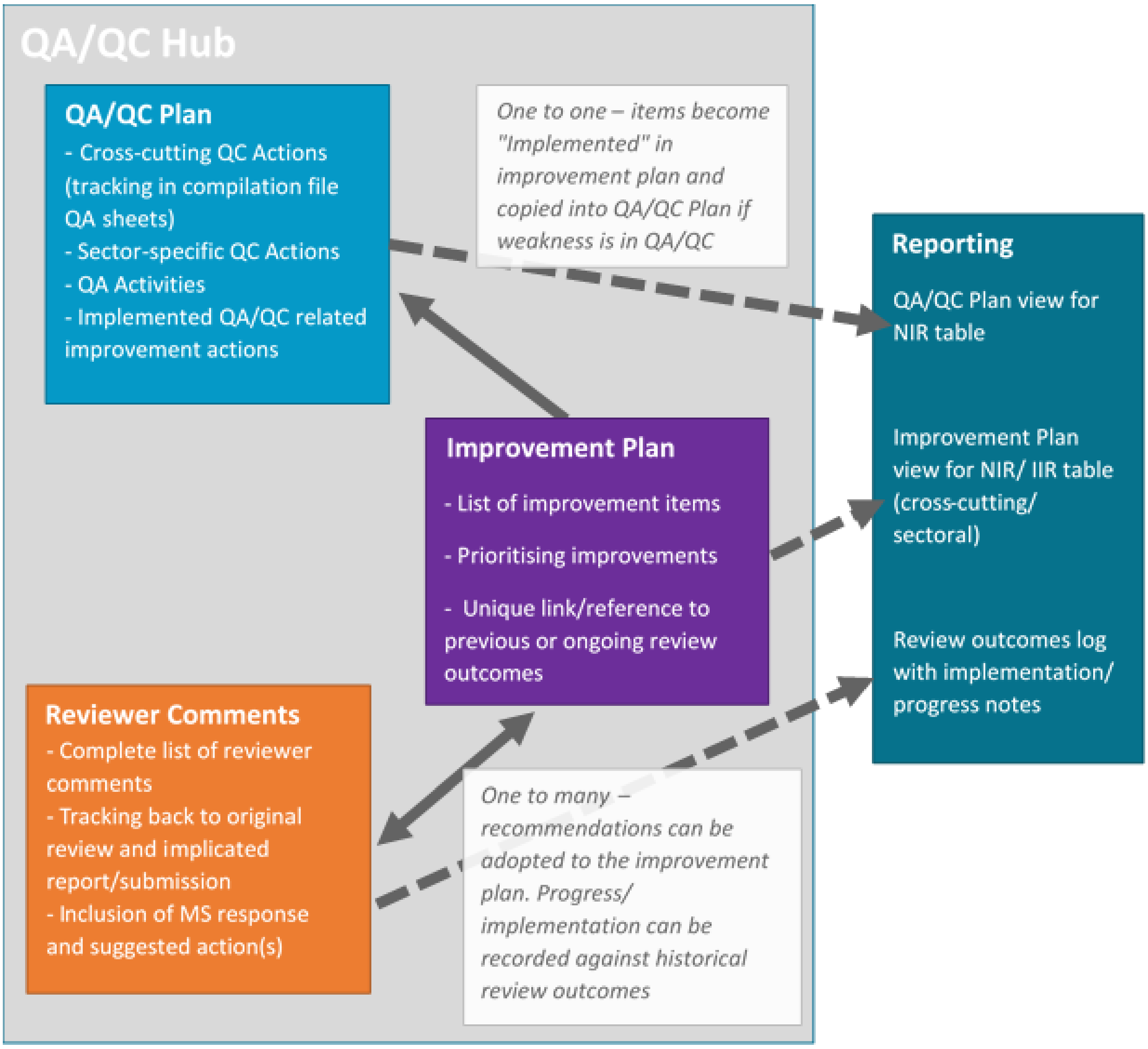


Figure 1.3 Schematic overview of the elements included in the QA/QC hub

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

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

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

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

1.5.2 Roles and responsibilities overview

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

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

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 Forestry 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 inventory submitted in 2017 was subjected to a UNFCCC in-country review, but no UNFCCC review took place in 2018. In September 2019, a UNFCCC desk review took place.

Iceland volunteered for an EU step 2 review (as described in Art. 32 of Regulation (EU) 749/2014), which took place in April 2019. In 2020, the inventory was submitted to a comprehensive review by the EU, as specified by Art. 4 of Regulation (EU) 2018/842. This review focussed on emissions falling within the scope of Regulation 2018/842, which are all emissions outside of the EU-ETS and outside of LULUCF (so called "Effort-sharing" emissions). Emissions of the years 2005, 2016, 2017 and 2018 were reviewed, as emissions for those years were used in order to determine Iceland's annual emission allocations (AEAs) pertaining to Art. 4 of Regulation 2018/842. At the end of the review, Iceland provided the review team with 3 revised estimates (one in the IPPU sector, one in the Agriculture sector and one in the Waste sector). Details of the changes made following the Comprehensive Review can be found in Chapter 10.2.

The most recent review took place in the autumn of 2021, with a centralised UNFCCC review during the first week of October 2021. The review did not lead to a resubmission of the 2021 inventory. At the time of this writing, we have not yet received the draft 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
- A comparison of implied emission factors with the EU-15

Furthermore, Iceland participates in various international experts' groups which aim at discussing and enhancing the overall quality of the inventory. Compilers of Iceland's inventory participate in following international collaborative groups:

- Participation in a Nordic inventory experts' workgroup, where inventory compilers from Norway, Sweden, Finland, Denmark and Iceland meet once a year (separate meetings for LULUCF and for the other sectors (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.

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). 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.

As the QA/QC procedure is still being implemented, sector- and subsector specific guidelines on nature and frequency of QC checks are in the process of being developed. An example of a general checklist all sectors have to complete is given in Table 1.3. 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.

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 used to report on emissions under the EU ETS via the MMR-IR Article 10 Template. 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.

Further QC activities include the comparison between the atmospheric pollutants NO_X, CO, NMVOC and SO_2 reported in this inventory with the data reported under CLRTAP. This comparison is submitted to the EU via MMR-IR Article 7 template. In general, the data agrees well, except in the case of aviation where the data reported under CLRTAP comes from the Eurocontrol dataset, whereas the data reported in the NIR, where the disaggregation between landing and take-off is not necessary, are based on fuel sales and emission factors from the 2006 IPCC Guidelines.

Table 1.3 Example of minimum, medium and full QC requirements to be performed within the emission inventory team according to time constraints and staff capacities.

Check	Description
1 - MINIMUM: small degree of sector knowledge necessary	
Activity data source	Is the appropriate data source being used for activity data?
Correct units	Check that the correct units are being used
Unit carry through	Are all units correctly carried through calculations to the summary table? This includes activity data and emission factors.
Calculations check	All calculations checked by a second person
Double counting	Check to ensure no double counting is present
Notation keys	Review the use of notation keys and the associated assumption to ensure they are correct.
2 - MEDIUM: a certain degree of sector knowledge necessary	
Method validity	Are the methods used valid and appropriate?
Trend check	Carry out checks on the trend to identify possible errors. Document any stand out data points.
Emission factor applicability	Where default emission factors are used, are they correct? Is source information provided?
Time series consistency	Are activity data and emission factor time series consistent?
Spot checks	Complete random spot checks on a data set.
3 - FULL: sector specific knowledge required	
Recalculations	Check values against previous submission. Give reasons where the two values do not match.
Sub-category completeness	Is the reporting of each sub-category complete? If not, this should be highlighted.
Documentation	Is there sufficient documentation?
Colour coding	Has colour coding been used in a consistent and accurate manner? Are there any significant data gaps of weaknesses?
Cross check data	Where possible cross check data against alternative data sources.
Data source referencing	All source data submitted must be referenced
Links to source data	Where possible, links to the source data must be provided
Raw primary data	All raw primary data must be present in the workbook

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. It is also planned to fully document the results of QC activities for each sector and providing evidence of such activities by including screenshots of the Q Comments tool discussed under section 1.5.4.

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

1.6 Uncertainty Analysis

The uncertainty analysis is based on the Approach 1 – error propagation of the IPCC 2006 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 1.4 Uncertainties 2020

	With LULUCF		Without LULUCF	
	Uncertainty 2020 [%]	Trend [%]	Uncertainty 2020 [%]	Trend [%]
CO_2	22.0%	15.5%	1.6%	2.3%
CH_4	54.5%	8.5%	3.1%	4.3%
N_2O	2.4%	0.8%	7.2%	3.3%
HFCs	1.5%	2.2%	4.6%	7.8%
PFCs	0.11%	0.49%	0.32%	2.09%
SF_6	0.010%	0.011%	0.030%	0.039%
Total GHG	**58.9%**	**17.9%**	**9.2%**	**10.0%**

The total inventory uncertainty is 58.9% and the trend uncertainty estimate for this submission is 17.9%. When excluding LULUCF the trend uncertainty is 10.0% and the total inventory uncertainty is 9.2% as can be seen in Table 1.4.

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[12] are reported.

[12] 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 are not included in 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. Typically, this sector is dominated by the big fossil fuel users including electricity generation and road transport. This is however different in Iceland due to electricity being produced by hydropower and geothermal, and so the energy sector is dominated by road transport and fishing industry.

- Industrial Processes and Project Use (***IPPU***): non-fuel related emissions from industrial processes and use of products with global warming impacts. This is often 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 SF_6 from electrical equipment.

- ***Agriculture***: non-energy use emissions only 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 or organic manure and synthetic fertiliser to land results in both direct and indirect N_2O from soils. Additional products which can be added to soils include liming and urea, which react with the soils composition to release CO_2. Finally, the process of burning crop residues left on agricultural soils is typically a small source of CH_4 and N_2O from the combustion as well as biogenic CO_2 (which is not counted in national totals).

- Land use change, land use 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/open burning, and wastewater. 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[13], 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 industry potentially using NF_3 (e.g. semiconductors, LCD manufacture, solar panels and chemical lasers) is present.

Total amounts of GHGs emitted in Iceland during the period 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).

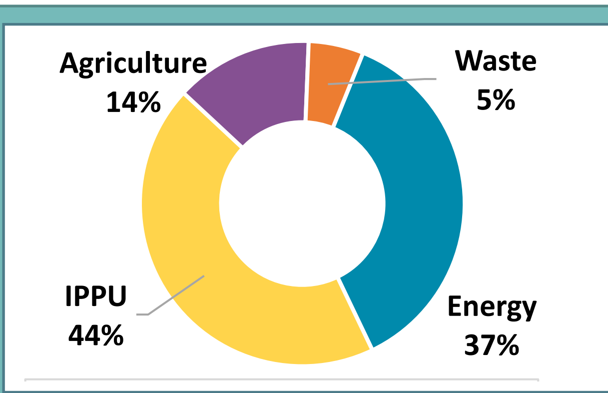
Iceland also reports emissions from indirect GHGs, this includes:

- nitrogen oxides (NO_X), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) which have an indirect effect on climate through their influence on GHGs, especially ozone; and
- sulphur dioxide (SO_2) which affects climate by increasing the level of aerosols that have in turn a cooling effect on the atmosphere.

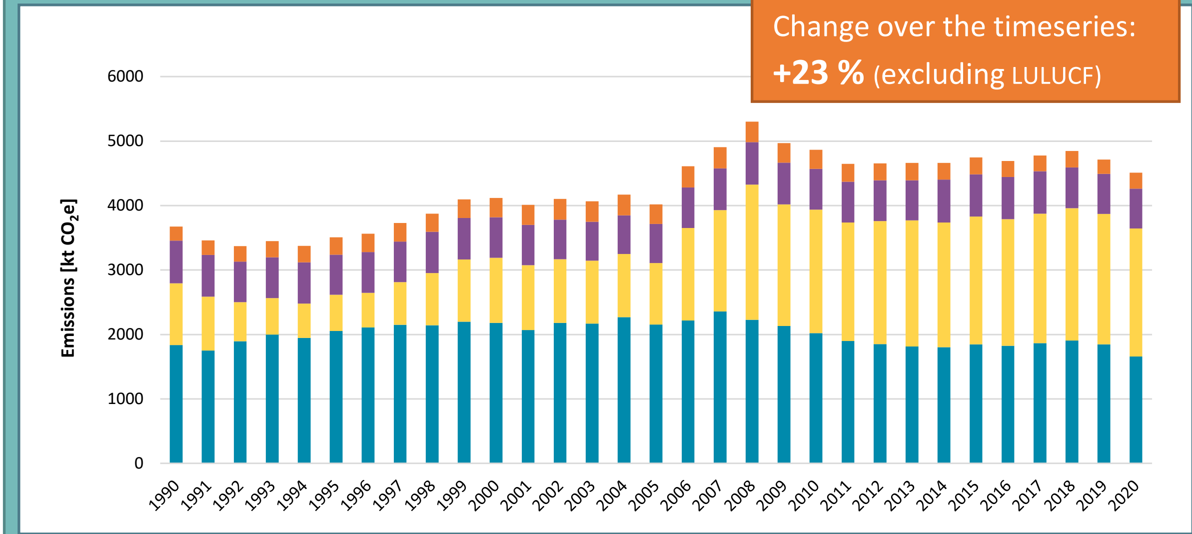
The emission trends from indirect GHGs are presented separately in Section 2.2.

[13] 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.



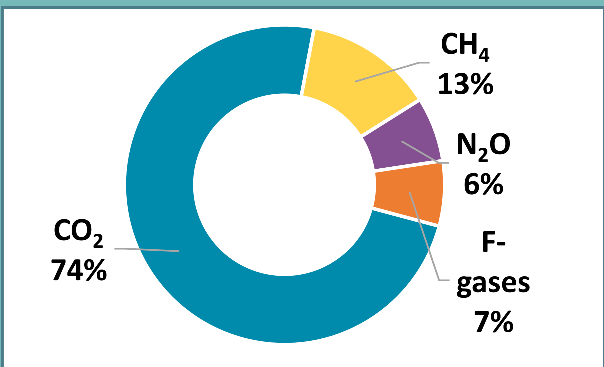
Change over the timeseries:
+23 % (excluding LULUCF)



By the middle of the 1990's, 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 was established 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.

Overall trend

Since 1990, Iceland's total GHG emissions have increased by almost a quarter This trend in increasing emission is dominated by:

- the expansion of the metal production sector, in particular the aluminium sector;
- increases in emissions from geothermal energy utilization 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.

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, with the exception of 1993. From 1995-1999 total emissions increased slightly.

By the middle of the 1990's, 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, 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, building time from 2002 to 2007) led to further increase in emissions from the sector.

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 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 sector 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 the year 2016 which saw a slight decrease.

In 2019, **aluminium production** increased 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 2019 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].

Sector	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '19-'20
1 Energy	1,836	2,053	2,181	2,155	2,020	1,848	1,849	1,659	-10%	-10%
2 Industrial Processes	958	565	1,010	955	1,917	1,983	2,020	1,986	107%	-1.7%
3 Agriculture	662	618	627	605	631	655	621	618	-6.5%	-0.5%
4 Land Use, Land Use Change and Forestry	9,199	9,175	9,194	9,232	9,196	9,107	9,020	9,010	-2.1%	-0.1%
5 Waste	219	270	302	304	296	261	223	247	12%	10%
Total without LULUCF	**3,674**	**3,506**	**4,119**	**4,019**	**4,865**	**4,746**	**4,713**	**4,510**	**23%**	**-4.3%**
Total with LULUCF	**12,873**	**12,681**	**13,314**	**13,251**	**14,061**	**13,853**	**13,733**	**13,519**	**5.0%**	**-1.6%**
Memo Items	249	241	465	427	380	829	1,170	342	37%	-71%

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.

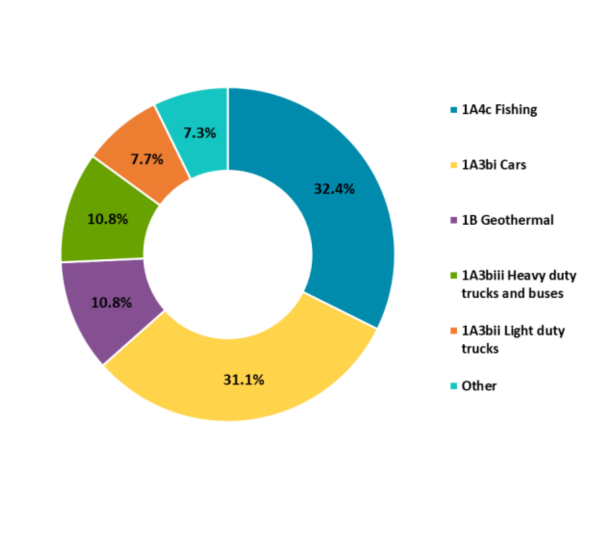
Table 2.2 Emissions of GHG gases by gas for the reported time series (without LULUCF) [kt CO_2e].

GHG	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '19-'20	% Total in latest year
CO_2	2,216	2,460	2,923	2,968	3,617	3,534	3,546	3,329	50%	-6.1%	74%
CH_4	606	630	659	648	656	631	570	590	-2.8%	3.4%	13%
N_2O	356	343	342	311	305	312	295	295	-17%	0.1%	6.5%
PFCs	495	69	150	31	172	104	97	96	-81%	-1.4%	2.1%
HFCs	0.3	3.4	44	58	111	163	203	198	57348%	-2%	4.4%
SF_6	1.1	1.2	1.3	2.5	4.7	1.6	2.3	3.2	188%	39%	0.1%
Total	**3,674**	**3,506**	**4,119**	**4,019**	**4,865**	**4,746**	**4,713**	**4,510**	**23%**	**-4.3%**	**100%**

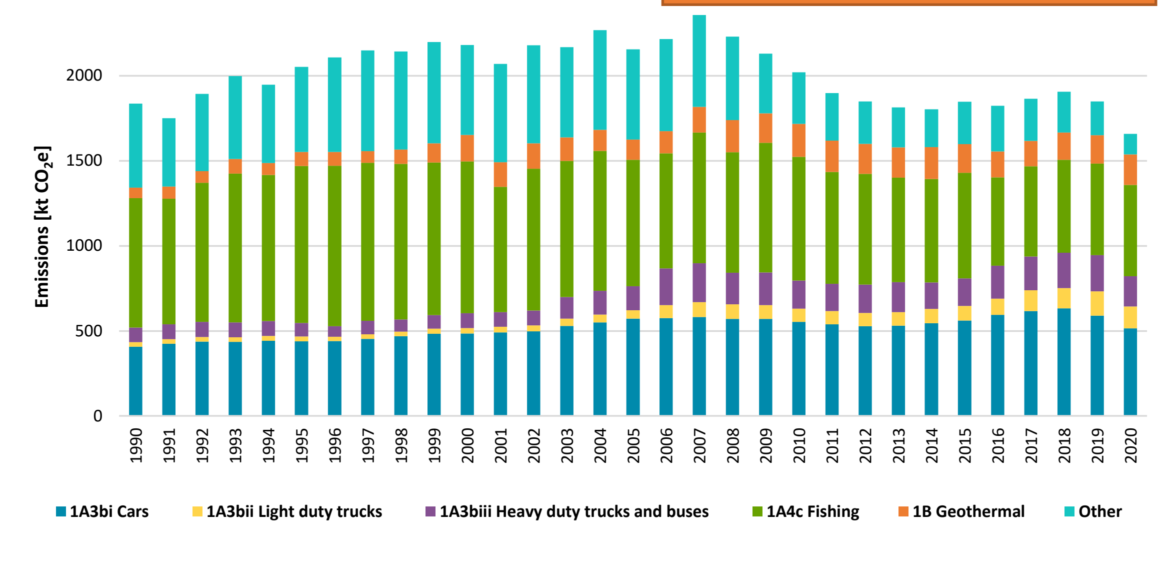
2.1.1 Energy (CRF sector 1)

37% of total emissions (excluding LULUCF)

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 call for high energy use and transport. Together with road transport, fisheries also dominate emissions in the energy sector.



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



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; projects are ongoing to capture CO_2 from geothermal plants and mineralise it underground for permanent storage.

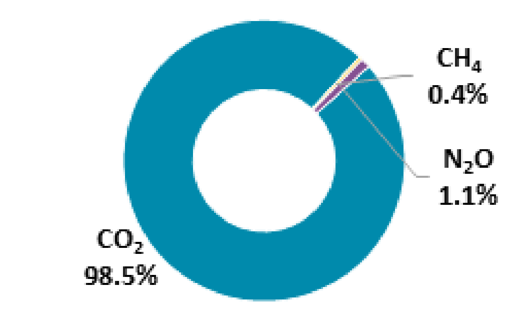


Figure 2.2 Overview of emissions from the Energy sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year

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 the 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, geothermal and fugitive emission, which covers emission 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 >1% of the sector's total emission for the whole timeseries). The sources of emissions from electricity and heat production are:

- ***Electricity produced with fuel combustion***, which occurs at two locations, which are located far from the distribution system (two islands, Flatey and Grimsey).
- ***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 industries sector have generally decreased since 1990. In 1995 there were issues in the electricity distribution system (snow avalanches in the west fjords 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 category over the period 1990 to 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, building time from 2002 to 2007). The construction sector collapsed in fall 2008 due to the economic crisis and 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 an increase in the number of cars per capita, more mileage driven and until 2007 an increase in larger vehicles. Since 1990, the vehicle fleet in Iceland has increased significantly, driven by the growing population, increase in cars per capita and increased tourism. Emissions from road vehicles 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, more fuel economic vehicles have, however, been imported – a turn-over of the trend from the years 2002 to 2007 when larger vehicles were imported. New registrations of electric vehicles and plug-in hybrids have also been increasing rapidly since 2014. Emissions from both domestic flights 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

The fisheries dominate the Other sector (1A4). Emissions from fisheries rose from 1990 to 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 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 utilization has 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 (approx. 30% of the total electricity production in recent years). Table 2.3 shows the emissions from geothermal energy from 1990 to 2019. Electricity production using geothermal power increased approximately 20-fold during this period resulting in an increase in emissions. Emissions from geothermal utilization are site and time-specific and can vary greatly between areas and the wells within an area 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 is 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.

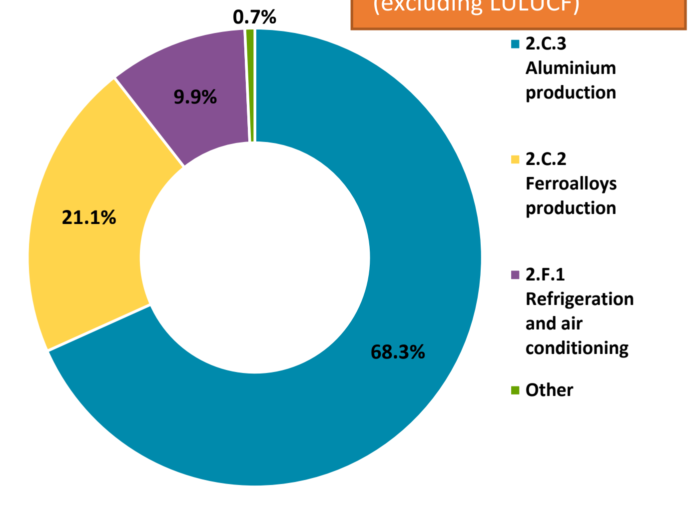
Table 2.3 Total GHG emissions from the Energy sector for the reported time series [kt CO_2e].

Energy Sector	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '19-'20
1A1 Energy industries	13.5	15.3	6.6	3.4	8.6	4.2	5.0	1.8	-87%	-64%
1A2 Manufacturing industries	238	217	226	185	85	62	54	45	-81%	-17%
1A3 Transport	724	784	869	1,056	981	984	1,075	887	23%	-17%
1A3a Domestic aviation	34	30	28	26	21	21	28	13	-61%	-53%
1A3b Road transport	523	550	608	766	805	819	950	825	58%	-13%
1A3d Domestic navigation	33	38	13	23	35	27	53	25	-24%	-53%
1A4 Other sectors (fishing)	797	952	920	761	737	630	546	545	-32%	0%
1A4a Commercial/ Institutional	8	8	7	5	2	2	4	3	-64%	-24%
1A4b Residential stationary	28	22	21	13	9	6	4	5	-81%	23%
1A4c Fishing	761	922	892	743	727	622	538	537	-29%	0%
1A5 Other	0	2	5	29	14	0	2	0	197%	-79%
1B2 Fugitive emissionsfrom fuels (incl. Geothermal energy	62	83	155	120	195	168	167	179	189%	7%
1B2d Geothermal	62	82	154	119	194	167	166	179	190%	8%
Total Emissions	**1,836**	**2,053**	**2,181**	**2,155**	**2,020**	**1,848**	**1,849**	**1,659**	**-10%**	**-10%**
International aviation (Memo)	221	238	411	425	380	680	965	264	19%	-73%
International navigation (Memo)	28	3	54	2	0	149	206	78	178%	-62%
CO_2 from biomass (memo)	NO	4	5	6	7	43	58	53	-	-9%

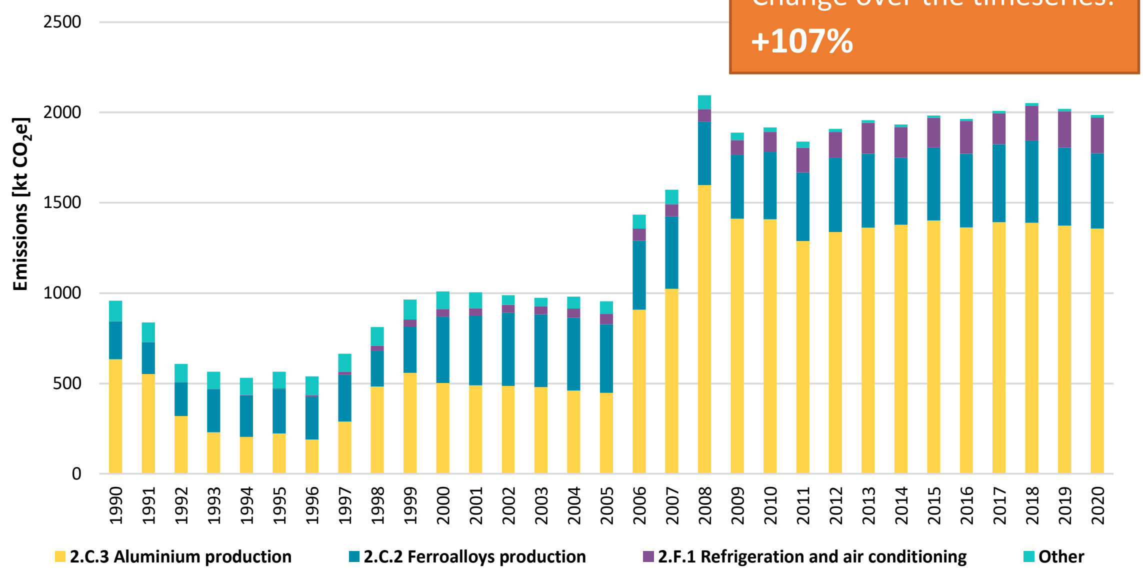
2.1.2 Industrial Processes and Product Use (CRF sector 2)

44 % of total emissions (excluding LULUCF)

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 like hydropower in Iceland allows the metal industry to lower emissions of CO_2 per ton of metal produced compared to the use of fossil fuels for energy generation.



Change over the timeseries: **+107%**



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.

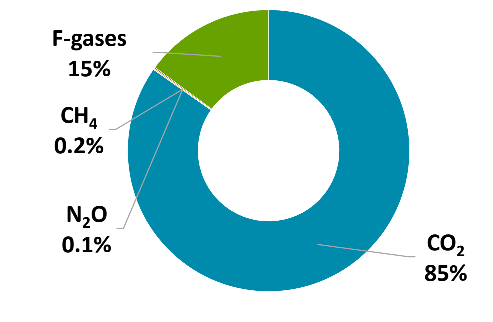


Figure 2.3 Overview of emissions from the IPPU sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year.

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.

The ***production of ferroalloys*** 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 the year 2017. The new plant ceased operations in mid-2017, but another silicon plant started its operations in May 2018.

Emissions from the ***production of minerals*** has 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 fertilizers, 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.

HFCs are used as substitutes for ozone depleting substances (ODS) that are being phased out in accordance with the Montreal Protocol. 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 (Table 2.5). 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 oxidized 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 fertilizer plant in 2001.

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

Industry Sector	1990	1995	2000	2005	2010	2015	2019	2020	Change '90- '20	Change '19- '20
2A Mineral products	52	38	65	55	10	0.7	1.0	0.9	-98%	-6%
2B Chemical industry	47	41	18	-	-	-	-	-	NA	NA
2C Metal production	844	469	868	828	1,781	1,807	1,805	1,775	110%	-2%
2D Non-energy products from fuels and solvent use	7.1	7.8	7.7	7.3	5.6	6.1	6.0	6.2	-13%	3%
2F Product uses as substitutes for ozone depleting substances	0.3	3.4	44	58	111	163	203	198	57367%	-2%
2G Other product manufacture and use	7.2	5.8	6.3	6.5	8.6	4.9	5.1	6.0	-17%	18%
Total Emissions	**958**	**565**	**1,010**	**955**	**1,917**	**1,983**	**2,020**	**1,986**	**107%**	**-2%**

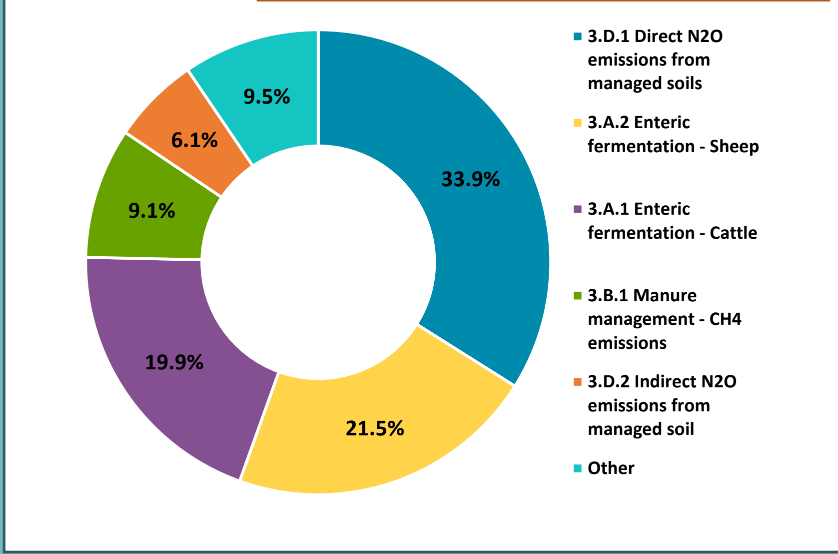
Table 2.5 Total HFC, PFC and SF_6 emissions from F-gas consumption [kt CO_2e].

GHG	1990	1995	2000	2005	2010	2015	2019	2020	Change '90- '20	Change '19- '20
HFCs	0.34	3.4	44	58	111	163	203	198	57348%	-2%
PFCs	495	69	150	31	172	104	97	96	-81%	-1%
SF_6	1.1	1.2	1.3	2.5	4.7	1.6	2.3	3.2	188%	39%

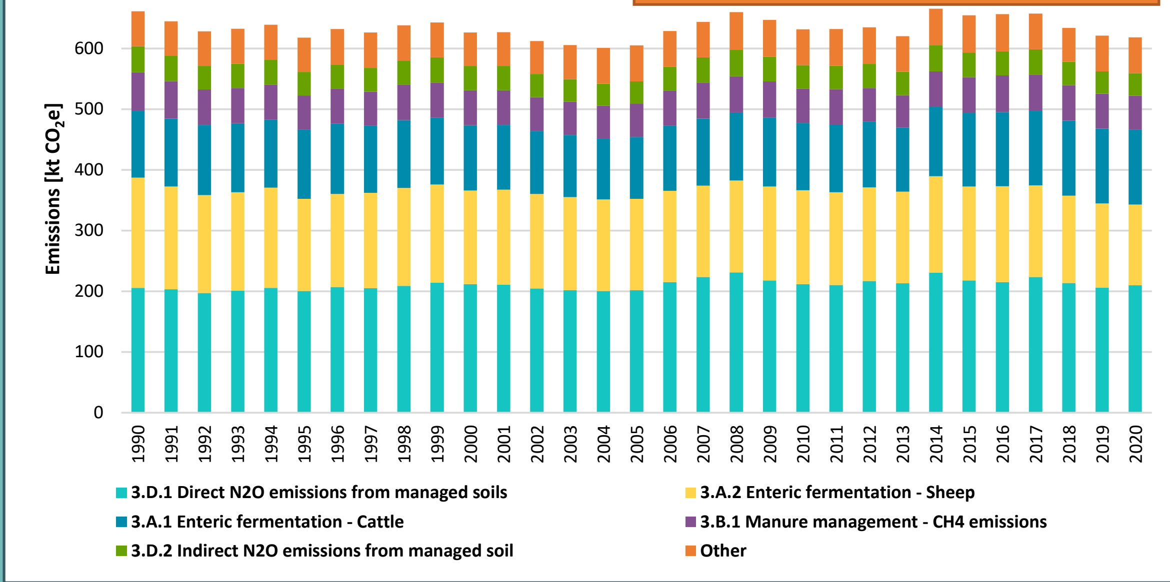
2.1.3 Agriculture (CRF sector 3)

14% 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: **- 6.5%**



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.

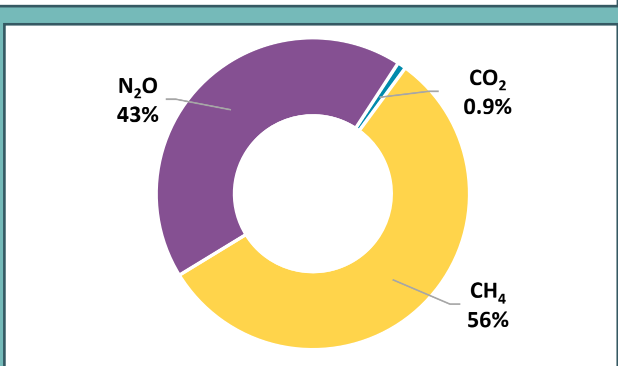


Figure 2.4 Overview of emissions from the agriculture sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year.

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

Since 2005, emissions from agriculture have increased due to an increase in livestock population size but still remain close to 1990 levels. This general trend is modified by the amount of synthetic nitrogen applied annually to agricultural soils.

N_2O emissions from the agriculture sector have decreased since 1990. This is mainly due to a decrease in livestock population accompanied by a decrease in manure production.

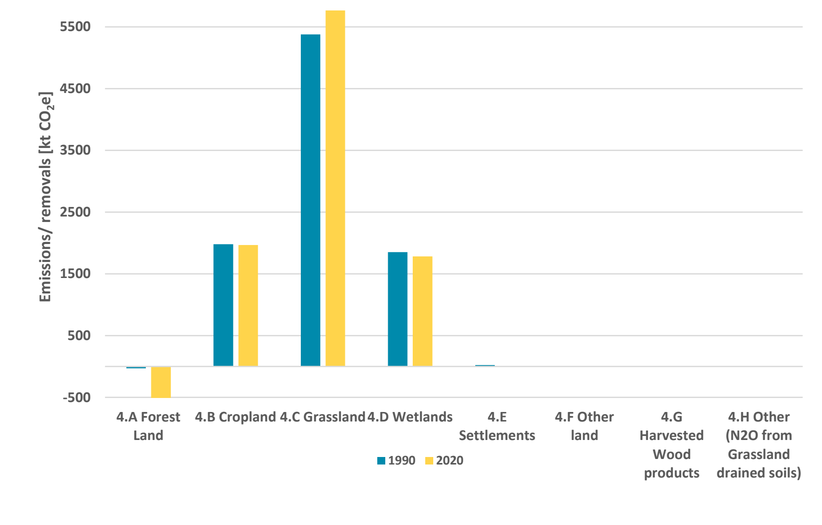
Table 2.6 GHG emissions from agriculture sector for the reported time series [kt CO_2e].

Agriculture sector	1990	1995	2000	2005	2010	2015	2019	2020	Change '90- '20	Change '19- '20
3A Enteric fermentation	326	303	298	289	303	314	297	291	-11%	-2%
3B Manure managment	86	76	77	74	76	79	76	74	-14%	-2%
3D Agricultural soils	248	239	252	238	250	258	243	248	0%	2%
3G Liming	0.5	0.0001	0.04	1.8	0.3	2.1	3.7	3.9	735%	4%
3H Urea application	0.06	0.06	0.07	0.07	0.13	0.17	0.22	0.19	252%	-12%
3I Other C-containing fertilizers	NE	NE	NE	2.3	1.7	1.2	1.9	1.4	NA	-26%
Total Emissions	**662**	**618**	**627**	**605**	**631**	**655**	**621**	**618**	**-6.5%**	**-0.5%**

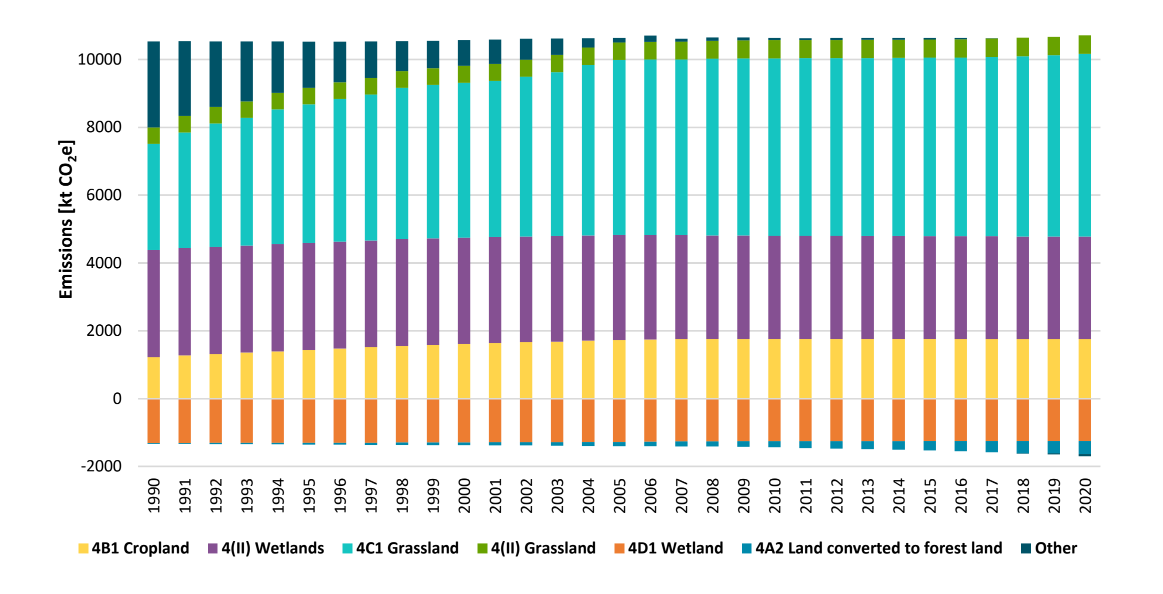
2.1.4 Land Use, Land-Use Change and Forestry (LULUCF, CRF sector 4)

66% of total emissions

Both emissions from sources and removals by sinks are reported for this sector. Overall, the LULUCF sector results in net emissions, which are greater that all other sectors combined. This is primarily due to emissions from grassland, wetlands and cropland.



Change over the timeseries: **-2.1%**



The LULUCF sector is dominated by CO_2 emissions from the drainage of wetlands.

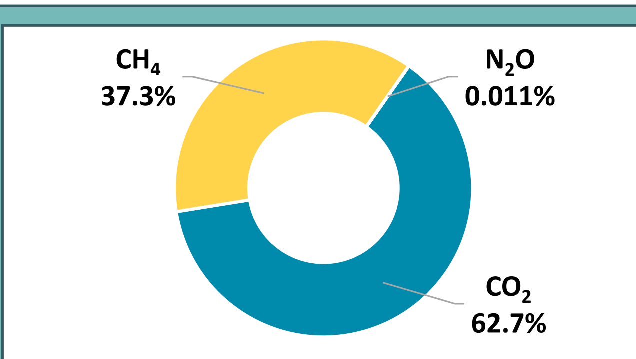


Figure 2.5 Overview of emissions and removals from the LULUCF sector, from top to bottom: (1) absolute emission and removals by subsector for the latest year, (2) emission and removals by subsector over the time series and (3) absolute emissions and removals by gas for the latest year.

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. Decreased emissions from Cropland are explained by changes in the agricultural sector, leading to less cropland area.

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.

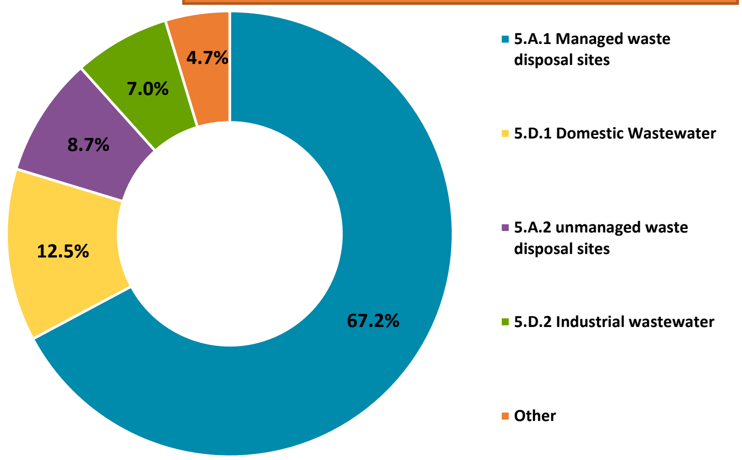
Table 2.7 GHG emissions and removals from the LULUCF sector for the reported time series [kt CO_2e].

LULUCF Sector	1990	1995	2000	2005	2010	2015	2019	2020	Change '90- '20	Change '19- '20
4.A Forest Land	-30	-53	-89	-140	-295	-400	-490	-510	1604%	4%
4.B Cropland	1,979	1,977	1,974	1,972	1,970	1,969	1,967	1,967	-1%	0%
4.C Grassland	5,375	5,372	5,446	5,557	5,718	5,744	5,756	5,766	7%	0%
4.D Wetlands	1,852	1,858	1,844	1,825	1,799	1,791	1,784	1,783	-4%	0%
4.E Settlements	22	22	18	18	4	4	4	4	-82%	3%
4.F Other land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.0028	NA,NE	0.001	NA	NA
4.G Harvested Wood products	NO,NA	NO,NA	0.0004	-0.0002	-0.03	-0.12	-0.08	-0.04	NA	-47%
Total Emissions	**9,199**	**9,175**	**9,194**	**9,232**	**9,196**	**9,107**	**9,020**	**9,010**	**-2.1%**	**-0.1%**

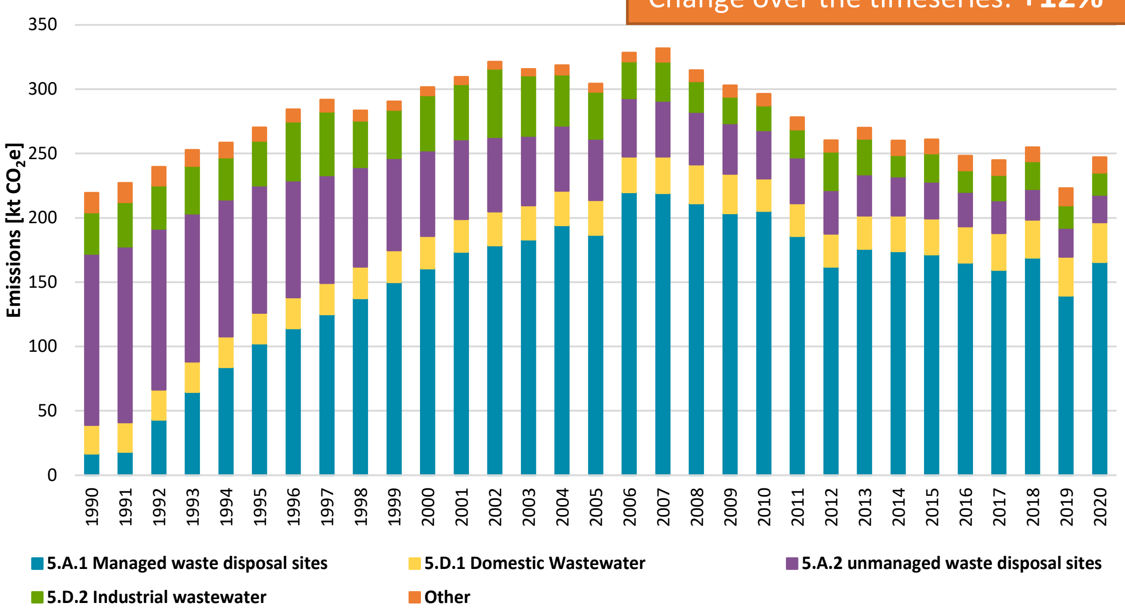
2.1.5 Waste (CRF sector 5)

Emissions from the waste sector show a parabolic shape increasing from 1990 to 2007 and then decreasing to reach similar levels of 1990. 2007. Emissions are dominated by solid waste disposal and wastewater treatment activities.

5% of total emissions (excluding LULUCF)



Change over the timeseries: **+12%**



Emissions from the waste sector are dominated by CH_4 emissions from solid waste disposal and wastewater treatment and discharge.

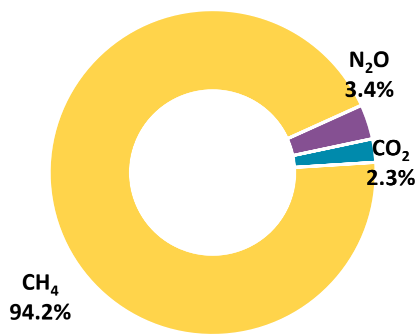


Figure 2.6 Overview of emissions from the waste sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year.

The majority of emissions from the waste sector are CH_4 emissions from solid waste disposal on land. The remaining emissions arose from wastewater treatment, waste incineration and the biological treatment of waste, i.e. 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. The total increase of SWD emissions between 1990 and 2019 amounted to 9%.

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*** 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 handling 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].

Waste Sector	1990	1995	2000	2005	2010	2015	2019	2020	Change '90- '20	Change '19- '20
5A Solid Waste Disposal	150	201	227	234	243	200	162	187	25%	16%
5B Biological Treatment of Solid Waste	NO	0.3	0.3	0.9	2.6	3.7	4.1	5.4	NA	33%
5C Incineration and Open Burning of Waste	15	10	6.0	5.5	6.5	7.1	9.4	6.0	-60%	-36%
5D Wastewater Treatment and Discharge	55	59	68	64	45	50	48	48	-12%	0%
Total	**219**	**270**	**302**	**304**	**296**	**261**	**223**	**247**	**12.4%**	**10.5%**

2.2 Emission Trends for Indirect Greenhouse Gases and SO_2

Nitrogen oxides (NO_X), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) have an indirect effect on climate through their influence on GHGs, especially ozone. Sulphur dioxide (SO_2) affects 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[14]. 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.

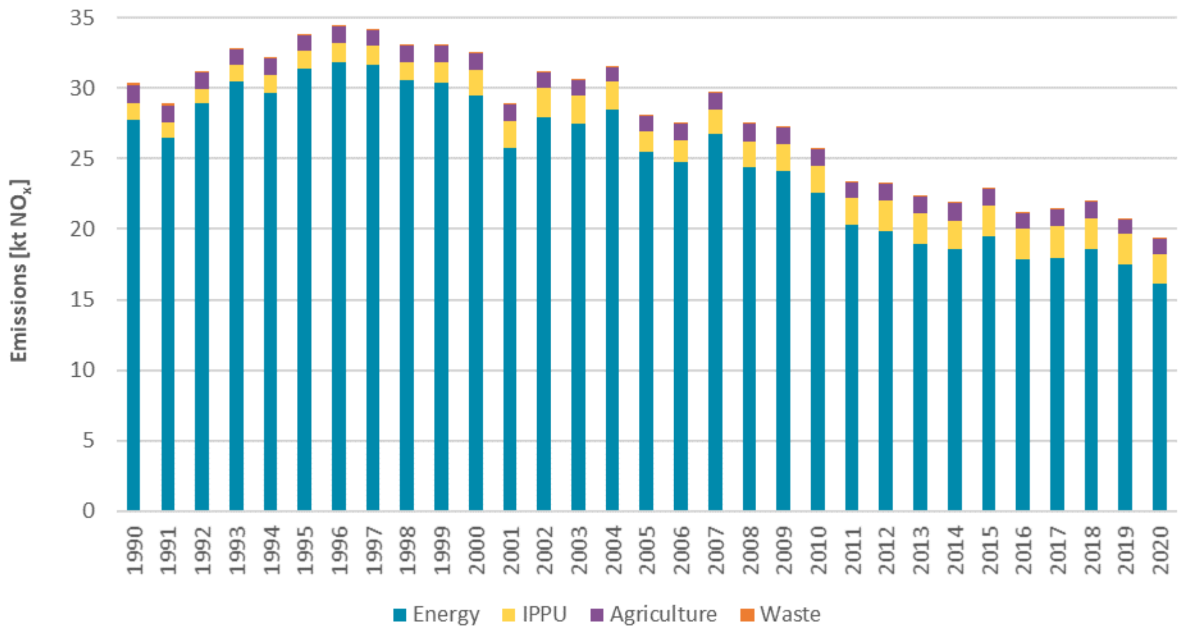


Figure 2.7 Emissions of NO_X by sector for the reported time series [kt].

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.

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

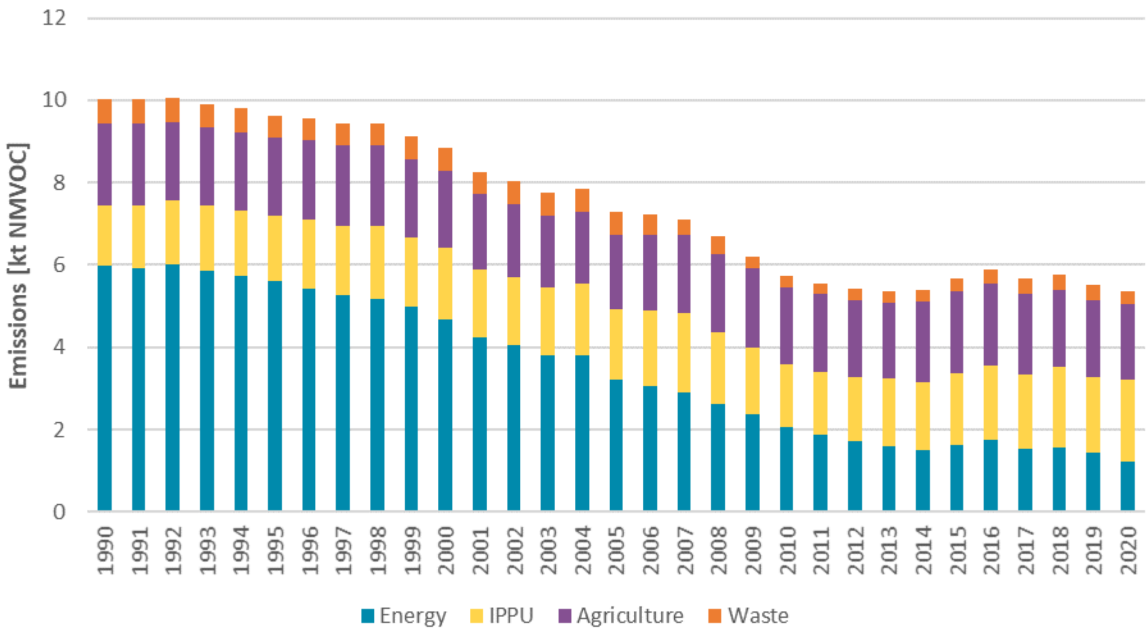


Figure 2.8 Emissions of NMVOC by sector for the reported time series [kt].

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 more than doubled since 1990.

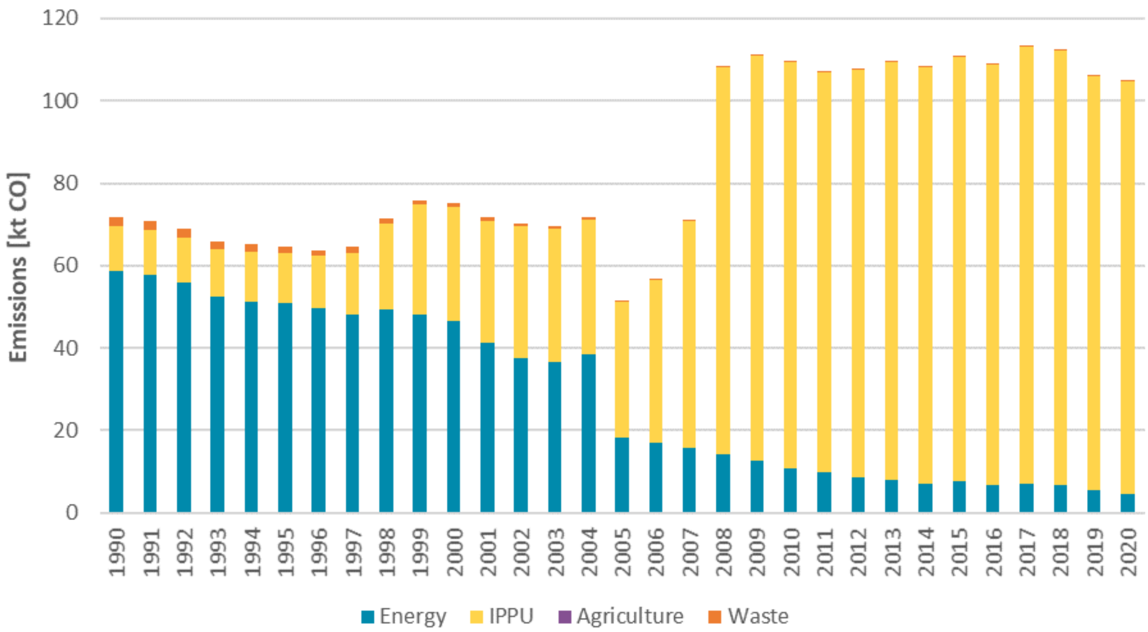


Figure 2.9 Emissions of CO by sector for the reported time series [kt].

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.

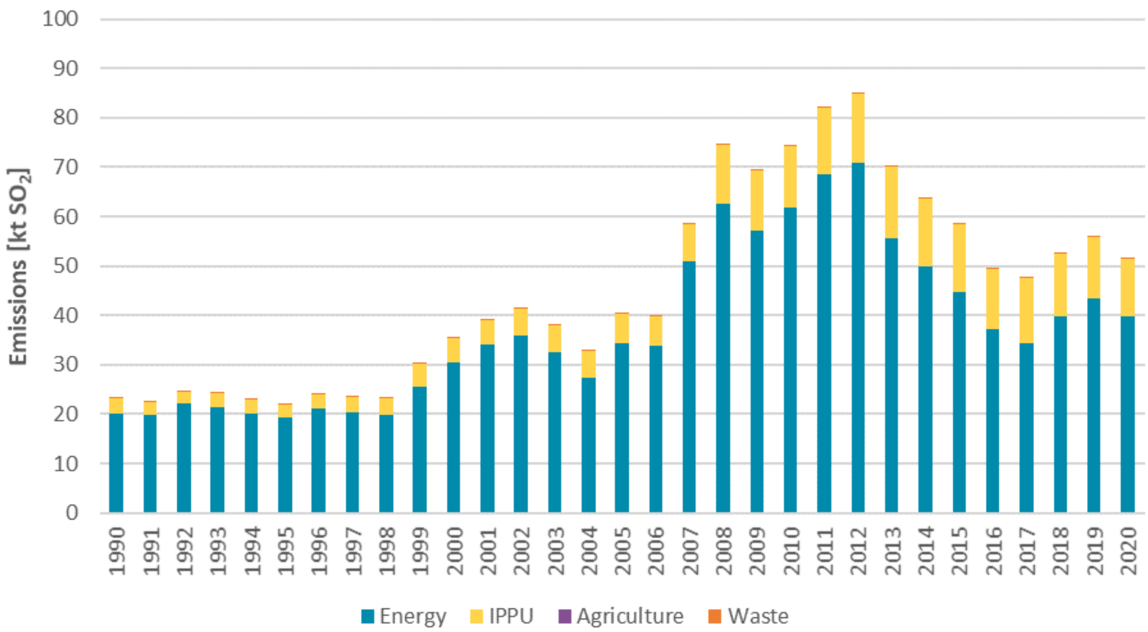


Figure 2.10 Emissions of SO_2 by sector for the reported time series [kt SO_2].

In 2010, the volcano Eyjafjallajökull erupted. The eruption lasted from 14 April until 23 May. During that time, 127 kt of SO_2 were emitted which is 71% more than total anthropogenic emissions in 2010. In 2011, the volcano Grímsvötn started erupting. The eruption lasted from 21 until 28 May. During that time around 1000 kt of SO_2 were emitted, or 12 times more than total anthropogenic emissions in 2011.

A large effusive eruption started in Holuhraun on 29 August 2014 and ended on 27 February 2015. It was the biggest eruption in Iceland since the Laki eruption 1783. Total SO_2 emission from this eruption was estimated 12,006 kt. Divided on calendar years 10,880 kt of SO_2 was emitted in the year 2014 and 1,126 kt of SO_2 in the year 2015. To put these numbers in perspective it can be said that the total SO_2 emission from all the European Union countries for the year 2012 was 4,576 kt. So, the emission from the eruption in the year 2014 i.e. from 29 August 2014 to 31 December 2014 was more than twice the total SO_2 emission from all the European Union countries for the whole year. For September alone, during the most intensive period of the eruption, the SO_2 emission from the eruption was similar to the annual emission of the European Union.

As the emissions from volcanos are natural, they are not included in national totals.

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 5.5.1. 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).

3.1.2 Key category analysis

The key categories for 1990, 2020 and 1990-2020 trend in the Energy sector are shown in Table 3.1 (compared to total emissions without LULUCF):

Table 3.1 Key category analysis for the Energy sector

IPCC source category		Gas	Level 1990	Level 2020	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 3.2 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 3.2 Energy – completeness (E: estimated, NA: not applicable, NO: not occurring)

Sources	CO_2	CH_4	N_2O	Methodology	Notes
1A Fuel Combustion Activities					
1. Energy Industries					
a. Public electricity and heat production	E	E	E	T1, T2	
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	T1	
b. Non-Ferrous Metals	E	E	E	T1	
c. Chemicals	E	E	E	T1	NO since 2004
d. Pulp, Paper and Print	NO	NO	NO	-	
e. Food Processing, Beverages and Tobacco	E	E	E	T1	
f. Non-Metallic Minerals	E	E	E	T1	
g. Transport Equipment	E	E	E	T1	IE for 1990-2018, reported under 1A3eii “off-road vehicles and other machinery”
3. Transport					
a. Domestic Aviation	E	E	E	T1	
b.i. Cars	E	E	E	T2, T3	
b.ii. Light duty trucks	E	E	E	T2, T3	
b.iii. Heavy duty trucks and buses	E	E	E	T2, T3	
b.iv. Motorcycles	E	E	E	T2, T3	
b.v. Other	NO	NO	NO	-	
c. Railways	NO	NO	NO	-	
d. Water-borne Navigation	E	E	E	T2, T1	
e. Other Transportation	E	E	E	T1	
4. Other sectors					
a. Commercial/Institutional	E	E	E	T1	
b. Residential	E	E	E	T1	
ci. Agriculture/Forestry/Fishing - Stationary	E	E	E	T1	
cii. Agriculture/Forestry/Fishing - Off-road vehicles	E	E	E	T1	IE for 1990-2018, reported under 1A3eii “off-road vehicles and other machinery”
ci. Agriculture/Forestry/Fishing - Fishing	E	E	E	T2, T1	
5. Non-specified elsewhere					
a. Stationary	E	E	E	T1	
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	Methodology	Notes
2. Oil and Natural Gas and Other Emissions from Energy Production					
a5 Oil – Distribution of Oil Products	E	E	NA	T1	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	T2	
1C CO_2 Transport and Storage					
1 . Transport of CO2	NO	NO	NO	-	
2. Injections and Storage	NO	NO	NO	-	
3. Other	NO	NO	NO	-	
1D Memo Items					
1. International Bunkers	E	E	E	T1	
a. International Aviation	E	E	E	T1	
b. International Navigation	E	E	E	T2, T1	
2. Multilateral Operations	NO	NO	NO	-	
3. CO_2 Emissions from Biomass	E	E	E	T1	
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:

- Identify and document discrepancies between the sectoral approach and the reference approach.
- All emissions calculations are quality checked by a second sectoral expert, which did not compile the inventory.
- Cross-checks with data from the NEA with total input data in calculations files to ensure that all fuels are accounted for.
- Review of the Energy chapter in this NIR by external stakeholders (planned improvement).
- 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 are checked and the attribution between IPCC subsectors are discussed.

3.1.5 Planned Improvements

Several improvements are planned for the next submission:

- Increased collaboration with the Icelandic Transport Authority to streamline data transfer to the EA.
- 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.
- The use of charcoal for grilling is being investigated. This issue was brought up in the 2017 UNFCCC in-country review and Iceland is planning on working with búf to obtain this data.
- It is planned to send the Energy chapter for review by national stakeholders.

3.1.6 Activity Data

Activity data is provided by the National Energy Authority (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 fuels sales data from the NEA is attributed to IPCC sectors. For that submission the review only included the years 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 b Commercial/Residential combustion - sales statistics are used directly and no adjustments are needed
- 1A5 Other – all fuels that are categorised as Other in sales statistics without any explanation of use are attributed to this category.

Due to insufficiently detailed splits in the sales statistics between fuel used for different manufacturing industries that belong to 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 and that data is used for 1A2a, 1A2b, 1A2c and 1A2f – this is the known usage.
- Because these fuels are purchased from domestic oil companies, they will be subtracted from the sales statistics received from the NEA.
- The difference between known usage and sales statistics is attributed to the category 1A2gviii Other Industry.

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

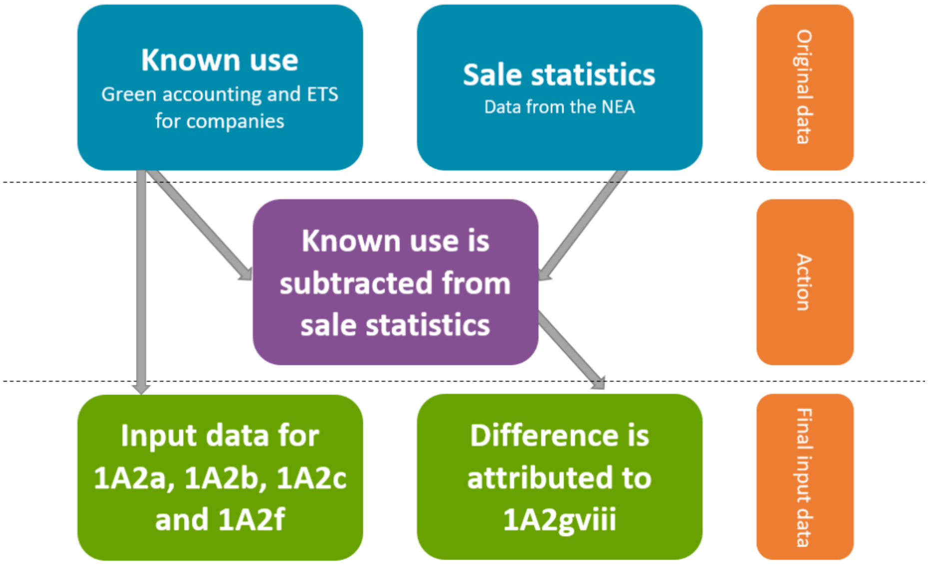


Figure 3.1 Description of adjustments in input data for IPCC category 1A2

In the sales statistics received from the NEA there are unspecified categories for all fuels, labelled as “Other”. These fuels are accounted for in CRF category 1A5. For future submissions the EA 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. These emission factors for stationary combustion can be seen in Table 3.3. Emission factors for mobile combustion are shown in the chapters for each subsector as they vary.

Table 3.3 Emission factors used for calculations emissions from stationary combustion

Fuel / Factor	Value	Unit	Reference
Gas/Diesel Oil			
NCV	42.8	TJ/kt	Country Specific from 2017, based on annual measurements
C-content	20.2	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
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
N_2O emission factor	0.60	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2

Fuel / Factor	Value	Unit	Reference
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

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 in the past few decades, and the emissions from energy industries are therefore lower than in most other countries, which utilize 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 3.4), with hydropower as the main source of electricity (Orkustofnun, 2019). Electricity was produced with fuel combustion at two places 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 very seldom used, apart from testing and during maintenance. In 2013 the first wind turbines were connected and used for public electricity production.

Table 3.4 Electricity production in Iceland [GWh]

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

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 with fuel combustion. Activity data for fuel combustion are given in Table 3.5. 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 3.5 Fuel use [kt] from electricity production.

	1990	1995	2000	2005	2010	2015	2019	2020
Gas/Diesel oil	1.30	1.09	1.07	0.02	1.01	1.19	1.24	0.56
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 3.6. 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, Kalka, in Iceland and it does not qualify as a recovery operation. From 2013, no solid waste was used for the production of heat.

Table 3.6 Fuel use [kt] from heat production

	1990	1995	2000	2005	2010	2015	2019	2020
Gas/Diesel Oil	NO	NO	NO	NO	NO	NO	0.33	NO
Residual Fuel Oil	2.99	3.08	0.12	0.20	NO	0.14	NO	NO
Biodiesel	NO	NO	NO	NO	NO	NO	0.02	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 3.3. 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 for other years.

CO_2 emission factors reflect the average carbon content of fossil fuels and are taken from 2006 IPCC Guidelines for National GHG Inventories. For diesel country specific NCV values are used for 2017 and onwards which are reflected in the t CO_2/t fuel emission factors. 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 was an 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.

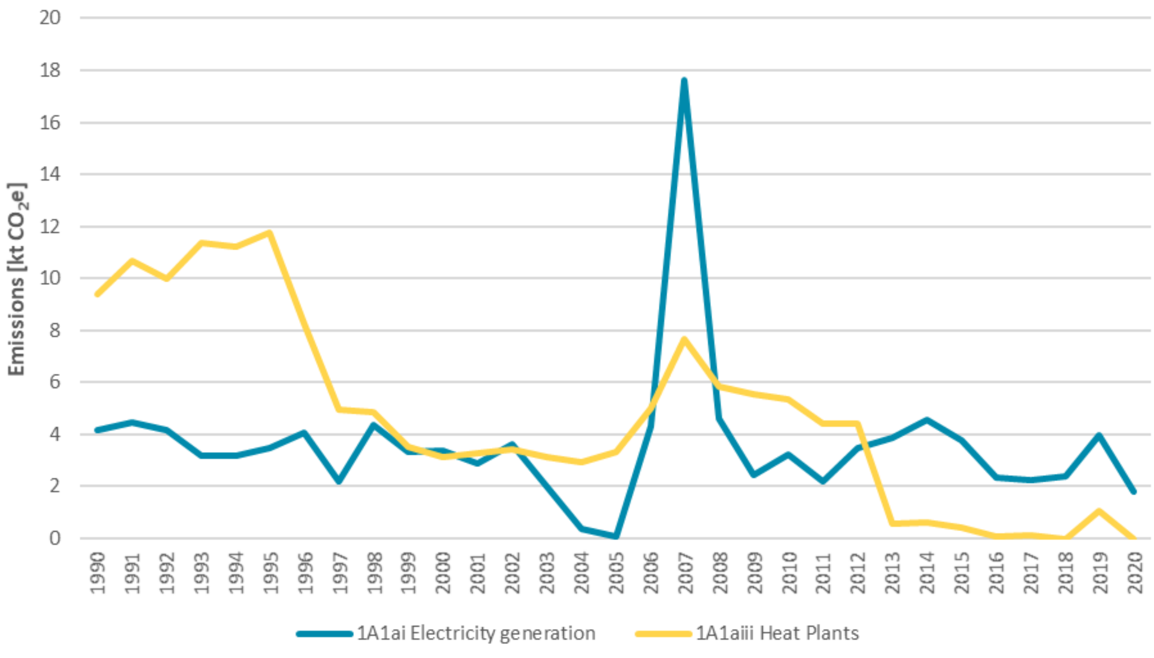


Figure 3.2 Emissions from 1A1 Energy industries.

Table 3.7 Emissions [kt CO_2e] from 1A1 Energy industries

	1990	1995	2000	2005	2010	2015	2019	2020
1A1ai Electricity generation	4.15	3.49	3.40	0.07	3.23	3.79	3.96	1.78
1A1aii Heat plants	9.37	11.8	3.15	3.34	5.35	0.43	1.04	NO
Total Emissions [kt CO_2e]	**13.5**	**15.3**	**6.56**	**3.40**	**8.58**	**4.22**	**5.01**	**1.78**

3.2.1.4 *Recalculations*

1A1ai: Electricity Generation

A minor recalculation was done for biodiesel emissions from electricity generation 1A1ai. This was due to an error in the NCV for biodiesel which has been corrected according to IPCC guidebook and now utilizes the default NCV for biodiesel. This has affected emissions of bio-CO_2, CH_4 and N_2O for the years 2017 and 2018.

Table 3.8 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 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 the years 1993-2013 (see Table 3.9) 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.

Table 3.9 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 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' NIR (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 3.10 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 3.10 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	Aluminium production (primary and secondary)
1A2c	Chemicals	Fertilizer 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 National Energy Authority (NEA). The sales statistics do not fully specify by which type of industry the fuel is being purchased. This division is made by the Environment Agency (EA) on the basis of the reported fuel use by all major industrial plants falling under Act 70/2012 and the EU ETS Directive 2003/87/EC (metal production, fish meal production and mineral wool) and from green accounts submitted by the industry in accordance with regulation No 851/2002. All major industries falling under Act 70/2012 report their fuel use to the EA along with other relevant information for industrial processes. The difference between the given total for the sector and the sum of the fuel use as reported by industrial facilities is categorized as 1A2gviii other non-specified industry (see Figure 3.1).

Table 3.11 shows the fuel sales statistics for the various fuel types used for stationary combustion in CRF sector 1A2:

Table 3.11 Fuel use [kt] from stationary combustion from subsectors in the manufacturing industry (1A2)

	1990	1995	2000	2005	2010	2015	2019	2020
1A2a - Iron and steel								
Gas/Diesel Oil	0.11	0.22	0.56	0.46	0.46	0.29	0.20	0.21
LPG	NO	NO	NO	NO	NO	0.10	0.37	0.20
1A2b - Non-ferrous metals								
Gas/Diesel Oil	NO	NO	0.55	5.37	1.35	0.05	0.62	1.72
Residual Fuel Oil	3.93	5.16	7.51	NO	3.31	1.40	1.80	NO
LPG	0.41	0.31	0.67	0.66	0.61	0.39	0.25	0.23
1A2c - Chemicals								
Residual Fuel Oil	2.38	2.31	2.27	NO	NO	NO	NO	NO
1A2e - Food processing, beverages and tobacco (Fishmeal production)								
Gas/Diesel Oil	NO	NO	NO	NO	2.16	NO	NO	NO
Residual Fuel Oil	41.03	48.54	36.37	5.37	9.61	8.41	0.88	1.22
Waste Oil	NO	NO	NO	NO	1.36	1.59	0.70	0.37
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
1A2e - Food processing, beverages and tobacco (Other)								
Gas/Diesel Oil	NO	NO	NO	NO	2.71	3.75	3.26	3.37

	1990	1995	2000	2005	2010	2015	2019	2020
Residual Fuel Oil	NO	NO	NO	NO	1.71	0.33	NO	NO
1A2f - Non-metallic minerals (cement)								
Gas/Diesel Oil	NO	NO	0.01	0.02	0.01	NO	NO	NO
Residual Fuel oil	0.06	NO	NO	NO	NO	NO	NO	NO
Petroleum Coke	NO	NO	NO	8.13	NO	NO	NO	NO
Waste Oil	NO	4.99	6.04	1.82	NO	NO	NO	NO
Other Bituminous Coal	18.60	8.65	13.26	9.91	3.65	NO	NO	NO
1A2f - Non-metallic minerals (mineral wool)								
Gas/Diesel Oil	NO	0.15	0.17	0.16	0.07	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	NO	2.13
Residual Fuel oil	7.91	0.16	0.00	19.64	0.30	0.05	NO	NO
LPG	NO	NO	0.19	0.27	0.44	0.32	0.94	0.57
Other bituminous coal	NO	NO	NO	NO	NO	NO	NO	NO

3.2.2.2 *Emission factors*

All emission factors used for stationary combustion from CRF 1A2 can be seen in Table 3.3.

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 years more fishmeal factories have been using electricity instead of fossil fuels and therefore the emissions have decreased.

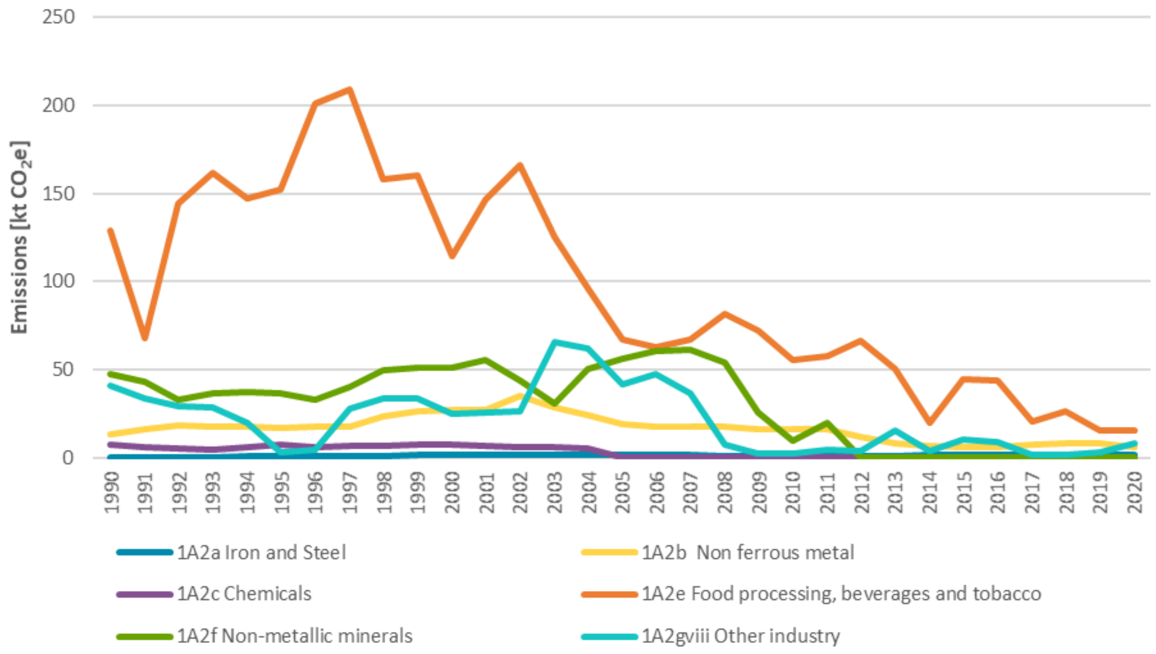


Figure 3.3 Emissions from stationary combustion of subcategories of CRF 1A2.

Table 3.12 Emissions [kt CO_2e] from stationary combustion of subcategories of CRF 1A2

	1990	1995	2000	2005	2010	2015	2019	2020
1A2a - Iron and steel	0.36	0.72	1.78	1.45	1.46	1.22	1.77	1.28
1A2b - Non-ferrous metals	13.5	17.1	27.3	19.1	16.5	5.69	8.40	6.15
1A2c - Chemicals	7.45	7.26	7.11	NO	NO	NO	NO	NO
1A2e - Food processing, beverages and tobacco	128.7	152.2	114.1	16.8	55.1	44.2	15.3	15.7
1A2f - Non-metallic minerals	47.8	36.5	51.0	56.2	9.22	0.34	0.42	0.41
1A2gviii - Other industry	40.7	2.93	25.0	91.8	2.24	10.44	2.79	8.45
Total Emissions [kt CO_2e]	**238.4**	**216.7**	**226.2**	**185.3**	**84.5**	**61.9**	**28.7**	**32.0**

3.2.2.4 *Recalculations*

1A2a, 1A2b, 1A2c, 1A2f, 1A2gviii

For these categories not recalculations have been performed for the current 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 3.13. 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.

Table 3.13 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 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:

1. A recalculation was made for CH_4 and N_2O emissions from waste oil utilization 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 3.14 and Table 3.15). Consequently, total emissions increased by 0.05 – 0.16 kt CO_2e in the time period 2007 – 2019.

Table 3.14 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 3.15 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 the years 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 3.16 Recalculation 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 its renewable energy sources, fuel use for residential, commercial, and institutional heating is low and GHG emissions from stationary subsectors of 1A4a and 1A4b are very low. Residential heating with electricity is subsidized 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 National Energy Authority (NEA) collects data on fuel sales by sector. Activity data for fuel combustion from the Commercial/Institutional sector and in the Residential sector are given in Table 3.17.

Table 3.17 Fuel use [in kt] from stationary combustion from subsectors of CRF 1A4

	1990	1995	2000	2005	2010	2015	2019	2020
1A4ai - Commercial/Institutional								
Gas/Diesel Oil	1.80	1.60	1.60	1.00	0.30	0.30	0.65	0.53
LPG	0.78	0.83	0.46	0.50	0.17	0.37	0.59	0.41
Waste – fossil	NO	0.14	0.19	0.19	0.15	NO	NO	NO
Waste – Biogenic	NO	0.31	0.39	0.39	0.20	NO	NO	NO
1A4bi - Residential								
Gas/Diesel Oil	8.82	6.94	6.03	3.24	1.34	0.99	0.30	0.66
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
LPG	NO	NO	0.72	0.93	1.42	0.93	1.14	1.10
1A4ci - Agriculture								
LPG	NO	NO	NO	NO	NO	0.004	0.006	0.008

3.2.3.2 *Emission factors*

All emission factors for this subsector can be seen in Table 3.3.

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, 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 Figure 3.4 and Table 3.18.

Table 3.18 Emissions from stationary combustion of subsectors under CRF 1A4

	1990	1995	2000	2005	2010	2015	2019	2020
1A4ai - Commercial/Institutional	8.09	7.83	6.77	4.95	1.71	2.07	3.83	2.92
1A4bi - Residential	28.3	22.2	21.4	13.2	8.52	5.96	4.37	5.39
1A4ci - Agriculture	NO	NO	NO	NO	NO	0.012	0.018	0.024
Total Emissions [kt CO_2e]	**36.4**	**30.0**	**28.2**	**18.1**	**10.2**	**8.04**	**8.22**	**8.33**

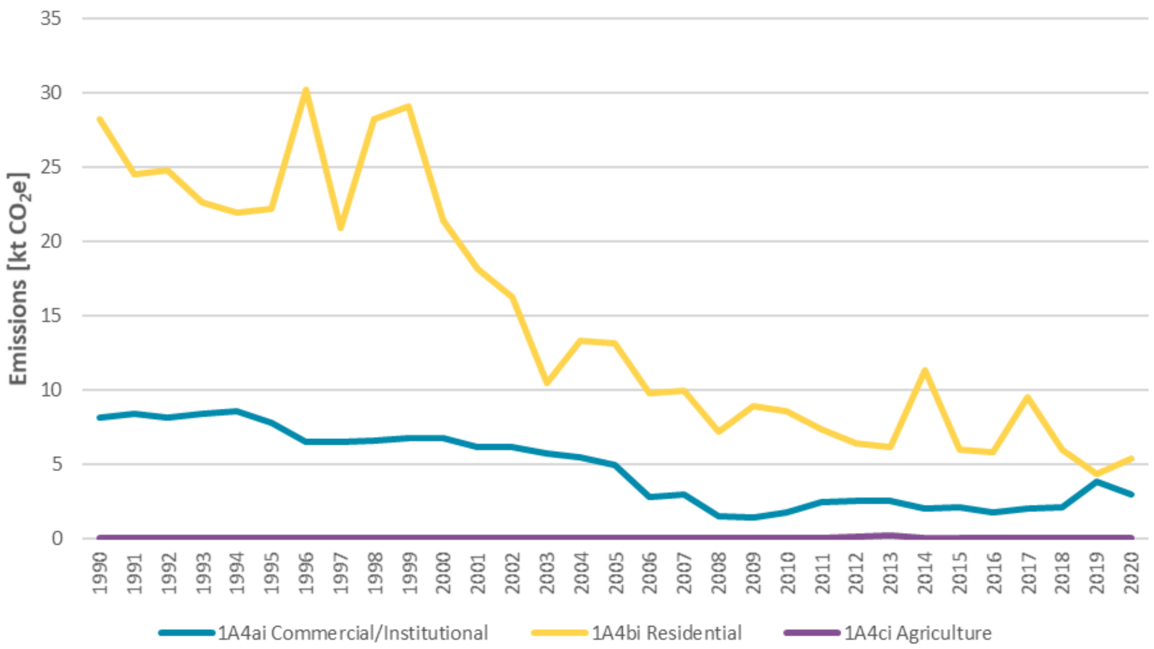


Figure 3.4 Emissions from stationary combustion of subsectors under CRF 1A4

3.2.3.4 ***Recalculations***

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 3.19).

Table 3.19 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 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 the year 2019 and LPG was increased 333, 556 and 517% in the years 2017-2019, respectively. This increased emissions from 1A4ai by 1.17-2.61 kt CO_2e in the respective years, see Table 3.20.

Table 3.20 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 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 3.21.

Table 3.21 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 the years 2017-2019 due to reallocation of fuels by the NEA. This caused gas/diesel oil to become reduced in 2019 and LPG reduced in 2017-2019. This reduced total emissions from 1A4bi by 1.38, 1.47 and 2.74 kt CO_2e in the years 2017-2019, respectively, see Table 3.22.

Table 3.22 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 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)

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

3.2.4.1 *Activity data*

Table 3.23 Fuel use [in kt] from sector 1A5 Other

	1990	1995	2000	2005	2010	2015	2019	2020
Gas/Diesel Oil	NO	0.458	1.386	8.928	2.728	NO	0.393	0.084
Residual Fuel Oil	0.039	0.052	0.067	NO	1.629	NO	0.075	NO
Other Kerosene	NO	NO	NO	0.151	0.047	0.029	0.064	0.030
LPG	NO	NO	NO	NO	NO	0.032	NO	NO
Biodiesel	NO	NO	NO	NO	NO	NO	0.022	0.044
Biomethane	NO	NO	NO	NO	NO	NO	0.091	0.111
Biogasoline	NO	NO	NO	NO	NO	NO	NO	0.001

3.2.4.2 *Emission factors*

All emission factors for this sector can be seen in Table 3.3.

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.

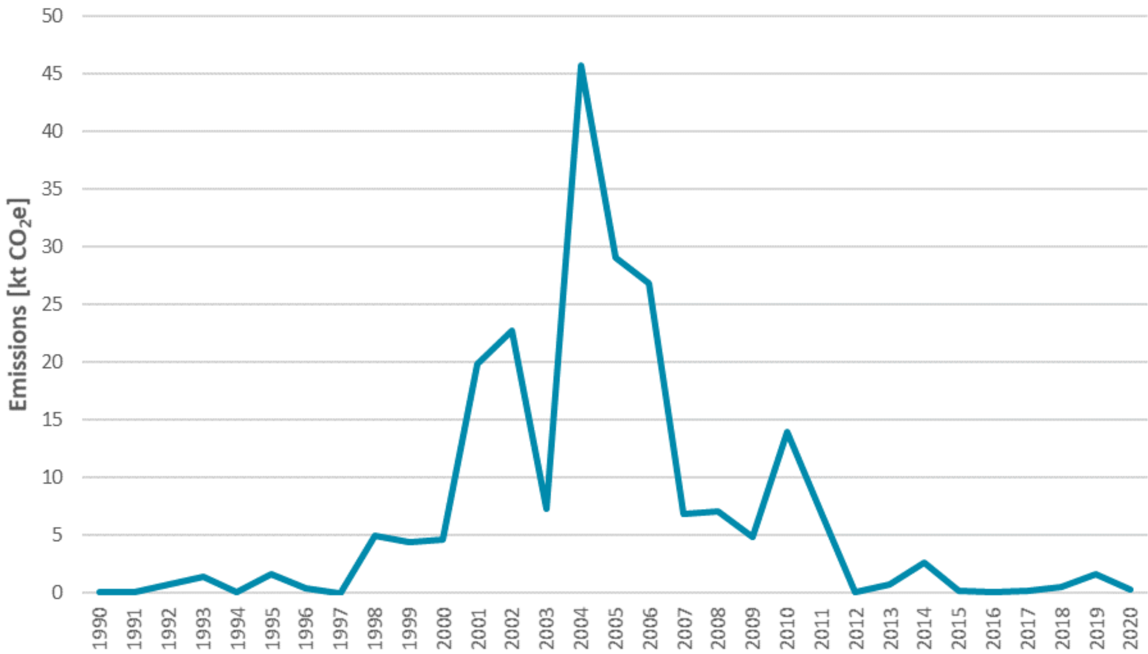


Figure 3.5 Emissions from stationary combustion from CRF 1A5

Table 3.24 Emissions from stationary combustion from CRF 1A5

	1990	1995	2000	2005	2010	2015	2019	2020
1A5 - Total emissions [kt CO_2e]	0.122	1.63	4.64	29.0	14.0	0.19	1.69	0.363

3.2.4.4 *Recalculations*

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 3.25.

Table 3.25 Recalculations in 1A5 due to bio gasoline NCV

Other – Liquid bio fuel	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 the year 2019 in the current submission of activity data from the NEA. This had been reported as NO in the previous submission. Therefore, bio methane emissions in 2019 have been increased by 0.25 kt CO_2, see Table 3.26.

Table 3.26 Recalculation in 1A5 due to change in activity data of bio methane

Other - Bio methane	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 EA 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 3.27.

Table 3.27 Information on subsectors reported as Mobile Machinery

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

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 3.28.

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

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

Table 3.28 Fuel use (in kt) from mobile combustion in the construction industry (1A2gv), Agriculture (1A4cii) and other (1A2gvii).

	1990	1995	2000	2005	2010	2015	2019	2020
1A2gvii - Mobile machinery in Construction								
Gas/Diesel Oil	IE	IE	IE	IE	IE	IE	7.1	3.7
Biodiesel	IE	IE	IE	IE	IE	IE	NO	NO
1A3eii - Other mobile machinery								
Gas/Diesel Oil	38.0	46.7	61.9	67.8	32.2	33.1	12.3	6.4
Other kerosene	NO	NO	NO	0.02	1.17	0.16	0.03	0.33
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
1A4cii - Mobile machinery in Agriculture								
Gas/Diesel Oil	IE	IE	IE	IE	IE	IE	5.4	7.6
Biodiesel	IE	IE	IE	IE	IE	IE	0.028	NO

3.3.1.2 *Emission factors*

All emission factors used to calculate emissions from fuel combustion from mobile machinery can be seen in Table 3.29. All factors, except NCV for diesel, are from 2006 IPCC guidelines.

Table 3.29 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	42.8	TJ/kt	Country Specific from 2017, based on annual measurements
C-content	20.2	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
Other kerosene			
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	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

3.3.1.3 *Emissions*

As can be seen in Figure 3.6 and Table 3.30, emissions from mobile machinery increased in the beginning of the timeseries but they have generally been decreasing from 2008, with some fluctuations.

Table 3.30 Emissions [kt CO_2e] from mobile machinery (1A2gvii, 1A3eii and 1A4cii). For 1990-2018 1A2gvii and 1A4cii are included in 1A3eii.

	1990	1995	2000	2005	2010	2015	2019	2020
1A2gvii - Mobile machinery in Construction	IE	IE	IE	IE	IE	IE	25.4	13.2
1A3eii - Other mobile machinery	135.1	166.2	220.1	241.1	118.7	118.2	44.0	23.8
1A4cii - Mobile machinery in Agriculture	IE	IE	IE	IE	IE	IE	19.3	26.8
Total	**135.1**	**166.2**	**220.1**	**241.1**	**118.7**	**118.2**	**88.6**	**63.8**

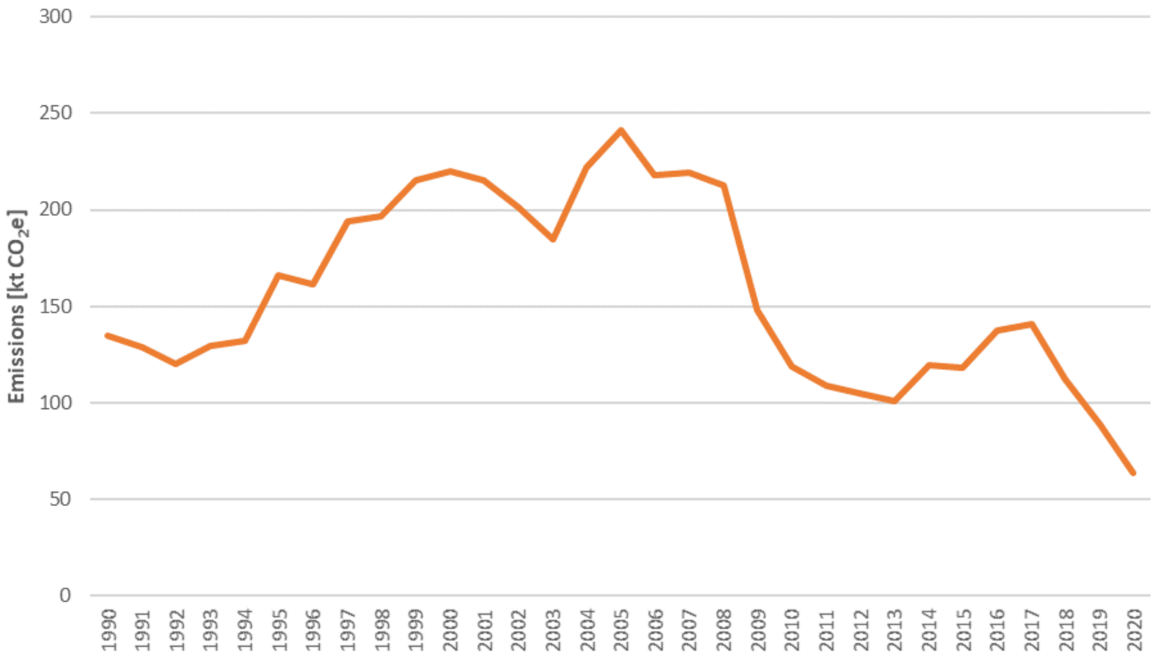


Figure 3.6 Combined emissions from mobile machinery (1A2gvii, 1A3eii and 1A4cii)

3.3.1.4 ***Recalculations***

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 3.31). This did not affect total emissions from the energy sectors, but it did affect emissions from subcategories 1A2 and 1A3e.

Table 3.31 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 the years 2014 and 2019, by -7kt 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 3.32.

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 the years 2013, 2016 and 2017.

Table 3.32 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 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 the year 2019 by 3 kt of gas/diesel oil.

Table 3.33 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 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 the year 2019 by 2 kt of gas/diesel oil.

Table 3.34 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 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*

For future submissions it is planned to extrapolate the activity data split, which is available from 2019, to previous years.

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 inTable 3.35.

Table 3.35 Fuel use [kt] for domestic aviation.

	1990	1995	2000	2005	2010	2015	2019	2020
Aviation gasoline	1.68	1.13	1.10	0.87	0.65	0.50	0.37	0.20
Jet kerosene	8.92	8.41	7.87	7.39	6.07	5.99	8.44	3.98

3.3.2.2 *Emission factors*

The emission factors for greenhouse gases are taken from the 2006 IPCC Guidelines and are presented in Table 3.36. Emission factors for NO_X, NMVOC and CO are taken from EMEP/EEA 2019 guidebook, Table 3.3.

Table 3.36 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 emssions 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 emssions 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 3.37.

Table 3.37 Emissions [kt CO_2e] from 1A3a Domestic aviation

	1990	1995	2000	2005	2010	2015	2019	2020
Total emissions [kt CO_2e]	33.6	30.3	28.5	26.2	21.3	20.6	28.0	13.3

3.3.2.4 *Recalculations*

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 the year 2014, see Table 3.38. 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.

Table 3.38 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 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 200% (with an activity data uncertainty of 5% and emission factor uncertainty of 200%). 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 5.5.1. 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 3.39.

Table 3.39 Fuel use [kt] in road transport

	1990	1995	2000	2005	2010	2015	2019	2020
Gasoline	67.1	117.6	142.6	156.7	148.2	132.5	118.7	91.6
Gasoline, leaded	60.7	18.0	NO	NO	NO	NO	NO	NO
Gas/Diesel Oil	36.6	36.9	47.5	83.5	106.4	126.4	180.9	167.9
Biomethane	NO	NO	0.006	0.039	0.595	2.18	1.49	1.44
Biodiesel	NO	NO	NO	NO	NO	11.9	14.9	13.0
Biogasoline	NO	NO	NO	NO	NO	1.93	6.24	11.04
Hydrogen	NO	NO	NO	0.00001	0.002	NO	0.001	0.0004

All of the biogasoline in Iceland is bioethanol and does therefore not include any fossil carbon. The team for chemicals at the EA, which is responsible for monitoring reporting under the Fuel Quality Directive (Directive 2009/30/EC of the European Parliament and of the Council), has confirmed that no FAME biodiesel has been imported to Iceland, only HVO. Therefore, there is no carbon of fossil origin in biodiesel for which CO_2 emissions would need to be accounted for in this inventory.

Activity Data for COPERT

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

- Average temperature values were obtained from the Icelandic Met Office.
- Vehicle stock numbers for 2017-2020 were obtained from the Icelandic Transport Authority.
- Measurements collected by the EA for energy content, density and sulphur content were used where available.
- Total fuel sales were obtained from sales statistics collected by the NEA for the whole timeseries.
- Measurements of carbon content (%C/%H/%O) in gasoline and diesel oil used in road transport were done from fuel samples from 2019. These values were applied for 1990-2019. New measurements were done for 2020.

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

3.3.3.2 *Emission factors*

Emissions from Road Transportation are estimated using COPERT 5.5.1. which uses a tier 3 methodology to estimate N_2O and CH_4 emissions, and a tier 2 methodology to estimate CO_2 emissions. Energy balance feature in COPERT was preformed to ensure that emissions from all fuel sold is accounted for. The emission factors can be seen in Table 3.40.

Table 3.40 Emission factors used for calculations emissions from road transport

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

3.3.3.3 *Emissions*

Emissions from road transport were steadily increasing from 1990-2007. In 2008 emissions started decreasing due to the 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. The emissions can be seen in Table 3.41 and Figure 3.7.

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 3.41 Emissions from subcategories and total emissions [kt CO_2e] from 1A3b Road transport

Sector	1990	1995	2000	2005	2010	2015	2019	2020
1A3bi - Passenger cars	407.1	439.0	485.2	571.9	553.0	560.7	590.0	515.9
1A3bii - Light duty trucks	27.0	28.0	31.9	49.0	78.5	86.0	142.9	128.0
1A3bii - Heavy duty trucks and buses	86.0	80.3	87.4	141.8	164.3	161.7	213.1	178.5
1A3biv - Motorcycles	2.53	2.68	3.21	3.44	9.43	10.44	3.66	2.77
Total [kt CO_2e]	**522.6**	**550.0**	**607.7**	**766.2**	**805.3**	**818.9**	**949.8**	**825.2**

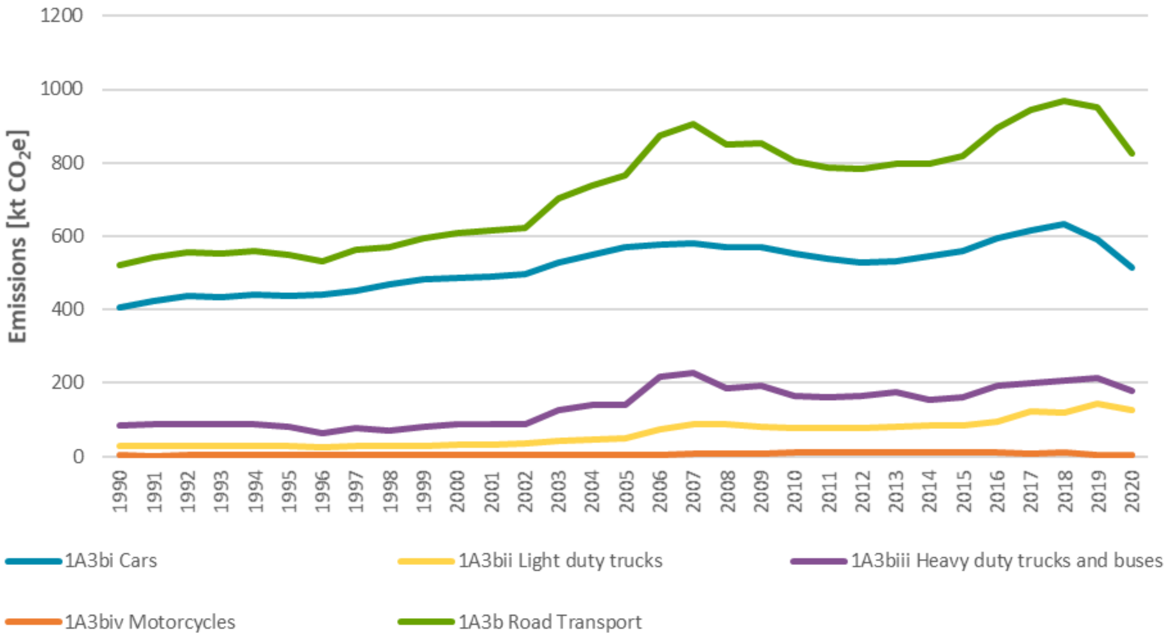


Figure 3.7 Emissions from subcategories and total emissions [kt CO2e] from 1A3b Road transport

3.3.3.4 *Recalculations*

The most extensive recalculation in road transport between the 2021 submission and 2022 submission is due to a reallocation of diesel oil in road transport in 2014. Review by the NEA of allocation of diesel between sub-sectors of mobile combustion revealed outliers which the NEA corrected for this submission. Diesel oil utilized in mobile machinery was re-allocated to road transport for 2014 which caused an increase of 301 TJ which increased total emissions by 2.7% or 21 kt CO_2e.

Emissions of N_2O from heavy duty trucks and buses due to diesel consumption has decreased total emissions by 0.0015 – 0.006 kt N_2O or 0.5 – 2.2 kt CO_2e over the timeline (see Table 3.42). 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.

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 3.42 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%**

Recalculations in the 2021 submission:

For the 2021 submission a measurement of country specific carbon content in fuels was applied to the whole time series, replacing the default carbon content, which caused recalculation for CO_2. For the 2021 submission an updated version of COPERT was implemented (COPERT 5.4.36) for calculations of emissions for the whole timeseries, which caused recalculations for CH_4 and N_2O.

Emissions of CO_2 have decreased for the whole timeseries by 8-10 kt CO_2. This is due to a measurement of country specific carbon content in fuels which was applied to the whole time series, replacing the default carbon content. There is a small increase in CH_4 emissions, i.e. 0.03-0.1 kt CO_2e over the timeseries and emissions of N_2O have increased by between 0.6-1.5 kt CO_2e over the timeseries. These recalculations are due to updated parameters in version 5.4.36. of COPERT.

3.3.3.5 *Planned Improvements*

For future submissions further collaboration with the Icelandic Transport Authority will be needed to obtain information on vehicle stock numbers split by Euro standards and driven kilometres for each vehicle category.

Carbon content in gasoline and diesel will be measured again using samples from 2021 to get a comparative value.

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 EQ. 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 3.43.

Table 3.43 Fuel use [in kt] in 1A3d domestic navigation

	1990	1995	2000	2005	2010	2015	2019	2020
Residual Fuel Oil	3.94	4.76	0.54	0.88	2.61	0.44	4.82	NO
Gas/Diesel Oil	6.40	7.04	3.43	6.20	8.46	7.89	11.88	7.83
Biodiesel	NO	NO	NO	NO	NO	NO	0.001	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 3.44.

Table 3.44 Fuel use [in kt] in 1A4ciii fishing

	1990	1995	2000	2005	2010	2015	2019	2020
Residual Fuel Oil	35.64	57.15	22.27	32.61	69.89	52.45	25.84	NO
Gas/Diesel Oil	202.6	231.8	256.9	199.9	158.3	142.5	136.6	158.7
Biodiesel	NO	NO	NO	NO	NO	0.094	0.034	0.075

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 the years 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 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 the years 1995 to 1999, for diesel oil and fuel oil; this percentage was then applied to the fuel sales for the years 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 3.45.

Table 3.45 Emission factors for CO_2, CH_4 and N_2O for ocean-going ships.

Fuel / Factor	Value	Unit	Reference
Marine Diesel Oil			
NCV	42.8	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1, country-specific from 2017
C-content	20.26*	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 emssions 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 emssions 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 emssions Factor	0.6	kg/TJ	Table 2.5 2006 IPCC Guidelines, V2, Ch2

*A country specific value for 2020

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 3.46:

Table 3.46 Emissions [kt CO_2e] from ocean-going ships

	1990	1995	2000	2005	2010	2015	2019	2020
1A3d - Domestic navigation	33.0	37.7	12.7	22.7	35.5	26.8	53.5	25.1
1A4ciii - Fishing	764.6	926.4	896.9	746.4	729.9	624.2	522.2	508.3
Total	**797.6**	**964.0**	**909.6**	**769.1**	**765.4**	**651.0**	**575.7**	**533.3**

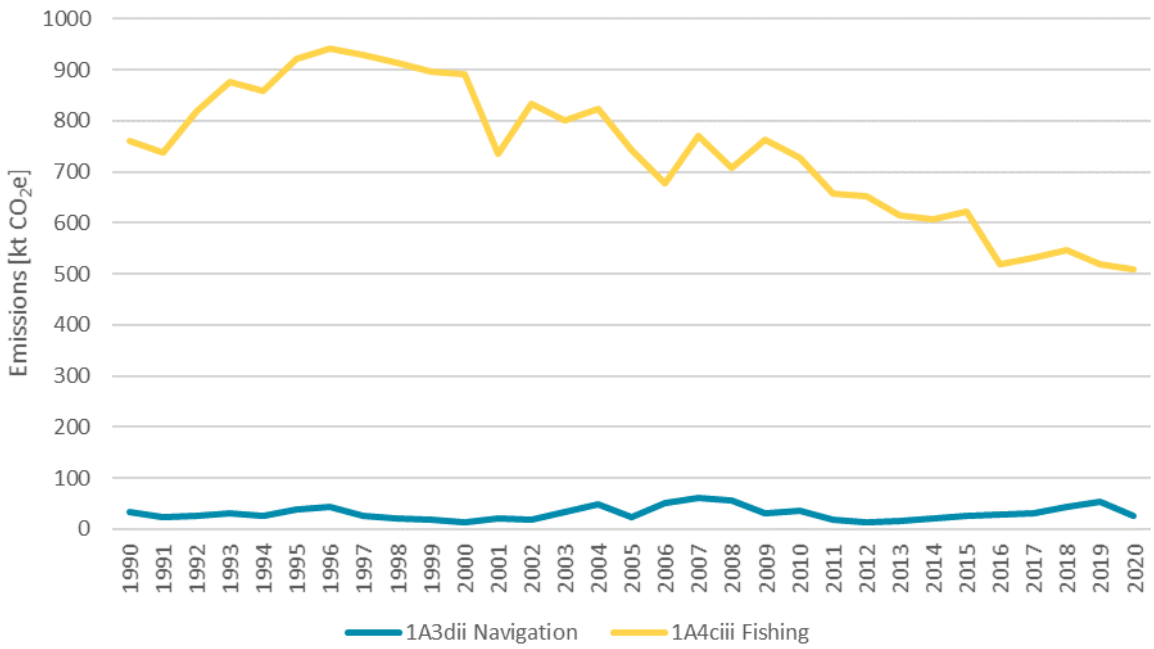


Figure 3.8 Emissions 1990-2020 from ocean-going ships

3.3.4.4 ***Recalculations***

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 the years 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 3.47. 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 3.48.

Table 3.47 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 2021 submission [%]	-46%	-58%	-54%	-48%	-54%

Table 3.48 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 the years 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 3.49. 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 3.50.

Table 3.49 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 2021 submission [%]	1.9%	3.1%	2.2%	1.6%	1.3%

Table 3.50 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 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 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 100% (with an activity data uncertainty of 5% and emission factor uncertainty of 100%) 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.

3.3.5 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 Airport. Under normal circumstances almost all international flights depart and arrive from Keflavík Airport, except for flights to Greenland, the Faroe Islands, and some flights by private airplanes which depart/arrive from Reykjavík airport. Domestic flights sometimes depart from Keflavík airport in case of special weather conditions. Oil products sold to Keflavík airport are reported as international usage. The deviations between national and international usage are believed to level out. Fuel use attributed to international aviation, and associated GHG emissions, are shown inTable 3.51.

Table 3.51 Fuel use [in kt] and resulting emissions [GHG, in kt CO_2e] from international aviation

	1990	1995	2000	2005	2010	2015	2019	2020
Jet kerosene	69.4	74.6	129.2	133.2	119.5	213.7	303.3	82.9
Gasoline	0.20	0.18	0.03	0.40	0.01	0.01	NO	NO
Emissions [kt CO_2e]	**221.3**	**237.9**	**410.8**	**424.8**	**380.1**	**679.7**	**964.5**	**263.6**

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 3.52. 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 the years 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 the years 1990-1994. This was done by averaging the percentage of fuel sold to fishing vessels relative to total fuel sales over the years 1995 to 1999, for diesel oil and fuel oil; this percentage was then applied to the fuel sales for the years 1990 to 1994.

Table 3.52 Fuel use [in kt] and resulting emissions [GHG, in kt CO_2e] from international navigation

	1990	1995	2000	2005	2010	2015	2019	2020
Residual Fuel Oil	0.25	NO	2.00	0.44	0.08	13.25	19.33	NO
Gas/Diesel Oil	8.53	1.05	15.04	0.12	NO	33.55	45.19	24.28
Emissions [kt CO_2e]	**28.25**	**3.39**	**54.70**	**1.76**	**0.25**	**149.8**	**206.8**	**77.8**

3.3.5.2 *Emission factors*

Emission factors for international aviation are reported in Table 3.36 and the ones for international navigation can be found in Table 3.45.

3.3.5.3 *Recalculations*

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.

Table 3.53 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 years 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 3.54. 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 3.55.

Table 3.54 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 2021 submission [%]	48%	93%	78%	60%	90%

Table 3.55 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 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 3.56.

Table 3.56 Emission factors for 1B2a5 Fugitive Emissions from Fuels

Fuel / Factor	Value	Unit	Reference
Liquid Fuels			
CO_2 emission factor	2.3.E-06	Gg per 1000 m^3 total oil transported	Table 4.2.4 2006 IPCC Guidelines Tanker Trucks and Rail Cards
CH_4 emission factor	2.5.E-05	Gg per 1000 m^3 total oil transported	Table 4.2.4 2006 IPCC Guidelines Tanker Trucks and Rail Cards
N_2O emission factor	NA	Gg per 1000 m^3 total oil transported	Table 4.2.4 2006 IPCC Guidelines Tanker Trucks and Rail Cards
LPG			
CO_2 emission factor	4.3.E-04	Gg per 1000 m^3 total LPG	Table 4.2.4 2006 IPCC Guidelines Liquefied Pertoleum Gas
CH_4 emission factor	NA	Gg per 1000 m^3 total LPG	Table 4.2.4 2006 IPCC Guidelines Liquefied Pertoleum Gas
N_2O emission factor	2.2.E-09	Gg per 1000 m^3 total LPG	Table 4.2.4 2006 IPCC Guidelines Liquefied Pertoleum 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 3.57*.

Table 3.57 Fuel use [in kt] and resulting GHG emissions [in kt CO_2e] from distribution of oil products

	1990	1995	2000	2005	2010	2015	2019	2020
Gasoline	129.4	132.2	153.4	164.2	144.5	139.6	122.8	101.5
Jet Kerosene	78.7	72.3	146.5	139.4	120.4	218.3	277.5	96.0
Gas/Diesel oil	335.8	309.3	427.9	418.2	292.3	342.1	392.9	387.3
Residual Fuel Oil	106.0	151.9	64.1	62.9	93.1	105.3	57.2	0.1
LPG	1.29	1.32	1.68	2.46	2.62	2.56	2.99	2.61
Emissions [kt CO_2e]	**0.49**	**0.50**	**0.60**	**0.60**	**0.49**	**0.61**	**0.65**	**0.45**

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 5 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 National Energy Authority of Iceland (NEA – Orkustofnun), 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 07.05.2021[15] 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 3.58 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 3.58 Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2010	2015	2019	2020
Electricity Productions [GWh]	283	288	1,323	1,655	4,465	5,003	6,018	5,961
CO_2 emissions [kt]	61.4	82.2	153.1	118.2	189.6	163.1	163.1	174.9
CH_4 emissions [kt CO_2e]	0.20	0.20	0.91	1.14	4.58	3.95	3.14	3.86
H_2S emissions [kt SO_2e]	13.3	11.0	26.0	30.3	58.7	42.4	41.9	39.3

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 by (Baldvinsson, Þórisdóttir, & Ketilsson, 2011) in the report "Gaslosun jarðvarmavirkjana á Íslandi 1970-2009" (e. Gas emissions of geothermal power plants in Iceland 1970-2009). The report describes the methodologies the power companies, Orkuveita Reykjavíkur, HS Orka and Landsvirkjun, that run the individual power plants, use when estimating the gas emissions. The power companies use similar methodologies, i.e., 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

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

liquid by the well-head and that all the gas is released into the atmosphere. HS Orka and Landsvirkjun collect 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, i.e., 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 3.9 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 Plant, has been pioneering CO_2 capture and reinjection on site into the basaltic subsurface, and has proven rapid and complete reaction to calcium carbonate precipitate (Matter, et al., 2016). Reported emissions from the Hellisheiði Power Plant have been adjusted to reflect the amount of injected CO_2. The CO_2 captured and injected can be seen in Table 3.59.

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 3.59 Amount of CO_2 captured and injected using the Carbfix method

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

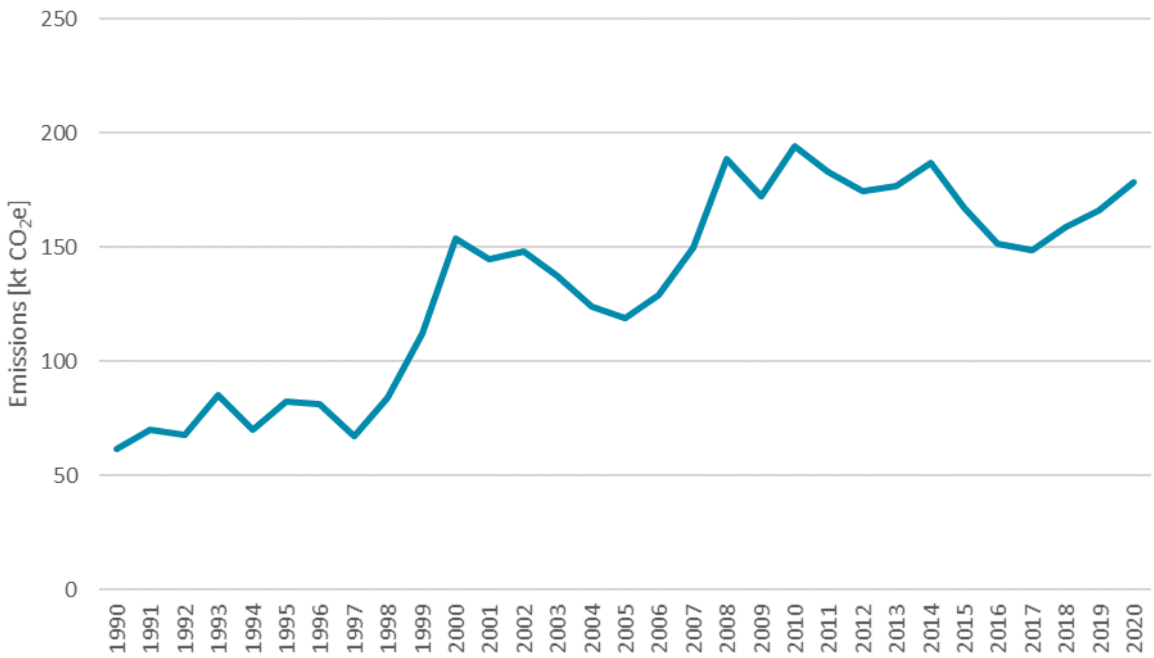


Figure 3.9 Emissions from 1B2d Geothermal Power

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

3.4.2.4 ***Recalculations***

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 3.60.

Table 3.60 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

The sectoral approach calculations are based on activity data per sector as provided by the NEA and reallocated by the EA where necessary (see chapter 3.1.1 for details). The reference approach is calculated based on the national energy statistics files submitted to Eurostat by the NEA, which include information on imports, stock changes, international navigation and international aviation.

Currently there are some large discrepancies between the sectoral and reference approach (see Annex 3). These discrepancies are being analysed in collaboration with the NEA.

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, lubricants and electrodes.

4 Industrial Processes and Product Use (CRF sector 2)

4.1 Overview

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

4.1.1 General 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 (CRF sector 1A2).

NF_3 is reported in the Icelandic Inventory as “NO” or “NA”. The Chemical Team of the Environment Agency 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 in Iceland.

4.1.2 Key Category Analysis

The key categories for 1990, 2020 and 1990-2020 trend in the Industrial processes sector are as follows (compared to total emissions without LULUCF) (Table 4.1).

Table 4.1 Key category analysis for Industrial Processes, 1990, 2020 and trend (excluding LULUCF).

IPCC source category		Gas	Level 1990	Level 2020	Trend
IPPU (CRF sector 2)					
2A1	Cement Production	CO_2	✓		✓
2B10	Fertilizer 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 4.2 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 4.2 Industrial Processes - Completeness (E: estimated, NE: not estimated, NA: not applicable, IE: included elsewhere).

	Greenhouse gases						Indirect greenhouse gases			
Sector	**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					
2A4b Other Uses of Soda Ash	IE[1]	NA	NA	NA	NA	NA	IE	NA	NA	NA
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: Fertilizer 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
2D3d Coating applications	E	NA	NA	NA	NA	NA	NA	NA	E	NA

Sector	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NO_X	CO	NMVOC	SO_2
	Greenhouse gases						Indirect greenhouse gases			
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
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 Silica production (Silica 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 fertilizer production plant that closed down in 2001. Resulting emissions of N_2O and NO_X are reported under 2B10 Fertilizer 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] SO_2 emissions were reported by the plant and included both process-related and combustion-related SO_2 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.
- All emissions calculations are quality checked by a second sectoral expert, which did not compile the inventory.
- 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.

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 Guideline (Equation 2.2), 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 × 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 EA 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 the years 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 4.3 Clinker production and CO_2 emissions from cement production from 1990-2011. The cement factory closed down in 2011.

Year	Cement production [t]	Clinker production [t]	CaO content of clinker	EFcl	CFckd	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 4.3. 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 planet 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, 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, due to the fact that 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 the years 2005 to 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 the year 2009 and mineral wool production.

Emissions from the mineral wool plant were 0.90 kt CO_2e in 2020. 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 fertilizer 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 fertilizers during the period 1990-2001. The associated emissions are marked as Included Elsewhere under 2B1 Ammonia Production and are included in the emissions reported under 2B10 Fertilizer Production. The methodology associated with ammonia Production is also described under Fertilizer 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 we use 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 *Fertilizer Production*

Category description

A fertilizer 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 fertilizer was produced (a nitrogen fertilizer), whereas at the end of its production phase it was producing over 20 different types of fertilizers. CO_2 and CH_4 emissions are considered insignificant, as the fertilizer plant used H_2 produced on-site by electrolysis.

Methodology

NO_X and N_2O emissions were reported directly by the factory to the EA.

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 (Table 4.1, Chapter 4 of the 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 has stopped production in 2017. Both active operators are under the EU Emission Trading Scheme (as per Directive 2003/87/EC). In both factories, raw ore, carbon material and slag forming materials are mixed and heated to high temperatures for reduction and smelting.

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, and 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 (Vol. 3, Chapter 4, Table 4.8) 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 4.4.

Table 4.4 Raw materials [kt], production [kt] and resulting GHG emissions [kt CO_2e] from the production of ferroalloys

	1990	1995	2000	2005	2010	2015	2019	2020
Electrodes, casings and paste	3.8	3.9	5.7	6.0	4.8	4.9	4.6	4.8
Carbon blocks								
Anthracite/coking coal	45.1	52.4	73.2	86.9	96.1	115	142	129
Coke oven coke	24.9	30.1	46.6	42.6	30.3	30.9	21.2	23.5
Charcoal								
Wood	16.7	7.7	16.2	15.6	11.3	27.2	78.1	59.9
Limestone	0.00	0.00	0.47	1.62	0.50	2.19	1.83	0.95
FeSi, silicon metal production	62.8	71.4	109	111	102	118	119	116
Emissions [kt CO_2e]	**210**	**246**	**365**	**380**	**372**	**404**	**432**	**418**

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 the years 2005 to 2010. Upon request by the EA, the company provided this information for the years 2000 to 2004 and 2011. Since 2013 these data have 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 - Table 4.8, Volume 3 Chapter 4 of the 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 CH4/t product - Table 4.8, Volume 3 Chapter 4 of the 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.

Category-specific recalculations

There were two recalculations for the year 2019. The first recalculation is due to the industry starting to use microsilica to reduce CO_2 emissions (Table 4.5). That was not accounted for in the last submission and it only effects emissions in 2019.

Table 4.5 Comparison between the 2021 v1 submissions and the 2022 submission for CO_2 emission from Ferroalloys production (2C2) for the year 2019.

Ferroalloys production	2019
2021 v1 submission CO_2 [kt]	429.8
2022 submission CO_2 [kt]	428.8
Change relative to 2021 submission	-0.24%

The second recalculation concerns methane emissions and is due to human error in the emission estimation files (Table 4.6).

Table 4.6 Comparison between the 2021 v1 submissions and the 2022 submission for methane emission from Ferroalloys production (2C2) for the year 2019.

Ferroalloys production	2019
2021 v1 submission CH_4 [kt CO_2e]	2.80
2022 submission CH4 [kt CO_2e]	3.23
Change relative to 2021 submission	15%

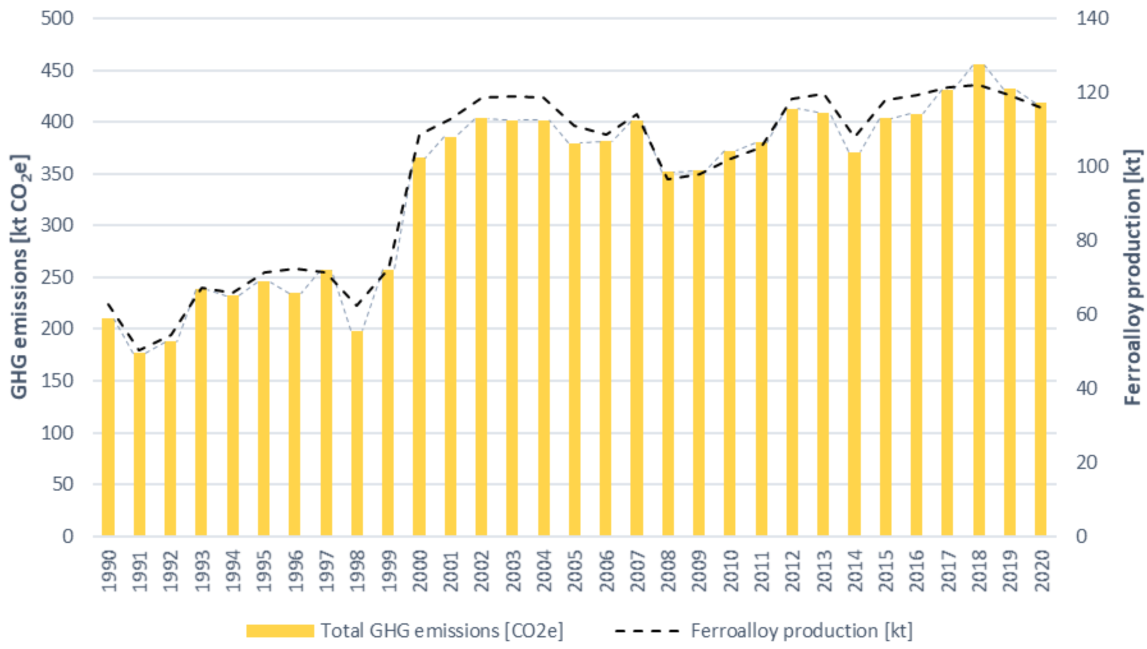


Figure 4.1 Total GHG emissions (CO_2 and CH_4) from the Ferroalloy production, and annual production [kt]

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 EA 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 4.7and are displayed in Figure 4.2.

Table 4.7 Aluminium production, CO_2 and PFC emissions, IEF for CO_2 and PFC since 1990.

	1990	1995	2000	2005	2010	2015	2019	2020
Primary aluminium production [kt]	87.8	100	226	272	819	857	834	831
CO_2 emissions [kt]	139	154	353	417	1238	1300	1276	1261
PFC emissions [kt CO_2e]	495	69.4	150	30.8	171.7	103.7	97.0	95.1
CO_2 [t/t Al]	1.58	1.54	1.56	1.53	1.51	1.52	1.53	1.52
PFC [t CO_2e/t Al]	5.63	0.69	0.66	0.11	0.21	0.12	0.12	0.12
Total Emissions [kt CO_2e]	634	223	503	448	1409	1403	1373	1357

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 the years 2005 to 2010. Upon request by the EA, 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 to 2012. Since 2013the information comes from submitted data from the operators under the EU ETS. The weighted average carbon content of the electrodes ranges from 98% to 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

No category-specific recalculations were done for this submission.

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.

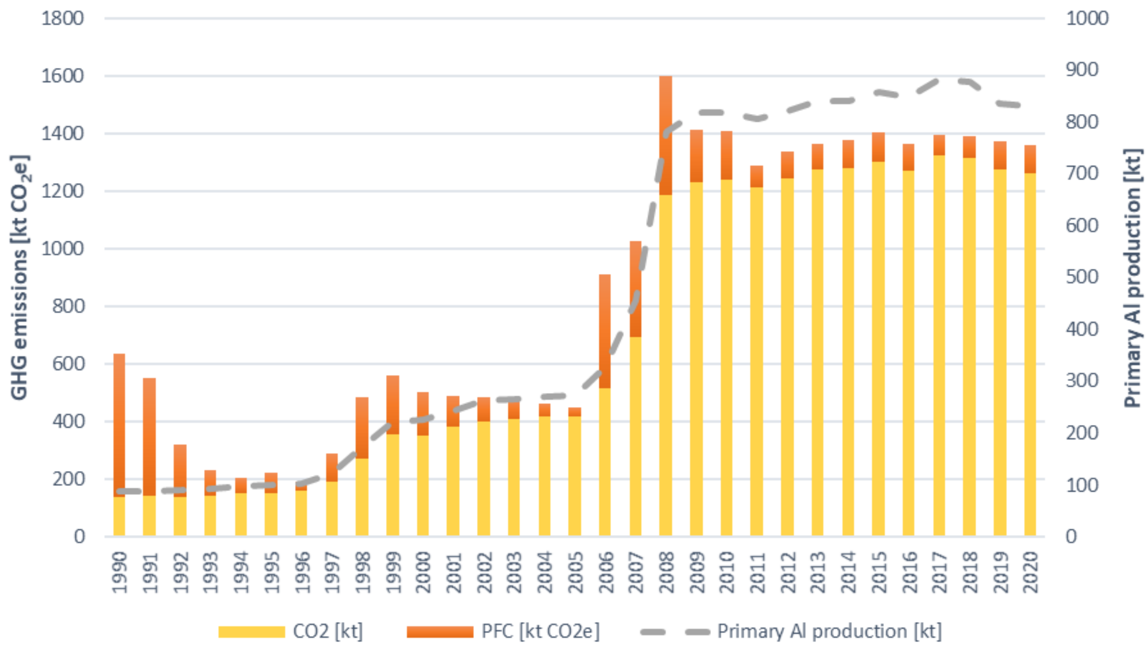


Figure 4.2 GHG emissions (CO_2 and PFC) from primary Al production, and annual production [kt].

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

No category-specific recalculations were done for this submission.

Category-specific planned improvements

There are no improvements planned in this category.

Uncertainties

The activity data uncertainty is 5% (2006 IPCC Guidelines, vol 3, chapter 5.2.3.2) 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 have been estimated to be 0.17 kt CO_2 in 1990 and 0.34 kt CO_2 in 2020.

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

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

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} = “Oxidized 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:

$$PW = (m_{candles} * 0.66 + m_{paraffin}) * NCV$$

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

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 4.8.

Table 4.8: Comparison between the 2021 v1 submissions and the 2022 submission for CO_2 emission from Paraffin wax use (2D2) for the year 2019.

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% (2006 IPCC Guidelines, vol 3, chapter 5.3.3.2) 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 (2006 IPCC Guidelines, vol 3, chapter 5.3.3.1). 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 EMEP/EEA 2019 guidebook.
NMVOCs are not considered direct greenhouse gases but once they are emitted, they will oxidize 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 4.9 and is shown in Figure 4.3.

Methodology

NMVOC emissions are estimated according to the 2019 EMEP/EEA air pollutant emission inventory 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 (Vol. 3, Chapter 5, §5.4.4). For all other subcategories of 2D3, the default value of 0.6 was given (Vol. 3, Chapter 5., §5.5.4).

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 $\eta_{\text{abatement}} = 89\%$ 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 (Statistics Iceland, 2019). In Iceland, creosotes were used from 1990 to 2010, and have been banned since 2011.

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 fertilizer was registered in the same category until January 2020 (see also Agriculture sector, chapter 5.11.2.2 and Figure 5.10). 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 0.46 kt CO_2e for the year 2020 and were 0.012 kt CO_2e in 2008, the first year in which this activity is reported.

Emissions of Sector 2D3

Table 4.9 and Figure 4.3 show the NMVOC emissions from the sector 2D3 from 1990.

Table 4.9 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	2019	2020
2D3a Domestic solvent use	0.625	0.657	0.687	0.723	0.782	0.810	0.879	0.896
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	0.293	0.442
2D3e Degreasing	0.076	0.057	0.085	0.058	0.038	0.046	0.058	0.043
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	0.001	0.008
2D3h Printing	0.077	0.109	0.198	0.305	0.189	0.207	0.126	0.078
2D3i Wood preservation	0.009	0.019	0.025	0.086	0.031	0.026	0.048	0.038
Total NMVOC [kt]	1.32	1.41	1.58	1.53	1.34	1.42	1.41	1.51
Total NMVOC [kt CO_2e]	**2.89**	**3.10**	**3.46**	**3.36**	**2.94**	**3.11**	**3.10**	**3.32**

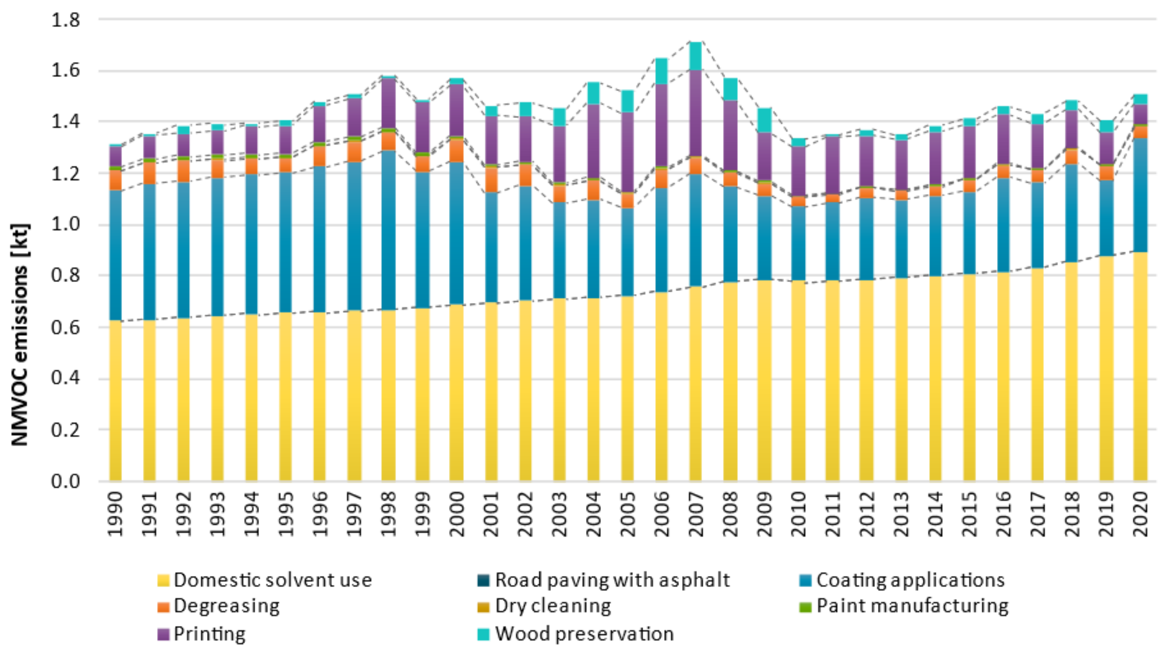


Figure 4.3 NMVOC emissions from all subgroups of Sector 2D3, other non-energy products from fuels and solvent use.

Category-specific recalculations

Recalculation within the 2D3 subsector 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 4.10 and Table 4.11 show the emission change due to these recalculations.

Table 4.10 Recalculations of emission within 2D3a (Domestic solvent use Including Fungicides) between 2021 and 2022 submissions

Domestic Solvent use Including Fungicides	1990	1995	2000	2005	2010	2015	2018	2019
2021 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 4.11 Recalculations of emission within 2D3f (Dry cleaning) between 2021 and 2022 submissions

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%

Recalculation for 2021 submission:

For the 2021 submission, emissions from urea-based additives were estimated for the first time. The emissions were added from the year 2008 in the timeline. There has therefore been recalculation within 2D3.

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% 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 4.12 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 4.12 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, producing and selling 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 hight 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, 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 GL 2006, using Emission Factors (EF) and other calculation factors from the default range (Table 7.9 GL 2006). 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 EA 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

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

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 come from different sources:

- Environment Agency (EA), 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
- 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 4.13. For the years between 2012 and 2020 they change linearly from the 2012 to the 2020 values.

Table 4.13 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 EA 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 EA has also managed to get information from some of the service providers. After analysing the data, the EA 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 between 1990-2020 as registered by the Chemical Team of the Environment Agency. The drop in import between 2019 and 2020 can partly be explained by stricter measures to decrease the use of F-gases (tax and import quota) and party 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 enter in force of the import quota from the year 2019 (see 4.7.1.1 Legislation).

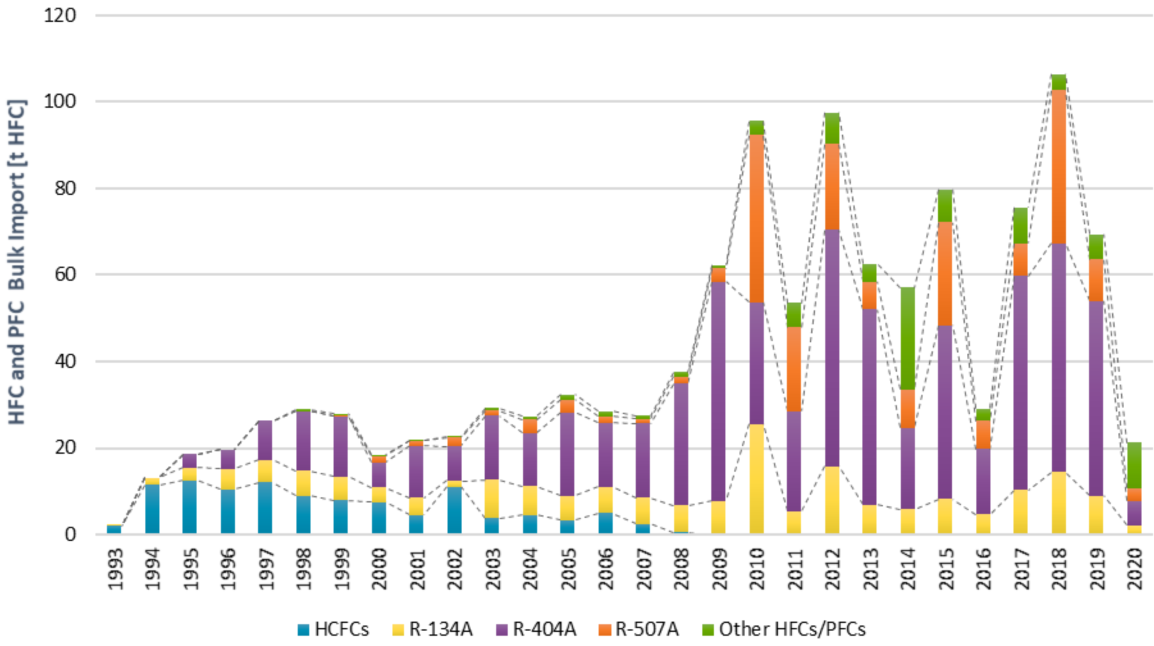


Figure 4.4 Quantity of F-gases imported in bulk to Iceland since 1993

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 (Table 7.9). 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 “NO”.

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 that 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 due to the fact that 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 (i.e., 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 no emissions occur therefore 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 4.14. They are taken from the 2006 IPCC Guidelines, Tables 7.9, taking into consideration Icelandic conditions and variations over the time series (such as the operation emission factor in transport refrigeration-fishing vessels).

Table 4.14 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 refrigeration[1]	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 (Table 7.9, Vol. 3, Ch. 7). Stand-alone and medium and 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 by a considerable extent 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 thus that 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 $\eta_{\_rec,d}$ value from Eq 7.13 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 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 4.15.

Table 4.15 HFC and PFC emissions [kt CO_2e] for all individual compounds, recalculated into kt CO_2e using AR4 GWPs.

	1990	1995	2000	2005	2010	2015	2019	2020
HFC-23	NO	NO	NO	0.035	0.014	0.014	0.081	0.052
HFC-32	NO	NO	0.005	0.016	0.061	0.11	0.29	0.42
HFC-125	NO	0.80	19	22	41	60	71	73
HFC-134a	NO	1.7	5.6	10	16	23	35	26
HFC-143a	NO	0.2	19	25	54	79	95	97
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	0.37	0.19
Total HFC [kt CO_2e]	**NO**	**2.7**	**43.2**	**57.6**	**110.5**	**162.5**	**201.7**	**196.8**
C_2F_6 (PFC-116)	NO	NO	NO	0.0032	0.0012	0.0080	0.050	0.067
C_2F_8 (PFC-218) [	NO	NO	NO	NO	0.0006	0.0002	0.00008	0.00007
Total PFC [kt CO_2e]	**NO**	**NO**	**NO**	**0.0032**	**0.0019**	**0.0082**	**0.050**	**0.067**
Total HFC+PFC [kt CO_2e]	**NO**	**2.7**	**43.2**	**57.7**	**110.5**	**162.5**	**201.8**	**196.9**

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 explainable 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.

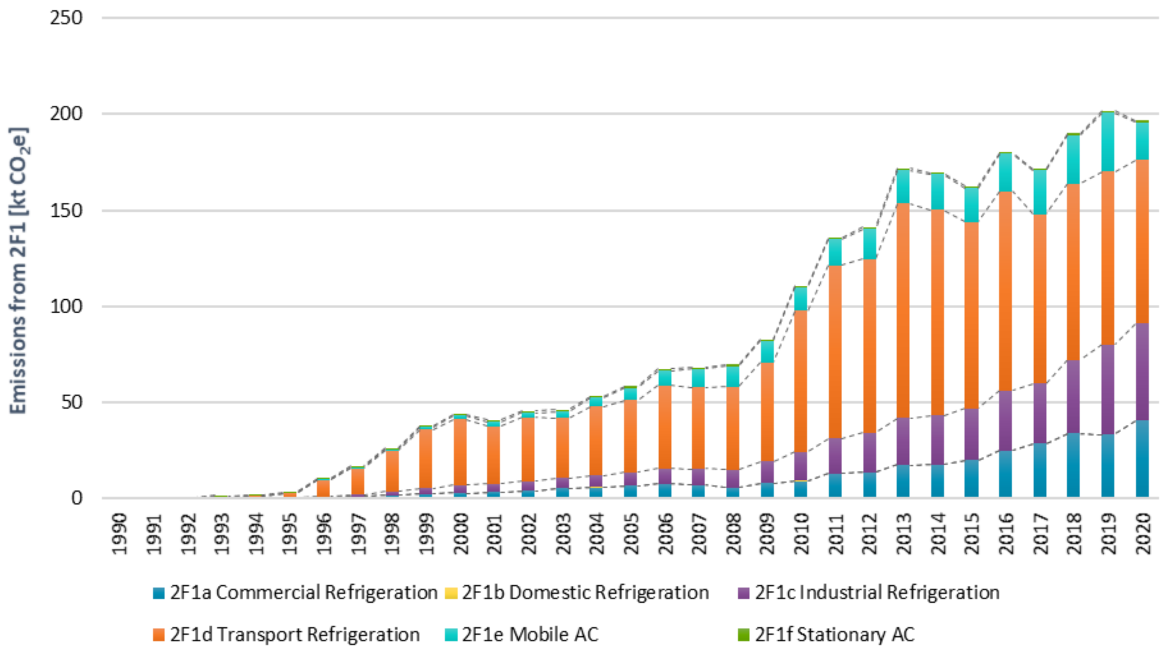


Figure 4.5 Total F-gas emissions from Refrigeration and Air Conditioning, split by subcategories [kt CO_2e].

Category-specific recalculations

There were three recalculations within the 2F1 subsector. One is a minor one due to updated activity data about number of reefers from one logistic 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 complete one was in 2012. For this submission, a new thorough survey was made. All importers returned a spreadsheet to the EA with information about the distribution of each blend between these sectors. The distribution is based on 2020 sale numbers. Since parts of the sales were to service providers of F-gases, the EA has also managed to get information from some of the service providers. After analysing the data, the EA 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 the year 2020. For the years 1990-2012, the distribution from the 2012 survey is applied, just as in the last submission. For the years minus Reefers (2F1d), respectively, of unallocated blends before from 2012 until 2020, the share of each blend and subsector changed linearly from the 2012 value to the 2020 value. Table 4.16, Table 4.17 and Table 4.18 show the shares of the subsectors Commerical Refrigeration (2F1a), Industrial Refrigeration (2F1c) and Transport and after the recalculation.

Table 4.16 Distribution of unallocated blends to Commercial Refrigeration (2F1a), changes from the last submission.

Distribution of unallocated blends, Commerical 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 4.17 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 4.18 Distribution of unallocated blends to Transport minus 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 4.19, Industrial Refrigeration (2F1c), see Table 4.20 and Transport minus Reefers (2F1d), see Table 4.21. 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.

Table 4.19: 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 4.20: Recalculations within 2F1c Commercial 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 4.21: Recalculations within 2F1d Commercial Refrigeration 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 4.22 and Figure 4.6.

Table 4.22: 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%

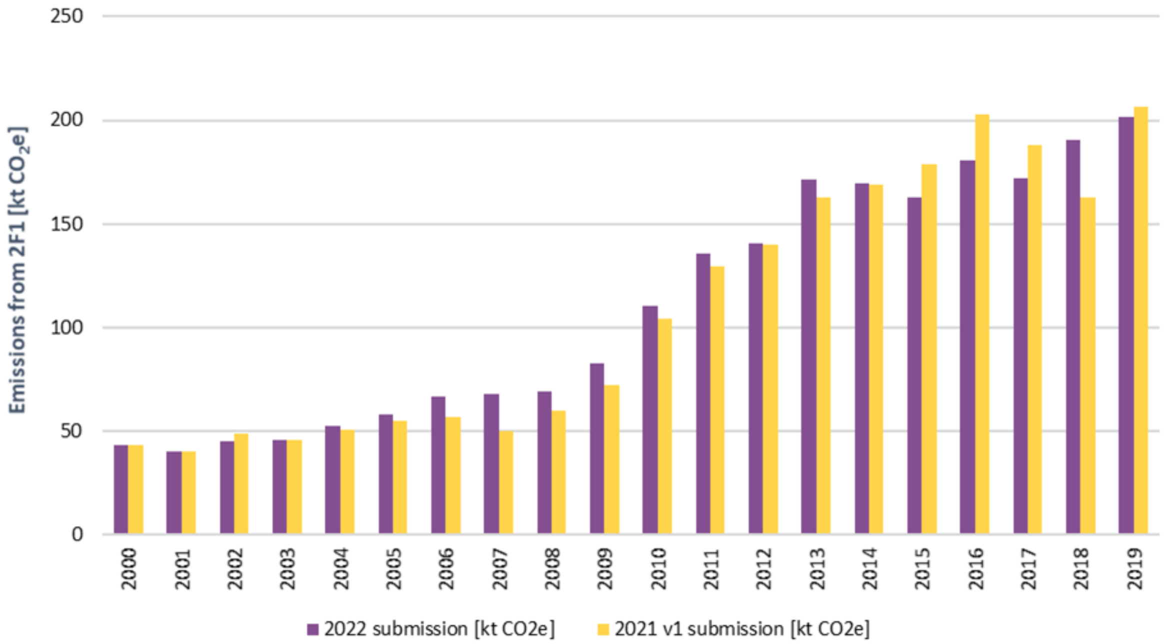


Figure 4.6 Recalculation within the subsector Refrigeration and Air Conditioning (2F1) between 2021 and 2022 submission.

Recalculation for 2021 submission:

Following the ESD comprehensive review in 2020 one revised estimate for CRF category 2F1e MACs was submitted by Iceland. Iceland assumed that 80% of all vehicles since 2010 contained R-134A.

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 in Iceland 3% of newly registered vehicles 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% in 2019. This caused recalculations for 2016-2018 of HFC emissions from 2F1e.

Category-specific planned improvements

It is planned to increase transparency in reporting, investigate recovery and disposal emissions further and to repeat the survey among end users and importers of F-gases for future submissions.

Uncertainties

The activity data uncertainty for all subcategories of sector 2F1 was derived by analysing each category and combine the uncertainty to one value, which is 100%. The same approach was taken for the emission factor uncertainties where the uncertainty was calculated by combining 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. The combined uncertainty was calculated as per equation 3.2 from 2006 IPCC GL, Vol 3 Chap 5. The combined emission factor uncertainty is 35.4% and the total uncertainty, activity data and emission factors combined, is 106%.

Details about the retrieval of the uncertainty factors are summarized in Table 4.23. They can also be found in Annex 2.

Table 4.23 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%	
	Initial Em.	2	0.5	3	63%	
	Operation Em.	10	10	35	125%	
	Recovery Effic.	70	0	70	50%	
	Combined EF Uncertainty				60.1%	
	AD Uncertainty					100%
2F1b Domestic ref.	Lifetime EF	12	12	20	33%	
	Initial Em.		No first fills in Iceland			
	Operation Em.	0.3	0.1	0.5	67%	
	Recovery Effic.	70	0	70	50%	
	Combined EF Uncertainty				35.6%	
	AD Uncertainty					50%

Sector		EF used	Lower bound	Upper bound	EF uncertainty (%)	AD uncertainty
2F1c Industrial ref.	Lifetime EF	15	15	30	50%	
	Initial Em.	2	0.5	3	63%	
	Operation Em.	10	7	25	90%	
	Recovery Effic.	85	0	90	53%	
	Combined EF Uncertainty				71.8%	
	AD Uncertainty					100%
2F1d Transport fishing	Lifetime EF	15	15	30	50%	
	Initial Em.	2	0.5	3	20%	
	Operation Em.	20	15	50	88%	
	Recovery Effic.	70	0	70	50%	
	Combined EF Uncertainty				66.1%	
	AD Uncertainty					100%
2F1d Transport reefers	Lifetime EF		NA			
	Initial Em.		No first fills in Iceland			
	Operation Em.	20	15	50	88%	
	Recovery Effic.		NA			
	Combined EF Uncertainty				87.5%	
	AD Uncertainty					100%
2F1e Mobile air-con.	Lifetime EF	14	9	16	25%	
	Initial Em.		No first fills in Iceland			
	Operation Em.	10	10	20	50%	
	Recovery Effic.		NA			
	Combined EF Uncertainty				22.5%	
	AD Uncertainty					100%
2F1f Stationary air-con.	Lifetime EF	12	10	20	42%	
	Initial Em.	1.0	0.2	1.0	40%	
	Operation Em.	3.0	1.0	10	150%	
	Recovery Effic.	75	0	80	53%	
	Combined EF Uncertainty				52.4%	
	AD Uncertainty					100%

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 EA 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 all occur in the same year as they are imported.

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 1990-2002. 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 2020 were approx. 0.88 kt CO_2e.

Category-specific recalculations

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

Recalculation for 2021 submisson

Data was obtained from the Icelandic Medicine Agency which contained:

- Data on import of MDIs containing R-227ea from 2014. This caused a small increase in emissions for 2014-2018.
- Amount of HFC in each piece of MDIs imported to Iceland. This caused a small change in the emissions from this sector for the whole timeseries.

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 (ca. 95% of total N_2O use)) and 2G4 where we report CH_4, N_2O, NO_X, CO and NMVOC emissions from tobacco consumption and CO_2, 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 comprises 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 report also 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[16]. Based on this information the amount

[16] https://www.lota.is/power-and-energy/?lang=en

"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.

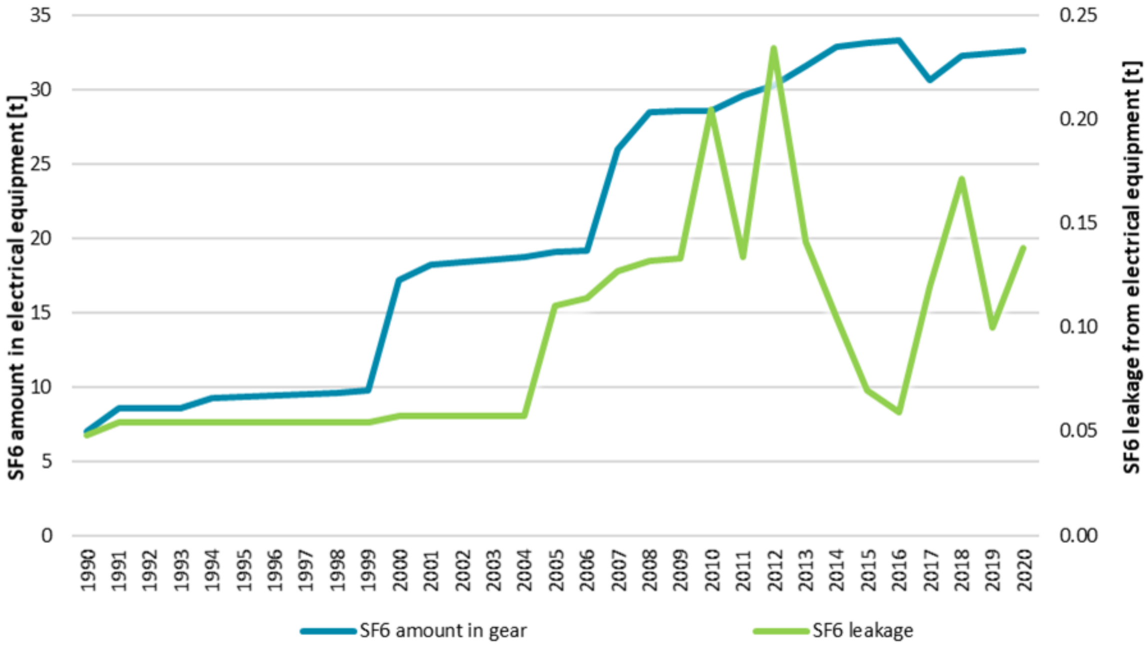


Figure 4.7 Total SF_6 amounts contained in and SF_6 leakage from electrical equipment [t].

Recalculations

Activity data was updated due to new information from the stakeholders for the years 2009, 2012-2019. Table 4.24 shows the emission change of SF_6 due to these recalculations.

Table 4.24 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

There are no category-specific improvements planned 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 SF6 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

$$EN_2O(t) = \sum_i \{[0.5 * Ai(t) + 0.5 * Ai(t-i)] + EFi\}$$

Where:

- $EN_2O(t)$ = emissions of N_2O in year t, tonnes
- Ai (t) = total quantity of N_2O supplied in year t for application type i, tonnes
- Ai (t-1) = total quantity of N_2O supplied in year t-1 for application type i, tonnes
- EFi = 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 (5.3 kt CO_2e) to 6.9 t in 2020 (2.1 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 (718 t CO_2e) and 1.57 t N_2O (467 t CO_2e) in 2020.

Recalculations

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 4.25 shows the emission change of N_2O due to these recalculations.

Table 4.25 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

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

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.

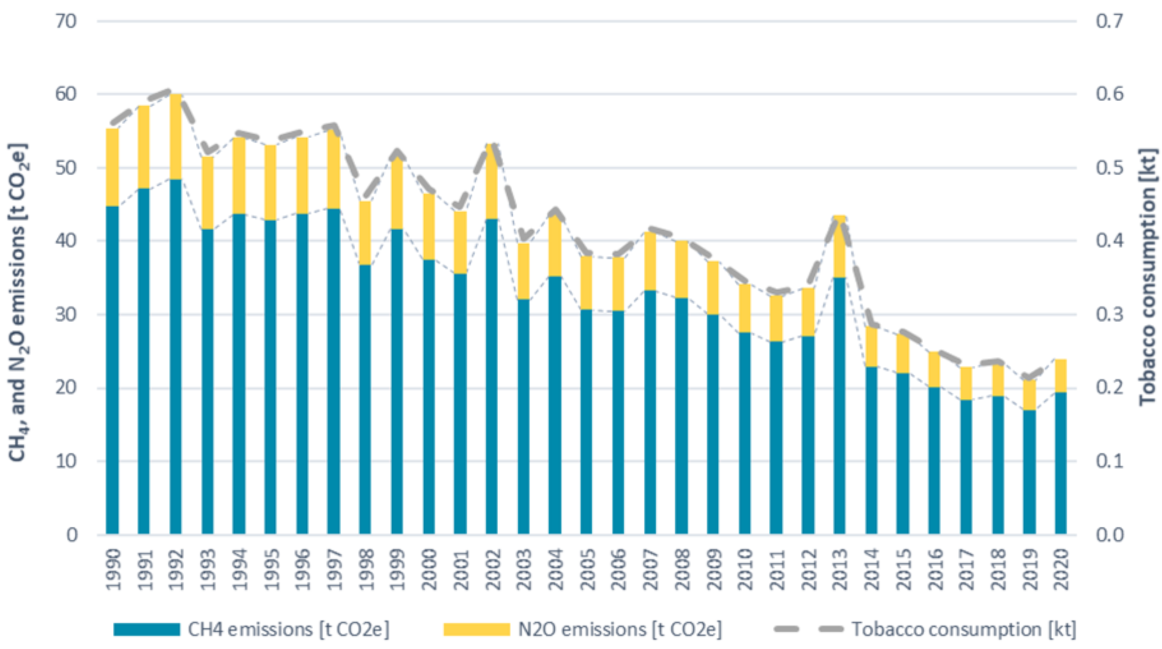


Figure 4.8 Tobacco imports and GHG emissions [t CO_2e] from tobacco use.

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_2 in 1990 and amounted to 0.3 kt CO_2e in 2020. The main contributor to GHG emissions from fireworks is N_2O, with about 90% of total emissions (when calculated in CO_2e).

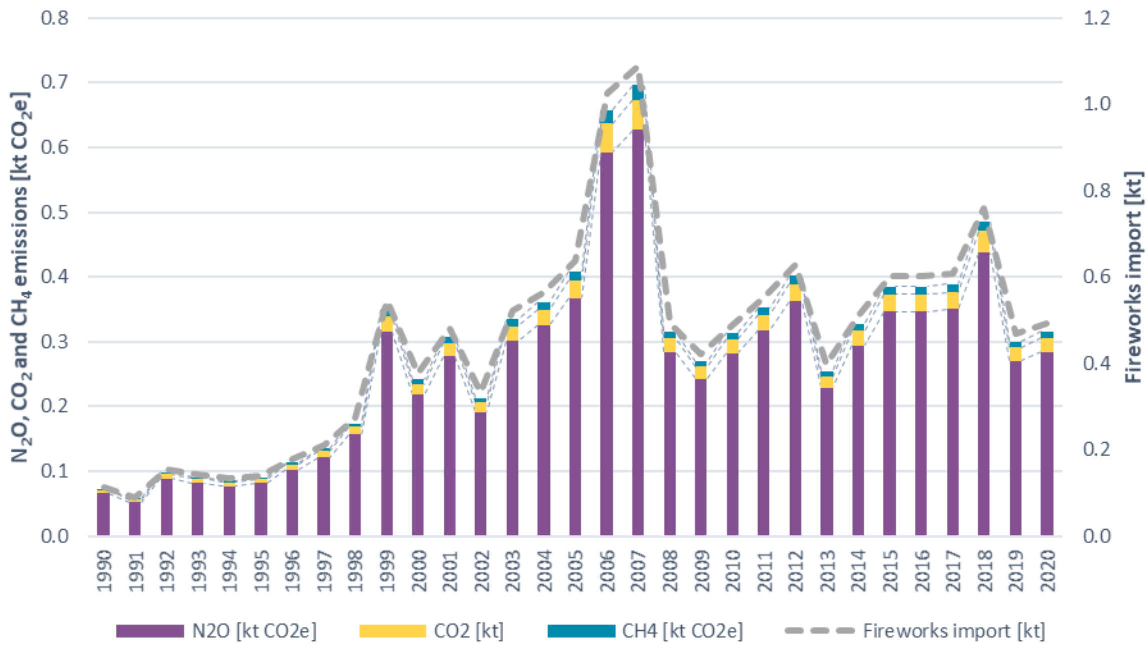


Figure 4.9 Fireworks import and GHG emissions [kt CO_2e] from firework use.

Recalculations and planned improvements

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

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, 2011), (Embætti Landlæknis, 2002), (Embætti

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

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

Emission factor for NMVOC were taken from the 2019 EMEP/EEA Guidebook (EEA, 2019) and are presented in Table 4.26.

Table 4.26 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.

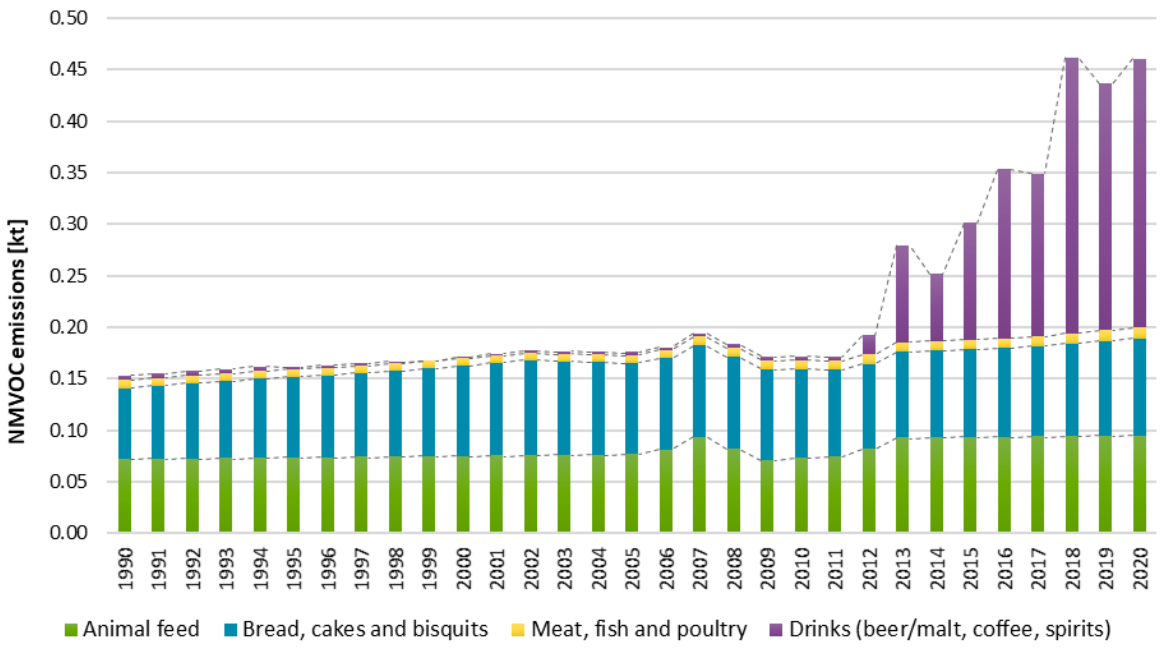


Figure 4.10 NMVOC emissions [kt NMVOC] for various food and beverage processing.

Recalculations

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 4.27 shows the recalculation of the subsector due to these changes.

Table 4.27 Recalculations of emission within 2H2 (Food and beverages industry) between submissions

Food and beverages industry	1990	1995	2000	2005	2010	2015	2018	2019
2021 submission NMVOC [kt]	0.33	0.31	0.33	0.37	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, i.e. dairy cattle, sheep, horses, and goats, which are all of an ancient Nordic origin, one breed for each species. These animals are generally smaller than the breeds common elsewhere in Europe. Beef production, however, is partly through imported breeds, as is most poultry and all pork production. There is not much arable crop production in Iceland, due to 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 618 kt CO_2e in the year 2020 and were 7% below the 1990 level (Table 5.1). Emissions of CH_4 account for 56%, N_2O for 43% 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. 84% of CH_4 emissions were caused by enteric fermentation, the rest by manure management. 93% of N_2O emissions were caused by agricultural soils, the rest by manure management, i.e. storage of manure.

For the 2022 submission work continued in reviewing and updating calculations in this sector, by improving the quality of activity data, increasing transparency throughout the calculation process and implementing comments received by Iceland during the 2021 UNFCCC centralized review. In addition, the 2019 EMEP/EEA Air Pollutant Emissions Inventory Guidebook was applied to the calculations for the second time.

Table 5.1 Emission of GHG in the agricultural sector in Iceland 1990-2020, [kt CO_2e]

	1990	1995	2000	2005	2010	2015	2019	2020
CH_4	390	360	355	344	360	373	354	347
N_2O	271	258	271	257	270	278	262	265
CO_2	0.52	0.06	0.12	4.21	2.09	3.48	5.87	5.49
Total	**662**	**618**	**627**	**605**	**631**	**655**	**621**	**618**
Emission reduction (year-base year)/base year		-6.5%	-5.3%	-8.5%	-4.5%	-1.0%	-6.1%	-6.5%

5.1.1 Methodology

Livestock characterisation follows the Tier 2 methodology of the 2006 IPCC Guidelines, Volume 4 (AFOLU) for the main animal categories, such as cattle and sheep. CH_4 emissions from enteric fermentation and manure management build upon this livestock characterization 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 Air Pollutant Emissions Inventory Guidebook. 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 fertilizers are calculated by applying the default emission factors and methodology as presented in the 2006 IPCC Guidelines.

5.1.2 Key Category Analysis

The key sources for 1990, 2020 and 1990-2020 trend in the Agriculture sector are as follows (compared to total emissions without LULUCF):

Table 5.2 Key source analysis for Agriculture, 1990, 2020 and trend (excluding LULUCF)

IPCC source category		Gas	Level 1990	Level 2020	Trend
	Agriculture (CRF sector 3)				
3A1	Enteric Fermentation - Cattle	CH_4	✓	✓	
3A2	Enteric Fermentation - Sheep	CH_4	✓	✓	✓
3A4 Horses	Enteric Fermentation - Horses	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 5.3 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 Agricultural sector.

Table 5.3 Agriculture – completeness (E: estimated, NE: not estimated, NA: not applicable, 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		NO	
3D	Agricultural Soils			
	Direct Emissions	NA	NA	E
	Animal Production	NA	NA	E
	Indirect Emissions	NA	NA	E
	Other			NO
3E	Prescribed burning of Savannas		NO	
3F	Field burning of Agricultural Residues		NE	NE
3G	Liming	E	NA	NA
3H	Urea application	E	NA	NA
3I	Other Carbon-containing fertilizers	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 consistency and quality of data; communication with livestock associations to obtain expert judgement on quality of data used.
- For the category mature dairy cows, the correlation between milk yield and Nex rate, between gross energy intake and Nex rate and between milk yield and feed digestibility is checked.
- Data reported under 3B and 3D are 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 fertilizer usage data from the International Fertilizer 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*

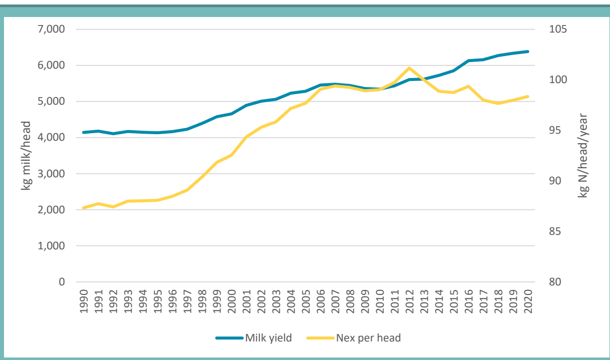
This check for the livestock category mature dairy cows is conducted because the parameters milk yield, Nex rate (nitrogen excretion rate) and feed digestibility are all inherently connected:

- Increasing milk production requires a higher protein intake;
- A higher protein intake means a higher feed intake;
- Higher productivity 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)

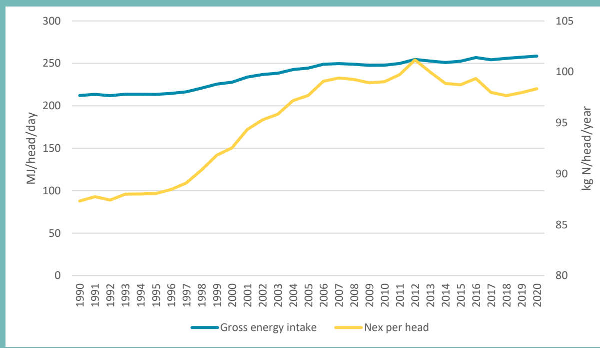
This is described in more detail in the textbox on the next page.



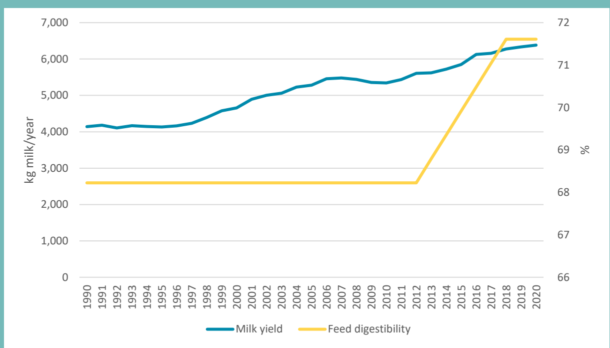
Consistency between milk yield and Nex rate

The Nex rate is calculated with information about the milk yield, based on Equation 10.31 from the 2006 IPCC GL. Therefore, the correlation between the parameters is quite high, or approx. 0.89.

Consistency between gross energy intake and Nex rate



The average nitrogen excretion rate per animal (Nex) is calculated based on Equation 10.31 (Tier 2) from the 2006 IPCC GL. This equation uses the **N intake rate for cattle**, which is calculated based in part on gross energy intake (GE) (Eq. 10.32), **and N retention rates for cattle**, which is calculated based in part on milk production (Eq. 33). Therefore, the correlation between the parameters is very high, or approx. 0.97.



Consistency between milk yield and feed digestibility

The correlation between milk yield and feed digestibility is the weakest out of the three, or approx. 0.74. While data about milk yield is collected annually and published by the Icelandic Agricultural Advisory Centre (and other entities in the past), national data on feed digestibility is not collected or published regularly. The Environment Agency collected new data on feed digestibility for the 2020 submission (2018 reporting year), and previously for the reporting year 2012. It is not expected that information about historical feed digestibility prior to 2012 will become available, which is the main reason the correlation is slightly weaker. In the future it is, however, planned to update feed digestibility data more regularly, e.g. every 3 to 4 years.

5.1.4.2 ***3.B.2 Pasture range and Paddock consistent with 3.D.1.3 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 category 3.B.2 should be consistent with *Urine and Dung Deposited by Grazing Animals* in category 3.D.1.3.

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 fertilizers use in 2009 and 2014. It was recommended that Iceland conducts a comparison between the Icelandic CS data on synthetic fertiliser consumption and fertilizer usage data from the International Fertilizer Association (IFA) and synthetic fertiliser consumption estimates from the Food and Agriculture Organization of the United Nations (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 27% 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 2004, then grows up to 54% lower than the CS data in 2018.

As was communicated during the 2019 UNFCCC desk review, all synthetic fertiliser data for the inventory is obtained from Statistics Iceland, which receive the information from the Icelandic Food and Veterinary Authority (IFVA). The IFVA has to be notified about every import or manufacture of fertilizers 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, fertilizers and seeds, animal diseases and prevention of them and relative changes.

According to information provided by the Food and Veterinary Authority, the peak in import of fertilizers 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 2000 tonnes of fertilizers which were then sold over the following spring 2015 – this can distort the overall picture and lead to these kinds of „artificial“ peaks.

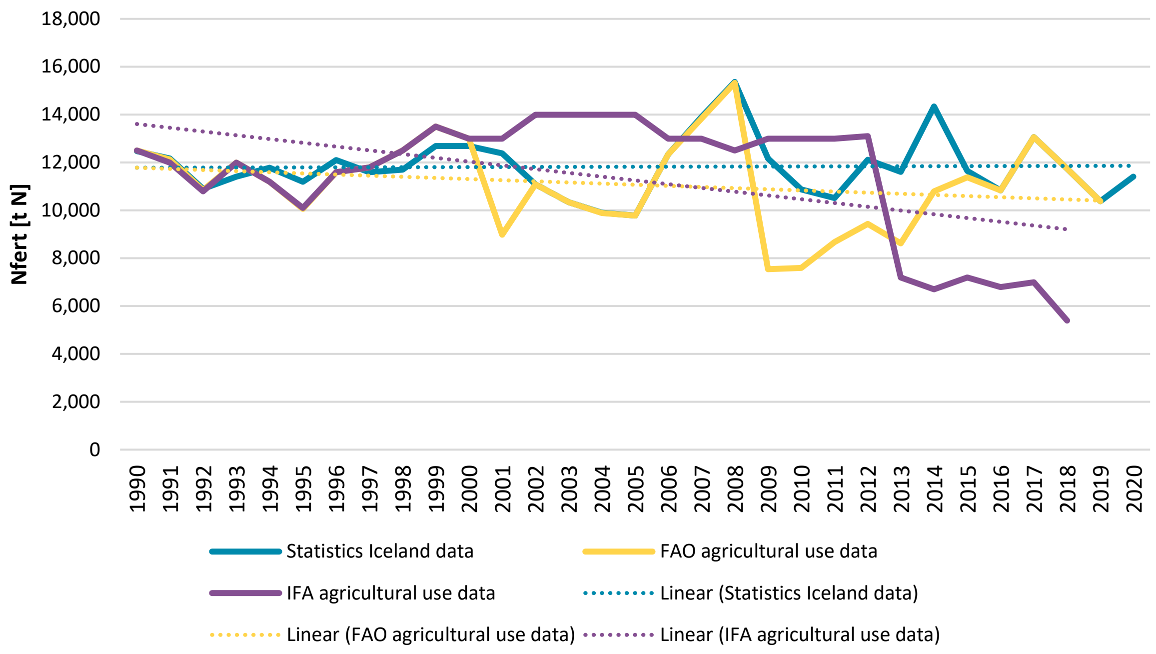


Figure 5.1 Comparison of different datasets on synthetic fertilizer use in agriculture.

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 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 Environment Agency. The main data providers are listed in Table 5.4. 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 5.4 Main data providers for the agricultural sector

Data provider	Website	Data/information
Ministry of Food, Agriculture and Fisheries (MFAF)	www.government.is /ministries/ministry-of- food-agriculture-and-fisheries/	annual livestock census (bustofn.is) (formerly reported by IFVA)
Icelandic Food and Veterinary Authority (IFVA)	mast.is	slaughtering data inorganic fertilizer import data
Icelandic Agricultural Advisory Centre (Ráðgjafarmiðstöð landbúnaðarins – RML)	rml.is	milk yield fat content of milk expert judgements
Soil Conservation Service (SCS)	land.is	areas of drained organic soils use of sewage sludge for land reclamation purposes use of other organic fertilizers for land reclamation
Statistics Iceland	hagstofa.is	crop production import data of carbon containing fertilisers and urea livestock numbers for comparison
District Commissioner	syslumenn.is	information about the occurrence of agricultural field burning
Agricultural University of Iceland	lbhi.is	specific studies about Icelandic agricultural practices emission factor for drained organic soils expert judgements

5.2.1 Animal Population Data

The Ministry of Food, Agriculture and Fisheries (MFAF) conducts an annual livestock census, formerly conducted by the Icelandic Food and Veterinary Authority. 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 Environment Agency has access to the online application bustofn.is and downloads the livestock numbers directly from there.
This 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 chickens). The following was undertaken to address this issue:

- The population of lambs was calculated with information on infertility rates, single, double, and triple birth fractions for both mature ewes and animals for replacement, i.e., one-year old ewes (Farmers Association of Iceland, written information, 2012, RML, written information, 2020 and the Icelandic Sheep Farmer’s Association, written information, 2021).
- The number of piglets was calculated with data on piglets per sow and year (Farmers Association of Iceland[17], written information, 2012, 2021).
- The number of kids was calculated with information on birth rates received from Iceland´s biggest goat farmer (Þorvaldsdóttir, oral information, 2012).
- 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 expert judgment from the MFAF.
- The number of hens, ducks and turkey chickens missing in the census is added with information received from the association of slaughter permit holders and poultry slaughterhouses. Information on age at slaughter was reviewed in collaboration with a poultry expert at the Food and Veterinary Authority in 2021.

[17] The farmer‘s association of Iceland, sections for each livestock category: https://www.bondi.is/bugreinadeildir

For animals with a life span of less 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 as reported in Table 5.5. The estimated number of young animal populations are provided in Table 5.6.

Equation 10.1

Annual average population

$$AAP = Days_{alive} * \left(\frac{NAPA}{365}\right)$$

Where:

- AAP= annual average population
- NAPA= number of animals produced annually

Table 5.5 Age at slaughter for young animals with a lifespan of less than one year used for calculating AAP

Animal type	Age at slaughter
Lambs	4.5 – 4.6 months
Piglets	5.4 – 7.1 months
Foals	5 months
Kids	5 months
Chickens (hens)	1.2 months
Chickens (ducks)	1.7 months
Chickens (turkeys)	2.8 months

Table 5.6 Annual average animal places calculated for young animals with a lifespan of less than one year

Animal type	1990	2000	2010	2020
Lambs	312,801	263,750	271,156	207,823
Piglets	26,620	28,380	34,633	36,190
Foals	8,600	6,789	8,559	7,801
Kids	153	173	320	746
Chickens (hens)	139,095	184,202	392,689	520,601
Chickens (ducks)	1,659	1,241	0	0
Chickens (turkeys)	0	6,403	8,191	11,206

As a result, the numbers of several animal species are higher in the NIR than they are in the national census as reported by Statistics Iceland, as can be seen in Table 5.7. While differences are small for most species, they are significant for animals with a life span of less than one year, such as lambs and piglets. Lambs and piglets are not reported in Statistics Iceland or in the MFAF autumn reports, because at the time of the national census they have already been slaughtered. Therefore, they are calculated through equation 10.1 from the 2006 IPCC Guidelines. This explains the notable differences between the two counts as shown in Table 5.7

Animal categories have, furthermore, changed and improved over time. In the Statistics Iceland data, cows for producing meat or other mature cattle were not reported until 1998. The discrepancy between mature dairy cattle as reported in Statistics Iceland and the NIR derives from the assumption that other mature cattle was included in the mature dairy cattle and were therefore disaggregated 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 Statistics Iceland. 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 Statistics Iceland.

Animal category	Source	1990	1995	2000	2005	2010	2015	2019	2020
Mature dairy cattle	Statistics Iceland	32,246	30,428	27,066	24,538	25,711	27,386	26,217	25,763
	NIR	31,604	30,428	27,066	24,488	25,379	27,441	26,217	25,763
Other Mature Cattle	Statistics Iceland	...	...	949	1,355	1,672	2,049	2,891	3,295
	NIR	645	737	953	1,355	1,608	2,049	2,891	3,295
Ewes	Statistics Iceland	445,513	372,202	373,340	360,375	374,266	374,863	328,290	315,122
	NIR	445,185	372,222	373,240	360,119	372,672	373,278	328,881	315,552
Lambs	Statistics Iceland	...	...	...	...	...	...	...	...
	NIR	312,801	261,163	263,750	256,227	271,156	272,279	216,237	207,823
Swine	Statistics Iceland	3,116	3,726	3,862	3,982	3,615	3,550	3,155	3,063
	NIR	3,148	3,726	3,862	4,017	3,399	3,518	3,155	3,063
Piglets	Statistics Iceland	...	...	...	...	...	...	...	...
	NIR	26,620	27,020	28,380	35,333	34,633	39,024	35,159	36,190
Laying hens	Statistics Iceland	214,936	164,402	193,097	166,119	173,419	238,000	205,079	203,643
	NIR	506,165	186,295	284,612	212,795	164,374	171,161	267,065	240,853

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[18] 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 more 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 submission 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). 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

[18] https://www.worldfengur.com/

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 2015-2020 and calculated livestock numbers to be used in this submission

Source	2015	2016	2017	2018	2019	2020
MFAF (bustofn.is)	67,417	67,239	64,816	53,453	55,198	58,479
Studbook (worldfengur.com)	97,941	97,955	96,840	96,689	93,733	91,648
Calculated for NIR	77,592	77,478	75,491	67,865	70,612	71,747

5.2.2 Livestock Population Characterization

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 this submission. 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” summarizes the three categories of the autumn census: 1) Heifers 2) Steers for producing meat (male animals from the age of 12 to 27 months and young cows from the age of 12 months to 18 months) 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 in the category “growing cattle” in CRF. An overview of the NIR categories is provided in Table 5.9.

Table 5.9 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. Young cows move into this category when they are inseminated at the age of 18 months and remain here until they are calving	Heifer
Geldneyti eldri en 1 árs	Bullocks between the age of 12 to 27 months Young cows from the age of 12 months to 18 months	Steers for producing meat
Kvígkálfar yngri en 1 árs	Female calves younger than 12 months	Calves
Nautkálfar yngri en 1 árs	Male calves older than 12 months	Calves

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 95kg. 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 500,000 sheep in Iceland during the winter and 800,000 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.

The livestock category "sheep" comprises "mature ewes", "animals for replacement", "other mature sheep" and "lambs". "Animals for replacement" match the category of yearlings in the autumn census, while "other mature sheep" are rams. The category "lambs" is calculated from the number of mature ewes and their pregnancy rate.

Livestock characterization is carried out applying the Tier 2 method from Chapter 10, Volume 4, of the 2006 IPCC Guidelines for cattle and sheep.

Table 5.10 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, 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 of the 2006 IPCC Guidelines.

Table 5.10. 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 IPCC 2006 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 cattle	10.3	10.4	NA	10.8	NA	10.13
Other mature cattle	10.3	10.4	NA	10.8	NA	10.13
Heifers[1]	10.3	10.4	10.6	NA	NA	4.8
Steers for producing meat	10.3	10.4	10.6	NA	NA	NA
Calves	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[1]	10.3	10.4	10.7	NA	10.12	10.13
Lambs	10.3	10.4	10.7	NA	10.12	NA

[1] Animals for replacement are considered from their birth until they are one year of age, which is also when they give birth for the first time. Therefore, net energy for pregnancy is calculated whereas net energy for lactation is not applicable.

Table 5.11 shows national parameters that were used to calculate gross energy intake for cattle in 2020. 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. For cattle, the number of calves is taken directly from the autumn census of the Food and Veterinary Authority because calves have a lifespan longer than one year.

Table 5.11. Animal performance data used in calculation of gross energy intake for cattle in 2020. (NA: Not applicable, NO: Not occurring)

	Mature dairy cattle	Other mature cattle	Heifers	Steers for producing meat[1]	Calves
Weight [kg]	471.3	500	370	328	126
Days in stall	265	30	245	330	365
Days on pasture	100	335	120	35	0
Mature body weight [kg]	471.3	500	430	551	512
Daily weight gain [kg]	NO	NO	0.5	0.5	0.5
Kg milk per day	17.4	5.5	NA	NA	NA
Fat content of milk [%]	4.25	4.2	NA	NA	NA
Cf_i[2]	0.3755	0.3430	0.322	0.322	0.322

[1] The category *steers for producing meat* 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 for producing meat* is 35 days.
[2]The parameter Cfi is taken from Table 10.4 in the 2006 IPCC GL. 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*).

Table 5.12 shows national parameters that were used to calculate gross energy intake for sheep in 2020. For sheep, the number of lambs is calculated from the birth fractions shown in that table. It is estimated that 0.05% of lambs die soon after birth in the spring. Therefore, the final number of lambs produced annually is estimated with the following equation:

Equation

Number of lambs produced annually

$$NLPA = (1 - 0.05) * \left(Frac_{ewes} * N_{ewes} + Frac_{afr} * N_{afr}\right)$$

Where:

- NLPA = Number of lambs produced annually
- $Frac_{ewes}$ = Birth rate fraction for ewes
- $Frac_{afr}$ = Birth rate fraction for animals for replacement
- N_{ewes} = Number of ewes
- N_{afr} = Number of animals for replacement

Table 5.12 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	Animal for replacement	Lambs
Weight (kg)	65	95	36	23
Months in stall	7	7	7	0
Months on flat pasture	2	2	2	1
Months on hilly pasture	3	3	3	3.5
Body weight at weaning (kg)	NA	NA	22	0
Body weight at 1 year or old or at slaughter (kg)	NA	NA	55	17
Birth weight (kg)	4	4	4	4
Single birth fraction[1]	0.16	NA	0.6	NA
Double birth fraction	0.71	NA	0.1	NA
Triple birth fraction	0.09	NA	NO	NA
Annual wool production (kg)	2.5	3.0	1.5	1.5
Digestible energy (in % of gross energy)	64.3	64.3	64.3	77.2
Cf_i[2]	0.217	0.250	0.236	0.256

[1] Difference between sum of birth fractions and one is due to infertility rates of 3.5% for mature ewes and 31% for animals for replacement. [2]The parameter Cfi is taken from Table 10.4 in the 2006 IPCC GL.

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 multicolored and show more diverse colors than any other cattle breed in Europe. Average milk yield reported in 2020 per cow is 6,384 kg with 4.26% fat and 3.42% 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 (AUI) (Sveinbjörnsson, written communication) and this information is based on feeding plans and research. In 2020 feed digestibility parameters and mature body weight for mature dairy cattle were updated in collaboration with the Icelandic Agricultural Advisory Centre (RML, written communication, 2020). 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 5.13 shows dry matter digestibility, digestible energy and ash content of feed 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 8. These values are used for the 2021 submission.

Equation 10.16

Gross energy for cattle and sheep

$$GE = \left[\frac{\left(\frac{NE_m + NE_a + NE_1 + NE_{work} + NE_p}{REM} \right) + \left(\frac{NE_g + NE_{wool}}{REG} \right)}{\frac{DE\%}{100}} \right]$$

Where:

- GE = gross energy intake, MJ/head/day
- NE_m, NE_a, NE_1, 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 consumes
- 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 5.13 Dry matter digestibility, digestible energy and ash content of cattle and sheep feed in 2020

	DMD [%]	DE [%]	Ash in feed [%]
Mature dairy cattle	77.90	71.61	7.80
Other mature cattle	74.36	68.14	7.00
Heifers	74.42	68.20	7.11
Steers for producing meat	72.50	66.32	7.17
Calves	79.73	73.41	7.57
Mature ewes	70.46	64.31	7.01
Other mature sheep	70.46	64.31	7.01
Animals for replacement	70.46	64.31	7.01
Lambs	83.54	77.15	7.39

Figure 5.2 shows the gross energy intake (GE) in MJ per day for all cattle and sheep subcategories. Only mature dairy cattle have time dependent values for GE (see paragraph 5.2.4), increasing from 212 MJ/day in 1990 to 259 MJ/day in 2020. This increase is owed in small part to increased activity,

i.e. more days grazing on pasture and in large part to the increase in average annual milk production from 4.1 t in 1990 to 6.4 t in 2020.

Feed digestibility is constant in Iceland for all other cattle and sheep types, except for growing cattle, which slightly varies along the time series (annual decrease or increase), because the proportion of heifers, steers and calves varies along the time series and the feed digestibility presented in CRF is a weighted average of the three.

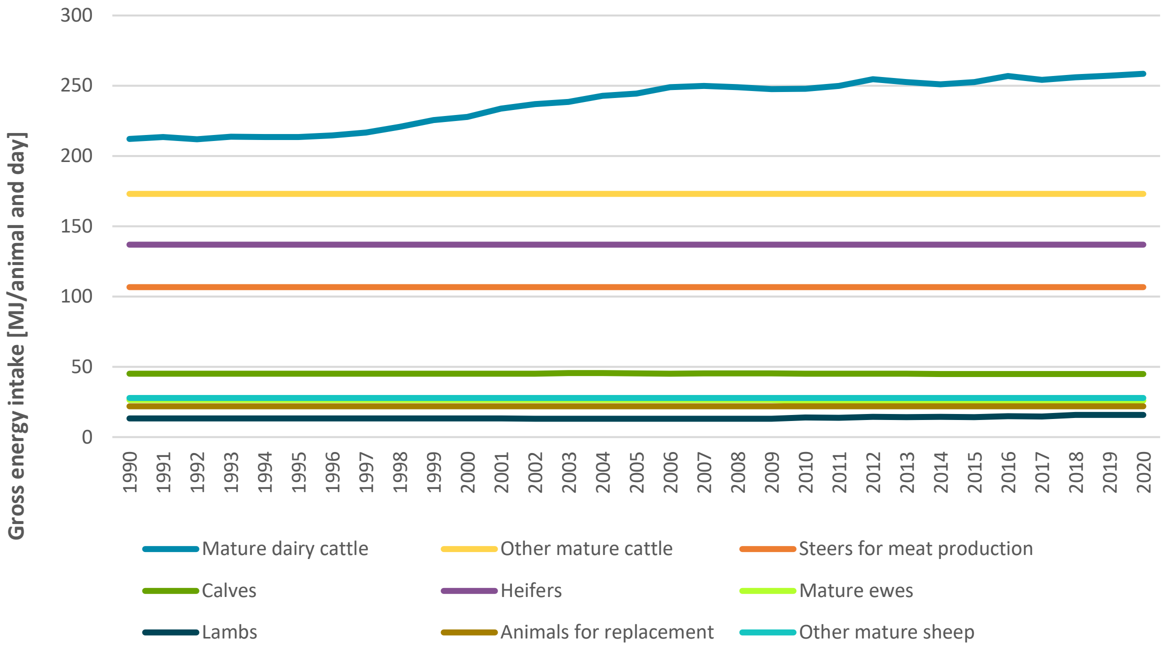


Figure 5.2 Gross energy intake [MJ/day] for cattle and sheep subcategories from 1990-2020.

5.2.4 Recalculations

5.2.4.1 *Animal characterization update for the 2022 submission*

Current livestock parameters were sent for review by external experts to ensure their quality for the 2022 submission. The parameters that were checked include single/double/triple birth fractions and average age of animal at slaughter. We either confirmed or updated the values used for the 2020 calculations for the livestock categories: sheep, pigs, horses and poultry.

During this review 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 Icelandic Food and Veterinary Authority. Table 5.14 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 3.B.1.4 Other livestock – poultry, 3.B.2.4 Other livestock – poultry, 3.B.2.5 Indirect N_2O Emissions, 3.D.1.2.a Animal Manure Applied to Soils and 3.D.2 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 5.14 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

5.2.4.2 *Recalculations for the 2021 submission*

In the previous 2021 submission the interpolation of the gross energy (GE) for mature dairy cattle from 2013-2017 to avoid a step change between 2017 and 2018, in response to an issue raised during the 2020 EU Comprehensive Review (EMRT-ID IS-3A-2020-0004) lead to recalculations. Revising the GE for dairy cattle impacts emissions in: 3A Enteric Fermentation (CH_4), 3B Manure Management (CH_4, N_2O) and 3D Agricultural Soils (N_2O) (specifically 3Da2a Animal Manure Applied to Soils, 3Da3 Urine and Dung Deposited by Grazing Animals, 3Db1 Atmospheric Deposition, and 3Db2 Nitrogen Leaching and Run-off).

5.2.5 Planned Improvements

Iceland is working on improving the quality of the animal characterization data by working with the Icelandic Agricultural Advisory Centre (IAAC) and the Ministry of Food, Agriculture and Fisheries with the aim of updating productivity data, such as the digestible energy content of feed and gross energy intake, approximately every three years. In addition, it is planned to update animal characterization parameters regularly for all livestock categories, as was done for this submission. The first collaboration with the IAAC took place in 2020 in order to update feed digestibility for the 2018 reporting year. Prior to that the last update was in 2012.

The plan is to collaborate with the IAAC to update the feed digestibility parameters for cattle and sheep again in 2022, for the results to be ready in time for the 2023 submission. Furthermore, it will be checked whether it is possible to estimate feed digestibility for the historical timeline, in line with Iceland's response to the 2021 UNFCCC centralised review question 2021ISLQA194. Based on preliminary discussions with experts it seems unlikely, however, since this data has not been regularly collected or published.

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 5.15). For poultry and fur-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 5.15 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 IPCC 2006 Guidelines and reported in

Table 5.16 was used to calculate emission factors for methane emissions from enteric fermentation by applying Equation 10.21.

Table 5.17 shows the country specific emission factors for cattle and sheep and the respective subcategories.

Equation 10.21

CH_4 emission factors for enteric fermentation for a livestock category

$$EF = \frac{GE * \frac{Ym}{100} * 365}{55.65}$$

Where:

- EF = emission factor, kg CH_4/head/yr
- GE = gross energy intake, MJ/head/day
- Ym = 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 5.16 Methane conversion rates for cattle and sheep (from tables 10.12 and 10.13 IPCC, 2006)

Category/Subcategory	Cattle	Mature sheep	Lambs (<1-year-old)
Ym	6.5%	6.5%	4.5%

Table 5.17 Country specific emission factors [kg CH_4/head/year] for cattle and sheep, calculated based on Equation 10.21 (IPCC, 2006)

Livestock category	2020
Mature dairy cattle	110.2
Other mature cattle	73.8
Heifers	58.4
Steers used for producing meat	45.5
Calves	19.1
Mature ewes	11.1
Other mature sheep	11.9
Animals for replacement	9.4
Lambs	4.7

5.3.2 Emissions

Methane emissions from enteric fermentation in domestic livestock are calculated by multiplying the emission factors from paragraph 5.3.1 per head for the specific livestock category with respective population sizes and subsequent aggregation of emissions of all categories.

There is only one livestock subcategory that has a gross energy intake that varies over time and as a result a fluctuating emission factor: mature dairy cattle (mainly due to the increase in milk production during the last two decades). Therefore, the fluctuations in methane emissions from enteric fermentation for all other livestock categories shown in Table 5.18 are solely based on fluctuations in population size. The population size of mature dairy cattle has decreased by 18% between 1990 and 2020. Methane emissions, however, have only decreased by 1% (from 2.86 kt to 2.84 kt) during the same period due to the increase in the emission factor associated with the increase in milk production.

The livestock category growing cattle comprises the categories heifers, steers for meat production and calves. The methane emissions are calculated separately for each category as shown in Table 5.19 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. In particular, for the years in which the calf population is much higher than heifers and steers for producing meat, the IEF will be lower and be outside the default IPCC range (35-48 kg CH_4/head/year) as the EF for calves calculated according to Equation 10.21 of the 2006 IPCC guidelines is 19 kg CH_4/head/year.

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 30% between 1990 and 2020 (from 5.04 to 3.52 kt). 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 decreased only slightly in 2020 compared to 1990 (by 2%), and therefore, the methane emissions are fairly constant around 1.3 kt.

The decrease in methane emissions from sheep caused total methane emissions from enteric fermentation in agricultural livestock to drop from 13 kt in 1990 to 11.7 kt in 2020, or by 10.7% (Table 5.18).

Table 5.18 Methane emissions from enteric fermentation from agricultural animals [CH_4 t]

Livestock category	1990	1995	2000	2005	2010	2015	2019	2020
Mature dairy cattle	2,860	2,770	2,629	2,552	2,681	2,955	2,875	2,840
Other mature cattle	48	54	70	100	119	151	213	243
Heifers	267	746	371	393	386	418	380	358
Steers for producing meat	817	700	903	694	858	899	1,049	1,036
Calves	388	267	345	351	387	429	425	434
Mature ewes	5,043	4,217	4,228	4,092	4,045	4,054	3,666	3,518
Other mature sheep	158	148	144	134	144	141	131	131
Animals for replacement	845	695	756	786	872	834	724	707
Lambs	1,231	1,028	1,038	1,000	1,132	1,154	1,011	971
Swine	45	46	48	59	57	64	57	59
Horses	1,330	1,444	1,361	1,379	1,419	1,430	1,304	1,325
Goats	2	3	3	3	5	7	11	12
Fur animals	5	4	4	4	4	5	1	2
Poultry	14	7	11	16	13	14	18	17
Total CH_4 emissions [t]	**13,052**	**12,129**	**11,913**	**11,561**	**12,122**	**12,554**	**11,866**	**11,652**
Emission reduction (year-base year)/base year		-7.1%	-8.7%	-11.4%	-7.1%	-3.8%	-9.1%	-10.7%

Table 5.19 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	2019	2020
Population heifers	4,579	12,781	6,361	6,728	6,620	7,157	6,504	6,133
Population steers for meat production	17,957	15,379	19,848	15,250	18,873	19,757	23,066	22,782
Population calves	20,118	13,874	17,916	18,149	20,029	22,372	22,217	22,670
Weighted average Body weight (BW) kg	237.4	274.2	252.2	243.8	245.4	242.6	246.8	244.4
Weighted average digestible energy (DE) %	69.9	69.2	69.5	69.8	69.7	69.8	69.6	69.7
Weighted average gross energy (GE) MJ/day	80.9	95.6	86.1	84.0	84.1	83.1	84.0	83.1
Weighted average Volatile solid excretion (VS) kg VS/day	1.4	1.7	1.5	1.5	1.5	1.5	1.5	1.5
Sum CH_4 emissions [kt]	**1.47**	**1.71**	**1.62**	**1.44**	**1.63**	**1.75**	**1.85**	**1.83**
IEF	34.50	40.75	36.70	35.83	35.84	35.41	35.80	35.44

5.3.3 Recalculations

5.3.3.1 *Recalculations for 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 (Table 5.20), showing a decrease of less than 0.0001%

Table 5.20 Recalculation due to error in the parameter maximum methane producing capacity (Bo) of cattle over the whole timeseries 1990-2019

CRF 3A1 – Cattle[kt CH_4]	1990	1995	2000	2005	2010	2015	2019
2021 v1 submission	4.37951	4.53793	4.31879	4.08920	4.43091	4.85140	4.94242
2022 submission	4.37902	4.53759	4.31836	4.08920	4.43091	4.85140	4.94242
Change relative to 2021 submission	-0.0001%	-0.0001%	-0.0001%	-0.0001%	-0.0001%	-0.0001%	-0.0001%

5.3.3.2 *Recalculations for the 2021 submission*

For the previous 2021 submission, the linear interpolation of gross energy between 2013-2017 lead to recalculations in the methane emission factor.

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% 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 are 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) and 3A4 (swine) is 40% and for 3A4 (all other animals) 81%. 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 5.21 summarizes 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 5.21 Tier 1 default emission factors for methane emissions from manure management.

Livestock category	Source	2020
Swine	Table 10.14 2006 IPCC	6.0
Horses	Table 10.15 2006 IPCC	1.09
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
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 characterization 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

$$ET = (VS * 365) * [B_O * 0.67\ {}^{kg}/_{m^3} * \sum_{S,k} \frac{MCF_{S,k}}{100} * MS_{S,k}]$$

Where:

- ET = 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 (Bo) for both livestock categories, cattle and sheep, are taken from the 2006 IPCC Guidelines and shown in Table 5.22.

Table 5.22 MCF and Bo form the 2006 IPCC Guidelines used for the calculations of the 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; MCF used for liquid/slurry

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 are based on expert judgement (Sveinsson, oral communication; Sveinbjörnsson, oral communication; Dýrmundsson, oral communication) and are assumed to be constant since 1990 except for mature dairy cattle. The average amount of time mature dairy cattle spend on pasture has increased from 90 to 100 days over the last 20 years. Heifers spend 120 days per year on pasture whereas cows used for meat production spend 11 months on grazing pastures. Young cattle and steers are housed all year round. All cattle manure, i.e. not spread on site by the animals themselves, is managed as liquid/slurry without natural crust cover. Sheep spend 5.5 months on pasture and range; 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. 65% of the manure managed is managed as solid storage, the remaining 35% as liquid/slurry (Table 5.23).

Table 5.23 Manure management system fractions for all livestock categories.

	Liquid/slurry	Solid storage	Pasture/range/paddock
Mature dairy cattle	73%		27%
Other mature cattle	8%		92%
Heifers	67%		33%
Steers for producing meat	91%		9%
Calves	100%		
Mature ewes	19%	36%	45%
Other mature sheep	19%	36%	45%
Animals for replacement	19%	36%	45%
Lambs			100%
Goats		55%	45%
Horses		14%	86%
Young horses		14%	86%
Foals			100%
Sows	100%		
Piglets	100%		
Poultry, fur animals		100%	

The emission factors calculated with volatile solid excretion rates, methane conversion factors, and manure management fractions for cattle and sheep are shown in Table 5.24. Mature dairy cows and steers have the highest emission factors for methane from manure management.

Table 5.24 Emission factors values and range for the tier 2 calculations of methane emissions from manure management.

Livestock category	Emission factor 2020	Emission factor range 1990-2020	Source
	[kg CH_4/head year]	[kg CH_4/head year]	
Mature dairy cattle	30.99	29.23-34.05	LPS
Other mature cattle	3.19		LPS
Heifers	12.75		LPS
Steers for producing meat	13.80		LPS
Calves	5.15	5.15-5.25	LPS
Mature ewes	1.08		LPS
Other mature sheep	1.16		LPS
Animals for replacement	0.91		LPS
Lambs	0.10		LPS

LPS: Livestock population characterisation.

5.4.3 Emissions

As can be seen in Table 5.24, there are no emission factor fluctuations for most livestock categories and only minor fluctuations for the two cattle subcategories. This implies that fluctuations in methane emission estimates for all livestock subcategories except mature dairy cattle are explained by fluctuations in population sizes. Three livestock categories alone are responsible for roughly two thirds of methane emissions from manure management: mature dairy cattle, steers used for producing meat and mature ewes. The CH_4 emission factor for mature ewes is roughly twenty times lower than the ones for dairy cattle and steers, but the mature ewe population is much larger. Other important livestock categories for methane emissions from manure management are calves, animals for replacement, swine, horses, and poultry.

Total methane emissions from manure management decreased from 2.56 kt in 1990 to 2.25 kt in 2020 or by 12% (Table 5.25).

Table 5.25 Methane emissions from manure management [t].

Livestock category	1990	1995	2000	2005	2010	2015	2019	2020
Mature dairy cattle	928	893	838	808	840	882	808	798
Other mature cattle	2	2	3	4	5	7	9	11
Heifers	58	163	81	86	84	91	83	78
Steers for producing meat	248	212	274	210	260	273	318	314
Calves	104	72	93	94	104	115	114	117
Mature ewes	488	408	409	396	391	392	355	340
Other mature sheep	15	14	14	13	14	14	13	13
Animals for replacement	82	67	73	76	84	81	70	68
Lambs	26	22	22	21	24	24	21	21
Swine	179	184	193	236	228	255	230	236
Horses	81	87	82	84	86	87	79	80
Goats	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.3
Fur animals (minks and foxes)	32	26	28	25	27	32	10	11
Rabbits	0.15	0.01	0.06	0.02	0.01	0.03	0.01	0.01
Poultry	315	118	181	143	111	117	178	161
Total CH_4 from manure management [t]	**2,558**	**2,269**	**2,292**	**2,197**	**2,261**	**2,371**	**2,289**	**2,248**
Emission reduction (year-base year)/base year		-11%	-10%	-14%	-12%	-7%	-11%	-12%

5.4.4 Recalculations

5.4.4.1 *Recalculations for the 2022 submission*

The update of the maximum methane production capacity (Bo) for cattle, from 0.17 to 0.18 for other mature cattle, heifers, steers and young cattle lead to recalculations in the methane emissions for the time series 1990-2019. As can be seen in Table 5.26 the emissions increase between 1.7% and 2.2%.

Table 5.26 Recalculations for cattle due to the update of the maximum methane production capacity Bo for 1990-1990.

CRF 3B1.1 – Cattle [kt CH_4]	1990	1995	2000	2005	2010	2015	2019
2021 v1 submission	1.317	1.317	1.264	1.181	1.269	1.341	1.304
2022 submission	1.340	1.342	1.289	1.203	1.294	1.368	1.333
Change relative to 2021 submission	1.7%	1.9%	2.0%	1.9%	2.0%	2.0%	2.2%

On the other hand, the livestock characterization change within the poultry category leads to substantial recalculations in methane emissions from manure management. 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 Icelandic Food and Veterinary Authority. This leads to an increase of methane emissions in this category as the emission factor for laying hens (0.6 kg CH_4/head, Table 10.15 2006 GL, average between layers dry (0.03) and layers wet (1.2) is higher than the one for broilers (0.02 kg CH_4/head, Table 10.15 2006 GL). As can be seen, the emissions increase over the time series 1990-2019 on average by 41%.

Table 5.27 Recalculation for methane emissions from manure management for poultry due to the update of livestock categorisation for 1990-2019.

CRF 3B1.4 – Poultry [kt CH_4]	1990	1995	2000	2005	2010	2015	2019
2021 v1 submission	0.142	0.105	0.127	0.107	0.099	0.086	0.141
2022 submission	0.315	0.118	0.181	0.143	0.111	0.117	0.178
Change relative to 2021 submission	122%	12%	43%	34%	12%	35%	26%

5.4.4.2 ***Recalculations for the 2021 submission***

Recalculations in the previous 2021 submission were due to the update of the gross energy (GE) for mature dairy cattle for 2013-2017 as described in paragraph 5.2.4.2. An update of GE influences the calculation of the volatile solid excretion rates (VS).

5.4.5 Uncertainties

The activity data uncertainties are a combination between the livestock number uncertainty (5% 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 (25% 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) 32%, 3B3 (swine) 32%, 3B4 (all other animals) 65%. The complete uncertainty analysis is shown in Annex 2.

5.4.6 Planned Improvements

There are no planned improvements in this subsector.

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 5.7and 5.8)

A nitrogen mass-flow approach has been used, as presented in the 2019 version of the EMEP/EEA air pollutant Emissions Inventory 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.

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 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 heifers, steers for producing meat and calves; mature ewes, 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 3.B Manure management and selected sources that are reported under 3.D 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 Air Pollutant Emissions Inventory Guidebook. 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 Air Pollutant Emission Inventory 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 the year 2020 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. The table abbreviations refer to the Reporting Tables and the term NFR refers to the Reporting Tables of the air pollutant inventory under CLRTAP.

5.5.2 Activity Data

The activity data for the N-flow approach is considered to be N and TAN (Total Ammoniacal Nitrogen) that is quantified throughout the manure management process, rather than livestock numbers. However, the N input into each of the management systems is determined by livestock numbers combined with N excretion rates and 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 are assumed to be stable over the past thirty years and are summarized in Table 5.23.

The nitrogen excretion rate is calculated applying Tier 1 methodology from the 2006 IPCC Guidelines for all livestock categories except mature dairy cattle.

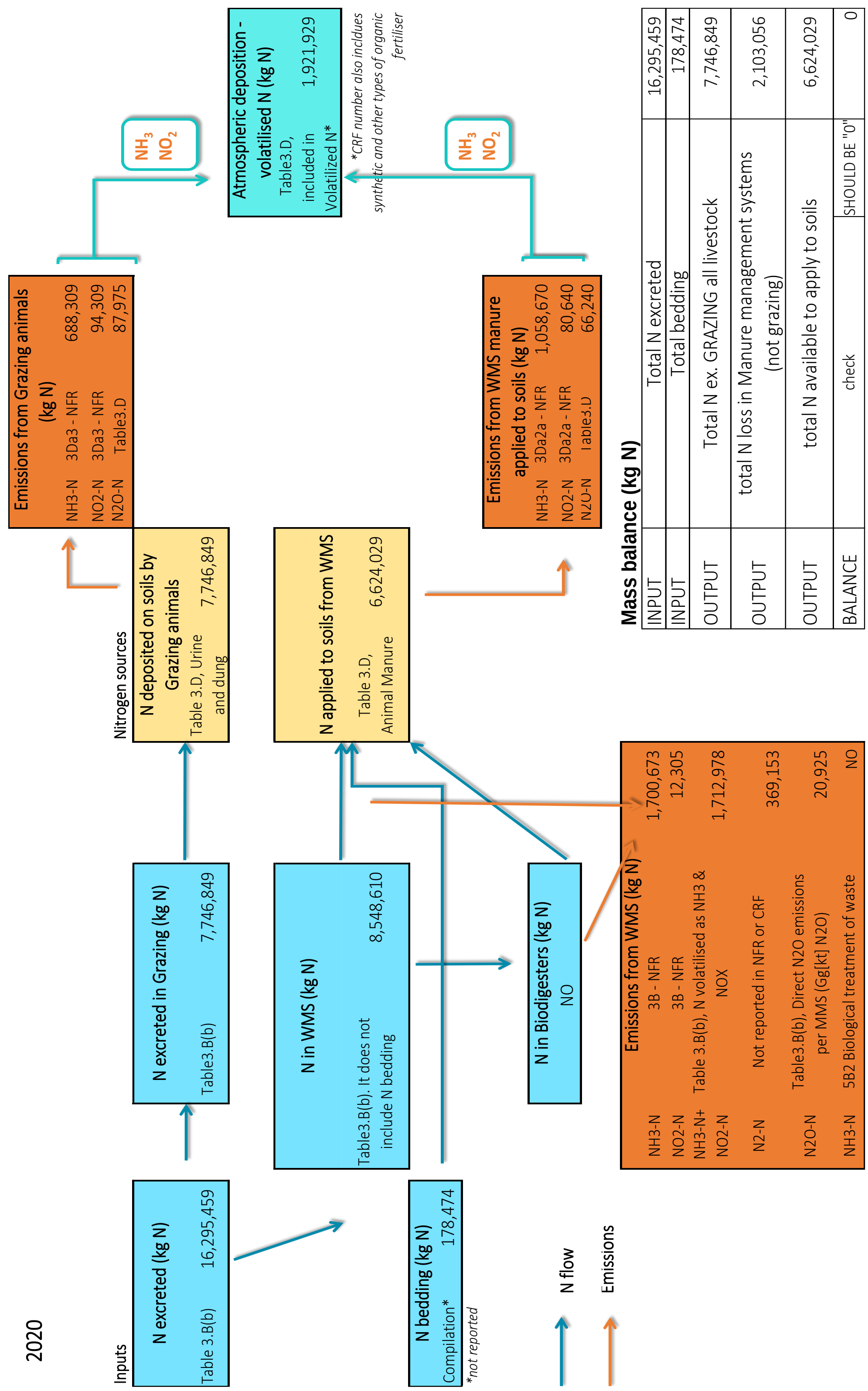


Figure 5.3 Complete Nitrogen flow applied to the categories 3B Manure Management and 3D Agricultural soils for the year 2020. Biodigesters are not occurring in Iceland. In Atmospheric Deposition – volatilized CRF includes also synthetic and other types of organic fertilizers. NFR refers to the reporting of air pollutants under CLTRAP (NH_3 and NO_X).

Table 5.28 shows the used Nex default values, multiplied by the animal weight. For most animal categories the animal parameters are not changing over the timeseries and the Nex rate is also constant. Exceptions are mature dairy cattle, calculated using the Tier 2 approach and those animal categories for which the Nex rate has been calculated on a more disaggregated level and reported as a weighted average in relation to the population data (growing cattle, horses, poultry).

The calculation method for the Nex rate for mature dairy cattle follows the Tier 2 methodology from the 2006 IPCC Guidelines (Volume 4, chapter 10) by applying Equation 10.31, Equation 10.32 and Equation 10.33 for dairy cows.

Equation 10.31

Annual N excretion rates (Tier 2)

$$Nex = N_{intake} * \left(1 - N_{retention_{frac}}\right) * 365$$

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

$$N_{intake} = \frac{GE}{18.45} * \left(\frac{\frac{CP\%}{100}}{6.25}\right)$$

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

$$N_{retention} = \left[\frac{Milk * \left(\frac{Milk\ PR\%}{100}\right)}{6.38}\right] + \left[\frac{WG * \left[268 - \left(\frac{7.03 * Ne_g}{WG}\right)\right]}{1000 * 6.25}\right]$$

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

Table 5.28 Nitrogen excretion rates defaults, animal weight and Nex for the time series 1990-2020

Livestock category	Nex default [kg N/1000 kg animal mass/day]	animal weight [kg]	1990	1995	2000	2005	2010	2015	2019	2020
Mature dairy cattle	(1)	(2)	87	88	93	98	99	99	98	98
Other mature cattle	0.33	500	60	60	60	60	60	60	60	60
Heifers	0.33	370	45	45	45	45	45	45	45	45
Steers for producing meat	0.33	328	40	40	40	40	40	40	40	40
Calves	0.33	126	15	15	15	15	15	15	15	15
Growing cattle	weighted average from heifers, steers, calves		29	33	30	29	30	29	30	29
Mature ewes	0.85	65	20	20	20	20	20	20	20	20
Other mature sheep	0.85	95	29	29	29	29	29	29	29	29
Animals for replacement	0.85	36	11	11	11	11	11	11	11	11
Lambs	0.85	23	7	7	7	6	6	7	7	7
Sows	0.42	150	23	23	23	23	23	23	23	23
Piglets	0.51	41	8	8	8	8	8	8	8	8
Horses	0.26	375	36	36	36	36	36	36	36	36
Young horses	0.26	175	17	17	17	17	17	17	17	17
Foals	0.26	60	6	6	6	6	6	6	6	6
Horses (weighted average)	weighted average from horses, young horses, foals		28	27	29	29	28	29	28	28
Goats	1.28	44	20	20	20	20	20	20	20	20
Minks	NE	NE	5	5	5	5	5	5	5	5
Foxes	NE	NE	12	12	12	12	12	12	12	12
Rabbits	NE	NE	8	8	8	8	8	8	8	8
Hens	0.96	4	1	1	1	1	1	1	1	1
Pullets	0.55	3	1	1	1	1	1	1	1	1
Chickens	0.55	1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ducks/geese	0.83	4	1	1	1	1	1	1	1	1
Turkeys	0.74	5	1	1	1	1	1	1	1	1
Poultry	weighted average from all poultry subcategories		1	1	1	1	1	1	1	1

(1) Calculated with Tier 2, Eq. 10.31, 10.32 and 10.33 of the 2006 IPCC Guidelines. (2) Weight in 1990 = 430 kg, in 2020 = 471.3 kg and in the years between interpolated linearly.

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 Air Pollution Inventory Guidebook (Tables 3.8, 3.9 and 3.10) and an extract is given in Table 5.29.

Table 5.29 Proportion of TAN and other 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	EF NO-N storage
Dairy cattle	0.6	1	0	265	slurry	0.24	0.25	0.01	0.0001
					solid	0.08	0.32	0.02	0.01
Non-dairy cattle	0.6	1	0	30	slurry	0.24	0.25	0.01	0.0001
					solid	0.08	0.32	0.02	0.01
Sheep	0.5	0.35	0.65	200	slurry	0	0	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
Other 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

The emission factors used to calculate emissions of N_2O-N during manure storage (Table 5.29) 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 Air Pollutant Inventory Guidebook, chapter 3B Manure Management 2019. The addition of straw is quantified using the default values from the 2019 EMEP EEA guidebook, Table 3.7, for all categories except for sheep, goats and horses. For these categories the default values are adjusted for a different housing period. For example, sheep have a default housing period of 30 days (Table 3.7 of the Guidebook) but in Iceland it is 200 days. So, the default straw value of 20 kg/yr is multiplied by 200/30 to obtain 133.3 kg/yr.

The emission factor for indirect emissions due to volatilized NH_3-N and NO-N is taken from the 2006 IPCC Guidelines (Volume 4, chapter 11), EF4, and corresponds to 0.01 kg N_2O-N/(kg NH_3–N + NO–N volatilised). Indirect emissions from leaking 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 liquid/slurry and solid storage amounted to 33 tonnes N_2O in 2020 and 44 tonnes in 1990 (-25%).

Emissions from liquid systems make up only a small part of total emissions from managed systems or 11% of total N_2O emissions from manure management systems in 2020. This is because the emission factor is twenty times lower for liquid systems than for solid storage. The majority of emissions in 2020 originated from the solid storage of sheep manure (79%), followed by solid storage of horse manure (7%), poultry manure (3%), and fur animal manure (0.3%).

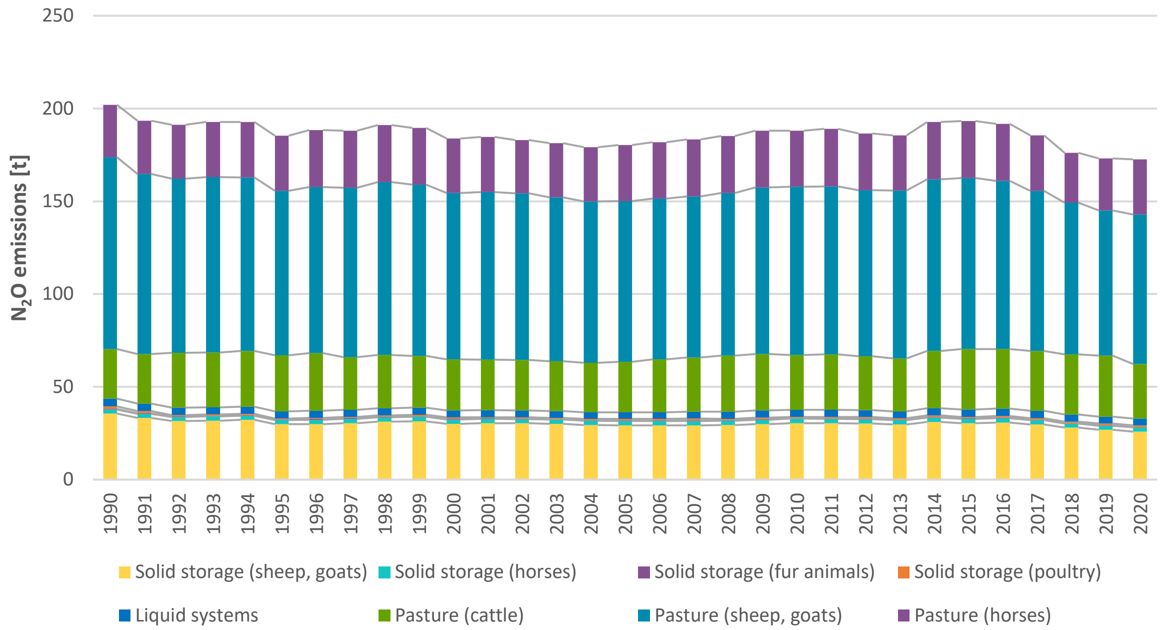


Figure 5.4 N_2O emissions from manure management, [t N_2O]

Figure 5.4 shows N_2O emissions from liquid systems 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 2020 N_2O emissions from manure spread on pasture by livestock amounted to 140 tonnes. Emissions from sheep manure were 81 tonnes, emissions from horse manure were 30 tonnes, and emissions from cattle manure amounted to 29 tonnes N_2O.

Indirect emission from manure management due to the losses of volatilization of N resulted in a total of 27 tonnes N_2O for 2020, decreasing by 13% from 31 tonnes 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 3.D Managed soils.

5.5.6 Recalculations

5.5.6.1 *Recalculations for the 2022 submission*

The livestock characterization change within the poultry category leads to recalculations in nitrous oxide emissions from manure management. 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 Icelandic Food and Veterinary Authority. This leads to a decrease of emissions in this category as can be seen in Table 5.30.

Table 5.30 Recalculation for N_2O emissions in tonnes from manure management for poultry due to the update of livestock categorisation for 1990-2019.

CRF 3B2.4 – Poultry [t N_2O]	1990	1995	2000	2005	2010	2015	2019
2021 v1 submission	1.435	0.560	0.888	0.900	0.644	0.703	0.987
2022 submission	1.341	0.553	0.858	0.880	0.637	0.687	0.974
Change relative to 2021 submission	-6.6%	-1.3%	-3.3%	-2.2%	-1.0%	-2.4%	-1.3%

Consequently, there are also recalculations in the indirect emissions, as shown in Table 5.31.

Table 5.31 Recalculation for indirect N_2O emissions in tonnes from manure management due to the livestock update within the poultry category, 1990-2019.

CRF 3B2.5 – Indirect emissions [t N_2O]	1990	1995	2000	2005	2010	2015	2019
2021 v1 submission	32.15	27.71	28.21	27.13	27.74	29.21	27.80
2022 submission	31.03	27.62	27.86	26.90	27.67	29.01	27.58
Change relative to 2021 submission	-3.5%	-0.3%	-1.2%	-0.9%	-0.3%	-0.7%	-0.8%

5.5.6.2 *Recalculations for the 2021 submission*

The main changes in the 2021 submission stem from the update of the N-flow methodology from the 2016 EMEP/ EEA Air Pollution Inventory Guidebook to its newest 2019 edition. In particular, emission factors for the NH_3-N emissions in the different stages of manure management systems (housing, storage, application and grazing) and for the manure types slurry and solid changed for some animal categories. The emission factors for N_2O, NO and N_2 are unchanged compared to the 2016 edition of the EMEP/EEA Guidebook. In addition, the update of the gross energy calculation for mature dairy cattle (2013-2017) contributed also to recalculations (see 5.2.4.2).

5.5.7 Uncertainties

The activity data uncertainty is based on the livestock number uncertainties, the manure management system distribution, the difference between N excreted and N volatilised which is retrieved by applying Equation 3.2 of the 2006 IPCC Guidelines. The combination of all these activity data uncertainties are combined using Equation 3.1 of the 2006 IPCC Guidelines and differ for each animal category ranging from 46.6% for fur animals to 59.0% for swine. 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) 101%, 3B22 (sheep) 103%, 3B23 (swine) 101%, 3B24 (all other animals) 201%.

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

Based on Iceland's response to UNFCCC review question n. 2021ISLQA195 "Amount of straw for solid systems", it is planned to crosscheck the value used for the amount of bedding material for dairy cattle with national expertise in Iceland.

5.6 Rice Cultivation (CRF 3C)

This activity is not occurring in Iceland.

5.7 Direct N2O 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 fertilizer
- Application of organic N fertilizer (animal manure, sewage sludge, other organic fertilizers)
- Urine and dung deposited by grazing animals
- Crop residues
- Mineralization/ immobilization 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)

$$N_2O_{Direct-N} = [(F_{SN} + F_{ON} + F_{CR}) * EF_1] + (F_{PRP} * EF_{PRP}) + (F_{OS} * EF_{OS})$$

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 Air Pollutant Inventory 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 Fertilizer (FSN)*

All fertilizers imported to Iceland need to be registered by customs and the Icelandic Food and Veterinary Authority (IFVA) has to 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. The Environment Agency 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[19]. Table 5.32 reports the nitrogen content in inorganic fertilizers and the associated N_2O emissions from 1990-2020. 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 fertilizers 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 5.32 Nitrogen applied in inorganic fertilizers to soils and the associated emissions, 1990-2020

	1990	1995	2000	2005	2010	2015	2019	2020
N content in inorganic N fertilizer [kt N]	12.47	11.20	12.68	9.78	10.88	11.65	10.38	11.41
N_2O emissions [kt N_2O]	0.20	0.18	0.20	0.15	0.17	0.18	0.16	0.18

5.7.2.2 *Organic N Fertilizer (FON)*

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 5.33).

Table 5.33 Nitrogen input from animal manure, both slurry and solid, applied to soils and associated N_2O emissions

	1990	1995	2000	2005	2010	2015	2019	2020
N input – slurry [kt N]	4.47	4.16	4.09	3.91	4.13	4.32	4.09	4.01
N input – solid [kt N]	3.67	2.92	3.04	2.95	2.98	3.02	2.72	2.61
N_2O emissions [kt N_2O]	0.128	0.111	0.112	0.108	0.112	0.115	0.107	0.104

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

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

reclamation purposes in collaboration with the Soil Conservation Service of Iceland. A pilot project has been 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 the year 2020 (Magnus H. Johannsson, e-mail, August 2021) 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 known. As can be seen from Table 5.34 the emissions from the application of sewage sludge are low, with 0.103 t N_2O in 2020.

Table 5.34 Nitrogen content of sewage sludge 2013-2020 and associated N_2O emissions

	1990	1995	2012	2013	2014	2015	2019	2020
N in sewage sludge [t N]	NO	NO	1.44	1.92	0.96	0.81	4.75	6.56
N_2O emissions [t N_2O]	NO	NO	0.023	0.030	0.015	0.013	0.075	0.103

Other Organic Fertilizers 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 Soil Conservation Service of Iceland (Magnus H. Johannsson, e-mail May 2020) and written communication (Magnus H. Johannson, e-mail, August 2021) reporting type and quantity of organic fertilizers used from 2009-2020 for land reclamation purposes and related N-contents. In this category we report other organic fertilisers used by the Soil Conservation Service 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 5.35 shows the N-content and associated N_2O emissions from this category, reaching 2.68 t N_2O in 2020.

Table 5.35 Nitrogen content of other organic fertilizers and associated N_2O emissions

	1990	1995	2000	2009	2010	2015	2019	2020
N in other organic fertilizers [t N]	NO	NO	NO	59	103	163	186	171
N_2O emissions [t N_2O]	NO	NO	NO	0.93	1.62	2.56	2.93	2.68

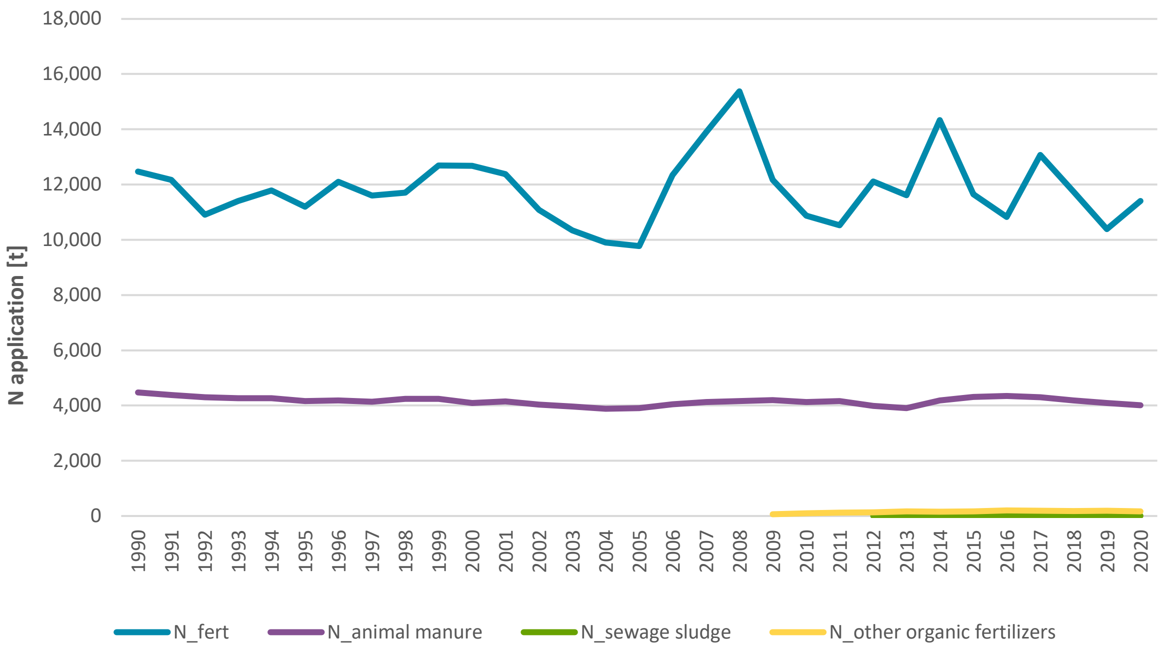


Figure 5.5 Amounts of nitrogen from synthetic (N_fert) and organic fertilizer (animal manure, sewage sludge, and other organic fertilizers) applied to soils[t]

5.7.2.3 *Urine and Dung Deposited by Grazing Animals (FPRP)*

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 5.36) to calculate the N_2O emissions from this category.

Table 5.36 Nitrogen deposited by grazing animals (pasture, range and paddock) and associated N_2O emissions, 1990-2020

	1990	1995	2000	2009	2010	2015	2019	2020
N excretion, grazing [kt N]	9.37	8.49	8.43	8.31	8.67	8.80	7.90	7.75
N_2O emissions [kt N_2O]	0.161	0.148	0.146	0.144	0.151	0.155	0.141	0.138

5.7.2.4 *Nitrogen in Crop Residues Returned to Soils (FCR)*

There are four N-fixing crops cultivated in Iceland: potatoes, barley, beets and carrots. After harvest, crop residues are returned to soils. The amount of residue returned to the soils is derived from crop production data. Statistics Iceland has production data for the four crops. The amount of residue per crop returned to soils is calculated using equation 11.6 from the IPCC 2006 Guidelines.

For the residue/crop ratio, dry matter fraction and nitrogen fraction, the IPCC default values are used. Dry matter fraction defaults do, however, not exist for potatoes and beets. By expert judgement, they are estimated to be 0.2 for both crops. No default values exist for carrots and, therefore, beet defaults are applied. It is estimated that 80% of barley residue is used as fodder. Crop produce amounts and associated N_2O emissions are shown in Figure 5.6.

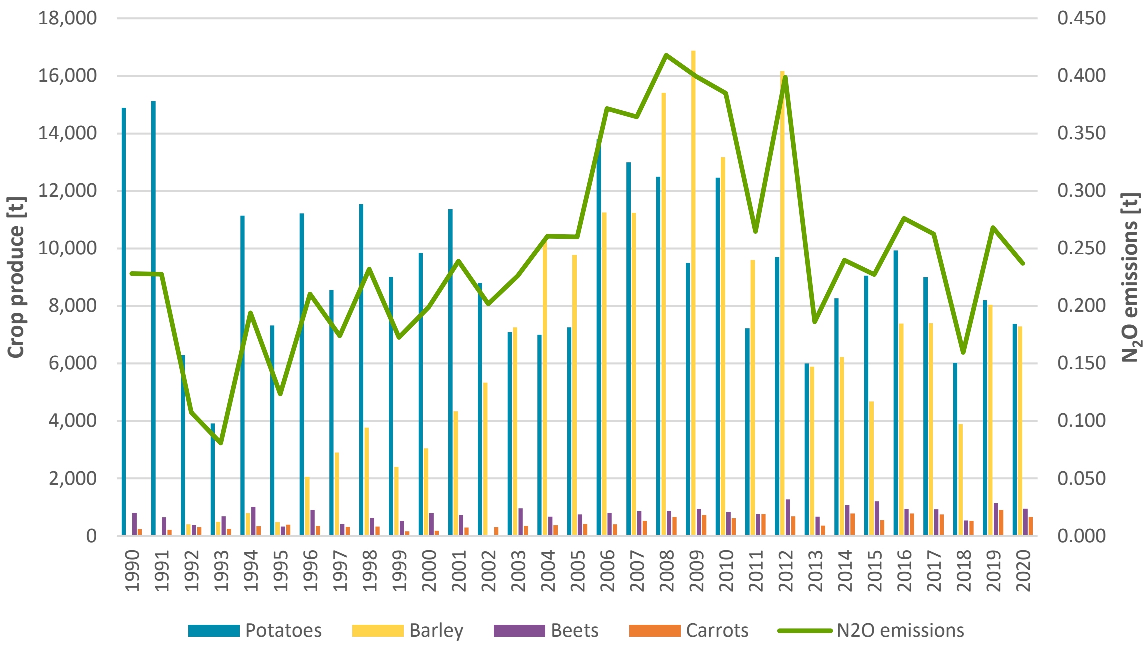


Figure 5.6 Crop produce and associated N_2O [t] emissions for 1990-2020

The amount of nitrogen in crop residues returned to soils was at its lowest in 1993, when it amounted to roughly 5 tonnes and highest in 2008 when it amounted to roughly 27 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 10 and 20 tonnes per year, N inputs to soils from synthetic fertiliser application ranges from 5,000 – 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 EA. The areas and associated N_2O emissions are reported in Table 5.37.

Table 5.37 Area of organic soils [kha] and associated N_2O emissions, 1990-2020

	1990	1995	2000	2005	2010	2015	2019	2020
Organic soils-histosols	65	65	65	65	65	65	65	65
Drained organic soils-grasslands	150	196	219	247	251	253	257	259
Total area[kha]	215	261	284	312	316	318	322	324
N_2O emissions [kt N_2O]	**0.205**	**0.237**	**0.252**	**0.272**	**0.275**	**0.276**	**0.279**	**0.280**

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 5.38. 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 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 fertilized (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 9, 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 5.38 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 fertilizers	EF1	0.01	Table 11.1 IPCC 2006
Animal manure applied to soils	EF1	0.01	Table 11.1 IPCC 2006
Sewage sludge applied to soils	EF1	0.01	Table 11.1 IPCC 2006
Urine and Dung deposited by grazing animals	EFPRP	0.02 cattle, poultry, pigs	Table 11.1 IPCC 2006
	EFPRP	0.01 sheep and other	
Crop residues	EF1	0.01	Table 11.1 IPCC 2006
Cultivation of organic soils	EFOS	0.99/0.44 [kg N_2O-N/ha/yr]	CS (Annex 9)

5.7.4 Emissions

The direct emissions from agricultural soils amount to 704 t of N_2O in 2020 and are slightly higher than in 1990 (690 t). The main fluctuations are due to the import and use of synthetic N-fertilizers as can be seen in Figure 5.7.

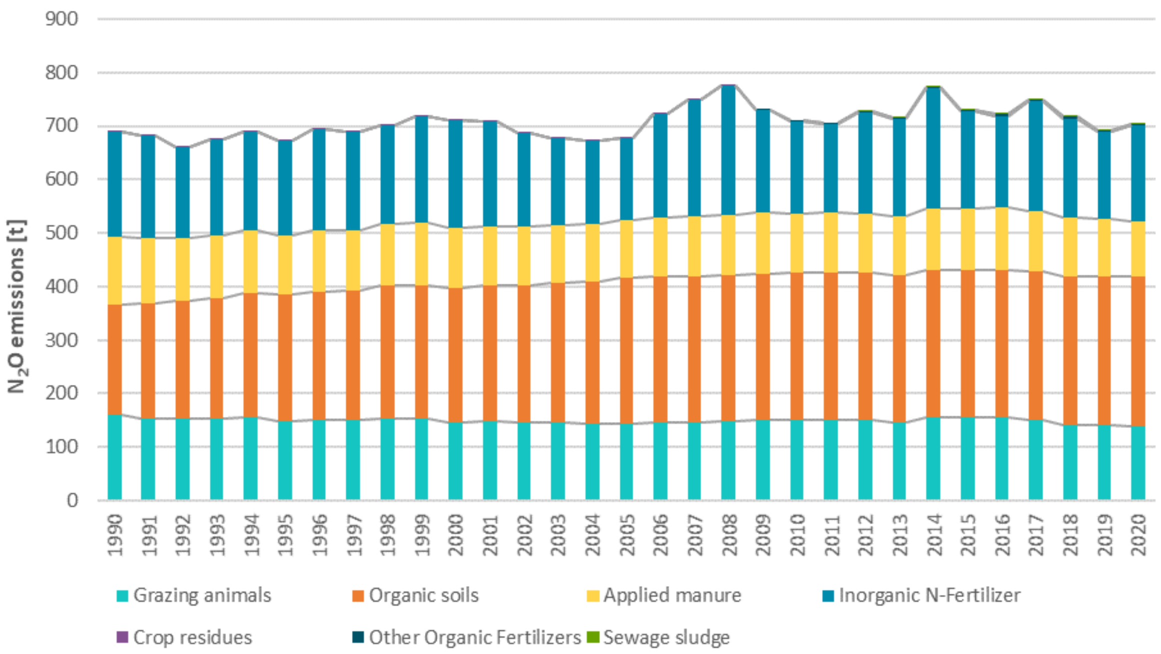


Figure 5.7 Direct N_2O emissions from Agricultural soils [t].

5.7.5 Recalculations

5.7.5.1 *Recalculations for the 2022 submission*

The livestock characterization change within the poultry category leads 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 Icelandic Food and Veterinary Authority. As the nitrogen excretion rate for laying hens is higher, moving all animals previously categorised as broilers to laying hens, increases the emissions slightly for the time series 1990-2019, or on average by 0.1% as can be seen in Table 5.39.

Table 5.39 Recalculation for N_2O emissions in tonnes animal manure applied to soils due to the update of livestock categorisation within poultry for 1990-2019.

CRF 3D1.2.a – Animal Manure [t N_2O]	1990	1995	2000	2005	2010	2015	2019
2021 v1 submission	127.56	111.14	112.06	107.67	111.69	115.15	106.82
2022 submission	127.89	111.17	112.16	107.74	111.72	115.21	106.93
Change relative to 2021 submission	0.26%	0.02%	0.09%	0.06%	0.02%	0.05%	0.10%

Recalculations in the subcategory cultivated organic soils are due to changes in the areas of histosols as reported by the LULUCF specialists. This leads to minor recalculations over the whole time series 1990-2019 with an average increase in emissions of 0.5% as can be seen in Table 5.40.

Table 5.40 Recalculations for the N_2O emission from the cultivation of organic soils due to minor changes in the areas of histosols.

CRF 3D1.6 Organic Soils [t N_2O]	1990	1995	2000	2005	2010	2015	2019
2021 v1 submission	205.0	236.0	251.2	270.3	272.4	273.1	275.6
2022 submission	205.0	236.5	251.0	271.9	274.6	275.6	278.4
Change relative to 2021 submission	0.0%	0.2%	0.4%	0.6%	0.8%	0.9%	1.0%

5.7.5.2 *Recalculations for the 2021 submission*

For the previous 2021 submission, several recalculations have been performed in this category for the whole time series due to the update of parameters and emission factors of the N-flow methodology used to estimate the nitrogen emissions from Manure Management, and from which the quantities of Animal Manure Applied to Soils stem, and the update of activity data (for Sewage Sludge and for Cultivation of Organic Soils) as well as emission factors for the calculations of emissions in cultivated organic soils due to a typo in the emission estimation files (the emission factor for drained hayfields has been updated from 0.96 to 0.99 kg N_2O-N/ha/yr for the whole time series).

5.7.6 Uncertainties

The activity data uncertainties vary according to the used activity data. For 3D11 Inorganic fertilizers the uncertainty is 5% based on expert judgement and based on the fact that the amount of imported N-fertilizers 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 56.1%, while for sewage sludge and other organic fertilizers 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 56.8%. 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 233.33%.

The combined uncertainties of activity data and emission factors are the following: 3D11 Inorganic fertilizers 233.4%, 3D12 Organic fertilizers 241.6%, 3D13 Urine and dung deposited by grazing animals 240.1 %, 3D14 Crop residues 253.9% and 3D16 Cultivation of organic soils 201%. The complete uncertainty analysis is shown in Annex 2.

5.7.7 Planned improvements

Efforts will be made to assure the completeness of the inventory by improving the research of the use of other organic fertilisers in the country. It has proved most efficient to contact the Soil Conservation Service of Iceland directly for data, because they are the predominant users of other organic fertilisers in Iceland.

5.8 Indirect N2O Emissions from Managed Soils (CRF 3D2)

Indirect N_2O emissions originate from three sources:

- Volatilization of N as NH_3 and NO_X from agricultural fertilizers and manure and subsequent atmospheric deposition.
- Leaching and runoff of applied fertiliser and animal manure, crop residues, 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 synthetic fertilisers, animal manure applied to soils, urine and dung deposited by grazing animals and from the application of sewage sludge 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-fertilizer and crop production. This data is calculated in section 5.7. From 1990 to 2020, volatilized nitrogen from agricultural inputs diminished by 10% or from 2,425 t in 1990 to 2,194 t in 2020.

5.8.2.2 *Leaching and Runoff*

The amount of N input (deriving from the application of inorganic and organic N-fertilizers, 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 13% from 8,999 tonnes in 1990 to 7,791 tonnes in 2020.

5.8.3 Emission factors

Table 5.41 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 5.41 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 1990-2020 - after conversion from nitrogen to nitrous oxide - is shown in Figure 5.8. N_2O emissions amounted to 126 tonnes N_2O in 2020, which is 12% lower than the 1990 emissions of 144 tonnes. The general slight downward trend in emissions was reversed from 2006 to 2008, when high amounts of synthetic fertiliser application caused an increase in indirect N_2O emissions from agricultural soils, above the 1990 level.

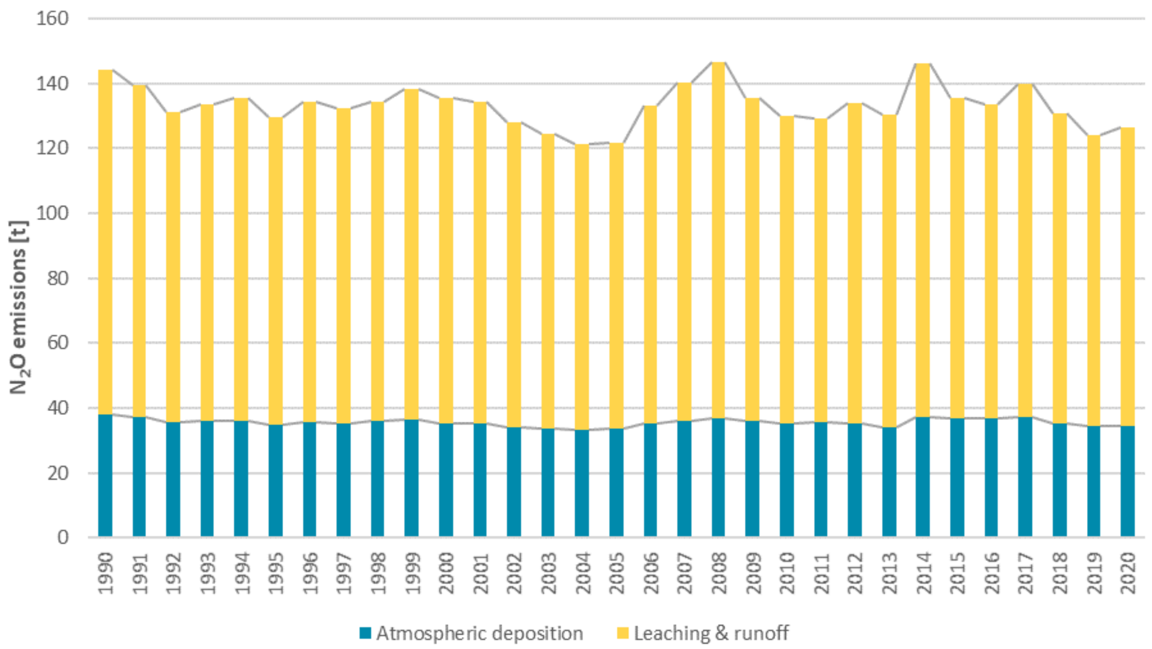


Figure 5.8 Indirect N_2O[t] emissions from agricultural soils.

5.8.5 Recalculations

5.8.5.1 ***Recalculations for the 2022 submission***

An issue was raised during the 2021 UNFCCC Review (Question 2021ISLQA197: Consistency of FracGASF and FracGASM). Consequently, external consultants at Aether performed a quality check of the 3.D 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 volatilized N from agricultural inputs of N and consequent N_2O emissions reported under CRF category 3.D.2.1 Atmospheric Deposition (Table 5.42).

Table 5.42 Recalculation due to error in previous calculations in 3.D.2.1 Atmospheric Deposition.

CRF 3D2.1 Atmospheric dep. [t N_2O]	1990	1995	2000	2005	2010	2015	2019
2021 v1 submission	37.72	34.97	35.33	33.50	34.98	36.38	34.23
2022 submission	38.11	35.00	35.45	33.58	35.15	36.68	34.59
Change relative to 2021 submission	1.0%	0.1%	0.3%	0.2%	0.5%	0.8%	1.0%

5.8.5.2 ***Recalculations for the 2021 submission***

For the previous 2021 submission, the changes in the estimates of N_2O direct emissions from agricultural soils (3D1) and the connected changes within the sector Manure Management (3B) lead to recalculations

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

During the 2021 UNFCCC review Iceland was encouraged to take steps to define an appropriate FracLeachMS 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. Preliminary steps to look into defining a country specific FracLeachMS will, however, be taken for the next submission.

5.9 Prescribed Burning of Savannas (CRF 3E)

This activity is not occurring in Iceland.

5.10 Field burning of agricultural residues (CRF 3F)

According to Act Nr. 40/2015 (Law about the treatment of fire and fire prevention) and Regulation Nr. 325/2016 about the treatment of fire and fire prevention, agricultural field burning needs a permit from the district commissioner in Iceland. In general, field burning is not permitted, but farmers and landowners of land where agriculture is practiced, can apply for a permit for burning between the 1st of April and 1st of May each year, provided the purpose is justified. The district commissioner can, after consultation with the Ministry of Food, Agriculture and Fisheries, set a different date for burning which, however, needs to be within the period of 15th of March and 15th of May each year. It is, however, altogether forbidden to practice field burning in areas where public danger may result or nature, bird life, moss, heaths, forests or human developments could be damaged[20]. A repealed regulation Nr. 157/1993 (regulation about field burning and treatment of fire in open country) states the same as the newer law.

The nine district commissioners of Iceland have been contacted and data about issued and fulfilled permits has been collected for the period 1990-2020. Table 5.43 reports the results from the enquiry carried out during the year 2019 and again in 2021. Currently not enough activity data is available to estimate emissions from field burning. Therefore, Iceland reports this category as “NE”, not estimated. It is planned to improve the knowledge in this field and provide an estimation for the next submission.

[20] https://www.syslumenn.is/thjonusta/leyfi-og-loggildingar/leyfi-til-sinubrennu/

Table 5.43 Data collection regarding the occurrence of field burning of agricultural residues

District	
Suðurnes (SW)	No permit given 1990-2020
Höfuðborgarsvæðið (Capital area)	No permit given 1990-2020
Vesturland (W)	
Vestfirðir (Westfjords)	
Norðurland vestra (NW)	1 permit given in 2015, 2 permits given in 2016
Norðurland eystra (NE)	
Austurland (E)	4 permits given between 1990-2020
Suðurland (S)	
Vestmannaeyjar (Westman Islands)	No permit given 1990-2020

5.11 CO2 Emissions from Liming, Urea Application, Other Carbon Containing Fertilizers and Other (CRF 3G, 3H, 3I, 3J)

Combined CO_2 emissions from liming (3G), urea application (3H) and other carbon containing fertilizers (3I) account for 1% of the total GHG emissions from the Agricultural sector.

5.11.1 Methodology

Tier 1 methodology from the 2006 IPCC Guidelines, Volume 4, Chapter 11 is applied for all three subsectors.

Equation 11.12

Annual CO_2 emissions from lime application (Tier 1)

$$CO_2 - C\ Emission = (M_{Limestone} * EF_{Limestone}) + (M_{Dolomite} * EF_{Dolomite})$$

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(CO3)2), t/yr
- EF = emission factor, t of C/ t of limestone or dolomite

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

After applying the equations, CO_2-C is converted to CO_2 by multiplying with 44/12.

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 fertilizers applied make this source relatively large in terms of emissions. Activity data about imported limestone, dolomite and synthetic fertilizers are registered through the customs system and obtained either from Statistics Iceland or from the Icelandic Food and Veterinary Authority (IFVA). It was possible to complete the time series 1990-2003 for limestone by an update in data collection from Statistics Iceland. Data for dolomite 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 used during these years. Therefore, it is now estimated as not occurring for the period 1990-2002. 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.

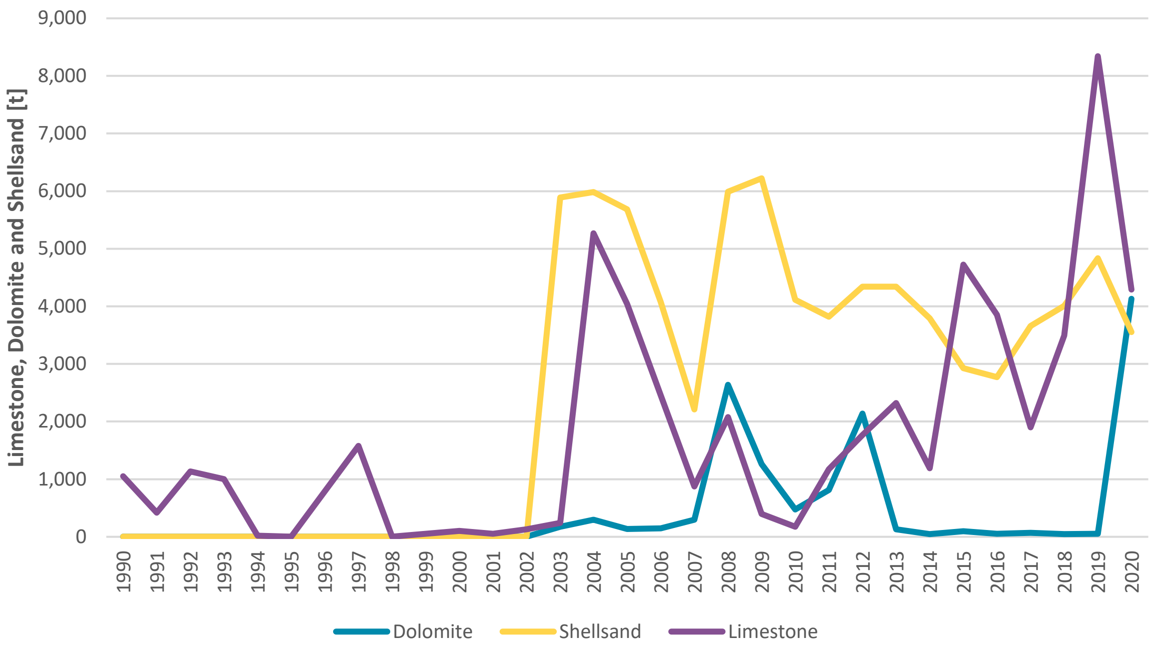


Figure 5.9 Data on the amount of limestone, dolomite and shellsand [t] sold 1990-2020

The peak in imports of dolomite in 2020 is due to a significant increase in imports by one distributor according to information received from the Food and Veterinary Authority. 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.[21]

5.11.2.2 *Urea Application*

Activity data about imported urea fertilizers are registered through the customs system and obtained either from Statistics Iceland or from the Icelandic Food and Veterinary Authority (IFVA). Urea fertilizer imports showed 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 fertilizer. 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 (Figure 5.10). From the year 2020 onwards, there are different custom numbers and this issue should not be of concern anymore.

[21] https://www.yara.is/kolkun-er-grundvallaratridi-thegar-kemur-ad-godri-upptoku-naeringarefna/

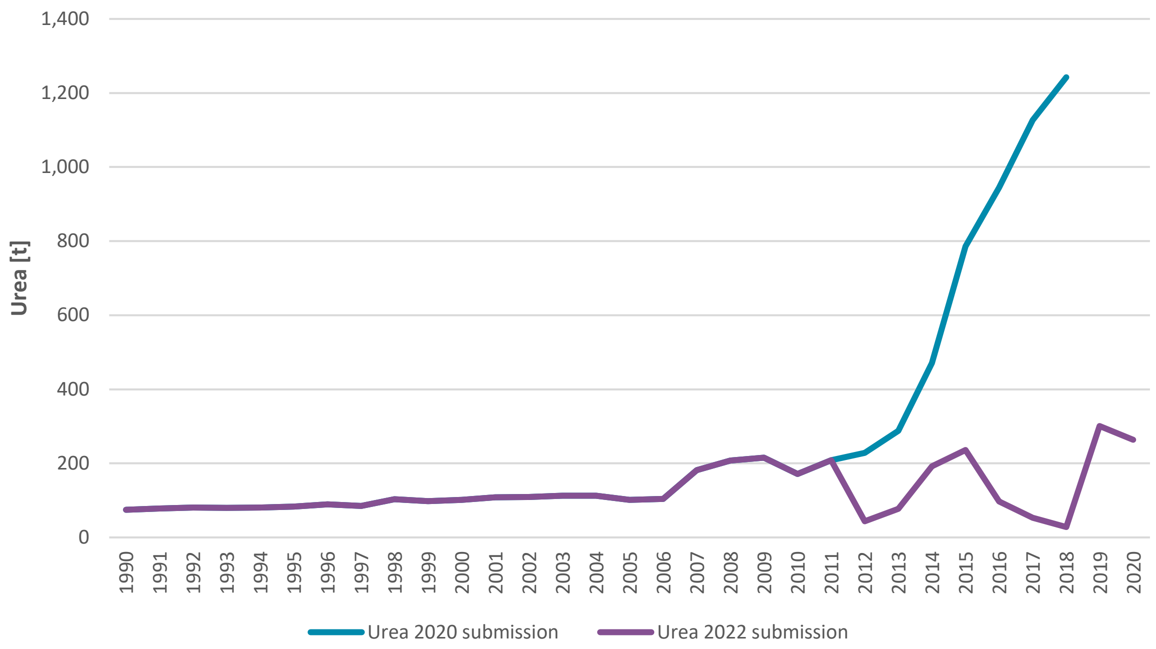


Figure 5.10 Import data of urea fertilizers 1990-2020 [t], comparison between 2022 and 2020 submission

5.11.2.3 *Other Carbon-containing Fertilizers*

In this subsector the use of shell sand as a liming agent is estimated. Shell sand 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 shell sand used by single farmers. Activity data is derived from distributor sales numbers. No activity data are available from 1990-2002. 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 shell sand used during these years. Therefore, it is now estimated as not occurring for the period 1990-2002.

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. For shell sand an emission factor of 0.11 is applied. The emission factor for the application of urea fertilizers is 0.20.

5.11.4 Emissions

The CO_2 emissions due to liming of cropland are calculated by conversion of carbonated carbon to CO_2. CO_2 emissions from liming amounted to 1.9 kt in 2020. CO_2 emissions from dolomite increased from 0.02 kt in 2019 to 1.97 kt in 2020 (CRF 3G). Dolomite emissions, therefore, increased by 7,783% in the past year. The peak is explained in section 5.11.2.1. CO_2 emissions from urea are 0.19 kt (CRF 3H) and other carbon containing fertilisers (shell sand) 1.43 kt (CRF 3I). Other (CRF 3J) is not occurring for the timeseries. Figure 5.11 reports the CO_2 emissions from the whole time series available in the current inventory. For the years 1990-2002 liming and shell sand application is not occurring.

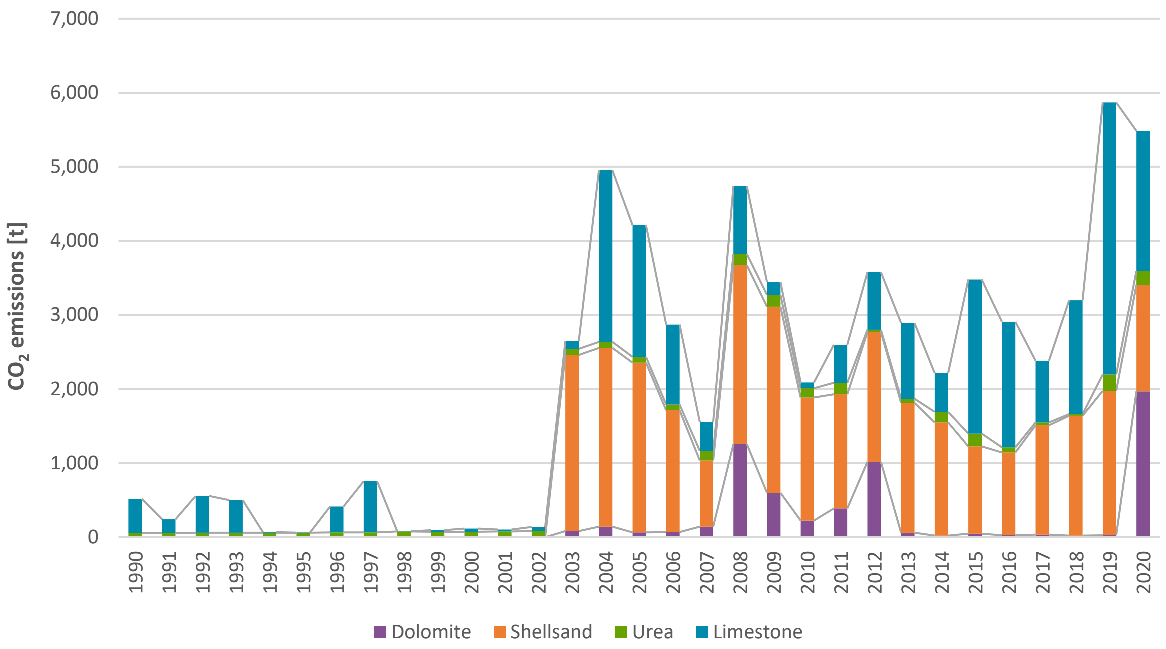


Figure 5.11 CO_2 emissions from liming (limestone and dolomite), urea application and other carbon containing fertilizers (shell sand).

5.11.5 Recalculations

5.11.5.1 *Recalculations for the 2022 submission*

There were no recalculations in this category for the 2022 submission.

5.11.5.2 *Recalculations for the 2021 submission*

For the previous 2021 submission recalculations were carried out for liming (3G) and urea application (3H) due to an update of activity data.

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 CO2 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

During the 2021 UNFCCC centralised review, a question was asked about ammonitrates (question 2021ISLQA198). According to the NIR ammonitrates are used in Iceland and, although this source is not mentioned in the 2006 IPCC GL nor the 2019 IPPC refinement, it is now reported by some Parties. We contacted the expert at the Food and Veterinary Authority in Iceland, which is responsible for giving permits for importing and registering these imports in Iceland. The response was that calcium ammonitrates (CAN) are not imported alone, but in fertiliser blends, which makes it difficult to extrapolate a time series of only CAN imported.

Nevertheless, the expert provided an estimation of CAN imported in 2020, which was approximately 22,206 t CAN. If it is assumed that CAN has 27% of N, the portion of limestone is $1 - \left(27\% \times \frac{80}{28}\right) = 23\%$ (information given during an EU Capacity Building Webinar). That results in: $23\% \times 22{,}206\ t = 5{,}107\ t$ of limestone. Applying the default emission factor of 0.12 t CO_2-C/t (2006 GL, Vol. 4, Ch. 11) and the conversion factor of 44/12 we obtain emissions of 2,247 t CO_2e = 2.25 kt CO_2e, which is slightly below the threshold of significance of Iceland ($\sim$2.5 kt CO_2e).

The conservative approach in this estimation shows that the emissions could be significant and should be added to the inventory. To perform exact calculations and obtain a complete timeline, however, more research is necessary. It needs to be ensured that there is no double counting of emissions and data providers for limestone use need to be contacted regarding this issue. This matter is on the improvement plan for the next submission and the goal is to obtain satisfactory activity data by that time.

6 Land-Use, Land-Use Changes and Forestry (CRF sector 4)

6.1 Overview

In this sector emissions and removals related to land use, land use changes and forestry (LULUCF), are reported. The categorization of land use is according to 2006 IPCC guidelines (IPCC 2006). This defines six main land use categories and conversions between them. Emissions and removals of GHG are reported for all managed lands 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 Wetland Supplement. The Soil Conservation Service of Iceland (SCSI) and the Icelandic Forest Research (IFR) the research division of the Icelandic Forest Service (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 i.e. “Other land” and Grassland. Land categories are changed considerably in the 2021 submission as part of the Other land category is now under “Grassland”. This change is 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 main land use categories reported.

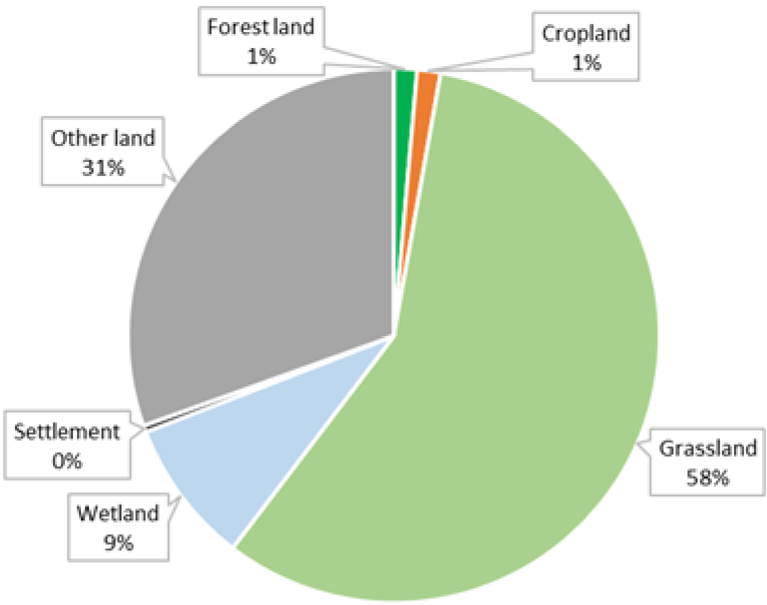


Figure 6.1 Relative size of land use categories in Iceland according to IGLUD land use map 2020 and other land use estimates available for the reporting.

Both emissions from sources and removals by sinks are reported for this sector. The net contribution of the main land use categories is summarized in Figure 6.2.

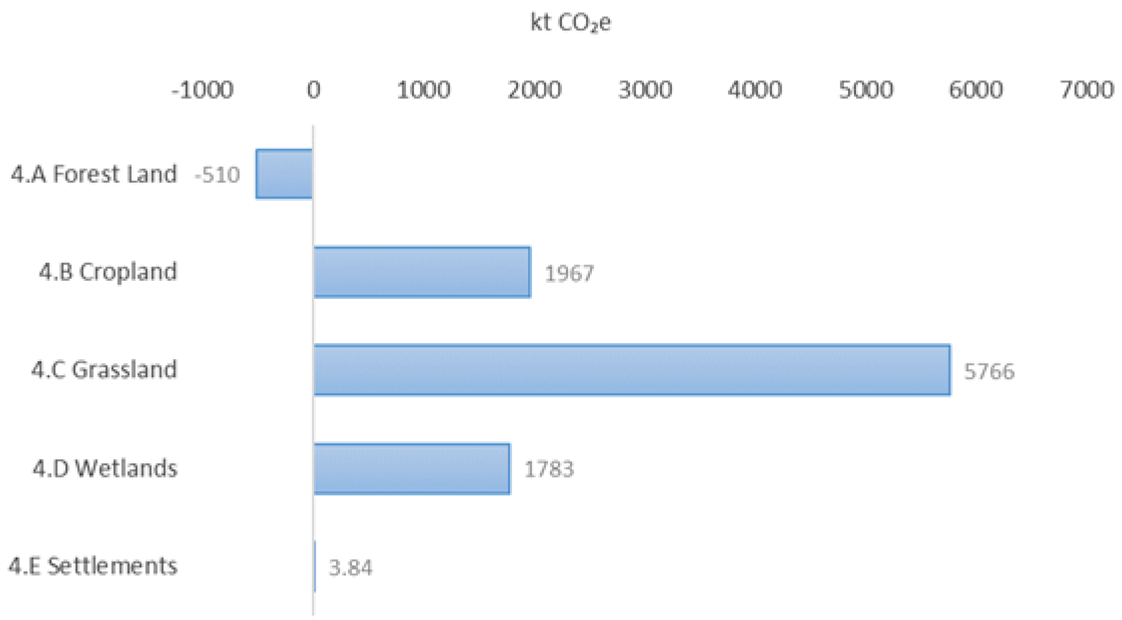


Figure 6.2. The net emissions/removals of land use categories [kt CO_2e] in 2020. Emissions from Other land (4F) and Harvested wood products 4(G)are not included in this graph. Since last year's submission, the N_2O emissions from Cropland management of organic soils are reported under the Agricultural sector and are not included here.

The total gross emissions reported are 11,645.8 kt CO_2e and they are dominated 73.1% by 8,518.4 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 24.4% or 2,841.3 kt CO_2e, are 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 49.9% or 1,244.6kt CO_2, to biomass and SOC in revegetation 27.5% or 686.1 kt CO_2, and to biomass and SOC in forest 20.8% or 517.8 kt CO_2. Other contributing components total of 4.1% include: increase in SOC of mineral soils in some Cropland, increase in biomass and mineral soil SOC in Natural birch shrubland, increase in biomass of abandoned Cropland.

Compared to last year the net emission reported for the LULUCF sector has decreased from 9, 072.06 kt CO_2e to 9,009.76 kt CO_2e. New area estimate of some land-use categories is included in this submission explains most of the changes. Table 6.1 summarizes the GHG emissions in kt CO_2e for the LULUCF sector from 1990 to 2020. Total GHG emissions in 2020 are -2.1% below total GHG emissions reported for the year 1990.

The CRF tables are prepared through new version of the CRF reporter (version 6.0.8). The information on all categories has the same structure as in the 2021 submission.

Table 6.1 GHG emissions in LULUCF sector 1990-2020, [kt CO2e]

GHG	1990	1995	2000	2005	2010	2015	2019	2020
CO_2	5759.2	5736.6	5771.4	5829.6	5857.1	5741.6	5662.3	5651.4
CH_4	3439.4	3438.1	3422.1	3401.7	3374.9	3364.4	3356.9	3357.4
N_2O	0.2	0.4	0.6	0.8	0.9	1.2	1.0	1.0
Total	**9198.9**	**9175.1**	**9194.1**	**9232.1**	**9232.9**	**9107.1**	**9020.1**	**9009.8**
Emissions increases/ reductions (year-base year)/base year		-0.3%	-0.1%	0.4%	0.4%	-1.0%	-1.9%	-2.1%

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 from the Icelandic Forest Research (IFR), maps of natural birch forest and shrubland from the IFR, activity data (incl. active grazing areas), and maps on revegetation, compiled or collected by the Soil Conservation Service of Iceland (SCSI) , time series of Afforestation, Reforestation, and Grassland categories, including revegetation, drainage and cropland abandonment, and of reservoirs are based on data from IFR, the Agricultural University of Iceland (AUI), Registers Iceland (RI)/ the Icelandic Agricultural Advisory Centre (IAAC) and Landsvirkjun/ National Land Survey of Iceland's (NLSI), respectively. Data on biomass burning is based on area mapping of the Icelandic Institute of Natural History (IINH) and biomass estimation for relevant land categories was obtained through IGLUD field sampling Guðmundsson et al. (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 size 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 2022 Submission (Table 6.2). The IGLUD map now consists of 99 categories, of which 69 belong to the Habitat Type Map (HMI). There is no specific information regarding uncertainties for the habitat type classification. However, this is being assessed by GróLind (National Soil and Vegetation Monitoring Program: https://grolind.is/; an independent research program coordinated by the SCSI). The other 30 are from the SCSI, IFR, Ministry of Industry and Innovation, Landsvirkjun, the National Registry, the National Land Survey of Iceland and the Agricultural University of Iceland. 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 in now replaced with IFD data. The IFD data used had comparable IGLUD/LULUCF classification 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 Habitat Type Map (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 Habitat Type Map (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 2020.

In preparing the IGLUD land use map, other map layers, also included in previous versions, are still utilised. This includes map of Grassland on Drained (organic) Soils, map of Reservoirs, map of Revegetated Land (with its subcategories), map of Forest Land (with subcategories), map of Cropland (with subcategories), map of Birch Shrubland, and Settlement. There are still some discrepancies between these layers that will be addressed in future submission as an effort to improve the overall quality and accuracy and to comply with current guidelines.

Maps of Forest Land: The HMI map layer is map of forest from the IFR from the year 2015. The map layer currently applied in the IGLUD map represents all cultivated forest up to and including 2020. In the current submission the maps of Forest land also include the IFD layer “Cultivated forest before 1990”. The HMI category “Mixed Forest plantations (Icelandic: skógrækt) is an older version of cultivated forest than the version included in IGLUD. Accordingly, the latest map of cultivated forest is ordered higher in the map layer hierarchy than the HMI map layer. The area of the HMI layer “Mixed Forest Plantations” extending the present layer of cultivated forest is categorized as other Grassland.

Map of birch shrubland: In HMI the map layer Birkiskógur (Birch woodland) includes the two categories of birch woodland in IGLUD but categorized to different land use categories. The natural birch woodland reaching average height of 2 m or more at maturity, categorized as Forest land and natural birch woodland reaching height less than 2 m, categorized as Grassland. These maps are updated annually by the IFR with last update in 2021. Accordingly, the category Birch woodland < 2 m is ordered lower in the IGLUD compilation hierarchy. In the current submission the map of birch shrubland includes the IFD layer “Cultivated forests before 1990”.

Map of Cropland: The HMI layer “Cultivated agricultural, horticultural and domestic habitats”, which represents Cropland in IGLUD, was originally prepared from AUI data of cultivated land with addition of data layers representing new cultivations and renewals of older hayfields, based on subsidies by the government, obtained from the Icelandic Agricultural Advisory Centre (IAAC). The current submission also includes additional data now available from RI (including abandoned cropland).

Major changes were made in Settlements. The SCSI has prepared four new urban areas maps in a certain time resolution, i. e 1990, 2000, 2010 and 2020. Maxar Satellite Images, aerial images from National Land Survey of Iceland and Loftmyndir ehf were used for the purpose. As described above in this chapter, 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 fit entirely the replaced HMI layer, the Icelandic Farmland Database (IFD) was used for this purpose which appeared to have comparable IGLUD/LULUCF classification of the land surface for the IGLUD database / mapping. The new Settlements map layer included towns and villages where a minimum of 200 inhabitants is required. Roads map layer has a buffer zone ranging from 2.5 -15.0 m from central line.

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 1990-2020	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/	25
	Natural Birch forest	Not HMI category	Not HMI category/	5
Cropland	Harvested croplands 2020	Not HMI category	Not HMI category/	13
	Harvested croplands 2019	Not HMI category	Not HMI category/	14
	Harvested croplands 2018	Not HMI category	Not HMI category/	15
	Harvested croplands 2017	Other land types	Not HMI category/	16
	Cropland other [(1)]	Other land types	Not HMI category/	17
	Cropland inactive (fallow) [(2)]	Other land types	Not HMI category/	18
Grassland	Revegetated land SCSI before 1990	Not HMI category	Not HMI category/	6
	Revegetated land SCSI 1990 - 2020	Not HMI category	Not HMI category/	7
	Farmers revegetation before 1990	Not HMI category	Not HMI category/	8
	Farmers revegetation 1990-2020	Not HMI category	Not HMI category/	9
	Natural Birch shrubland	Not HMI category	Not HMI category/	12
	Croplands	Other land types	L14.2 Other land types	19
	Icelandic Farmland Database (IFD) - Grassland	Not HMI category	Not HMI category	20
	Icelandic Farmland Database (IFD)-Richly vegetatated heath land	Not HMI category	Not HMI category	21
	Icelandic Farmland Database (IFD) - Cultivated land	Not HMI category	Not HMI category/	22
	Icelandic Farmland Database (IFD)- Poorly vegetated heath land	Not HMI category	Not HMI category/	23
	Icelandic Farmland Database (IFD)- Birch shrubland	Not HMI category	Not HMI category/	24
	Icelandic Farmland Database (IFD)- Moss land	Not HMI category	Not HMI category/	26
	Icelandic Farmland Database (IFD)- Partially vegetated land	Not HMI category	Not HMI category/	29
	Grassland on drained soils	Not HMI category	Not HMI category/	35
	Other Grassland [Grazing areas / Grassland without grazing]	Fell fields, moraines and sands	L1.6 Icelandic inland dunes	36
		Exposed aeolian soils	L2.1 Icelandic exposed andic soils	37
		River plains	L4.2 Icelandic braided river plains	38
		Moss lands	L5.3 Moss and lichen fjell fields	39
		Lava fields	L6.4 Icelandic lava field shrub heaths	40
		Coastal lands	L7.1 Icelandic sand beach perennial communities	41
			L7.4 Northern fixed grey dunes	42
			L7.7 Atlantic sea-cliff communities	43
		Grasslands	L9.1 Icelandic Carex bigelowii grasslands	44

Land use category	Subcategories	Habitat type class	Habitat type/or other map layer	Compilation hierarchy
			L9.2 Insular Nardus-Galium grasslands	45
			L9.3 Wavy hair-grass grasslands	46
			L9.4 Boreal tufted hairgrass meadows	47
			L9.5 Icelandic Festuca grasslands	48
			L9.6 Boreo-subalpine Agrostis grasslands	49
			L9.7 Northern boreal Festuca grasslands	50
		Heathlands	L10.1 Icelandic Racomitrium grass heaths	51
			L10.2 Arctic Dryas heaths	52
			L10.3 Icelandic Carex bigelowii heaths	53
			L10.4 Icelandic Empetrum Thymus grasslands	54
			L10.5 Icelandic lichen Racomitrium heaths	55
			L10.6 North Atlantic boreo-alpine heaths	56
			L10.7 Oroboreal moss-dwarf willow snowbed communities	57
			L10.8 North Atlantic Vaccinium-Empetrum-Racomitrium heaths	58
			L10.9 Icelandic Salix lanata/S. phylicifolia scrub	59
			L10.10 Oroboreal willow scrub	60
		Woodlands	L11.1-3 subclasses of Birch wood	61
		Other land types	L14.3 Mixed forestry plantations	62
		Other land types	L14.4 Land reclamation forb fields	63
Wetland	Reservoirs	Reservoirs Landsvirkjun &AUI	Not HMI category	1
	Icelandic Farmland Database (IFD) - Semi wetland	Not HMI category	Not HMI category/	27
	Icelandic Farmland Database (IFD) - Wetland	Not HMI category	Not HMI category/	28
	Icelandic Farmland Database (IFD) - Lakes and rivers	Not HMI category	Not HMI category/	31
	Lakes	Standing waters	V1	33
	Rivers	Running waters	V2	34
	Coastal wetlands	Coastal lands	L7.5 Atlantic lower shore communities	64
			L7.6 Icelandic Carex lyngbyei salt meadows	65
	Mires and fens	Wetlands	L8.1 Philonotis-Saxifraga stellaris springs	66
			L8.2 Icelandic stiff sedge fens	67
			L8.3 Cottonsedge marsh-fens	68
			L8.4 Juncus arcticus meadows	69
			L8.5 Boreal black sedge-brown moss fens (high altitude)	70
			L8.6 Boreal black sedge-brown moss fens (low altitude)	71
			L8.7 Aapa mires	72
			L8.8 Palsa mires	73

Land use category	Subcategories	Habitat type class	Habitat type/or other map layer	Compilation hierarchy
			L8.9 Icelandic black sedge-brown moss fens	74
			L8.10 Icelandic Carex rariflora alpine fens	75
			L8.11 Common cotton-grass fens	76
			L8.12 Icelandic black sedge-brown moss fens	77
			L8.13 Basicline bottle sedge quaking mires	78
			L8.14 Icelandic Carex lyngbyei fens	79
	Geothermal wetland	Geothermal lands	L12.1 Geothermal wetlands	80
Settlements	Settlements	Not HMI category	Not HMI category	10
	Roads	Not HMI category	Not HMI category	11
	Icelandic Farmland Database (IFD) - Sparsely vegetated land	Not HMI category	Not HMI category	30
	Icelandic Farmland Database (IFD) - Uncategorized, islands and reefs	Not HMI category	Not HMI category	32
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	81
			L1.2 Sparsely- or un-vegetated habitats on mineral substrates not resulting from recent ice activity	82
			L1.3 Oroboreal Carex bigelowii-Racomitrium moss-heaths	83
			L1.4 Glacial moraines with very sparse or no vegetation	84
			L1.5 Volcanic ash and lapilli fields	85
		Screes and cliffs	L3.1 Icelandic talus slopes	86
			L3.2 Icelandic Salix herbacea screes	87
			L3.3 Icelandic Alchemilla screes	88
		River plains	L4.1 Unvegetated or sparsely vegetated shores	89
		Moss lands	L5.1 Boreal moss snowbed communities	90
			L5.2 Icelandic Racomitrium ericoides heaths	91
		Lava fields	L6.1 Barren Icelandic lava fields	92
			L6.2 Icelandic lava field lichen heaths	93
			L6.3 Icelandic lava field moss heaths	94
		Coastal lands	L7.2 Upper shingle beaches with open vegetation	95
			L7.3 Atlantic embryonic dunes	96
		Geothermal lands	L12.2 Geothermal heathlands	97
			L12.3 Geothermal alpine habitats	98
			L12.4 Geothermal bare grounds	99
	Glaciers, rock glaciers and un-vegetated ice-dominated moraines	Glaciers	L13.1 Glaciers, rock glaciers and un-vegetated 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, 2020 Level, and 1990-2020 trend.

IPCC source category			Level 1990	Level 2020	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	✓		✓
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 few categories/ 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 presents the status of emission/removals estimates from all sub - land categories in the LULUCF sector for 2021 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
Afforestations 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
Afforestations 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 changes in carbon stock changes and net CO2 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 .	e	e	e	NO	e
Grassland converted to cropland	e	e	IE	e	IE
Wetlands converted to cropland	e	e	IE	IE	e
Settlements converted to cropland	NA	NA	NA	NA	NA
Other land converted to cropland	IE	IE	IE	IE	NA
4.C.1 Grassland remaining Grassland					
Revegetated land older than 60 years	NA	NA	NA	NA	NA
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	NA
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	NA	NA	NA	NA	NA
Other Land converted to grassland					
Revegetation before 1990	e	IE	IE	e	NA
Other land converted to natural birch shrubland	e	IE	e	e	NO
Revegetation since 1990 - protected from grazing	e	IE	IE	e	NA
Revegetation since 1990 - limited grazing allowed	e	IE	IE	e	NA
4.D.1 Wetlands remaining wetlands					
Peat extraction remaining peat extraction	NA	NA	NA	NA	NA
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	NA
4.D.2 Land converted to Wetlands					
Land converted to peat extraction	NA	NA	NA	NA	NA
Land converted to flooded land					
4.D.2.2.3 Grassland converted to flooded land					
Medium SOC to reservoirs	IE	IE	IE	e	NA
4.D.2.2.5 Other land converted to flooded land					
Low SOC to reservoirs	IE	IE	IE	e	NA
Land converted to other wetlands					
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	NE
4.E.1 Settlements remaining settlements	NA	NA	NA	NA	IE
4.E.2 Land converted to Settlements					

Land use category	Living biomass		Dead organic matter	Soils	
	Gains	Losses		Mineral	Organic
Forest land converted to settlements	e	e	e	e	NO
Cropland converted to settlements	NE	IE	IE	NE	NE
Grassland converted to settlements					
All other Grassland subcategories converted to Settlement	NE	e	IE	NE	IE
Natural birch shrubland converted to Settlement	NE	e	NO	NO	NO
Wetlands converted to settlements	NE	IE	IE	NE	NE
Other Land converted to settlements	NE	IE	IE	NE	NE
4.F.2 Land converted to Other land					
Forest land converted to other land	NO	NO	NO	NO	NO
Cropland converted to other land	NA	NA	NA	NA	NA
Grassland converted to other land	NA	NA	NA	NA	NA
Wetlands converted to other land	NA	NA	NA	NA	NA
Settlements converted to other land	NA	NA	NA	NA	NA

6.2 Land-use Definitions and Classification Systems Used

Definitions of the six main land use categories as applied in IGLUD are listed below, along with description of how they were compiled from the existing data.

Settlements: All areas included within the map layers “Towns and villages” and “Airports” as defined in the IS 50 v2020 geographical database (NLSI). Settlement includes roads classified having 15 m wide road zone, including primary and secondary roads. Roads within Forest land are excluded if actual road zone does not reach 20 m, the minimum width of Forest land.

Forest land: All land, not included under Settlements, presently covered with trees or woody vegetation on the average more than 2 m high, crown cover of minimum 10%, covering at least 0.5 ha in continuous area and having minimum width of 20 m. Land which currently falls below these thresholds but is expected to reach them *in situ* at mature state, are also included.

Cropland: All cultivated land not included under Settlements or Forest land, at least 0.5 ha in continuous area and having minimum width 20 m. This category, besides including fields with annual or bi-annual crops, includes harvested hayfields with perennial grasses.

Wetland: 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, Cropland categories. It includes intact mires and reservoirs as managed subdivisions, and natural rivers and lakes as unmanaged subdivision.

Grassland: All land where vascular plant cover is >20% and not included under the Settlements, Forest land, Cropland or Wetland categories. This category includes, as subcategory, land which 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.

In 2021 submission a new sub-category has been added. This is the sub-category „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 as a result of the new available land use data.

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, Figure 6.4, Figure 6.5 and Figure 6.6; they are also available at the AUI website http://www.lbhi.is/vefsja.

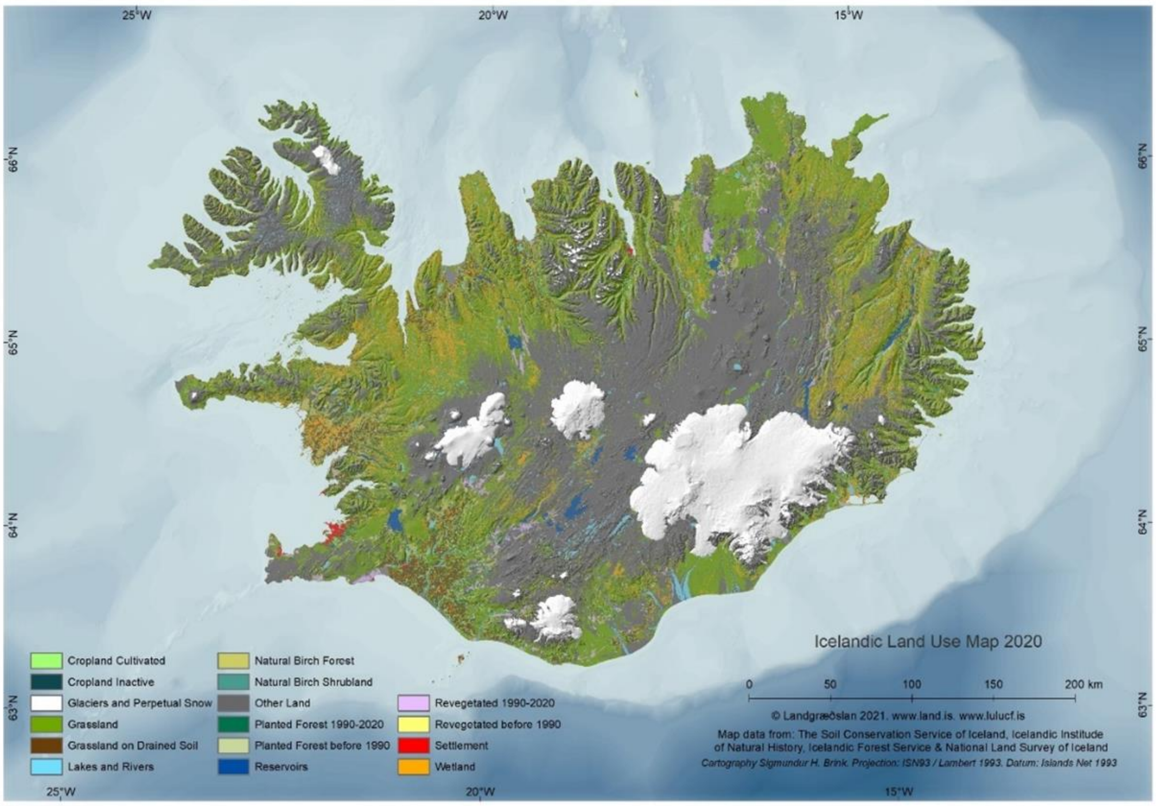


Figure 6.3 The land use map of IGLUD prepared for the year 2020.

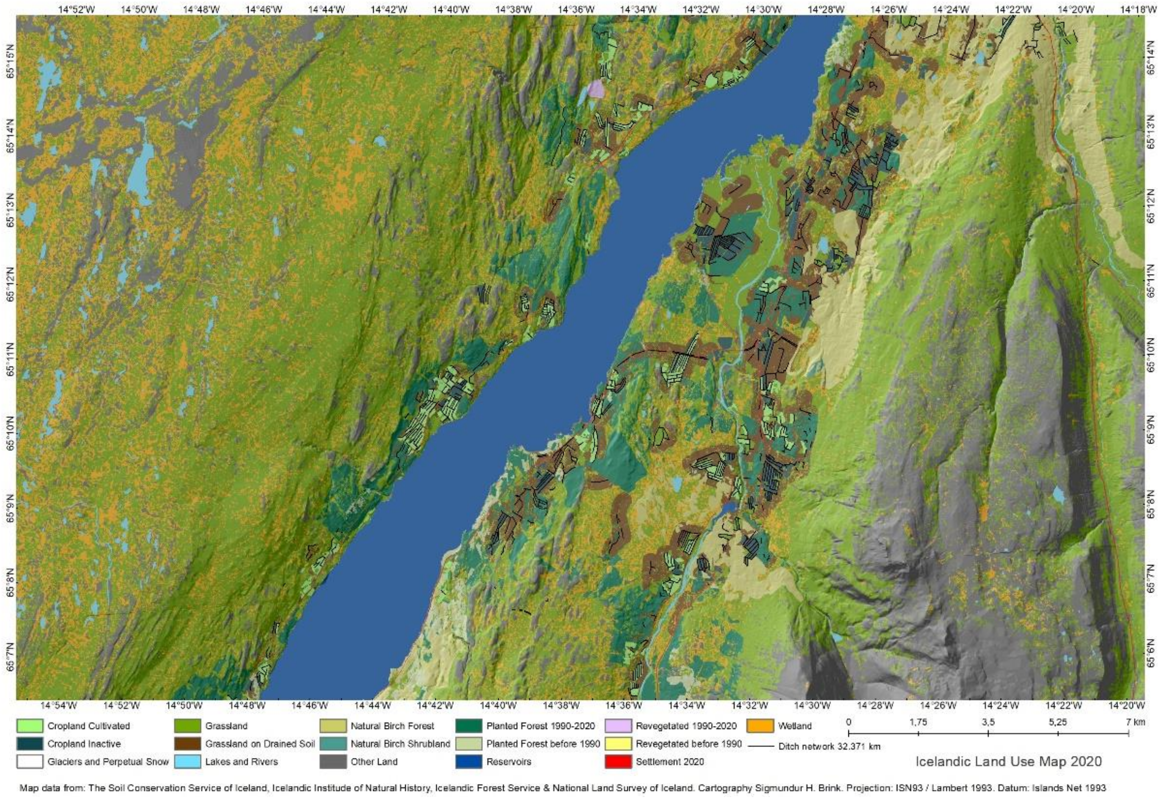


Figure 6.4 Enlargement of land use map for the year 2020, emphasizing the different Forest land subcategories.

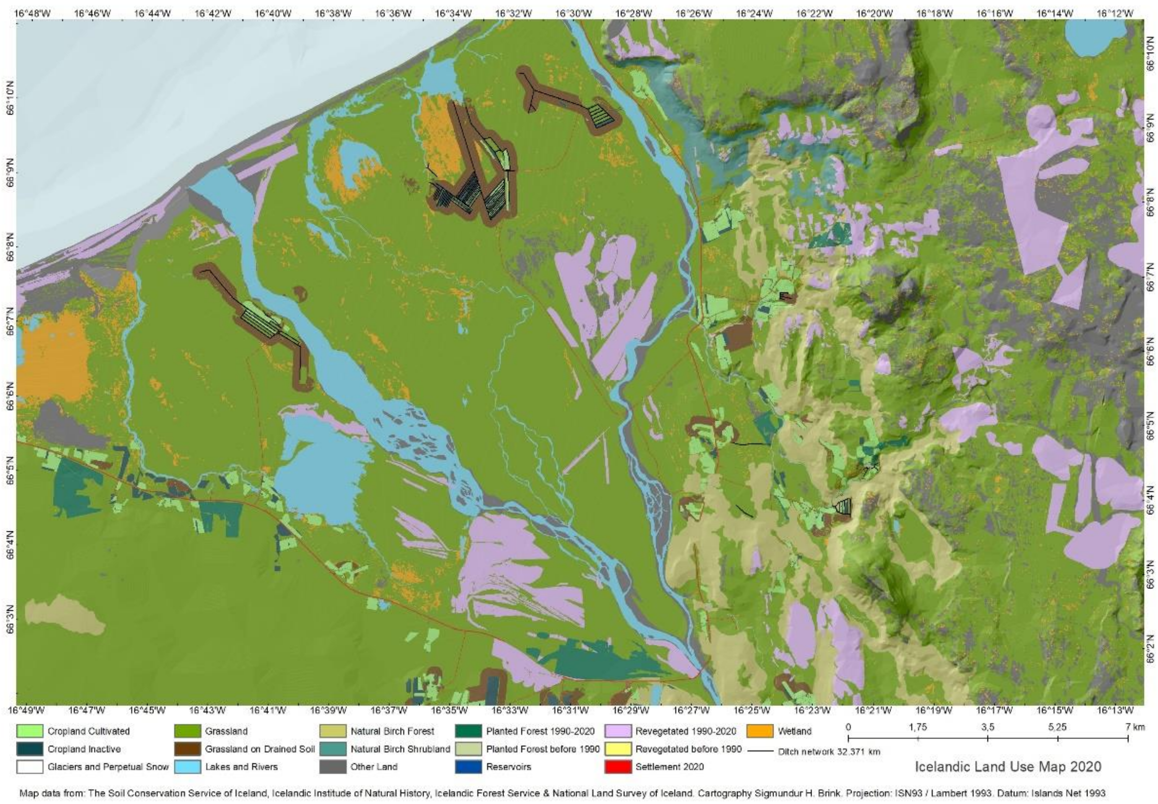


Figure 6.5 Enlargement of land use for the year 2020, emphasizing the Revegetation areas.

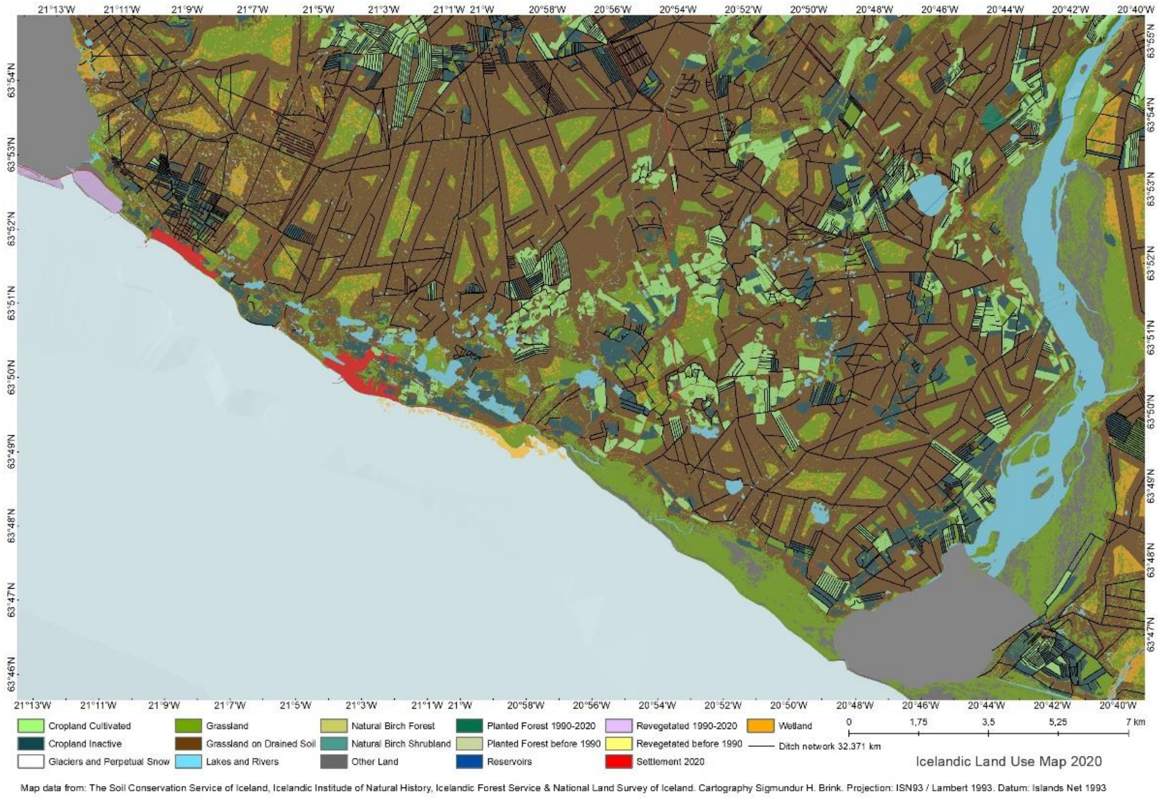


Figure 6.6 Enlargement of land use map for the year 2020, emphasizing the subcategory Grassland on drained soils and Cropland inactive.

6.3 Land use changes

The reported land use changes relay on few independent time series of new area converted to a land use category. There is ongoing development in the qualities of these series, both regarding 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 show this well. Both improvements in mapping accuracy and categorization of previous land use, can be traced through previous submissions.

From the year 2017 agricultural support was modified with Regulation No.1240/2016 on General Support for Agriculture[22], putting more emphasis on land-based support. Due to these modifications in support, farmers applying for support must turn in annually maps of harvested land. This new recording of harvested cropland was not available for the preparation of the present IGLUD land use map but expected to be for 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 previously not accessible. Preliminary results from this work are ready and used in this submission. Next year's submission will represent the new data on ditches.

[22] "Reglugerð No. 1240/2016 um almennan stuðning við landbúnað"

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 case of "Grassland" the inconsistency is only for the year 2007 where the finale 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" the 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 (finale area in Table 4.1 smaller than CRF Table 4.F).

6.4 Approaches Used for Representing Land Areas and on Land-use Databases

Information on land use is mostly in line with Approach 1, although for some categories the origin of land converted to the category is estimated through survey (Approach 2), as for cultivated forest, or is spatially known (Approach 3), as for some land converted to reservoirs and Settlements.

The land use database used in this reporting is IGLUD. That database was constructed by AUI but is now maintained by the SCSI. The compilation of available geographical data into Land use map is as described in Guðmundsson et al. (2013).

Other estimates than 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 summarized in the following Table 6.6.

The IGLUD database contains map layers of diverse origin, geographically referable datasets obtained through IGLUD field work, results of analyses of the samples obtain in that field work, photographs taken at sampling points, geographical data related to surveys on specific map layers or topics related to the database, metadata describing the above data.

Description of fieldwork for collecting land information for the database and some preliminary results can be found in Guðmundsson et al. (2010).

Table 6.6 Land use map area transfer matrix showing area transfer (ha) between land use categories to adjust other mapped area to other estimates available. Lines shows area moved from category and columns area moved to category.

Land use map units From\to [ha]	FL C	FL NB	CL	GL. drained	GL. Nb. shrub	RV before. “ 90	RV s. “ 90	G a	GL w g	Gr a OL	WL.O	WL. L&R	WL. Reserv.	Settlements	OL eG & G a	Glaciers
FL C								8,008	989							
FL NB																
CL																
GL. drained																
GL. Nb. shrub																
RV before. “90																
RV since. “90																
G a		1,700			1,954	137,158										
GL w g		209			241	16,931										
Gr a OL															2,947	
WL.O				19,010												
WL. L&R																
WL. Reserv.																
Settlements																
OL eG & G a							16,215			2,275,614						
Glaciers																
Other																
Other estimate	45,044	98,840	145,199	281,853	56,303	158,333	149,222									
Map area	54,041	96,930	145,199	262,843	54,108	4,244	133,007	2,795,889	345,133	2,256,684	638,890	217,883	59,349	41,113	2,098,879	1,033,133
Difference	8,997	-1,910		-19,010	-2,195	-154,089	-16,215									
Corrected area	45,044	98,840	145,199	281,853	56,303	158,333	149,222	2,663,086	328,739	2,253,737	619,880	217,883	59,366	41,113	2,085,594	1,033,133
Total area [ha]																10,237,326

Abbreviations:

FL C: Cultivated forest.	GL w g.: Grassland without grazing
FL NB: Natural birch forest.	Gr a OL: Grazing areas on Other Land
CL: Cropland	WL. O: other wetlands
GL. Drained: Grassland on drained Soils	WL. L&R: Lakes and rivers
GL Nb. shrub: Natural birch shrubland	WL. Reserv.: reservoirs
RV b. "90: Revegetation initiated before 1990	Settlements: settlements
RV s. "90: Revegetation initiated since 1990	OL eG & G a: Other Land except glaciers and Grazing areas
Ga.: Grazing areas	Glaciers: Glaciers and perpetual snow

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 minimal crown cover and the minimal height of forest at maturity is 10% and 2 m accordingly. The minimal area forest is 0.5 ha and minimal 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 the natural birch woodland is defined as one of the two predefined strata to be sampled. The other stratum is the 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. , National Forest Inventories reports: Iceland, 2010). All plots in the NFI are permanent. CF-NFI plots are visited in 5 years interval and every year one fifth of the plots are visited. NBW-NFI plots are visited with 10 years interval. 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 actors 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 mapped border. Current buffering is 16 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 merge geographically 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 did result 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 mature state and is defined a forest is 64% of the total area. Natural birch forest (NBF) is accordingly estimated 87.72 kha in 1989 and 95.97 kha in 2012, the former figure categorizing NBF classified as Forest remaining Forest and the differences between the two figures (8.25 kha) as NBF classified as Grassland or Other Land converted to Forest land with mean annual increase of 0.36 kha.

In accordance with the Forest Law (Alþingi, 2019), the Icelandic Forest Service 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 Icelandic Forest Service and the National Planning Agency. IFR does sample 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 is in this year submission reported for the inventory years 2004-2007, 2011, 2013, 2015, 2017 and 2020. Three different types of deforestation have 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 the trees were removed but also the litter and dead wood, together with the uppermost soil layer. These afforestation areas were relatively young (around 10 years from initiation) so dead wood did not occur. The second type of deforestation is one event in 2006 where trees in an afforested area were cut down for a new power line. Bigger trees were removed. In this case dead wood, litter and soil is 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. These two types of Deforestation are 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. Conversion period for land use changes to Forest land is defined 50 years and as plantations measured on plots are of known age, they move to Forest Land Remaining Forest Land when they reach 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 NBF that existed before the 1987-1991 survey are assumed to be existing more than 50 years ago. The majority are without doubt pristine natural 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 is the mapping of the CF done by adding annually to the map activity mapping of afforestation collected from forest management centres around the country. This map has turned out not to be accurate and overestimate 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 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 2006 AFOLU Guidelines (IPCC, 2006). Biomass losses caused by mortality 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 2007-2020 are for the first 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 ten years period 2007 to 2017 with significant change 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. Increase in the biomass stock in this ten years period can partially been explained with skewed age distribution as shown in Figure 6.7 with median age class 21-40 years old. Biomass stock per hectare is increasing with age and with growing mean age will the NBW most likely be a sink of Carbon.

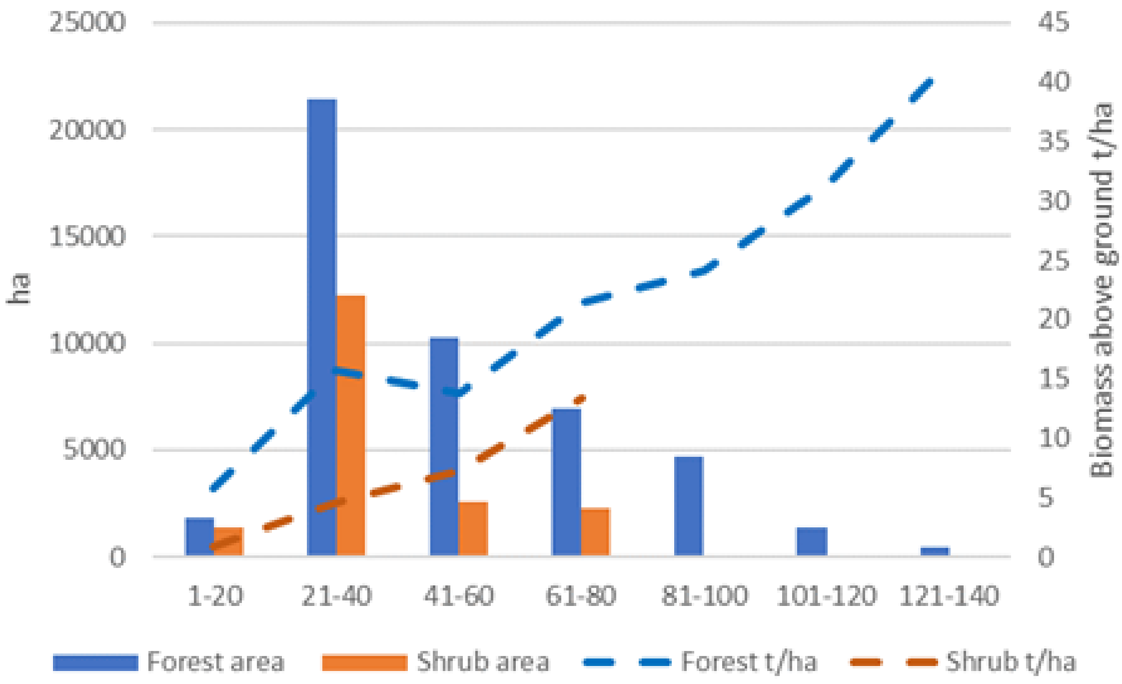


Figure 6.7 Age distribution and the mean stock of biomass aboveground of the Natural birch woodland

A new 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 conducted and used to estimate the woody above ground biomass of the NBW in 1987 and 2007 and compare these estimates (Snorrason, Jónsson, & Eggertsson, 2019) . The new estimate is built on same newly made biomass equations as used to estimate C-stock in 2005-2011 (Jónsson & Snorrason, 2018). C-stock in above ground biomass of birch trees and shrubs in NBW was according to the new estimate 752 kt C (±88 kt SE, n=272) with average of 5.45 t C ha^{-1} in 1987. A rough older estimate from same raw data was only for biomass above ground 1300 kt C with average of 11 t C ha^{-1} (Sigurdsson & Snorrason, 2000). A new estimate of the C-stock 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 not to be significant (Snorrason, Jónsson, & Eggertsson, 2019). Consequently, 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 subcategory of Grassland remaining Grassland.

Carbon stock gain of the living biomass of trees in CF is based on data from direct sample plot field measurement of the NFI. The figures provided by IFR are based on the inventory data from 2005-2021. In 2010 the second inventory round of cultivated forest started with re-measurement of plots measured in 2005 and of new plots since 2005 on new afforestation areas. 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 5 years 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 years sample plot measurements Table 6.7. The most accurate estimates are for 2007-2019 as they are built on growth measurement of; two nearest years before, two nearest years after and of the year of interest (here named midvalue estimates). In these cases, biomass growth rate is equally forwarded and backwarded. For the year 2020 the estimate is forwarded one year respectively, compared to the midvalue for 2019. Estimates for the year 2005 and 2006 are backwarded values for two and one year accordingly, from the midvalue for the field measurements of the period 2005-2009. They are calibrated with the relative difference between backwarded value and the midvalue of the year 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 forwarded value for 2020 was calibrated by the average difference between midvalues and forwarded values of the years 2008-2019 which was 0.84. In next submission a midvalue estimate build on measurement years 2018-2022 will be used instead of the forwarded calibrated estimate. This is the reason for regular update of the biomass CsC of the second last year of the inventory.

Table 6.7 Measurement years used to estimate different annual estimates of biomass stock change in CF.

Mid value estimates	Forwarded estimates	Backwarded estimates	Built on measurement years
	2020		2017-2021
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 in the living woody biomass are based on two sources:

1. Annual wood removal is reported as 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, Skógræktarárið 2017, 2019) (Elefsen & Brynleifsdóttir, 2020; Jóhannesdóttir Þ., 2020; Brynleifsdóttir & Jóhannsdóttir, 2021). Most of the cultivated forests in Iceland are relatively young, only 47% are older than 20 years, and clear cutting is very rare. As an example, in the year of 2019 only 3 ha of forest were clear cut, 73 ha were commercial thinned and 87 ha pre commercial 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 few natural birch forests 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 cultivated forest.
2. Dead wood measurements on sample plots. New dead wood measured is reported as C-stock losses in the assessed year of death. Dead wood is measured on the field plot of the NFI. Current occurrence of dead wood that meet the definition of dead wood (>10 cm in diameter and >1 m length) on field plots is rare but with increased cutting activity C-stock losses from living biomass to the carbon pool of dead wood will probably increase. As occurrence of dead wood on measurements plots are rare, reporting of C-stock losses from living biomass to dead wood is not occurring every year. Future improvement is needed to include dead wood in stumps, root stock of cut trees and standing dead trees as losses of biomass and to include continuous decomposition of all deadwood. Improvement of the biomass loss calculation that will include other parts of cut trees and natural mortality figures is planned. The solution will probably be to introduce and adapt a CsC simulation model such as the Canadian Forest Service Carbon Balance Model. Losses from living biomass, both as removed wood and deadwood, cannot be classified by different land categories or between Forest land remaining Forest land and Land converted to Forest Land. 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 – Cultivated forest, 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).

For C-stock changes in litter and mineral soil for Land converted to Forest, 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 increase in litter and mineral soil pools in the long run 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 sink rather than source and are therefore reported as not applicable. As Tier 1 approach they are assumed to be 0 (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 0 (zero) as recommended in AFOLU (see page 2.29).

Direct CO_2-emission from drained organic soil is 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 CO2 estimates in 23-25 years old Black Cottonwood plantation on drained peatland in South Iceland did unexpectedly result 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 support the use of 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 /removals calculations for Forest land remaining Forest land subcategories are summarized in Table 6.8.

Table 6.8 Carbon stock changes and related CO_2 emissions/removals for Forest remaining Forest sub-categories in 2020

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	87.72	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	1.68	OTH	T3	2.95	4.95	-18.16
	organic soil	0.05	D	T1	-0.37	-0.02	0.07
Plantations in natural birch forest	biomass gain	1.22	OTH	T3	2.12	2.59	-9.50
Total							**-127.82**

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 4%. 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 project (Snorrason, Sigurðsson, Guðbergsson, Svavarsdóttir, & Jónsson, 2002; Sigurðsson, Elmarsdóttir, Bjarnadóttir, & Magnússon, 2008).

Because of the design of the NFI it is possible to estimate uncertainties by calculating statistical error of the estimates. Currently, error estimates are available for the area of cultivated forest as mentioned above (4%), 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 25.10% in this year 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 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 changes in biomass in CF are based on direct stock measurements (Tier 3) as in last year's submission. They are recalculated for 2019 due to new data from NFI measurements in 2021. Estimates of the net gain of biomass of the natural birch forest are totally revised in this year submission built on 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 impact are shown in Table 6.9.

Table 6.9 Comparison between the 2021 submission and 2022 submission on CSC in Forest remaining Forest category and subcategories for the year 2019

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
Natural Birch forest older than 50 years	biomass gain	87.71	87.72	0.0%	0.04	0.31	659.5%	3.58	27.37	664.5%
	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	1.06	1.11	5.1%	2.92	2.95	1.2%	3.09	4.95	60.2%
	organic soil	0.05	0.01	-89.4%	-0.37	-0.37	0.0%	-0.02	0.00	-90.2%
Plantations in natural birch forest	biomass gain	1.06	1.22	15.1%	2.75	2.12	-22.9%	2.92	2.59	-11.3%
Total		**89.83**	**90.05**	**0.2%**	**0.11**	**0.39**	**264.7%**	**9.54**	**34.88**	**265.6%**

6.5.1.5 *Category-specific planned improvements*

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.

Improvement of the biomass loss calculation that will include other parts of cut trees and natural mortality figures is planned. The solution will probably be to introduce and adapt a CsC simulation model such as the Canadian Forest Service Carbon Balance Model.

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 recognized as key source/sink in level (2020) as well as in the 1990-2020 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 significant increase in the soil organic carbon (SOC) on fully vegetated sites with well-developed deep mineral soil profile (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. Conversion period for land use changes to Forest land is defined 50 years and 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 area of these categories' changes between reporting years. They are too 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 to 2012. More exactly they are expanding from zero in 1989 to 8.25 kha in 2012. Mean annual area increase of 0.36 kha is interpolated over the 1989-2012 period and extrapolated for the years 2013 – 2020.

Conversion from other land use classes doesn't occur. Old hayfields are sometimes used for afforestation but are before afforestation converted from Cropland to Grassland.

6.5.2.2 *Methodology*

Area estimation for categories in Land converted to Forest is identical to Forest remaining forest. 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 addition of afforestation area every year and increasing age of the cultivated forest. Skewed age distribution with high ratio of young age classes is accelerating the annual increase of C-stock change in tree biomass as can be seen in Figure 6.8.

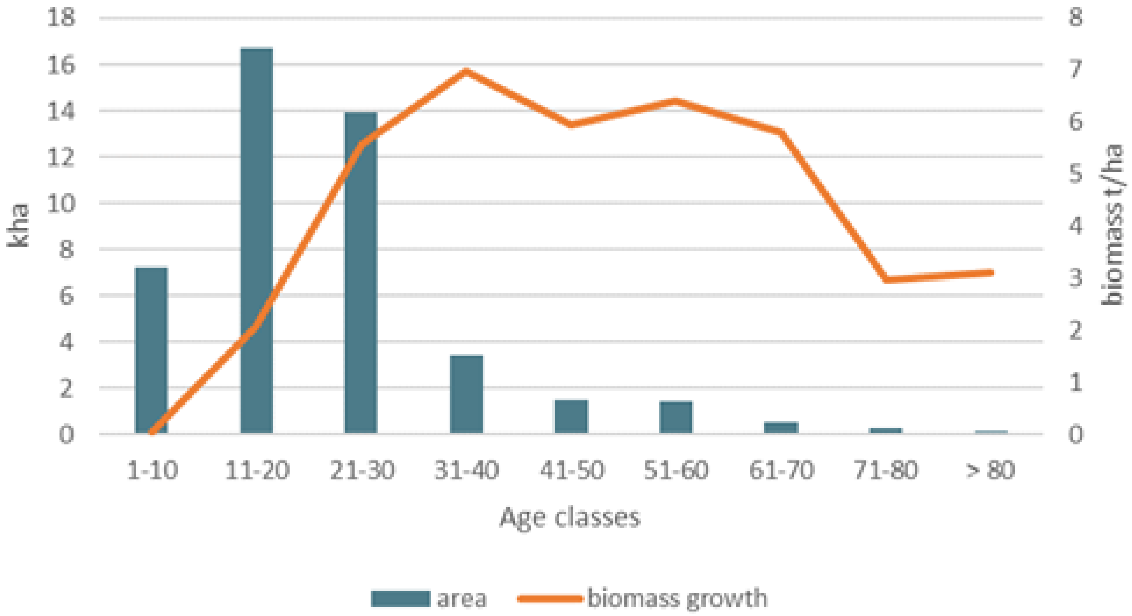


Figure 6.8 Age distribution of Cultivated Forest showing area and mean annual biomass growth of each class.

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 other vegetation than trees did show very low increase 50 years after afforestation by the most commonly used tree species, Siberian larch, although the variation inside this period was considerable (Sigurðsson, Magnússon, Elmarsdóttir, & Bjarnadóttir, 2005).

Carbon stock samples of other vegetation than trees are collected on field plots under the field measurement in NFI together with samples of litter and soil. Estimate of carbon stock changes in other vegetation than trees are planned to be available from NFI when sampling plots have been revisited and the samples analysed for C-content.

As mentioned above carbon stock samples of litter are collected on field plots under the field measurement in the NFI. Estimate of carbon stock changes in dead organic matter will as for other vegetation 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 change are used to estimate carbon stock change 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 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 plantations of Siberian larch, Lodgepole Pine, Sitka spruce and Natural Birch Woodland compared to treeless grazed heathland which is defined as Grassland (Bjarnadóttir, 2009). Snorrason et al. (2000; 2002) found 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 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 this two research are used as a factor of annual increase of C-stock in litter, 0.141 t C ha^{-1} yr^{-1}. New research results from Southwest Iceland show 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.

Dead wood is measured on the field plot of the NFI as mentioned earlier. Current occurrence of dead wood that meet the definition of dead wood (>10 cm in diameter and >1 m length) on the field plot is rare but with increased cutting activity carbon pool of dead wood will probably increase. Measured dead wood is reported as a C-stock gain in the dead wood pool on the year of death. As occurrence of dead wood on measurements plot is rare, reporting of dead wood is not occurring every year. With re-measurements of the permanent plot it will be possible to estimate the Carbon stock changes in this pool from one time to another as the dead wood will be composed and, in the end, disappear.

Same research results as mentioned above did show 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), and in the ICEWOODS study 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 stock in mineral soils for Grassland converted to Forest Land. New research results from Southwest Iceland did show 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 at least the Southwest region of Iceland (Owona, 2019).

Research results of carbon stock changes in soil on revegetated and afforested areas show 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 16 years old plantation on 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 did show removal of 0.4 to 0.65 t C ha^{-1} yr^{-1} to soil seven year after revegetation and afforestation on poorly vegetated land (Arnalds, Orradottir, & Aradottir, Carbon accumulation in Icelandic desert Andosols during early stages of restoration, 2013). Another chronosequence research with native birch did show a mean annual removal of 0.466 t C ha^{-1} to soil up to 65 years after afforestation on desertified areas (Kolka-Jónsson, 2011). All these findings highly 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 result in direct and indirect CO_2 emission and CH_4 and N_2O emission. As estimation and calculation is identical to Forest remaining forest description of methodology and applied emission factors is found in the methodology chapter 6.5.1.2 for Forest remaining forest above and in the Methodology Chapter of 6.14 Emissions and Removals from Drainage and Rewetting and Other Management of Organic and Mineral Soils (CRF 4(II)). Area estimation for drained organic soils in Land converted to Forest is identical to Forest remaining forest. Appearance of drained organic soil is for the CF assessed on the measurement plots in field but for the NBF the mapping ratio between mineral soil and drained organic soil is used.

Table 6.10 Carbon stock changes and related CO_2 emissions/removals for 6.5.2 Land Converted to Forest Land sub-categories in 2020.

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	33.88	OTH	T3	1.89	64.09	-235.00
	living biomass loss		OTH	T3		-0.74	2.72
	net CSC in litter	33.88	CS	T2	0.14	4.78	-17.51
	mineral soil	30.71	CS	T2	0.37	11.22	-41.16
	organic soil	3.16	D	T1	-0.37	-1.17	4.29
Afforestation natural birch forest 1-50 years old	living biomass gains	6.45	CS	T2	0.19	1.24	-4.53
	net CSC in litter	6.45	CS	T2	0.14	0.91	-3.33
	mineral soil	5.70	CS	T2	0.37	2.08	-7.64
	organic soil	0.75	D	T1	-0.37	-0.28	1.02
Other land converted to Forest land							
Afforestation 1-50 years old	living biomass gains	8.26	OTH	T3	1.62	13.38	-49.05
	net CSC in litter	8.26	CS	T2	0.14	1.17	-4.27
	mineral soil	8.26	CS	T2	0.51	4.24	-15.55
Afforestation natural birch forest 1-50 years old	living biomass gains	4.67	CS	T2	0.19	0.90	-3.28
	net CSC in litter	4.67	CS	T2	0.14	0.66	-2.42
	mineral soil	4.67	CS	T2	0.51	2.40	-8.79
Total							**-384.52**

6.5.2.3 *Uncertainties and time-series consistency*

Uncertainties in area and biomass C-stock change estimation in Cultivated Forest are the same as in category Forest remaining forest and described in 6.5.1.3 (4%). Biomass C-stock changes in NBW are estimated with statistical uncertainty of 47%. 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 reliable and with uncertainty most likely below 5% is the biomass loss calculation still not complete. It is therefore an expert judgement to quadruple the harvest statistic uncertainty and use for biomass losses 20% uncertainty. Combined uncertainty for CO_2 emissions of Land converted to Forest land category is 8.92% 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 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 changes in biomass in CF are based on direct stock measurements (Tier 3) as in last year’s submission. They are recalculated for 2019 due to new data from NFI measurements in 2021. Estimates of the net gain of biomass of the new natural birch forest are totally revised in this year submission built on 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 impact are shown in Table 6.11.

Table 6.11 Comparison between the 2021 submission and 2022 submission on CSC in Land converted to Forest Land category and subcategories for 2019.

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
Grassland converted to Forest land										
Afforestation 1 - 50 years old – Cultivated forest	living biomass gains	33.31	33.75	1.3%	2.10	1.83	-12.8%	70.06	61.88	-11.7%
	living biomass loss	33.31	33.75	1.3%	-0.02	-0.02	-1.0%	-0.60	-0.60	0.3%
	net CSC in litter	33.31	33.75	1.3%	0.14	0.14	-0.1%	4.70	4.76	1.3%
	mineral soil	30.16	30.54	1.3%	0.37	0.37	0.0%	11.02	11.16	1.3%
	organic soil	3.15	3.21	1.9%	-0.37	-0.37	-0.4%	-1.17	-1.19	1.5%
Afforestation natural birch forest 1-50 years old	living biomass gains	6.25	6.24	-0.2%	0.21	0.19	-10.6%	1.34	1.20	-10.8%
	net CSC in litter	6.25	6.24	-0.2%	0.14	0.14	0.1%	0.88	0.88	0.0%
	mineral soil	5.52	5.52	-0.1%	0.37	0.37	-0.1%	2.02	2.02	-0.2%
	organic soil	0.73	0.73	-0.7%	-0.37	-0.37	0.0%	-0.27	-0.27	-0.6%
Other land converted to Forest land										
Afforestation 1-50 years old	living biomass gains	8.51	8.31	-2.4%	1.79	1.34	-25.0%	15.24	11.16	-26.8%
	net CSC in litter	8.51	8.31	-2.4%	0.14	0.14	0.0%	1.2	1.17	-2.4%
	mineral soil	8.51	8.31	-2.4%	0.51	0.51	0.1%	4.36	4.26	-2.2%
Afforestation natural birch forest 1-50 years old	living biomass gains	4.52	4.52	0.1%	0.21	0.19	-10.7%	0.97	0.87	-10.6%
	net CSC in litter	4.52	4.52	0.1%	0.14	0.14	-0.4%	0.64	0.64	-0.3%
	mineral soil	4.52	4.52	0.1%	0.51	0.51	-0.1%	2.32	2.32	0.0%
Total		**52.59**	**52.82**	**0.4%**	**2.14**	**1.90**	**-11.4%**	**112.71**	**100.25**	**-11.1%**

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 recognized as key source/sink in level (1990 and 2020) as well as in 1990-2020 trend.

Cropland in Iceland consists mainly of cultivated hayfields, many of which are on drained organic soil, and cultivation of potatoes and vegetables. Cultivation of barley is on a small but increasing part of the category. The new HMI map introduced as base map for the IGLUD land use map in 2019 submission, contains extended map layer for Cropland, compared to previous versions. The extension involves adding area of recently cultivated fields obtained from Icelandic Agricultural Advisory Centre (IAAC) and RI. The IGLUD Cropland map layer was originally digitized from satellite images 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 2020 map layer through the IGLUD processing, taking into account the order of compilation applied, is 145.20 kha compared to 140.46kha in 2019 IGLUD map layer. This small decrease in map area is not interpreted as decrease in Cropland area. It is instead considered reflecting larger area of abandoned Cropland and inaccuracy in mapping and not as such affecting 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 145.20 kha, whereof 64.75kha 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 are prepared by AUI from agricultural statistics, available reports and unpublished data. The preparation of time series will be described in detail elsewhere.

The area of Cropland organic soils is estimated through the time series available. In 2021 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 calculation between the total area of Cropland and Cropland active and Cropland inactive (Fallow) areas emerged from the new map layers through the IGLUD process and subtracting the ratio of Land converted to Cropland areas also emerged from the new map layers through the IGLUD process. 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 analyses. A special project in IGLUD aiming at identifying cropland organic soils was started in 2011 and the fieldwork is still open. The results of this project are expected to improve geographical identification of Cropland organic soils.

No information is available on emission/removal regarding different cultivation types and subdivision 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 93.04 kha whereof 40.82 kha is organic soil (Table 6.12).

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 46.90 kha whereof 21.20 kha is organic soil (Table 6.12).

6.6.1.2 ***Methodology***

No perennial woody crops are cultivated in Iceland, 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 dead organic matter in cropland remaining cropland. The majority of 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 recognized as a possible sink/source.

Annual change of SOC for mineral soil of Cropland remaining Cropland were estimated for the first time in in 2018 submission, according to Tier2. The estimate is based on study of Helgason (1975) on effects of different N fertilizers on soil properties. The experiment site was conducted at four different locations, the one presented here is in Sámsstaðir South-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 fertilizers. Changes were largely restricted to the top of the soil (0-5 cm) and seem to disappear in the 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 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 62.02 kha. These organic soils are estimated to lose -489.97 kt C. Areas and emission factors used for carbon stock changes and comparable CO_2 emission /removals calculations for Cropland remaining Cropland subcategories are summarized in Table 6.12.

Table 6.12 Carbon stock changes and related CO_2 Emissions/removals for Cropland remaining Cropland sub-categories in 2020

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	52.22	CS	T2	0.15	7.96	-29.20
	organic soil	40.82	D	T1	-7.90	-322.48	1182.44
Cropland inactive (Fallow)	mineral soil	25.70	CS	T2	0.15	3.92	-14.37
	organic soil	21.20	D	T1	-7.90	-167.48	614.11
Total							**1752.98**

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 500×500m 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 9187 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%, based on Þorvaldsson (1994), and the time series of Croplands on organic soils have 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 50×50 m 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 20%, or the same as for Cropland total area.

The area of cropland in use is as in previous submissions estimated through 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 1990–2020 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). The uncertainty associated to C change factors for Cropland remaining Cropland in 2020 is 14.20% deriving from combined uncertainty of C-stock change factors in mineral and organic soils. Emissions/removals reported from organic soils are based on default EF from table 2.1 in 2013 wetland supplement to AFOLU (IPCC, 2006). Emissions/removals reported for mineral soils are based on country specific EF. 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. QC procedure are T1, involving 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 t C $ha^{-1}yr^{-1}$ 0.17 to t C $ha^{-1}yr^{-1}$ 0.15 for the 2022 Submission. The changes values and relative impact in CSC in mineral soils for these two subcategories are shown in Table 6.13.

Table 6.13 Comparison between the 2021 submission and 2022 submission on CSC in Cropland remaining cropland category subcategories for 2019.

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
Cropland active	mineral soil	49.84	52.27	4.9%	0.17	0.15	-10.7%	8.51	7.97	-6.4%
	organic soil	38.99	40.83	4.7%	-7.90	-7.90	0.0%	-308.04	-322.55	4.7%
Cropland inactive (Fallow)	mineral soil	25.34	25.73	1.5%	0.17	0.15	-10.7%	4.33	3.92	-9.4%
	organic soil	21.03	21.20	0.9%	-7.90	-7.90	0.0%	-166.10	-167.52	0.9%
Total		**135.20**	**140.03**	**3.6%**				**-461.30**	**-478.18**	**3.7%**

6.6.1.6 *Category-specific planned improvements*

A new map of cultivated land was prepared by the Registers Iceland (Þjóðskrá Íslands) 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 the year 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 enable 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 recognized as key source/sink in level (1990 and 2020) as well as in 1990-2020 trend.

The category “Land converted to Cropland” is in the CRF reported from three sources, i.e, “Forest land converted to Cropland”, “Grassland converted to Cropland”, and “Wetland converted to Cropland”. Only small area (12 ha) of Forest land converted to Cropland was detected in the year 2015 through IFR data sampling. The separation to land remaining and land converted to Cropland is not presently recognizable in the land use maps. Grassland and Wetland, converted to Cropland are assumed to be included in the mapping units Cropland, and Cropland on drained soils.

Forest land converted to Cropland

As described in Chapter 6.5, 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 conversion of land to Cropland are reported. These changes are estimated according to the Tier 1 method, 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, including litter and standing dead, for Grassland and Wetlands below 200 m height above sea level, 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 kgC/m2) was estimated based on the same date set described above, whereas F_{LU}, F_{MG} and F_I stock change factors are IPCC default 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 imput).

Organic soils of land converted Cropland are reported in two categories i.e., Forest land converted to Cropland, and Wetland converted to Cropland (Table 6.14). 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, 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 oxidized. Same Tier 2 approach as used in KP-LULUCF Deforestation when Forest Land is converted to Settlement is used for C-stock losses of litter. C-stock emission from drained organic soil is estimated by Tier 1 approach and default emission factor of -7.9 t CO_2-C ha^{-1} yr^{-1} for Cropland, drained in Boreal or Temperate Climate zone from Table 2.1 in 2013 Wetland 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 emission /removals calculations for Land converted to Cropland subcategories are summarized in Table 6.14.

Table 6.14 Carbon stock changes and related CO_2 Emissions/removals for Land converted to Cropland sub-categories in 2020.

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	T1	-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 estimated applying same method as in 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 is assumed to have continued, and fixed ratio of mineral and organic soils. That ratio was adjusted to estimated proportion of cropland of wetland origin in survey conducted 1990-1993 (Þorvaldsson, 1994). The area of land converted is thus assumed to highly uncertain on yearly basis.

The area of "Forest land converted to Cropland" is estimated through deforestation recording 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 1990–2020 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 2020 is 28.99% 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 default EF from table 2.1 in 2013 wetland supplement to AFOLU (IPCC, 2006). Emissions/removals reported for mineral soils are based on country specific EF with uncertainty assigned based on expert judgment. Emissions/removals in C changes in living biomass are based on default EF from table 5.9 in 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. QC procedure are T1, involving 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 Land converted to Cropland sub-categories. Changes in values between 2021 and 2022 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 grasslands subcategories for 2021 and 2022 submissions are shown in Table 6.15.

Table 6.15 Comparison between the 2021 submission and 2022 submission on CSC in Land converted to cropland category subcategories for 2019.

Land category	Soil type/ biomass	[kha] 2021 sub m.	[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 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.

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 emissions from “Land converted to Cropland” are recognized as key sources, it is important to move to a higher tier in estimating that factor.

6.7 Grassland (CRF 4C)

Grassland is a very diverse category regarding vegetation, soil type, erosion and management. Included in the category is the area of 43 map layers as emerging form the compilation process for the IGLUD Land use map, 28 of them originating from the HMI map. From 2021 submission significantly area increase for this category is reported as large part of "Other land" is added in Grassland. For the 2020's submission Grassland had an extension of 3693.65 kha, whereas for this year´s submission this category has extended to 5892.51kha. The reasons for this change relate to the overlay of the "Grazing areas map" (information regarding the "Grazing areas map" are 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 thirteen subcategories from 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" reported until 2020 submission 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 categorized 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 taken into account. 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 originate from Other Grassland, including Forest land, Cropland, other Grassland subcategories, Reservoirs, and Settlement. However, in 2021 submission the time series for "Other Grassland" was disaggregated in two new time series, i. e., "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 to the IGLUD map.

Similar approach as described here 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 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 areas 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 recognized as key source/sink in level (1990 and 2020) as well as in 1990-2020 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 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 22.46 kha whereof 5.60 kha is organic soil.

Natural Birch Shrubland:

Natural birch shrubland is the part of the natural birch woodland not meeting the thresholds to be accounted for as forest but covered with birch (*Betula pubescens*) to a minimum of 10% in vertical cover and at least 0.5 ha in continuous area. The natural birch shrubland is included in the NFI and the area and stock changes 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 unchanged between 1987 and 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 and revised estimates of the mean annual net change of C-stock biomass. Further information about this revision is to be found in Chapter 6.5.1.2 above. The second subcategory i.e., “Grassland converted to Natural birch shrubland” is representing “Other Grassland” converted to shrubland. As this change in vegetation cover, does not shift the land between categories this land remains as Grassland. Conversion period is set to 50 years as for grassland converted to natural birch forest and with same; in country removal factors for biomass, dead organic matter and mineral soil and the IPCC default emission factor for drained organic soil on ‘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 is “Grassland converted to Natural birch shrubland”. It 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 to 2012. More exactly they are expanding from zero in 1989 to 2.59 kha in 2012. Mean annual gross area increase of 0.10 kha is interpolated over the 1989-2012 period and extrapolated for the years 2013 – 2020.

Grazing areas:

As described in chapter 6.7 the mapping unit” for "Grazing areas" obtained by the disaggregation of the subcategory "Other Grassland" include all land categorized as Grassland, where vascular plant cover is 20% or more, as compiled from IGLUD and not included in the other Grassland subcategories. Accordingly, all land within the land use categories, ranked higher than Grassland in the hierarchy (Table 6.2) are excluded a priory. The land in this category is e.g., 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, heath-lands 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 2644.49 kha.

Grassland without grazing

For this subcategory category description is the same as reported in "Grazing areas". The total area reported in this year´s submission for this subcategory is 326.44 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 7.02 kha. This area is not at present recognized as separate mapping unit but assumed to be included in the mapping unit Revegetation before 1990, despite currently limited area of that mapping unit (see Table 6.6). Notation key 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 very limited. However, it is assumed that changes in C-stock in mineral soils under this sub-category is likely to be sink rather than source and is therefore estimated as NA as Tier 1 approach where mineral soils under this sub-category 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 Kristján Bjarndal Jónsson consultant, collected in his local district (personal communication) and upscaled to the whole country. The estimate of the new area drained from 2008 to present is estimated from preliminary results from re-digitisation of the ditch network. All ditches recognizable on SPOT 4 satellite images were digitized 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 current 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 area such included the overlap 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 e.g., where buffer had extended across a river. 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 still remaining HMI habitat types not stated to include organic soils was explored. On basis of that exploration, habitat type description and expert judgement decision was 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 ratio of mapped ditches and area estimated as effected. 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 253.25 kha and all of it assumed to be with organic soils. This category is not at present identified as 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. Current data on “Revegetated land older than 60 years”, “Grazing areas” and “Grassland without grazing” are very limited. However, it is assumed that changes in C-stock in mineral soils under these three sub-categories are likely to be sinks rather than sources and are therefore estimated as NA based on 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 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 is presented in the NFI applying Tier 3 methodology of direct estimate of stock changes. As already described in chapters 6.5.1.2 and 6.7.1.1 are the net C-stock changes in biomass of the natural birch woodland for the period 2007-2020 for the first 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.

The carbon stock changes in dead organic matter for “Natural birch shrubland-recently expanded into Other Grassland” is estimated by the same country specific EF as used for Grassland converted to Forest Land and described above in Chapter 6.5.2.2. The carbon stock changes in category “Natural birch shrubland- old” are as in Natural birch forest assumed to be a slight sink and reported as NA based on Tier 1 approach.

The carbon stock changes in the DOC of the mineral soil of subcategory “Natural birch shrubland recently expanded to Other Grassland” is estimated by the same country specific EF 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, i.e., “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 emission is estimated by the same Tier 1 default emission factor as used for drained organic soil on Forest Land, of 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 emission is 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 emission is summarized in Table 6.16.

Areas and emission factors used for carbon stock changes and comparable CO_2 emission /removals calculations for Grassland remaining Grassland subcategories are summarized in Table 6.17.

Table 6.16. Area of drained soils and estimated C losses and on-site CO_2 emission of Grassland categories/subcategories. 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	**259.36**	**-1,475.61**	**5,410.56**
Cropland abandoned for more than 20 years	5.60	-31.90	116.97
Natural birch shrubland (N.b.s)- old	0.26	-0.09	0.35
N.b.s.- recently expanded into Other Grassland	0.26	-0.10	0.37
Wetland drained for more than 20 years	253.25	-1,443.51	5,292.88
Land converted to Grassland	**23.73**	**-135.28**	**496.02**
Cropland converted to Grassland	2.98	-16.99	62.30
Wetland converted to Grassland	20.75	-118.29	433.72
Total	**283.09**	**-1,610.89**	**5,906.59**

Table 6.17 Carbon stock changes and related CO_2 Emissions/removals for Grassland remaining Grassland sub-categories in 2020

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	5.60	D	T1	-5.70	-31.90	116.97
Natural birch shrubland - recently expanded into other grassland	mineral soil	2.71	CS	T2	0.37	0.99	-3.63
	organic soil	0.26	D	T1	-0.37	-0.10	0.35
	biomass gains	2.97	CS	T2	0.19	0.57	-2.09
	dead organic matter	2.97	CS	T2	0.14	0.42	-1.54
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	253.25	D	T1	-5.70	-1443.51	5292.88
Total							**5389.94**

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, aiming at improving the geographical identification of drained organic soils, was initiated within the IGLUD. This project involved 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, remaining points 163 (17%) need 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, remaining points 66 (31%) need 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. On-going survey on the type of soil drained has already revealed that some features mapped as ditches are not ditches but e.g., tracks or fences. During the summer 2010 the reliability of the ditch map was tested. Randomly selected squares of 500x500 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 put 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 Tier 1 approach. 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 change factors for Grassland remaining Grassland in 2019 is 49.61% deriving from combined uncertainty of C-stock change factors in living biomass and in mineral and organic soils. Emission/removal reported from organic soils are based on default EF from table 2.1 in 2013 wetland supplement to AFOLU (IPCC, 2006). Emissions/removals reported for mineral soils are based on country specific EF 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. QC procedure are 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 sub-categories except for Natural birch shrubland were C-stock changes in biomass were totally revised as described in Chapter 6.5 above. Changes in values between 2021 and 2022 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 grasslands subcategories for 2021 and 2022 submissions are shown in Table 6.18.

Table 6.18 Comparison between the 2021 submission and 2022 submission on CSC in Grassland remaining grassland category subcategories for the year 2019.

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
Cropland abandoned for more than 20 years	organic soil	6.07	5.45	-10.3%	-5.70	-5.70	0.0%	-34.61	-31.06	-10.3%
Natural birch shrubland - recently expanded into other grassland	mineral soil	2.62	2.62	0.0%	0.37	0.37	0.0%	0.96	0.96	0.0%
	organic soil	0.25	0.25	0.0%	-0.37	-0.37	0.0%	-0.09	-0.09	0.0%
	biomass gains	2.88	2.88	0.0%	0.21	0.19	-10.6%	0.62	0.55	-10.6%
	dead OM	2.88	2.88	0.0%	0.14	0.14	0.0%	0.41	0.41	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%	0.02	0.07	261.8%	1.01	3.64	261.8%
Wetland drained for more than 20 years	organic soil	251.44	251.44	0.0%	-5.70	-5.70	0.0%	-1433.18	-1433.18	0.0%
Total		**310.35**	**309.73**	**-0.2%**				**-1464.99**	**-1458.87**	**-0.4%**

6.7.1.6 *Category-specific planned improvements*

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 emission of drained land within these categories, is in this submission 6512.42 kt CO_2e making that component the far largest identified anthropogenic source of GHG in Iceland. Further 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 planned in next years 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.

AUI has initiated 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 was to finish this new mapping in mid-year 2018 and to utilize the new map in this submission, but final results have been delayed. 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 newly published Icelandic data (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 since 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 potentially large source of carbon emissions. The importance of this source must be emphasized since Icelandic mineral grassland soils are almost always Andosols with 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 relative division of 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 its range estimated. This report shows clearly 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.

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 recognized as key source/sink in level (1990) as well as in 1990-2020 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 Settlement 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 7.13 kha with 2.98 kha on organic soil (Table 6.19).

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 20.75 kha and the whole area assumed to be on organic soil (Table 6.19). 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 them originating from revegetation activities i.e., “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” originate from the ongoing expansion of birch shrubland noted in the NFI. The total area reported for these subcategories are shown in Table 6.19.

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 are currently being put into improving the NIRA database, and it is expected that by the end of 2022 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 e.g., 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: The fourth subcategory is “Other land converted to Natural birch shrubland”. It is extracted from the new mapping survey of the NBW as Natural birch shrubland that did not exist before the 1987-1991. The increment is from zero in 1989 to 2.50 kha in 2012. Mean annual area increase of 0.11 kha is interpolated over the 1989-2012 period and extrapolated for the years 2013 – 2020.

Conversion period is set to 50 years as for other land converted to natural birch forest and with 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 as 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. 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 6.19).

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” see 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 Tier 1 approach.

Conversion period for “Other land converted to Natural birch shrubland” is set to 50 years as for other land converted to natural birch forest and with 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 (Chapter6.6.2.2). 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 applying Tier 2 and CS emission (removal) factor. C-stock changes in mineral soils of “Other land converted to Natural birch shrubland” is estimated applying same CS emission (removal) factor as used for revegetation categories (Table 6.19).

Organic soils are reported under two subcategories, i.e., “Cropland converted to Grassland”, and “Wetland converted to Grassland”. In all categories the emission is estimated according to Tier 1, and default EF= 5.70 t C ha^{-1} yr^{-1}.

Areas and emission factors used for carbon stock changes and comparable CO2 emission /removals calculations for Land converted to Grassland subcategories are summarized in Table 6.19.

Table 6.19 Carbon stock changes and related CO2 Emissions/removals for Land converted to Grassland sub-categories in 2020.

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	4.15	CS	T2	-0.10	-0.43	1.58
	organic soil	2.98	D	T1	-5.70	-16.99	62.30
	biomass gains	7.13	CS	T2	0.53	3.77	-13.83
Wetlands converted to Grassland							
	organic soil	20.75	D	T1	-5.70	-118.29	433.72
Other land converted to Grassland							
Revegetation before 1990	mineral soil	158.33	CS	T2	0.51	81.22	-297.82
	biomass gains	158.33	CS	T2	0.06	9.02	-33.09
Other Land Converted to Grassland NBS	mineral soil	3.36	CS	T2	0.51	1.73	-6.33
	biomass gains	3.36	CS	T2	0.19	0.64	-2.36
	dead OM	3.36	CS	T2	0.14	0.47	-1.74
Revegetation since 1990-protected from grazing	mineral soil	103.20	CS	T2	0.51	52.94	-194.13
	biomass gains	103.20	CS	T2	0.06	5.88	-21.57
Revegetation since 1990 limited controlled grazing allowed	mineral soil	46.02	CS	T2	0.51	23.61	-86.56
	biomass gains	46.02	CS	T2	0.06	2.62	-9.62
Total							**-169.453**

6.7.2.3 *Uncertainties and time-series consistency*

The uncertainty of area of the categories reported is estimated at 20% except for Revegetation. Uncertainties of the subcategories of “Other land converted to Grassland” involving revegetation have been estimated using data from the KP LULUCF sampling program (see Chapter 11.3.1). 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 remains 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 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 it´s 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 subcategories of Other land converted to Grassland is for the revegetation subcategories based on estimate of total C-stock changes in all categories and estimate of average proportion of vegetation in those changes being 10%.

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 Grassland is 20.82% deriving from combined uncertainty of C-stock change factors in living biomass and in mineral and organic soils. Emission/removal reported from organic soils are based on default EF from table 2.1 in 2013 wetland supplement to AFOLU (IPCC, 2006). Emissions/removals reported for mineral soils are based on country specific EF 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 procedure 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 Land converted to grassland sub-categories. Changes in values between 2021 and 2022 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 Land converted to Grasslands sub-categories for 2021 and 2022 submissions are shown in Table 6.20.

Table 6.20 Comparison between the 2021 submission and 2022 submission on CSC in Land converted to Grassland category subcategories for 2019.

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
Cropland converted to Grassland	mineral soil	6.09	4.15	-31.9%	-0.10	-0.10	-0.1%	-0.63	-0.43	-31.9%
	organic soil	4.37	2.98	-31.9%	-5.70	-5.70	0.0%	-24.93	-16.99	-31.9%
	biomass gains	10.46	7.13	-31.9%	0.53	0.53	0.0%	5.54	3.77	-31.9%
Wetlands converted to Grassland	organic soil	22.06	22.06	0.0%	-5.70	-5.70	0.0%	-125.77	-125.77	0.0%
Other land converted to Grassland										
Revegetation before 1990	mineral soil	159.50	159.50	0.0%	0.51	0.51	0.0%	81.82	81.82	0.0%
	biomass gains	159.50	159.50	0.0%	0.06	0.06	0.0%	9.09	9.09	0.0%
Other Land Converted to Grassland NBS	mineral soil	3.26	3.26	0.0%	0.51	0.51	0.0%	1.67	1.67	0.0%
	biomass gains	3.26	3.26	0.0%	0.21	0.19	-10.6%	0.70	0.62	-10.6%
	dead OM	3.26	3.26	0.0%	0.14	0.14	0.0%	0.46	0.46	0.0%
Revegetation since 1990- protected from grazing	mineral soil	99.25	100.90	1.7%	0.51	0.51	0.0%	50.91	51.76	1.7%
	biomass gains	99.25	100.90	1.7%	0.06	0.06	0.0%	5.66	5.75	1.7%
Revegetation since 1990 limited controlled grazing allowed	mineral soil	45.24	45.24	0.0%	0.51	0.51	0.0%	23.21	23.21	0.0%
	biomass gains	45.24	45.24	0.0%	0.06	0.06	0.0%	2.58	2.58	0.0%
Total		**317.71**	**316.03**	**-0.5%**				**30.31**	**37.56**	**23.9%**

Table 6.15 Comparison between the 2021 submission and 2022 submission on CSC in Land converted to cropland category subcategories

6.7.2.6 *Category-specific planned improvements*

The planned improvements described above for drained areas of "Grassland remaining Grassland" also applies for drained area of this "Land converted to Grassland". New map of the drainage network presently in progress and will be finished in 2021 is expected to provide 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 have been improved along with reformation of agricultural support payments. These improvements enable better tracking of abandoned Cropland i.e., Cropland converted to Grassland or eventually to other categories.

Improvements in sequestration rate estimates, and recording for other revegetation areas, aim at establishing a transparent, verifiable inventory of carbon stock changes accountable according to the Kyoto Protocol as the corresponding emission/removal factors, based on the ongoing NIRA update has been delayed and is 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 recognized as key source/sink in level (1990 and 2020) as well as in 1990-2020 trend.

Wetland is the third largest land use category identified by present land use mapping as described above. The total area of the Wetland category is reported as 897.25 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 the rangeland grazed by livestock and are grazed to some extent and accordingly included as managed land.

The subdivision of Wetland remaining Wetland is described below. Contrary to other land use categories, except "Other land" this category contains land defined as unmanaged, i.e., 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 emission of GHG is affected. Examples of potential impacts on lakes and rivers are urban, agricultural and industrial inputs of nutrients and organic matters. Channelling of rivers and other alteration of their paths could also potentially affect their GHG profile. Although there is no attempt made to separate potentially managed lakes and rivers from unmanaged, except the 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". The first "Mires converted to reservoirs" is reported as 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 Wetland remaining Other Wetland".

Mires converted to reservoirs.
"Mires converted to reservoirs" are 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 6.21Table 6.21). 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". It was discussed to include them as remaining mires, but since the inundation does change the functionality of mires through vegetation die off, it was decided to categorize them as flooded land remaining flooded land in order to estimate GHG emissions.

Lakes and rivers. As described in Chapter 6.2 all land that is covered or saturated by water for at the least part of the year and does not fall into the Settlements, Forest land, Cropland categories. It includes intact mires and reservoirs as managed subdivisions, and natural rivers and lakes as unmanaged subdivision.

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 wetland supplement (IPCC, 2014) guidelines are provided for estimation of emission 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 618.76 kha compared to 650.05 kha in the year 1990. All the area is included as organic soils.

6.8.1.2 *Methodology*
The CO_2 removal due to carbon stock changes in category "Wetland remaining Wetland -Other wetlands" is recognized as a key category in level in 1990 and 2020 and in trend 1990-2020.

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 living biomass and dead organic matter are included in aggregate number 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 emission from reservoirs is estimated for three subcategories. However, CO_2 emission from organic soils is estimated only for "Flooded Land Remaining Flooded Land – Mires converted to reservoirs", whereas CO_2 emission from mineral soils is 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 available (Óskarsson & Guðmundsson, 2008). For the three new reservoirs established reservoir specific emission factors were calculated according to from 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 applying equation 3.4 and EF= - 0.55 t CO_2-C ha^{-1} yr^{-1}, as for “Boreal nutrient rich soils” from table 3.1 in 2013 wetland supplement (IPCC, 2014). Areas and emission factors used for carbon stock changes and comparable CO2 emission /removals calculations for Wetlands remaining Wetlands subcategories are summarized in Table 6.21.

Table 6.21 Carbon stock changes and related CO2 Emissions/removals for Wetlands remaining Wetlands sub-categories in 2020

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	618.76	D	T1	0.55	340.32	-1247.83
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							**-1245.08**

6.8.1.3 *Uncertainties and time-series consistency*

The area of intact mires and rivers and lakes the two largest wetland remaining wetland categories is not recorded specifically but estimated through the process of compilation of land use map. The increase in extent of drained land is not directly recorded either but estimated through time series for drainage ditches. The accuracy of time series of drainage has not been estimated.

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 Wetland remaining Wetland is 39.91% deriving from combined uncertainty of C-stock change factors in organic soils. Emission/removal reported from organic soils are based on default EF from table 3.1 in 2013 wetland supplement to AFOLU (IPCC, 2006) and country specific EF 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 procedure 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 Wetlands remaining wetlands sub-categories. Changes in values between 2021 and 2022 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 Wetlands remaining Wetlands sub-categories for 2021 and 2022 submissions are shown in Table 6.22.

Table 6.22 Comparison between the 2021 submission and 2022 submission on CSC in Wetlands remaining wetlands category subcategories for 2019.

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
4.D.1.3 Other Wetlands remaining Other Wetlands										
Intact mires	organic soil	625.65	619.12	-1.0%	0.55	0.55	0.0%	344.11	340.52	-1.0%
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		**626.64**	**620.11**	**-1.0%**				**343.36**	**339.77**	**-1.0%**

6.8.1.6 *Category-specific planned improvements*

New digitisation of drainage ditches is ongoing at AUI, including also evaluation of excavation of new ditches in the period 2005- 2016. Survey of extent of drainage in ditches surrounding was completed in 2014 and analysing of the data is pending. New ditch map and re-evaluation of ditches effect is expected in 2021.

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 to 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: “Rewetted wetland soils” and “Refilled lakes and ponds”. These two subcategories include re-established wetland areas previously disturbed. Activity data for mineral soils in Rewetted wetland soils subcategory is reported with the notation key NO from 1990 until 2015 as no rewetting actions on wetlands mineral soils have occurred during that period. In the case of “Refilled lakes and ponds” C-stock changes in soils are reportes 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 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 area flooded is available (Table 6.23).

Reservoir emission factors include diffusion from surface and degassing through spillway for both CO_2 and CH_4 and bubble emission 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 6.23 Emission factors applied to estimate emissions from flooded land based (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
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 applying equation 3.4 and EF= - 0.55 t CO_2-C ha^{-1} yr^{-1}, as for “Boreal nutrient rich soils” from table 3.1 in 2013 wetland supplement (IPCC, 2014). No changes in C-stocks of soils or other pools are estimated for the category “Refilled lakes and ponds”.

CO2 emission from mineral soils is estimated for “Grassland converted to flooded land - Medium SOC to reservoirs”, for “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 CO2 emission /removals calculations for Land converted to Wetlands subcategories are summarized in Table 6.24.

Table 6.24 Carbon stock changes and related CO_2 Emissions/removals for Land converted to Wetlands sub-categories in 2020

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	1.12	D	T1	0.55	0.61	-2.25
Total							**4.97**

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, potentially the uncertainty of the area estimate of intact mires is 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 emission from intact mires. One on lowland mires, and the other on highland mires. The annual emission was in estimated 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 137 kg CH_4-C ha^{-1} yr^{-1} is thus in good agreement with those estimates. The comparison also indicate that uncertainty might decrease by subdividing intact mires to emission categories by altitude or regions. The second EF comparison is on N_2O emission through surface of intact mires. The default EF is zero emission but Icelandic measurements for lowland mires the emission was estimated 0.04 kg N_2O-N ha^{-1} yr^{-1} (Guðmundsson J. , 2009) but for highland mires no emission was detected (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 emission from reservoirs of different age, and how different quality, 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 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 114.62% deriving from combined uncertainty of C-stock change factors in mineral and organic soils. Emission/removal reported from organic soils are based on default EF from table 3.1 in 2013 wetland supplement to AFOLU (IPCC, 2006) and country specific EF 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 procedure 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 Land converted wetlands sub-categories. Changes in values between 2021 and 2022 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 for Land converted to wetlands sub-categories for 2021 and 2022 submissions are shown in Table 6.25.

Table 6.25 Comparison between the 2021 submission and 2022 submission on CSC in Land converted to wetlands category subcategories for 2019.

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
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										
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	0.86	0.86	0.0%	0.55	0.55	0.0%	0.47	0.47	0.0%
Total		**26.96**	**26.96**	**0.0%**				**-1.49**	**-1.49**	**0.0%**

6.8.2.6 *Category-specific planned improvements*

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.

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 characterized by using spatially explicit observations of land-use categories and land-use conversions. The SCSI created four new urban areas maps in a certain time resolution, i.e., 1990, 2000, 2010 and 2020. Maxar Satellite Images, aerial images from National Land Survey of Iceland and Loftmyndir ehf were used for the 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 fit entirely the replaced HMI layer, the Icelandic Farmland Database (IFD) was used for this purpose which appeared to have comparable IGLUD/LULUCF classification of the land surface for the IGLUD database / mapping. The new Settlements map layer included towns and villages where a minimum of 200 inhabitants is required. Roads map layer has a buffer zone ranging from 2.5 -15.0 m from central line. No subdivision of this category is reported but the estimated total area consists of two components represented in IGLUD land use map i.e., towns and villages and other settlements (Roads). Time series for these two components are now constructed on interpolation of the new 4 map areas. The total area reported in this submission is 41.22 kha, whereas areas for towns and villages and other settlements (Roads) are 11.45 kha and 29.66 kha respectively. No maps are available for these time series. The area of Settlement remaining Settlement is set as the total area of Settlement the year before subtracting the recorded conversions from Forest and natural birch shrubland.

6.9.1.2 *Methodology*
No emissions are estimated for Settlement remaining Settlement.

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 2022 submission. The activity data uncertainty for the areas is 5%. Emission uncertainties for Settlements remaining settlements are not estimated as no emissions are reported from this sub-category (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 procedure 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 sub-category 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, i.e. “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 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 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 Settlement: 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 and house building as removal of trees and shrubs caused by construction of power lines is reported to the Icelandic Forest Service and reported as conversion to settlement. It is assumed that this deforestation is included in Settlements maps, although comparison of maps has not been carried out.

Areas of **Cropland,** , **Wetlands** and **Other Land converted to Settlements** 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” i.e. “Forest land converted to Settlement”, “Natural birch shrubland converted to Settlement”, and “All other Grassland subcategories converted to “Settlements”(Table 6.26).

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 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 years old afforestation site would be 1.51 t C ha^{-1}. Using the similar ratio between poor and fully vegetated land as in this year submission, i.e., 17% and 83%, accordingly, will give 2.29 t C ha^{-1} as weighted C-stock of 10 years 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). Annual increase in poor soil according to this year 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, ten years old forests will then have a C-stock of 20 and 76.6 t ha^{-1} on poor 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 years conversion period this means an estimated carbon stock loss of 1% during the year of conversion, i.e. the annual emission from SOC will be 0.67 t C ha^{-1}. These factors were used to estimate emission from litter and soil in this first type of deforestation.

The second type of deforestation leading to conversion of Forest land to Settlement is one event in 2006 where trees in an afforested area were cut down under new power line. Bigger trees were removed. In this case litter and soil is 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 Settlement is based on average carbon stock of IGLUD field sampling points on land below 200 m a.s.l. categorized to the Grassland category, and the assumption that 70% of the original vegetation cover is removed in the conversion. The estimation of 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 CO2 emission /removals calculations for Land converted to Wetlands subcategories are summarized in Table 6.26.

Table 6.26 Carbon stock changes and related CO2 Emissions/removals for Land converted to Settlements sub-categories in 2020

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 Settlement	mineral soil	0.05	D	T1	-0.60	-0.03	0.12
	biomass losses	0.05	OTH	T3	-0.69	-0.04	0.14
Grassland converted to Settlement							
All other subcategories converted to Settlements	biomass losses	0.11	CS	T2	-8.88	-0.97	3.55
NBS converted to Settlements	biomass losses	0.01	CS	T2	-1.16	-0.01	0.03
Total							**3.83**

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 1990–2020 have been assessed following Approach 1 of 2006 AFOLU Guidelines (IPCC, 2006). Emissions/removals reported for land converted to Settlements mineral soils are based on country specific EF. Uncertainty associated to C-stock change factors for this category is 150.00% 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 procedure are T1, 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 2021 and 2022 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 for Land converted to settlements sub-categories for 2021 and 2022 submissions are shown in Table 6.27.

Table 6.27 Comparison between the 2021 submission and 2022 submission on CSC in Land converted to settlements category subcategories for 2019

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 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	0.18	0.11	-37.6%	-8.88	-8.88	0.0%	-1.56	-0.97	-38.0%
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		**0.23**	**0.17**	**-28.2%**				**-1.60**	**-1.01**	**-37.0%**

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 in not known to occur. Potential processes capable of converting land to other land are, however, recognized. Among these is 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 recognized as the area of the map layers 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 2020 submission "Other land" area decreases significantly. In 2020 Other Land was reported with an area of 5314.54 kha whereas for this submission Other Land covers an area of 3118.73kha 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 procedure 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 no recalculations 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/removals related to harvested wood products (HWP) are estimated for the fifth time in this year’s submission. Although data on domestic wood utilization 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[23] the annual unofficial report of

[23] http://faostat3.fao.org/download/F/FO/E

the Iceland Forest Association does contain data about sawnwood production from domestic harvested wood for the years 1996 to 2020 (see Table 6.28); (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).

Table 6.28 Annual wood production (in m^3 on bark) and sawnwood production (in m^3) in 1996 to 2020

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	1444	21
2009	1528	46
2010	4185	50
2011	3845	112
2012	3459	93
2013	5511	93
2014	5923	165
2015	4744	64
2016	4182	133
2017	4333	202
2018	3131	118
2019	2702	76
2020	3537	77

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 default half-live 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%.

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 fertilizers 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 fertilizers used in Forestry under the total synthetic fertilizer under 3D1 (see Chapter 5.7. above). According to this decision use of inorganic fertilizer previously reported under Land Converted to Forest Land (CRF 4.A.2)/ Grassland Converted to Forest land/ Afforestation 1 - 50 years old – Cultivated forest, have been removed and replaced with IE (included elsewhere) in the CRF 4.A.2. Activity data are still reported in CRF 4.A.2 Inorganic Fertilizers.

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 2020 and CH_4 in trend 1990- 2020.

Forest land: As described in the chapter 6.5 Forest land is all drained organic soil reported with direct and indirect CO_2 emission and CH_4 and N_2O emission (see methodology in chapter 6.5.1.2 above).

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 emission 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 recognized and the relevant categories of 4(II) reported with notation key NO.

Grassland: Two sources of emission are reported here i.e., 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. From the 2020 submission this emission is reported under the Agriculture sector under the subcategory “Cultivation of organic soils” (3.D.1.6).

The rewetting of Grasslands occurring is reported as Grassland converted to Wetland. No other source or sink of GHG related to drainage or rewetting of Grassland soils is recognized and the relevant categories of 4(II) reported with notation key NO.

For the 2020 submission the emission of N2O form drained Grassland soil is no longer reported under the LULUCF sector but moved under the Agriculture sector (See also Chapter 6.12 Other (CRF 4H)) in response to the UNFCCC expert review team request, as well as by the review team during the 2019 EU step 2.

Wetland: Included in this category is off-site CO2 emission and CH4 emission from wet organic soils.

Settlement: 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 Settlement category.

6.14.2 Methodology

Other land: The category is by definition unmanaged, and no drainage or rewetting is occurring.

Forest land: Indirect CO_2 emission from drained organic soil which is an off-site emission 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). Newly published research where Eddy Covariance technic was used to estimate CO_2 fluxes in 23-25 years old Black Cottonwood plantation on drained peatland in South Iceland offsite CO_2 was measured simultaneously (Bjarnadóttir B., 2021). Waterborne carbon losses were measured 0.04 t C ha^{-1} yr^{-1} which is the 1/3 of the default value. Nevertheless, the default value will be used in this submission.

CH_4 emission from drained organic soil is too estimated by default emission factors using Equation 2.6 in the 2013 Wetlands Supplement, assuming average ditches width 2.5 m and average distance between ditches 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 for ditches 217 kg CH_4 ha^{-1} yr^{-1} for 'Boreal/Temperate-Drained Forest Land/Drained Wetlands' in Table 2.4 in 2013 Wetlands Supplement. Combined emission factor is then 7.375 kg CH_4 ha^{-1} yr^{-1}.

N_2O emission from drained organic soil is estimated with country specific emission factor, same as used for drained organic soil of Grassland which is 0.44 kg N_2O-N ha^{-1} yr^{-1} (see further description in chapter 5.7.2.6 above).

Area, implied emission factors and estimated off- site CO_2 and CH_4 emissions of for Forest land are shown in Table 6.29 and Table 6.30 below.

Cropland: Off-site CO2 emission via waterborne losses from drained inland soils for Cropland is calculated according to Tier 1 applying equation 2.4 in the 2013 wetland Supplement. Area, implied emission factors and estimated off- site CO_2 for Cropland are shown in Table 6.29.

CH_4 emission and removals from drained inland soils: The CH_4 emission from drained land is calculated according to Tier 1 applying equation 2.6 in 2013 wetland supplement. The equations separate the emission into two components, i.e., emission from the drained land and the emission from the ditches. The Tier 1 default EF for drained land under Cropland is zero and consequently the emission reported is only from the ditches. The CH_4 emission and removal from drained cropland is calculated according to Tier 1 applying EFCH4_laNd = 0 and EFCH4_ditCH = 1,165 kg CH_4 ha^{-1} yr^{-1} from table 2.3 and 2.4 in 2013 wetland supplement respectively. Area, implied emission factors and estimated CH_4 emissions of for Cropland are shown in Table 6.30.

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 wetland supplement applying Tier 1 methodology. The off-site emission is reported for all Grassland subcategories with drained soils. The off-site CO2 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 wetland supplement. Area, implied emission factors and estimated off- site CO_2 for Grassland are shown in Table 6.29.

CH4 emission and removals from drained inland soils: The CH_4 emission from drained land is calculated according to Tier 1 applying equation 2.6 in 2013 wetland supplement. The equations separate the emission into two components i.e., emission from the drained land and the emission from the ditches. No estimate on the fraction of area covered by ditches is available and the indicated value from table 2.4 in the 2013 wetland supplement is applied. In general, the drainage ditches in Iceland are deep 1.5m-4m and EF for Grassland ditches selected accordingly. The CH4 emission and removal from drained Grassland is calculated according to T1 applying EFCH4_land = 1.4 and EFCH4_ditCH = 1,165 kg CH_4 ha^{-1} yr^{-1} from table 2.3 and 2.4 in 2013 wetland supplement respectively. The emission of CH_4 is reported for all the Grassland subcategories including drained soils. Area, implied emission factors and estimated CH_4 for Grassland are shown in Table 6.30.

Wetland: Off-site CO_2 emission via waterborne losses from wetland soils: Off-site CO_2 emissions via waterborne losses form wet organic soils is reported for four wetland subcategories i.e., “Mires converted to reservoirs”, “Intact mires”, of Wetland remaining Wetland, and “Refilled lakes and ponds”, and “Rewetted wetland soils”, of land converted to Wetland. In all cases the emission is estimated according to T1 applying equation 3.5. in 2013 wetland supplement. The off-site CO_2 emission via waterborne losses from “Mires converted to reservoirs”, “Intact mires”, “Refilled lakes and ponds”, and “Rewetted wetland soils” is calculated according to T1 using EF= 0.08 t CO_2-C ha^{-1} yr^{-1} from table 3.2 in 2013 wetland supplement. Area, implied emission factors and estimated off- site CO_2 for Wetland are shown in Table 6.29.

CH4 emission and removals from wetlands: The CH_4 emissions from reservoirs is estimated for reservoirs as in previous submissions. Emissions of CH_4 from reservoirs were estimated applying a comparative method as 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 emission from wet soils in the “Intact mires”, “Refilled lakes and ponds”, and “Rewetted organic soils” categories is estimated according to Tier 1 applying equation 3.8 in 2013 wetland supplement.

The CH_4 emission and removal from “Intact mires”, “Refilled lakes and ponds”, and “Rewetted wetland soils” is calculated according to Tier 1 applying EF= 137 kg CH_4-C ha^{-1} yr^{-1} from table 3.3 in 2013 wetland supplement. Area, implied emission factors and estimated CH_4 for shown in Table 6.31.

N2O emission from wetland soils: Emission of N_2O from reservoirs is considered as not occurring. Zero emissions were measured in a recent Icelandic study on which the emission estimate of CO_2 and CH_4 for reservoirs is based (Óskarsson & Guðmundsson, 2008).

The Tier 1 approach of 2013 wetland supplement emission of N_2O is considered negligible for rewetted soils and the same is assumed here to apply for intact mires.

Table 6.29 Drained soils: area, implied emission factors and estimated off- site CO_2 emissions of categories/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	**0.13**		**0.02**
Afforestation more than 50 years old	0.05	120.00	0.01
Forest land remaining Forest land _ Natural birch forest older than 50 years	0.08	120.00	0.01
Land converted to Forest land	**3.91**		**0.47**
Grassland converted to Forest land Natural birch forest 1 to 50 years old	0.75	120.00	0.09
Grassland converted to Forest land Afforestation 1 to 50 years old	3.16	120.00	0.38
Cropland remaining cropland	**62.02**		**27.29**
Cropland active	40.82	440.00	17.96
Cropland inactive	21.2	440.00	9.33
Land converted to cropland	**2.73**		**1.21**
Wetland converted to Cropland	2.72	440.00	1.2
Forest land converted to Cropland	0.01	440.00	0.01
Grassland remaining Grassland	**259.36**		**113.95**
Cropland abandoned for more than 20 years	5.60	440.00	2.46
Natural birch shrubland (N.b.s)- old	0.26	120.00	0.03
N.b.s.- recently expanded into Other Grassland	0.26	120.00	0.03
Wetland drained for more than 20 years	253.25	440.00	111.43
Land converted to Grassland	**23.73**		**10.44**
Cropland converted to Grassland	2.98	440.00	1.31
Wetland converted to Grassland	20.75	440.00	9.13
Wetlands remaining wetlands	**619.75**		**181.79**
Intact mires	618.76	293.33	181.50
Mires converted to reservoirs	0.99	293.33	0.29
Land converted to Wetlands	**1.24**		**0.36**
Refilled lakes and ponds	0.12	293.33	0.03
Rewetted wetland soils	1.12	293.33	0.33
Total	**972.87**		**335.54**

Table 6.30 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]	CH_4 land [kt CH_4]	EF ditches [kg CH_4/ha/yr]	CH_4 ditches [kt CH_4]	CH_4 total [kt CH_4]	[kt CO_2e]
Forest land remaining Forest land	**0.130**		**0.000**		**0.001**	**0.001**	**0.025**
Afforestation more than 50 years old	0.050	2.000	0.000	217.000	0.000	0.000	0.010
Forest land remaining Forest land _ Natural birch forest older than 50 years	0.080	2.000	0.000	217.000	0.000	0.001	0.015
Land converted to Forest land	**3.910**					**0.029**	**0.721**
Grassland converted to Forest land Natural birch forest 1 to 50 years old	0.750	2.000	0.001	217.000	0.004	0.006	0.138
Grassland converted to Forest land Afforestation 1 to 50 years old	3.160	2.000	0.006	217.000	0.017	0.023	0.583
Cropland remaining cropland	**62.020**		**0.000**		**3.613**	**3.613**	**90.318**
Cropland active	40.820	-	0.000	1165.000	2.378	2.378	59.445
Cropland inactive	21.200	-	0.000	1165.000	1.235	1.235	30.873
Land converted to cropland	**2.730**		**0.000**		**0.159**	**0.159**	**3.968**
Wetland converted to Cropland	2.720	-	0.000	1165.000	0.158	0.158	3.958
Forest land converted to Cropland	0.010	-	0.000	1165.000	0.001	0.001	0.010
Grassland remaining Grassland	**259.360**		**0.345**		**15.081**	**15.426**	**385.644**
Cropland abandoned for more than 20 years	5.597	1.400	0.007	1165.000	0.326	0.333	8.336
Natural birch shrubland (N.b.s)- old	0.256	2.000	0.000	217.000	0.001	0.002	0.047
N.b.s.- recently expanded into Other Grassland	0.259	2.000	0.001	217.000	0.001	0.002	0.048
Wetland drained for more than 20 years	253.248	1.400	0.337	1165.000	14.752	15.089	377.213
Land converted to Grassland	**23.733**		**0.032**		**1.382**		**35.350**
Cropland converted to Grassland	2.981	1.400	0.004	1165.000	0.174	0.178	4.440
Wetland converted to Grassland	20.752	1.400	0.028	1165.000	1.209	1.236	30.910
Total	**349.15**		**0.38**		**20.08**	**19.07**	**512.06**

Table 6.31 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	**619.750**		**113.027**	**2828.503**
Intact mires	618.760	182.667	113.027	2825.671
Mires converted to reservoirs	0.990	114.440	0.113	2.832
Land converted to Wetlands	**1.233**		**0.225**	**5.629**
Rewetted wetland soils	1.116	182.667	0.204	5.095
Refilled lakes and ponds	0.117	182.667	0.021	0.534
Total	**620.983**		**0.377**	**2834.132**

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 bases 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% related to CO_2 emissions, 71.24% for CH_4 emissions and 20% for N_2O as estimated in Chapter 5.7.6 above.

Uncertainties for Cropland are 41.51% related to CO_2 emissions and 50.70% for CH_4 emissions. Uncertainties for Grassland are 52.44% for CO_2 emissions and 64.07% related to CH_4 emissions. Uncertainties for Wetlands are 37.37% for CO_2 emissions and 258.42% for CH_4 emissions.

6.14.4 Category-specific QA/QC and verification

No specific QA has been performed for this category. QC procedure are Tier 1, involving checking the emission calculation processes and data sources during the inventory preparation.

6.14.5 Category-specific recalculations

No specific recalculation was performed for this category. Changes in values between 2021 and 2022 submissions are related to new areas emerged from the new map layers through the IGLUD process.

6.14.6 Category-specific planned improvements

There are no specific improvements planned for this category.

6.15 Direct N_2O Emissions from N Mineralization and Immobilization (CRF 4(III))

6.15.1 Category description

Direct N_2O emissions from N mineralization and immobilization is reported for Cropland converted to Grassland, and Forest land converted to Settlement.

6.15.2 Methodology

Conversion of Cropland on mineral soils to Grassland, and Forest land converted to Settlements result in loss of SOC. Emission of associated mineralization of N is calculated by assuming C:N of 15. The resulting N_2O emission is estimated 0.13 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 soil already described for relevant land use categories. Additional uncertainty for this emission is the assumption of fixed C:N ratio of 15.

6.15.4 Category-specific QA/QC and verification

No specific QA has been performed for this category. QC procedure are Tier 1, involving 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 under Agricultural sector and is reported there (Chapter 5.8).

Although moderate scarification is partially practiced when land is afforested/reforested, research as ICEWOOD did not show net C-stock losses from mineral soil of afforestation with scarification but on contrary net C-stock gain 11 year 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 Icelandic Institute of Natural History has in cooperation with regional Natural History Institutes started recently to record incidences of biomass burning categorized 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 in this submission reported for the land use categories; “Forest land remaining Forest land”, “Cropland remaining Cropland”, “Grassland remaining Grassland”, “Wetland remaining wetland”, and “Other land”.

Biomass estimate is based on biomass sampling in the IGLUD project from the relevant land use category as identified in land use map. Emission of CH_4 and N_2O is calculated on according to equation 2.27 from AFOLU guidelines (IPCC 2006).

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

Equation 1. Equation 2.27 from AFOLU guidelines (IPCC 2006): 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].

Emission from woodland wildfire is reported for the first time. The fire burned in 18-19th of May 2020 in West Iceland. As reported by the specialist of Icelandic Institute of Natural History that mapped and examined the burned area of natural birch forest that was 11.3 ha (http://www.ni.is/greinar/grodureldar-i-nordurardal). Only part the trees died and most of the biomass of trees that died was turned into necromass (litter or deadwood). The height of the forest was 2-5 m.

Tier 1 methodology using Equation 2.27 from the 2006 AFOLU Guidelines, Volume 4, Chapter 2 is applied. Forest reaching 2-5 m height at maturity has 11.9 Mgha^{-1} in above ground biomass in average (Snorrason et. al. 2019) and was used as an estimate of M_B. Emission factors given for “Extra tropical forest” were chosen together with combustion factor of “All boreal forest”.

The area burned each year due to wildfires other than forest fires is according to the above-described mapping and classification of the burned area to IGLUD land use mapping units. 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 emission of $_{CO2}$ is reported as biomass is assumed to reach its pre-burning values within few years from the burning. Available biomass range from 18.7 ±3.8 to 29.9 ±1.9 tons organic matter Dw ha^{-1} the standard error for individual categories from 6-29%. In Table 6.32 a summary of area, CO_2, CH_4 and N_2O emissions and their corresponding value in CO_2e.

Table 6.32 Biomass burning due to wildfires. Area, CO2, CH4 and N2O emissions and their corresponding value 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	0.0113	0.0717	0.0002	0.0054	0.0000	0.0035	0.0806
Cropland	0.0289	NA	0.0008	0.0205	0.0001	0.0223	0.0428
Grassland	0.0222	NA	0.0000	0.0005	0.0000	0.0005	0.0010
Wetlands	0.0005	NA	0.0000	0.0003	0.0000	0.0004	0.0007
Other land	0.0009	NA	0.0000	0.0005	0.0000	0.0005	0.0010
Total							**0.1262**

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 grasslands 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 for Grassland and Wetlands is reported as NE because there are not enough data to report biomass burning as NO. For all other land use categories, controlled burning is reported as NO.

6.17.2 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 on land (5A), Biological treatment of solid waste (5B), Waste incineration and open burning of waste (5C), and Wastewater treatment and discharge (5D). The category Other waste treatment (5E) is currently reported as NO.

Table 7.1 shows an overview of the emissions from the waste sector. The main contributor to the waste sector is CH_4 emissions from solid waste disposal on land (5A), contributing 68% (1990) and 75% (2020) to the total emissions from this sector. From 1990, emissions increased by 25%.

Composting is the only category reported under biological treatment of solid waste (5B) and started in Iceland in 1995. The CH_4 and N_2O emissions generated by composting contributed 0.13% in 1995 to total emissions from the waste sector and reach 2% in 2020, showing an increase of 1,607% between 1995 and 2020.

Incineration and open burning of waste (5C) contributed 7% to the total emissions in 1990, decreasing to 4% in 2020. 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 bonfires are reported within this category which did not occur in 2020 due the COVID-19 pandemic. Under 5C1 the only active incinerator of the country, active since 2004 is reported.

The category wastewater handling and discharge (5D) shows a contribution of 25% in 1990 and 19% in 2020 to total waste emissions and consequently a decrease of 12% between 1990 and 2020.

Overall, the emission from the waste sector increased by 14% between 1990 and 2020 and by 12% between 2019 and 2020, which is mainly due to an exceptionally high methane collection from landfills which occurred in 2019 and is further explained in 7.2.4.1.

Table 7.1 Emissions from the waste sector, [kt CO_2e]

		1990	1995	2000	2005	2010	2015	2019	2020
5A Solid waste disposal	CH_4	149.7	201.1	227.2	234.4	242.7	200.1	161.8	187.1
5B Biological treatment of solid waste	CH_4	NO	0.2	0.2	0.5	1.5	2.1	2.4	3.4
5B Biological treatment of solid waste	N_2O	NO	0.1	0.1	0.4	1.1	1.5	1.7	2.4
5C Incineration and open burning of waste	CH_4	6.1	4.2	2.6	0.4	0.4	0.3	0.4	0.1
5C Incineration and open burning of waste	N_2O	1.7	1.2	0.7	0.3	0.3	0.3	0.6	0.2
5C Incineration and open burning of waste	CO_2	7.3	4.9	2.7	4.7	5.9	6.5	8.4	5.8
5D Wastewater treatment and discharge	CH_4	50.0	53.8	62.9	58.8	39.4	44.6	41.9	42.0
5D Wastewater treatment and discharge	N_2O	4.6	4.9	5.1	4.7	5.2	5.4	5.9	6.0
5 E Other		NO	NO	NO	NO	NO	NO	NO	NO
5 Waste	**Total**	**219.4**	**270.4**	**301.6**	**304.3**	**296.4**	**260.9**	**223.2**	**247.0**

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 to 3.6 people per square km in 1970 and 2020 respectively)[24], 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)", "National Plan on Waste Treatment 2013-2024 (2013)" and "Towards a circular economy, the Minister of the Environment and Natural Resources policies on waste matters (2021)", all in Icelandic[25]. Figure 7.1 shows a summary of the most important developments from 1970-2020.

From 1970 to 1990 little or no waste management practises 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 SWDS in the 1970s and 1980s.

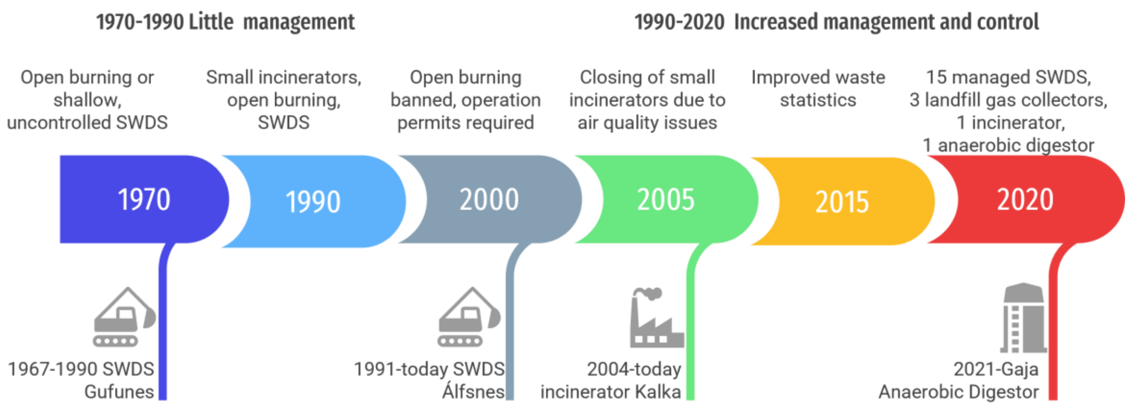


Figure 7.1 Timeline of the most important developments in waste management in Iceland from 1970

From 1990 onwards, the number of landfills 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 to achieve operational efficiency, creating fewer, but larger disposal sites. Composting, as a waste management practise, was started 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

[24] The Worldbank, population density, accessed 04/11/2021 https://data.worldbank.org/indicator/EN.POP.DNST?end=2020&locations=IS&start=1970

[25] The three reports can be accessed here: https://ust.is/graent-samfelag/urgangsmal/stefna-rikis-og-sveitarfelaga/landsaaetlun-um-urgang/

waste openly was the island of Grímsey, which stopped doing so in 2010. Only traditional New Year's Eve 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 have to report data on the amount of waste landfilled, incinerated and recycled.

In 2003 the law 55/2003 "On waste treatment" regulated waste management practices, together with three more specific regulations, regarding waste management, landfilling and waste incineration. Icelandic legislation regarding management of solid waste is in accordance with EU legislation. All activities connected to waste management are subject to environmental permits: special requirements are needed for waste operators regarding the collection, handling, and disposal of waste. The Environment Agency is responsible for giving operating permits, 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, D= Default.

CRF source		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
5C	Incineration and open burning			
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 1	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
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 Environment Agency of Iceland and the waste operators use the categories of the European Waste Statistics Regulation (WStatR) to communicate the waste amounts. The so communicated waste amounts are then translated to the waste categories as outlined in the 2006 IPCC Guidelines. Data about the recovery of methane is collected from the single operators running methane 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 through surveys and the treatment systems utilisation is collected by the Environment Agency of Iceland. 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, 2020 and the 1990-2020 trend in the Waste sector are as follows (compared to total emissions excluding LULUCF):

Table 7.3 Key source categories for Waste (excluding LULUCF).

IPCC source category		Level 1990	Level 2020	Trend
Waste (CRF 5)				
5A1 Managed Waste Disposal	CH4		✓	✓
5A2 Unmanaged Waste Disposal	CH4	✓		✓
5D2 Industrial Wastewater Treatment	CH4	✓		✓

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 Waste - - completeness (E: estimated, NE: not estimated, NA: not applicable, NO: not occurring).

	Direct GHG			Indirect GHG		
Waste (CRF 5A)	CO_2	CH_4	N_2O	NO_X	CO	NMVOC
Solid Waste Disposal (CRF 5A)						
Managed Waste Disposal Sites (CRF 5A1)	NA	E	NA	NE	NE	E
Unmanaged Waste Disposal Sites (CRF 5A2)	NA	E	NA	NE	NE	E
Uncategorised Waste Disposal Sites (CRF 5A3)	NO	NO	NO	NO	NO	NO
Biological Treatment of Solid Waste (CRF 5B)						
Composting (CRF 5B1)	NA	E	E	NE	E	NE
Anaerobic Digestion at Biogas Facilities (CRF 5B2)	NO	NO	NO	NO	NO	NO

	Direct GHG			Indirect GHG		
Waste Incineration and Open Burning of Waste (CRF 5C)						
Waste Incineration (CRF 5C1)	E	E	E	E[1]	E[1]	E[1]
Open Burning (CRF 5C2)	E	E	E	E[1]	E[1]	E[1]
Wastewater Treatment and Discharge (5D)						
Domestic Wastewater (CRF 5D1)	NA	E	E	NA[3]	NA[3]	NE[3]
Industrial Wastewater (CRF 5D2)	NA	E	IE[2]	NA[3]	NA[3]	NE[3]
Other (CRF 5E)	NO	NO	NO	NO	NO	NO

[1] Data also submitted under CLRTAP; [2]: Included in Domestic Wastewater (CRF 5D1); [3] 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.

N_2O emissions from Solid Waste Disposal Sites (CRF 5A1 and CRF 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 (CRF 5B1) are also not applicable since the 2006 IPCC Guidelines do not require their reporting. For the category Wastewater treatment and discharge (CRF 5D), both for Domestic and Industrial wastewater, the calculation of NOx 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 the one used to calculate the greenhouse gases (Tier 1). Therefore, these emissions are not estimated (NE).

7.1.6 Source Specific QA/QC Procedures

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 methane 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 methane 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 Environment Agency of Iceland (EA) compiles data on total amounts of waste generated since 1995. This data is published by Statistics Iceland (2020). The data for the time-period from 1995 to 2004 relies on assumptions and estimation and is less reliable than the data generated since 2005. Data from 2005-2014 was received from most operators according to the EWC (European Waste Catalogue) categorization. Smaller operators did not submit data on waste amounts during that period, so some gap-filling estimations were performed by experts at the Environment Agency. From 2014 the Environment Agency has received data according to the WStatR (Waste Statistic Regulation) categorization from all waste operators in Iceland. Data on methane 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, i.e. from 1990 to 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 EA 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.

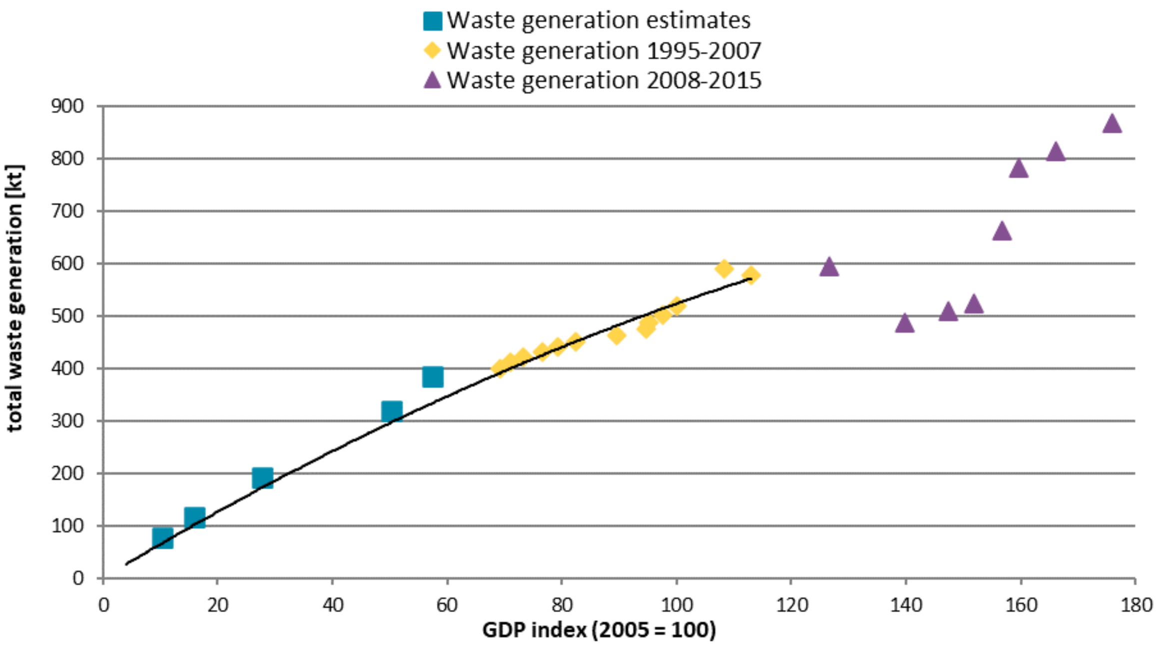


Figure 7.2 Correlation between waste generation and GDP index in Iceland used for waste generation estimates before 1995.

7.2.2.2 ***Waste allocation***

The data since 1995 described above, allocates fractions of waste generated to SWDS, incineration, recycling and composting. Recycling and composting began in 1995. For the time 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, i.e., Reykjavík plus 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 1990-2020 are shown in Figure 7.3 and Figure 7.4.

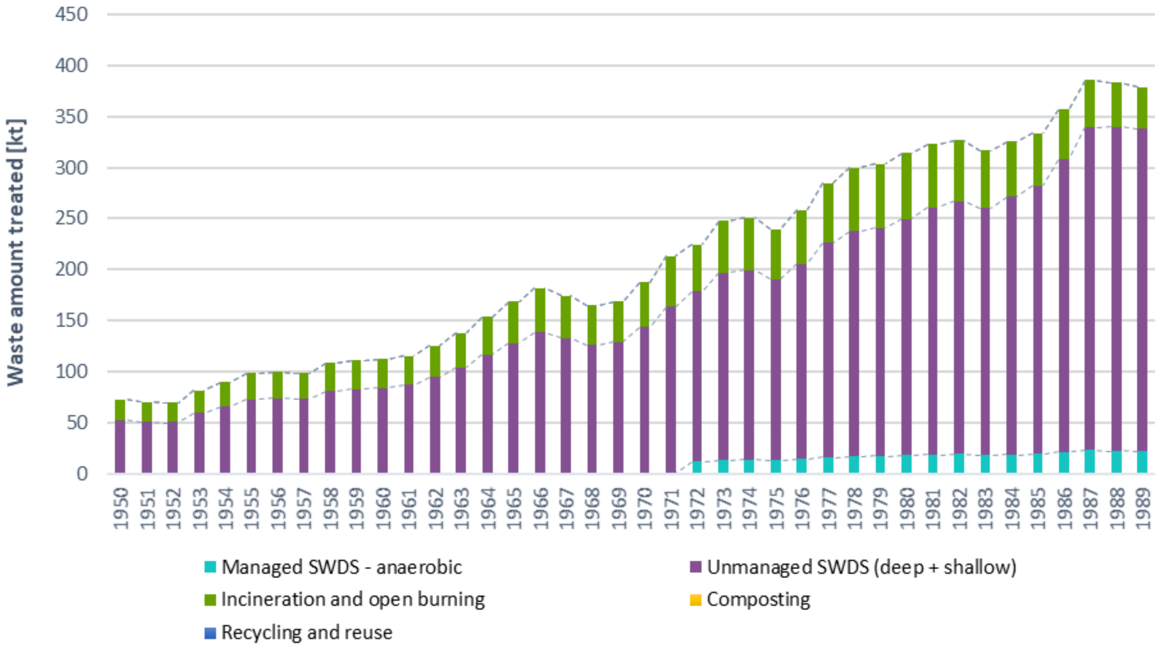


Figure 7.3 Waste amount and allocation to incineration/open burning, solid waste disposal, recycling and composting 1950-1989

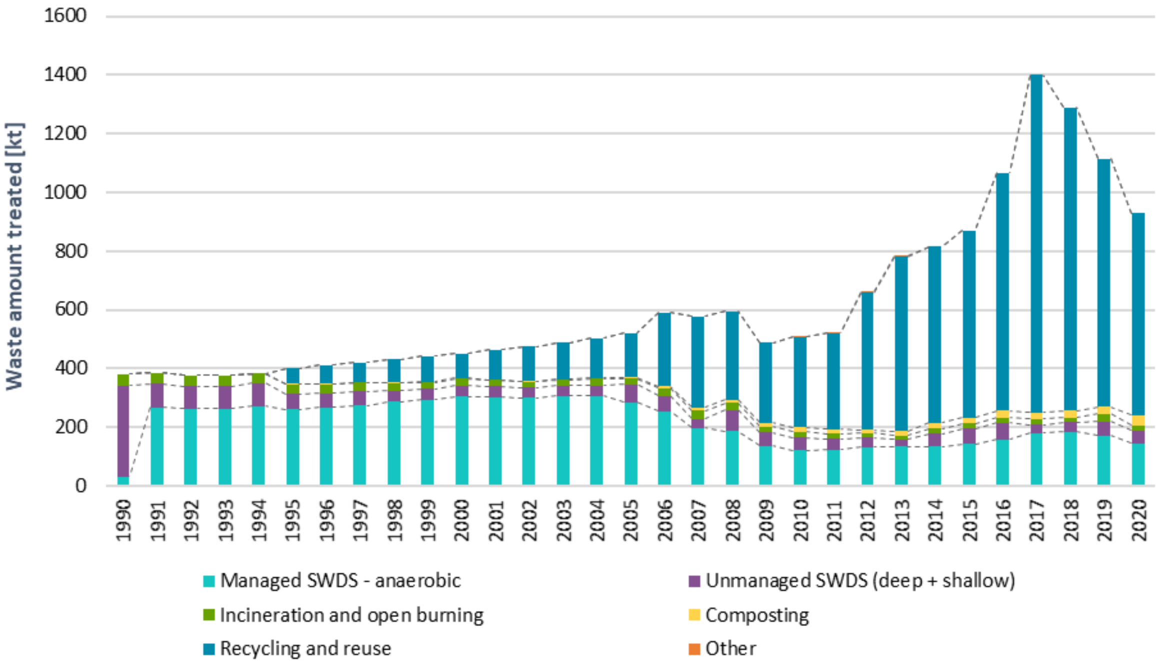


Figure 7.4 Waste amount and allocation to incineration/open burning, solid waste disposal, recycling and composting, since 1990.

In accordance with the 2006 IPCC Guidelines the amount of waste landfilled was allocated to one of three solid waste disposal site 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”).

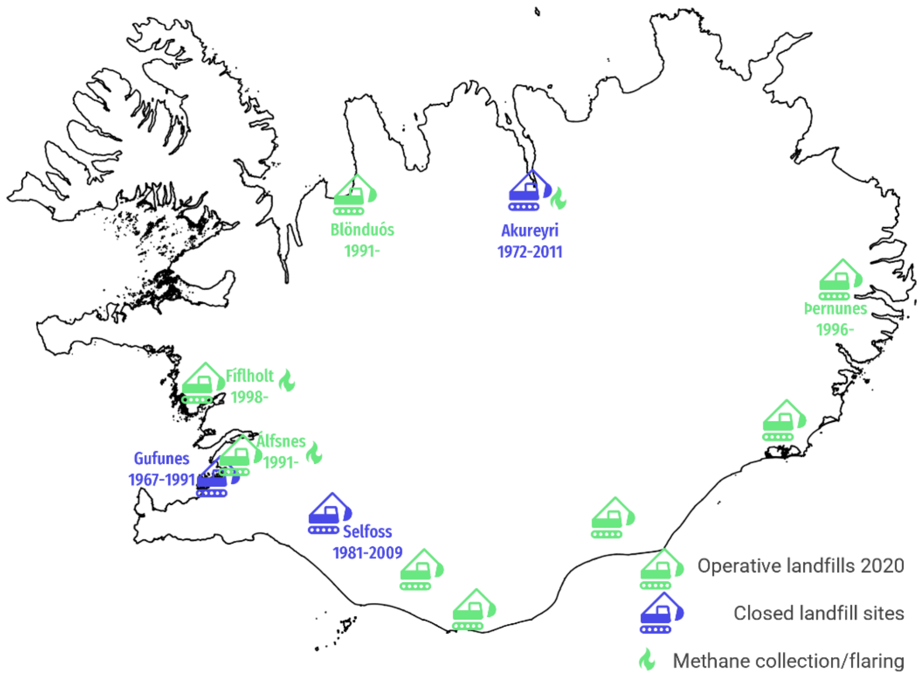


Figure 7.5 Main SWD sites in Iceland, operative in 2020 (green) and closed sites (blue). There are several other smaller sites which are still operative or dismissed.

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 down 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).
- 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 EA.

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. From 2005 onwards, actual waste amounts going to the five landfills classified as managed (Álfsnes, Akureyri, Selfoss, Fíflholt, Þernunes) are reported to the Environment Agency and the waste amount going to unmanaged landfills is estimated by subtraction from the total amount of waste landfilled. This can induce fluctuations over the years, as the data is now based on real reported data 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. Nowadays, however, all landfills are running with operation permits and this classification needs to be revised. At the moment, the inventory team has no basis and/or evidence to reclassify or adjust the existing unmanaged site classification.

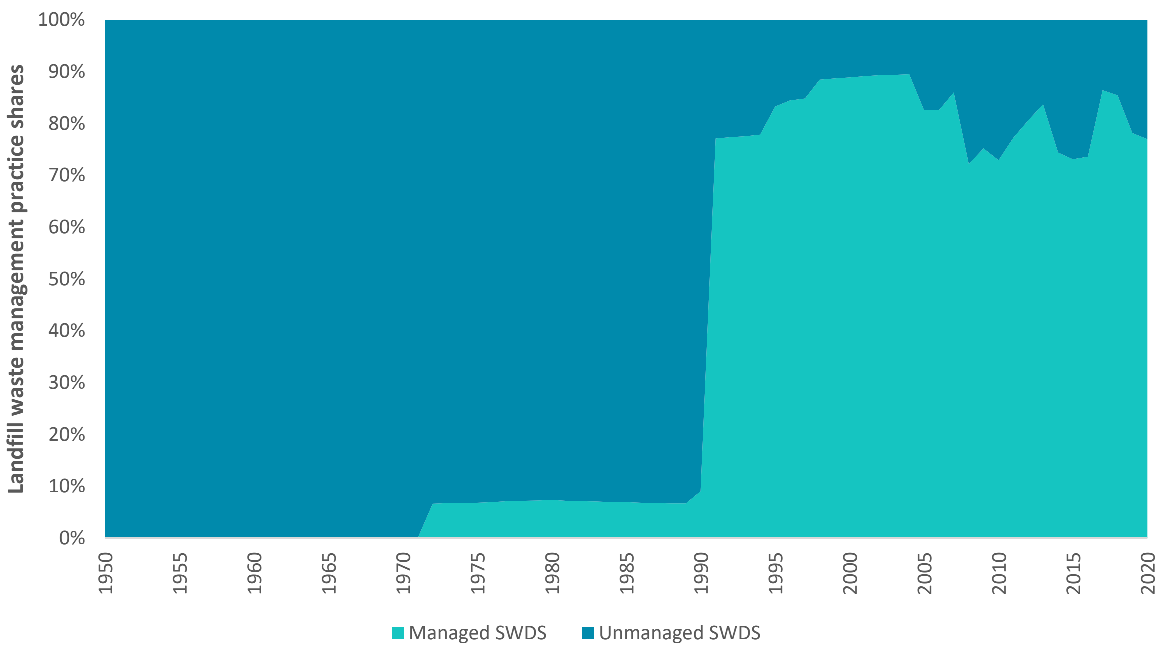


Figure 7.6 Waste management practice shares of total waste disposed of in managed and unmanaged SWDS.

7.2.2.3 *Waste categories*

From 2005 the Environment Agency of Iceland has gathered information on waste quantities and composition from waste operators. From 2005-2013 data was received from most operators according to the EWC (European Waste Catalogue) categorization. Smaller operators generally did not submit data during that period, so some estimations had to be done by experts at the Environment Agency.

From 2014 the Environment Agency has received data according to the WStatR (Waste Statistic Regulation) categorization from all waste operators in Iceland. 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 categorization level, the Environment Agency is required to transform the data so that it matches the IPCC categorization.

Current waste composition used for the emission estimates (i.e. used in the IPCC FOD models) are shown in Annex 9 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 subject to changes as streamlining of the WStatR to IPCC categorization processes have been revised for future submission.

Assumptions and explanations for specific waste category amount estimates

Since 2005 the EA 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 methane emissions from SWDS only. For purposes other than GHG emission estimation the EA 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, mixed waste from collection points, does not contain food waste. Therefore, the studies' fractions without their food waste fractions were used to attribute this category to the waste categories from the list. 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 EA 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 EA data does 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. For the time 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 amount 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 Environment Agency 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 Agency'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 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

Methane emissions from solid waste disposal sites 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 methane recovered is discussed in chapter 7.2.4.1. In order to calculate methane 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 methane generated.

Emission factors/parameters	Values
Degradable organic carbon in the year of deposition (DOC)	Table 7.7
Fraction of DOC that can decompose (DOCf)	0.5
Methane correction factor for anaerobic decomposition (MCF)	Table 7.8
Oxidation factor (OX) for SWDS	0.1
Fraction of methane in generated landfill gas (F)	0.5
Molecular weight ratio CH_4/C	16/12 (=1.33)
Methane 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), methane generation rate (k) and half-life time in years ($t_{1/2}$ for each waste category.

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	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 (DOCf), as well as the methane correction factor, results in the mass of decomposable DOC deposited annually (DDOCm).

The default methane correction factors for types of SWDS account for the fact that unmanaged and semi-aerobic SWDS produce less methane 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) no methane 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 methane 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 methane 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 three sites in Iceland: Álfsnes, the biggest landfill in Iceland, serving the capital area since 1996, Glerárdalur (Akureyri), a SWDS situated in the North of the country, which is not used for landfilling anymore, and Fíflholt, a landfill serving all the Western part of the country and collecting methane since 2019. Figure 7.5 shows the location of the SWDS with methane 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 European Pollutant Release and Transfer Register (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 methane 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. Methane has been collected at Fíflholt since 2019 and all the gas is burned in a burner on site. Information about the amount of methane collected and burnt is retrieved from the company, Sorpurðun Vesturlands, through their environmental reporting obligations.

Landfill gas is converted to methane using a methane fraction of 54% which is based on regularly performed measurements. Methane volume is converted to methane mass assuming standard conditions (0.717 kg at 0°C and 101.325 kPa) and 95% purity.

From 1996 until 2001 recovered methane 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 methane 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 gives an overview of the annual methane amounts by utilization. There is currently a discrepancy between the values reported under the Energy sector, retrieved from the National Energy Authority, 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 harmonize these numbers for the 2023 submission and check which version is the correct one.

As can be seen in Figure 7.7, methane 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 methane decreased, and the collection amount was reduced again (information from SORPA ltd, e-mail).

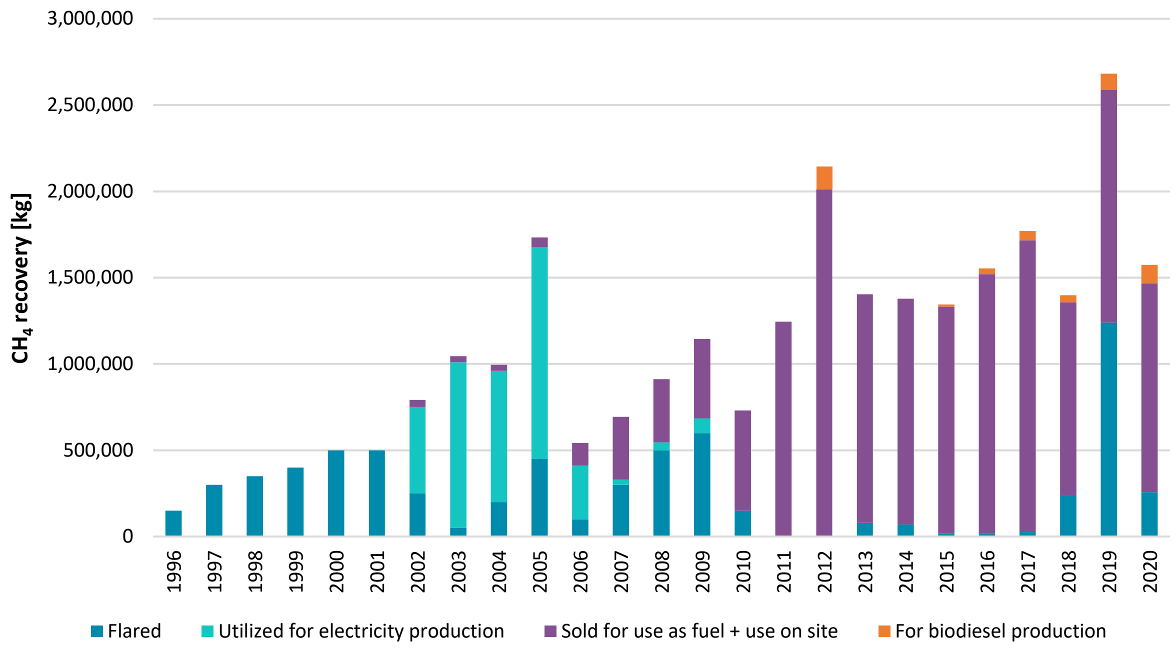


Figure 7.7 Methane recovery (CRF 5A1a) at Álfsnes, Glerárdalur and Fíflholt (since2019) SWDS's [kg CH_4].

7.2.4.2 *Methane emissions*

In 1990 methane emissions from SWDS amounted to 6 kt CH_4 and increased to 10.6 kt in 2006. Since 2006 they decreased again, reaching 7.5 kt CH_4 in 2020. This equals an increase of 25% between 1990 and 2020.

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 methane 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 fraction of CH_4 emissions from managed SWDS amounted to only 11% of all SWDS emissions, whereas the fraction of emissions from unmanaged SWDS accounted for 89%. This trend has been reversed since then and in 2020 90% 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: since 2003 the amount of waste landfilled is decreasing rapidly and an increasing amount of waste is recycled. 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 methane.

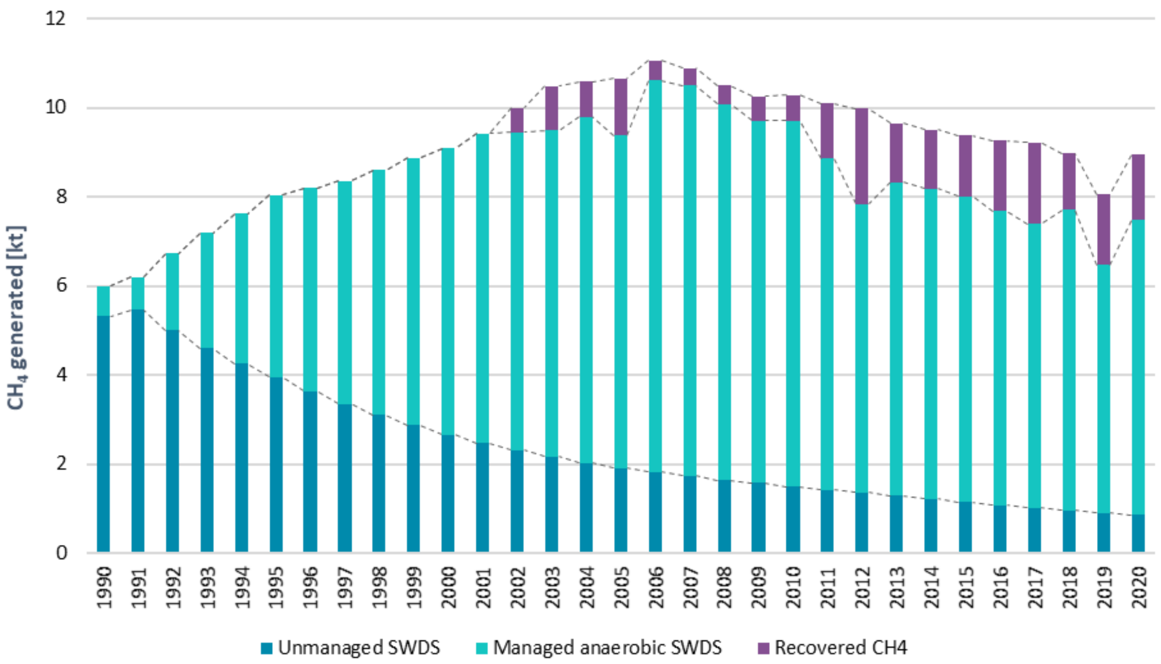


Figure 7.8 Methane generation estimates and recovery from Solid Waste Disposal sites since 1990.

7.2.5 Uncertainties

Activity data uncertainty for managed solid waste disposal sites was calculated based on Table 3.5, chapter 3, volume 5 of the 2006 IPCC Guidelines and is 52%, while for unmanaged waste disposal sites it is slightly higher at 52.2%. 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 42.72% and 41.23%, respectively for managed and unmanaged SWDS.

The combined uncertainty between activity data and emission factor is 67.3% for managed solid waste disposal sites (5A1) and 66.5% for unmanaged solid waste disposal sites (5A2). The complete uncertainty analysis is shown in Annex 2.

7.2.6 Recalculations

For the current submission there was a recalculation for the year 2019 as the methane collection on the SWDS Fíflholt in Western Iceland was added. This led to a decrease of CH_4 emissions for the year 2019 of 0.04 kt, or by 0.75% as can be seen in Table 7.9.

Table 7.9 Recalculation in the sector 5A1 due to the addition of methane collection at one SWDS site.

[kt CH_4]	2018	2019
2021 v1 submission	6.763	5.619
2022 submission	6.763	5.577
Change relative to 2021 submission	0.00%	-0.75%

7.2.6.1 *Recalculations performed between 2020 and 2021 submission*

Between the 2020 and 2021 submission there have been two major changes, pointed out during the 2020 EU Comprehensive Review:

- Application of an oxidation factor for all SWDS of 0.1 instead of 0. According to Icelandic regulation nr. 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 the majority of landfills use a combination of soil and wood chips as cover material, except for a few exceptions which use sand and gravel. Therefore, an oxidation factor of 0.1 is more appropriate.
- The DOC value for Industrial waste was found not to be appropriate. This category was reviewed and now comprises: (1) non-hazardous residues from waste treatment and (2) mixed construction and demolition waste. Therefore, the average share of the categories between 2014-2018 of total industrial waste going to managed SWDS was calculated (72% non-hazardous residues from waste treatment, 28% mixed construction and demolition waste) and used to estimate the amount of waste going to SWDS in each category in 2005. Then the shares of each category were multiplied with the appropriate DOC (Table 2.5 from the IPCC Guidelines) to calculate a weighted DOC for managed industrial waste: $(72\% \cdot 0.15) + (28\% \cdot 0.04) = 0.1195$. The DOC value was therefore changed from 0.15 (2020 submission) to 0.1195 for managed industrial waste leading to recalculations. Only category (2) is present in unmanaged waste, and therefore the default DOC for construction and demolition waste (DOC=0.04) is used for all unmanaged industrial waste.

7.2.7 Planned Improvements

It is planned to review the classification of landfills into managed and unmanaged sites and increase the detail of information on landfill gas utilization. A request to the data provider for the Energy sector, the National Energy Authority, has been sent out, since more research is necessary to confirm which datasets are correct. Consequently, the inconsistency between the reporting of landfill gas between the Energy and the Waste sector can be tackled for the 2023 submission.

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

CH4 emissions from biological treatment

$$CH_4Emissions = \sum_i (M_i \times EF_i) \times 10^{-3} - R$$

Where:

- $CH_4Emissions$ = 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

$$CH_{4,leakage} = CH_{4,production} \times C \times Frac_{leakage}$$

Where:

- $CH_{4,leakage}$= emissions from anaerobic digestion, [Nm^3]
- $CH_{4,production}$ = 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 Environment Agency of Iceland. Therefore, the amounts composted from 1995-2004 are estimated to be between 2 and 3 kt. Since 2005 this amount has increased by roughly 2 kt per year and was 34 kt in 2020. The collected data refers to wet weight and is transformed to dry matter as can be seen in Table 7.10.

Table 7.10 Waste amounts composted since 1990, data reported to EA on a wet basis and transformed to dry matter.

	1990	1995	2000	2005	2010	2015	2019	2020
Waste amount composted - wet [kt]	NO	2	2	5	15	21	24	34
Waste amount composted – dry [kt]	NO	1	1	2	6	21	10	14

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 7.11 Activity data from anaerobic digestion of organic waste in 2020.

	2020
Waste amount sent to anaerobic digestion at biogas facilities - wet [kt]	0.77
Waste amount sent to anaerobic digestion at biogas facilities – dry [kt]	2.31
Biogas production [Nm^3]	55,400
CH_4 production [Nm^3]	35,000

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 for wet weight are used as reported in Table 7.12.

Table 7.12 Tier 1 emission factors for CH_4 and N_2O from the 2006 IPCC Guidelines

CH_4	4 [g/kg wet weight]	Table 4.1 2006 IPCC Guidelines
N_2O	0.24 [g/kg wet weight]	Table 4.1 2006 IPCC Guidelines

CH_4 emissions from anaerobic digestion at biogas facilities are calculated by multiplying the amount 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

CH_4 emissions from composting amounted to 0.14 kt CH_4 or 3.4 kt CO_2e in 2020. N_2O emissions amounted to 0.008 kt N_2O or 2.4 kt CO_2e in 2020. The mass of waste composted and emission trend since 1990 is shown in Figure 7.9.

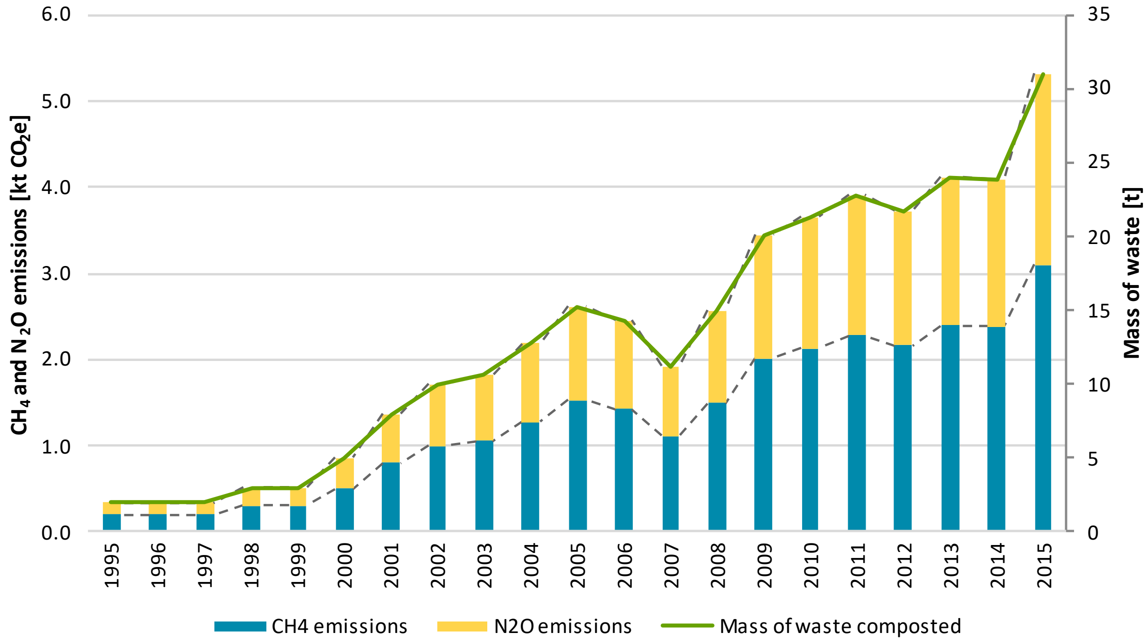


Figure 7.9 Mass of waste (wet) composted and estimated CH_4 and N_2O emissions [kt CO_2e]

CH_4 emissions from anaerobic digestion at biogas can be seen in Table 7.13. Emissions reported here under the waste sector relates to the estimated CH_4 as leakage from the facility ($FRAC_{leakage}$) component only. Any emissions that result downstream due to onward use of the produced biogas for energy generation are accounted for in the energy sector. In this sense, the biogas / CH_4 produced (Table 7.11) acts as activity data for the energy sector where it is utilised rather than being released directly.

Table 7.13 Methane emissions from anaerobic digestion at biogas facilities in 2020

	2020
CH_4 emissions [kt]	0.0013
CH_4 emissions [kt CO_2e]	0.031

7.3.5 Uncertainties

Uncertainty for emissions from composting was calculated using value ranges from the 2006 Guidelines (Table 4). 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.

7.3.6 Recalculations

No recalculations were done for the 2022 submission for biological treatment of solid waste.

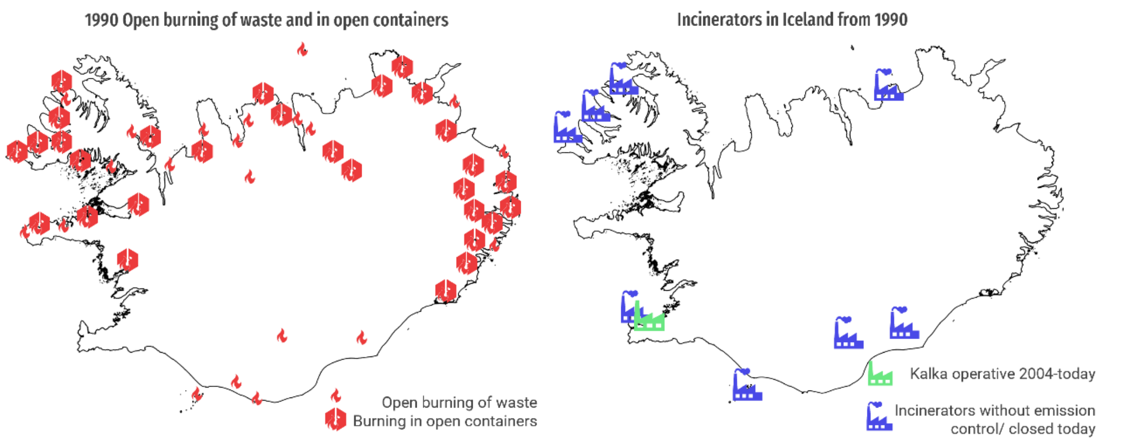
7.3.7 Planned Improvements

Emissions from the new anaerobic facility, GAJA, have been estimated for the first time in this submission. Facility level data has been used to understand the biogas and CH_4 output from the plant. The biogas is utilised 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 in reality. We intend 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 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 (ER) 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 kt CO_2e in 2020.

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.

Methane and nitrous oxide 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 EMEP/EEA air pollutant emission inventory guidebook 2019.

7.4.2 Activity Data

7.4.2.1 *Waste Incineration (5C1)*

Currently, there is only one active incinerator in Iceland, operative since 2004. The amount of waste incinerated there is reported yearly to the EA 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 (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 bonfires, are shown in Figure 7.10.

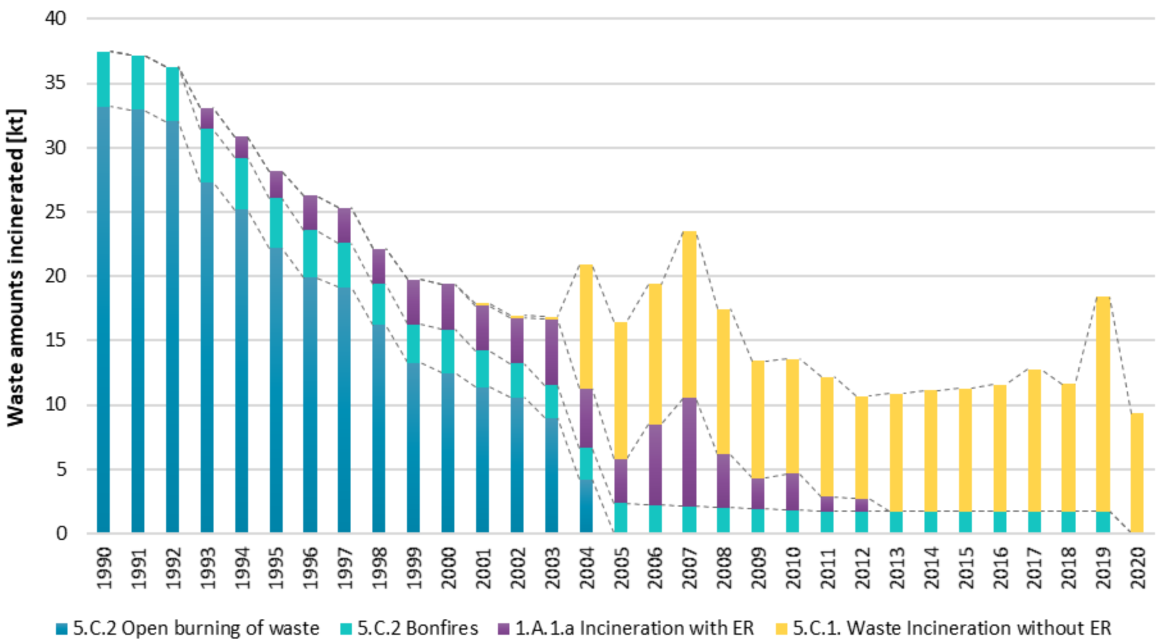


Figure 7.10 Amounts of MSW waste incinerated with and without energy recovery, burned openly and amount of wood burned in bonfires 1990-2020.

7.4.2.2 *Open burning of waste and bonfires (5C2)*

The following types of incineration are accounted for under this category:

- Open burning of waste in open pits and concrete containers (see info box in the beginning of 7.4)
- Waste burned in incinerators without satisfactory air pollution and temperature control
- New Year's Eve bonfires

The amount of waste burned openly is estimated using information on population in municipalities that were known to utilize 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 bonfires which are celebrated all around the country. After stricter regulations and inspections of bonfires were adopted around the year 2000, their number has significantly decreased, the bonfires have become smaller, and only unpainted wood is allowed to be used. In 2010 the Environment Agency 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 Environment Agency, 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, due to the COVID-19 pandemic, public gatherings were not allowed and therefore, no bonfires occurred. Therefore, this activity is reported as “NO” for 2020, as can be seen in 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 yearly 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, public gatherings were banned due to the COVID-19 pandemic and no bonfires were held on New Year’s Eve.

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 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, 2006 Guidelines defaults of 1 for waste incineration (= 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 exemplary for the year 2020 in Table 7.14.

Table 7.14 Calculation of non-biogenic CO_2 emissions from incineration in 2020 (for all incineration subcategories under 5C).

	Mass of incinerated waste [t]	Fraction of incinerated waste	(f) Dry matter	(f) Carbon in dry matter	(f) Fossil carbon in total carbon	CO_2 emissions [t/yr]
Paper	1,450	0.13	0.9	0.46	0.01	22
Textiles	304	0.03	0.8	0.5	0.2	89
Wood	1,961	0.18	0.85	0.5	0	0
Garden	NO	NO	0.4	0.49	0	0
Diapers	561	0.05	0.4	0.7	0.1	58
Food	2,826	0.25	0.4	0.38	0	0
Inert	433	0.04	0.9	0.03	1	43
Plastics	1,742	0.16	1	0.75	1	4,790
Hazardous	971	0.09	0.5	NA	0.275[1]	490[2]
Clinical	412	0.04	0.65	NA	0.25[1]	246[2]
Rubber	46	0.004	0.84	0.67	0.2	19
Sludge plus manure	2	0.0002	0.4	0.45	0	0
Industrial solid waste	446	0.04	0.4	0.38	0	0
Sum	**11,153**	**1.00**				**5,757**

[1] These numbers are the fraction of fossil carbon in waste, 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, dry matter fraction, fraction of fossil carbon in waste and converting from C to CO_2.

The input for individual years from 2005 to 2011 differs from Table 7.14 in the distribution of waste category fractions and total waste amount incinerated. For the time period from 1990-2004 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 Guidelines. They differ between incineration and open burning of waste. Emission factors for NO_x, CO, and NMVOC are taken from the EMEP/EEA air pollutant emission inventory guidebook (EEA, 2019), chapter 5.C.1.a: Municipal waste incineration, 5.C.1.b: Industrial waste incineration including hazardous waste & sewage sludge, 5.C.b.iii: Clinical waste incineration and 5.C.2: Open burning of waste. Emission factors used for these GHG are shown in Table 7.15.

Table 7.15 Emission factors (EF) for incineration and open burning of waste. All values are in g/tonne wet waste except were indicated otherwise.

GHG	CH_4	N_2O		NO_x	CO	NMVOC	SO_x
Incineration (MSW) EF	237	60	With abatement technology	1,071	41	5.9	87
			With little or no abatement technology	1,800	700	20	1,700
Incineration (ISW, hazardous) EF	237	100	With abatement technology	1,071	41	5.9	87
			With little or no abatement technology	NA	NA	NA	NA
Incineration (hazardous) EF	237	100	With abatement technology	870	70	7,400	47
			With little or no abatement technology	NA	NA	NA	NA
Incineration (clinical) EF	237	100	With abatement technology	1,800	180	700	451
			With little or no abatement technology	1,800	1,500	700	1,100
Open burning EF	6,500	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. Total GHG emission estimates have decreased from 15.1 kt CO_2e in 1990 to 6 kt CO_2e in 2020. 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. CH_4 emissions from waste incineration and open burning have decreased from 6.1 kt CO_2e in

1990 to 0.07 kt CO_2e in 2020 and N_2O emissions have decreased from 1.7 kt CO_2e in 1990 to 0.22 kt CO_2e in 2020.

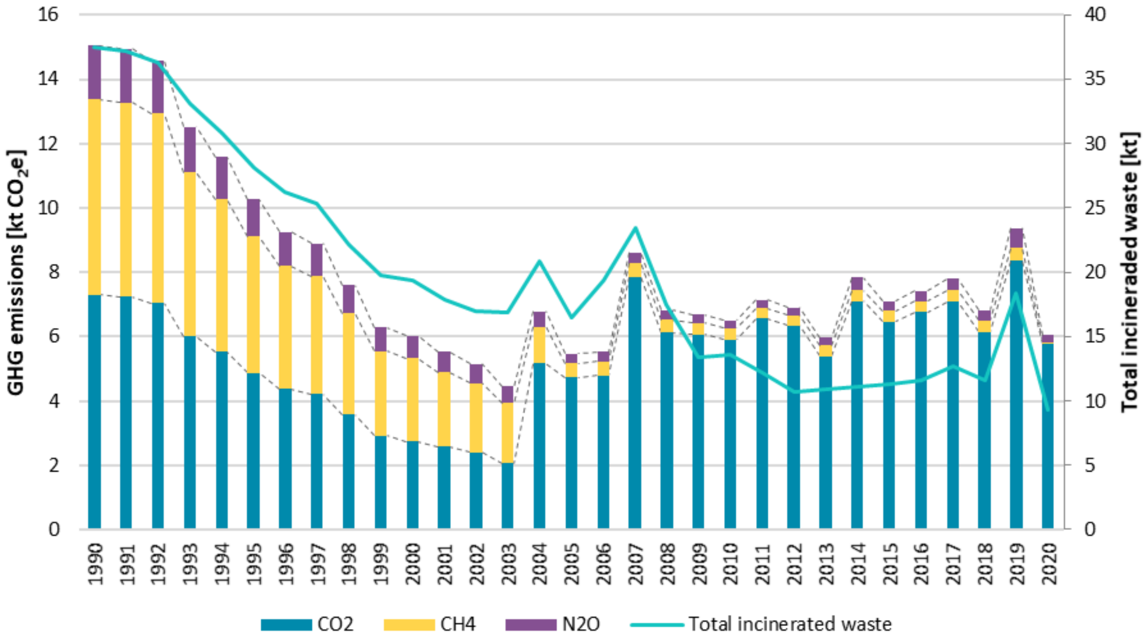


Figure 7.11 Emission estimates from incineration and open burning of waste since 1990

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 65.6%.

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 ±112.7% (100% for emission factor and 52% for the activity data). The complete uncertainty analysis is shown in Annex 2.

7.4.6 Recalculations

No recalculations were performed for the current submission.

7.4.7 Planned Improvements

No specific improvements are planned for waste incineration and open burning.

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 the year 2002, some smaller municipalities have taken up secondary treatment of wastewater. This involves aerobic treatment, secondary settlement, and removal of sludge. In eastern Iceland one of these wastewater facilities is in the process of attempting to use sewage sludge as fertilizer. Therefore, the removed sludge is filled into ditches for break down.

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 methane emissions from wastewater in Icelandic, 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 nitrous oxide emissions from the wastewater. Total CH_4 and N_2O emissions from wastewater amounted to 48 kt CO_2e in 2020. Compared to 1990 emissions of 55 kt CO_2e this is a decrease of 12%.

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 methane 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, kg biochemical oxygen demand (BOD) 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). Between 1990 and 2020 annual TOW increased proportionally to population from 5.6 kt to 7.9 kt.

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 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 since emissions from industrial wastewater are calculated separately)

Table 7.16 provides information on activity data used to estimate emissions from wastewater treatment and discharge in Iceland.

Table 7.16 Information on population, protein consumption and total organic matter in domestic wastewater since 1990.

	1990	1995	2000	2005	2010	2015	2019	2020
Population [n]	253,785	266,978	279,049	293,577	317,630	329,100	356,991	366,747
Protein consumption [kg/person/yr]	37.2	37.2	37.2	32.9	32.9	32.9	32.9	32.9
Total organic matter [kt BOD/yr]	5.6	5.8	6.1	6.4	7.0	7.2	7.8	8.0

Industrial wastewater

Activity data for emissions from domestic wastewater treatment and discharge consists of the annual amount of total organics in wastewater. Total organics in industrial wastewater (TOWi) are calculated using Equation 6.6 of the 2006 IPCC Guidelines. In the equation, the annual amount of TOWi is a product of the total industrial product for industrial sector i, wastewater generated and kg chemical oxygen demand (CODi).

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 BOD/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 biggest industry in Iceland which produces organic wastewater is fish processing. The default COD_i value for fish processing, 2.5 kg/m^3 (Table 6.9 of the 2006 IPCC Guidelines), was used. For fish processing W_i is 13 m^3/t product. Table 7.17 provides information on activity data used to estimate emissions from industrial wastewater treatment and discharge in Iceland. Activity data on the number of processed fish was only available from 1992 and onwards. Therefore, the number for 1990-1991 was estimated based on the average of the years 1992-1995.

Table 7.17 Information on fish processing and organic matter in industrial wastewater since 1990.

	1990	1995	2000	2005	2010	2015	2019	2020
Processed fish [kt]	1371.1	1376.4	1704.7	1253.8	729.4	1104.9	877.6	978.3
COD generated [kt COD/yr]	44.6	44.7	55.4	40.7	23.7	35.9	28.5	31.8

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 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

The fraction of nitrogen in protein, factor for non-consumed protein added to wastewater, and factor for industrial and commercial co-discharged protein are 2006 Guidelines defaults and are shown in Table 7.18.

Table 7.18 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 (Steingrímsdóttir, Þorgeirsdóttir, & Ólafsdóttir, 2002; Þorgeirsdóttir, et al., 2012) 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 further 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 was multiplied with a literature value of 2% (N content of domestic septage (McFarland, 2000).

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 methane correction factor (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 = methane correction factor (fraction)

The default maximum CH_4 production capacity (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 7.19 along with respective shares of total wastewater discharge and MCFs.

Table 7.19 Wastewater discharge pathways fractions of MSW and population of Iceland since 1990.

		MCF	I	1990	1995	2000	2005	2010	2015	2019	2020
Not known		0.5	1.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Collected - untreated systems	Not known sea, river, lake	0.1	1.25	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02
	No treatment	0.1	1.25	0.75	0.72	0.49	0.31	0.22	0.23	0.23	0.23
Collected - treated systems	Primary treatment	0.1	1.25	0.02	0.03	0.26	0.39	0.57	0.50	0.50	0.50
	Secondary treatment	0.0	1.25	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
	Tertiary treatment	0.0	1.25	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Uncollected Septic tank	Urban	0.5	1.00	0.03	0.05	0.05	0.09	0.06	0.00	0.00	0.00
	Rural	0.5	1.00	0.20	0.20	0.20	0.20	0.12	0.22	0.22	0.22
Population				253,785	266,978	279,049	293,577	317,630	329,100	356,991	364,134

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 methane from wastewater is recovered in Iceland.

Industrial wastewater

The CH_4 emission factor for industrial wastewater is a function of the maximum CH_4 producing capacity (Bo) and the methane correction factor (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 = methane correction factor (fraction)

The default maximum CH_4 production capacity (B_O) for industrial wastewater, 0.25 kg CH_4/kg COD, was applied (2006 IPCC Guidelines). Eight wastewater discharge pathways exist in Iceland. They are shown for industrial wastewater in Table 7.20 along with the respective shares of total wastewater discharge and MCFs.

Table 7.20 Wastewater discharge pathways fractions for industrial wastewater since 1990.

		MCF	1990	1995	2000	2005	2010	2015	2019	2020
Not known		0.5	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Collected - untreated systems	Not known sea, river, lake	0.1	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.06
	No treatment	0.1	0.94	0.90	0.61	0.39	0.25	0.22	0.22	0.22
Collected - treated systems	Primary treatment	0.1	0.02	0.04	0.33	0.49	0.65	0.70	0.70	0.70
	Secondary treatment	0.0	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
	Tertiary treatment	0.0	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Uncollected Septic tank	Urban	0.5	0.04	0.06	0.06	0.11	0.07	0.00	0.00	0.00

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 methane, 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

7.5.4.1 *Methane*

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 methane emissions.

Domestic wastewater

The correlation between biochemical oxygen demand and methane emissions from domestic wastewater discharge can be seen in Figure 7.12. CH_4 emissions from domestic wastewater were at their highest in 2009, when they reached 1.02 kt. The significant drop in emissions after 2009 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.

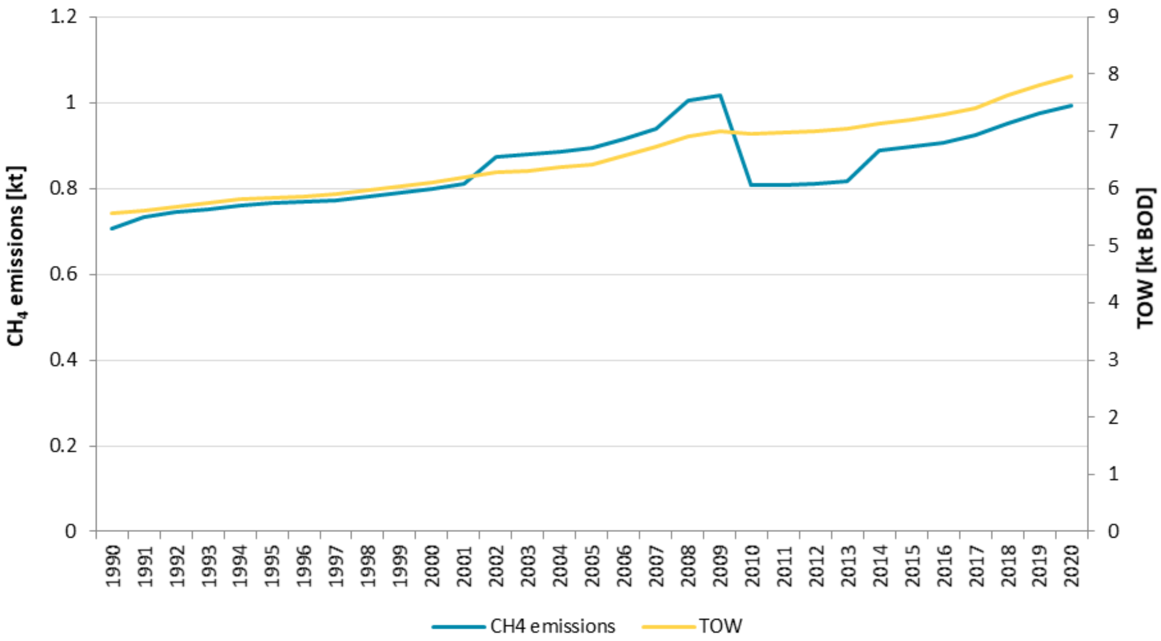


Figure 7.12 Methane emissions and total organics in domestic wastewater in Iceland since 1990.

Industrial wastewater

The correlation between chemical oxygen demand and methane emissions from industrial wastewater discharge 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 because of 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***

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). Table 7.21 shows the amount of sludge removed and $N_{EFFLUENT}$ calculated using Equation 6.8 from the 2006 Guidelines. Emissions from sludge removed are accounted for in CRF categories 5.A.1.a Managed waste disposal sites and 5.C.1.1.b.iv Waste incineration - biogenic - other - sewage sludge, and under the Agriculture sector, CRF category 3.D.1.2.b Organic fertilizers applied to soils-sewage sludge.

Table 7.21 Amount of sludge removed and N in effluent.

	1990	1995	2000	2005	2010	2015	2019	2020
Sludge removed [kt DC]	6.0	5.5	6.0	4.9	3.9	3.3	2.9	3.3
N in effluent [kt N/year]	2.0	2.1	2.2	2.0	2.2	2.3	2.5	2.6

The resulting emissions are shown in Figure 7.14. Emissions rose from 0.015 kt in 1990 to 0.02 in 2020, or by 32%. The main driver behind this development was a 43% 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).

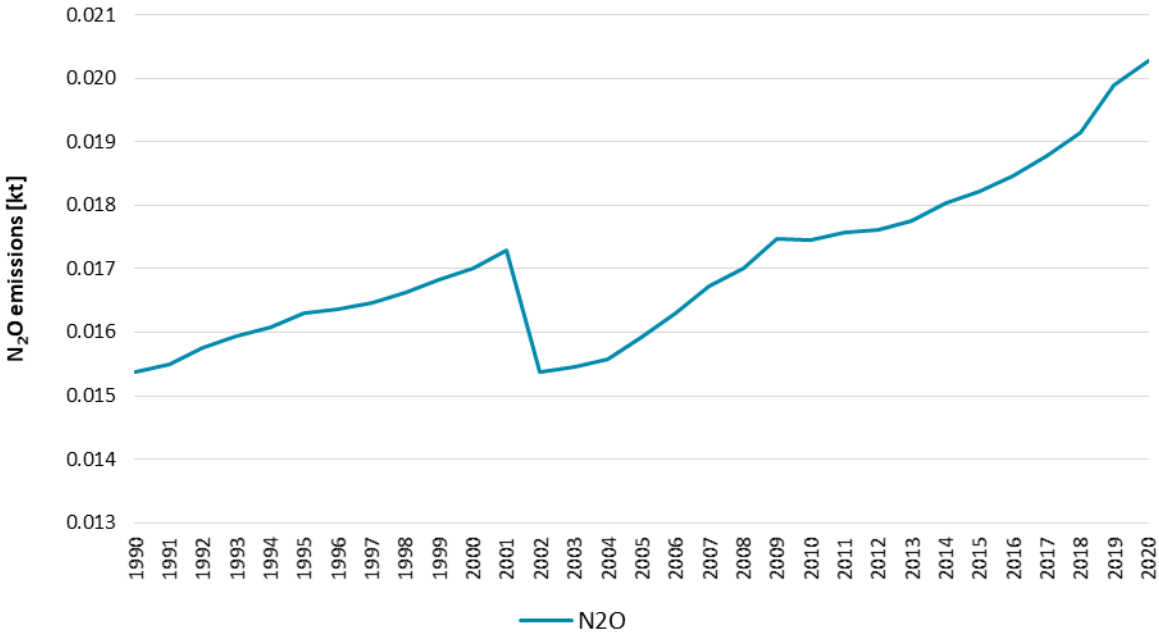


Figure 7.14 Emission estimates for N_2O from wastewater effluent since 1990.

7.5.5 Uncertainties

The activity data uncertainty of domestic wastewater was calculated to be 58.8% for CH_4 emissions and the emission factor uncertainty is 58.3% based on values from Table 6.7 of the 2006 IPCC Guidelines (Volume 5, chapter 6). The combined uncertainty is, therefore, 83%. The activity data uncertainty of industrial wastewater was calculated to be 38.7% for CH_4 emissions and the emission factor uncertainty is 58.3% 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 59% 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 2496%. 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.

7.5.6 Recalculations

For the current submission, the sewage sludge used in Agriculture for land restoration purposes (CRF 3.D.1.2.b) 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 as can be seen in Table 7.22. Sewage sludge has been used as a fertilizer since 2012. N_2O emissions are reduced on average by 0.15%.

Table 7.22 Recalculations for amount of sludge removed and N_2O emissions.

Sludge removed [kt DC]	2012	2013	2014	2015	2016	2017	2018	2019
2021 v1 submission	3.45	3.45	3.04	3.18	2.79	2.85	3.46	2.35
2022 submission	3.63	3.69	3.16	3.28	2.98	3.12	5.40	2.94
Change relative to 2021 submission	5%	7%	4%	3%	7%	9%	56%	25%
N_2O emissions [kt]								
2021 v1 submission	0.01763	0.01776	0.018044	0.01822	0.01847	0.01879	0.01927	0.01993
2022 submission	0.01762	0.01775	0.018036	0.01821	0.01846	0.01878	0.01915	0.01990
Change relative to 2021 submission	-0.06%	-0.08%	-0.04%	-0.03%	-0.06%	-0.09%	-0.63%	-0.19%

7.5.7 Planned Improvements

The industrial wastewater category is calculated at the moment only for fish processing on land. It is planned to research this topic further and add more industries, if applicable.

A new survey on the diet of people in Iceland has been conducted and will be published in spring 2022 according to the Directorate of Health. This information will be collected and added to the inventory.

8 Other (CRF sector 6)

Iceland has no activities and emissions to report under the CRF sector 6.

9 Indirect CO_2 and Nitrous Oxide 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, we 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

A recalculation file was used for this submission. This QAQC file compares emissions from all GHG for year x-3 (2019) and the base year (1990) as reported in the current and in the previous submission. The file is set up to enable any changes in the data to be easily identified and justifications for changes provided where required. The file calculates the actual difference between the current and previous submission. If one or both values are notation keys, and are not the same in both submissions, then this is highlighted. If the values in both submissions are numeric but not equal, then the difference in submissions as a percentage of the current submissions is also shown and the cells are highlighted for ease of reference. Sectoral experts include an explanation for recalculations for each subsector where a difference is highlighted.

The Icelandic 2022 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, or issues detected by the sectoral experts.

Table 10.1 and Table 10.2 show the difference between the total emissions in the 2022 submission and the 2021 submission, without and with emissions from the LULUCF sector. Explanations for the differences are given in Chapter 10.3 Sector-specific Recalculations.

Table 10.1 Total emissions according to the 2022 submission compared to the 2021 submission, [kt CO_2e] - without LULUCF.

Inventory year	2021 submission	2022 submission	Change [kt]	Change [%]
1990	3,683	3,674	-8	-0.23
1995	3,513	3,506	-7	-0.20
2000	4,127	4,119	-7	-0.18
2005	4,023	4,019	-4	-0.10
2010	4,866	4,865	-1	-0.03
2015	4,764	4,746	-18	-0.38
2018	4,822	4,847	25	0.51
2019	4,722	4,713	-9	-0.20

Table 10.2 Total emissions according to the 2021 submission compared to the 2020 resubmission, [kt CO_2e] - with LULUCF.

Inventory year	2021 submission	2022 submission	Change [kt]	Change [%]
1990	12,875	12,873	-2	-0.01
1995	12,674	12,681	7	0.06
2000	13,311	13,314	3	0.02
2005	13,256	13,251	-5	-0.04
2010	14,160	14,061	-99	-0.70
2015	13,966	13,853	-113	-0.81
2018	13,928	13,863	-65	-0.47
2019	13,794	13,733	-61	-0.44

10.2 Most recent eviews

10.2.1 EU review 2021

In 2021 the Icelandic inventory underwent the yearly "EU step 1 review checks"[26]

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 (525/2013) can form the basis for the determination of the ESD emissions (Effort Sharing Decision No 406/2009/EC).

10.2.2 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.

10.2.3 EU Review 2022

In February 2022 the inventory underwent the yearly EU step 1 review checks. All questions were answered and addressed, and appropriate changes were made for the 15 march submission.

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 2021 and the 2022 submission amounting to -6.3 kt CO_2e for the year 2019 and -13.5 kt CO_2e for the year 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). Two main reasons caused these recalculations:

[26] cf. Art. 29, Commission Implementing Regulation (EU) 749/2014

- Activity data for international navigation, domestic navigation and fishing for 1990-1994 was revised by the NEA. This resulted in more fuel being allocated to international navigation and fishing, and less to domestic navigation.
- Activity data for 1A2e Food processing, beverages and tobacco (fishmeal factories) for the years 2003-2006 was reallocated by the NEA. This did not cause reacalculations for the energy sector, only for diffrent subsectors.
- Emission factor for N_2O from road transport was changed in version 5.4.52 of COPERT.

10.3.2 Industrial Processes and Products Use (CRF sector 2)

Recalculations were performed for the IPPU sector for this submission in the following subsectors:

- 2C2, Ferroalloys Production, for the year 2019 two recalculations were made. The first is due to the industry starting to use microsilica to reduce CO_2 emissions. That was not accounted for in the last submission and it only effects emissions in 2019. The second recalculation concerns methane emissions and is due to human error in the emission estimation files.
- 2D2, Paraffin was use, 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.
- 2D3, Other non-energy products from fuels and solvent use, recalculation 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.
- 2F1, Refrigeration and air conditioning, there were three recalculations. One is a minor one due to updated activity data about number of reefers from one logistic 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.
  The lifetime of transport refrigeration equipment on fishing vessels was 7 years in previous submissions. It is now 15 years for the whole timeline, 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. Recalculation has been made for the years 2001-2019 due to these changes.
  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) is between Commercial Refrigeration, Industrial refrigeration and Transport minus Reefers. The percentages were updated based on a new survey among service providers and importers of F-gases. Recalculation has been made for the years 2013-2019 due to these changes.
- 2G1, Electrical equipment. Activity data was updated due to new information from the stakeholders for the years 2009, 2012-2019.
- 2G3b, Emissions from other product use. 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.

- 2H2, Food and beverages industry, recalculation has been made for two reasons. First, there was an update of the activity data from Statistics Iceland and second, a human error concerning beer and malt calculation was corrected for the whole timeseries.

Details about the recalculations listed above are to be found in the corresponding chapters within IPPU.

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 2021 and 2022 submission amounting to +2.5 kt CO2e for the year 2019 and +4.8 kt CO2e for the year 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). Four main reasons caused these recalculations:

- The categorisation of poultry activity data was updated based on the recommendations a poultry expert veterinarian at the Icelandic Food and Veterinary Authority. Poultry previously categorised as broilers should, in fact, be categorised as laying hens for the whole timeseries. The total number of poultry 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 N2O Emissions, 3D12a Animal Manure Applied to Soils and 3D2 Indirect N2O Emissions from Managed Soils are affected.
- During the quality checking of the parameters used, 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 Guidelines. This resulted in slight recalculations of emissions from CRF categories: 3A1 – Cattle and 3B11 – Cattle, over the whole timeseries.
- Recalculations in the subcategory Cultivated organic soils (3D16) are due to slight changes in the areas of histosols as reported by the LULUCF experts. This leads to minor recalculations in this subcategory over the whole time series 1990-2019.
- The calculations in CRF category 3D were checked after an issue was raised during the 2021 UNFCCC Review (Question 2021ISLQA197: Consistency of FracGASF and FracGASM). Consequently, an error in the calculation of NO2-N and NH3-N from sludge and other organic fertilisers was discovered. This issue has now been resolved and resulted in a slight change in the volatilized N from agricultural inputs of N and consequent N2O emissions reported under CRF category 3D21 Atmospheric Deposition.

10.3.4 LULUCF (CRF sector 4)

Recalculations have been done to the LULUCF sector between the 2021 and 2022 submission, mostly due to revised area estimation. The effect of the recalculations on the emissions from the sector are shown in Table 10.3. Further explanations for the subsectors are also explained below.

Table 10.3 Total emissions from LULUCF according to the 2022 submission compared to the 2021 submission, [kt CO_2e]

Inventory year	2021 submission	2022 submission	Difference [kt CO_2e]	Difference [%]
1990	9,192	9,199	-63	0.07%
1995	9,161	9,175	-101	0.15%
2000	9,184	9,194	-149	0.11%
2005	9,233	9,232	-185	-0.01%
2010	9,293	9,196	-210	-1.05%
2015	9,202	9,107	-222	-1.03%
2019	9,072	9,020	-268	-0.57%

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 to new data from the NFI sampled last summer.

Major revision of the C-stock change of the biomass of the natural birch woodlands results in revision of both Natural birch forest older than 50 years under Forest Land Remaining Forest Land and Natural birch shrubland old under Grassland Remaining Grassland C-stock changes of biomass for whole time series. Removal factor of C-stock changes of biomass in natural birch woodland was too revised resulting in revised estimates of C-stock changes of biomass for Land changed to natural birch woodland under both Forest land and Grassland categories.

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. The area for Revegetation since 1990 protected from grazing back to 1990 was revised and emissions accordingly re calculated. 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, i.e., 1990, 2000, 2010 and 2020. 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).

Other Land (4F)
No emissions are reported under this category.

Harvested wood products (4G)
No recalculations were done in this category.

Other (please specify) (4H)
N_2O emissions/removals estimate for “Other (please specify) 4.H” 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))
No recalculations were done in this category.

Direct N_2O Emissions from N Mineralization and Immobilization (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)

For the 2022 submission, the recalculations in the waste chapter were done in the chapter Solid Waste Disposal (5A) and in Wastewater Treatment and Discharge (5D):

- For the current submission there was a recalculation for the year 2019 as the methane collection on the SWDS Fíflholt in Western Iceland was added. This led to a decrease of CH_4 emissions for the year 2019 of 0.04 kt, or by 0.75%.
- For the current submission, the sewage sludge used in Agriculture for land restoration purposes (CRF 3.D.1.2.b) 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%.

All details regarding the above-mentioned recalculations can be found in chapters 7.2.6 and 7.5.6.

10.3.6 KP-LULUCF (CRF Sector 7)

As explained in Chapter 6.5 and in Chapter 10.5.4 are data on area in CF slightly revised and data on C-stock changes of biomass in natural birch forest totally revised. This will lead to revision of area and stock changes. Emission/removal factors used are unchanged except the removal factor of Land converted to natural birch forest is slightly revised (See further explanation in chapter 6.5).

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 mostly 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 2021 submission was reviewed during the UNFCCC centralised review conducted remotely.

Tables Table 10.4- Table 10.9 show the status of implementation of each general recommendation for each sector listed in the 2021 Preliminary Main Findings received in October 2021 after the review week (according to paragraph 84 of the annex to decision 13/CP.20)

Status of implementation in response to EU’s review process can be found in Annex 5: Status of implementation of recommendations from most recent EU review report.

The following table shows the status of implementation of each general recommendation listed in Tables 1 and 2 of the 2021 Preliminary 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	Chapter/ section
National registry (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. The ERT considers that the recommendation has not yet been addressed because the National Disaster Recovery Plan is still not ready, due to both limited human resources and lack of understanding on the content of the plan, it was not completed in time.	FCCC/ARR/2021 /ISL/G.1	In progress	
National system (G.4, 2019) (G.5, 2017) KP reporting adherence	Report comprehensive information in the NIR on the status of implementation of regulation 520/2017, including how Iceland ensures that the institutional, legal and procedural arrangements between different government agencies, including the roles and responsibilities, are fully understood by all the institutions involved (e.g. Agricultural University of Iceland, Icelandic Forest Research and the Ministry for the Environment and Natural Resources), and the changes in the national system resulting from such implementation, if any. The Party reported in its NIR Chapter 13 (Table 13.2) describing the status of implementation of Regulation 520/2017 for each article of the Regulation. The regulation is currently being revised and a draft of the revised version is currently (as of September 2021) under consideration at the Ministry for the Environment and Natural Resources.	FCCC/ARR/2021 /ISL/G.2	Chapter 13 of NIR 2021 described the level of implementation of the Regulation. Currently the Regulation is being revised, a final draft is expected to be accepted within the next few months and subsequently published. Main changes will be highlighted in next year's NIR submission.	
National system (G.5, 2019) (G.6, 2017) KP reporting adherence	Include in the NIR complete information on efforts made to continue supporting the enhancement of the technical competence of the new inventory team and report on any change in its capacity to ensure that the national system performs its functions (these efforts could include, for example, ensuring a sufficient number of competent national experts for each inventory sector and facilitating the participation of relevant institutions in the inventory process, as well as promoting continuous improvement via training and practical experience). The Party reported in its NIR additional information in Chapter 1 and sections 1.3.4 (Training and capacity-building activities) and 1.3.5 (capacity and staffing).	FCCC/ARR/2021 /ISL/G.3	Done	
QA/QC and verification (G.6, 2019) (G.7, 2017)	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 have added more text on QA/QC to the NIR 2021, chapter 1.5. The QA/QC manual is being updated very regularly, and it plans for the next submission to add the QA/QC manual as an annex to the NIR. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet finalised its QA/QC activities	FCCC/ARR/2021 /ISL/G.4	In progress	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
Convention reporting adherence				
National system (G.8, 2019) KP reporting adherence	Include in the NIR information on the improvement of the inventory team's technical competence, including the addition of personnel, the division of responsibilities of the current inventory team and any activities undertaken to increase the technical capacity of the inventory team. Information on this has been added to the NIR, chapters 1.2, 1.3 and 1.5. of the NIR.	FCCC/ARR/2021 /ISL/G.5	Done	
Article 3.14 (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. Updated information was added to the NIRs 2020 and 2021.	FCCC/ARR/2021 /ISL/G.6	Done	
QA/QC and verification (G.11, 2019) Convention reporting adherence	Use the 2006 IPCC Guidelines as the only guidelines for QA/QC procedures and for assessing completeness. The ERT also recommends that Iceland remove all outdated references to earlier IPCC guidelines from the NIR in order to improve its transparency and comparability. Iceland removed all outdated references to earlier IPCC Guidelines and confirmed that it uses only the 2006 IPCCC Guidelines for QA/QC procedures and assessing of completeness.	FCCC/ARR/2021 /ISL/G.7	Done	
Recalculations (G.12, 2019) Transparency	Improve its reporting on recalculations, particularly for the agriculture and LULUCF sectors, by clearly documenting and justifying the recalculations and clearly indicating the reason for the changes compared with previously submitted inventories (e.g. error correction, statistical reasons) in the NIR in line with the UNFCCC Annex I inventory reporting guidelines, annex I, paragraphs 44–45. The ERT commends Iceland for improved transparency for agriculture recalculations but considers that the recommendation has not yet been fully addressed because the Party has not yet provided full transparency for its LULUCF recalculations (see a number of issues identified as not resolved for the sectors below)	FCCC/ARR/2021 /ISL/G.8	In progress	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
Recalculations (G.12, 2019, G.13, 2019) Transparency, Accuracy	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. (G.12, 2019) Establish clearer linkages between its improvement plan and QA/QC findings. The ERT considers that the recommendation has not yet been fully addressed. During the review Iceland confirmed that it is still finalising this process with progressively adding new elements.	FCCC/ARR/2021 /ISL/G.9	In progress	
Annual submission	The ERT noted that for a number of questions during the review and issues raised for energy, agriculture, LULUCF and KP LULUCF and waste that some general improvements in transparency are needed. Particularly improvements for notation keys for CRF 1A4aii and 1A4bii, on productivity of animals and some missing parameter used in the calculations of gross energy intake, for a range of issues for LULUCF and KP LULUCF estimates, and for wastewater treatment and discharge, use of NE for NOx CO and NMVOC and for wastewater treatment and discharge which needs to accurately describe source and pathways included in modelling	FCCC/ARR/2021 /ISL/G.10	All recommendations on improvements in transparency are welcome and we aim at enhancing the text of each submission by following the recommendations of the ERT.	

10.5.1 Energy (CRF Sector 1)

For this submission the EA had measurements done for the second time on the carbon content in fossil fuels used in road transport in Iceland, also a country-specific emission factor for CO_2 emissions from marine gas oil was also obtained to move to T2 for navigation and fishing. There is ongoing work between the EA and the NEA to improve the data reported in the reference approach.

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	Chapter/ section
1.A.2 Manufacturing industries and construction (E.1, 2019) (E.2, 2017) (E.2, 2016) (E.2, 2015) (21, 2014) Transparency	Report information on electrode consumption, steam coal consumption and 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 did not include in the NIR information explaining the reasons for the significant inter-annual changes in the time series for other bituminous coal (that due to a translation error was reported as steam coal in the 2014 NIR (p. 54)) and for petroleum coke under category 1.A.2.f (non-metallic minerals). For other bituminous coal (reported under solid fuels) significant inter-annual variation occur for AD from 2005-2007 (from 255 to 630 TJ and decreasing to 94 TJ in 2010. For petroleum coke (reported under liquid fuels) significant inter-annual changes occur from 1992-2007, especially for 2003-2005, where AD increased from 22 to 345 TJ, and decreasing to 16 TJ in 2007. Regarding electrodes the Party explained that the amount of electrodes reported under category 1.A.2.f (non-metallic minerals) is related to waste electrodes and that these are exported and therefore removed from the energy sector (see NIR section 3.3.2, p.53). Related to the gaps in time series, the Party reported in the NIR that other bituminous coal was used as a fuel for cement production under category 1.A.2,f and clarified in the IPPU sector (section 4.2.1.1, p. 71) that cement production ceased in 2011; The ERT considers that this explanation clarify why NO is reported for this category in the CRF table 1.A(a)s2s for 2012- 2019. However, for petroleum coke there is no explanation in the NIR. The Party explained during the review that petroleum coke was also used for combustion under cement production industry reported under category 1.A.2.f for 2004-2007; and that since 2013 it has been used for stationary emissions in mineral wool production (also reported under category 1.A,2,f.). The ERT noted that NIR table 3.8 (p. 51) indicates that NO is reported for petroleum coke for 1990-2000.	FCCC/ARR/2021 /ISL/E.1	Implemented / Petroleum Coke was only used in Iceland for cement production 2004-2007	Table 3.11 in 2022 NIR

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
1. General (energy sector) (E.3, 2019) (E.4, 2017) (E.4, 2016) (E.4, 2015) (23, 2014) (21, 2013) Transparency	Provide more transparent information on the modification methodologies used when recategorizing the data received from NEA.The recategorization of the data concerns the values of diesel oil and fuel oil sales reported by NEA to match with the IPCC categories for electricity production (1.A.1.a), manufacturing industries and construction (1.A.2), commercial/institutional (1.A.4.a) and residential (1.A.4.b). Iceland explained the method developed by EA to attribute fuels consumption based on sales statistics from NEA in NIR section 3.1.1 (p. 43). In addition, the Party clarified in the NIR that for the 2020 submission a comprehensive review was performed on how the fuels sales data from the NEA is attributed to IPCC sectors. For that submission the review only included the years 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. Recalculations were reported accordingly in NIR 2020 and 2021	FCCC/ARR/2021 /ISL/E.2	Implemented	Chapter 3.1.6 in 2022 NIR
1. General (energy sector) (E.4, 2019) (E.17, 2017) Convention reporting adherence	Reassess the uncertainty values for AD and EFs used to carry out the uncertainty analysis and archive the relevant supporting information in accordance with decision 19/CMP.1, and implement the provision from regulation 520/2017 on the joint work of EA and NEA regarding the uncertainty analysis. Iceland has provided category specific uncertainty values for AD, EFs and the emissions of CO2, CH4 and N2O in each of the category specific sections in the NIR (e.g. sections 3.3.1 – 3.3.8). Iceland has also provided a source for each uncertainty assessment. The complete uncertainty analysis is shown in Annex 2 (Table A2. 1 and Table A2. 2). The uncertainty values for the activity data (fuel sales) are in general estimated by NEA and the uncertainty values for the emission factors for CO2 and CH4 are default 2006 IPCC Guidelines uncertainties. The uncertainty value for the emission factor for N2O is based on an expert judgement. The ERT received information during the review that Iceland have specific files for their uncertainty analysis, where they document the used values as well as references to the source of the data.	FCCC/ARR/2021 /ISL/E.3	Implemented	
1. General (energy sector) (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. Iceland did not correct the omission related to the use of charcoal. During the review, the Party clarified that it is aware that charcoal is used for grilling, but data on this activity has not been obtained. Work is in progress in collaboration with Statistics Iceland to obtain the data.	FCCC/ARR/2021 /ISL/E.4	In progress	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
1.A. Fuel combustion – sectoral approach – all fuels – CO2 (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 has developed country specific emission factors for CO2 for gasoline and diesel, which are applied for category 1.A.3.b (road transportation) in submission 2021. This is described in NIR section 3.3.4 (p.57-58) The emission factors are based on the measured carbon content in gasoline and diesel for 2019 and CS NCV for 2017-2019 and default 2006 IPCC GL carbon content for 1990-2016 which is described in NIR 2020 section 3.4.4.2 but not in NIR 2021. In the previous submission the emission factors for CO2 were based on IPCC default carbon content and CS NCV for 2017-2018 and default NCV for 1990-2016. The implied emission factor for CO2 and diesel in submission 2021 varies between 73,22-73,39 ton/TJ for 2017-2019 as the CS NCV varies between the years. The implied emission factor for CO2 and diesel used in 1990-2016 is 73,56 ton/TJ and is based on the CS carbon content for 2019 and the default value for NCV from 2006 IPCCC GL for 1990-2016. The default value for CO2 and diesel in 2006 IPCC GL is 74,1 ton/TJ with a lower and upper value of 72,6 respectively 74,8 ton/TJ. The implied emission factor for CO2 and gasoline used in submission 2021 varies between 70,59-71,07 ton/TJ for 2017-2019 as the CS NCV varies between the years. The implied emission factor for CO2 and gasoline used in 1990-2016 varies between 69,96- 70,15 ton/TJ and is according to Iceland based on CS carbon content for 2019 and the default NCV from 2016 IPCCC GL for 1990-2016. But according to the ERT the IEF for CO2 should not vary between the years if it's based on these two values. The default value for CO2 and gasoline in 2006 IPCC GL is 69,3 ton/TJ with a lower and an upper value of 67,5 respectively 73,0 ton/TJ.	FCCC/ARR/2021 /ISL/E.5	In progress	
1.A.2 Manufacturing industries and construction – CO2 (E.12, 2019) (E.23, 2017) Accuracy	Provide justification for the country-specific values or, if that is not possible, use the tier 1 IPCC default values of NCV and carbon content defined in the 2006 IPCC Guidelines for steam coal and wastes of electrodes, and archive all relevant information regarding the selection of AD, EFs and associated parameters (e.g. NCV) used to estimate the emissions. For other bituminous coal (that due to a translation error was reported as steam coal in the 2017 NIR (p. 49)), 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 wastes of electrodes, the party informed the amount of electrodes reported under category 1.A.2.f (non-metallic minerals) is related to waste electrodes and that these are exported and therefore removed from the energy sector (see NIR section 3.3.2, p.53). (See also ID# E.1 above).	FCCC/ARR/2021 /ISL/E.6	Implemented	Table 3.3. in 2022 NIR
1.A.3.b Road transportation – liquid fuels – CO2, CH4 and N2O	Use a consistent methodology for the division of vehicle groups and conduct recalculations for the earlier years of the time series (1990–2005). The Party has implemented the road emission model COPERT, which uses a consistent methodology for the whole timeseries.	FCCC/ARR/2021 /ISL/E.7	Implemented	Chapter 3.3.3 in 2022 NIR

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
(E.14, 2019) (E.15, 2017) (E.14, 2016) (E.14, 2015) (36, 2014) Consistency				
1.A.3.b Road transportation – diesel oil – CH4 and N2O (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. The Party reported in its NIR (p.57) that emissions from road transportation are estimated by the road emission model COPERT, which uses a tier 3 methodology to estimate N2O and CH4 emissions.	FCCC/ARR/2021 /ISL/E.8	Implemented	Chapter 3.3.3 in 2022 NIR
1.A.4 Other sectors – other fuels – CO2, CH4 and N2O (E.18, 2019) (E.27, 2017) Completeness	Collect AD on the consumption of charcoal, estimate emissions from charcoal consumption, report the corresponding CO2 emissions as a memo item and include the non-CO2 emissions in the corresponding CRF table and national totals. Collect AD on the consumption of charcoal, estimate emissions from charcoal consumption, report the corresponding CO2 emissions as a memo item and include the non-CO2 emissions in the corresponding CRF table and national totals. The ERT considers that the recommendation has not yet been fully addressed because, although the Party is aware that charcoal is used for grilling, but data on this activity has not been obtained. Work is in progress in collaboration with Statistics Iceland.	FCCC/ARR/2021 /ISL/E.9	In progress	
1.B.2.d Other (oil, natural gas and other emissions from energy production) other fuels – CO2 and CH4 (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. The Party reports in its NIR section 3.3.8. (p.65-66) the data source used (data-repository of NEA) and describes the methodology used to estimate the emissions.	FCCC/ARR/2021 /ISL/E.10	Implemented	Chapter 3.4.3.3 in 2022 NIR

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
1.B.2.d Other (oil, natural gas and other emissions from energy production) other fuels – CO2 and CH4 (E.20, 2019) (E.29, 2017) Transparency	Include in the NIR additional information regarding the use of geothermal fluids and associated emissions, making it explicit that all geothermal power plants are covered and that other uses of geothermal power are not considered. This information can be found in the Party's NIR section 3.3.8. (p.65).	FCCC/ARR/2021 /ISL/E.11	Implemented	Chapter 3.4.2. in 2022 NIR
1.B.2.d Other (oil, natural gas and other emissions from energy production) other fuels – CO2 and CH4	Identify the main drivers for the trend in CO2 and CH4 emissions (e.g. power plants, geothermal fields) and investigate why geothermal electricity is being produced with decreasing levels of CO2 emissions per GWh since 1993, and report the findings in the NIR. New information regarding "Time series consistency issues" has been added to the Party's NIR section 3.3.8 (p.66), which include information regarding the fluctuations of CO2 emission from geothermal energy production.	FCCC/ARR/2021 /ISL/E.12	Implemented	Chapter 3.4.2. in 2022 NIR
Fuel combustion – reference approach – electrodes – CO2 (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. The Party has clarified that electrodes are reported as NO in the reference approach. The electrodes are used and reported in the IPPU sector.	FCCC/ARR/2021 /ISL/E.13	In progress	
1.A.3.b.i Cars – liquid fuels – CO2 (E.23, 2019) Convention reporting adherence	Revise the AD for fuel consumption for road transportation using a consistent approach across the entire time series. When applying the recalculation, indicate in the NIR the reason for the changes compared with previously submitted inventories in line with paragraph 45 of the UNFCCC Annex I inventory reporting guidelines. The Party has implemented the road emission model COPERT, which uses a consistent methodology for the whole timeseries. Information can be found in NIR 2021 section 3.3.4 (p.57).	FCCC/ARR/2021 /ISL/E.14	Implemented	Chapter 3.3.3 in 2022 NIR

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
Fuel combustion – reference approach – CO_2 (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. The ERT considers that the recommendation has not yet been fully addressed because, as the Party explained that work is in progress, in collaboration with the NEA.	FCCC/ARR/2021 /ISL/E.15	In progress	
Fuel combustion – reference approach – jet kerosene – CO_2 (E.27, 2019) Convention reporting adherence	Correctly report consumption of and CO_2 emissions from jet kerosene in CRF table 1.A(b). Iceland corrected the reporting of jet kerosene in CRF table 1.A(b) and CO_2 emissions for 2017 is 44.72 kt CO_2 (instead of NA)	FCCC/ARR/2021 /ISL/E.16	In progress	
Fuel combustion – reference approach – peat – CO_2 (E.28, 2019) Convention reporting adherence	Report on peat consistently between the sectoral and reference approach. Iceland continued to report NO for peat consumption and emissions for the entire time series in the CRF table 1.A(b). During the review, the Party clarified that Statistics Iceland had confirmed that all peat is used for non-energy purposes, hence not included in the energy sector/reference approach. However, this is not in accordance with the UNFCCC reporting Guidelines. If peat is used for non-energy purpose, its AD should be reported in the reference approach (CRF table 1.A(b)) and the amount of carbon used as NEU or stored in product (even if 100%) should be excluded and reported in CRF table 1.A.d with an indication in which sector peat is reported as NEU.	FCCC/ARR/2021 /ISL/E.17	Implemented	
Comparison with international data – solid, liquid and other fuels – CO_2 (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 (a) report correctly in CRF table 1.A(b) the production of waste (non-biomass fraction) for the entire time series; (b) the export of liquid fuels for the time series; (c) and stock changes for coke oven/gas coke between 2007 and 2012 and make corrections to the emission estimates. (a) Iceland reported the production of waste (non-biomass fraction) for 1993-2013 accordingly and from 2014 onward “NO” in CRF table 1.A(b). Collaboration in ongoing with IEA to update IEA data for 2011-2013 accordingly. (b) For liquid fuels, export of other oil is reported in the CRF table 1.A(b) from 2004 onward intermittently. Iceland explained that it used export data from Statistics Iceland in the inventory, which reports some exports. The IEA data come from NEA, which does not report any exports. Collaboration in ongoing with IEA to update IEA data accordingly (c) Stock change values reported in the CRF table 1.A(b) for coke oven/gas coke is related only for sub-bituminous coal while for IEA it includes sub-bituminous coal and coke oven/gas	FCCC/ARR/2021 /ISL/E.18	In progress	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
	coke. The Party clarified during the review, that NEA is currently investigating this issue and will check if the numbers for stocks under coke oven/gas coke reported in the inventory are correct			
Feedstocks, reductants and other non-energy use of fuels – liquid fuels – CO2 (E.30, 2019) Convention reporting adherence	Correctly fill in CRF table 1.A(d) for lubricants. The ERT also recommends that the Party correctly estimate and consistently report the use of petroleum coke across the time series. Iceland continue to report IE for CO2 emissions under "CO2 emissions from the NEU reported in the inventory" in CRF table 1.A(d). The ERT notes that emissions from lubricants and petroleum coke reported in CRF table 1.A(d) as NEU are not attributed to combustion in the energy sector and should be included for information purpose. In CRF table 1.A(b) Iceland reported correctly carbon stored or excluded for lubricants and petroleum coke and indicated in CRF table 1.A(d) the sector where these CO2 emissions are allocated: categories 2.D.1 (lubricant use) and 2.C.2 (ferroalloy production). During the review, the Party explaining that it plans to report these emissions in CRF table 1.A(b) in the next submission. The Party also explained that the consumption of petroleum coke has been double counted as it was included in both the energy and IPPU sector. As the petroleum coke is used in the production of mineral wool, as a reducing agent, it will only be reported in the IPPU sector in the next submission. However, the ERT notes that in ID#E.1 above, the Party indicated that there is consumption of petroleum coke in stationary combustion under category 1.A.2.f (non-metallic minerals) related to the cement industry from 2004-2007 and mineral wool industry from 2013 onward. In the IPPU sector, emissions are reported as IE and is related to process (p. 70).	FCCC/ARR/2021 /ISL/E.19	Implemented	
1.A Fuel combustion – sectoral approach – liquid fuels – CO2 (E.31, 2019) Convention reporting adherence	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. After 2013, NO is reported because the district heating stations stopped burning waste for energy recovery. However, the Party continue to report blank cells for fossil fuels under this information item. Emissions from fossil fuels are reported for 1993-2013.	FCCC/ARR/2021 /ISL/E.20	Implemented	
1.A.3.b.i Cars – gasoline – CH4 and N2O (E.32, 2019) Transparency	Explain in the NIR any significant inter-annual and trend changes in the AD, emissions and IEFs for CH4 and N2O emissions related to the use of gasoline for passenger cars. Iceland implemented the COPERT model for road transport for the whole timeseries and the inter annual variation for CH4 and N2O IEF observed in the previous review does not exist anymore. However, the recalculation lead to an inter-annual variation between 2005 (5.16	FCCC/ARR/2021 /ISL/E.21	In progress	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
	kg/TJ) and 2006 (2.37 kg/TJ) for the N2O IEF and for emissions (0.034 and 0.016 kt N2O respectively) that is not explained in the NIR.			
1.A.3.b.i Cars – biomass – CO2, CH4 and N2O (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 (see ID# E.21 above). The CO2, CH4 and N2O IEF in the 2021 submission still presents some inter-annual variation, however, the ERT could not identify in the NIR explanation on the reasons for the annual changes or trends in AD and EFs for biomass. The ERT notes that sales data from NEA is used as AD (NIR table 3.16. p. 56).	FCCC/ARR/2021 /ISL/E.22	In progress	
1.A.3.b.i Cars – biomass –N2O (E.34, 2019) Transparency	Update the N2O EF for biogasoline and ensure that the EF choice is well documented and justified in the NIR. Iceland recalculated emissions under this sector using COPERT model (see ID# E.21 above). Due to the recalculation the maximum value for N2O IEF for biomass under this category is 1.99 kg/TJ in 2018. Further information on the recalculation see NIR p. 57.	FCCC/ARR/2021 /ISL/E.23	Implemented	
1.A.3.e Other transportation – liquid fuels – CO2, CH4 and N2O (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 informed the ERT that sales statistics for off road machinery was separated for 2019 between the categories 1.A.2.g.v (construction), 1.A.4.c.ii (off-road vehicles and other machinery, agriculture/forestry/fishing), and (1.A.2.g.vii (Off-road vehicles and other machinery) . All sales statistics for off-road transportation are reported under category 1.A.2.g.viii for 1990-2018. The Party also clarified that this was the first-year fuel sales for off road machinery used in the construction sector was collected and allocated to category 1.A.2.g.v. No fuel consumption was allocated for categories 1.A.3.e.ii, 1.A.4.a.ii or 1.A.4.b.ii.	FCCC/ARR/2021 /ISL/E.24	Implemented	Chapter 3.3.1 in 2022 NIR
1.A.3.b Road transportation– liquid fuel- CO2	The Party reported in its NIR section 3.3.4. (p. 57) that country specific CO2 emission factors for gasoline and diesel were used in submission 2021 and they were based on the carbon content in gasoline and diesel in 2019. The carbon content in 2019 was applied for the whole time series and replaced the default carbon content. A country specific NCV for gasoline and diesel is used for 2017-2019 and a default NCV from 2006 IPCC GL for 1990-2016. But the implied emission factor for CO2 and gasoline varies for the years 1990-2016, which shouldn't be the case as it's based on two constant values. During the review, the Party provided the ERT with a table, which showed the carbon content in gasoline and diesel as well as the NCV and the emission factors for CO2 for gasoline and diesel based on the measured carbon content in gasoline and diesel in 2019. The ERT is if the view that Iceland should look over the table as it does not show a constant value for the carbon content in gasoline and diesel for	FCCC/ARR/2021 /ISL/E.17	The emission factors are now presented in tonn/TJ in table 3.40. The implied emission factor for gasoline is still being investigated.	Chapter 3.3.3.2 in 2022 NIR.

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
	1990-2019. It would also be more transparent if the carbon emission factor is presented as ton/TJ Investigate why the implied emission factor varies along the time series considering that it is based on two constant values.			
1.A.3.b Road transportation – liquid fuel- CO2	During the review, the Party informed the ERT that the measured carbon content in gasoline from 2019 was measured in gasoline with a mixture of biofuel and not in pure fossil gasoline. Since the value of the CO2 emission factor is completely related to the carbon content, it's of utmost importance that the correct carbon content is measured. Investigate whether the carbon content differs between ethanol (biogasoline) and fossil gasoline and, if necessary, have new measurements made of the carbon content of fossil gasoline.	FCCC/ARR/2021 /ISL/E.18	This is still being investigated. Carbon content will be measured for fuel from 2021 and this will be resolved for the 2023 submission.	
1.A Fuel combustion – sectoral approach -All fuels – all gases	The Party reported in its NIR section 3.3.2 (p.51) that NEA improved their data gathering in 2019, making it possible to distinguish between fuel used by off-road vehicles in category "1A4cii Off-road vehicles and other machinery (Agriculture /forestry)" and in category "1A2gv Construction". All fuel consumption by off-road vehicles is reported in category CRF 1A2gvii Off-road vehicles and other machinery for 1990-2018, but for 2019 the fuel used by off-road vehicles in construction and agriculture was reallocated to category 1A2gv and 1A4cii. The remaining fuel reported in category 1A2gvii consist according to Iceland of fuel used by transport activities not reported under road transport, such as ground activities in airports and harbours. But 2006 IPCC reporting guidelines states that this fuel should be reported in category 1A3eii (Volume 1, chapter 1, table 8.2). The CRF tables also indicate that fuel used by off-road vehicles in the category "1A2 Manufacturing industries and construction" should only be reported in category "1A2gvii Off-road vehicles and machinery". Look over the allocation of fuels used by off-roads vehicles again and reallocate the fuel consumption to the correct category.	FCCC/ARR/2021 /ISL/E.19	This has been implemented	Chapter 3.3.1 in 2022 NIR.
1.A.4 Other sectors – Liquid fuel- CO2	The Party did not report any information in its NIR regarding working machinery used in the categories 1.A.4.a.ii and 1.A.4.b.ii, e.g. garden equipment and road construction machinery. The fuel consumption and the emissions are reported as NO in the CRF tables. During the review, the Party clarified that the fuel consumption most probably is included in the category 1A3b Road transportation, as fuel sold at pump stations is defined as fuel consumption by road transportation according to NEA. Change the notation keys from NO to IE and to include this information in the NIR.	FCCC/ARR/2021 /ISL/E.20	This has been implemented. Notation key has been changed to IE.	
1.A.3.a Domestic aviation – Jet kerosene	The ERT noted that the consumption of Jet kerosene in category 1A3a more than doubled between the years 2013 and 2014 to bounce back to the same level in 2015. During the review, the Party clarified that there was an over-allocation of 6.7 kt jet kerosene in 2014 in category 1A3a Domestic aviation; fuel which should have been included in category 1D1a	FCCC/ARR/2021 /ISL/E.21	This has been fixed.	Chapter 3.3.2.4 in 2022 NIR.

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
	International aviation. Correct the allocation of jet kerosene in the next submission.			
1.A.4.c.ii Off-road vehicles and other machinery	The ERT noted that Iceland doesn't have a separate section in its NIR for the off-road vehicles used in the category 1a4cii off-road vehicles (Agriculture/forestry). Information regarding the off-road vehicles in the category1A4cii Agriculture is instead included in the section "3.3.2 Manufacturing Industries and Construction & Other (1A5)" in the NIR. Create a separate section in its NIR for information regarding the off-road vehicles used by agriculture.	FCCC/ARR/2021 /ISL/E.22	This has been implemented. There is a seperate section for off-road mobile machinery.	Chapter 3.3.1 in 2022 NIR.

10.5.2 Industrial Processes and Products Use (CRF Sector 2)

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. Also it is planned to keep improving the input data quality for the sector non-energy products from fuels and solvent use.

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	Chapter/ section
2	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). The Party reported in its NIR (p.265) that CRF Table2(I)s1 and Table2(I)s2 have been updated with the required notation keys. Regarding categories 2.F.2, 2.F.3, 2.F.5, and 2.F.6, the Party stated that the CRF Reporter does not allow notation keys to be uploaded for them.	FCCC/ARR/2021 /ISL/I.1	Done.	NA
2.F	Regularly conduct F-gas and product use surveys in order to estimate F-gas emissions for all relevant subcategories on the basis of the latest possible information, with a frequency of at most three years, and include in the NIR information on the level of enforcement of the prohibition of F-gas fire extinguishers and other aerosol products, including personal care products (e.g. haircare products, deodorant, shaving cream), household products (e.g. air fresheners, oven and fabric cleaners), industrial products (e.g. special cleaning sprays such as those for operating electrical equipment, lubricants, pipe freezers). The Party reported in its NIR (p.265) that the “F-gases were thoroughly revised in 2019 in collaboration with consultants from Aether Ltd. Included in the revision was a product use survey to obtain updated estimates about the allocation of the different F-gases to the subcategories. Chapter 4.7 was rewritten, and relevant information was included”. Moreover, information of legislation on enforcement of the prohibition of F-gases for the referred uses was provided in the NIR (p.90).	FCCC/ARR/2021 /ISL/I.2	Updated in 2022 NIR	Chapters 4.7.1.1 and 4.7.2 in 2022 NIR
2.G.1 Electrical equipment – SF6 (I.5, 2019) (I.15, 2017)	Obtain clear information about the recovery of SF6 emissions from electrical equipment and revise the emission estimates as necessary.The Party reported in its NIR (p.101) that “Iceland acquired its first SF6 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.”	FCCC/ARR/2021 /ISL/I.3	Updated in 2022 NIR.	Chapter 4.8.1.1 in 2022 NIR

CRF category / issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
2	Include in the NIR an explanation, based on the information provided during the review, for the non-occurrence of NF3 emissions in the country. The Party reported in its NIR (p.68) the explanation for the use of notation keys “NO” and “NA” for NF3.	FCCC/ARR/2021 /ISL/I.4	Updated in 2022 NIR.	Chapter 4.1.1 in 2022 NIR.
2.D.2	Carry out the planned improvement and revise the AD, if appropriate, and report on any improvements in the quality of the data on paraffin wax use in the NIR. The Party reported in its NIR (p.83) submitted in 2020 that “due to updated activity data collection for the years 1990-2003 there are recalculations for that years as well for the rest of the time series.” In the NIR submitted in 2021 (p.264), the Party states that it “keeps improving the input data quality for the sector non-energy products from fuels and solvent use, including paraffin wax and candles"	FCCC/ARR/2021 /ISL/I.5	Done. Improvement of data quality finished.	Chapter 4.5.2 in 2022 NIR.
2.D.2	Carry out the planned improvement and include AD for candle production to improve the completeness of the estimates for the category. The Party reported in its NIR (p.84) that “candles produced by very small local craft workshops might be missing from the estimates”.	FCCC/ARR/2021 /ISL/I.6	Done. Insignificant production within the country.	Chapter 4.5.2 in 2022 NIR.
2.F.1	Include consistent data on HFC-23 emissions from the disposal of commercial refrigeration equipment over the entire time series, or include information justifying the reporting of “NO” for some of the years, explaining the trend in emissions, in the NIR. The Party reported in its NIR (p.266) that “the ‘NO’ for the disposal emission for HFC-23 in the commercial refrigeration (2F1a) are due to the non import or non allocation of this species to the commercial refrigeration subsector. Gaps in the time series derive from the calculation method taking into account the lifetime of the equipment and that the disposal can only occur if there has been an import of this species (and subsequently an allocation to this subsector).”	FCCC/ARR/2021 /ISL/I.7	Clarified during review.	NA
2.G.3	Include estimates for N2O emissions from whipped cream containers in its next submission. The Party reported in its NIR submitted in 2020 (p.103) that “N2O that could be emitted from whipped cream containers”, and that it “follows the Finnish example of applying an average of the EFs used in Central Europe, that is, 3.3 g N2O/inhabitant/year”.	FCCC/ARR/2021 /ISL/I.8	Done. Emissions from whipped cream included.	Chapter 4.8.2 in 2022 NIR.

CRF category / issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
2.F	The Party reported in its NIR (p.90) the f-gases regulation in place. Nevertheless, as there is the information that “the bans of production, import and sale of HFCs were only allowed to reach to the year 2013 and have not been re-established”, the ERT raised a question. During the review, the Party explained more thoroughly the regulation as follows. Regulation 834/2010 (with the implementation of (EC) 842/2006) was in effect until 2019 (not only up to 2013). The transitional provision in regulation 823/2010 which banned the production, import and sale of HFCs was only valid until 2013. From 2013, article 9 (and Annex II) of regulation (EC) 842/2006 states which products and equipment are prohibited. Regulation 834/2010 is to a large extent an implementation of (EC) 842/2006. Therefore, instead of import and sale ban with exceptions, there was a list of those products and equipment prohibited. Uses not banned with (EC) 842/2006 were therefore allowed. 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). Used not banned with (EC) 517/2014 are therefore allowed. Icelandic regulation 1279/2018 does also implement import quotas for the phasing out of the use of F-gases and from 2019 a tax scheme was established with act No. 135 from 18 December, putting a tax on the import of F-gases (blends and species) according to their global warming potential. Be more transparent on the explanation about the f-gases legal restriction by including the above details in the next submission.	FCCC/ARR/2021 /ISL/I.9	Included in 2022 NIR.	Chapter 4.7.1.1 in 2022 NIR.
2.D.2	The Party reported in its NIR (p.84) the equation used for this category. The ERT noted that it was not clear how to use the proportion of paraffin candles provided in the text, as it was not in the equation. During the review, the Party clarified that there was another information, not provided in the text, which was the amount of candles (66% made of paraffin) e paraffin other than in form of candles. Update this information in the NIR.	FCCC/ARR/2021 /ISL/I.10	Updated in 2022 NIR.	Chapter 4.5.2 in 2022 NIR.
2.C.2	The Party reported in its NIR (p.78) table 4.4 emissions of 431,4 kt CO_2e for this category in 2019. Nevertheless, CRF Table2(I).A-Hs2, indicates 429,81 kt CO_2 and 0,11 kt CH_4, which amounts 432,6 kt CO_2e in 2019. During the review, the Party clarified that this was a mistake.	FCCC/ARR/2021 /ISL/I.11	Updated in 2022 NIR.	Chapter 4.4.2 in 2022 NIR.

CRF category / issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
	Correct this table in the NIR to maintain consistency with both reports.			
2.D.3	The Party reported in its NIR (p.88) table 4.7 NMVOC emissions with total at the bottom line in CO2e. The ERT noted that this results are not compatible with CRF Table2(I).A-Hs2. During the review, the Party clarified that this total refers to CO2e for NMVOC emissions within 2D3, not including the CO2 emissions deriving from the use of urea-based additives. The total CO2e from NMVOC emissions within 2D3 in NIR table 4.7 is therefore not compatible with the CRF Table2(I).A-Hs2. The Party acknowledged that the bottom-line name in the table is misleading ("Total CO2e [kt]"). Add some information to NIR table 4.7, indicating that it does not inform the total CO2 of this category or also include CO2 emissions deriving from the use of urea-based additives, to better inform the reader.	FCCC/ARR/2021 /ISL/I.12	Updated in 2022 NIR.	Chapter 4.5.3.10 in 2022 NIR.
2.D.3	The Party reported in its NIR (p.68) that there has been no recalculation for this category. Nevertheless, CO2 emissions raised 20,20% in 2018. During the review, the Party clarified that it first estimated the emissions deriving from the use of urea-based additives for diesel vehicles and this led to the recalculation, which was not referred to in the NIR. Improve is QA/QC procedure to inform all the recalculations in the NIR.	FCCC/ARR/2021 /ISL/I.13	Done.	NA

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 is working on improving the quality of the animal characterization data by working with the Icelandic Agricultural Advisory Centre (IAAC) and the Ministry of Food, Agriculture and Fisheries with the aim of updating productivity data, such as the digestible energy content of feed and gross energy intake, approximately every three years. In addition, it is planned to update animal characterization parameters regularly for all livestock categories, as was done for this submission. The plan is to collaborate with the IAAC to update the feed digestibility parameters for cattle and sheep again in 2022, for the results to be ready in time for the 2023 submission. Furthermore, it will be checked whether it is possible to estimate feed digestibility for the historical timeline.

Other improvements that will be performed for the next submission are crosschecking the value used for the amount of bedding material for dairy cattle with national expertise in Iceland, research of the use of other organic fertilisers in Iceland and research on emissions from the use of ammonitrates as fertiliser to assure the completeness of the inventory. Preliminary steps will be undertaken to look into defining a country specific FracLeachMS based on a 2021 UNFCCC review recommendation.

Comments and suggestions received during the 2021 reviews which could not be addressed during the current submission will be tackled in future submissions.

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	Chapter/ section
3.	Include detailed explanations of the AD, EFs and emission trends for all categories, including for young cattle population and for N2O emissions from synthetic N fertilizer applied to agricultural soils. The Party reported in its NIR detailed information compared to previous reviewed NIRs. Time series are presented for major activities (table 5.6), especially population for young cattle (table 5.17), nitrogen excretion rates (table 5.25), nitrogen application from fertilizers (tables 5.31 and 5.32). Time series are presented for emissions from enteric fermentation (table 5.16), manure management (table 5.23), N2O emissions from N fertilizer. For the emission factors, ranges are presented when the emission factors fluctuate overtime.	FCCC/ARR/2021/ISL/A.1	Completed. Time series presented for major activities (5.7), population for young cattle (table 5.19), nitrogen excretion rates (5.28), nitrogen application from fertilizers (5.32 and 5.33). Time series presented for emissions from enteric fermentation (5.18), manure management (5.25), N2O emissions from N fertilizer (figure 5.3).	Chapter 5
3.	Include in the NIR additional tables with the animal numbers from Statistics Iceland (or other data sources) combined with the background estimations of animal numbers reported in the CRF tables for the agriculture sector for the whole time series and, in	FCCC/ARR/2021/ISL/A.2	Completed.	Chapter 5.2.1

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section
	cases where the 2006 IPCC Guidelines prescribe the use of average animal populations, include additional information on how the animal numbers from Statistics Iceland have been converted to average animal populations. The Party reported in its NIR the method used to estimate average animal populations and presented comparisons between statistics Iceland (table 5.6) and associated explanations (para 5.2.1) including the use of additional data from specific organisation in particular “Farmers Association of Iceland”. For horses a specific calculation was also implemented takin to account 2 different datasets (table 5.7). When annual average population is not directly available (animals living less than one year), it is described in the NIR that estimates are made thanks to IPCC methodology from production and estimated age of slaughter provided in table 5.5.			
3.	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. The Party reported in its NIR (p.268) that animal characterization data have been updated for mature dairy cattle for the year 2018 and for lambs 2003-2018, mature ewes 2018. The weights for mature dairy cattle and lambs were updated since the last review and are increasing overtime the other weights are stable for the whole period (CRF Table3.As2). For poultry, living age is used to estimate annual average populations from production but constant over time (table 5.5). The live weights of poultry are also constant overtime. For sows, the productivity (piglets per sow) is not presented in the NIR, the age of slaughter for pigs changes over time (5.9 months (1990) – 4.5 months (2010). In the NIR, tables 5.9 and 5.10 show the characterisation of cattle and sheep. In its NIR (p.119) Iceland indicates that they are working on improving the quality of the animal characterization data by working with the Icelandic Agricultural Advisory Centre and the Ministry of Industries and Innovation with the aim of updating productivity data, such as the digestible energy content of feed and gross energy intake, on a regular basis. In addition it is planned to update animal characterization parameters regularly for all livestock categories.	FCCC/ARR/2021/ISL/A.3	Completed.	Chapter 5.2.1
3.	Report weighted average AD for feed intake, typical animal mass, volatile solid excretion rates and Nex rates in the CRF tables and in the NIR, as used in the calculations. The Party reported in its CRF tables aggregated values for growing cattle which includes (heifers steers, calves) in relation with option B of reporting for cattle. The calculation for this specific category is made with more disaggregated values. The values presented in the NIR are detailed for these subcategories in both the NIR and annex 7. In particular, Iceland presented tables (5.17 and 5.25) with weighted average body weight, digestible	FCCC/ARR/2021/ISL/A.4	Completed. Average VS for growing cattle has been added to table 5.19: livestock category Growing Cattle: weighted averages of parameters necessary to calculate the methane emissions as reported in CRF.	Chapter 5.3.2, 5.5.2

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section
	energy, gross energy and nitrogen excretion for growing cattle. Only average of VS for growing cattle is not presented in the NIR and could thus be added.			
3.	Correct the CH4 and N2O emission estimates for other livestock on the basis of the correct number of horses for 2013–2015 and avoid any underestimation of emissions for this subcategory. The CH4 and N2O emission implied emission factors are now fully related to animal population of horses in CRF tables. Previous slight discrepancy was corrected in latest submission.	FCCC/ARR/2021/ISL/A.5	Completed.	Chapter 5.2.1
3.B	Include in the NIR information on the circumstances under which the country-specific Nex rates have been estimated. The Party reported in its NIR (p.129) a new methodology to estimate nitrogen rates. Now it is directly linked with IPCC tier 2 for cattle and tier 1 for other animals. It is correctly described in the NIR.	FCCC/ARR/2021/ISL/A.6	Completed.	Chapter 5.5.2
3.B	Provide additional information in the NIR to allow for a better understanding of the N mass flow approach, in particular the correlation between the volatilization of N-containing compounds reported under the United Nations Economic Commission for Europe and under the Convention. The Party reported in its NIR (p.135) a new figure with nitrogen fluxes (Figure 5.3) and a nitrogen Balance showing inputs (excretion + bedding), outputs of nitrogen (manure spreading minus pasture) and a correct balance.	FCCC/ARR/2021/ISL/A.7	Completed. The Nitrogen fluxes are demonstrated in figure 5.4	Chapter 5.5.
3.B	Correct the N2O emission estimates by using the total amount of N excreted in the different manure management systems. The Party reported in its NIR (p.132) that N2O emissions from manure management are now not directly estimated on the basis of the 2006 IPCC guidelines but only indirectly through the use of the 2019 EMEP guidelines. This option is supported by Annex 1 Table A1.8 of the 2019 EMEP guidelines and facilitate the production of a correct nitrogen balance.	FCCC/ARR/2021/ISL/A.8	Completed.	Chapter 5.5.3
3.B	Correct the N2O emission estimates from manure management systems by using the default N2O EFs from the 2006 IPCC Guidelines or provide additional information that supports the use of other N2O EFs that may be more representative of manure management systems in Iceland. The Party reported in its NIR (p.132) that N2O emissions from manure management are now not directly estimated on the basis of the 2006 IPCC guidelines but only indirectly through the use of the 2019 EMEP guidelines. This option is	FCCC/ARR/2021/ISL/A.9	Completed.	Chapter 5.5.3

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section
	supported by Annex 1 Table A1.8 of the 2019 EMEP guidelines and facilitate the production of a correct nitrogen balance.			
3.D.a.2	Collect information on sewage sludge and other organic fertilizers applied to soils and estimate the related emissions, or, if the Party considers these emissions to be insignificant, provide in the NIR sufficient information showing that the likely level of emissions meets the criteria in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. The Party reported in its NIR (p.140), all the investigations that were made on sludge application and other organic fertilizer application. According to the NIR sludge application is only known since 2012 with a specific pilot project (2012-2014) and no indication of any sludge application before was found. The use of the notation key NO for sludge application before 2012 is reasonable. For other organic fertilizers, application was found since 2009 and the notation key NO is reported before. The trend of other organic fertilizer after 2009 indicate the reporting of the notation key NO before 2009 is also reasonable.	FCCC/ARR/2021/ISL/A.10	Completed.	Chapter 5.7.2.2
3.D.a.5	Estimate N2O emissions from mineral soils, or, if the Party considers these emissions as insignificant, provide in the NIR sufficient information showing that the likely level of emissions meets the criteria in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. The Party reported in its NIR (p.142) that “there is a carbon stock gain (+) reported in land remaining cropland, and therefore there are no associated N2O emissions”.	FCCC/ARR/2021/ISL/A.11	Completed.	Chapter 5.7.2.5
3.D.a.6	Include in the NIR a comparison of the country-specific N2O EF for the cultivation of histosols with peer-reviewed studies. The Party reported in its NIR (p.357) a new Annex 8 named “Justification of use of country-specific N2O emission factor for cultivation of organic soils (histosols)”. This document was elaborated for 2019 review and accepted by former review team to justify the use of CS emission factors. It is now part of the NIR. The annex is comprehensive and well referenced.	FCCC/ARR/2021/ISL/A.12	Completed.	Annex 8

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section
3.D.a.6	Correct the misallocation of N2O emissions by moving the N2O emissions under the subcategory other (4.II.H) in CRF table 4(II) to the subcategory cultivation of organic soils (3.D.a.6) in CRF table 3.D. The Party moved in its CRF table N2O emissions under the subcategory other (4.II.H) in CRF table 4(II) to the subcategory cultivation of organic soils (3.D.a.6) in CRF table 3.D.	FCCC/ARR/2021/ISL/A.13	Completed.	Chapter 5.7.2.6
3.D.b.1	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. The Party reported in its NIR (p.135) a new figure with nitrogen fluxes (Figure 5.3). The figure presents nitrogen from livestock which contributes to indirect emissions of N2O, but the contribution of inorganic fertilizers and from other organic compounds is not fully clear in the NIR.	FCCC/ARR/2021/ISL/A.14	Completed. The contribution of inorganic fertilizers and from other organic compounds is demonstrated in the N-Flow in Figure 5.4 as "Atmospheric deposition - volatilised", which includes synthetic and all other types of organic fertiliser.	Chapter 5.5
3.F	Include in the NIR additional information on the non-occurrence of the field burning of agricultural crop residues.The Party reported in its NIR (p.149) that currently not enough activity data is available to estimate emissions from field burning".	FCCC/ARR/2021/ISL/A.15	Completed. Additional information has been included in chapter 5.10 and table 5.45.	Chapter 5.10
3.	Document and justify the recalculations in the NIR in line with paragraph 44 of the UNFCCC Annex I inventory reporting guidelines and include in the NIR up-to-date and complete information on recalculations applied in the sector (e.g. in specific recalculation sections for each category) and ensure consistent reporting on recalculations between the CRF tables and the NIR. The Party reported in its NIR for each subcategory recalculations that were implemented in latest submission, the outline is consistent with UNFCCC expected outline. No missing explanation were found.	FCCC/ARR/2021/ISL/A.16	Completed.	Chapter 5
3.	Correct the reporting of the AD for growing cattle across the time series (see ID# G.12 in table 6). The Party reported in its CRF tables (Table3.As1, Table3.B(a)s1), activity data for growing cattle accordingly with Option B. No doubtful trend is observed on growing cattle activity, this animal population was maintained constant in the NIR reviewed in 2019, it now slightly fluctuating in the same range of magnitude. Detailed information on subcategories (heifers, steers, calves) included in growing cattle are provide in the NIR in different tables (tables 5.9, 5.11, 5.17) and in Annex 7.	FCCC/ARR/2021/ISL/A.17	Completed.	Chapter 5.2.2, 5.2.3, 5.3.2 Annex 7

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section
3.A.1	Justify the appropriateness of the current parameters and/or update the input parameters and consequently the CH4 EF for future submissions, as planned. 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.	FCCC/ARR/2021/ISL/A.18	Completed.	Chapter 5.2
3.A.1	(a) Ensure time-series consistency for subcategory 3.A.1 cattle by obtaining data on animal population for 1990–1991 and, if this is not possible, use one of the techniques included in the 2006 IPCC Guidelines (vol. 1, chap. 5), as appropriate, to extrapolate the time series. (b) Include a section in the NIR that explains how it has ensured time-series consistency for the estimates in the category. The Party reported in its CRF tables (for instance Table3.As1) animal population extrapolated for the years 1990 and 1991 accordingly with the recommendation. This issue is presented in the NIR (p112).	FCCC/ARR/2021/ISL/A.19	Completed.	Chapter 5.2.1
3.A.1	Justify the low CH4 IEF reported for growing cattle and explain any significant changes in the animals covered by this subcategory that would affect the CH4 IEF trend. The Party reported in its NIR (p121) a table showing the population composition for growing cattle and the relative emissions, with the IEF. The NIR indicates that “for the years in which the calf population is much higher than heifers and steers for producing meet, the IEF will be low and outside the default IPCC range (35-48 kg CH4/head/year) as the EF for calves calculated according to Equation 10.21 of the 2006 IPCC guidelines is 19 kg CH4/head/year.” Considering the parameters provided in terms of weight digestibility and growth, the different emission factors are in the good order of magnitude and consistent with a tier 2 methodology.	FCCC/ARR/2021/ISL/A.20	Completed.	Chapter 5.3.2
3.A.1	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. The Party does not indicate in the NIR the value which is used for Cfi as expected by previous reviews although it appears that correct Cfi in now used in the inventory. During the review, in response to a question raised by the ERT, the values of Cfi and the related assumptions (share of lactating cows..) were indicated by the Pary. This information was considered in line with 2006 IPCC guidance.	FCCC/ARR/2021/ISL/A.21	Completed. In the 2022 NIR, Table 5.11 shows national parameters that were used to calculate gross energy intake for cattle in 2020 and Table 5.12 shows national parameters that were used to calculate gross energy intake for sheep in 2020. Both tables now include the parameter Cfi, including an explanatory footnote.	Chapter 5.2.2
3.B.1	Update the NIR with the revised information on the estimation method and the input parameters used for the N2O estimates for mature dairy cattle across the time series. The Party reported in its NIR (p121) that nitrogen excretion rates for dairy cattle were	FCCC/ARR/2021/ISL/A.22	Completed.	Chapter 5.5.2, 5.5.6

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section
	updated and now estimated thanks to the IPCC tier 2 methodology, detailed information can be found in sections 5.5.2 (p. 128) and 5.5.6 (p.133) in the 2020 NIR.			
3.B.2	Correct the volatile solid values and recalculate emissions from sheep for the entire times series, transparently documenting the change in the NIR. The Party reported, since 2020 submission, in its CRF tables, values of VS calculated consistently with IPCC 2006 tier 2 methodology and including the contribution of urine in the estimate of the parameter VS (equation 10.24 of the NIR) (p123).	FCCC/ARR/2021/ISL/A.23	Completed.	Chapter 5.4.1
3.D.a.1	Include in the next NIR the explanation provided during the review for the cause of sudden peaks in the use of N fertilizers, along with any other relevant explanations for significant changes in the emission trend. The Party reported in its NIR (p.139) the expected explanation on fertilizer use, explaining the peaks and the trends of fertilizer data.	FCCC/ARR/2021/ISL/A.24	Completed. In addition to chapter 5.7.2.1 and Figure 5.5 a new chapter 5.1.4.3 has been added where synthetic fertiliser consumption and usage data from the International Fertilizer Association and synthetic fertiliser consumption estimates from the Food and Agriculture Organization of the United Nations have been compared with the Icelandic country specific data.	Chapter 5.1.4.3, 5.7.2.1
3.D.a.6	Include in the NIR the explanation for the low country-specific N_2O EF for cultivated organic soils provided during the review. The Party reported in its NIR (p.357) a new Annex 8 named “Justification of use of country-specific N_2O emission factor for cultivation of organic soils (histosols)”. This document was elaborated for 2019 review and accepted by former review team to justify the use of CS emission factors. It is now part of the NIR. The annex is comprehensive and well referenced.	FCCC/ARR/2021/ISL/A.25	Completed.	Annex 8
3.G	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. The Party reported in CRF Table3.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. Thoroddur Sveinsson, Assistant Professor at the Agricultural University, stated in	FCCC/ARR/2021/ISL/A.26	Completed. This information has now been updated in the 2022 NIR and is provided in chapter 5.11.2.	Chapter 5.11.2

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section
	an email from 17/09/2021 that dolomite has not been used in agriculture at that time, that is from 1990-2002. 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“. 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 this category.			
3.I	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. The Party reported in its CRF table 3.G-I, activity data for other carbon-containing fertilisers since 2003 but no data on shell sand is reported for the period 1990-2002. The Party reported in its NIR (p.152) that it is planned to continue to improve the activity data collection.	FCCC/ARR/2021/ISL/A.27	Partially completed. Information on the use of shell sand has now been updated in the 2022 NIR and is provided in chapter 5.11.2.3. Furthermore, it has been added to the improvement plan to investigate the potential emissions from ammonitrates (CAN) for the next submission further.	Chapter 5.11.2.3, 5.11.7
3.D	Iceland reported in CRF table3.D additional information related to the parameters FracGASF and FracGASM as required by CRF tables. The ERT noted that the values of FracGASF and/or FracGASM were not consistent with activity data reported under category 3.D.b.1 (atmospheric deposition) . During the review, the Party acknowledges that FracGASM was calculated incorrectly, as there was an omission of the newest additions in organic fertilizers input (sewage, compost, other organic fertilizers). When adding NH3 and NOX from other organic fertilizers, animal manure applied to soils and urine and dung deposited from grazing animals the FracGASM results to the value of 0.1317 compared to the submitted value of 0.158 for 2019. The Party indicated that this error will be corrected for next submission. Correct the reported value for FracGASM, accordingly with 2006 IPCC guidelines.	FCCC/ARR/2021/ISL/A.28	Completed.	Chapter 5.8.5.1
3.	Iceland reported in its NIR (p.113) explanations on the calculation of horse population and presented in NIR table 5.7 a comparison of different datasets related to horses. The ERT noted that values presented in this table 5.7 were not the same that the ones in CRF tables. During the review, the Party clarified that the table 5.7 of the NIR show the difference of the two data sources and the final calculated total horse number used then to calculate the foals. The difference was thus due to the foals included in CRF tables but not in the table 5.7 of the NIR. A calculation file was provided to the ERT showing that the population of foals are partially estimated on the basis of recorded living foals and partially on the number of slaughtered foals.	FCCC/ARR/2021/ISL/A.29	Completed.	Chapter 5.2.1

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section
	Clarifie in its NIR how the global population for horses is estimated by adding some explanations on the methodology applied for the inclusion of foals			
3.	Iceland reported in its NIR (p.11 and 112) the fact that some young animals are based on mature animals and assumptions on productivity and lifetime of animals. The ERT noted that ages of slaughtered are presented (Table 5.5). But a few parameters, that are used in the calculation, are not presented in particular productivity of sows (number of piglets per year), productivity of female goats (single and double birth) and the fact that early mortality is just considered for lambs and not for piglets and goat kids. During the review, the Party provided a file with the calculations for the populations of young animals (lambs, piglets, goat kids, and foals) and indicated that the number of piglets per sow changed from 15 in 1990 to 25 in 2019. The calculations were considered in accordance with IPCC principles and equation 10.1 of the NIR presenting the calculation of annual average population for animals living less than one year. 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.	FCCC/ARR/2021/ISL/A.30	Completed. Table 5.6 in chapter 5.2.1 has been added where the annual average animal places calculated for young animals with a lifespan of less than one year has been calculated. Because sheep are a Tier 2 category, more information on the parameters used to estimate the number of lambs produced annually is provided in chapter 5.2.1, table 5.12. For the other Tier 2 category, cattle, the registered number of calves born are used because calves have a lifespan of more than one year. No birth rate information is, therefore, provided for cattle in table 5.11.	Chapter 5.2.1, 5.2.2

10.5.4 LULUCF and KP-LULUCF (CRF Sectors 4 and7)

10.5.4.1 *Forest land (4A)*

Data from NFI are used for the 12th 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.

Improvement of the biomass loss calculation that will include other parts of cut trees and natural mortality figures is planned. The solution will probably be to introduce and adapt a CsC simulation model such as the Canadian Forest Service Carbon Balance Model.

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 the year 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) 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 submission, 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 the year 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 recognized 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 emission of drained land within these categories, is in this submission 6512.42 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 utilize 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 emphasized 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 shows clearly 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”. New map of the drainage network presently in progress and expected to be finished in 2022 is expected to provide 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 2023 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, including also 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 Mineralization and Immobilization (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.

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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	Chapter/section
4. General (LULUCF) (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. The Party has included in its NIR (p 180, 182, 188, 192, 195,197, 200) information on uncertainty of EF for cropland, grassland, wetland and land converted to settlements similar to the information included in the Annex 2 Assessment of uncertainty. The ERT noted that Party has not included additional information about uncertainty of forest land and expert judgements used were not reported, for instance, in land converted to cropland the Party indicated in its NIR (p.182) that country specific information for living biomass is assigned based on expert judgement. During the review, the Party clarified that uncertainties analysis were conducted for most of the land categories and additional text was provided in its NIR.	FCCC/ARR/2021/ISL/L.1	Resolved regarding forest land. ArSn 220103 Resolved regarding land converted to cropland. LT 220110	6.5.1.3, 6.5.2.3 and 6.14.3 regarding forest land. 6.6.2.3 regarding land converted to cropland
4. General (LULUCF) – CO2, CH4 and N2O (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. The Party reported in its NIR (p 180, 182, 188, 192, 195,197, 200) uncertainty assessment for land categories (See ID# L.1). However, the Party has not provide an uncertainty assessment for some carbon pools such as DOM and soil for certain land-use. The ERT noted that the Party included in its NIR (p. 174) for forest land that error estimates for all data sources and calculation processes has currently not been conducted but are planned in the near future.	FCCC/ARR/2021/ISL/L.2	Resolved regarding forest land. ArSn 220103 resolved regarding DOM. However, uncertainties will be revised each year. LT 220110	6.5.1.3, 6.5.2.3 and 6.14.3 regarding forest land.
4. General (LULUCF) – CO2, CH4 and N2O (L.3, 2019) (L.15, 2017) Comparability	Review and, as appropriate, revise the use of notation keys under the LULUCF sector for categories estimated using a tier 1 method, in line with decision 24/CP.19, annex I, paragraph 37, and provide additional information to justify why the notation keys used are appropriate. The Party reported correctly CSC using notation key “NA” when using a tier 1 method where it could be assumed there were no changes in carbon stocks.	FCCC/ARR/2021/ISL/L.3	Resolved. LT 27.12.2021	
Land representation (L.4, 2019) (L.2, 2017) (L.3, 2016) (L.3, 2015) (68, 2014)	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. The Party has not reorganized the information of land representation in its NIR 2021 (section 6.1). 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	FCCC/ARR/2021/ISL/L.4	Partially resolved. The Party has added in section 6.1.3 Completeness in a tubular format all Notation keys used for changes in carbon stock changes and net CO2 emissions/removals in soils. The Party will improve trasparency in future submissions. LT 27.12.2021	NIR 2022: 6.1.3 Completeness

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
Transparency	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 it is taken into consideration in future submissions			
Land representation (L.5, 2019) (L.16, 2017) Transparency	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. The Party 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 166) and 11.2.2 (p 294) of the NIR has not been improved according to the previous recommendations. During the review, the Party clarified that some small inconsistencies between final areas in CRF table 4.1 and the corresponding total areas in CRF tables on carbon stocks 4.D and 4.F still occur. There is ongoing processing in order to improve the transparency of the land representation.	FCCC/ARR/2021/ISL/L.5	Partially resolved. The inconsistencies between final areas in CRF table 4.1 and the corresponding total areas in CRF tables on carbon stocks 4.D and 4.F still occur for 2022 submission. However, the Party has improved the trasparency of the land representation adding information about the issue for CRF table 4.1 in the NIR 2022 in section 6.3 Land use change. and 11.2.2 Methodology used to develop the land transition matrix. LT 27.12.2021	NIR 2022: Section 6.3 Land use change. Section 11.2.2 Methodology used to develop the land transition matrix.
4.A Forest land – CO_2 (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. The Party has not included in its NIR additional description of the processes by which CSC and associated emissions and removals were estimated. The ERT reiterates that the Party could improve the transparency of the NIR, for example, including summary tables of average carbon stocks with relevant data on forest areas and intermediate outputs stratified by year and forest type. During the review, the Party clarified that will consider this recommendation in future submissions.	FCCC/ARR/2021/ISL/L.6	Resolved 21.12.16. Ar.Sn. See figures: 6.7 and 6.8 in 2022 submission	6.5.1.2 and 6.5.2.2

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
4.A Forest land – CO2 (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. The Party 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. The ERT observed in NIR (p. 173) that the deadwood carbon will be included for future improvement to include losses of biomass to dead wood in stumps, root stock of cut trees and standing dead trees and to include continuous decomposition of all deadwood. During the review, the Party clarified that will consider this issue in future submissions.	FCCC/ARR/2021/ISL/L.7	Not resolved 21.12.16. Ar.Sn. in 2022 submission	
4.A.2 Land converted to forest land – CO2 (L.10, 2019) (L.18, 2017) Transparency	Include transparent information in the NIR on carbon stock for the land-use categories occurring in Iceland. The Party reported in its CRF table 4.A as "IE" losses in living biomass for other land converted to forest land and grassland converted forest land (afforestation natural birch forest), however the Party has not included additional information in the NIR to clarify where these losses are included (p.176). The Party has reported its NIR (p. 181) for grassland converted to cropland EF of 1.27 kg C m-2 equivalent to 12.7 t C ha-1. The ERT noted that this value is higher than default values for grassland given in table 6.4 of the 2006 IPCC Guidelines, and the Party has not included additional information to explain the main differences of the EF county-specific with the default values of the 2006 IPCC Guidelines. In addition, the Party reported in CRF table 4.A an EF for losses of living biomass in grassland converted to forest land (cultivated forest) lower than the EF reported for grassland converted to cropland. The ERT noted that NIR has not included some to understand transparently the differences of the losses of biomass of grassland when it is converted to forest land and when it is converted to cropland. Furthermore, The ERT noted that for land converted to cropland the Party is using an EF of 2.1 tC ha-1 for gains in living biomass according to the NIR (p. 181), however the Party has not included information in the NIR about the origin of this EF. During the review, the Party clarified that for the case of other land and grassland converted to forest land (afforestation natural birch forest) Party is using the stock-difference method as described in Chapter 2.3.1.1 with Equation 2.8 in 2006 IPCC Guidelines. Biomass losses are therefore included in the net annual removal and reported as "IE" in the CRF reporting table as they are included in the gain value as net gain value. The ERT noted that it should be important to include complementary information in the NIR for the transparency of the report.	FCCC/ARR/2021/ISL/L.8	This is explained in the NIR and in Documentation boxex in CRF tables. Resolved.	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
4.A.2 Land converted to forest land – CO_2 (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 Party reported in its NIR (p. 176) that in the estimation of CSC of living biomass for land converted to forest land (natural birch woodland) there is a linear regression between biomass per area unit in trees on measurement plots in natural birch woodland and measured age of sample trees is used to measure net annual CSC. 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. During the review, the Party clarified that both chronosequence studies referred to in the NIR, Sigurdsson et al. (2005) and the tree measurement in the NFI show clearly an increase of the biomass stock when grassland is converted to forest. According to the Party, loss of C stock in biomass has never been measured so the Party has no intention to assume C stock loss if only C stock gain has been measured. The ERT revised the reference of Sigurdsson et al. (2005) and noted that in this study areas of grassland were fenced protecting areas from grazing and studied the evolution of biomass of the natural birch forest during a period of years. This could be interpreted as that the carbon stock before land-use conversion is maintained in the land converted. However, the ERT noted that it is not clear if the results of this specific study of grassland converted to forest land, with grassland fenced to allow establishment of the forest, is enough to extrapolate to all conversion of grassland to forest land in the country. The ERT is of the view that the Party include information with more details of the study of Sigurdsson et al. (2005) and assumptions to use this study as base for all conversion of grassland to forest land with the objective document that the carbon stock before land-use conversion is maintained in the land converted. Otherwise the Party should implement the calculation methods in line with equations 2.15 and 2.16 of volume 4 of the 2006 IPCC guidelines in the grassland converted to forest land that do not have the same conditions of the study.	FCCC/ARR/2021/ISL/L.9	As mentioned in chapter 6.5.2.2. of the 2021 NIR (page 176) other studies supports the results of Sigurdsson et al. (2005). To use instant oxidation of all amounts of living biomass and litter when making land-use conversions from grassland to forest land is in the case of Icelandic afforestation a very unrealistic approach and would entail a reconstruction of removal factors for litter and construction of removal factors for other vegetation than trees in the accordance to research results.	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
4.B.2 Land converted to cropland (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. The Party 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 documentation box of CRF table 4.B, but it was not included in the CRF table 9. During the review, the Party clarified that it has not been made improvement for this recommendation and it will be considered in future submissions	FCCC/ARR/2021/ISL/L.10	Information about forest land converted cropland before 1990 are not available. In accordance with extraordinary low ratio of forest cover in the country especially close to farms where modern cropland cultivation is practisized conversion of forest land to cropland can be assumed as very rare. In the period 1990 - 2020 only one event of 11. ha is reported. ArSn 220103	
4.B.2.2 Grassland converted to cropland – CO2 (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. The Party reported in its NIR table 10.9 (p. 280) that it have not been 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 transparency in the upcoming NIR submissions with more specific information	FCCC/ARR/2021/ISL/L.11	Partially resolved. Trasparency in NIR: The Party has improved transparency regarding this issue adding information in section 6.6.2.2 Methodology In NIR 2022. However, no 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. LT 27.12.2021	NIR 2022: Section 6.6.2.2 Methodology
4.C Grassland – CO2 (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. The Party reported in its NIR Table 10.9 (p. 280) that improvements have not been made to locate degraded areas of grassland. During the review, the Party clarified that measurements and data collection of degraded grassland areas have started in the summer of 2021 and estimations of the emissions from these areas will be conducted in future submissions.	FCCC/ARR/2021/ISL/L.12	Not resolved. Measurements and data collection of degraded grassland areas have started in the summer of 2021 and estimations of the emissions from these areas will be conducted in future submissions. LT 27.12.2021	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
4.C.1 Grassland remaining grassland – CO2 (L.16, 2019) (L.10, 2017) (L.12, 2016) (L.12, 2015) Completeness	Estimate and report CSC in mineral soils under grassland remaining grassland for “Natural birch shrubland – old” and “Revegetated land older than 60 years”. The Party has corrected notation key “NA” instead of “NE” for CSC in mineral soils in the CRF table 4.C for “revegetated land older than 60 years” according to the UNFCCC Annex I inventory reporting guidelines. For “natural birch shrubland – old” the Party continued using notation key “NA” without information about the review of estimation in the future submissions. During the review, the Party clarified that preparation of soil, litter and vegetation samples from the NFI systematic plot sampling is ongoing and the samples will be analysed this year (2021). In addition, the Party informed that CSC in soil of natural birch shrubland has more in common with natural birch forest than grassland, and numerous research results show that cold temperate forests in general are adding C to soil. For this reason, the Party mentioned that assuming equilibrium and reporting notation key “NA” should be reasonable Tier 1 approach for the category “natural birch shrubland-old”.	FCCC/ARR/2021/ISL/L.13	Resolved regarding "Revegetated land older than 60 years": notation key for CSC in mineral soils for the sub-category "Revegetation land older than 60 years" is reported as NA in the CRF table 4.C. Resolved regarding "Natural birch shrubland-old". As described in NIR 2022 the methodology used for this subcategory follow directly the methodology used for Natural birch forest older than 50 years. Argumentation for reporting CSC in SOC as NA is therefore the same: "models and model modifications used in other Nordic countries show increase in litter and mineral soil pools in the long run in forest in general (Dalsgaard, et al., 2016)	NIR 2022: 6.7.1.1; 6.5.1.2
4.C.2 Land converted to grassland – CO2 (L.17, 2019) (L.19, 2017) Accuracy	Revise the CO2 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. The Party has not included new information about the review of the CO2 estimates for land converted to grassland using updated data on carbon sequestration in soils, especially for other land converted to grassland and the Party informed in its NIR (p. 280) that is working to improve this issue. During the review, the Party clarified that preparation of soil, litter and vegetation samples from the Soil Conservation Service of Iceland systematic plot sampling is ongoing and the samples will be analysed this winter. The Party will expect further scientific analyses of the data in next years.	FCCC/ARR/2021/ISL/L.14	Not resolved. The Party is still working on this issue and estimate to improve data on C-sequestration in soils, especially for Other land converted to Grassland, in 2023 submission. LT 27.12.2021	
4.D.2.3 Land converted to wetlands – CO2 (L.18, 2019) (L.11, 2017) (L.13, 2016)	Estimate and report CSC in mineral soils under land converted to wetlands. The Party has included estimation for CSC in mineral soils for “rewetted wetland soils” in the CRF table 4.D for the years when there was activity data (2016-2019) and according to the recommendation of the previous review the Party has changed notation key using “NO” instead of “IE for the years 1996-2015. The ERT noted that Party has not included additional information in its NIR to improve the transparency about the use	FCCC/ARR/2021/ISL/L.15	Resolved. LT 27.12.2021	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
(L.13, 2015) Transparency	of notation key "NO". The Party has reported using notation key "NE" for "land converted to refilled lakes and ponds" in the CRF table4.D, without additional explanation in the NIR. During the review, the Party clarified that regarding the transparency for the "rewetted wetland soils" will include further clarifications in the future submissions. In the case of "land converted to refilled lakes and ponds, the Party will continue using "NE" because 2006 IPCC Guidelines (Vol 4, chap. 7, p. 7.20) do not provide any methodology for estimating CSC in soils due to land conversion to flooded land.			
4.D.2.3 Land converted to wetlands – CO_2 (L.19, 2019) (L.20, 2017) Transparency	Correct the statement in section 6.7.3.2 of the NIR referring to the reporting of aggregate CSC for mineral and organic soils so as to clarify that the value reported in CRF table 4.D as loss from mineral soils on land converted to wetlands consists of two subcategories (grassland converted to flooded land and other land converted to flooded land) and that CSC in mineral and organic soils are reported separately in the CRF tables. The Party has corrected the statement in section 6.8.1.2 of the NIR (p. 194) referring to the separated reporting of CSC for mineral soils and organic soils. For mineral soils CSC is estimated for "grassland converted to flooded land - Medium SOC to reservoirs" and "other land converted to flooded land – low SOC reservoirs", for organic soils CSC is estimated for "Flooded Land remaining flooded land – Mires converted to reservoirs". The ERT noted that the information is reported adequately in CRF table 4.D	FCCC/ARR/2021/ISL/L.16	Resolved. LT 27.12.2021	
4.E.2 Land converted to settlements – CO_2 (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. The Party has not estimated and reported CSC in mineral soils for land conversion to settlements, with the exception of forest land converted to settlements that was reported in the same way in the previous submissions. The Party has informed that will start in the next years CSC estimations in land converted to settlements.	FCCC/ARR/2021/ISL/L.17	Not resolved. LT 27.12.2021	
4(IV) Indirect N_2O emissions from managed soils –	Estimate and report indirect N_2O emissions from managed soils, excluding those from agricultural lands that are reported in CRF table 3.D, and, where the notation key "IE" is used, indicate in the NIR and in the documentation box of the corresponding CRF table where in the inventory the emissions have been included and report information on the use of this notation key in CRF table 9. The Party estimated and reported indirect N_2O emissions from managed soils, emissions are reported in CRF	FCCC/ARR/2021/ISL/L.18	Resolved. LT 27.12.2021	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
N2O (L.23, 2019) (L.22, 2017) Completeness	table 3.D, the Party included a notation key "IE" in table 4 (IV) with documentation box and information in CRF table 9. The Party included in its NIR (p. 207) the information.			
4(V) Biomass burning – CO_2, CH_4 and N_2O (L.24, 2019) (L.23, 2017) Transparency	Correct the use of notation keys to report on emissions from biomass burning in CRF table 4(V). The Party has changed notation key "NE" for "NO" in CRF table 4(V) for controlled burning in all land use categories except for forest land. However, the Party in its NIR (p. 208) included an explanation that controlled burning on grazing land near the farm was common practice in sheep farming in the past. This management regime of grassland and wetland is becoming less common and now is 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. During the review, the Party clarified that controlled burning is not part of the management regime of grassland and wetland. However, this activity is allowed under official licensing, this rule is not followed, so reliable data on burning control is not available. According to this, the ERT considers that notation key "NE" should be used for the controlled burning in grasslands and wetlands, because it is an activity that could occur in the country, and the Party should include relevant justification of the use of this notation key.	FCCC/ARR/2021/ISL/L.19	Resolved. LT 27.12.2021	
Land representation – CO_2 (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. The Party reported new recalculations for land areas in CRF table 4.1and NIR (p. 163, p. 182-183), especially for grassland and other land. The Party indicated in its NIR (p. 183) increasing areas of grassland corresponding to areas of other land previously considered unmanaged, where instead grazing activities occur. According to the NIR this change was possible for the use of the IGLUD map and the adoption of the habitat type map to obtain better information of land use. The ERT noted that habitat type map is updated regularly, and the last update used for NIR 2021 was in 2020. Considering that the Party updated data activity in some uses of land (grassland and other land), based on regular updates of the habitat type map, it is important to provide information on the uncertainties related to habitat type classification according to the previous recommendation.	FCCC/ARR/2021/ISL/L.20	Not resolved. LT 27.12.2021	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
	During the review, the Party clarified that the recommendation will be taken into consideration for future submissions.			
4.C.1 Grassland remaining grassland – CO_2 (L.26, 2019) Transparency	Update the information on the EF used for organic soils under natural birch shrubland in the NIR and ensure that the information in the NIR is up-to-date and consistent with the information reported in the CRF tables. The Party reported for natural birch shrubland in its NIR (p.184) and in the CRF table 4.C the same information of emission factor of organic soils. The EF of organic soils is reported on the basis of the tier 1 method from the Wetlands Supplement, that is 0.37 tC ha-1 year-1.	FCCC/ARR/2021/ISL/L.21	Resolved. LT 27.12.2021	
4(I) Direct N_2O emissions from nitrogen inputs to managed soils – N_2O (L.28, 2019) Accuracy	Check the EF used for inorganic fertilizer and revise it, if appropriate, and report any recalculations made for N_2O emissions from inorganic fertilizers on forest land. The Party reported in its NIR (p. 146, 207) and in CRF table 3.D direct N_2O emissions from nitrogen inputs to managed soils for land converted to forest land. The Party has used EF according to the default method described in the 2006 IPCC Guidelines (Vol 4 chapter 11.2).	FCCC/ARR/2021/ISL/L.22	Resolved	
4 (II) Emissions and removals from drainage and rewetting and other management of organic/mineral soils – CO_2, CH_4 and N_2O	Check and revise, if appropriate, the EFs for CO_2 and CH_4 emissions from drained organic soils under the forest land category in CRF table 4(II) to avoid the possibility of emissions from forest land soils being underestimated and report any recalculations in the next submission (see also ID# G.12 in table 6). The Party reported in CRF table 4(II) EFs for CO_2 and CH_4 emissions from drained organic soils under the forest land category according the default method described in the 2013 IPCC Wetlands supplement.	FCCC/ARR/2021/ISL/L.23	Resolved	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
(L.29, 2019) Accuracy				
4. General (LULUCF) – (L.30, 2019) Convention reporting adherence	Improve its QA/QC plan to avoid discrepancies in cross references between NIR sections and to ensure that section numbering is correct. The Party has improved cross references between NIR sections. The ERT noted some discrepancies, for instance, page 174 has a reference to chapter 5.7.2.6, however the methodology is described in chapter 5.7.3 and the complementary information was included in Table 5.37 (p. 143) with reference to Annex 9, but the information is in Annex 8. During the review, the Party clarified that an update of the QA/QC plan is in progress, and the issue of consistency of numbering will be added to it.	FCCC/ARR/2021/ISL/L.24	The final checks of the report will be improved by a) moving the deadlines of the single chapters, b) aggregating the text earlier, c) allowing a quality check by all authors in the final stage of editing.	
4. General (LULUCF) – (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. The Party reported some land uses and land-use changes as "IE" in CRF table 4.1 (cropland and wetlands (managed) converted to settlements, other land converted to cropland, other land converted to settlements). The Party has not included information in the NIR section with the explanations about the land transition matrix and the use of the notation key "IE". During the review, the Party clarified that recommendation will be taken into consideration in future submissions.	FCCC/ARR/2021/ISL/L.25	Resolved. The Party has provided information with the explanations about the land transition matrix and the use of the notation key "IE" in the NIR section 6.9.2.1 Category description. LT 27.12.2021	6.9.2 Land Converted to Settlements (CRF 4E2) 6.9.2.1 Category description
Land representation – CO_2, CH_4 and N_2O (L.32, 2019) Accuracy	Report a consistent national land area across the inventory time series in line with the 2006 IPCC Guidelines. This can be derived, for example, from the official land area of the Party and applied across the entire time series, possibly leading to recalculations of areas. The Party reported a consistent national land area across the inventory time series (CRF Table 4.1) in line with the 2006 IPCC Guidelines.	FCCC/ARR/2021/ISL/L.26	Resolved. LT 28.12.2021	
4.A Forest land – CO_2 (L.33, 2019) Comparability	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 (see ID#s L.7 above and KL.14 below). The Party 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 document box in CRF table 4.A about the use of the notation key "IE" for CSC in deadwood for forest land remaining forest land and for other land converted to forest	FCCC/ARR/2021/ISL/L.27	Resolved 21.12.16 Ar.Sn. See NIR Chapter: 6.5.1.2. and Document box in CRF: tables: 4.A.2.5 Other Land Converted to Forest Land][Afforestation 1-50 years old and 4.A.1 Plantations in natural birch forest and Afforestations older than 50 years.	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
	land. During the review, the Party clarified that the main source of deadwood is cutting activities and harvest activities 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 will include this information in the box of the CRF table4.1 and CRF table 9 in the next submission			
4.B.1 Cropland remaining cropland – CO_2 (L.34, 2019) Transparency	Provide information to justify the high EF for mineral soils in the next annual submission. The Party included additional information about EF in mineral soils in NIR (p. 179) related to Andosol. The ERT noted that it is important to have additional information used to determine the EF such as depth considered for the carbon content, assumptions about different N fertilizers and content of carbon used and relation with cropland remaining cropland category. During the review, the Party clarified that the base experiment site was conducted at four different locations, and the Party provided additional information on one site. The base experiment was conducted to estimate the changes in base status and soil organic matter content resulting from long-term use of three different nitrogen fertilizers. Changes were largely restricted to the top of the soil (0-5 cm) and seem to disappear in the 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. However, after reviewing the original paper the Party decided that the initially calculated factor must be corrected from tC/ha/year 0.1708 to tC/ha/year 0.1525 in the next submission (New issue Table 5 accuracy)	FCCC/ARR/2021/ISL/L.28	Resolved. LT 28.12.2021	NIR 2022: 6.6.1.2
4.B.2 Land converted to cropland – CO_2 (L.35, 2019) Transparency	Provide an explanation for reporting “IE” in CRF table 9 with regard to net CSC in DOM for grassland and wetlands converted to cropland and consider adding explanatory information to the documentation box to CRF table 4.B. The Party provided an explanation for reporting “IE” in CRF table 9 with regard to net CSC in DOM from grassland and wetlands converted to cropland and added explanatory information to the documentation box to CRF table 4.B.	FCCC/ARR/2021/ISL/L.29	Resolved. LT 28.12.2021	
4.C Grassland – CO_2 (L.36, 2019) Transparency	Explain the reporting of “IE” for each subcategory and pool in CRF table 9 in the reporting of grassland CSC in DOM and soils, and consider adding explanatory information to the documentation box to CRF table 4.C. The Party included an explanation of the reporting of “IE” for each subcategory and pool in CRF table 9 in the reporting of grassland CSC in DOM and soils and added explanatory information to the documentation box to CRF table 4.C.	FCCC/ARR/2021/ISL/L.30	Resolved. LT 28.12.2021	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
4.C.1 Grassland remaining grassland – CO2 (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). The Party has used notation key "NA" for CSC under grassland mineral soils for revegetated land older than 60 years for complete time series. However, the ERT noted that the Party has reported in its NIR (p. 185) that CSC of revegetated land older than 60 years are presently estimated as not occurring. The NIR has not included additional explanation about the use of the notation key "NA" where CSC is assumed to be in equilibrium. During the review, the Party clarified that updated notation key using "NA" in the CRF table 4.C.	FCCC/ARR/2021/ISL/L.31	Resolved. LT 28.12.2021	
4.D.1 Wetlands remaining wetlands – CO2 (L.38, 2019) Accuracy	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. The Party reported other wetlands remaining other wetlands (intact mires) in CRF table 4.D using an EF according tier 1 based on guidance in the Wetlands Supplement (NIR p. 195). The Party recognized that wetlands remaining wetlands is a key category (NIR p. 193), in particular other wetlands remaining other wetlands are a key category. During the review, the Party indicated that this recommendation will be considered in future submissions.	FCCC/ARR/2021/ISL/L.32	Not resolved. LT 28.12.2021	
4(III) Direct N2O emissions from N mineralization/immobilization – N2O (L.40, 2019) Transparency	Report in the NIR the reasons for carbon accumulation on cropland soils, especially on mineral soils converted to cropland (see ID#s L.34 above and A.20 in table 3). The Party included additional information about EF in mineral soils in NIR (p 179) related to Andosol soil. The ERT noted that it is important to have additional information used to determine the EF such as depth considered for the carbon content, assumptions about different N fertilizers and content of carbon used to understand the reasons for carbon accumulation. During the review, the Party provided additional information of the study (see L.28) and clarified that after the revision of the data based on the study, the initially calculated factor must be corrected from 0.1708 tC/ha/year to 0.1525 tC/ha/year in the next submission.	FCCC/ARR/2021/ISL/L.33	Additional information regarding the EF used for mineral soils in Cropland remaining Cropland are added in NIR 2022 in section 6.6.1.2 Methodology. For 2022 submission 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. LT 28.12.2021	6.6.1.2 Methodology
4(V) Biomass burning – CO2, CH4 and N2O (L.41, 2019)	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 (see ID# L.19 in table 3 on correcting the use of notation keys). The Party has changed notation key "NE" for "NO" in CRF table 4(V) for	FCCC/ARR/2021/ISL/L.34	Resolved. Additional information are added in NIR 2022 in section 6.17.1 Category description under Chapter 6.17 Biomass Burning (CRF 4(V)). LT 28.12.2021	6.17 Biomass Burning (CRF 4(V)) - section 6.17.1 Category description

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
Completeness	controlled burning in all land use categories except for forest land. However according to the previous recommendation (see ID# L.19) the ERT considers that notation key “NE” should be used for the controlled burning in grasslands and wetlands, because it is an activity that could occur in the country, and the Party should include relevant justification of the use of this notation key			
4(I) Direct N2O emissions from N input to managed soils – N2O	Iceland reported in its NIR (p. 202) that the fertilizer used in forest land is included under the total synthetic fertilizer under category 3.D.1. The ERT noted that the Party reported in its CRF table 3.D the same activity data of synthetic fertilizer nitrogen in NIR 2019 and NIR 2021. However, according to chapter 5.6.2 (p. 117) of the NIR 2019 the activity data excluded the amount of fertilizer applied in forestry. The ERT noted that fertilizers used in forest land could be excluded from the activity data of the agriculture sector of the 2021 submission. During the review, the Party clarified that there was a mistake in the activity data included in CRF table 3.D. The Party provided correct estimates and the ERT checked that the estimation of indirect N2O emissions were correct. Correct activity data of synthetic fertilizers in CRF table 3.D f and include information of activity data of synthetic fertilizer of forest land in the NIR.	FCCC/ARR/2021/ISL/L.35	Resolved. Activity data are reported in table [4. Land Use, Land-Use Change and Forestry][4.A Forest Land][4.A.2 Land Converted to Forest Land][4(I) Direct N2O Emissions from N Inputs to Managed Soils][Inorganic N Fertilizers] with following text in Documentation box; In response to the comment from the UNFCCC ERT about the completeness of 4(IV) Indirect N2O emissions from managed soils - N2O (L 22, ARR 2017) under the LULUCF chapter it was decided to include the fertilizers used in Forestry under the total synthetic fertilizer under 3D1. According to this decision use of inorganic fertilizer previously reported under Land Converted to Forest Land (CRF 4.A.2)/ Grassland Converted to Forest land/ Afforestation 1 - 50 years old – Cultivated forest, have been replaced with IE (included elsewhere) in the CRF 4.A.2. Ar.Sn. 220103	
4.A Forest land – CO2	Iceland reported in its CRF table 4.A carbon stock change in deadwood using notation key “IE” (see L.27). The ERT noted that there is no transparent information in the NIR about where carbon stock change is included. During the review, the Party clarified that the main source of deadwood is cutting activities and harvest activities and these activities 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. Incorporate in the NIR additional information about the use of notation key “IE” in CSC of deadwood for forest land to improve the transparency.	FCCC/ARR/2021/ISL/L.36	Resolved 21.12.16 Ar.Sn. See NIR Chapter: 6.5.1.2. and Document box in CRF: tables: 4.A.2.5 Other Land Converted to Forest Land][Afforestation 1-50 years old and 4.A.1 Plantations in natural birch forest and Afforestation older than 50 years.	
4.B.1 Cropland remaining	Iceland reported in its NIR (p. 178-179) and in CRF table 4.B a subdivision in cropland remaining cropland, named cropland active and cropland inactive (fallow), where cropland inactive includes all cropland not being currently considered under	FCCC/ARR/2021/ISL/L.37	Not resolved. The Party is working to correct this issue before 2026, hopefully in the 2023 submission. Leone 222.12.2021	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
cropland – CO2	cultivation. The ERT noted that the Party is using the same EF for CSC in mineral soil in cropland active and cropland inactive in CRF table 4.B, and according to the explanation in NIR section 6.6.12 (p. 179) EF of CSC in mineral soil is estimated based on study of Helgason (1975) on effects of different N fertilizers on soil properties. The ERT observed that cropland inactive is not considered under cultivation therefore is not adequate to use the same EF that cropland active. During the review, the Party clarified 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 Party is working to correct the situation before 2026, hopefully in the 2023 submission. However, after reviewing the original paper the Party decided that the initially calculated EF must be corrected from 0.1708 to 0.1525 tC/ha/year in the next submission. Revise the use of the same EF for CSC in mineral soils for cropland inactive and cropland active, because cropland inactive is not under cultivation and the content of carbon in mineral soils should be different that cropland active.			
4(II) Emissions/removals from drainage and rewetting and other management of organic/mineral soils – CH4	Iceland reported in its NIR (p. 173) that for the estimation of CH4 emissions from drained organic soils it is using the proportion of 5 % of ditches. The ERT noted that using the proportion 5 % of ditches the emissions of CH4 should be 12.75 kg CH4/ha, however the Party is using 7.37 kg CH4/ha (NIR, p. 174 and CRF Table 4(II)) for Forest Land, Grassland remaining Grassland (Natural birch shrub land old) and Grassland remaining Grassland (Natural birch shrubland recently expanded to other grassland)). During the review, the Party clarified that there is a typing error in the NIR text. Assumed area of ditches in forest are 2.5% as given in table 2.4 for CH4 from ditches in drained Forest Land instead of 5%. The error will be corrected in the next submission. Correct the information in the NIR about the proportion of ditches for drained organic soils to improve the transparency of the report.	FCCC/ARR/2021/ISL/L.38	Resolved. ArSn220103	NIR 2022: Section 6.14.2 Methodology
4.D.1.2 Flooded land remaining flooded land – CO2, CH4	Iceland reported in its NIR (p.193) that mires converted to reservoirs are 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. Mires converted to reservoirs correspond to land with high soil organic content and includes land with organic soil or complexes of peatland and upland soils that were inundated. The Party reported carbon stock changes in organic soils in the CRF table 4.D and emissions of	FCCC/ARR/2021/ISL/L.39	Resolved. In response to the ERT´s comment the Party has added information in NIR 2022 in section 6.8.1.1: "As the CRF table does not allow land use changes within the main category, Inundated mires should not be reported as “Other Wetlands	NIR 2022: Section 6.8.1.1 Category description

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
	CH4 and CO2 in CRF table 4(II) according to the methodology of Wetlands Supplement (NIR p. 205) using Equation 3.5 for rewetted organic soils . The ERT noted that mires have a substantial change in water surface area and are converted to flooded lands (reservoirs), and 2006 IPCC guidelines provide methodology for flooded lands but no guidance is provided on carbon stock changes from soils. During the review, the Party explained that mires are included as wetlands subcategory, so does flooded land. As the CRF tables does not allow land use changes within the main category, i.e. from other wetlands to flooded land, inundated mires are categorized as land remaining flooded, although strictly speaking they should be reported as "other wetland" converted to "flooded land". But that option is not valid in CRF. Inundated mires thus still remain as wetland, although converted from one wetland subcategory to another. The Party did not include an explanation about the use of the methodology of Wetlands Supplement. Review the methodology to use for mires converted to reservoirs. If the Party defined reservoirs as flooded land then it should be used 2006 IPCC guidelines according to chapter 7.3 flooded land and for emissions of CH4 the Party should explore peer reviewed guidance such as 2019 IPCC that could inform its country specific approaches. On the other hand, if the Party is considering reservoirs as rewetted organic soils, then the methodology of Wetlands Supplement should be appropriate. For the transparency of the report, the Party should include more information about the characteristic of the reservoirs in the NIR.		converted to Flooded Land". It was discussed to include them as remaining mires, but since the inundation does change the functionality of mires through vegetation die off, it was decided to categorize them as flooded land remaining flooded land in order to estimate GHG emissions. LT 4.1.2022	
General (KP-LULUCF activities) – CO2, CH4 and N2O (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. The Party reported in its NIR (p.298, 301) that no historical data of natural disturbance events of forest under AR and FM exist, so calculation of background level and margin as described in the Kyoto Protocol Supplement (pp.2.45–2.54) is not possible and should be reported as zero or "NO". The Party reported background level as "NO" under AR in CRF table 4(KP-I) A.1.1 and "NE" under FM in CRF table 4(KP-I) B.1.3. The Party did not provide country- specific information (data and methods) in its NIR associated with FM and AR and background levels of emissions associated with annual disturbances. In addition, the ERT noted that the Party provided estimates of background level and margin for FM in the ARR(2016). During the review, the Party clarified that it chose to apply the ND provision. The reasons for doing so were described in the initial review report of the initial	FCCC/ARR/2021/ISL/KL.1	Resolved. See information in NIR. ArSn 220107	Chapter: 11.4.4, 11.5.4

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
	submission for the second commitment period of KP. In the report, where wildfires are described, it was stated that "only two of these events are of a size (bigger than 0.5 ha) to be reported in the UNFCCC-CRF, in 2010 and 2013". As mentioned above Iceland was asked to calculate background level and its margin for ND for FM and AR under the review in 2016. An attempt to do so was delivered in the ARR(2016). Only one of the two events mentioned above turned out to be forest fire as the one burned in 2010 was a fire in grassland covered partly with natural birch shrubland (7.9 ha of 13.3 ha were natural birch shrubland). The fire in 2013 was reported 0.4 ha and the background level and its margin for ND was calculated as the standard deviation of the emission of this fire and value zero for the year 2006-2012 and 2014 (background level for forest management (0.00004586875 kt CO2 eq) and the margin (0.000275213 kt CO2 eq)). No fires were reported on AR areas for the period 2006-2014 so background level and margin for AR was assigned zero. In 2018 submission the Party decided not to report the 0.4 ha forest fire of 2013 as it doesn't hold the minimum reporting unit for forest changes (0.5 ha). In accordance with that decision a new value for background level and margin for FM should have been zero or "NO" as in AR. Unfortunately, this was not done and instead "NE" was reported for background level and margin in FM as already mentioned above. The Party will correct the use of the notation key in the next submission.			
General (KP-LULUCF activities) – CO2, CH4 and N2O (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. The Party included in its NIR (p. 301) section 11.5.5 named "information that demonstrates that emissions and removals resulting from elected Article 3.4 are not accounted for under activities under Article 3.3", however this section did not include content of information. On the other hand, section 11.1.3 and 11.1.4 (p.293) provides information about definitions of AR and FM, and description of precedence conditions or hierarchy among 3.4 activities. The ERT noted that the information included in these sections with a complement of additional information would help to report in the section 11.5.5. During the review, the Party clarified that the recommendation will be included in future submission.	FCCC/ARR/2021/ISL/KL.2	Resolved. LT 07.01.2022	11.5.5 Information that demonstrates that emissions and removals resulting from elected Article 3.4 activities are not accounted for under activities under Article 3.3.

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
General (KP-LULUCF activities) – CO2, CH4 and N2O (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. The Party reported in its NIR (p.298) an error estimate for activity data for afforestation, FM of cultivated forest and revegetation. However, the Party did not provide a description of the methodologies used for conducting an uncertainty analysis for KP-LULUCF activities. The ERT noted that information on the uncertainty according to the 2006 IPCC Guidelines, such as, information on methods used for conducting the uncertainty assessment, underlying assumptions, data sources and documentation of expert judgment used to calculate uncertainties, would help to the transparency of the uncertainty analysis of AD, EFs and emissions for each carbon pool. During the review, the Party clarified that the recommendation will be included in future submission.	FCCC/ARR/2021/ISL/KL.3	Resolved. See information in NIR. ArSn 220107	Chapter: 11.3.2.5, 11.6
General (KP-LULUCF activities) – CO2, CH4 and N2O (KL.5, 2019) (KL.8, 2017) Transparency	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. The Party reported in its NIR (p. 298, 301) that it intends to apply zero values to background level and margin under AR and FM, respectively. The Party also reported that no historical natural disturbances were detected in afforestation or FM forests. In accordance with decision 2/CMP.7, annex, paragraph 33, if the background level is defined using a country-specific approach or the Party's reference level is zero, the Party must describe how a margin is established, where a margin is needed (see also ID# KL.1 above). During the review, the Party clarified that the recommendation will be included in future submission (see KL.1).	FCCC/ARR/2021/ISL/KL.4	Resolved. See information in NIR. ArSn 220107	Chapter: 11.4.4, 11.5.4
AR – CO2, CH4 and N2O (KL.6, 2019) (KL.4, 2017) (KL.1, 2016) (KL.1, 2015) (86, 2014)	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. The Party has not included in its NIR additional description of the processes by which CSC and associated emissions and removals were estimated (see ID#L.6). The ERT reiterates that the Party could improve the transparency of the NIR, for example, including summary tables of average carbon stocks with relevant data on forest areas and intermediate outputs stratified by year and forest type.	FCCC/ARR/2021/ISL/KL.5	Resolved 21.12.16. Ar.Sn. See figures: 6.7 and 6.8 in 2022 submission	6.5.1.2 and 6.5.2.2

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
Transparency	During the review, the Party clarified that it will consider this recommendation in future submissions.			
AR – CO2 (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. The Party reported in CRF table 4(KP-I)A.1 and CRF table 4(KP-I)C using the notation key "NA" for CSC in the HWP pool under AR. The ERT noted that according to the explanation in the NIR (p. 295) the wood removal after commercial thinning or clear-cutting has not been detected in the national forest inventory in afforestation areas since 1990. Carbon stock losses in living woody biomass are therefore reported as "NO". During the review, the Party clarified that the use of notation key "NO" will be used instead of "NA" for reporting of CSC of the HWP pool under AR.	FCCC/ARR/2021/ISL/KL.6	Resolved in CRF table and NIR. Ar.Sn. 220107	Chapter 11.4.5
Deforestation – CO2, CH4 and N2O (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). The Party has not reported recalculations CSC in soil organic matter in CRF table 4(KP-I)A.1 and CRF table 4 (KP-I)A.2 by ensuring symmetry among pairs of land-use conversion, for instance, grassland converted to forest land and forest land converted to grassland. During the review, the Party clarified that the recommendation will be taken into consideration in future submissions.	FCCC/ARR/2021/ISL/KL.7	Not resolved in 2022 submission but will be taken consideration in future submission	
FM – CO2 (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). The Party reported in its CRF table 4(KP-I)B.1 gains for below-ground biomass under FM on cultivated forest land for 2013–2019 but reported corresponding losses as "NE" for 2013–2019. The ERT noted that the Party did not provide a justification for reporting "NE" or explain why this carbon pool is not a net source in accordance with decision 2/CMP.8, annex II, paragraph 2(e). During the review, the Party clarified that the recommendation will be included in future submissions.	FCCC/ARR/2021/ISL/KL.8	Not resolved for Cultivated Forest but will be included in future submissions as discussed in NIR regarding forest land. Ar.Sn. 220107	Chapter 6.5.1.5

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
RV – CO2 (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. The Party reported in its NIR (p.296) that for CSC in soils there is an ongoing field sampling started in 2007, the second sampling started in 2018, and it is expected to result in better estimates in the future. In addition, in NIR (p 297) the Party informed that the changes in carbon stocks at revegetation sites were estimated based on a country specific EF covering all carbon pools. Current, but unpublished, results from National Inventory on Revegetation Areas for 2007-2011 indicate considerable variation between reclamation method and land types, and the data has not been fully analysed. During the review, the Party clarified that is working to improve the estimation of CSC in living and dead biomass and carbon stock soil, with the preparation of soil, litter and vegetation samples from the Soil Conservation Service of Iceland, systematic plot sampling is ongoing and the samples will be analysed for C later this winter. Further scientific analyses of the data are expected in next years.	FCCC/ARR/2021/ISL/KL.9	Not resolved: The Party is still working on this issue and estimate to improve data on C-sequestration in soils, especially for Other land converted to Grassland, in 2023 submission. LT 07.01.2022	
HWP – CO2 (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). The Party has reported in its NIR (p. 302) information about wood production and sawn production until 2019, the Party informed that activity data is originated from different information sources, including the annual unofficial report of the Iceland Forest association. The ERT noted that the Party has not included additional information on how to distinguish between domestic and imported HWP. The Party has not provided information about the methodology used to estimate HWP from deforestation and FM During the review, the Party clarified that the information about the origin of HWP is scattered and unclear in its NIR and will be improved in the next submission. Regarding the methodology used to estimate HWP from deforestation and FM, the Party informed that all deforestation activities are followed thoroughly by the Icelandic Forest Service in accordance with the Icelandic Forest act (NIR p. 170). Until now only one deforestation event has yielded harvested wood but in that case, the wood was not usable to produce sawnwood and was used for firewood production.	FCCC/ARR/2021/ISL/KL.10	Resolved ArSn 220107	Chapters 6.11.1 and 11.6

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
FM – CO2 (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). The Party reported EFs recalculated for cultivated forests on mineral soils between the 2019 and 2020 submissions in CRF table 4(KP-I) B.1. There is no information on recalculations for FM in the 2020 NIR. For instance, for 2017, 2016 and 2015 the EFs for cultivated forests on mineral soils was reported as 0.21 tC/ha in the 2019 submission and it was reported as 0.25 tC/ha between 2017 and 2015 for 2020 and 2021 submissions. During the review, the Party clarified that cultivated forests under FM have not a single EF. For cultivated forest older than 50 years no CSC in mineral soil is reported. For cultivated forest 50 years or younger converted from other land an EF of 0.513 tC/ha is used and for cultivated forest 50 years or younger converted from grassland an EF of 0.365 tC/ha is used. This EF are unchanged. On the other hand an average EF on mineral soil for cultivated forest will vary from one reporting year to another according to the fractional changes of the subgroups of the cultivated forest. Another factor of variation is new data input of annual NFI data as the data input of the sample data.	FCCC/ARR/2021/ISL/KL.11	Resolved. Ar.Sn. 220107	Chapter 11.3.1.1
FM – CO2 (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. The Party reported in its CRF table 4(KP-I)B.1 lower losses of above-ground biomass for cultivated forests compared to the previous submission, although this is not mentioned in the NIR. For example, according to the 2021 submission, losses were 0.67 kt C in 2018, while in the 2020 submission they were reported as 1.09 kt C for the same year. The ERT observed that the difference is in the EF considered for losses of above-ground biomass, for the submission 2020 the EF was 0.18 kt C/ha and in 2021 submission was 0.11 kt C/ha, in addition the AD was different in both submissions. During the review, the Party clarified that losses in above-ground biomass are mostly estimated based on annual harvest activity data. In the 2020 submission activity data on 2018 harvest were not available in time to be used in the estimation of the 2020 submission. Instead, a trend line with data from 2010-2017 was used as a preliminary estimate for the losses in above-ground biomass due to harvest activity resulting in 1.09 kt C as mentioned above. New estimate based on real activity data replaced the trend line estimation in the 2021 submission resulting in lower losses of above-ground biomass. The ERT noted that the explanation provided for the Party would help to the transparency of the report.	FCCC/ARR/2021/ISL/KL.12	Resolved. Revisions of AD concerning above ground biomass losses were done in this year submission. Ar.Sn. 220107	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
AR – CO2 (KL.16, 2019) Convention reporting adherence	Carry out additional QA/QC procedures to update the cross references in the latest NIR to other chapters within the document and update the text of the NIR as needed (e.g. in this case, extrapolated years should be updated from 2013–2016 to 2013–last reported year). The Party reported in its NIR ((p.294) correct cross references to other chapter within the document and the Party updated the text of the NIR as needed (e.g. extrapolated years was updated to 2013 – 2019) in NIR (p. 175).	FCCC/ARR/2021/ISL/KL.13	Resolved Ar.Sn. 220107	
AR – CO2 (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. The Party reported in its CRF table 4(KP-I)A.1 the same EF for litter in natural birch forests and cultivated forests under AR (0.14 tC/ha) and the EF under FM (0.09 tC/ha) reported in CRF table 4(KP-I)B.1 was lower than the EF for litter in cultivated forest under AR. In addition, the Party reported as "NE" for litter in natural birch forests under FM in the CRF table 4(KP-I)B.1.(see KL.16). The Party explained in its NIR (p. 296) that CSC for litter on AR and FM are estimated using EF described in section 6.5 (p. 173, 176). According to the NIR (p. 176) the emission factor for litter under AR is an arithmetic average of the results from two research projects, however there is no additional information about both birch forest and cultivated forest were considered by the projects. During the 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 Party informed that it will improve the transparency report including the explanation about EF in litter on AR.	FCCC/ARR/2021/ISL/KL.14	Resolved with sufficient text in NIR: In the ICEWOOD research project carbon removal in 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 plantations of Siberian larch, Lodgepole Pine, Sitka spruce and Natural Birch Woodland compared to treeless grazed heathland which is defined as Grassland (Bjarnadóttir, 2009). Snorrason et al. (2000; 2002) found 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 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 this two research are used as a factor of annual increase of C-stock in litter, 0.141 t C ha-1 yr-1. New research results from Southwest Iceland show 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.	Chapter 6.5.2.2 and 11.3.1.1

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
Deforestation – C and N2O (KL.18, 2019) Completeness	(a) Report the AD, CSC and related N2O emissions for this category to avoid underestimating the emissions. (b) If this is not possible, provide information that justifies the reporting of “NE” for AD and CSC related to N2O 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. The Party reported “NE” in CRF table 4(KP-II)3 for activity data and CSC for deforestation for 2013–2019 in relation to N2O emissions from N mineralization and immobilization and “NA” for N2O emissions. There is no additional information on the use of the notation key in the documentation box to CRF table 4(KP-II)3. During the review, the Party indicated that it would include estimates related to N2O emissions in the next submission.	FCCC/ARR/2021/ISL/KL.15	Resolved. Reported for the first time in 2022 submission accordance to Default Tier 1 methods ArSn 220107	[7. KP LULUCF][4(KP)][KP.A Article 3.3 Activities][KP.A.2 Deforestation][N2O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils]
FM – CO2 (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). The Party reported in its CRF table 4(KP-I)B.1 as “NE” for CSC in litter in natural birch forests under FM for 2013-2019, without justifying in the NIR why the pool is not a net source of emissions. In contrast, the Party reported CSC in litter for cultivated forests under FM and included the description in its NIR (p.176). During the review, the Party clarified there will be estimations for CSC in the litter of natural birch forests under FM in the next submission.	FCCC/ARR/2021/ISL/KL.16	Resolved in NIR with text: In accordance with the definition of NBF in the Forest land remaining Forest land, all FM of NBF are defined older than 50 years and are and in line with Forest land remaining Forest land likely to be sink rather than source regarding litter and mineral soil and are therefore reported as not applicable. As Tier 1 approach they are assumed to be 0 (zero) as recommended in 2006 AFOLU Guidelines (see page 2.21).	Chapter 11.3.1.1 and 6.5.1.2
FM – CO2 (KL.20, 2019) Transparency	Report transparently the technical corrections made to the FMRL, including those made in previous submissions, as stated in sections 2.7.5 and 2.7.6 of the Kyoto Protocol Supplement and in CRF table 4(KP-I)B.1.1. The Party reported in its NIR (p.299-301) the information about technical corrections made to the FMRL in 2018 submission.	FCCC/ARR/2021/ISL/KL.17	Resolved ArSn 220107	Chapter 11.5.3
FM – CO2 (KL.21, 2019) Accuracy	Provide the revised technical correction to the FMRL, as planned, before the end of the commitment period. The Party reported in its NIR (p.301) that further technical correction will be done in the 2022 submission when stock changes in natural birch forest between first period (2005-2011) and second period (2015-2020) of the systematic sample plot inventory has been estimated and published. During the	FCCC/ARR/2021/ISL/KL.18	Resolved ArSn 220107	Chapter 11.5.3

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/section
	review, the Party clarified that a new field inventory of the natural birch woodland started in 2015 consisting of remeasurement of the plots from 2005-2011 inventory. Field work was finished this summer (2021) and analysis and estimate of new mean annual CSC estimate for NBF under FM will be used for the 2008 to 2020 period in next submission. Other changes that lead to improvement of the FMRL will also be introduced in the 2022 submission. The ERT noted that the Party will include in the technical correction CSC of litter for NBF under FM as a new pool of carbon (see ID# KL. 16).			
FM – CO2 (KL.22, 2019) KP reporting adherence	Report in the CRF accounting table the FM cap as established in the initial report and in accordance with decision 6/CMP.9, paragraph 12. The Party reported in its CRF table accounting the FM cap as established in the initial report and in accordance with decision 6/CMP.9, paragraph 12	FCCC/ARR/2021/ISL/KL.19	Resolved	
HWP – CO2 (KL.23, 2019) Comparability	Include harvest data (e.g. in m3 or kt C) for FM in column D of CRF table 4(KP-I)C on CSC in the HWP pool and report data that are consistent with those in NIR table 11.2. The Party included in its CRF table 4(KP-I)C harvest data in m3 for FM that are consistent with the information reported in NIR table 11.3 (p. 302).	FCCC/ARR/2021/ISL/KL.20	Resolved ArSn 220107	Chapter 6.11 and 11.6

10.5.5 Waste (CRF Sector 5)

Iceland is continually working on updating the Waste chapter. Comments and suggestions received during the 2021 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	Chapter/ section
5.D – CH4, N2O	Iceland reported in its NIR (p 237) that the correction factor for discharge of industrial wastewater into sewers is set to 1 because emissions from industrial wastewater are calculated separately. The Party reports on a single industrial wastewater activity, fish processing, the discharge of which is reported separately in CRF Table 5 D, and therefore assumed to not enter domestic sewage. The ERT noted that industrial wastewater includes discharge from a variety of commercial activities including accommodation services (hotels, motels, etc.), restaurants, butchers, grocery stores that commonly co-discharge with domestic wastewater (2006 IPCC Guidelines Vol 5, Sect 6.2.2.3, p 6.14). The ERT provided this example; Statistics Iceland reports that tourism is a major industry and that, in 2019, tourism accommodation provided 7, 316,651 overnight stays by foreign nationals visiting Iceland. Yet emission estimates for this and other commercial sources are not reported in the NIR. During the review, the Party clarified that the text in the NIR is partially wrong. The text states ‘The correction factor was set to 1 because emissions from industrial wastewater are calculated separately” but that applies only for the following pathways: not known, septic tanks urban and septic tank rural. The pathways not known into sea, river, lake, no, primary, secondary and tertiary treatment have a correction factor I=1.25. The Party estimated the additional emissions regarding overnight stays associated with foreign visitors to Iceland and demonstrated that, during the period 2015 – 2019, this source represented annual emissions of between 1 to 1.4 kt CO2e, which are below the threshold of significance. Correct its text in the NIR and accurately describe sources and pathways included in its modelling, and its application of correction factors. Develop its data on commercial and industrial wastewater sources so as to improve modelling accuracy and completeness.	FCCC/ARR/2021 /ISL/W.8	Updated in 2022 NIR.	Chapter 7.5.2.1 in 2022 NIR.
5.D – NOx, CO, NMVOCs	Iceland reported NE in CRF table 5 for NOx, CO and NMVOX under domestic and industrial wastewater (categories 5.D.1 and 5.D.2). During the review, the Party clarified that after reviewing the notation keys in CRF table and the air pollutant inventory prepared under the Convention on Long-Range Transboundary Air Pollution they propose the following changes to the notation keys: (a) for NOx and CO the use of NA as stated in the EMEP/EEA air	FCCC/ARR/2021 /ISL/W.9	Updated in 2022 NIR.	Chapter 7.5 in 2022 NIR.

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
	pollutant emission inventory guidebook 2019 (https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/5-waste/5-d-wastewater-handling/view); (b) for NMVOC the use of NE, as there is an EF available in the EMEP/EEA air pollutant emission inventory guidebook 2019 but to use it the Party indicated that it needs to change AD and obtain the volume of wastewater handled, for calculating the GHG emissions based on tier 1 and using BOD from population. Update the notation keys as proposed above and provide in CRF table 9 the reasons for reporting NE for NMVOCs under domestic and industrial wastewater. The Party could consider justify exclusion based on paragraph 37(b) of the UNFCCC Annex 1 reporting Guidelines			
5.B.1 – CH4, N2O	Iceland reported in its NIR table 7.13 (p 229) that 24kt of waste were composted in 2019, but only 9.6 kt dm were reported in CRF Table 5.B. In addition, the Party stated that it applied the default EF of 4 g CH4/kg waste and 0.24 g N2O/kg waste in its NIR (p 229), whereas CRF table 5.B records implied EF values of 10 g CH4/kg waste and 0.6 g N2O/kg waste. During the review, the Party clarified that an observation made during the EU review it was realized that in CRF table the AD for category 5.B.1 should be expressed on a dry basis (kt dm), as well as the IEF factors, which should correspond to the default values expressed on a dry basis (10 g CH4/kg of waste on a dry basis and 0,6 g N2O/kg of waste on a dry basis). Iceland, however, has always reported wet weight, as it obtains the amounts of waste sent to composting on a wet basis. calculated the AD on dry basis and added that to CRF table but failed to update the table 7.13 in the NIR, generating confusion. The Party will update the NIR for the 2022 submission. The emissions, however, do not change and are calculated with the IPCC default emission factors for wet weight. Reports its composting emissions consistently between its NIR and CRF Table 5.B., and that the NIR text correctly reports the basis for the estimation, whether by dry weight or wet weight.	FCCC/ARR/2021 /ISL/W.10	Updated in 2022 NIR.	Chapter 7.3.2 in 2022 NIR.
5.D – CH4 and N2O (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 2019, sludge removed accounted for 2.4 kt DC and N effluent 2.5 kt N (see NIR section 7.5.4.2 and table 7.21, p. 244). 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.	FCCC/ARR/2021 /ISL/W.1	Updated in 2022 NIR.	Chapter 7.5.4.2 in 2022 NIR.

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
	NIR table 5.33 (p. 140) indicates that in 2019 the N content of sewage sludge applied to soil as fertilizer was 4.75 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). The Party provided a spreadsheet estimating N2O emissions by removing from category 5.D.1 the amount of sludge used as fertilizers and emissions reduced by 37 kg N2O. The Party stated that will correct the reporting in the next submission.			
5.A.1 – CO2, CH4 and N2O (W.11, 2019) Completeness	(a) 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). (b) Improve its explanation of the allocation of emissions from landfill gas in the inventory (NIR section 7.2.4.1). (a) Iceland stated in the NIR that between 2002 -2006 landfill gas recovery was used for electricity production and that since 2007 it is sold for use as fuel in vehicles (reported under category 1.A.3.b (road transport)). The Party recalculated emissions under category 1.A.1.a.i (electricity generation) and included in the inventory emissions from landfill gas used for electricity generation (under biomass). However, these emissions were reported for 2003-2007 and 2017-2018 (and not 2002-2006). The Party also do not explain the recalculation in the NIR clearly. In the energy sector (table 3.4, p. 47) the Party indicated the use of biomethane and biodiesel as fuel but there is no clear explanation in the NIR indicating that biodiesel was also included in the calculation and for which years or in the documentation box of the CRF table 1.A(a).s4 indicating for which years which type of fuel is reported under biomass. (b) The ERT considers that there is a lack of transparency because the NIR indicates that landfill gas is used for electricity for 2002-2006 (p. 225) but the Party calculated biomass emissions in the energy sector for 2003-2007 and 2017-2018. In addition, Figure 7.5 (p.226) indicates that there is allocation of landfill gas for electricity production from 2002-2009.	FCCC/ARR/2021 /ISL/W.2	Thank you for pointing this out, there is indeed an inconsistency in reporting landfill gas between the Energy and the Waste sector. A request to the data provider for the Energy sector, the National Energy Authority has been sent out and more research is necessary to confirm which datasets are correct. This is part of the improvement plan and will be tackled for the next (2023) submission.	Chapter 7.2.7 in 2022 NIR.
'5.A – CH4 (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 in its future submissions the population data and waste generation rates used as input data in the IPCC solid waste disposal model. Iceland included in the NIR a new annex (Annex 9, p. 366) 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 (same tables also included in the NIR as table 7.4 and 7.5 (pp. 218-221).	FCCC/ARR/2021 /ISL/W.3	Updated in 2022 NIR.	Chapter 7.2.2.1 in 2022 NIR.

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
	However, the Party has not provided information supporting the historical and current distribution of solid waste disposal between SWDS and incineration/open burning, and the distribution between incineration and open burning.			
5.A – CH4 (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 (See NIR p. 213). 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. In addition, the Party explained that data received according to the Iceland's Waste Statistic Regulation (WStatR) does not exactly match IPCC categorization. The Party also explained that streamlining of the WStatR to IPCC categorization is in progress and that composition amounts may be revised in future submissions (p 217).	FCCC/ARR/2021 /ISL/W.4	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 EA 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. Streamlining of the WStatR to IPCC categorization is in progress and that composition amounts may be revised in future submissions.	Chapter 7.2.2 in 2022 NIR.
5.A – CH4 (W.13, 2019) Transparency	Report information on waste composition for municipal solid waste and industrial waste separately in its future submissions in order to enhance the transparency of the NIR. See ID# W.4 above.	FCCC/ARR/2021 /ISL/W.5	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 as	Chapter 7.2.2 in 2022 NIR.

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
			the data does not support splitting it. Streamlining of the WStatR to IPCC categorization is in progress and that composition amounts may be revised in future submissions.	
5.A.1 – CH4 (W.14, 2019) Convention reporting adherence	Correct the value for the half-life of industrial waste in the NIR and enhance its QA/QC procedures in order to ensure that the information reported in the NIR is consistent with the information used in its estimation files. Iceland update the NIR table 7.8 (p. 224) to reflect the correct half- life (of 8) for industrial waste	FCCC/ARR/2021 /ISL/W.6	Updated in 2022 NIR.	Chapter 7.2.3 in 2022 NIR
5.D – CH4 (W.15, 2019) Transparency	Correct the statement in its NIR on the correction factor used to account for additional biochemical oxygen demand from industrial wastewater co-discharge in order to ensure that the information reported in the NIR is consistent with the estimates reported in CRF table 5.D. Iceland revised the methodology in 2020 submission and is reporting industrial wastewater separated from domestic wastewater. As a result, the correction factor for account to additional industrial BOD discharge into sewers is not considered (the Party applied 1 instead of 1.25).	FCCC/ARR/2021 /ISL/W.7	Updated in 2022 NIR.	Chapter 7.5.2.1 in 2022 NIR.

11 Kyoto Protocol - LULUCF (CRF sector 7)

11.1 General Information

11.1.1 Definition of forest and other criteria

Iceland's definitions of forest are identified as the following, in accordance with decision 16/CMP.1 adopted by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol.

Forest definitions are consistent with those historically reported to and subsequently published by the Food and Agriculture Organisation (FAO) of the United Nations, except for tree height.

Definitions of forest as used by IFR

- Minimum value for forest area: 0.5 ha
- Minimum value for tree crown cover: 10%
- Minimum value for tree height: 2 m

In the Global Forest Resources Assessment 2005 and onward (coordinated by FAO), countries are requested to use uniform forest definitions.

Criteria in forest definitions of the Marrakech Accord (MA), the UNEP Convention on Biological Diversity (CBD) and the Forest Resource Assessment (FAO/FRA) are listed in the Table 11.1.

Table 11.1 Criteria in forest definitions of the Marrakech Accord (MA), the UNEP Convention on Biological Diversity (CBD) and the Forest Resource Assessment (FAO/FRA).

Parameters	MA	CBD	FAO/FRA
Minimum area (ha)	0.05-1.0	0.5	0.5
Minimum height (m)	2-5	5	5
Crown cover (%)	10-30	10	10
Strip width (m)			20

Iceland uses the suggested FAO definition, but instead of the suggested 5 m height minimum, Icelandic forests are defined as being at least 2 m in height (which is the lower limit of the MA definition). That is in agreement with the general perception in Iceland and current legislative definitions. Only 10% of the natural birch woodland will reach 5 m height at maturity according to National Forest Inventory (NFI) data. By widening the definition of forest, bigger portion of the natural birch woodland can be included as an ARD and FM activities under the Kyoto Protocol, hence promoting the use of native species in afforestation and prevent deforestation of the natural birch woodlands.

The functional definition of Forest land as it is applied under the KP – LULUCF is: All forested land, not belonging to Settlement, that is presently covered with trees or woody vegetation more than 2 m high, crown cover of a minimum 10% and at least 0.5 ha in continuous area with a minimum width of 20 m. Land which currently falls below these thresholds, but in situ will reach these thresholds at mature state, is included.

11.1.2 Elected activities under Article 3.4 of the Kyoto Protocol

For both Kyoto Commitment Periods, the only elected activity under Article 3.4 is Revegetation.

11.1.3 Description of how the definitions of each activity under article 3.3 and each elected activity under article 3.4 have been implemented and applied consistently over time

Afforestation

Afforestation in KP is defined as conversion of Land, that has not been Forest Land for 50 years, to Forest Land that occurred since 1990. The initiation time is set to plantation year of plantations and the estimated age for afforestation through natural expansion. All forest formed since 1990 are defined as Afforestation.

Deforestation

Deforestation in KP is defined as permanent conversion of Forest Land to other Land use class that occurred since 1990. The initiation time is set to the year of clear-cut or removal of the trees in another way than clear-cut.

Reforestation

Reforestation in KP is defined as conversion of Land, that was Forest Land less than 50 years ago, to Forest Land that occurred since 1990. The initiation time is set to plantation year of plantations and the estimated age for afforestation through natural expansion. Reforestation has not yet occurred in Iceland and has not been reported.

Forest management

Forest under Forest Management in KP is defined as all Forest Land that was Forest Land before 1990. The initiation time is set to plantation year of plantations and the estimated age for afforestation through natural expansion. All forest that existed or were formed before 1990 are defined as Forest under Forest Management.

11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining of how land was classified

As already stated, are FM and Revegetation the activities reported under Article 3.4. In accordance with the hierarchy of land use classes in UNFCCC reporting, Forest Management takes precedence over Revegetation.

Forest management include Natural Birch Forests (NBF) as estimated in the end of 1989. They are all defined as Forest remaining forest and not in a transitional state; Cultivated Forests (CF) as estimated in the end of 1989. These are of CF afforestation areas before 1990 and plantations in the NBF. Plantations in the NBF are all defined as Forest remaining forest. Afforestation areas are either defined as Forest remaining forest or Land converted to forest, depending on their age (years from plantation). The transition period in forest has been set to 50 years.

Iceland has elected Reporting Method 1 to report land areas subject to Article 3.3 and Article 3.4 activities as described in 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC, 2014), page 2.16, section 2.2.2. Only one stratum, Region 1 is defined covering all land areas in Iceland.

11.2 Land-Related Information

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

Maps of cultivated forest do exist. They are made from spatial activity data aggregated from actors in afforestation in Iceland. Although they can be used to locate forests, they are not precise and overestimate the area of cultivated forest. Natural birch woodland (NBW) was remapped in the period 2010-2014. The new map of the NBW together with its attribute information and the old map of the NBW are used in this submission to isolate the forest part of the NBW and estimate the changes in area which turned out to increase between the old and the new mapping surveys (Snorrason, et al., 2016). The area increase can be identified spatially and are defined as afforestation of the NBF. Both the map of the CF and the NBW are used with an external buffer as a population for systematic sampling of permanent plots (SSPP) of the NFI. The permanent plots are used to estimate the area of cultivated forest. For the NBF the new map is used to estimate the total area. The area of afforestation of CF since 1990 is determined on basis of stand age within the sample plots. New afforested areas are added to the population for the SSPP annually and new sample plots falling within these areas are included in the forest inventory. The area of afforestation of natural birch forest is determined by the difference between historical mapping and current mapping. Beyond the periods between mapping survey estimates, new areas of NBF are built on extrapolation of the mean annual increase of the area between the old and the new survey (see chapter 6.5 for further description of estimation methods).

Afforestation and FM are estimated in the NFI for Region 1 by systematic sampling of permanent plots (SSPP). The plots of the cultivated forest (CF) and the natural birch forest (NBF) are re-measured at five- and ten-year intervals, respectively. They were first measured in the period 2005-2009. The third re-measurement of the CF started in 2020 and the first re-measurement of the NBF is finished.

11.2.2 Methodology used to develop the land transition matrix

Land transition matrix was prepared based on data for activity area in the years 1990-2020. All revegetation activity involving tree planting are categorized from the beginning as Afforestation and reported as coming from “Other” than eligible KP categories of either article 3.3 or article 3.4. No conversion of land previously reported under Revegetation, to Afforestation or Reforestation is occurring. All additions to the land included as 3.3 or 3.4 accordingly originate from the category other in the Land transition matrix.

At each sample plot in AR and FM, the land use is assessed and compared to former land use. No Reforestation has been detected at the SSPP of the NFI. Although SSPP of NFI will in the future detect deforestation, special deforestation inventory aimed at deforested areas is performed together with official annual register of deforestation in accordance with the forest act (Alþingi, 2019) (see further description above in Chapter 6.5).

Changes in areas between submissions are related to new areas emerged from the new map layers through the IGLUD which was constructed by AUI but is now maintained by the SCSI. Information on land use is mostly in line with Approach 1, although for some categories the origin of land converted to the category is estimated through survey (Approach 2), as for cultivated forest, or is spatially known (Approach 3), as for some land converted to reservoirs and Settlements. Other estimates than 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 (see also Chapter 6.3).

However, small inconsistencies between final areas in CRF table 4.1 and the corresponding total areas in CRF tables on carbon stocks for 4.D Wetlands and 4.F Other Land are occurring.

11.2.3 Maps and /or database to identify the geographical locations and the system of identification codes for the geographical locations

Maps of CF do exist, but it is not possible to isolate land subjected to ARD or FM from these maps. The proportion of the area mapped identified as cultivated forest is determined through the inspection of the IFR on the systematic sampling plots of the NFI. Geographical locations of ARD and FM can be partially identified by the geographical distribution of the systematic sample plots identified as ARD. Maps of NBF does on the other hand exist as already mentioned and described in Chapter 6.5. Deforestation is too mapped separately and is fully identifiable geographically.

The land subject to Revegetation is mapped and identified in IGLUD. The area reported as Revegetation since 1990 is larger in the present submission than the area mapped as such in IGLUD. The present area estimates of revegetation activities since 1990 is an accumulation of annual estimates for the revegetation activity. Not all of these activities have been mapped and are accordingly not included in IGLUD. The mapping of the activities recorded as Farmers Revegetate the Land (FRL) activities is particularly incomplete, but improvements in this field in the NIRA database are currently ongoing and are expected to be included in the 2023 submission. Excluding the FRL activity the reported activity is all within the mapped area. The SCSI is running the NIRA based on systematic sampling of plots within the mapped areas. New results from the NIRA on total activity area are reported in this year's submission.

11.3 Activity-Specific Information

11.3.1 Methods for carbon stock change and GHG emission and removal estimates

11.3.1.1 *ARD and FM*

Carbon stocks changes in living biomass in cultivated forest are based on measurements on sampling plots in the NFI. At each plot parameters to calculate aboveground and belowground biomass are determined including tree height, diameter and number of trees inside the plot area. These parameters are then used to calculate the living biomass by functions (Snorrason & Einarsson, 2006) and measured root-to-shoot ratios (Snorrason, Sigurðsson, Guðbergsson, Svavarsdóttir, & Jónsson, 2002). Wood removal after commercial thinning or clear cutting has not been detected in the NFI in afforestation areas since 1990. Carbon stock losses in the living woody biomass are therefore reported as not occurring in AR.

All wood removals are on the other hand reported as FM activity whereas roundwood utilization is ongoing. Data of commercial roundwood utilization are sampled and published by the Icelandic Forestry Association (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) and used in this submission to estimate wood removal from FM forests.

C-stock changes in dead wood are also based on measurements of sampling plots in the NFI. All dead wood meeting the minimum requirement of 10 cm in diameter and 1 m in length are measured and reported on the year of death as an increase of the dead wood stock and loss of biomass. These stocks will in the future be a source of C when decomposing as the plots will be revisited and they will be remeasured and assessed in new decomposing class.

As already described in Chapter 6.5.2, net carbon stock changes of afforestation of the NBF under Afforestation are estimated by a country specific removal factor built on the relation between age and woody biomass C-stock of natural birch woodland.

Carbon stock changes in the NBF under FM and existing before 1990 are estimated by comparing biomass stock of the trees in two different times and use mean annual change as an estimate for the annual change in the C- stock. This is a net change in the C-stock of living biomass and is described as "The Stock-Difference Method" in Chapter 2.3.1.1. with Equation 2.8 in 2006 AFOLU Guidelines (IPCC, 2006). Biomass losses caused by mortality are therefore included in the net annual removal and reported as "Included Elsewhere (IE)" in the CRF reporting table.

Changes of carbon stock in mineral soil of Grassland converted to forest land are based on Tier 2 methodology applying country specific EF. The EF is based on soil sampling from chrono-sequential research (Bjarnadóttir, 2009) showing significantly increasing SOC in 0-10 cm depth layer with stand age up to 50 years old stands. No significant changes in SOC in 10-30 cm depth layer were observed. The results of this study are assumed to apply for afforestation 1-50 years old on mineral soils. For FM 50 years or younger converted from other land an EF of 0.513 t C $ha^{-1}yr^{-1}$ is used as for afforestation and revegetation and for FM 50 years or younger converted from grassland an EF of 0.365 t C $ha^{-1}yr^{-1}$ is used as in afforestation and in accordance with the research mentioned above. For FM older than 50 years no CSC in mineral soil is reported which is in accordance with Forest land remaining forest land category described in Chapter 6.5.1 above. An average EF on mineral soil for FM will vary from one reporting year to another according to the fractional changes of the subgroups of the cultivated forest.

It should be noted that carbon stock changes in litter in FM follow the same pattern of variation as CsC in mineral soil as CsC in litter are only reported for FM 50 year or younger.

In accordance with the definition of NBF in the Forest land remaining Forest land, all FM of NBF are defined older than 50 years and are and in line with Forest land remaining Forest land likely to be sink rather than source regarding litter and mineral soil and are therefore reported as not applicable. As Tier 1 approach they are assumed to be 0 (zero) as recommended in 2006 AFOLU Guidelines (see page 2.21).

For the drained organic soil, a Tier 1 methodology is applied using a default EF. The area of organic soils is determined on basis of the NFI sampling plots. Changes in carbon stock of litter including woody debris, twigs and fine litter is estimated applying a Tier 2 methodology and CS EF as described above in Chapter 6.5.2.2.

More detailed information on the methodology used to estimate C-stock changes in various pools is shown in the methodology chapters of Forest remaining Forest (Chapter 6.5.1.2) and Land converted to Forest land above (Chapter 6.5.2.2).

11.3.1.2 *Revegetation*

The SCSI maintains the National Inventory on Revegetation Areas (NIRA) database based on the most current and best available data. It is currently being expanded to include all revegetation activities since 1907, also including data from FRL. As a part of this incentive, NIRA is being linked to the SCSI's GIS system so all activities will be georeferenced. An integral part of NIRA is the soil carbon stock data resulting from an ongoing field sampling started in 2007. The first sampling period ended in 2011, but the second sampling started in 2018, covering both previously sampled areas and new areas added since 2011. This is expected to result in better estimates in the future as carbon stock changes can now be reported based on observed changes as compared to only using control sites. The NIRA database is based on systematic sampling on predefined grid points in the same grid as is used by the IFR for NFI (Snorrason & Kjartansson, 2004) and in IGLUD field sampling. The basic unit of this grid as applied by SCSI and IFS is a rectangular, 0.5 x 0.5 km in size. A subset of approximately 1000 grid points that fall within the land mapped as revegetation since 1990 was initially selected randomly but new points are added as reclamation sites expand. Points found to fall within areas where fertilizer, seeds, or other land reclamation efforts have been applied, are used to set up permanent monitoring and sampling plots. Each plot is 10×10 m. Within each plot, five 0.5×0.5 m randomly selected subplots are used for soil and vegetation sampling for C-stock estimation. The detailed description of methods will be published elsewhere (Thorsson et al. 2023, in prep.). A conversion period of 60 year has been defined on the basis of NIRA data sampling. The length of the conversion period is preliminary as the data remains to be analysed further using the data from the second sampling period. The categories "Revegetation since 1990-protected from grazing" and "Revegetation since 1990-limited grazing allowed" represents activity since 1990 accountable as Kyoto Protocol commitments. The area reported as land revegetated before 1990 is reported as "Revegetation before 1990" and "Revegetated land older than 60 years" the latter as subcategory of Grassland remaining Grassland.

The changes in carbon stocks at revegetation sites are estimated on the basis of a country specific EF covering all carbon pools. Current, but unpublished, results from NIRA for 2007-2011 indicate considerable variation between reclamation methods and land types. The data has not been fully analysed, but to acknowledge the intrinsic variability, a reduction of 10% in EF is used as suggested by SCSI. This will be clarified elsewhere (Thorsson et al. 2023 in prep.). Built on the studies of Aradóttir et al. (2000), the EF was assumed to be divided into 10% caused by increase in living ground biomass and litter and 90% by changes in soil organic carbon.

11.3.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and Article 3.4

11.3.2.1 *ARD and FM*

Change in the carbon stock of other vegetation than trees are omitted in this year's submission. A research project where carbon stock in other vegetation than trees was measured on afforestation sites of different ages of larch plantations did show very low increase C-stock 50 years after afforestation although the variation inside this period where considerable (Sigurðsson, Magnússon, Elmarsdóttir, & Bjarnadóttir, 2005). Harvested Wood Products are estimated for the fifth time in this year submission. Although data on domestic wood utilization 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 such data[27], the annual unofficial report of the

[27] http://faostat3.fao.org/download/F/FO/E

Iceland Forest Association does contain data about sawnwood production (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). These data were used to estimate C-stock changes in HWP (see above further descriptions in Chapter 6.11).

11.3.2.2 *Revegetation*

Losses in Revegetation are not specifically detected. The losses are assumed to be reflected as changes in the C-pool estimates of NIRA. Potential losses include losses in revegetated area, due to changes in land use. Losses in C-pools through grazing, biomass burning, and erosion are also recognized as potential. These losses are expected to be detected in the current NIRA upgrade and will be reported in future submissions.

11.3.2.3 *Information on whether or not indirect and natural GHG emissions and removals have been factored out*

No attempt is made to factor out indirect or natural GHG removals/emissions. This applies both for ARD, FM and Revegetation. Both AR and Revegetation have 1990 as base year. This short time window makes factoring out irrelevant.

11.3.2.4 *Changes in data and methods since the previous submissions (Recalculations)*

As explained in Chapter 6.5 and above in Chapter 10.3 are data on area in CF slightly revised. This will lead to revision on area dependent stock changes. Emission/removal factors used are unchanged Biomass carbon stock change estimates in Cultivated Forest for 2019 have also been revised on basis of new annual NFI data from 2019 and 2020. Estimates of the net gain of biomass of the natural birch forest are totally revised in this year submission built on new data from the newly conducted NFI (2015-2021) of the natural birch woodland already described in Chapters 6.5.1.2 and 6.5.2.2 above.

11.3.2.5 *Uncertainty estimates*

Uncertainty estimates for afforestation and FM are identical to uncertainty estimates for Land converted to Forest land and Forest land remaining forest land described in chapters 6.5.1.3 and 6.5.2.3 above. Uncertainty of area is estimated 4% and of stocks 8.92% for Land converted to Forest land and 25.10% for Forest land remaining forest land.

Uncertainties estimates for Land converted to Grassland and Grassland remaining Grassland are described in chapters 6.7.2.3 and 6.7.1.3 respectively. Uncertainties estimated for revegetation are 20.00% for area and 17.01% for stocks

11.3.2.6 *Information on other methodological issues*

The Year of the Onset of an Activity, if after 2008: For FM 2013.

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2020 and are direct human-induced

The age of afforestation is estimated in field on the sample plots of the NFI. Cultivated forests are mostly plantations. A minority are direct seeded or self-seedlings originating from cultivated forests. Afforestation of natural birch forests are self-seeded areas in the neighbourhood of older natural birch forest areas. Land use has been changed in both cases from other land use to forest with afforestation by planting and/or by total protection or drastic reduction of grazing of domestic animals. These actions are considered direct human-induced.

11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from Deforestation

Deforestation is estimated by special inventory where the change in the area of forest where deforestation has been reported is estimated by GPS delineation of a new border between forest and the new land use which is dominantly settlements (new power lines, roads or buildings). Major forest disturbances will be detected in the NFI but local forest disturbances (wildfires etc.) will be handled with special inventory as done for deforestation.

11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

The only human induced forest degradation occurring is when trees have to give way for summer houses and roads to summer houses. There the forest removed is below the minimum area of 0.5 ha or 20 m with, no direct estimate of the effect of decrease of the C-stock is made. The permanent sample plot system of the NFI will, however, detect significant forest degradation.

11.4.4 Information related to the natural disturbances provision under Article 3.3

Iceland did choose to apply for the provision of Natural disturbance (ND). ND events as wildfires, natural disasters, severe pests, and disease events in forest that lead to drastic emission of greenhouse gasses have until now been very rare and have only been detected occasionally and on small areas in Iceland. As no reported data of natural disturbance events in forest in the period before the second commitment period of the Kyoto protocol under AR does exist calculation of background level and margin as described in pages 2.45 – 2.54 of the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC, 2014) was not possible and are defined as not occurring (NO).

11.4.5 Information on Harvested wood products under Article 3.3

Afforestation since 1990 has not yet yielded wood removals as these forests are still too young for commercial thinning. Harvested wood products are consequently reported as not occurring (NO).

11.5 Article 3.4

11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

All the revegetation activity included under Article 3.4 is included on the bases of SCSI activity records. No area not recorded by SCSI as revegetation activity is included.

11.5.2 Information relating to Cropland Management, Grazing Land Management and Revegetation (if elected) for the base year

The removal recorded due to Revegetation in base year is estimated from SCSI archives on revegetation prior to 1990. All land revegetated before 1990 is included in the estimate. The estimate of changes in C-pools is according to Tier 2 methods as described in Chapter 6 (LULUCF).

11.5.3 Information relating to Forest Management

FM consist of CF that are mostly plantations and NBF that are defined as managed forest as their existence depend on management of grazing of domestic animals.

Forest Management Reverence level (FMRL) for the current commitment period was technically corrected in this year submission and its methodology is described below.

Iceland did estimate Forest Management Reverence level (FMRL) for current commitment period in February 2011 (Snorrason A. , 2011). It was clear in the beginning that the estimates were uncertain. Especially was the estimate for the natural birch forest (NBF) critical as the ERT did point out (see page 19 paragraph h) in Synthesis report of the technical assessments of the forest management reference level submissions. Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol Sixteenth session, part four Durban, 29 November 2011. FCCC/KP/AWG/2011/INF.2)

The first submission of Technical Correction (TC) was done in the 2018 submission of NIR. In this submission a new and final TC is submitted.

New estimates affects both all pools reported in the Icelandic FMRL report and the area of forest categories.

Area estimates:

1. Natural birch forest before 1990: The area of the NBF has been revised. In the FMRL the area of NBF was estimated 54.500 kha and only on mineral soil but revised new estimate are 87.72 kha in 2009 which is the historical comparison year used in the FMRL-report. NBF on drained organic soil are included in these estimates being 0.084 kha constant from 1990 to 2020. Update of the area of NBF was a result of a remapping of the natural birch woodland conducted in 2010-2014 (Snorrason, et al., 2016).

2. Cultivated Forest (CF): Includes afforestation before 1990 and reforestation in the NBF. They were estimated 5.800 kha in the FMRL (more exactly 5.772 kha) but revised estimate in this year submission is 6.273 kha in 2009. Included are estimates of the area on drained organic soils, estimated 0.426 kha in 2009 in this year submission. Update of the area of CF has been done gradually with gradual improvement of the maps of cultivated forest and the annual SSPI of the NFI.

<u>Pools and greenhouse gases:</u>

1. Carbon stock changes:
    a. Biomass gain was included in the FMRL and are revised by this year TC due to revision of the estimate of historical CSC in both CF and NBF.
    b. Biomass losses due to harvest was included in the FMRL. It is not revised by this year TC as the changes of harvest rate from the projected harvest in the FMRL are defined as deviations in actual policies compared to those historical policies included in the FMRL
    c. C-stock change in litter was included in the FMRL and are revised by this year TC due to revised area and age classification
    d. C-stock change in the dead wood pool was omitted in the FMRL and is not added to this year TC

e. C-stock change in soil was included in the FMRL and are revised by this year TC due to revised area and age classification
f. Direct C-stock changes in drained organic soil was included in the FMRL and are revised by this year TC due to revised area and emission factors
g. Indirect C-stock changes in drained organic soil was not included in the FMRL or in the TC-2018 but are added to this year TC

2. Emission of N_2O and CH_4
   a. Emission of N_2O from drained organic soils was included in the FMRL and are revised by this year TC due to revised area and emission factors
   b. Emission of CH_4 from drained organic soils was not included in the FMRL but are added to this year TC due to revised area and emission factors

Carbon stock changes in HWP: C-stock changes in HWP was not included in the FMRL but a projected estimate assuming constant amount of input to the HWP pool as was reported in 2010 was reported in 2018-TC. T Unfortunately was the calculation erroneous resulting in doubled amount of C-stock change in the 2018 submission. The estimate for the mean annual removal to HWP reported in the TC-2018 was -0.059 CO_2 kt yr^{-1}, but corrected estimate is -0.029 CO_2 kt yr^{-1}. The corrected estimate is used in the TC of this year submission but no revision according to real activity data is done as changes in HWP pool from the projected pool are defined as deviations in actual policies compared to those historical policies included in the $FMRL_{corr}$.

<u>Emission/removal factors:</u>

1. Country specific removal factor of litter C-stock change in afforestation 1-50 years old are unchanged 0.141 t C $ha^{-1}yr^{-1}$. For forest existing for more than 50 years C-stock are in equilibrium with changes not occurring.
2. Two country specific removal factors of mineral soil C-stock change in afforestation 1-50 years old, one for other land converted to forest land (0.675 t C $ha^{-1}yr^{-1}$) and the other for grassland converted to forest land (0.365 t C $ha^{-1}yr^{-1}$) were used in the FMRL. The second one is unchanged but the first one has been revised to 0.513 t C $ha^{-1}yr^{-1}$. For forest existing for more than 50 years C-stock are in equilibrium with C-stock changes not occurring.
3. Default emission factor of direct C-stock changes on drained organic soil (-0.16 t C $ha^{-1}yr^{-1}$) used in the FMRL has been revised by a new default factor from the 2013 Wetland supplement ((IPCC, 2014) (-0.37 t C $ha^{-1}yr^{-1}$).
4. Default emission factor of indirect C-stock changes on drained organic soil was not included in the FMRL but was added to this year TC (120 kg CO_2 $ha^{-1}yr^{-1}$).
5. Default emission factor of CH_4 on drained organic soil was not included in the FMRL but was added to this year TC (7.37 kg CH_4 $ha^{-1}yr^{-1}$).
6. Default emission factor of N_2O on drained organic soil (0.6 kg N_2O $ha^{-1}yr^{-1}$) used in the FMRL has been revised by a country specific emission factor of 0.44 kg N_2O $ha^{-1}yr^{-1}$ (Guðmundsson J. , 2009).

Estimation of biomass stock changes:

1. C-stock changes of biomass in the NBF was in the FMRL estimated on the basis of forest measurements in the first SSPI conducted in the years 2005-2011. The C-stock gain was estimated by the current tree growth and the losses on occurrence of standing dead stems. Net biomass gain was estimated -88.592 CO_2 kt yr^{-1} in 2009 and assumed to be unchanged in following years including the commitment period (2013-2020). Preliminary results of

comparing inventory from 1987-1988 to the SSPI-2005-11 did result in much lower mean annual increase of C-stock from 1987 to 2007 (-13.138 CO_2 kt yr^{-1}). This result was used for the period beyond the comparison period (2008-2020) in the revised FMRL in the TC of 2018. Recalculation of measurement data of both inventories using new biomass equations for birch in natural birch woodland (Jónsson & Snorrason, 2018) did show no significant change in above ground biomass in the 21 years period from 1987 to 2006 (Snorrason, Jónsson, & Eggertsson, 2019). Preliminary estimates in comparing paired measurements of SSPI-2005-11 and newly finalized SSPI-2015-21 results in -100.345 CO_2 kt yr^{-1} mean annual net removal between 2007 and 2017. With this result the revised estimate for the FMRL will be identical to this value and are used in this submission TC.

2. C-stock gain of biomass in the CF was in the FMRL estimated with model build on C-stock curves for eleven different species-groups. They were made from 1345 forest measurements performed around the turn of the century on plots evenly spread around the island. The activity data describing species composition and age classification were reports of annual plantation of forest seedling. The output of the model did not fit well with estimation of C-stock gain from the first SSPI conducted in the years 2005-2010 which yielded 55% higher C-stock gain than the model in the year 2009. The level of the model output was adjusted to the 2009 estimation from the SSPI. This projection ended in -62.921 CO_2 kt yr^{-1} mean annual gross removal in the commitment period (2013-2020).
   An improved model where data from the NFI was used to describe species composition and age classes instead of annual seedling plantation was run on biomass gain. It yielded lower biomass gain than reported gain in the historical control year of 2009 in the 2022 submission. The modelled value for 2009 was then calibrated by the ratio between reported and modelled value. This ratio of 1.257 was used to calibrate modelled values for the 2013-2020 period yielding an average value of – 53.64 kt CO_2 for the period.

Estimation of the C-stock changes in HWP

The FMRL did not include estimation of the C-stock changes in HWP. C-stock changes in HWP was first reported in the 2017 submission. In the 2018 submission an estimate for mean annual C-stock changes in HWP for the commitment period (2013-2020) was reported in TC. The amount of harvested wood product was projected to be equal to the amount reported in 2010 (49.6 m^3 of sawnwood) in the commitment period. Unfortunately, was the calculation erroneous resulting in doubled amount of C-stock change in the 2018 submission. The estimate for the mean annual removal to HWP reported in the 2018 TC was -0.059 CO_2 kt yr^{-1}, but corrected estimate is -0.029 CO_2 kt yr^{-1}.

Table 11.2 Sources and sinks in the FMRL and their technical correction (TC)

Sources and sinks in Gg CO_2 e	FMRL	$FMRL_{corr}$	TC
Net removals from biomass stocks in Natural Birch Forest[1,3]	-88.952	-100.345	-11.393
CO_2 emissions from organic soils in Natural Birch Forest[1]	NE	0.124	0.124
N_2O emissions from organic soils in Natural Birch Forest[1]	NE	0.017	0.017
CH_4 emissions from organic soils in Natural Birch Forest[1]	NE	0.015	0.015
CO_2 emissions from organic soils in Cultivated Forest[1,2]	0.229	0.766	0.537
N_2O emissions from organic soils in Cultivated Forest[1,2]	0.114	0.088	-0.026
CH_4 emissions from organic soils in Cultivated Forest	NE	0.079	0.079
Removals to litter in Cultivated Forest[1]	-1.893	-2.063	-0.171
Removals to mineral soil in Cultivated Forest[1,2]	-4.865	-5.052	-0.187
Biomass gain in Cultivated Forest[1,3]	-62.921	-53.643	9.279
Biomass loss in Cultivated Forest[4]	3.935	NA	NA
Removals to Harvested Wood Products[4]	NE	-0.029	-0.029
Sum	-154.352		-1.755

[1]Revised area estimation [2]Revised emission/removal factors [3]Revised carbon stock change estimation [4] Built on unchanged and steady 2010 harvesting level as in the original FMRL

11.5.4 Information related to the natural disturbance provision under Article 3.4

Iceland did choose to apply for the provision of Natural disturbance (ND). ND events as wildfires, natural disasters, severe pests, and disease events in forest that lead to drastic emission of greenhouse gasses have until now been very rare and have only been detected occasionally and on small areas in Iceland. Only one event of amplitude (> 0.5 ha) that triggered reporting of emission under FM has occurred in the second commitment period of the Kyoto protocol. That was a wildfire of 11.3 ha in 2020 and is described in detail in Chapter 6.17 above and reported as wildfire under Forest remaining Forest and KP-FM. As no reported data of natural disturbance events in forest in the period before the second commitment period of the Kyoto protocol under FM does exist, calculation of background level and margin as described in pages 2.45 – 2.54 of the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC, 2014) was not possible and reported not occurring (NO). Consequently, the only possible ND event reported in the GHG reporting is not accounted for under the ND provision in reporting table KP.B.1 Forest Management/Carbon stock change/Land subject to natural disturbances (t.44) and Emissions and removals from natural disturbances (t.47) and reported as not occurring (NO).

11.5.5 Information that demonstrates that emissions and removals resulting from elected Article 3.4 activities are not accounted for under activities under Article 3.3.

Afforestation

Afforestation in KP is defined as conversion of Land, that has not been Forest Land for 50 years, to Forest Land that occurred since 1990. The initiation time is set to plantation year of plantations and the estimated age for afforestation through natural expansion. All forest formed since 1990 are defined as Afforestation.

Deforestation

Deforestation in KP is defined as permanent conversion of Forest Land to other Land use class that occurred since 1990. The initiation time is set to the year of clear-cut or removal of the trees in another way than clear-cut.

Reforestation

Reforestation in KP is defined as conversion of Land, that was Forest Land less than 50 years ago, to Forest Land that occurred since 1990. The initiation time is set to plantation year of plantations and the estimated age for afforestation through natural expansion. Reforestation has not yet occurred in Iceland and has not been reported.

Forest management

Forest under Forest Management in KP is defined as all Forest Land that was Forest Land before 1990. The initiation time is set to plantation year of plantations and the estimated age for afforestation through natural expansion. All forest that existed or were formed before 1990 are defined as Forest under Forest Management.

Forest management include Natural Birch Forests (NBF) as estimated in the end of 1989. They are all defined as Forest remaining forest and not in a transitional state; Cultivated Forests (CF) as estimated in the end of 1989. These are of CF afforestation areas before 1990 and plantations in the NBF. Plantations in the NBF are all defined as Forest remaining forest. Afforestation areas are either defined as Forest remaining forest or Land converted to forest, depending on their age (years from plantation). The transition period in forest has been set to 50 years.

Revegetation

Revegetation in KP is defined as conversion of other land to grassland, resulting from land reclamation activities that have occurred since 1990. The original vegetation cover is less than 20% for the vast majority of the land before revegetation activities.

11.6 Harvested Wood Products

Emissions/removals related to harvested wood products (HWP) are estimated for the fifth time in this year’s submission. Although data on domestic wood utilization and production of wood products from domestic wood are not official and the official statistical agency in Iceland (Statistics Iceland (http://www.statice.is/)) has fragmented, unverified and incomplete reporting of these data (see: http://faostat3.fao.org/download/F/FO/E) the annual unofficial report of the Iceland Forest Association does contain data about sawnwood production from domestic harvested wood for the years 1996 to 2020 (Table 11.3) (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).

Table 11.3 Annual wood production (in m^3 on bark) and sawnwood production (in m^3) in 1996 to 2020.

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	3537	77

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 default half-live 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%.

11.7 Other Information

11.7.1 Key Category Analysis for Article 3.3. and 3.4.

A key category analysis was performed for activities reported under Article 3.3 and 3.4, following the guidelines given in Volume 1, Chapter 4 of the 2006 IPCC guidelines, as well as Paragraph 2.3.6, Chapter 2 of the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol. The following approach (Paragraph 2.3.6, 2013 KP supplement) was used: “Several activities under the KP can occur in more than one land category of the UNFCCC inventory. In such cases, it is good practice to consider the total emissions and removals from the activity for purposes of the key category analysis. When this approach is needed, an activity is considered key if the emissions or removals from the sum are greater than the emissions from the smallest category that is identified as key in the UNFCCC inventory (including LULUCF)".

Thus, the sum of the absolute value of the emission or removal for each GHG for each activity was calculated, and its percentage relative to the total of all contributions (including LULUCF) determined. If this percentage was equal or larger than the smallest contributor to the UNFCCC inventory for 1990/2019 level or trend, then it was considered a key category.

Table 11.4 below shows the results of the key category analysis for Article 3.3 and Article 3.4 activities under the Kyoto Protocol.

Table 11.4 Key category analysis for Article 3.3 and Article 3.4 activities

Kyoto Protocol Art.3.3 and Art. 3.4 activities			Level 1990	Level 2019	Trend
Article 3.3					
A.1	Afforestation and reforestation	CO_2		✓	✓
A.2	Deforestation	CO_2			
Article 3.4					
B.1	Forest Management	CO_2		✓	✓
B.4	Revegetation	CO_2	✓	✓	✓

12 Information on Accounting of Kyoto Units

12.1 Background Information

The national registry is maintained by the Environment Agency of Iceland. The registry holds as of 31 December 2021: 57 EU ETS accounts, thereof 9 Operator holding accounts, 35 Aircraft operator holding accounts, 11 Verifier accounts, 1 National holding account and 1 Party holding account. Iceland's AAUs were 15,327,217 tonnes of CO_2e, on December 31, 2021.

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 the year 2021. Iceland´s Standard Electronic Format (SEF) reports for 2021, for the second commitment period, are reported with the CRF data and NIR, and will be made available at the UNFCCC website[28]. Chapter 14 includes information on changes in the national registry.

12.1.1 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 October 17th, 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 industrialized 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

[28] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10116.php

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 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 be 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 12.1 and Figure 12.1 show all Kyoto units accounting relevant to the CP1, as well as the emissions for the period.

Table 12.1. 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

		2008	2009	2010	2011	2012	CP1
Emissions from Annex A sources	t CO2e	5,021,786	4,779,267	4,646,161	4,441,127	4,467,730	23,356,071
Difference AAU - Annex A emissions	t CO2e	1,061,296	799,265	634,087	398,479	364,014	3,257,140
Emissions falling under Decision 14/CP.7	t CO2e	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 CO2e	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 CO2e	1,061,296	799,265	634,087	398,479	364,014	3,257,140

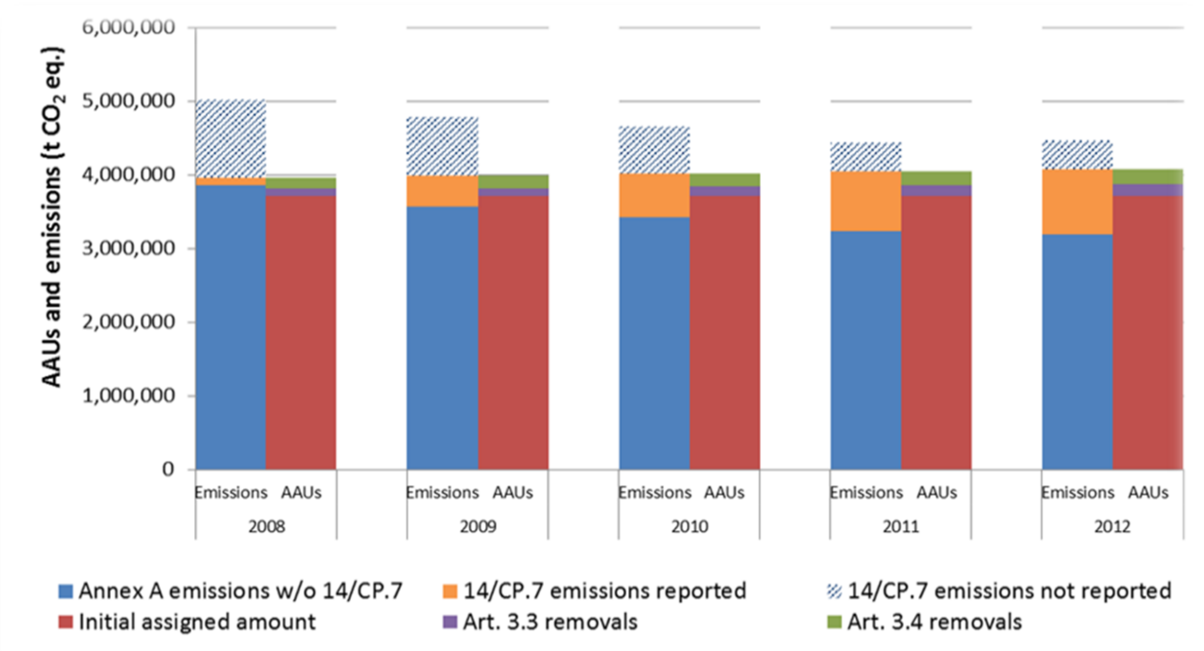

Figure 12.1 Summary of Kyoto accounting for CP1

12.1.2 Second Commitment Period - CP2

The second Commitment Period started 1. January 2013 and ended 31. December 2020. The EU, its Member States and Iceland have agreed to the immediate implementation of the Doha Amendment as of 1st 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[29]). Iceland does not intend to 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.

[29] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015D1339&from=EN

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 (Council Decision (EU) 2015/1339).

12.2 Summary of Information Reported in the SEF Tables

Article 3 in part I 'General reporting instruction', to Annex 'Standard electronic format for reporting of information on Kyoto Protocol units', of decision 15CMP.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 the year 2021, 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 the year 2021, 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

There were 15,327,217 AAUs for CP2 in Iceland's party holding account at the end of the year 2021. The Voluntary cancellation account CP1 in the registry did not contain any units.

Iceland submitted the SEF tables for the first time in April 2014 for the issued Kyoto Protocol units in 2013 and the 2021 SEF tables for second commitment period were submitted in March 2022.

12.3 Discrepancies and Notifications

No discrepancies or notifications have occurred in relation to Iceland's accounting of Kyoto units in 2021.

Table 12.2 Discrepancies and notifications in 2021.

Annual Submission Item	Reporting Information
15/CMP.1 Annex 1.E paragraph 12: List of discrepant transactions	No discrepant transaction occurred in 2021
15/CMP.1 Annex 1.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2021
15/CMP.1 Annex 1.E paragraph 15: List of non-replacements	No non-replacements occurred in 2021
15/CMP.1 Annex 1.E paragraph 16: List of invalid units	No invalid units exist as of 31 December 2021
15/CMP.1 Annex 1.E paragraph 17: Actions and changes to address discrepancies	No discrepant transactions occurred in 2021

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.

12.4 Publicly Accessible Information

A set of information regarding the registry and guidance on accessing registry accounts has been updated on the homepage of the Environment Agency, 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

12.5 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".

Therefore, Iceland's commitment period reserve is calculated as, either:

$$\begin{gathered}\text{90\% of Iceland's assigned amount}\\ = 0.9 \times 15{,}327{,}217 \text{ tonnes } CO_2 \text{ equivalent}\\ = 13{,}794{,}495 \text{ tonnes } CO_2 \text{ equivalent.}\end{gathered}$$

or,

$$\begin{gathered}\text{100\% of } 8 \times \text{(the national total in the most recently reviewed inventory)}\\ = 8 \times 4{,}722{,}349 \text{ tonnes } CO_2 \text{ equivalent}\\ = 37{,}778{,}792 \text{ tonnes } CO_2 \text{ equivalent}\end{gathered}$$

This means Iceland's Commitment Period Reserve is 13,794,495 tonnes CO_2e, calculated as 90% of Iceland's assigned amount.

The Icelandic registry did not violate the CPR during 2021.

12.6 KP-LULUCF Accounting

12.6.1 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 12.3. 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

12.6.2 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 Reforestation 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 12.4 below shows the calculated RMUs for the second commitment period.

Table 12.4 Calculated RMUs (in t CO_2e) from Art. 3.3 and Art. 3.4 activities for CP2.

	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: -4,299,128								

13 Information on Changes in National System

No changes have been made in the National System since the 2021 submission.

The main legal acts describing Iceland's national system are Act No 70/2012 and Regulation No 520/2017, as described in paragraph 1.2.3 of Chapter 1. Regulation No 520/2017 is currently being revised. A final draft of the revised regulation is expected to be accepted within the next few months and the updated regulation published in 2022. Main changes will be highlighted in next year's NIR.

14 Information on Changes in the National Registry

The information included in this chapter is based on the requirements laid out in Paragraph 32 of Decision 15/CMP.1. The following changes to the national registry of Iceland have therefore occurred in 2021. Note that the 2021 SIAR confirms that previous recommendations have been implemented and included in the annual report.

Table 14.1 Changes in the National Registry in 2021.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	Registry System Administrator: Sigríður Rós Einarsdóttir sigridur.einarsdottir@umhverfisstofnun.is
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	There was a change in the cooperation arrangement during the reported period as the United Kingdom of Great Britain and Northern Ireland no longer operate their registry in a consolidated manner within the Consolidated System of EU registries, CS EUR.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	There has been 6 new EUCR releases (versions 12.4, 13.0.2, 13.2.1, 13.3.3 , 13.5.1 and 13.5.2) after version 11.5 (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 12.4, 13.0.2, 13.2.1, 13.3.3, 13.5.1 and 13.5.2 compared with version 11.5 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.

15 Information on Minimization of Adverse Impacts in Accordance with Article 3, Paragraph 14 of the Kyoto Protocol

No changes have occurred in the information on minimization of adverse impacts since last submission.

Actions	Implementation
Progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities	Planning of economic instruments in Iceland, inter alia for limiting emissions in the greenhouse gas emitting sectors is subject to different methodologies. These involve feasibility and efficiency and consideration of national and international circumstances.
Removing subsidies associated with the use of environmentally unsound and unsafe technologies	Subsidies associated with the use of environmentally unsound and unsafe technologies have not been identified in Iceland.
Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end	Iceland does not have support activities in this field.
Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort	• Iceland is the home of the Carbfix project[30], a multinational project located at the Hellisheiði geothermal plant where CO_2 captured in geothermal steam is injected back into the basaltic rock underground. Now in its second phase (CarbFix2), the project is demonstrating the feasibility of sequestering carbon dioxide into basaltic bedrock and store it there permanently as a mineral. The project's implications for the fight against global warming may be considerable, since basaltic bedrock susceptive of CO_2 injections are widely found on the planet and CO_2 capture-and-storage and mineralization in basaltic rock is not only confined to geothermal emissions or areas. Furthermore, a direct air capture plant has been set up, where the CO_2 captured from the air is injected into the bedrock together with the CO_2 captured from the geothermal wells. With funding from the European Union, the aim is to demonstrate how the CarbFix method can be used worldwide. • The Government of Iceland has supported developing countries in the area of sustainable utilization of natural resources through its administration of the United Nations University Geothermal Training Program. The Geothermal Training Program, which started thirty-five years ago, has built up expertise in the utilization of geothermal energy by training 554 experts from 53 countries. The program provides their graduating fellows with the opportunity to enter MSc and PhD programmes with Icelandic universities. Iceland will continue its support for geothermal projects in developing countries with geothermal resources, which can be utilized to decrease their dependency on fossil fuels for economic development. • Furthermore, the government of Iceland has financially contributed to various climate-specific projects within the Geothermal Exploration Project East Africa, the Energy Sector Management Assistance Program (ESMAP), Sustainable Energy for All (SEforALL), Ukraine geothermal project, Nicaragua geothermal project, as well as the International Renewable Energy Agency (IRENA). More information can be found in Iceland's fourth Biennial Report submitted to the UNFCCC, in particular Tables 6-3 and 6-4.

[30] www.carbfix.com

Actions	Implementation
Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities	See above
Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies	Iceland does not have support activities in this field.

16 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 categories

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 method.

Table 1.2 lists identified key categories. Tables A1, A2 and A3 show the 1990 level, 2020 level and 1990-2020 trend assessment without LULUCF, and Table A4, A5 and A6 show the 1990 level, 2020 level and 1990-2020 trend assessment with LULUCF. All categories are listed in decreasing order of level or trend % contribution.

Table A1.1 Key Category analysis approach 1 Level Assessment for 1990 excluding LULUCF, [kt CO_2e].

IPCC code	IPCC category	Gas	1990 Emissions [kt CO_2e]	Level assessment [%]	Cumulative total of level [%]
1A4c	Agriculture/Forestry/Fishing	CO_2	753.1	20.49%	20.49%
1A3b	Road Transport	CO_2	511.7	13.9%	34.4%
2C3	Metal Production: Aluminium	C_2F_6	494.6	13.46%	47.88%
1A2	Manufacturing and Construction	CO_2	237.5	6.5%	54.3%
2C2	Metal Production: Ferroalloys	CO_2	208.8	5.68%	60.03%
3D1	Agricultural Soils	N_2O	205.5	5.6%	65.6%
3A2	Enteric Fermentation: Sheep	CH_4	182.0	5.0%	70.6%
2C3	Metal Production: Aluminium	CO_2	139.2	3.79%	74.36%
5A2	Unmanaged waste disposal sites	CH_4	132.9	3.62%	77.98%
1A3e	Other Mobile Machinery	CO_2	121.0	3.29%	81.27%
3A1	Enteric Fermentation: Cattle	CH_4	109.5	2.98%	84.25%
1B2d	Fugitive Emissions	CO_2	61.4	1.67%	85.92%
2A1	Mineral Products: Cement	CO_2	51.6	1.40%	87.32%
2B10	Other	N_2O	46.5	1.27%	88.59%
3D2	Agricultural Soils: Indirect	N_2O	43.0	1.2%	89.8%
3A4	Enteric Fermentation: Other	CH_4	33.8	0.92%	90.68%
3B1	Manure Management: Cattle	CH_4	33.5	0.9%	91.6%
1A3a	Domestic Aviation	CO_2	33.3	0.91%	92.50%
1A3d	Navigation	CO_2	32.6	0.89%	93.38%
5D2	Wastewater Treatment and Discharge: Industrial wastewater	CH_4	32.3	0.88%	94.26%
1A4b	Residential Stationary	CO_2	28.1	0.76%	95.03%

Table A1. 2 Key category analysis approach 1 level for 2020, excluding LULUCF, [kt CO_2e].

IPCC code	IPCC category	Gas	2020 Emissions [kt CO_2e]	Level assessment [%]	Cumulative total of level [%]
2C3	Metal Production: Aluminium	CO_2	1261.3	28.0%	27.97%
1A3b	Road Transport	CO_2	817.0	18.1%	46.08%
1A4c	Agriculture/Forestry/Fishing	CO_2	528.6	11.7%	57.81%
2C2	Metal Production: Ferroalloys	CO_2	415.3	9.2%	67.01%
3D1	Agricultural Soils	N_2O	209.9	4.7%	71.67%
2F1	Refrigeration and Air Conditioning	HFC	196.8	4.4%	76.03%
1B2d	Fugitive Emissions	CO_2	174.9	3.9%	79.91%
5A1	Managed waste disposal sites	CH_4	165.7	3.7%	83.59%
3A2	Enteric Fermentation: Sheep	CH_4	133.2	3.0%	86.54%
3A1	Enteric Fermentation: Cattle	CH_4	122.8	2.7%	89.26%
2C3	Metal Production: Aluminium	C_2F_6	95.6	2.1%	91.38%
1A2	Manufacturing and Construction	CO_2	43.6	1.0%	92.35%
3D2	Agricultural Soils: Indirect	N_2O	37.6	0.8%	93.18%
3A4	Enteric Fermentation: Other	CH_4	33.9	0.8%	93.93%
3B1	Manure Management: Cattle	CH_4	33.0	0.7%	94.66%
1A3d	Navigation	CO_2	24.9	0.6%	95.22%

Table A1. 3 Key category analysis approach 1 1990-2020 trend assessment, excluding 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 [%]
2C3	Metal Production: Aluminium	CO_2	139.2	1261.3	29.7%	30.3%	30.3%
2C3	Metal Production: Aluminium	C_2F_6	494.6	95.6	13.9%	14.2%	44.5%
1A4c	Agriculture/Forestry/Fishing	CO_2	753.1	528.6	10.8%	11.0%	55.4%
1A2	Manufacturing and Construction	CO_2	237.5	43.6	6.7%	6.9%	62.3%
1A3b	Road Transport	CO_2	511.7	817.0	5.1%	5.2%	67.6%
2C2	Metal Production: Ferroalloys	CO_2	208.8	415.3	4.3%	4.4%	72.0%
5A1	Managed waste disposal sites	CH_4	16.8	165.7	3.9%	4.0%	76.0%
5A2	Unmanaged waste disposal sites	CH_4	132.9	21.4	3.9%	3.9%	79.9%
1A3e	Other Mobile Machinery	CO_2	121.0	21.3	3.5%	3.5%	83.5%
1B2d	Fugitive Emissions	CO_2	61.4	174.9	2.7%	2.8%	86.2%
3A2	Enteric Fermentation: Sheep	CH_4	182.0	133.2	2.5%	2.5%	88.7%
2A1	Mineral Products: Cement	CO_2	51.6	0.0	1.7%	1.8%	90.5%
2B10	Other	N_2O	46.5	0.0	1.6%	1.6%	92.1%
3D1	Agricultural Soils	N_2O	205.5	209.9	1.2%	1.2%	93.3%
1A4b	Residential Stationary	CO_2	28.1	5.4	0.8%	0.8%	94.1%
1A3a	Domestic Aviation	CO_2	33.3	13.1	0.8%	0.8%	94.8%
5D2	Wastewater Treatment and Discharge: Industrial wastewater	CH_4	32.3	17.2	0.6%	0.6%	95.5%

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 [%]
4C1	Grassland	CO_2	3133.9	20.1%	20.1%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	2970.5	19.1%	39.2%
4C2	Grassland	CO_2	1757.0	11.3%	50.5%
4D1	Wetlands	CO_2	1309.6	8.4%	59.0%
4B1	Cropland	CO_2	1220.9	7.9%	66.8%
1A4c	Agriculture/Forestry/Fishing	CO_2	753.1	4.8%	71.7%
4B2	Cropland	CO_2	634.8	4.1%	75.7%
1A3b	Road Transport	CO_2	511.7	3.3%	79.0%
2C3	Metal Production: Aluminium	C_2F_6	494.6	3.2%	82.2%
4(II) - Grasslands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	374.0	2.4%	84.6%
1A2	Manufacturing and Construction	CO_2	237.5	1.5%	86.1%
2C2	Metal Production: Ferroalloys	CO_2	208.8	1.3%	87.5%
3D1	Agricultural Soils	N_2O	205.5	1.3%	88.8%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	190.8	1.2%	90.0%
3A2	Enteric Fermentation: Sheep	CH_4	182.0	1.2%	91.2%
2C3	Metal Production: Aluminium	CO_2	139.2	0.9%	92.1%
5A2	Unmanaged waste disposal sites	CH_4	132.9	0.9%	93.0%
1A3e	Other Mobile Machinery	CO_2	121.0	0.8%	93.7%
4(II) - Grasslands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	110.5	0.7%	94.4%
3A1	Enteric Fermentation: Cattle	CH_4	109.5	0.7%	95.1%

Table A1. 5 Key category analysis approach 1 level for 2020, including LULUCF, [kt CO_2e].

IPCC code	IPCC category	Gas	2020 Emissions/ Removals [kt CO_2e]	Level assessment [%]	Cumulative total of level [%]
4C1	Grassland	CO_2	5389.9	31.0%	31.0%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	2841.3	16.4%	47.4%
4B1	Cropland	CO_2	1753.0	10.1%	57.5%
2C3	Metal Production: Aluminium	CO_2	1261.3	7.3%	64.7%
4D1	Wetlands	CO_2	1245.1	7.2%	71.9%
1A3b	Road Transport	CO_2	817.0	4.7%	76.6%
1A4c	Agriculture/Forestry/Fishing	CO_2	528.6	3.0%	79.6%
4(II) - Grasslands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	421.0	2.4%	82.1%
2C2	Metal Production: Ferroalloys	CO_2	415.3	2.4%	84.5%
4A2	Forest land	CO_2	384.5	2.2%	86.7%
3D1	Agricultural Soils	N_2O	209.9	1.2%	87.9%
2F1	Refrigeration and Air Conditioning	HFC	196.8	1.1%	89.0%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	182.2	1.0%	90.1%
1B2d	Fugitive Emissions	CO_2	174.9	1.0%	91.1%
4C2	Grassland	CO_2	169.5	1.0%	92.0%
5A1	Managed waste disposal sites	CH_4	165.7	1.0%	93.0%
3A2	Enteric Fermentation: Sheep	CH_4	133.2	0.8%	93.8%
4A1	Forest land	CO_2	127.8	0.7%	94.5%
4(II) - Grasslands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	124.4	0.7%	95.2%

Table A1. 6 Key category analysis approach 1 - 1990-2020 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	3133.9	5389.9	12.1%	20.2%	20.2%
4C2	Grassland	CO_2	1757.0	169.5	11.5%	19.2%	39.4%
2C3	Metal Production: Aluminium	CO_2	139.2	1261.3	7.1%	11.8%	51.2%
4B2	Cropland	CO_2	634.8	90.9	4.0%	6.6%	57.8%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	2970.5	2841.3	3.1%	5.1%	62.9%
2C3	Metal Production: Aluminium	C_2F_6	494.6	95.6	2.9%	4.9%	67.8%
4B1	Cropland	CO_2	1220.9	1753.0	2.5%	4.2%	71.9%
4A2	Forest land	CO_2	27.8	384.5	2.3%	3.8%	75.7%
1A4c	Agriculture/Forestry/Fishing	CO_2	753.1	528.6	2.0%	3.3%	79.1%
1A3b	Road Transport	CO_2	511.7	817.0	1.6%	2.6%	81.7%
1A2	Manufacturing and Construction	CO_2	237.5	43.6	1.4%	2.4%	84.0%
4D1	Wetlands	CO_2	1309.6	1245.1	1.4%	2.3%	86.4%
2C2	Metal Production: Ferroalloys	CO_2	208.8	415.3	1.2%	1.9%	88.3%
5A1	Managed waste disposal sites	CH_4	16.8	165.7	0.9%	1.6%	89.9%
5A2	Unmanaged waste disposal sites	CH_4	132.9	21.4	0.8%	1.4%	91.3%
4A1	Forest land	CO_2	2.5	127.8	0.8%	1.3%	92.6%
1A3e	Other Mobile Machinery	CO_2	121.0	21.3	0.7%	1.2%	93.8%
1B2d	Fugitive Emissions	CO_2	61.4	174.9	0.7%	1.1%	94.9%
3A2	Enteric Fermentation: Sheep	CH_4	182.0	133.2	0.5%	0.7%	95.7%

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 59%. When looking at the uncertainty analysis without LULUCF, the trend uncertainty is 10%, and the uncertainty in total inventory is 9%.

Table A2. 1 and Table A2. 2 show the complete uncertainty assessment, with and without LULUCF, respectively.

Table A2. 1 Uncertainty Analysis including LULUCF

IPCC Category		Gas	1990 emissions [kt CO_2e]	2020 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	4.14	1.78	5%	5%	7.1%	8.6E-11	9.99E-06	9.75E-06	1.95E-10
1A1aiii	Public electricity and heat production (heat plants)	CO_2	9.34	0.00	5%	5%	7.1%	0	3.81E-05	0.00E+00	1.45E-09
1A2a	Iron and Steel	CO_2	0.36	1.28	2%	5%	5.2%	2.4E-11	3.52E-06	2.11E-06	1.69E-11
1A2b	Non-Ferrous Metals	CO_2	13.50	6.13	2%	5%	5.2%	5.6E-10	3.13E-05	1.01E-05	1.08E-09
1A2c	Chemicals	CO_2	7.43	0.00	5%	5%	7.1%	0	3.03E-05	0.00E+00	9.18E-10
1A2e	Food Processing, Beverages and Tobacco	CO_2	128.24	15.61	5%	5%	7.1%	6.7E-09	4.62E-04	8.57E-05	2.21E-07
1A2f	Non-metallic minerals	CO_2	47.42	0.41	5%	5%	7.1%	4.5E-12	1.92E-04	2.23E-06	3.68E-08
1A2g	Other manufacturing industries and Constructions	CO_2	40.53	20.22	5%	5%	7.1%	1.1E-08	8.68E-05	1.11E-04	1.99E-08
1A3a	Domestic Aviation	CO_2	33.34	13.15	5%	5%	7.1%	4.7E-09	8.49E-05	7.22E-05	1.24E-08
1A3b	Road Transport	CO_2	511.75	816.98	5%	3%	5.7%	1.2E-05	6.09E-04	4.49E-03	2.05E-05
1A3d	Domestic Water - borne Navigation	CO_2	32.59	24.91	5%	5%	7.1%	1.7E-08	3.62E-05	1.37E-04	2.00E-08
1A3e	Mobile machinery – Other	CO_2	120.96	21.34	5%	5%	7.1%	1.2E-08	4.11E-04	1.17E-04	1.82E-07
1A4a	Commercial/Institutional	CO_2	8.05	2.91	5%	5%	7.1%	2.3E-10	2.16E-05	1.60E-05	7.19E-10
1A4b	Residential	CO_2	28.10	5.37	5%	5%	7.1%	7.9E-10	9.38E-05	2.95E-05	9.66E-09
1A4c	Agriculture/Fishing	CO_2	753.07	528.59	5%	5%	7.1%	7.6E-06	1.02E-03	2.90E-03	9.47E-06
1A5a	Other - stationary	CO_2	0.12	0.36	5%	5%	7.1%	3.6E-12	9.04E-07	1.98E-06	4.74E-12
1B2a5	Oil - Distribution of oil products	CO_2	0.00	0.00	5%	5%	7.1%	3.8E-16	2.93E-09	2.04E-08	4.24E-16
1B2d	Other emission from Energy Production	CO_2	61.36	174.87	10%	10%	14.1%	3.3E-06	8.58E-04	1.92E-03	4.43E-06
2A1	Cement Production	CO_2	51.56	0.00	2%	30%	30.1%	1.26E-03	0	1.59E-06	1.26E-03
2A4d	Other: Mineral Wool Production	CO_2	0.70	0.89	2%	2%	2.7%	1.92E-07	2.21E-06	4.92E-12	1.92E-07
2B10	Other: Silica production	CO_2	0.36	0.00	5%	10%	11.2%	2.94E-06	0	8.64E-12	2.94E-06
2C1	Metal Production - Iron and steel	CO_2	0.00	0.00	10%	25%	26.9%	0	0	0	0
2C2	Metal Production - Ferroalloys	CO_2	208.80	415.30	2%	2%	2.1%	2.28E-04	6.84E-04	5.20E-07	2.28E-04
2C3	Metal Production - Aluminium Production	CO_2	139.21	1261.30	2%	2%	2.1%	1.30E-03	2.08E-03	6.01E-06	1.30E-03
2D1	Lubricants	CO_2	4.06	2.10	5%	50%	50%	5.7E-09	4.4E-05	1.1E-05	2.1E-09
2D2	Paraffin wax use	CO_2	0.17	0.34	5%	100%	100%	4.3E-10	4.6E-06	1.6E-06	2.4E-11
2D3a	Solvents	CO_2	1.37	1.97	2%	67%	67%	2.4E-08	1.7E-05	7.0E-06	3.5E-10

	IPCC Category	Gas	1990 emissions [kt CO_2e]	2020 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 [%]
2D3b	Domestic solvent use including fungicide	CO_2	0.01	0.01	2%	16%	16.5%	5.8E-10	6.71E-06	4.33E-06	6.38E-11
2D3d	Other (please specify) Road Paving with Asphalt	CO_2	1.12	0.97	2%	303%	303.1%	2.5E-12	4.07E-07	1.55E-08	1.66E-13
2D3e	Coating applications	CO_2	0.17	0.09	2%	16%	16.5%	1.4E-10	2.57E-06	2.14E-06	1.12E-11
2D3f	Degreasing	CO_2	0.00	0.00	2%	43%	43.5%	9.3E-12	2.75E-06	2.08E-07	7.60E-12
2D3g	Dry cleaning	CO_2	0.03	0.02	2%	496%	495.8%	2.9E-12	4.83E-07	1.03E-08	2.33E-13
2D3h	Chemical products	CO_2	0.17	0.17	2%	36%	36.4%	2.2E-13	5.29E-07	3.80E-08	2.81E-13
2D3i	Printing	CO_2	0.02	0.08	2%	207%	207.0%	7.0E-10	1.07E-06	3.79E-07	1.28E-12
2D3ure	Organic preservative	CO_2	0.00	0.46	2%	43%	42.9%	6.9E-12	2.09E-06	1.82E-07	4.39E-12
2G4fw	Other: Fireworks	CO_2	0.00	0.02	2%	50%	50%	5.4E-13	3.3E-07	4.5E-08	1.1E-13
3G	Liming	CO_2	0.46	3.86	50%	0%	50.0%	2.0E-08	0	2.12E-04	4.49E-08
3H	Urea application	CO_2	0.06	0.19	50%	0%	50.0%	5.1E-11	0	1.06E-05	1.13E-10
3I	Other Carbon Containing Fertilizers	CO_2	0.00	1.43	50%	0%	50.0%	2.8E-09	0	7.88E-05	6.21E-09
4(II)	Cropland	CO_2	28.65	28.49	20%	42%	46.1%	9.4E-07	5.16E-05	6.26E-04	3.95E-07
4(II)	Forest land	CO_2	0.07	0.49	4%	58%	58.5%	4.4E-10	1.87E-05	2.13E-06	3.54E-10
4(II)	Grasslands	CO_2	110.50	124.40	20%	52%	56.1%	2.7E-05	3.40E-04	2.73E-03	7.59E-06
4(II)	Wetlands	CO_2	190.82	182.15	20%	37%	42.4%	3.3E-05	5.30E-04	4.00E-03	1.63E-05
4A1	Forest Land Remaining Forest Land	CO_2	-2.47	-127.82	4%	25%	25.4%	5.8E-06	2.44E-03	5.62E-04	6.28E-06
4A2	Land Converted to Forest Land	CO_2	-27.77	-384.52	4%	9%	9.8%	7.7E-06	2.46E-03	1.69E-03	8.92E-06
4B1	Cropland Remaining Cropland	CO_2	1220.91	1752.98	20%	14%	24.5%	1.0E-03	5.19E-03	3.85E-02	1.51E-03
4B2	Land Converted to Cropland	CO_2	634.84	90.95	20%	29%	35.2%	5.6E-06	1.30E-02	2.00E-03	1.72E-04
4C1	Grassland Remaining Grassland	CO_2	3133.92	5389.94	20%	50%	53.5%	4.5E-02	8.07E-02	1.18E-01	2.05E-02
4C2	Land Converted to Grassland	CO_2	1756.98	-169.45	20%	21%	28.9%	1.3E-05	3.25E-02	3.72E-03	1.07E-03
4D1	Wetlands Remaining Wetlands	CO_2	-1309.57	-1245.08	20%	40%	44.6%	1.7E-03	4.04E-03	2.74E-02	7.65E-04
4D2	Land Converted to Wetlands	CO_2	0.51	4.97	20%	115%	116.3%	1.8E-07	3.95E-04	1.09E-04	1.68E-07
4E2	Land Converted to Settlements	CO_2	21.84	3.83	5%	150%	150.1%	1.8E-07	2.23E-03	2.11E-05	4.95E-06
5C	Incineration and Open Burning of waste	CO_2	7.30	5.76	52%	40%	65.6%	7.8E-08	5.92E-05	3.29E-04	1.11E-07
1A1ai	Public electricity and heat production (electricity generation)	CH_4	0.0042	0.0018	5%	100%	100.1%	1.8E-14	2.02E-07	9.87E-09	4.11E-14
1A1aiii	Public electricity and heat production (heat plants)	CH_4	0.0091	0.0000	5%	100%	100.1%	0.0E+00	7.39E-07	0.00E+00	5.46E-13

IPCC Category		Gas	1990 emissions [kt CO_2e]	2020 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 [%]
1A2a	Iron and Steel	CH_4	0.0004	0.0009	2%	100%	100.0%	4.7E-15	4.24E-08	1.52E-09	1.80E-15
1A2b	Non-Ferrous Metals	CH_4	0.0124	0.0058	2%	100%	100.0%	1.8E-13	5.62E-07	9.53E-09	3.16E-13
1A2c	Chemicals	CH_4	0.0072	0.0000	5%	100%	100.1%	0.0E+00	5.88E-07	0.00E+00	3.45E-13
1A2e	Food Processing, Beverages and Tobacco	CH_4	0.1243	0.0258	5%	100%	100.1%	3.7E-12	8.14E-06	1.42E-07	6.62E-11
1A2f	Non-metallic minerals	CH_4	0.1219	0.0004	5%	100%	100.1%	9.3E-16	9.91E-06	2.26E-09	9.83E-11
1A2g	Other manufacturing industries and Constructions	CH_4	0.0400	0.0240	5%	100%	100.1%	3.2E-12	1.40E-06	1.32E-07	1.96E-12
1A3a	Domestic Aviation	CH_4	0.0058	0.0023	5%	100%	100.1%	2.9E-14	2.98E-07	1.26E-08	8.92E-14
1A3b	Road Transport	CH_4	5.5806	1.0173	5%	219%	219.1%	2.7E-08	8.24E-04	5.59E-06	6.79E-07
1A3d	Domestic Water - borne Navigation	CH_4	0.0760	0.0587	5%	100%	100.1%	1.9E-11	1.65E-06	3.22E-07	2.81E-12
1A3e	Mobile machinery – Other	CH_4	0.1694	0.0299	5%	100%	100.1%	4.9E-12	1.15E-05	1.64E-07	1.32E-10
1A4a	Commercial/Institutional	CH_4	0.0239	0.0081	5%	100%	100.1%	3.6E-13	1.32E-06	4.45E-08	1.76E-12
1A4b	Residential	CH_4	0.0948	0.0135	5%	100%	100.1%	1.0E-12	6.69E-06	7.44E-08	4.47E-11
1A4c	Agriculture/Fishing	CH_4	1.7768	1.2227	5%	100%	100.1%	8.2E-09	5.00E-05	6.72E-06	2.54E-09
1A5a	Other - stationary	CH_4	0.0001	0.0008	5%	100%	100.1%	3.8E-15	5.48E-08	4.55E-09	3.02E-15
1B2a5	Oil - Distribution of oil products	CH_4	0.4869	0.4436	5%	100%	100.1%	1.1E-09	5.26E-06	2.44E-06	3.36E-11
1B2d	Other emission from Energy Production	CH_4	0.1955	3.8570	10%	25%	26.9%	5.9E-09	7.09E-05	4.24E-05	6.82E-09
2C2	Metal Production - Ferroalloys	CH_4	1.5698	3.0424	2%	10%	10.1%	5.2E-10	1.08E-05	5.01E-06	1.42E-10
2G4tob	Other: Tobacco	CH_4	0.0447	0.0193	2%	50%	50.0%	5.1E-13	1.07E-06	4.24E-08	1.15E-12
2G4fw	Other - Fireworks use	CH_4	0.0023	0.0102	2%	50%	50.0%	1.4E-13	3.00E-07	2.24E-08	9.04E-14
3A1	Enteric Fermentation - Cattle	CH_4	109.48	122.77	5%	40%	40.3%	2.42E-04	6.74E-04	5.13E-07	2.42E-04
3A2	Enteric Fermentation - Sheep	CH_4	181.95	133.18	5%	40%	40.3%	1.80E-03	7.32E-04	3.77E-06	1.80E-03
3A3	Enteric Fermentation - Swine	CH_4	1.12	1.47	5%	40%	40.3%	9.31E-06	8.09E-06	1.52E-10	9.31E-06
3A4	Enteric Fermentation – Other Livestock	CH_4	33.76	33.87	13%	80%	81.1%	9.90E-05	4.92E-04	2.52E-07	9.90E-05
3B1	Manure Management - Cattle	CH_4	33.50	32.95	11%	20%	22.9%	3.47E-05	4.05E-04	1.65E-07	3.47E-05
3B2	Manure Management - Sheep	CH_4	15.28	11.05	25%	20%	32.4%	7.76E-05	3.10E-04	1.02E-07	7.76E-05
3B3	Manure Management - Swine	CH_4	4.47	5.89	11%	30%	32.0%	2.79E-05	7.23E-05	6.01E-09	2.79E-05
3B4	Manure Management – Other Livestock	CH_4	10.71	6.30	24%	60%	64.6%	2.30E-04	1.66E-04	8.06E-08	2.30E-04
4(II)	Cropland	CH_4	94.83	94.29	20%	51%	54.5%	1.4E-05	2.09E-04	2.07E-03	4.34E-06
4(II)	Forest land	CH_4	0.11	0.75	4%	71%	71.4%	1.6E-09	3.51E-05	3.28E-06	1.24E-09

	IPCC Category	Gas	1990 emissions [kt CO_2e]	2020 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 [%]
4(II)	Grassland	CH_4	374.02	420.99	20%	64%	67.1%	4.4E-04	1.40E-03	9.25E-03	8.75E-05
4(II)	Wetlands	CH_4	2970.47	2841.33	20%	258%	259.2%	3.0E-01	5.58E-02	6.24E-02	7.01E-03
5A1	Managed waste disposal sites	CH_4	16.79	165.70	52%	43%	67.3%	4.7E-05	4.91E-03	9.46E-03	1.14E-04
5A2	Unmanaged waste disposal sites	CH_4	132.94	21.37	52%	43%	67.3%	6.8E-05	3.79E-03	1.23E-03	1.58E-05
5B	Biological treatment of solid waste	CH_4	0.00	3.24	52%	41%	66.5%	1.1E-06	2.65E-04	1.95E-04	1.08E-07
5C	Incineration and Open Burning of waste	CH_4	6.09	0.07	52%	100%	112.7%	8.1E-08	4.91E-04	3.77E-06	2.41E-07
5D2	Wastewater Treatment and Discharge Industrial Wastewater	CH_4	32.31	17.18	52%	100%	112.7%	3.0E-11	2.84E-04	1.61E-03	2.66E-06
5D1	Wastewater Treatment and Discharge Domestic Wastewater	CH_4	17.69	24.84	59%	58%	82.8%	2.3E-06	7.58E-04	7.31E-04	1.11E-06
1A1aiii	Public electricity and heat production (electricity generation)	N_2O	0.00999	0.00429	5%	100%	100.1%	1.0E-13	4.83E-07	2.35E-08	2.33E-13
1A1ai	Public electricity and heat production (heat plants)	N_2O	0.02159	0.00000	5%	100%	100.1%	0.0E+00	1.76E-06	0.00E+00	3.10E-12
1A2a	Iron and Steel	N_2O	0.00086	0.00192	2%	100%	100.0%	2.0E-14	7.88E-08	3.16E-09	6.22E-15
1A2b	Non-Ferrous Metals	N_2O	0.02896	0.01346	2%	100%	100.0%	9.9E-13	1.32E-06	2.22E-08	1.74E-12
1A2c	Chemicals	N_2O	0.01717	0.00000	5%	100%	100.1%	0.0E+00	1.40E-06	0.00E+00	1.96E-12
1A2e	Food Processing, Beverages and Tobacco	N_2O	0.29637	0.05254	5%	100%	100.1%	1.5E-11	2.01E-05	2.89E-07	4.04E-10
1A2f	Non-metallic minerals	N_2O	0.21915	0.00098	5%	100%	100.1%	5.3E-15	1.78E-05	5.39E-09	3.17E-10
1A2g	Other manufacturing industries and Constructions	N_2O	0.09528	1.37368	5%	100%	100.1%	1.0E-08	9.89E-05	7.55E-06	9.84E-09
1A3a	Domestic Aviation	N_2O	0.27881	0.10968	5%	200%	200.1%	2.6E-10	2.85E-05	6.02E-07	8.10E-10
1A3b	Road Transport	N_2O	5.25704	7.16128	5%	188%	188.0%	9.9E-07	2.39E-04	3.93E-05	5.89E-08
1A3d	Domestic Water - borne Navigation	N_2O	0.25896	0.19983	5%	200%	200.1%	8.7E-10	1.12E-05	1.10E-06	1.27E-10
1A3e	Mobile machinery – Other	N_2O	13.91929	2.45604	5%	250%	250.0%	2.1E-07	2.36E-03	1.35E-05	5.58E-06
1A4a	Commercial/Institutional	N_2O	0.01493	0.00464	5%	100%	100.1%	1.2E-13	8.58E-07	2.55E-08	7.37E-13
1A4b	Residential	N_2O	0.06783	0.00658	5%	100%	100.1%	2.4E-13	5.02E-06	3.61E-08	2.52E-11
1A4c	Agriculture/Fishing	N_2O	6.05132	6.80969	5%	200%	200.1%	1.0E-06	7.06E-05	3.74E-05	6.38E-09
1A5a	Other - stationary	N_2O	0.00028	0.00126	5%	100%	100.1%	8.7E-15	7.50E-08	6.93E-09	5.68E-15
1B2a5	Oil - Distribution of oil products	N_2O	2.E-06	3.E-06	5%	0%	5.0%	1.7E-22	0	1.74E-11	3.03E-22
2B10	Other: Fertilizer production	N_2O	46.48800	0.00000	5%	40%	40.3%	0	1.52E-03	0	2.30E-06

IPCC Category		Gas	1990 emissions [kt CO_2e]	2020 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 [%]
2G3a	N2O from Product Uses: Medical Applications	N_2O	5.29761	2.07088	6%	5%	7.8%	1.4E-10	1.36E-05	1.37E-05	3.72E-10
2G3b	N2O from Product Uses: Other	N_2O	0.71826	0.46708	6%	5%	7.8%	7.3E-12	1.12E-06	3.09E-06	1.08E-11
2G4tob	Other: Tobacco	N_2O	0.01070	0.00462	2%	50%	50.0%	2.9E-14	2.57E-07	1.02E-08	6.60E-14
2G4fw	Other: Fireworks	N_2O	0.06568	0.28480	2%	50%	50.0%	1.1E-10	8.38E-06	6.26E-07	7.07E-11
3B1	Manure Management: Cattle	N_2O	0.73600	0.74325	11%	100%	100.6%	3.1E-09	2.31E-06	9.13E-06	8.87E-11
3B2	Manure Management: Sheep		11.08590	8.02311	25%	100%	103.2%	3.8E-07	2.81E-04	2.25E-04	1.30E-07
3B25	Manure Management: Indirect	N_2O	9.24741	8.02163	100%	400%	412.3%	6.0E-06	5.25E-04	8.81E-04	1.05E-06
3B3	Manure Management: Swine	N_2O	0.00000	0.00000	11%	100%	100.6%	0.0E+00	0	0	0
3B4	Manure Management: Other Livestock	N_2O	1.18111	1.03228	24%	200%	201.4%	2.4E-08	3.23E-05	2.72E-05	1.79E-09
3D1.1	Inorganic N Fertilizers	N_2O	58.41396	53.42203	5%	233%	233.4%	8.5E-05	1.44E-03	2.93E-04	2.15E-06
3D1.2	Organic N Fertilizers	N_2O	38.11122	31.84966	63%	233%	241.6%	3.2E-05	1.48E-03	2.20E-03	7.03E-06
3D1.3	Urine and Dung Deposited by Grazing Animals	N_2O	47.85732	41.19728	57%	233%	240.1%	5.4E-05	1.64E-03	2.57E-03	9.30E-06
3D1.4	Crop Residues	N_2O	0.06803	0.07066	100%	233%	253.9%	1.8E-10	1.42E-07	7.76E-06	6.03E-11
3D1.6	Cultivation of organic soils	N_2O	61.08477	83.34704	20%	200%	201.0%	1.5E-04	2.98E-03	1.83E-03	1.22E-05
3D2.1	Indirect N2O Emissions	N_2O	11.35610	10.27253	100%	400%	412.3%	9.8E-06	5.14E-04	1.13E-03	1.54E-06
3D2.1	Nitrogen leaching and run-off	N_2O	31.60588	27.36444	100%	500%	509.9%	1.1E-04	2.26E-03	3.01E-03	1.42E-05
4(II)	Forest land	N_2O	0.11989	0.83390	4%	20%	20.4%	1.6E-10	1.10E-05	3.66E-06	1.34E-10
5B	Biological Treatment of Solid Waste	N_2O	0.00000	2.22043	52%	150%	158.7%	8.2E-08	2.84E-04	1.39E-04	1.00E-07
5C	Incineration and Open Burning of Waste	N_2O	1.67400	0.22170	52%	100%	112.7%	3.4E-10	1.19E-04	1.27E-05	1.44E-08
5D1	Wastewater Treatment and Discharge Domestic Wastewater	N_2O	4.58145	6.03950	59%	2495%	2495.7%	1.2E-04	2.38E-03	3.90E-04	5.82E-06
2F1	Refrigeration and Air Conditioning	HFC	0.00000	196.82724	100%	35%	106.1%	2.4E-04	5.42E-03	2.16E-02	4.97E-04
2F4	Aerosols	HFC	0.34415	0.87758	5%	5%	7.1%	2.1E-11	2.00E-06	4.82E-06	2.73E-11
2C3	Metal Production - Aluminium Production	PFC	494.642	95.577	2%	15%	15.1%	1.14E-06	4.94E-03	1.57E-04	2.44E-05
2F1	Refrigeration and Air Conditioning	PFC	0.000	0.067	100%	35%	106.1%	2.76E-11	1.85E-06	7.36E-06	5.76E-11
2G1	Electrical Equipment	SF_6	1.0964	3.1548	30%	30%	42.4%	9.80E-09	4.67E-05	1.04E-04	1.30E-08
	Total emissions		12873.4	13519.5							
	Total Uncertainties		% Uncertainty in total inventory (including LULUCF):					**58.9%**		Trend uncertainty:	**17.9%**

Table A2. 2 Uncertainty Analysis excluding LULUCF

	IPCC Category	Gas	1990 emissions [kt CO_2e]	2020 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	4.14033	1.77523	5%	5%	7.1%	7.75E-10	4.50E-05	3.42E-05	3.19E-09
1A1aiii	Public electricity and heat production (heat plants)	CO_2	9.34246	0.00000	5%	5%	7.1%	0.00E+00	1.56E-04	0	2.43E-08
1A2a	Iron and Steel	CO_2	0.35530	1.28012	2%	5%	5.2%	2.20E-10	1.15E-05	7.39E-06	1.87E-10
1A2b	Non-Ferrous Metals	CO_2	13.50060	6.12633	2%	5%	5.2%	5.03E-09	1.42E-04	3.54E-05	2.15E-08
1A2c	Chemicals	CO_2	7.42958	0.00000	5%	5%	7.1%	0.00E+00	1.24E-04	0.00E+00	1.54E-08
1A2e	Food Processing, Beverages and Tobacco	CO_2	128.24079	15.60745	5%	5%	7.1%	5.99E-08	1.93E-03	3.00E-04	3.81E-06
1A2f	Non-metallic minerals	CO_2	47.41541	0.40624	5%	5%	7.1%	4.06E-11	7.86E-04	7.82E-06	6.18E-07
1A2g	Other manufacturing industries and Constructions	CO_2	40.52507	20.21899	5%	5%	7.1%	1.00E-07	4.02E-04	3.89E-04	3.13E-07
1A3a	Domestic Aviation	CO_2	33.33821	13.14570	5%	5%	7.1%	4.25E-08	3.78E-04	2.53E-04	2.07E-07
1A3b	Road Transport	CO_2	511.74705	816.98374	5%	3%	5.7%	1.08E-04	1.44E-03	1.57E-02	2.49E-04
1A3d	Domestic Water - borne Navigation	CO_2	32.59043	24.90962	5%	5%	7.1%	1.53E-07	2.05E-04	4.79E-04	2.72E-07
1A3e	Mobile machinery – other	CO_2	120.96442	21.33674	5%	5%	7.1%	1.12E-07	1.73E-03	4.11E-04	3.16E-06
1A4a	Commercial/Institutional	CO_2	8.05059	2.90616	5%	5%	7.1%	2.08E-09	9.49E-05	5.59E-05	1.21E-08
1A4b	Residential	CO_2	28.10008	5.36878	5%	5%	7.1%	7.08E-09	3.96E-04	1.03E-04	1.68E-07
1A4c	Agriculture/Fishing	CO_2	753.06766	528.58597	5%	5%	7.1%	6.87E-05	5.37E-03	1.02E-02	1.32E-04
1A5a	Other - stationary	CO_2	0.12190	0.36072	5%	5%	7.1%	3.20E-11	2.87E-06	6.94E-06	5.64E-11
1B2a5	Oil - Distribution of oil products	CO_2	0.00282	0.00371	5%	5%	7.1%	3.38E-15	3.47E-09	7.14E-08	5.11E-15
1B2d	Other emission from Energy Production	CO_2	61.35543	174.86900	10%	10%	14.1%	3.01E-05	2.71E-03	6.73E-03	5.26E-05
2A1	Cement Production	CO_2	51.5612	0.0000	2%	30%	30.1%	0	5.17E-03	0	2.67E-05
2A4d	Other: Mineral Wool Production	CO_2	0.6951	0.8950	2%	2%	2.7%	2.88E-11	1.71E-07	7.74E-06	6.00E-11
2B10a	Other: Silica production	CO_2	0.3603	0.0000	5%	10%	11.2%	0	1.20E-05	0	1.45E-10
2C1	Metal Production - Iron and steel	CO_2	0.0000	0.0000	10%	25%	26.9%	0	0	0	0
2C2	Metal Production - Ferroalloys	CO_2	208.7966	415.3048	2%	2%	2.1%	3.82E-06	6.49E-04	2.40E-03	6.17E-06
2C3	Metal Production - Aluminium Production	CO_2	139.2106	1261.3042	2%	2%	2.1%	3.52E-05	4.45E-03	7.28E-03	7.28E-05
2D1	Lubricants	CO_2	4.0597	2.0982	5%	50%	50.3%	5.48E-08	3.93E-04	4.04E-05	1.56E-07

	IPCC Category	Gas	1990 emissions [kt CO_2e]	2020 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 [%]
2D2	Paraffin wax use	CO_2	0.1732	0.3397	5%	100%	100.2%	5.70E-09	3.46E-05	6.54E-06	1.24E-09
2D3a	Solvents	CO_2	1.3746	1.9723	2%	16%	16.5%	5.19E-09	1.27E-05	1.52E-05	3.91E-10
2D3b	Domestic solvent use including fungicide	CO_2	0.0051	0.0070	2%	303%	303.1%	2.24E-11	6.86E-07	5.42E-08	4.73E-13
2D3a	Other (please specify) Road Paving with Asphalt	CO_2	1.1190	0.9727	2%	16%	16.5%	1.26E-09	1.78E-05	7.49E-06	3.74E-10
2D3d	Coating applications	CO_2	0.1677	0.0947	2%	43%	43.5%	8.36E-11	1.31E-05	7.29E-07	1.73E-10
2D3f	Degreasing	CO_2	0.0033	0.0047	2%	496%	495.8%	2.65E-11	9.12E-07	3.60E-08	8.34E-13
2D3g	Dry cleaning	CO_2	0.0343	0.0173	2%	36%	36.4%	1.95E-12	2.46E-06	1.33E-07	6.05E-12
2D3h	Chemical products	CO_2	0.1705	0.1724	2%	207%	207.0%	6.26E-09	2.08E-05	1.33E-06	4.33E-10
2D3i	Printing	CO_2	0.0191	0.0827	2%	43%	42.9%	6.19E-11	6.92E-06	6.37E-07	4.83E-11
2D3ure	Organic preservative	CO_2	0.0000	0.4621	2%	5%	5.4%	3.04E-11	6.29E-06	3.56E-06	5.22E-11
2G4fw	Other: Fireworks	CO_2	0.00	0.02	2%	50%	50.0%	4.62E-12	1.4E-06	1.6E-07	2.0E-12
3G	Liming	CO_2	0.4620	3.8577	50%	0%	50.0%	1.83E-07	0	7.42E-04	5.51E-07
3H	Urea application	CO_2	0.0550	0.1933	50%	0%	50.0%	4.59E-10	0	3.72E-05	1.38E-09
3I	Other Carbon Containing Fertilizers	CO_2	0.0000	1.4343	50%	0%	50.0%	2.53E-08	0	2.76E-04	7.62E-08
5C	Incineration and Open Burning of waste	CO_2	7.2956	5.7556	52%	40%	65.6%	7.00E-07	3.48E-04	1.15E-03	1.45E-06
1A1ai	Public electricity and heat production (electricity generation)	CH_4	0.0042	0.0018	5%	100%	100.1%	1.59E-13	9.11E-07	3.46E-08	8.32E-13
1A1aiii	Public electricity and heat production (heat plants)	CH_4	0.0091	0.0000	5%	100%	100.1%	0.00E+00	3.03E-06	0.00E+00	9.15E-12
1A2a	Iron and Steel	CH_4	0.0004	0.0009	2%	100%	100.0%	4.19E-14	1.31E-07	5.33E-09	1.72E-14
1A2b	Non-Ferrous Metals	CH_4	0.0124	0.0058	2%	100%	100.0%	1.64E-12	2.57E-06	3.34E-08	6.58E-12
1A2c	Chemicals	CH_4	0.0072	0.0000	5%	100%	100.1%	0.00E+00	2.41E-06	0.00E+00	5.79E-12
1A2e	Food Processing, Beverages and Tobacco	CH_4	0.1243	0.0258	5%	100%	100.1%	3.28E-11	3.45E-05	4.96E-07	1.19E-09
1A2f	Non-metallic minerals	CH_4	0.1219	0.0004	5%	100%	100.1%	8.34E-15	4.06E-05	7.92E-09	1.65E-09
1A2g	Other manufacturing industries and Constructions	CH_4	0.0400	0.0240	5%	100%	100.1%	2.84E-11	6.82E-06	4.62E-07	4.67E-11
1A3a	Domestic Aviation	CH_4	0.0058	0.0023	5%	100%	100.1%	2.61E-13	1.33E-06	4.43E-08	1.76E-12
1A3b	Road Transport	CH_4	5.5806	1.0173	5%	219%	219.1%	2.44E-07	3.48E-03	1.96E-05	1.21E-05

	IPCC Category	Gas	1990 emissions [kt CO₂e]	2020 emissions [kt CO₂e]	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 [%]
1A3d	Domestic Water - borne Navigation	CH_4	0.0760	0.0587	5%	100%	100.1%	1.70E-10	9.43E-06	1.13E-06	9.02E-11
1A3e	Mobile machinery – other	CH_4	0.1694	0.0299	5%	100%	100.1%	4.41E-11	4.85E-05	5.75E-07	2.35E-09
1A4a	Commercial/Institutional	CH_4	0.0239	0.0081	5%	100%	100.1%	3.23E-12	5.79E-06	1.56E-07	3.36E-11
1A4b	Residential	CH_4	0.0948	0.0135	5%	100%	100.1%	9.04E-12	2.80E-05	2.61E-07	7.84E-10
1A4c	Agriculture/Fishing	CH_4	1.7768	1.2227	5%	100%	100.1%	7.37E-08	2.61E-04	2.35E-05	6.86E-08
1A5a	Other - stationary	CH_4	0.0001	0.0008	5%	100%	100.1%	3.39E-14	1.86E-07	1.60E-08	3.49E-14
1B2a5	Oil - Distribution of oil products	CH_4	0.4869	0.4436	5%	100%	100.1%	9.70E-09	4.19E-05	8.54E-06	1.83E-09
1B2d	Other emission from Energy Production	CH_4	0.1955	3.8570	10%	25%	26.9%	5.30E-08	2.46E-04	1.48E-04	8.26E-08
2C2	Metal Production - Ferroalloys	CH_4	1.5698	3.0424	2%	10%	10.1%	4.65E-09	3.04E-05	1.76E-05	1.23E-09
2G4tob	Other: Tobacco	CH_4	0.0447	0.0193	2%	50%	50.0%	4.59E-12	4.84E-06	1.49E-07	2.34E-11
2G4fw	Other: Fireworks	CH_4	0.0023	0.0102	2%	50%	50.0%	1.28E-12	9.94E-07	7.84E-08	9.94E-13
3A1	Enteric Fermentation - Cattle	CH_4	109.4755	122.7685	5%	40%	40.3%	1.20E-04	1.26E-03	2.36E-03	7.18E-06
3A2	Enteric Fermentation - Sheep	CH_4	181.9535	133.1803	5%	40%	40.3%	1.42E-04	9.81E-03	2.56E-03	1.03E-04
3A3	Enteric Fermentation - Swine	CH_4	1.1163	1.4720	5%	40%	40.3%	1.73E-08	1.11E-05	2.83E-05	9.25E-10
3A4	Enteric Fermentation – Other Livestock	CH_4	33.7641	33.8678	13%	80%	81.1%	3.71E-05	1.65E-03	1.72E-03	5.69E-06
3B1	Manure Management - Cattle	CH_4	33.5037	32.9550	11%	20%	22.9%	2.80E-06	4.45E-04	1.42E-03	2.21E-06
3B2	Manure Management - Sheep	CH_4	15.2785	11.0505	25%	20%	32.4%	6.30E-07	4.19E-04	1.08E-03	1.35E-06
3B3	Manure Management - Swine	CH_4	4.4652	5.8879	11%	30%	32.0%	1.75E-07	3.32E-05	2.53E-04	6.53E-08
3B4	Manure Management – Other Livestock	CH_4	10.7052	6.3030	24%	60%	64.6%	8.15E-07	1.12E-03	5.82E-04	1.58E-06
5A1	Managed waste disposal sites	CH_4	16.7948	165.6990	52%	43%	67.3%	6.11E-04	1.69E-02	3.31E-02	1.38E-03
5A2	Unmanaged waste disposal sites	CH_4	132.9374	21.3677	52%	41%	66.5%	9.93E-06	1.59E-02	4.29E-03	2.71E-04
5B	Biological treatment of solid waste	CH_4	0	3.23570	52%	100%	112.7%	7.27E-07	9.29E-04	6.83E-04	1.33E-06
5C	Incineration and Open Burning of waste	CH_4	6.0856	0.0661	52%	100%	112.7%	2.73E-10	2.01E-03	1.32E-05	4.06E-06
5D1	Wastewater Treatment and Discharge Domestic Wastewater	CH_4	17.6901	24.8438	59%	58%	82.8%	2.08E-05	4.97E-04	5.63E-03	3.19E-05
5D2	Wastewater Treatment and Discharge Industrial Wastewater	CH_4	32.3056	17.1843	39%	58%	70.0%	7.11E-06	3.57E-03	2.56E-03	1.93E-05

	IPCC Category	Gas	1990 emissions [kt CO_2e]	2020 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 [%]
1A1aiii	Public electricity and heat production (electricity generation)	N_2O	0.0100	0.0043	5%	100%	100.1%	9.05E-13	2.17E-06	8.25E-08	4.73E-12
1A1ai	Public electricity and heat production (heat plants)	N_2O	0.0216	0.0000	5%	100%	100.1%	0.00E+00	7.21E-06	0.00E+00	5.20E-11
1A2a	Iron and Steel	N_2O	0.0009	0.0019	2%	100%	100.0%	1.80E-13	2.35E-07	1.11E-08	5.52E-14
1A2b	Non-Ferrous Metals	N_2O	0.0290	0.0135	2%	100%	100.0%	8.90E-12	6.01E-06	7.77E-08	3.61E-11
1A2c	Chemicals	N_2O	0.0172	0.0000	5%	100%	100.1%	0.00E+00	5.74E-06	0.00E+00	3.29E-11
1A2e	Food Processing, Beverages and Tobacco	N_2O	0.2964	0.0525	5%	100%	100.1%	1.36E-10	8.47E-05	1.01E-06	7.18E-09
1A2f	Non-metallic minerals	N_2O	0.2191	0.0010	5%	100%	100.1%	4.74E-14	7.29E-05	1.89E-08	5.32E-09
1A2g	Other manufacturing industries and Constructions	N_2O	0.0953	1.3737	5%	100%	100.1%	9.30E-08	3.42E-04	2.64E-05	1.18E-07
1A3a	Domestic Aviation	N_2O	0.2788	0.1097	5%	200%	200.1%	2.37E-09	1.27E-04	2.11E-06	1.60E-08
1A3b	Road Transport	N_2O	5.2570	7.1613	5%	188%	188.0%	8.91E-06	3.62E-04	1.38E-04	1.50E-07
1A3d	Domestic Water - borne Navigation	N_2O	0.2590	0.1998	5%	200%	200.1%	7.86E-09	6.42E-05	3.85E-06	4.14E-09
1A3e	Mobile machinery – other	N_2O	13.9193	2.4560	5%	250%	250.0%	1.85E-06	9.95E-03	4.73E-05	9.91E-05
1A4a	Commercial/Institutional	N_2O	0.0149	0.0046	5%	100%	100.1%	1.06E-12	3.73E-06	8.92E-08	1.39E-11
1A4b	Residential	N_2O	0.0678	0.0066	5%	100%	100.1%	2.13E-12	2.09E-05	1.27E-07	4.36E-10
1A4c	Agriculture/Fishing	N_2O	6.0513	6.8097	5%	200%	200.1%	9.12E-06	3.36E-04	1.31E-04	1.30E-07
1A5a	Other - stationary	N_2O	0.0003	0.0013	5%	100%	100.1%	7.85E-14	2.49E-07	2.43E-08	6.27E-14
1B2a5	Oil - Distribution of oil products	N_2O	0.0000	0.0000	5%	0%	5.0%	1.23E-21	0.00E+00	6.10E-11	3.72E-21
2B5	Other: Fertilizer production	N_2O	46.4880	0.0000	5%	40%	40.3%	0.00E+00	6.21E-03	0.00E+00	3.86E-05
2G3a	N2O from Product Uses: Medical Applications	N_2O	5.2976	2.0709	6%	5%	7.8%	1.29E-09	6.03E-05	4.80E-05	5.94E-09
2G3b	N2O from Product Uses: Other	N_2O	0.7183	0.4671	6%	5%	7.8%	6.57E-11	5.64E-06	1.08E-05	1.49E-10
2G4tob	Other: Tobacco	N_2O	0.0107	0.0046	2%	50%	50.0%	2.63E-13	1.16E-06	3.56E-08	1.34E-12
2G4fw	Other: Fireworks	N_2O	0.0657	0.2848	2%	50%	50.0%	9.98E-10	2.78E-05	2.19E-06	7.77E-10
3B1	Manure Management: Cattle	N_2O	0.7360	0.7433	11%	100%	100.6%	2.75E-08	4.36E-05	3.20E-05	2.92E-09
3B2	Manure Management: Sheep	N_2O	11.0859	8.0231	25%	100%	103.2%	3.37E-06	1.52E-03	7.87E-04	2.93E-06
3B25	Manure Management: Indirect	N_2O	9.2474	8.0216	100%	400%	412.3%	5.38E-05	3.62E-03	3.09E-03	2.27E-05
3B3	Manure Management: Swine	N_2O	0.0000	0.0000	11%	100%	100.6%	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3B4	Manure Management: Other Livestock	N_2O	1.1811	1.0323	24%	200%	201.4%	2.13E-07	2.27E-04	9.53E-05	6.07E-08

	IPCC Category	Gas	1990 emissions [kt CO_2e]	2020 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 [%]
3D1.1	Inorganic N fertilizers	N_2O	58.4140	53.4220	5%	233%	233.4%	7.64E-04	1.16E-02	1.03E-03	1.36E-04
3D1.2	Animal manure applied to soils	N_2O	38.1112	31.8497	63%	233%	241.6%	2.91E-04	9.48E-03	7.70E-03	1.49E-04
3D1.3	Urine and dung deposited by grazing animals	N_2O	47.8573	41.1973	57%	233%	240.1%	4.81E-04	1.11E-02	9.00E-03	2.05E-04
3D1.4	Crop residues	N_2O	0.0680	0.0707	100%	233%	253.9%	1.58E-09	8.15E-06	2.72E-05	8.06E-10
3D1.6	Cultivation of organic soils (i.e. histosols)	N_2O	61.0848	83.3470	20%	200%	201.0%	1.38E-03	4.55E-03	6.42E-03	6.19E-05
3D2.1	Atmospheric deposition	N_2O	11.3561	10.2725	100%	400%	412.3%	8.82E-05	3.99E-03	3.95E-03	3.16E-05
3D2.2	Nitrogen leaching and run-off	N_2O	31.6059	27.3644	100%	500%	509.9%	9.57E-04	1.56E-02	1.05E-02	3.53E-04
5B	Biological Treatment of Solid Waste	N_2O	0.00000	2.22043	52%	150%	158.7%	7.38E-07	9.96E-04	4.88E-04	1.23E-06
5C	Incineration and Open Burning of Waste	N_2O	1.6740	0.2217	52%	100%	112.7%	3.07E-09	4.99E-04	4.43E-05	2.51E-07
5D1	Wastewater Treatment and Discharge Domestic Wastewater	N_2O	4.5814	6.0396	59%	2495 %	2495.7%	1.12E-03	2.82E-03	1.37E-03	9.85E-06
5D2	Wastewater Treatment and Discharge Industrial Wastewater	N_2O	0.0000	0.0000	39%	2495 %	2495.3%	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2F1	Refrigeration and Air Conditioning	HFC	0.0000	196.8272	100%	35%	106.1%	2.14E-03	1.90E-02	7.58E-02	6.10E-03
2F4	Aerosols	HFC	0.3441	0.8776	5%	5%	7.1%	1.89E-10	6.19E-06	1.69E-05	3.24E-10
2C3	Metal Production - Aluminium Production	PFC	494.6416	95.5772	2%	15%	15.1%	1.02E-05	2.09E-02	5.52E-04	4.35E-04
2F1	Refrigeration and Air Conditioning	PFC	0.0000	0.0670	100%	35%	106.1%	2.48E-10	6.47E-06	2.58E-05	7.06E-10
2G1	Electrical Equipment	SF_6	1.09640	3.15480	30%	30%	42.4%	8.81E-08	1.48E-04	3.64E-04	1.54E-07
	Total emissions		3674.5	4509.7							
	Total Uncertainties		% Uncertainty in total inventory (excluding LULUCF):					**9.2%**		Trend uncertainty:	**10.0%**

Annex 3: National Energy Balance for the year 2020

The Icelandic energy balance is compiled by the Environment Agency using data from the National Energy Authority and Statistics Iceland. 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 Statistics Iceland. 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 approach is 869 TJ, which is 4.2% of the total energy consumption in Iceland in 2020. 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 2020

2020 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	-	-	-	-	-	-	-	-	-	-	-	-	78	78
Imports	3,872	3,690	16,571	6	126	1,004	143	242	40.7	3,285	482	587	-	30,049
Exports	-	-	-	-	-	-	-	-	-	-	-	-	-	0
International Bunkers	-	3,655	1,039	-	-	-	-	-	-	-	-	-	-	4,694
Stock Change	-285	-155	-638	-24	1	-	-	-	-	-	-	-	-	-1,101
Primary Energy Supply	4,157	190	16,170	29	125	1,004	143	242	41	3,285	482	587	78	26,533
Non-Energy Use of Fuels						1,004	143	242	41	3,285	482	0		5,196
Available Final Energy Consumption	**4,157**	**190**	**16,170**	**29**	**125**	**0**	**0**	**0**	**0**	**0**	**0**	**587**	**78**	**21,337**
1A1ai - Electricity generation	-	-	24	-	-	-	-	-	-	-	-	-	-	24
1A1aiii - Heat Plants	-	-	-	-	-	-	-	-	-	-	-	-	-	0
1A2a - Iron and Steel	-	-	9	-	10	-	-	-	-	-	-	-	-	19
1A2b - Non-ferrous Metals	-	-	73	-	11	-	-	-	-	-	-	-	-	84
1A2e - Food processing, beverages and tobacco	-	-	144	64	-	-	-	-	-	-	-	-	-	209
1A2f - Non-metallic minerals (mineral wool)	-	-	5	-	-	-	-	-	-	-	-	-	-	5
1A2gvii - Off-road vehicles and mobile machinery	-	-	159	-	-	-	-	-	-	-	-	-	-	159
1A2gviii - Other industry	-	-	91	-	27	-	-	-	-	-	-	-	-	118
1A3a - Domestic Aviation	8.56	175	-	-	-	-	-	-	-	-	-	-	-	184
1A3b - Road Transport	4,020	-	7,185	-	-	-	-	-	-	-	-	649	73	11,927
1A3d - Domestic Navigation	-	-	335	-	-	-	-	-	-	-	-	-	-	335
1A3eii - Other Mobile machinery	-	14	274	-	-	-	-	-	-	-	-	-	-	289
1A4ai - Commercial/Institutional - Stationary combustion	-	-	23	-	19	-	-	-	-	-	-	-	-	42
1A4bi - Residential - Stationary combustion	-	-	28	-	52	-	-	-	-	-	-	-	-	80
1A4ci - Stationary Agriculture	-	-	-	-	0.4	-	-	-	-	-	-	-	-	0
1A4cii Off Road in agriculture	-	-	324	-	-	-	-	-	-	-	-	-	-	324
1A4ciii - Fishing	-	-	6,791	-	-	-	-	-	-	-	-	2	-	6,793
1A5 - Other	-	1	4	-	-	-	-	-	-	-	-	1	6	12
Final Energy Consumption	**4,029**	**191**	**15,471**	**64**	**119**	**0**	**0**	**0**	**0**	**0**	**0**	**652**	**78**	**20,605**
Statistical Differences	-128	1	-699	35	-6	0	0	0	0	0	0	65	1	869
Difference (%)	-3.1%	0.5%	-4.3%	118%	-4.5%							11.0%	0.8%	4.2%

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.

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]**
GHG emissions (total emissions without LULUCF for GHG inventory and without emissions from 1A3a Civil aviation, total emissions from installations under Article 3h of Directive 2003/87/EC)	Total GHG	4496.5	1780.1	39.6%	
CO_2 emissions (total CO_2 emissions without LULUCF for GHG inventory and without emissions from 1A3a Civil aviation, total emissions from installations under Article 3h of Directive 2003/87/EC)	CO_2	3315.7	1684.5	50.8%	

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	1459.0	7.9	0.5%	
1.A Fuel combustion activities, stationary combustion [4]	CO_2	48.3	7.9	16.3%	
1.A.1 Energy industries	CO_2	1.8	NO		Not verified emissions under Directive 2003/87/EC
1.A.1.a Public electricity and heat production	CO_2	1.8	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) [5]	CO_2	416.6	416.6	100.0%	
1.A.2. Manufacturing industries and construction	CO_2	43.6	7.9	18.1%	
1.A.2.a Iron and steel	CO_2	1.3	1.3	100.3%	Differencess due to slightly different NCV values used by ETS companies vs. inventory
1.A.2.b Non-ferrous metals	CO_2	6.1	6.2	100.8%	Differencess 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	15.6	0.39	2.5%	One company is included in ETS, others are not
1.A.2.f Non-metallic minerals	CO_2	0.4062	NO		Not verified emissions under Directive 2003/87/EC
1.A.2.g Other	CO_2	20.2	0.030	0.1%	One company is included in ETS, others are not
1.A.3. Transport	CO_2	876.4	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	536.9	NO		Not verified emissions under Directive 2003/87/EC
1.A.4.a Commercial / Institutional	CO_2	2.9	NO		Not verified emissions under Directive 2003/87/EC
1.A.4.c Agriculture/ Forestry / Fisheries	CO_2	528.6	NO		Not verified emissions under Directive 2003/87/EC
1.B Fugitive emissions from Fuels	CO_2	174.9	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	1676.6	1676.6	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	415.3	415.3	100.0%	
2.C.3 Aluminium production	CO_2	1261.3	1261.3	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	NA	Does not occur in Iceland
2.B.3. Adipic acid production	N_2O	NO	NO	NA	Does not occur in Iceland
2.B.4. Caprolactam, glyoxal and glyoxylic acid production	N2O	NO	NO	NA	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	95.6	95.6	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 CRF 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. Member States should add a short explanation when using IE or other notation keys to ensure transparency.

[3] Data to be reported up to one decimal point for kt and % values

[4] 1.A Fuel combustion, stationary combustion should include the sum total of the relevant rows below for 1.A (without double counting) plus the addition of other stationary combustion emissions not explicitly included in any of the rows below.

[5] To be filled on the basis of combined CRF categories pertaining to 'Iron and Steel', to be determined individually by each Member State; e.g. (1.A.2.a+ 2.C.1 + 1.A.1.c and other relevant CRF categories that include emissions from iron and steel (e.g. 1A1a, 1B1))

Annex 5: Status of implementation of recommendations from most recent EU review report

As described in Chapter 10.2, in 2021 the Icelandic inventory underwent the yearly "EU step 1 review checks"[31].

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 (525/2013) can form the basis for the determination of the ESD emissions (Effort Sharing Decision No 406/2009/EC).

Table A5. 1 Responses to recommendations listed in the review report resulting from the EU Step 1 review.

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
1 Energy	Question: This is a generic question to all countries. At the last WG1 meeting on 4 November 2020 the reporting of biogas in the gas network by ETS installations and in the GHG inventory was briefly addressed. A breakout group was set up in order to discuss this issue further. In the context of the current step 1 checks of GHG inventories it is of interest (1) if upgraded biogas is fed into the natural gas networks in the Member States and (2) if – where relevant - Member States report CO2 emissions from this biogas as a memo item. As you know - according to the UNFCCC reporting guidelines - CO2 emissions from the use of biogas should be reported as memo item in the GHG inventories; these emissions should not be included in the national totals. Note that the energy balances include the amount of biogas supply in the balance for "gas" under "Receipts from other sources - renewables". Therefore our questions: Do you have upgraded biogas blended with natural gas in your countries' gas networks? If yes, do you report the related CO2 emissions from biogas under memo items in the current inventory? We are aware that in many countries biogas in natural gas networks might be either not occurring or very small. However, as this is a generic question to all Member States, we flag this as a potential significant issue for the time being because in some Member States the amount of biogas used might be above the threshold of significance.	IS-1-2021-0001	Answer: Iceland only has bio-gas in the natural gas network. Therefore, there is no mixing of natural gas and bio-gas for the fuel industry in Iceland. Furthermore, Iceland reports CO2 emissions from bio-gas as memo item, as noted in the comment.	
1A2e Food processing, beverages and tobacco	Question: For subcategory 1.A.2.e (Liquid Fuels), the TERT noted that the CO2 IEF increased by 40.02 t/TJ compared to year 2018. Applied CO2 IEF equals to 115.75 t/TJ in 2019. Could you please explain the increase of the CO2 IEF in 2019 for this subcategory? Please note that applied IEF is above the IPCC higher default value (77.40 t/TJ) and that the applied IEF is the highest among the member states IEFs for this subcategory and also	IS-1A2e-2021-0001	Answer: Thank you for this comment. This was an error in our calculation files with the activity data but had no effect on the emissions. This has been fixed.	

[31] cf. Art. 29, Commission Implementing Regulation (EU) 749/2014

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
	that the IEF is the highest for years 1990 – 2019 in Icelandic inventory. Note that if this issue is not clarified this could trigger a technical correction. Therefore, the TERT considers this to be a potential significant issue. You may also wish to provide evidence in case you consider that the corresponding emissions are below the threshold of significance.			
1A4 Other sectors (fuel combustion activities)	Question: For category 1.A.4, the TERT noted that Iceland has carried out recalculations for the year 2018 and that 'Article8 table' and the NIR does not include a specific explanation. Please provide an explanation for the recalculations and include the explanation also into the following submission ('Article8 table' and the NIR).	IS-1A4-2021-0001	Answer: This recalculation was due to revised data by the NEA. This information was included in the NIR and Article8 table in the 15. march 2021 submission.	
1A3a Domestic aviation	Question: Based on IPCC guidelines, emissions from military aviation should be reported under category 1A5b Other Mobile and not under category 1A3a. Could you please explain under which category emissions from military aviation are reported in the CRF?	IS-1A3a-2021-0001	Answer: As there is not military in Iceland, emissions from military aviation are not occurring. This information has been added to the NIR.	Section 3.3.2
2F1 Refrigeration and air conditioning	Question: Product life factors are assumed to be stable throughout the last years. However, the introduction on legislation in Iceland mentions that Regulation No 834/2010 was to a large extent an implementation of regulation (EC) No 842/2006 as dictated by the EEA agreement. Hence it would contain requirements on certification of technicians, containment and recovery. Have these requirements resulted in improved containment and recovery practices? Has it been possible to reflect these aspects in the inventory? Question: Thanks for clarifying. I understand that the emission estimates reported for disposal emissions and the amounts for recovery are fully based on assumptions? Please confirm.	IS-2F1-2021-0001	Answer: We have not been able to obtain data on recovery amounts and therefor have not been able to reflect these aspects in the inventory. Answer: Although the regulation No. 834/2010 is the implementation of regulation (EC) No. 842/2006, now repealed by regulation No 1066/2019 which implemented the Regulation (EU) No 517/2014, it was not possible to obtain reliable recovery data from the end-users of F-gases. While the import data is strictly controlled and checked (once from Customs, once from the Chemical Team of the Environment Agency) data on the recovery of such gases are more difficult to retrieve. When gases are recovered, they are not split by blends and it is not possible to determine from which subcategory of 2F1 they are collected. Therefore, a strictly mathematical model is applied: a) the lifetime of the appliances using F-gases in the different subcategories is estimated based on the default values proposed in Table 7.9 Vol. 3, Ch. 7 of the 2006 IPCC Guidelines and	NA

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
			reported in Table 4.9 of the 2021 NIR of Iceland. b) recovery is calculated as the difference between the amount remaining in products at decomissioning (=at the end of the lifetime) minus disposal emissions using recovery percentages from the ranges given in Table 7.9 Vol. 3, Ch. 7 of the 2006 IPCC Guidelines. For some categories, such as MACs, research has shown that there is no recovery, therefore the recovery efficiency is set to 0% (see table 4.9 of the 2021 NIR). So to answer your question, yes, disposal emissions and amounts for recovery are still based on assumptions even though research is carried out in order to confirm these assumptions.	
2F1 Refrigeration and air conditioning	Question: Emissions from 2.F.1.d dropped sharply from 2016 and 2017 to 2018 and then increased again in 2019. Would you be able to provide further details on this recent development? In our understanding, the use of alternatives to high-GWP HFCs (R513A and R452A) in becoming increasingly common, also in reefers, and leak rates decreased on ships as stated in the NIR (p.92). Since transport refrigeration represents the most relevant 2.F. subcategory, this is considered as a potential significant issue.	IS-2F1-2021-0002	Answer: As can be seen in figure 4.4 in the NIR, a unusually high amount of F-gases was imported to Iceland in 2012 and most of those imports were allocated to 2.F.1.d. We assume a lifetime of 7 years of equipment in fishing vessels and a 70% recovery efficiency (see table 4.9 in NIR). Therefore, imported blends in 2012 are decommissioned 7 years later, increasing the total emissions in 2019 compared to 2018.	NA
3B Manure management	Question: NO was reported in category 3.B.2.3 for swine considering a liquid system. Indeed, the default EF for liquid systems without natural crust cover was equal to 0. However, in the NIR 2020, an EF of 0.01 N2O-N for liquid storage was reported (Table 5.28 of NIR 2020). Please check the inconsistency and provide information if correct data will be included in the 15. March submission.	IS-3B-2021-0001	Answer: In the NIR 2021 the emission factors are reported in table 5.26 and the emission factor for N2=-N storage for piglets and sows is 0 for liquid systems which explains the NO emissions. I attach the current NIR 2021 for reference.	Chapter 5.5.3
3F Field burning of agricultural residues	Question: Please provide information if correct data will be included in the 15. March submission.	IS-3F-2021-0001	Answer: Thank you for pointing out the missing notation keys, they will be added for the 15. March submission.	NA

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
4 Land use, land-use change and forestry	Question: The EU has repeatedly received from the UN ERT the recommendation to work with its MSs, UK and Iceland towards the harmonization of the use of the notation keys. This recommendation has been included in the last four annual review reports and applies equally to the LULUCF reporting under the Convention and under the KP. Specifically, the ERT recommends the use of the notation key "NA" to report carbon stock changes from carbon pools where carbon stock changes are neutral (i.e. where net emissions are equal to net removals) for instance this is the case when the IPCC tier 1 assumption of equilibrium for certain carbon pools and land use categories is applied. With the aim to comply with the UN ERT recommendation, could you please check this issue, and use the notation key "NA" in the CRF tables for reporting pools that are considered in "equilibrium" in terms of carbon stock changes in your inventory?	IS-4-2021-0002	Answer: This issue has been resolved	
4 Land use, land-use change and forestry	Question: Please note that "final" and "total" areas for each of the land use categories as reported in CRF table 4.1 and 4.A-4.F are expected to be the same. Iceland reports in CRF table 4.1 differences for the years 1990-2019 with areas reported in CRF tables 4.A-4.F. These differences are then translated into the EU CRF tables and have been subject to a recommendation from the UN ERT of the EU GHG inventory that we have to address. Could you please check this issue for March submission to ensure the consistency of the information among the tables?	IS-4-2021-0001	Answer: This issue has been resolved for Forest land (managed/unmanaged), Cropland and Grassland (managed/unmanaged). For Wetlands (unmanaged)the issue has been resolved for all the years except for the 1990. For Wetland (managed) and Other land the issue is not resolved and it is included in planned improvements.	
4A Forest land	Question: Please note that CRF table 4.A includes empty cells for the information on carbon stock changes in SOC mineral under the category 4.A.1 in row 13. Could you please correct this issue for next submission?	IS-4A-2021-0001	Answer: This was a typo and has now been corrected	
4B Cropland	Question: Please note that CRF table 4.AB includes empty cells for the information on carbon stock changes in DOM under the categories 4.B.2.2-4.B.2.5. Could you please correct this issue for next submission in March?	IS-4B-2021-0001	Answer: The issue regarding "empty cells for the information on carbon stock changes in DOM under the categories 4.B.2.2-4.B.2.5" has been corrected	
4B Cropland	Question: Please note that the same information has been provided on activity data and carbon stock changes for the category 4.B .2 for the years 2019-2018-2017. Could you please check this issue for next submission and provide an explanation on why the information provided is the same, or if relevant update the estimates for these years? Question: Thank you very much for your reply and information. We also understand	IS-4B-2021-0002	Answer: Before 1990 transition of wetlands to cropland and grassland to cropland were subsidized, therefore for the years before 1990 data of land transition are available. Due to policy changes after 1990 there are no longer comparable historical	

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
	the lack of data. However could you please comment on how the projection from data since 1900 is implemented. We see that starting from 1990 the areas and emissions in 4.B.2 decrease, but we do not understand how the values from 1990 are used to fill in each year.		records since 1990. The information provided on activity data and CSCs for the category 4.B.2 are, therefore, a projection of data available before 1990. Improvements are difficult but considered for future submissions. Answer: Thank you for your question. As it was explained in our previous answer dated 08 Feb 2021, all the transitions of wetlands areas to cropland and grassland areas to cropland were subsidized before 1990. Due to policy changes after 1990 there are no longer comparable historical records since 1990. However, according to experts judgement, it was estimated that about 5000 ha of land will be converted into new cultivated areas over a period of 19 years (1990-2019). That is 5000 ha / 19 years which gives an average of 263 ha per year. The total annual area of land converted to Cropland (263 ha/yr) was then divided proportionally between areas of Wetlands converted to Cropland and areas of Grassland converted to Cropland (the ratio was estimated by experts judgment). From 2010 to 2019 estimation of land converted to Cropland are based on extrapolation.	
5A Solid waste disposal	Question: The TERT noted for CH4 emissions from 5A1 - Solid waste disposal (managed SWDS) that emissions in 2019 are 17% lower than in 2018. This outlier (-28,6 kt CO2eq) is above the threshold of significance. Could you please explain the emissions evolution between 2018 and 2019?	IS-5A-2021-0001	Answer: The reason for this dip is that compared to 2018 in 2019 there is a) a decrease in annual waste sent to landfills (from 185 kt to 171 kt, - 14 kt) and b) an increase of methane recovered, from 1.5 kt in 2018 to 2.8 in 2019 (+ 1.3 kt). Of these two factor, factor b) has a higher impact and a calculation shows that when assuming the same methane recovery as in 2018, we would obtain CH4 emissions of 6.8 kt, which are in line with the emissions reported for 2018. The amount of methane recovered is communicated by two companies operating the landfills in which methane recovery occurs.	Chapter 7.2.4 in 2022 NIR

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
5B Biological treatment of solid waste	Question: 2020 Reference number: IS-5B-2020-0001 The TERT noted in CRF table 5B, cell C9 to D10, that the CH4 and N20 Implied Emission Factors (IEF) correspond to the default values proposed in the 2006 IPCC Guidelines expressed on a wet basis. However, in the CRF table, Activity Data (AD) should be expressed on a dry basis and, therefore, the IEF should correspond to the default values expressed on a dry basis (10 g CH4/kg of waste on a dry basis and 0,6 g N2O/kg of waste on a dry basis). In response to a question raised during the 2020 ESD review, you indicated that it will be corrected in the 2021 submission. Can you, please, report the correct value in the March 2021 submission? This observation has no impact on emissions and deals with the transparency of the CRF tables.	IS-5B-2021-0001	Answer: Thank you for pointing this out. We obtain the amounts send to composting on a wet basis and we back calculated now the dry weight amount based on the ratio between the wet and dry emission factors provided in the IPCC guidelines. The updated AD will be included in CRF now, the emissions are not changing.	Chapter 7.3.2 in 2022 NIR
5C Incineration and open burning of waste	Question: The TERT noted that in CRF 5C2 - Open burning of waste, CO2,CH4 and N2O emissions, activity data and IEFs reported for year 2019 are identical to the values reported for year 2018. Could you please explain why the reported values are identical for 2019 and 2018 ?	IS-5C-2021-0001	Answer: As stated in chapter 7.4 of the NIR "the only emissions currently arising from 5C2 are from new year´s eve bonfires. In 2010 an estimate was made by the Environment Agency of the amount and type of material burnt at these bonfires. This was done 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 Environment Agency, 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."	Chapter 7.4.2.2 in 2022 NIR

CRF category/ issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section
7 KP LULUCF	Question: Please note that the table NIR-3 lacks the information on KC analysis. We are aware that the lack of this information (for some MS) was in the past due to some bugs in the CRF Reporter. We also note the explanation provided by Iceland last year on this issue. Therefore, the only remark is: please ensure that the information on KC is included in the NIR in next submission?	IS-7-2021-0001	Answer: Yes, this is indeed due to an issue with the CRF reporter. The KC information is included in the NIR, p.305, table 11.4, section 11.7.	
7 KP LULUCF	Question: Total area at the end of the current inventory year reported in CRF table NIR-2 for KP activities should match total area of the relevant activity reported in CRF table 4(KP-I)A.1/B.5. For the year 2019, Iceland reports differences in the areas in CRF tables NIR-2 and 4(KP-I)B.4 that are then translated into the EU CRF tables. These differences although small are subject to a recommendation from the UN ERT of the EU GHG inventory that we have to address. Could you please check this issue for March submission to ensure the consistency of the information among the tables?	IS-7-2021-0002	Answer: This issue has been resolved	

Annex 6: Reporting on consistency of F gases

The provisions put forth in Article 7(1)(m)(ii) of Regulation (EU) No 525/2013 stipulates that data reported pursuant to Article 6(1) of Regulation (EC) No 842/2006 should be used to check the consistency of the data used to estimate emissions. This is not applicable in Iceland as Article 6 of Regulation (EC) No 842/2006 was excluded upon the incorporation of the regulation into the EEA Agreement as stated in Articles 1 and 2 of the Decision of the EEA Joint Committee No 112/2008 of 7 November 2008

Annex 7: Values used in Calculation of Digestible Energy of Cattle and Sheep Feed

Table A7. 1 Values used in Calculation of Digestible Energy of Feed: Mature Dairy Cattle

1. Dairy cattle, stallfed, lactation period[32],[33]		1990-2012	2018-
Hay	Feed intake [kg/day]	10	10
Barley	Feed intake [kg/day]	3	0.3
pulp	Feed intake [kg/day]	0.7	/
concentrate	Feed intake [kg/day]	2.5	5.1
Hay	Dry matter digestibility [%]	72	76
Barley	Dry matter digestibility [%]	86	86
pulp	Dry matter digestibility [%]	67	65
concentrate	Dry matter digestibility [%]	85	85
Hay	Ash content [%]	7	7.4
Barley	Ash content [%]	3.00	3.00
pulp	Ash content [%]	4	3.5
concentrate	Ash content [%]	8	9
	Crude protein content (of dry matter) [%]	/	16
	Crude protein content (of dry matter) [%]	/	12
	Crude protein content (of dry matter) [%]	/	21.5
	Weighted average dry matter digestibility [%]	76.4	79.2
	Weighted average ash content [%]	6.3	7.8
	Weighted average CP [%]	/	16.6
	Time in feeding situation [days]	230	230
2. Dairy cattle, stallfed, non-lactation		**1990-2012**	**2018-**
Hay	Feed intake [kg/day]	12	9
Concentrate	Feed intake [kg/day]	/	0.5
Hay	Dry matter digestibility [%]	68	70
Concentrate	Dry matter digestibility [%]	/	85
Hay	Ash content [%]	8	7.5
Concentrate	Ash content [%]	/	9.00
Hay	Crude protein content (of dry matter) [%]	/	13.7
Concentrate	Crude protein content (of dry matter) [%]	/	18
	Weighted average dry matter digestibility [%]	68	70.79
	Weighted average ash content [%]	8.00	7.58
	Weighted average CP [%]	/	13.9
	Time in feeding situation [days]	35	35
3. Dairy cattle, pasture, lactation period		**1990-2012**	**2018-**
Hay	Feed intake [kg/day]	12	11.5
Concentrate	Feed intake [kg/day]	3	4.5
Hay	Dry matter digestibility [%]	70	77
Concentrate	Dry matter digestibility [%]	85	85

[32] Þungi og átgeta íslenskra mjólkurkúa (Sveinbjörnsson & Harðarson, 2008).

[33] NorFor- the Nordic feed evaluation system (Volden, 2011).

Hay	Ash content [%]	8	7.4
Concentrate	Ash content [%]	8.00	9.00
Hay	Crude protein content (of dry matter) [%]	/	18
Concentrate	Crude protein content (of dry matter) [%]	/	18
	Weighted average dry matter digestibility [%]	73	79.25
	Weighted average ash content [%]	8.00	7.85
	Weighted average CP [%]	/	18
	Time in feeding situation [days]	75	75
4. Dairy cattle, pasture, non-lactation		**1990-2012**	**2018-**
Hay	Feed intake [kg/day]	14	10
Hay	Dry matter digestibility [%]	70	72
Hay	Ash content [%]	8	7.5
Hay	Crude protein content (of dry matter) [%]	/	13.7
	Weighted average dry matter digestibility [%]	70	72
	Weighted average ash content [%]	8.00	7.50
	Weighted average CP [%]	/	13.7
	Time in feeding situation [days]	25	25

Conversion of dry matter digestibility to digestible energy % of gross energy intake after Guðmundsson and Eiríksson (1995)	**1990-2012**	**2018-**
Digestible organic matter per kg of dry matter	681.5771	715.37184
Metabolizable energy per gram dry matter	15	15
Metabolizable energy per kg dry matter	10223.657	10730.578
Ratio of metabolizable to digestible energy	0.81	0.81
Digestible energy per kg dry matter	12621.798	13247.627
Gross energy per kg dry matter	18500	18500
Digestible % of gross energy intake	68.225936	71.608793

Table A7. 2 Values used in Calculation of Digestible Energy of Feed: Cows Used for Producing Meat

1. Cows used for prod. meat, stallfed[34]	Amount/day [kg dm]	Dry matter digestibility [%]	Ash [%]
Hay	10.0	70.0	7.0
Sum	10.0		
Average		70.0	7.0
2. Cows used for prod. meat, pasture3	**Amount/day [kg dm]**	**Dry matter digestibility [%]**	**Ash [%]**
Hay	4.0	70.0	7.0
Pasture	6.0	80.0	7.0
Sum	10.0		
Average		76.0	7.0
Duration of periods	**Days for periods**	**Dry matter digestibility [%]**	**Ash [%]**
1. Cows used for prod. meat, stallfed	100.0		
2. Cows used for prod. meat, pasture	265.0		
Annual average	10.0	74.4	7.0

Table A7. 3 Values used in Calculation of Digestible Energy of Feed: Heifers

1. Heifers, stallfed3,[35]	Amount/day [kg dm]	Dry matter digestibility [%]	Ash [%]
Hay	5.0	70.0	7.0
Concentrate	1.0	85.0	8.0
Sum	6.0		
Average		72.5	7.2
2. Heifers, pasture	**Amount/day [kg dm]**	**Dry matter digestibility [%]**	**Ash [%]**
Hay	1.0	70.0	7.0
Pasture	5.0	80.0	7.0
Sum	6.0		
Average		78.3	7.0
Duration of periods	**Days for periods**	**Dry matter digestibility [%]**	**Ash [%]**
1. Heifers, stallfed	245.0		
2. Heifers, pasture	120.0		
annual average	6.0	74.4	7.1

[34] Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi (Sveinbjörnsson & Ólafsson, 1999).
[35] NorFor- the Nordic feed evaluation system (Volden, 2011).

Table A7. 4 Values used in Calculation of Digestible Energy of Feed: Steers

1. Steers[36] ,[37]	Amount/day [kg dm]	Dry matter digestibility [%]	Ash [%]
Hay	5.0	70.0	7.0
Concentrate	1.0	85.0	8.0
Sum	6.0		
Average		72.5	7.2
Duration of periods	**Days for periods**	**Dry matter digestibility [%]**	**Ash [%]**
1. Steers	365.0		
Annual average	6.0	72.5	7.2

Table A7. 5 Values used in Calculation of Digestible Energy of Feed: Calves

1. Calves, first 90 days[38]	Amount/day [kg dm]	Dry matter digestibility [%]	Ash [%]
Milk/formula	1.0	93.0	9.0
Concentrate	0.2	82.0	8.0
Hay	0.1	75.0	7.0
Sum	1.3		
Average		89.9	8.7
2. Calves, days 91-365	**Amount/day [kg dm]**	**Dry matter digestibility [%]**	**Ash [%]**
Hay	2.0	75.0	7.0
Concentrate	0.5	82.0	8.0
Sum	2.5		
Average		76.4	7.2
Duration of periods	**Days for periods**	**Dry matter digestibility [%]**	**Ash [%]**
1. Calves, first 90 days	90.0		
2. Calves, days 91-365	275.0		
Annual average	2.2	79.7	7.6

[36] Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi (Sveinbjörnsson & Ólafsson, 1999).
[37] NorFor- the Nordic feed evaluation system (Volden, 2011).
[38] Uppeldi kálfa: Áhrif kjarnfóðurs með mismiklu tréni á vöxt og heilbrigði kálfa (Harðarson, Þórkelsson, & Sveinbjörnsson, 2007).

Table A7. 6 Values used in Calculation of Digestible Energy of Feed: Sheep

1. Sheep, stallfed[39]	**Amount/day [kg dm]**	**Dry matter digestibility [%]**	**Ash [%]**
Hay	1.6	68.0	7.0
Concentrate	0.0	85.0	8.0
Sum	1.6		
Average		68.2	7.0
2. Sheep, pasture[40]	**Amount/day [kg dm]**	**Dry matter digestibility [%]**	**Ash [%]**
Pasture	1.5	80.0	7.0
Hay	0.5	75.0	7.0
Sum	2.0		
Average		78.8	7.0
3. Sheep, range[41]	**Amount/day [kg dm]**	**Dry matter digestibility [%]**	**Ash [%]**
Gras/vegetation	1.8	70.0	7.0
Sum	1.8		
Average		70.0	7.0
Duration of periods	**Amount/day [kg dm]**	**Dry matter digestibility [%]**	**Ash [%]**
1. Sheep, stallfed	200.0		
2. Sheep, pasture	60.0		
3. Sheep, range	105.0		
Annual average	1.7	70.5	7.0

Table A7. 7 Values used in Calculation of Digestible Energy of Feed: Lambs

1. Lambs, pre-weaning[42],[43]	**Amount/day [kg dm]**	**Dry matter digestibility [%]**	**Ash [%]**
Gras/vegetation	0.4	70.0	7.0
Milk	0.3	95.0	5.1
Sum	0.7		
Average		79.9	6.2

[39] Fóðrun og fóðurþarfir sauðfjár (Sveinbjörnsson J. , 2013).
[40] Fóðuröflun og beit á ræktað land (Sveinbjörnsson J. , 2013).
[41] Átgeta búfjár og nýting beitar (Guðmundsson Ó. , 1987).
[42] Átgeta búfjár og nýting beitar (Guðmundsson Ó. , 1987).
[43] Winterfeeding, housing and management (Thorsteinsson & Thorgeirsson, 1989).

2. Lambs, after-weaning[44],12	Amount/day [kg dm]	Dry matter digestibility [%]	Ash [%]
Gras/vegetation	0.5	75.0	8.0
Rape/rye grass etc.	0.3	83.0	9.0
Milk	0.2	95.0	5.1
Sum	1.0		
Average		81.1	7.8
Duration of periods	**Days for periods**	**Dry matter digestibility [%]**	**Ash [%]**
1. Lambs, pre-weaning	60.0		
2. Lambs, after-weaning	80.0		
Annual average	0.3	83.5	7.4

Table A7. 8 Conversion of DMD into DE

	Dry matter digestibility	Organic matter digestibility	Metabo-lizable energy	Metabo-lizality	Net energy for lactation	Net energy of 1 kg barley	Digestible energy
	DMD	OMD	BO	q	NOm	FEm	DE
	[%]	[g/kg]	[kJ/kg dm]		[kj/kg]		[%]
Calculations	cf. A-G	(0.98*DMD-4.8)*10	15*OMD	BO/18500*100	0.6*(1+0.004*(q-57))*0.9752 *BO	NOm/6900	OMD*15/0.81/18.5/10
Mature dairy cows	74.4	681.6	10,224	55.3	5,941	0.861	68.2
Cows used for producing meat	74.4	680.7	10,210	55.2	5,931	0.860	68.1
Heifers	74.4	681.3	10,219	55.2	5,937	0.861	68.2
Steers used for producing meat	72.5	662.5	9,938	53.7	5,738	0.832	66.3
Young cattle	79.7	733.4	11,001	59.5	6,500	0.942	73.4
Sheep	70.5	642.5	9,637	52.1	5,528	0.801	64.3
Lambs	83.5	770.7	11,561	62.5	6,913	1.002	77.2

[44] Fóðuröflun og beit á ræktað land (Sveinbjörnsson J. , 2013).

Annex 8: Justification of use of country-specific N_2O emission factor for cultivation of organic soils (histosols)

As mentioned in Chapter 5.7 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_20 emission from cultivation of organic soils (i.e. 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, Iceland, 2002; Thordarson & Larsen, 2007). Volcanic eruptions defined as the ejection of magma, gas or rocks, are frequent and occur approximately every 5 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). These soils 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 characterized 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 ($(Al_2O_3)(SiO_2)1.3\bullet 2.5(H_2O)$), Imogolite ($Al_2SiO_3(OH)_4$), Ferrihydrite ($Fe^{3+}2O_3\bullet 0.5(H_2O)$) and Halloysite ($Al_2Si_2O_5(OH)_4$)[45]. 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 and this division is influenced by 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 and other overall properties (Arnalds O. , 2015). The aeolian input in Iceland is not

[45] all empirical formulas from http://webmineral.com

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 A9. 1). Andosols are divided into **Histic Andosols** comprising mostly wetlands with some drylands covered with rich heathlands, birch forests and grasslands far from aeolian sources, **Gleyic Andosols**, characterized by a carbon level below 12% due to increased aeolian deposition, by strong andic properties with 10-20% of allophane and ferrihydrite content. Gleyic Andosols can be found in wetlands while **Brown Andosols** are the soils of vegetated drylands and show many tephra layers and intermediate amounts of aeolian addition (Arnalds O. , 2015).

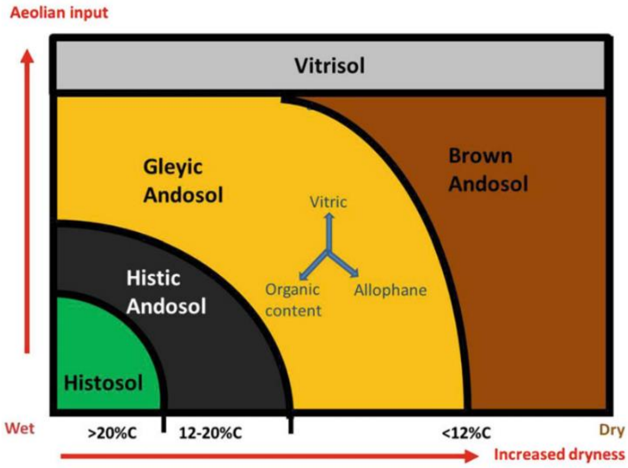

Figure A8. 1 Classification of Icelandic Andosols together with Vitrisols (soils of the desert) and Histosols (wetland soils), determined by the aeolian input and the drainage conditions. The amount of soil carbon is also given, separating Histosols (20%) from Andosols, (Arnalds O. , 2015).

The third main soil type in the Icelandic classification system is Histosol, characterized 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 A9. 1.

Table A8. 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)

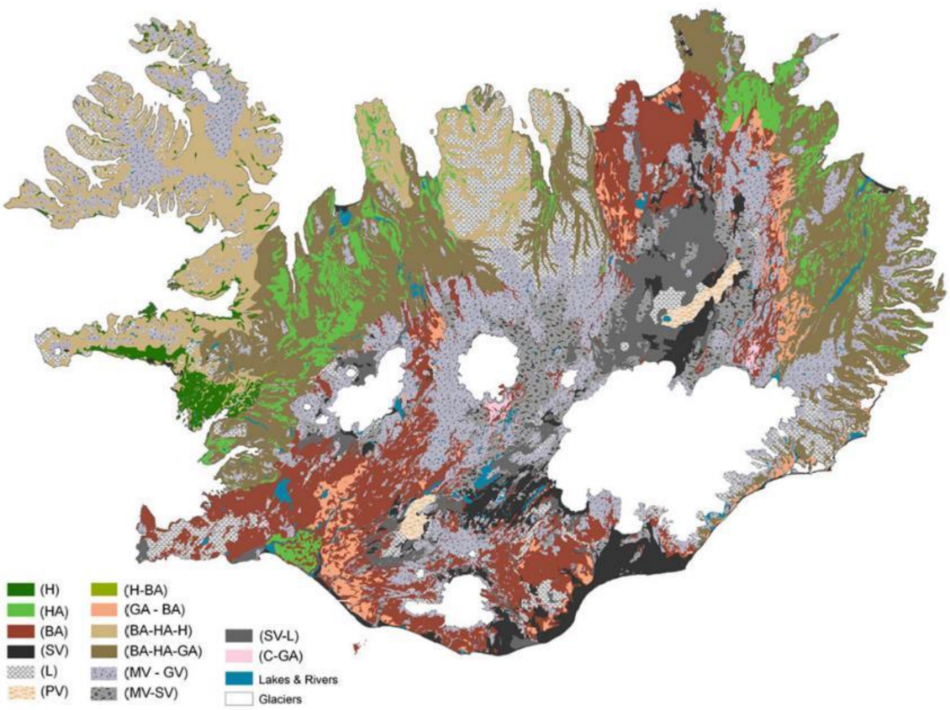

Figure A8. 2 General soil map of Iceland (Arnalds O. , 2015), based on (Arnalds & Óskarsson, 2009). H: Histosol, HA: Histic Andosol, GA: Gleyic Andosol, BA: Brown Andosol, MV: Cambic Vitrisol, GV: Gravelly Vitrisol, SV: Sandy Vitrisol, PV: Pumice Vitrisol, L: Leptosol, C: Cryosol

Cultivation of Organic Soils in Iceland

According to the IPCC 2006 Guidelines, Volume 4 (AFOLU), Chapter 11[46], soils are organic if they satisfy 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 A9. 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, Histic Andosols and Histosols are mainly found in wetland areas in Iceland and their extension is relatively small as can be seen from Figure A9. 2

[46] 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 A9. 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).

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 A9. 4 shows a close up of such a 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 Cryosols (permafrost), the Icelandic wetland soils are characterized by Andosols and small areas of Histosols which are also influenced by volcanic input through aeolian deposition (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016).

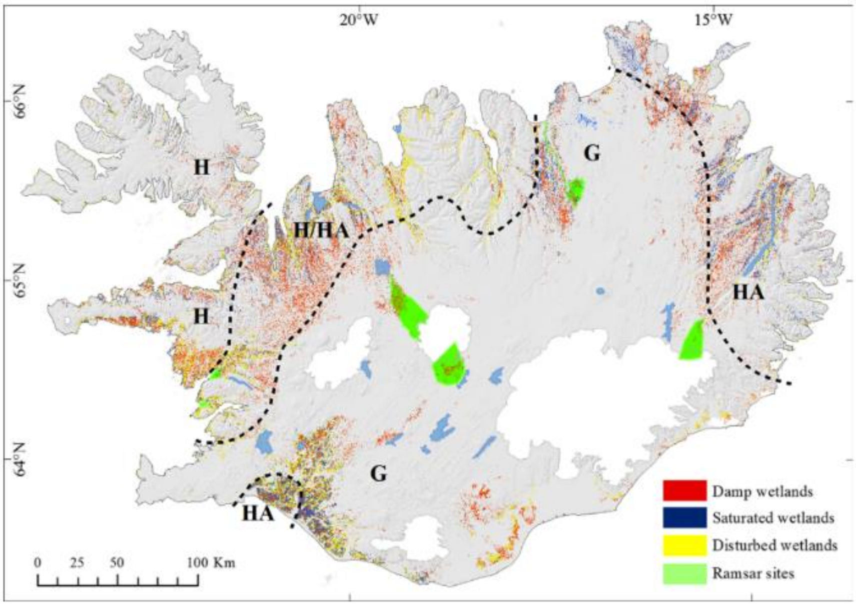

Figure A8. 3 Inland wetlands in Iceland. H: Histosols, HA: Histic Andosols, G: Gleyic Andosols. In green the Ramsar sites are shown. Large water bodies are light blue, in white are the main glaciers (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016).

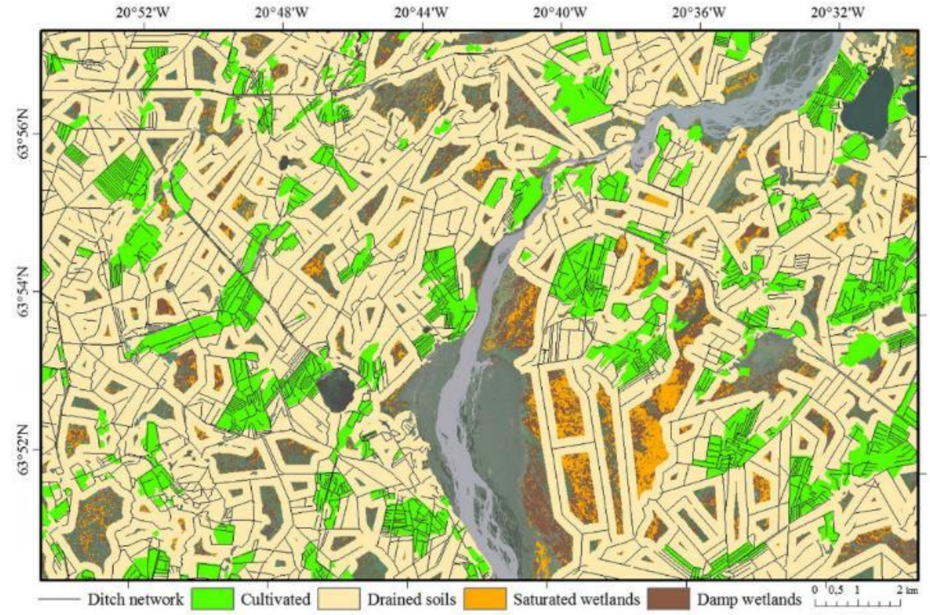

Figure A8. 4 South Iceland, close to the river Þjórsá. The black lines show the system of ditches created to drain the wetlands. Of the drained soils, only the green patches are cultivated as hay fields (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016).

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[47] 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 from the Agricultural University of Iceland over a period of three years comprising 9 measurement sites with three different land management types of organic soils: undrained land, drained but not cultivated land and drained, cultivated and fertilized (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 A9. 2 and Table A9. 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 over the year with more measurements carried out during the summertime. Therefore, the measurements have been weighted considering the number of measurements per month.

[47] IPCC 2006 Guidelines, Volume 4, Agriculture, Forestry and Other Land Use.

Table A8. 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 N2O ha^{-1} day^{-1}	kg N2O_N ha^{-1} yr^{-1}
Undrained	0.45	10.34	209	0.72	23.18	0.11	0.02
Drained non 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 A8. 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	4207.10
							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 phosphorous P and copper 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 A9. 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)[48]. 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 analyzed data are summarised in Table 1 of the study and reported here in Table A9. 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 favors 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 modeling has shown that this predominant iron 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, Hu, Zhao, Kuzyakov, & Liu, 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 iron, a consequence of the aeolian input of volcanic parent material.

[48] 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 A8. 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) -CI- and a drained field (not used for agriculture or forestry)-DI.

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).

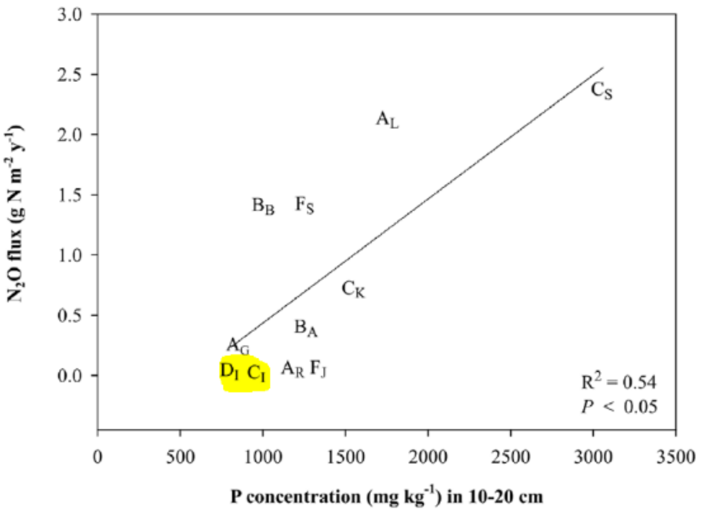

Fig. 4. Correlation between N_2O emissions ($g\ N\ m^{-2}\ y^{-1}$) *in situ* and the content of total P ($mg\ kg^{-1}$) in soil at the depth of 10–20 cm.

Figure A8. 5 Correlation between N_2O emissions in situ and total P content. Icelandic study sites are highlighted, comprising a cultivated field (hayfield) -CI- and a drained field (not used for agriculture or forestry) – DI. (Liimatainen, et al., 2018).

Annex 9: Input data for managed and unmanaged SWDS for the IPCC First Order Decay Model (5A1, 5A2)

A.9 1 Parameters used in the IPCC First Order Decay Model for Iceland, Managed and Unmanaged SWDS

Managed SWDS (5A1)			Unmanaged SWDS (5A2)		
	DOC	Methane generation rate constant (k)		DOC	Methane 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	0.1195	0.09		0.04	0.09
DOCf	0.5		DOCf	0.5	
Delay time	6		Delay time	6	
Fraction of methane (F) in developed gas	0.5		Fraction of methane (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	

A.9 2 Amounts Deposited in Managed Solid Waste Disposal Sites (SWDS, 5A1)

Year	Population	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industrial	Recovery
	millions	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]
1950	0.141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1951	0.144	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1952	0.147	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1953	0.149	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1954	0.153	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1955	0.156	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1956	0.159	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1957	0.163	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1958	0.167	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1959	0.170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1960	0.174	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1961	0.177	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1962	0.181	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1963	0.184	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1964	0.187	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1965	0.191	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1966	0.194	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1967	0.197	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1968	0.200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1969	0.203	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1970	0.204	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1971	0.205	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
1972	0.207	5.2	0.4	1.7	0.4	0.3	0.0	0.2	3.0	0.7	NO
1973	0.211	5.7	0.5	2.0	0.4	0.3	0.0	0.2	3.4	0.8	NO
1974	0.214	5.7	0.5	2.0	0.5	0.3	0.0	0.2	3.5	0.8	NO
1975	0.217	5.5	0.4	2.0	0.4	0.3	0.0	0.2	3.5	0.8	NO
1976	0.219	5.9	0.5	2.2	0.5	0.4	0.0	0.3	3.8	0.8	NO
1977	0.221	6.6	0.5	2.5	0.5	0.4	0.0	0.3	4.4	0.9	NO
1978	0.223	6.9	0.6	2.7	0.6	0.4	0.0	0.3	4.7	1.0	NO
1979	0.225	6.9	0.6	2.8	0.6	0.4	0.0	0.3	4.8	1.0	NO
1980	0.227	7.2	0.6	3.0	0.6	0.5	0.0	0.3	5.1	1.1	NO
1981	0.229	7.1	0.6	3.1	0.6	0.5	0.1	0.3	5.4	1.1	NO
1982	0.232	6.9	0.6	3.2	0.6	0.5	0.2	0.3	5.7	1.1	NO
1983	0.236	6.3	0.6	3.2	0.6	0.5	0.2	0.3	5.7	1.1	NO
1984	0.238	6.2	0.6	3.3	0.6	0.5	0.3	0.3	6.0	1.1	NO

Year	Population	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industrial	Recovery
1985	0.241	6.1	0.7	3.4	0.7	0.5	0.4	0.3	6.4	1.1	NO
1986	0.242	6.3	0.7	3.8	0.7	0.5	0.5	0.4	7.1	1.2	NO
1987	0.244	6.5	0.8	4.2	0.8	0.6	0.7	0.4	7.9	1.3	NO
1988	0.248	6.0	0.8	4.2	0.8	0.6	0.8	0.4	8.1	1.3	NO
1989	0.252	5.6	0.8	4.2	0.8	0.6	0.8	0.4	8.2	1.3	NO
1990	0.254	7.2	1.0	5.8	1.0	0.8	1.3	0.5	11.5	1.8	NO
1991	0.256	62.2	9.0	50.2	8.9	6.8	11.1	4.7	99.4	15.4	NO
1992	0.260	60.9	8.9	49.1	8.8	6.6	10.8	4.6	97.3	15.0	NO
1993	0.262	61.2	8.9	49.4	8.8	6.6	10.9	4.6	97.8	15.1	NO
1994	0.265	63.4	9.2	51.1	9.1	6.9	11.3	4.8	101.3	15.6	NO
1995	0.267	60.8	8.8	49.1	8.7	6.6	10.8	4.6	97.1	15.0	NO
1996	0.268	62.0	9.0	50.1	8.9	6.7	11.0	4.7	99.1	15.3	0.2
1997	0.270	63.5	9.2	51.2	9.1	6.9	11.3	4.8	101.4	15.7	0.3
1998	0.272	66.8	9.7	53.9	9.6	7.3	11.9	5.1	106.7	16.5	0.4
1999	0.276	68.0	9.9	54.9	9.8	7.4	12.1	5.1	108.7	16.8	0.4
2000	0.279	70.7	10.3	57.0	10.2	7.7	12.6	5.3	112.9	17.4	0.5
2001	0.283	70.2	10.2	56.7	10.1	7.6	12.5	5.3	112.3	17.3	0.5
2002	0.287	69.5	10.1	56.1	10.0	7.6	12.4	5.3	111.1	17.2	0.8
2003	0.288	71.1	10.3	57.4	10.2	7.7	12.6	5.4	113.6	17.5	1.0
2004	0.291	71.1	10.3	57.4	10.2	7.7	12.6	5.4	113.7	17.6	1.0
2005	0.294	66.4	9.7	53.6	9.5	7.2	11.8	5.0	106.1	16.4	1.7
2006	0.300	58.9	8.6	47.6	8.5	6.4	10.5	4.5	94.2	14.5	0.5
2007	0.308	32.7	12.1	39.8	13.1	5.8	7.1	5.0	61.8	19.5	0.7
2008	0.315	43.1	2.7	44.6	6.5	7.1	8.2	3.1	69.3	1.6	0.9
2009	0.319	40.1	2.0	17.2	4.8	7.1	9.0	2.8	52.4	1.2	1.1
2010	0.318	32.1	1.2	25.6	1.5	2.5	8.6	1.8	46.6	0.2	0.7
2011	0.318	46.5	1.6	25.7	2.3	3.1	8.7	1.9	29.7	4.1	1.2
2012	0.320	51.4	4.5	23.1	2.7	2.8	7.3	1.6	36.4	2.2	2.1
2013	0.322	63.6	4.5	9.3	3.6	3.7	9.5	2.0	36.1	0.8	1.4
2014	0.326	62.2	0.8	13.5	1.2	3.3	8.2	2.2	37.6	4.1	1.4
2015	0.329	66.2	2.4	13.6	3.5	4.5	8.2	2.9	39.4	2.4	1.4
2016	0.333	68.7	2.4	17.3	5.1	5.8	8.6	2.5	44.4	3.7	1.6
2017	0.338	61.6	0.0	36.9	17.9	5.5	3.3	2.4	47.9	4.5	1.8
2018	0.348	52.0	0.0	40.8	19.9	5.1	4.3	2.4	54.3	6.3	1.5
2019	0.357	54.2	0.7	28.5	31.6	4.1	6.8	1.3	38.6	5.2	2.9

A.9 3 Amounts Deposited in Unmanaged Solid Waste Disposal Sites (SWDS, 5A2)

Year	Population	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industrial
	millions	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]
1950	0.1	29.2	1.8	5.0	1.8	1.3	0.0	0.9	9.9	3.0
1951	0.1	27.8	1.7	4.9	1.7	1.3	0.0	0.9	9.6	2.9
1952	0.1	27.4	1.7	5.0	1.7	1.3	0.0	0.9	9.8	2.9
1953	0.1	31.9	2.0	6.0	2.0	1.5	0.0	1.0	11.7	3.4
1954	0.2	35.0	2.2	6.8	2.2	1.7	0.0	1.2	13.1	3.8
1955	0.2	38.2	2.5	7.7	2.4	1.8	0.0	1.3	14.7	4.2
1956	0.2	38.4	2.5	8.0	2.5	1.9	0.0	1.3	15.2	4.2
1957	0.2	37.7	2.5	8.1	2.5	1.9	0.0	1.3	15.3	4.2
1958	0.2	41.2	2.7	9.1	2.7	2.0	0.0	1.4	17.1	4.6
1959	0.2	41.8	2.8	9.5	2.8	2.1	0.0	1.5	17.8	4.8
1960	0.2	41.9	2.8	9.9	2.8	2.1	0.0	1.5	18.3	4.8
1961	0.2	42.9	2.9	10.4	2.9	2.2	0.0	1.5	19.2	5.0
1962	0.2	46.1	3.2	11.5	3.2	2.4	0.0	1.7	21.2	5.4
1963	0.2	50.2	3.5	12.9	3.5	2.6	0.0	1.8	23.6	6.0
1964	0.2	55.4	3.9	14.7	3.9	2.9	0.0	2.0	26.7	6.7
1965	0.2	60.3	4.3	16.5	4.3	3.2	0.0	2.3	29.8	7.3
1966	0.2	64.5	4.7	18.2	4.6	3.5	0.0	2.4	32.7	8.0
1967	0.2	61.3	4.5	17.8	4.5	3.4	0.0	2.3	31.8	7.6
1968	0.2	57.2	4.3	17.1	4.2	3.2	0.0	2.2	30.5	7.2
1969	0.2	58.0	4.4	17.9	4.3	3.3	0.0	2.3	31.6	7.4
1970	0.2	63.7	4.9	20.2	4.8	3.6	0.0	2.5	35.6	8.2
1971	0.2	71.8	5.5	23.4	5.5	4.1	0.0	2.9	41.2	9.4
1972	0.2	72.2	5.6	24.3	5.6	4.2	0.0	2.9	42.4	9.6
1973	0.2	78.4	6.2	27.1	6.1	4.6	0.0	3.2	47.2	10.5
1974	0.2	78.5	6.3	27.9	6.2	4.7	0.0	3.3	48.5	10.7
1975	0.2	74.0	6.0	27.1	5.9	4.5	0.0	3.1	46.8	10.2
1976	0.2	78.6	6.5	29.6	6.4	4.8	0.0	3.4	51.0	11.0
1977	0.2	85.3	7.1	33.0	7.0	5.3	0.0	3.7	56.7	12.1
1978	0.2	88.3	7.5	35.2	7.4	5.6	0.0	3.9	60.2	12.7
1979	0.2	88.2	7.5	36.1	7.5	5.6	0.0	3.9	61.6	12.8
1980	0.2	90.0	7.8	37.9	7.7	5.8	0.0	4.1	64.4	13.3
1981	0.2	90.5	8.2	40.3	8.1	6.1	1.0	4.3	69.8	13.9
1982	0.2	88.8	8.4	41.9	8.3	6.3	2.0	4.4	73.8	14.2
1983	0.2	82.7	8.2	41.4	8.1	6.1	3.0	4.2	74.1	13.9
1984	0.2	82.5	8.5	43.8	8.4	6.4	4.2	4.4	79.8	14.5

Year	Population	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industrial
1985	0.2	81.6	8.9	46.1	8.8	6.6	5.4	4.6	85.3	15.1
1986	0.2	84.7	9.7	51.1	9.6	7.2	7.1	5.0	96.0	16.5
1987	0.2	88.5	10.7	57.2	10.6	8.0	9.2	5.6	108.8	18.2
1988	0.2	83.6	10.7	58.0	10.6	8.0	10.5	5.6	111.9	18.2
1989	0.3	78.2	10.6	58.4	10.5	8.0	11.7	5.5	114.1	18.1
1990	0.3	72.3	10.5	58.4	10.4	7.9	12.9	5.5	115.6	17.9
1991	0.3	18.5	2.7	14.9	2.7	2.0	3.3	1.4	29.5	4.6
1992	0.3	17.8	2.6	14.4	2.6	1.9	3.2	1.3	28.5	4.4
1993	0.3	17.7	2.6	14.3	2.5	1.9	3.1	1.3	28.3	4.4
1994	0.3	18.0	2.6	14.5	2.6	2.0	3.2	1.4	28.8	4.5
1995	0.3	12.2	1.8	9.8	1.8	1.3	2.2	0.9	19.5	3.0
1996	0.3	11.4	1.7	9.2	1.6	1.2	2.0	0.9	18.2	2.8
1997	0.3	11.4	1.7	9.2	1.6	1.2	2.0	0.9	18.2	2.8
1998	0.3	8.7	1.3	7.0	1.3	0.9	1.6	0.7	13.9	2.2
1999	0.3	8.7	1.3	7.0	1.2	0.9	1.5	0.7	13.8	2.1
2000	0.3	8.8	1.3	7.1	1.3	1.0	1.6	0.7	14.1	2.2
2001	0.3	8.5	1.2	6.9	1.2	0.9	1.5	0.6	13.6	2.1
2002	0.3	8.3	1.2	6.7	1.2	0.9	1.5	0.6	13.3	2.1
2003	0.3	8.4	1.2	6.8	1.2	0.9	1.5	0.6	13.4	2.1
2004	0.3	8.3	1.2	6.7	1.2	0.9	1.5	0.6	13.3	2.1
2005	0.3	14.0	2.0	11.3	2.0	1.5	2.5	1.1	22.4	3.5
2006	0.3	12.4	1.8	10.0	1.8	1.3	2.2	0.9	19.8	3.1
2007	0.3	11.9	0.7	3.3	0.3	0.3	0.6	0.1	13.5	1.3
2008	0.3	16.0	10.0	5.8	1.1	0.8	1.0	3.5	28.5	4.9
2009	0.3	14.2	4.6	2.1	0.5	0.7	1.1	1.2	16.9	3.7
2010	0.3	11.7	2.3	2.9	0.9	0.5	1.0	0.5	21.9	2.9
2011	0.3	14.2	2.7	3.2	0.8	0.5	1.1	0.7	9.3	3.8
2012	0.3	13.0	0.2	2.4	1.7	0.4	0.8	0.9	10.7	1.6
2013	0.3	11.4	0.8	1.0	1.2	0.5	1.0	1.0	6.9	2.1
2014	0.3	5.6	0.1	0.8	0.3	0.2	0.5	0.4	37.0	0.9
2015	0.3	5.0	0.3	1.0	0.3	0.3	0.6	0.3	43.9	1.1
2016	0.3	3.9	0.1	1.0	0.5	0.3	0.5	0.2	48.9	1.3
2017	0.3	3.1	0.0	1.6	0.9	0.2	0.1	0.4	20.5	1.5
2018	0.3	3.1	0.0	2.0	1.1	0.2	0.2	1.1	22.6	1.2
2019	0.4	3.3	0.1	1.6	9.4	0.2	0.4	1.0	29.4	2.3

Annex 10: CRF (Common Reporting Format) Summary 2 Tables for 1990-2020

1990

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2022 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)	7975.10	4045.85	356.32	0.34	494.64	1.10	NO,NA	NO,NA	12873.35
1. Energy	1800.29	8.73	26.54						1835.56
A. Fuel combustion (sectoral approach)	1738.93	8.05	26.54						1773.51
1. Energy industries	13.48	0.01	0.03						13.53
2. Manufacturing industries and construction	237.47	0.31	0.66						238.43
3. Transport	698.64	5.83	19.71						724.19
4. Other sectors	789.22	1.90	6.13						797.25
5. Other	0.12	0.00	0.00						0.12
B. Fugitive emissions from fuels	61.36	0.68	NO,NA						62.04
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	61.36	0.68	NA,NO						62.04
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	407.76	1.62	52.58	0.34	494.64	1.10	NO,NA	NO,NA	958.03
A. Mineral industry	52.26								52.26
B. Chemical industry	0.36	NO,NA	46.49	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	46.85
C. Metal industry	348.01	1.57	NO	NO	494.64	NO	NO	NO	844.22
D. Non-energy products from fuels and solvent use	7.13	NA	NA						7.13
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				0.34	NO	NO	NO	NO	0.34
G. Other product manufacture and use	0.00	0.05	6.09		NO	1.10			7.24
H. Other	NA	NA	NA						NA
3. Agriculture	0.52	390.26	270.75						661.53
A. Enteric fermentation		326.31							326.31
B. Manure management		63.95	22.25						86.20
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	248.50						248.50
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.46								0.46
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry (1)	5759.25	3439.43	0.19						9198.87
A. Forest land	-30.16	0.11	0.12						-29.94
B. Cropland	1884.40	94.83	NO,NA						1979.23
C. Grassland	5001.40	374.02	0.07						5375.50
D. Wetlands	-1118.24	2970.47	NO,NA						1852.24
E. Settlements	21.84	NE,NA	NO,NE,IE,NA						21.84
F. Other land	NA	NA	NA						NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	7.30	205.81	6.26						219.36
A. Solid waste disposal	NO,NA	149.73							149.73
B. Biological treatment of solid waste		NO,NA	NO,NA						NO,NA
C. Incineration and open burning of waste	7.30	6.09	1.67						15.06
D. Waste water treatment and discharge		50.00	4.58						54.58
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	247.25	0.10	2.05						249.41
Aviation	219.44	0.04	1.83						221.31
Navigation	27.81	0.07	0.22						28.10
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,IE,NA								NO,IE,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									3674.48
Total CO_2 equivalent emissions with land use, land-use change and forestry									12873.35
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 2022 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)]	7859.91	4044.53	348.85	0.69	410.61	1.24	NO,NA	NO,NA	12665.84
1. Energy	1715.48	8.62	25.82						1749.92
A. Fuel combustion (sectoral approach)	1645.53	8.02	25.82						1679.37
1. Energy industries	15.08	0.01	0.04						15.13
2. Manufacturing industries and construction	166.50	0.23	0.48						167.21
3. Transport	699.68	5.95	19.38						725.01
4. Other sectors	764.13	1.83	5.93						771.89
5. Other	0.14	0.00	0.00						0.14
B. Fugitive emissions from fuels	69.95	0.59	NO,NA						70.54
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	69.95	0.59	NA,NO						70.54
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	373.35	1.31	50.54	0.69	410.61	1.24	NO,NA	NO,NA	837.74
A. Mineral industry	48.63								48.63
B. Chemical industry	0.31	NO,NA	45.00	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	45.31
C. Metal industry	317.42	1.26	NO	NO	410.61	NO	NO	NO	729.29
D. Non-energy products from fuels and solvent use	6.98	NA	NA						6.98
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				0.69	NO	NO	NO	NO	0.69
G. Other product manufacture and use	0.00	0.05	5.54		NO	1.24			6.83
H. Other	NA	NA	NA						NA
3. Agriculture	0.24	378.80	265.97						645.01
A. Enteric fermentation		316.85							316.85
B. Manure management		61.95	21.20						83.16
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	244.76						244.76
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.18								0.18
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5763.60	3442.14	0.25						9205.99
A. Forest land	-31.59	0.15	0.17						-31.27
B. Cropland	1884.47	94.81	NO,NA						1979.28
C. Grassland	5000.24	374.38	0.08						5374.70
D. Wetlands	-1111.34	2972.79	NO,NA						1861.45
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NA	NA	NA						NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	7.24	213.67	6.28						227.18
A. Solid waste disposal	NO,NA	154.75							154.75
B. Biological treatment of solid waste		NO,NA	NO,NA						NO,NA
C. Incineration and open burning of waste	7.24	6.04	1.66						14.94
D. Waste water treatment and discharge		52.87	4.62						57.49
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	0.07	1.96						237.67
Aviation	221.77	0.04	1.85						223.66
Navigation	13.87	0.03	0.11						14.01
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,IE,NA								NO,IE,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									3459.85
Total CO_2 equivalent emissions with land use, land-use change and forestry									12665.84
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.

1992

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1992
Submission 2022 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)]	7998.60	4049.45	334.18	0.70	183.04	1.24	NO,NA	NO,NA	12567.21
1. Energy	1858.39	8.91	26.14						1893.44
A. Fuel combustion (sectoral approach)	1790.77	8.26	26.14						1825.17
1. Energy industries	14.08	0.01	0.03						14.13
2. Manufacturing industries and construction	229.65	0.27	0.60						230.52
3. Transport	703.76	5.96	18.95						728.66
4. Other sectors	842.49	2.01	6.56						851.06
5. Other	0.79	0.00	0.00						0.80
B. Fugitive emissions from fuels	67.62	0.65	NO,NA						68.27
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	67.62	0.65	NA,NO						68.27
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	376.61	1.41	45.22	0.70	183.04	1.24	NO,NA	NO,NA	608.23
A. Mineral industry	45.67								45.67
B. Chemical industry	0.25	NO,NA	40.23	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	40.48
C. Metal industry	323.55	1.36	NO	NO	183.04	NO	NO	NO	507.94
D. Non-energy products from fuels and solvent use	7.14	NA	NA						7.14
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				0.70	NO	NO	NO	NO	0.70
G. Other product manufacture and use	0.01	0.05	4.99		NO	1.24			6.29
H. Other	NA	NA	NA						NA
3. Agriculture	0.56	371.38	256.19						628.12
A. Enteric fermentation		313.01							313.01
B. Manure management		58.36	20.04						78.41
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	236.14						236.14
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.50								0.50
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5756.00	3441.50	0.31						9197.81
A. Forest land	-36.23	0.21	0.23						-35.79
B. Cropland	1883.91	94.80	NO,NA						1978.71
C. Grassland	4997.44	374.74	0.08						5372.26
D. Wetlands	-1110.95	2971.76	NO,NA						1860.81
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NA	NA	NA						NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	7.04	226.25	6.32						239.61
A. Solid waste disposal	NO,NA	168.15							168.15
B. Biological treatment of solid waste		NO,NA	NO,NA						NO,NA
C. Incineration and open burning of waste	7.04	5.90	1.62						14.56
D. Waste water treatment and discharge		52.20	4.70						56.90
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	0.08	1.86						225.64
Aviation	203.42	0.04	1.70						205.15
Navigation	20.28	0.05	0.16						20.49
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,IE,NA								NO,IE,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									3369.40
Total CO_2 equivalent emissions with land use, land-use change and forestry									12567.21
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 2022 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)]	8143.03	4063.22	342.77	1.58	88.24	1.24	NO,NA	NO,NA	12640.08
1. Energy	1961.43	8.88	28.19						1998.50
A. Fuel combustion (sectoral approach)	1876.05	8.22	28.19						1912.46
1. Energy industries	14.44	0.03	0.10						14.57
2. Manufacturing industries and construction	248.33	0.30	0.65						249.27
3. Transport	714.08	5.75	20.41						740.24
4. Other sectors	897.77	2.14	7.03						906.94
5. Other	1.44	0.00	0.00						1.44
B. Fugitive emissions from fuels	85.38	0.66	NO,NA						86.03
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	85.38	0.66	NA,NO						86.03
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	425.56	1.73	47.23	1.58	88.24	1.24	NO,NA	NO,NA	565.58
A. Mineral industry	39.65								39.65
B. Chemical industry	0.24	NO,NA	42.32	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	42.56
C. Metal industry	378.27	1.68	NO	NO	88.24	NO	NO	NO	468.20
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				1.58	NO	NO	NO	NO	1.58
G. Other product manufacture and use	0.01	0.04	4.91		NO	1.24			6.20
H. Other	NA	NA	NA						NA
3. Agriculture	0.50	371.03	260.87						632.40
A. Enteric fermentation		312.71							312.71
B. Manure management		58.32	20.13						78.45
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	240.74						240.74
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.44								0.44
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5749.55	3440.84	0.33						9190.72
A. Forest land	-41.39	0.22	0.24						-40.93
B. Cropland	1883.38	94.78	NO,NA						1978.16
C. Grassland	4996.29	375.10	0.08						5371.47
D. Wetlands	-1110.56	2970.74	NO,NA						1860.18
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NA	NA	NA						NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	6.00	240.75	6.15						252.90
A. Solid waste disposal	NO,NA	179.69							179.69
B. Biological treatment of solid waste		NO,NA	NO,NA						NO,NA
C. Incineration and open burning of waste	6.00	5.11	1.41						12.51
D. Waste water treatment and discharge		55.95	4.75						60.70
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	0.10	1.87						226.99
Aviation	195.45	0.03	1.63						197.11
Navigation	29.57	0.07	0.24						29.88
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									3449.37
Total CO_2 equivalent emissions with land use, land-use change and forestry									12640.08
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 2022 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)]	8087.95	4069.72	348.54	2.03	52.53	1.24	NO,NA	NO,NA	12562.01
1. Energy	1909.88	8.66	28.84						1947.38
A. Fuel combustion (sectoral approach)	1839.76	7.99	28.84						1876.60
1. Energy industries	14.30	0.03	0.09						14.43
2. Manufacturing industries and construction	227.84	0.27	0.60						228.72
3. Transport	716.94	5.58	21.25						743.78
4. Other sectors	880.57	2.10	6.89						889.57
5. Other	0.10	0.00	0.00						0.10
B. Fugitive emissions from fuels	70.12	0.67	NO,NA						70.79
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	70.12	0.67	NA,NO						70.79
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	426.66	1.70	47.09	2.03	52.53	1.24	NO,NA	NO,NA	531.25
A. Mineral industry	37.35								37.35
B. Chemical industry	0.35	NO,NA	42.61	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	42.97
C. Metal industry	381.64	1.65	NO	NO	52.53	NO	NO	NO	435.82
D. Non-energy products from fuels and solvent use	7.31	NA	NA						7.31
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				2.03	NO	NO	NO	NO	2.03
G. Other product manufacture and use	0.01	0.05	4.48		NO	1.24			5.77
H. Other	NA	NA	NA						NA
3. Agriculture	0.07	372.84	266.17						639.08
A. Enteric fermentation		315.19							315.19
B. Manure management		57.65	20.20						77.84
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	245.98						245.98
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.01								0.01
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5745.81	3439.70	0.35						9185.86
A. Forest land	-44.25	0.23	0.26						-43.76
B. Cropland	1882.87	94.76	NO,NA						1977.63
C. Grassland	4995.27	375.69	0.09						5371.05
D. Wetlands	-1109.90	2969.01	NO,NA						1859.11
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NA	NA	NA						NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	5.53	246.82	6.10						258.44
A. Solid waste disposal	NO,NA	190.34							190.34
B. Biological treatment of solid waste		NO,NA	NO,NA						NO,NA
C. Incineration and open burning of waste	5.53	4.74	1.30						11.57
D. Waste water treatment and discharge		51.74	4.79						56.53
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	0.12	2.05						249.23
Aviation	213.41	0.04	1.78						215.23
Navigation	33.65	0.08	0.27						34.00
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									3376.16
Total CO_2 equivalent emissions with land use, land-use change and forestry									12562.01
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 2022 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
	CO₂ equivalent (kt)								
Total (net emissions) [(1)]	8196.18	4067.80	343.27	3.43	69.36	1.24	NO,NA	NO,NA	12681.30
1. Energy	2010.57	8.57	33.53						2052.67
A. Fuel combustion (sectoral approach)	1928.33	7.88	33.53						1969.74
1. Energy industries	15.12	0.04	0.11						15.27
2. Manufacturing industries and construction	215.90	0.25	0.55						216.69
3. Transport	753.16	5.34	25.47						783.97
4. Other sectors	942.54	2.25	7.39						952.18
5. Other	1.62	0.00	0.00						1.63
B. Fugitive emissions from fuels	82.24	0.69	NO,NA						82.93
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	82.24	0.69	NA,NO						82.93
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	444.06	1.83	45.01	3.43	69.36	1.24	NO,NA	NO,NA	564.94
A. Mineral industry	37.84								37.84
B. Chemical industry	0.46	NO,NA	40.53	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	40.98
C. Metal industry	397.93	1.79	NO	NO	69.36	NO	NO	NO	469.08
D. Non-energy products from fuels and solvent use	7.83	NA	NA						7.83
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				3.43	NO	NO	NO	NO	3.43
G. Other product manufacture and use	0.01	0.05	4.48		NO	1.24			5.78
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	359.96	258.17						618.19
A. Enteric fermentation		303.23							303.23
B. Manure management		56.73	19.21						75.95
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	238.96						238.96
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.00								0.00
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5736.62	3438.11	0.39						9175.12
A. Forest land	-54.04	0.27	0.30						-53.47
B. Cropland	1882.33	94.75	NO,NA						1977.08
C. Grassland	4995.48	376.52	0.09						5372.09
D. Wetlands	-1108.98	2966.57	NO,NA						1857.59
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NA	NA	NA						NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	4.87	259.33	6.17						270.37
A. Solid waste disposal	NO,NA	201.09							201.09
B. Biological treatment of solid waste		0.20	0.14						0.34
C. Incineration and open burning of waste	4.87	4.23	1.16						10.27
D. Waste water treatment and discharge		53.80	4.86						58.66
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	0.05	1.99						241.30
Aviation	235.92	0.04	1.97						237.93
Navigation	3.33	0.01	0.03						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									3506.18
Total CO_2 equivalent emissions with land use, land-use change and forestry									12681.30
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 2022 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]	8247.29	4087.96	359.37	10.65	29.64	1.24	NO,NA	NO,NA	12736.16
1. Energy	2065.44	8.47	34.18						2108.09
A. Fuel combustion (sectoral approach)	1984.17	7.70	34.18						2026.05
1. Energy industries	12.14	0.05	0.13						12.31
2. Manufacturing industries and construction	262.88	0.28	0.65						263.81
3. Transport	739.49	5.05	25.82						770.36
4. Other sectors	969.28	2.32	7.58						979.18
5. Other	0.39	0.00	0.00						0.39
B. Fugitive emissions from fuels	81.27	0.78	NO,NA						82.04
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	81.27	0.78	NA,NO						82.04
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	443.42	1.86	52.29	10.65	29.64	1.24	NO,NA	NO,NA	539.11
A. Mineral industry	41.76								41.76
B. Chemical industry	0.40	NO,NA	47.38	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	47.78
C. Metal industry	393.47	1.81	NO	NO	29.64	NO	NO	NO	424.93
D. Non-energy products from fuels and solvent use	7.78	NA	NA						7.78
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				10.65	NO	NO	NO	NO	10.65
G. Other product manufacture and use	0.01	0.05	4.91		NO	1.24			6.20
H. Other	NA	NA	NA						NA
3. Agriculture	0.41	365.21	266.41						632.03
A. Enteric fermentation		307.86							307.86
B. Manure management		57.35	19.44						76.79
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	246.97						246.97
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.35								0.35
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[1]	5733.65	3438.53	0.41						9172.59
A. Forest land	-58.13	0.29	0.32						-57.52
B. Cropland	1881.78	94.73	NO,NA						1976.51
C. Grassland	4994.80	377.22	0.09						5372.12
D. Wetlands	-1106.63	2966.29	NO,NA						1859.65
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NA	NA	NA						NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	4.37	273.90	6.07						284.34
A. Solid waste disposal	NO,NA	204.96							204.96
B. Biological treatment of solid waste		0.20	0.14						0.34
C. Incineration and open burning of waste	4.37	3.83	1.05						9.25
D. Waste water treatment and discharge		64.92	4.87						69.79
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	0.09	2.41						292.76
Aviation	271.24	0.05	2.26						273.55
Navigation	19.02	0.05	0.15						19.21
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									3563.57
Total CO_2 equivalent emissions with land use, land-use change and forestry									12736.16
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 2022 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)]	8344.14	4089.25	353.49	16.89	97.08	1.24	NO,NA	NO,NA	12902.08
1. Energy	2101.99	8.24	38.42						2148.65
A. Fuel combustion (sectoral approach)	2035.14	7.44	38.42						2081.00
1. Energy industries	7.01	0.04	0.12						7.17
2. Manufacturing industries and construction	301.02	0.34	0.76						302.11
3. Transport	780.41	4.80	30.08						815.30
4. Other sectors	946.66	2.26	7.46						956.39
5. Other	0.04	0.00	0.00						0.04
B. Fugitive emissions from fuels	66.85	0.80	NO,NA						67.65
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	66.85	0.80	NA,NO						67.65
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	502.63	1.83	44.44	16.89	97.08	1.24	NO,NA	NO,NA	664.12
A. Mineral industry	46.52								46.52
B. Chemical industry	0.44	NO,NA	39.51	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	39.95
C. Metal industry	448.00	1.79	NO	NO	97.08	NO	NO	NO	546.87
D. Non-energy products from fuels and solvent use	7.67	NA	NA						7.67
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				16.89	NO	NO	NO	NO	16.89
G. Other product manufacture and use	0.01	0.05	4.93		NO	1.24			6.23
H. Other	NA	NA	NA						NA
3. Agriculture	0.76	361.72	264.13						626.61
A. Enteric fermentation		305.41							305.41
B. Manure management		56.31	19.51						75.82
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	244.62						244.62
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.69								0.69
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5734.55	3435.98	0.43						9170.96
A. Forest land	-65.04	0.30	0.34						-64.40
B. Cropland	1881.26	94.71	NO,NA						1975.97
C. Grassland	5001.63	378.57	0.10						5380.30
D. Wetlands	-1105.14	2962.40	NO,NA						1857.26
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NA	NA	NA						NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	4.21	281.48	6.06						291.74
A. Solid waste disposal	NO,NA	208.76							208.76
B. Biological treatment of solid waste		0.20	0.14						0.34
C. Incineration and open burning of waste	4.21	3.67	1.01						8.89
D. Waste water treatment and discharge		68.85	4.91						73.76
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	0.14	2.74						332.83
Aviation	291.83	0.05	2.43						294.31
Navigation	38.12	0.09	0.31						38.51
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									3731.12
Total CO_2 equivalent emissions with land use, land-use change and forestry									12902.08
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 2022 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)	8369.61	4085.25	354.40	26.31	212.33	1.24	NO,NA	NO,NA	13049.15
1. Energy	2094.58	8.15	39.55						2142.28
A. Fuel combustion (sectoral approach)	2010.86	7.14	39.55						2057.55
1. Energy industries	9.04	0.04	0.12						9.20
2. Manufacturing industries and construction	271.86	0.32	0.71						272.89
3. Transport	785.50	4.52	31.34						821.36
4. Other sectors	939.48	2.25	7.36						949.09
5. Other	4.99	0.00	0.01						5.00
B. Fugitive emissions from fuels	83.72	1.01	NO,NA						84.73
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	83.72	1.01	NA,NO						84.73
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	530.48	1.60	39.53	26.31	212.33	1.24	NO,NA	NO,NA	811.51
A. Mineral industry	54.36								54.36
B. Chemical industry	0.40	NO,NA	34.45	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	34.85
C. Metal industry	467.90	1.56	NO	NO	212.33	NO	NO	NO	681.79
D. Non-energy products from fuels and solvent use	7.81	NA	NA						7.81
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				26.31	NO	NO	NO	NO	26.31
G. Other product manufacture and use	0.01	0.04	5.08		NO	1.24			6.38
H. Other	NA	NA	NA						NA
3. Agriculture	0.08	369.27	268.88						638.23
A. Enteric fermentation		311.28							311.28
B. Manure management		57.99	19.98						77.98
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	248.90						248.90
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.00								0.00
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry (1)	5740.90	3432.27	0.48						9173.65
A. Forest land	-73.51	0.34	0.38						-72.78
B. Cropland	1880.73	94.69	NO,NA						1975.43
C. Grassland	5014.65	380.52	0.10						5395.27
D. Wetlands	-1102.80	2956.71	NO,NA						1853.91
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NA	NA	NA						NA
G. Harvested wood products	-0.01								-0.01
H. Other	IE	IE	IE						IE
5. Waste	3.57	273.95	5.96						283.48
A. Solid waste disposal	NO,NA	214.88							214.88
B. Biological treatment of solid waste		0.20	0.14						0.34
C. Incineration and open burning of waste	3.57	3.16	0.87						7.59
D. Waste water treatment and discharge		55.72	4.95						60.67
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	389.32	0.18	3.23						392.73
Aviation	337.80	0.06	2.82						340.67
Navigation	51.52	0.12	0.41						52.06
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									3875.50
Total CO_2 equivalent emissions with land use, land-use change and forestry									13049.15
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 2022 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)]	8584.98	4087.41	363.38	37.98	204.17	1.24	NO,NA	NO,NA	13279.16
1. Energy	2148.81	8.31	41.80						2198.92
A. Fuel combustion (sectoral approach)	2037.53	6.94	41.80						2086.27
1. Energy industries	6.69	0.04	0.12						6.85
2. Manufacturing industries and construction	279.05	0.32	0.72						280.09
3. Transport	823.76	4.35	33.69						861.80
4. Other sectors	923.65	2.22	7.26						933.13
5. Other	4.38	0.00	0.01						4.40
B. Fugitive emissions from fuels	111.27	1.37	NO,NA						112.64
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	111.27	1.37	NA,NO						112.64
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	679.36	1.86	40.01	37.98	204.17	1.24	NO,NA	NO,NA	964.62
A. Mineral industry	61.41								61.41
B. Chemical industry	0.43	NO,NA	34.78	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	35.21
C. Metal industry	610.13	1.81	NO	NO	204.17	NO	NO	NO	816.11
D. Non-energy products from fuels and solvent use	7.37	NA	NA						7.37
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				37.98	NO	NO	NO	NO	37.98
G. Other product manufacture and use	0.02	0.05	5.23		NO	1.24			6.55
H. Other	NA	NA	NA						NA
3. Agriculture	0.09	367.59	275.19						642.87
A. Enteric fermentation		310.01							310.01
B. Manure management		57.58	20.08						77.66
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	255.11						255.11
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.02								0.02
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5753.80	3427.93	0.51						9182.24
A. Forest land	-79.81	0.36	0.41						-79.04
B. Cropland	1880.25	94.68	NO,NA						1974.93
C. Grassland	5031.88	382.69	0.10						5414.67
D. Wetlands	-1100.34	2950.20	NO,NA						1849.86
E. Settlements	21.82	NE,NA	NO,NE,IE,NA						21.82
F. Other land	NA,NE	NA	NA						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.92	281.71	5.88						290.51
A. Solid waste disposal	NO,NA	221.65							221.65
B. Biological treatment of solid waste		0.20	0.14						0.34
C. Incineration and open burning of waste	2.92	2.64	0.73						6.28
D. Waste water treatment and discharge		57.23	5.01						62.24
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	401.93	0.16	3.34						405.42
Aviation	363.01	0.06	3.03						366.10
Navigation	38.92	0.09	0.31						39.32
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									4096.92
Total CO_2 equivalent emissions with land use, land-use change and forestry									13279.16
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 2022 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)]	8694.52	4080.98	342.87	43.96	149.89	1.31	NO,NA	NO,NA	13313.54
1. Energy	2131.11	8.10	42.14						2181.34
A. Fuel combustion (sectoral approach)	1977.96	6.58	42.14						2026.68
1. Energy industries	6.40	0.04	0.12						6.56
2. Manufacturing industries and construction	225.35	0.27	0.60						226.22
3. Transport	830.58	4.08	34.22						868.89
4. Other sectors	911.00	2.18	7.19						920.37
5. Other	4.62	0.00	0.01						4.64
B. Fugitive emissions from fuels	153.15	1.51	NO,NA						154.66
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	153.15	1.51	NA,NO						154.66
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	789.17	2.76	22.84	43.96	149.89	1.31	NO,NA	NO,NA	1009.94
A. Mineral industry	65.45								65.45
B. Chemical industry	0.41	NO,NA	17.91	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	18.32
C. Metal industry	715.56	2.72	NO	NO	149.89	NO	NO	NO	868.17
D. Non-energy products from fuels and solvent use	7.74	NA	NA						7.74
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				43.96	NO	NO	NO	NO	43.96
G. Other product manufacture and use	0.02	0.05	4.93		NO	1.31			6.30
H. Other	NA	NA	NA						NA
3. Agriculture	0.12	355.13	271.40						626.65
A. Enteric fermentation		297.83							297.83
B. Manure management		57.31	19.43						76.74
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	251.96						251.96
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.04								0.04
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5771.38	3422.10	0.58						9194.06
A. Forest land	-90.16	0.43	0.48						-89.25
B. Cropland	1879.75	94.66	NO,NA						1974.41
C. Grassland	5060.60	385.61	0.10						5446.32
D. Wetlands	-1097.02	2941.39	NO,NA						1844.38
E. Settlements	18.21	NE,NA	NO,NE,IE,NA						18.21
F. Other land	NA	NA	NA						NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.74	292.89	5.92						301.55
A. Solid waste disposal	NO,NA	227.18							227.18
B. Biological treatment of solid waste		0.20	0.14						0.34
C. Incineration and open burning of waste	2.74	2.58	0.71						6.03
D. Waste water treatment and discharge		62.94	5.07						68.00
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	0.20	3.83						465.23
Aviation	407.33	0.07	3.40						410.80
Navigation	53.86	0.13	0.43						54.43
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									4119.48
Total CO_2 equivalent emissions with land use, land-use change and forestry									13313.54
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 2022 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)	8643.11	4086.48	338.21	40.81	108.04	1.31	NO,NA	NO,NA	13217.95
1. Energy	2021.25	7.60	41.11						2069.96
A. Fuel combustion (sectoral approach)	1877.48	6.07	41.11						1924.66
1. Energy industries	5.99	0.04	0.12						6.14
2. Manufacturing industries and construction	262.25	0.33	0.71						263.28
3. Transport	837.02	3.88	34.32						875.22
4. Other sectors	752.45	1.80	5.93						760.18
5. Other	19.77	0.02	0.05						19.84
B. Fugitive emissions from fuels	143.77	1.53	NO,NA						145.30
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	143.77	1.53	NA,NO						145.30
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	831.40	2.87	20.20	40.81	108.04	1.31	NO,NA	NO,NA	1004.63
A. Mineral industry	58.66								58.66
B. Chemical industry	0.49	NO,NA	15.53	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	16.02
C. Metal industry	765.37	2.82	NO	NO	108.04	NO	NO	NO	876.24
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				40.81	0.00	NO	NO	NO	40.81
G. Other product manufacture and use	0.02	0.05	4.68		NO	1.31			6.06
H. Other	NA	NA	NA						NA
3. Agriculture	0.10	356.47	270.33						626.90
A. Enteric fermentation		299.53							299.53
B. Manure management		56.94	19.38						76.32
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	250.95						250.95
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.02								0.02
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry (1)	5787.77	3418.41	0.63						9206.81
A. Forest land	-95.66	0.47	0.52						-94.68
B. Cropland	1879.30	94.64	NO,NA						1973.94
C. Grassland	5080.63	387.64	0.11						5468.38
D. Wetlands	-1094.70	2935.67	NO,NA						1840.97
E. Settlements	18.20	NE,NA	NO,NE,IE,NA						18.20
F. Other land	NA	NA	NA						NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.58	301.13	5.93						309.64
A. Solid waste disposal	NO,NA	235.47							235.47
B. Biological treatment of solid waste		0.20	0.14						0.34
C. Incineration and open burning of waste	2.58	2.31	0.64						5.53
D. Waste water treatment and discharge		63.15	5.15						68.30
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	0.20	3.38						411.37
Aviation	348.78	0.06	2.91						351.75
Navigation	59.01	0.14	0.48						59.63
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									4011.14
Total CO_2 equivalent emissions with land use, land-use change and forestry									13217.95
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 2022 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]	8796.15	4087.48	313.33	45.68	85.51	1.31	NA,NO	NA,NO	13329.47
1. Energy	2131.24	7.58	40.87						2179.69
A. Fuel combustion (sectoral approach)	1983.83	6.04	40.87						2030.74
1. Energy industries	6.87	0.04	0.12						7.03
2. Manufacturing industries and construction	278.36	0.32	0.72						279.40
3. Transport	828.37	3.62	33.26						865.26
4. Other sectors	847.61	2.03	6.72						856.36
5. Other	22.61	0.02	0.05						22.69
B. Fugitive emissions from fuels	147.41	1.54	NO,NA						148.95
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	147.41	1.54	NA,NO						148.95
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	848.71	3.02	4.36	45.68	85.51	1.31	NA,NO	NA,NO	988.60
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	2.97	NO	NO	85.50	NO	NO	NO	890.30
D. Non-energy products from fuels and solvent use	7.10	NA	NA						7.10
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				45.68	0.01	NO	NO	NO	45.69
G. Other product manufacture and use	0.01	0.05	4.36		NO	1.31			5.73
H. Other	NA	NA	NA						NA
3. Agriculture	0.14	349.84	262.11						612.10
A. Enteric fermentation		294.11							294.11
B. Manure management		55.74	19.15						74.88
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	242.97						242.97
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.06								0.06
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [1]	5813.66	3413.30	0.67						9227.63
A. Forest land	-104.66	0.50	0.56						-103.60
B. Cropland	1878.86	94.62	NO,NA						1973.48
C. Grassland	5112.95	390.48	0.11						5503.55
D. Wetlands	-1091.69	2927.70	NO,NA						1836.00
E. Settlements	18.20	NE,NA	NO,NE,IE,NA						18.20
F. Other land	NA	NA	NA						NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.40	313.74	5.32						321.46
A. Solid waste disposal	NO,NA	236.29							236.29
B. Biological treatment of solid waste		0.20	0.14						0.34
C. Incineration and open burning of waste	2.40	2.15	0.60						5.15
D. Waste water treatment and discharge		75.09	4.58						79.67
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	394.53	0.26	3.27						398.06
Aviation	309.54	0.05	2.58						312.18
Navigation	84.99	0.20	0.69						85.88
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									4101.84
Total CO_2 equivalent emissions with land use, land-use change and forestry									13329.47
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 2022 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)]	8793.71	4074.19	307.68	46.19	70.48	1.31	NA,NO	NA,NO	13293.56
1. Energy	2121.89	7.32	39.45						2168.66
A. Fuel combustion (sectoral approach)	1985.54	5.83	39.45						2030.82
1. Energy industries	5.00	0.04	0.11						5.16
2. Manufacturing industries and construction	257.10	0.30	0.67						258.06
3. Transport	907.28	3.55	32.20						943.03
4. Other sectors	808.85	1.93	6.44						817.23
5. Other	7.31	0.01	0.02						7.34
B. Fugitive emissions from fuels	136.34	1.49	NO,NA						137.84
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	136.34	1.49	NA,NO						137.84
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	849.58	3.02	4.32	46.19	70.48	1.31	NA,NO	NA,NO	974.89
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	2.98	NO	NO	70.47	NO	NO	NO	882.78
D. Non-energy products from fuels and solvent use	6.77	NA	NA						6.77
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				46.19	0.01	NO	NO	NO	46.19
G. Other product manufacture and use	0.02	0.04	4.32		NO	1.31			5.69
H. Other	NA	NA	NA						NA
3. Agriculture	2.65	345.41	257.87						605.92
A. Enteric fermentation		290.56							290.56
B. Manure management		54.85	18.96						73.81
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	238.90						238.90
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.19								0.19
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	2.37								2.37
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5817.54	3410.13	0.71						9228.38
A. Forest land	-115.39	0.54	0.60						-114.25
B. Cropland	1878.42	94.61	NO,NA						1973.02
C. Grassland	5126.15	392.21	0.11						5518.47
D. Wetlands	-1089.84	2922.78	NO,NA						1832.94
E. Settlements	18.20	NE,NA	NO,NE,IE,NA						18.20
F. Other land	NA	NA	NA						NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.05	308.30	5.34						315.70
A. Solid waste disposal	NO,NA	237.09							237.09
B. Biological treatment of solid waste		0.30	0.21						0.51
C. Incineration and open burning of waste	2.05	1.87	0.52						4.45
D. Waste water treatment and discharge		69.04	4.61						73.65
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	0.10	2.93						354.92
Aviation	332.67	0.06	2.77						335.50
Navigation	19.22	0.05	0.15						19.42
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									4065.17
Total CO_2 equivalent emissions with land use, land-use change and forestry									13293.56
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.

2004

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2022 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)	8923.27	4065.75	309.35	53.33	45.48	1.31	NA,NO	NA,NO	13398.48
1. Energy	2216.69	7.51	43.76						2267.96
A. Fuel combustion (sectoral approach)	2093.79	5.88	43.76						2143.43
1. Energy industries	3.16	0.04	0.11						3.31
2. Manufacturing industries and construction	239.07	0.31	0.66						240.04
3. Transport	992.39	3.52	36.30						1032.21
4. Other sectors	832.82	1.99	6.62						841.43
5. Other	26.35	0.03	0.06						26.44
B. Fugitive emissions from fuels	122.90	1.63	NO,NA						124.53
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	122.90	1.63	NA,NO						124.53
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	873.32	3.01	4.05	53.33	45.48	1.31	NA,NO	NA,NO	980.50
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	2.96	NO	NO	45.47	NO	NO	NO	862.98
D. Non-energy products from fuels and solvent use	7.55	NA	NA						7.55
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				53.33	0.00	NO	NO	NO	53.33
G. Other product manufacture and use	0.02	0.05	4.05		NO	1.31			5.43
H. Other	NA	NA	NA						NA
3. Agriculture	4.95	340.47	255.48						600.90
A. Enteric fermentation		286.73							286.73
B. Manure management		53.74	18.72						72.46
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	236.76						236.76
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	2.46								2.46
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	2.41								2.41
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5823.13	3406.63	0.74						9230.49
A. Forest land	-121.44	0.55	0.62						-120.27
B. Cropland	1877.94	94.59	NO,NA						1972.53
C. Grassland	5136.37	394.00	0.12						5530.49
D. Wetlands	-1087.84	2917.48	NO,NA						1829.64
E. Settlements	18.09	NE,NA	0.00						18.09
F. Other land	NA	NA	NA						NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	5.17	308.14	5.33						318.64
A. Solid waste disposal	NO,NA	244.83							244.83
B. Biological treatment of solid waste		0.30	0.21						0.51
C. Incineration and open burning of waste	5.17	1.14	0.47						6.78
D. Waste water treatment and discharge		61.87	4.64						66.51
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	0.12	3.33						403.92
Aviation	379.62	0.07	3.16						382.85
Navigation	20.84	0.05	0.17						21.06
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									4167.99
Total CO_2 equivalent emissions with land use, land-use change and forestry									13398.48
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 2022 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)	8798.05	4049.78	311.38	58.46	30.76	2.52	NO	NO	13250.94
1. Energy	2103.24	7.14	44.23						2154.61
A. Fuel combustion (sectoral approach)	1985.08	5.40	44.23						2034.71
1. Energy industries	3.26	0.04	0.11						3.40
2. Manufacturing industries and construction	184.66	0.22	0.47						185.34
3. Transport	1015.17	3.33	37.62						1056.12
4. Other sectors	753.09	1.79	5.95						760.83
5. Other	28.91	0.03	0.07						29.01
B. Fugitive emissions from fuels	118.16	1.74	NO,NA						119.90
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	118.16	1.74	NA,NO						119.90
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	856.27	2.82	3.88	58.46	30.76	2.52	NO	NO	954.70
A. Mineral industry	54.98								54.98
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	793.98	2.77	NO	NO	30.76	NO	NO	NO	827.52
D. Non-energy products from fuels and solvent use	7.27	NA	NA						7.27
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				58.46	0.00	NO	NO	NO	58.46
G. Other product manufacture and use	0.03	0.04	3.88		NO	2.52			6.47
H. Other	NA	NA	NA						NA
3. Agriculture	4.21	343.95	257.10						605.26
A. Enteric fermentation		289.03							289.03
B. Manure management		54.92	18.83						73.75
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	238.27						238.27
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	1.84								1.84
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	2.29								2.29
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry (1)	5829.60	3401.74	0.77						9232.11
A. Forest land	-140.89	0.58	0.64						-139.67
B. Cropland	1877.53	94.57	NO,NA						1972.10
C. Grassland	5159.88	396.55	0.12						5556.55
D. Wetlands	-1085.03	2910.04	NO,NA						1825.01
E. Settlements	18.11	NE,NA	0.00						18.12
F. Other land	NA	NA	NA						NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	4.73	294.13	5.41						304.27
A. Solid waste disposal	NO,NA	234.38							234.38
B. Biological treatment of solid waste		0.50	0.36						0.86
C. Incineration and open burning of waste	4.73	0.44	0.30						5.47
D. Waste water treatment and discharge		58.81	4.75						63.56
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	0.08	3.52						426.56
Aviation	421.23	0.07	3.51						424.81
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									4018.84
Total CO_2 equivalent emissions with land use, land-use change and forestry									13250.94
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 2022 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)]	9035.45	4079.48	326.92	67.62	392.79	2.61	NO	NO	13904.86
1. Energy	2171.72	7.78	36.87						2216.37
A. Fuel combustion (sectoral approach)	2044.29	5.36	36.87						2086.53
1. Energy industries	9.06	0.07	0.20						9.33
2. Manufacturing industries and construction	188.79	0.23	0.50						189.52
3. Transport	1137.51	3.42	30.70						1171.62
4. Other sectors	682.14	1.62	5.40						689.16
5. Other	26.80	0.03	0.06						26.90
B. Fugitive emissions from fuels	127.43	2.42	NO,NA						129.84
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	127.43	2.42	NA,NO						129.84
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	965.28	2.77	4.13	67.62	392.79	2.61	NO	NO	1435.20
A. Mineral industry	62.17								62.17
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	895.02	2.72	NO	NO	392.79	NO	NO	NO	1290.53
D. Non-energy products from fuels and solvent use	8.05	NA	NA						8.05
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				67.62	0.00	NO	NO	NO	67.62
G. Other product manufacture and use	0.04	0.05	4.13		NO	2.61			6.83
H. Other	NA	NA	NA						NA
3. Agriculture	2.87	352.16	273.88						628.92
A. Enteric fermentation		294.56							294.56
B. Manure management		57.60	19.05						76.65
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	254.83						254.83
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	1.15								1.15
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	1.64								1.64
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5890.78	3398.90	6.30						9295.98
A. Forest land	-147.15	0.60	0.67						-145.88
B. Cropland	1877.14	94.57	0.02						1971.72
C. Grassland	5221.98	405.78	4.48						5632.24
D. Wetlands	-1080.08	2897.95	1.13						1819.00
E. Settlements	18.89	NE,NA	0.00						18.89
F. Other land	NA	0.01	0.01						0.01
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	4.79	317.86	5.74						328.39
A. Solid waste disposal	NO,NA	265.32							265.32
B. Biological treatment of solid waste		0.80	0.57						1.37
C. Incineration and open burning of waste	4.79	0.43	0.31						5.53
D. Waste water treatment and discharge		51.31	4.86						56.16
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	0.13	4.30						520.99
Aviation	499.40	0.09	4.16						503.65
Navigation	17.16	0.04	0.13						17.34
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									4608.88
Total CO_2 equivalent emissions with land use, land-use change and forestry									13904.86
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 2022 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)	9299.05	4071.71	333.98	68.39	331.39	2.89	NO	NO	14107.42
1. Energy	2311.18	8.61	37.75						2357.55
A. Fuel combustion (sectoral approach)	2163.81	5.52	37.75						2207.08
1. Energy industries	24.96	0.09	0.26						25.31
2. Manufacturing industries and construction	183.18	0.34	0.66						184.17
3. Transport	1174.48	3.26	30.71						1208.45
4. Other sectors	774.36	1.82	6.11						782.30
5. Other	6.83	0.01	0.02						6.86
B. Fugitive emissions from fuels	147.37	3.09	NO,NA						150.46
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	147.37	3.09	NA,NO						150.46
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1163.09	2.91	4.59	68.39	331.39	2.89	NO	NO	1573.26
A. Mineral industry	64.33								64.33
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1091.13	2.85	NO	NO	331.38	NO	NO	NO	1425.37
D. Non-energy products from fuels and solvent use	7.58	NA	NA						7.58
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				68.39	0.00	NO	NO	NO	68.39
G. Other product manufacture and use	0.05	0.06	4.59		NO	2.89			7.59
H. Other	NA	NA	NA						NA
3. Agriculture	1.55	357.81	284.78						644.14
A. Enteric fermentation		298.84							298.84
B. Manure management		58.97	19.39						78.36
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	265.38						265.38
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.53								0.53
H. Urea application	0.13								0.13
I. Other carbon-containing fertilizers	0.89								0.89
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5815.36	3384.53	0.83						9200.72
A. Forest land	-255.32	0.61	0.69						-254.02
B. Cropland	1876.76	94.53	NO,NA						1971.29
C. Grassland	5250.31	405.33	0.13						5655.77
D. Wetlands	-1074.54	2884.05	NO,NA						1809.51
E. Settlements	18.15	NE,NA	0.01						18.16
F. Other land	NE,NA	NA	NA						NE,NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	7.86	317.85	6.04						331.75
A. Solid waste disposal	NO,NA	262.42							262.42
B. Biological treatment of solid waste		1.00	0.72						1.72
C. Incineration and open burning of waste	7.86	0.42	0.33						8.62
D. Waste water treatment and discharge		54.01	4.99						59.00
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	0.12	4.35						527.44
Aviation	511.03	0.09	4.26						515.38
Navigation	11.94	0.03	0.09						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									4906.70
Total CO_2 equivalent emissions with land use, land-use change and forestry									14107.42
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 2022 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)]	9665.18	4050.72	341.00	70.01	411.38	3.01	NO	NO	14541.29
1. Energy	2185.51	8.10	35.76						2229.37
A. Fuel combustion (sectoral approach)	1999.57	4.98	35.76						2040.32
1. Energy industries	10.18	0.07	0.20						10.44
2. Manufacturing industries and construction	159.92	0.30	0.58						160.79
3. Transport	1113.84	2.94	29.36						1146.14
4. Other sectors	708.52	1.67	5.61						715.80
5. Other	7.11	0.01	0.02						7.14
B. Fugitive emissions from fuels	185.94	3.12	NO,NA						189.06
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	185.94	3.12	NA,NO						189.06
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1604.75	2.45	4.09	70.01	411.38	3.01	NO	NO	2095.70
A. Mineral industry	61.80								61.80
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1536.09	2.41	NO	NO	411.38	NO	NO	NO	1949.88
D. Non-energy products from fuels and solvent use	6.84	NA	NA						6.84
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				70.01	0.00	NO	NO	NO	70.01
G. Other product manufacture and use	0.02	0.04	4.09		NO	3.01			7.16
H. Other	NA	NA	NA						NA
3. Agriculture	4.74	361.11	294.07						659.92
A. Enteric fermentation		301.85							301.85
B. Manure management		59.26	19.27						78.53
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	274.80						274.80
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	2.17								2.17
H. Urea application	0.15								0.15
I. Other carbon-containing fertilizers	2.42								2.42
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5864.04	3376.45	0.94						9241.43
A. Forest land	-259.45	0.64	0.71						-258.10
B. Cropland	1876.40	94.52	NO,NA						1970.92
C. Grassland	5298.75	409.44	0.20						5708.39
D. Wetlands	-1069.93	2871.86	0.02						1801.95
E. Settlements	18.28	NE,NA	0.01						18.29
F. Other land	NA	0.00	0.00						0.00
G. Harvested wood products	-0.01								-0.01
H. Other	IE	IE	IE						IE
5. Waste	6.13	302.61	6.13						314.87
A. Solid waste disposal	NO,NA	252.08							252.08
B. Biological treatment of solid waste		1.06	0.76						1.82
C. Incineration and open burning of waste	6.13	0.40	0.30						6.83
D. Waste water treatment and discharge		49.07	5.07						54.14
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	0.18	3.93						479.05
Aviation	427.40	0.07	3.56						431.04
Navigation	47.53	0.11	0.37						48.01
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									5299.87
Total CO_2 equivalent emissions with land use, land-use change and forestry									14541.29
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 2022 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)]	9576.80	4041.62	317.35	83.18	180.05	3.04	NO	NO	14202.02
1. Energy	2094.03	7.54	28.88						2130.45
A. Fuel combustion (sectoral approach)	1923.92	4.69	28.88						1957.48
1. Energy industries	7.76	0.05	0.15						7.96
2. Manufacturing industries and construction	116.36	0.17	0.36						116.89
3. Transport	1029.35	2.66	22.31						1054.32
4. Other sectors	765.61	1.80	6.05						773.46
5. Other	4.84	0.01	0.01						4.86
B. Fugitive emissions from fuels	170.11	2.85	NO,NA						172.96
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	170.11	2.85	NA,NO						172.96
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1616.18	2.49	3.59	83.18	180.05	3.04	NO	NO	1888.53
A. Mineral industry	28.69								28.69
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1582.10	2.45	NO	NO	180.05	NO	NO	NO	1764.60
D. Non-energy products from fuels and solvent use	5.38	NA	NA						5.38
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				83.18	0.00	NO	NO	NO	83.18
G. Other product manufacture and use	0.02	0.04	3.59		NO	3.04			6.69
H. Other	NA	NA	NA						NA
3. Agriculture	3.44	366.03	277.62						647.08
A. Enteric fermentation		306.14							306.14
B. Manure management		59.89	19.61						79.50
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	258.01						258.01
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.77								0.77
H. Urea application	0.16								0.16
I. Other carbon-containing fertilizers	2.51								2.51
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5857.08	3374.95	0.88						9232.91
A. Forest land	-272.91	0.66	0.74						-271.51
B. Cropland	1876.07	94.50	NO,NA						1970.57
C. Grassland	5304.52	410.34	0.13						5714.99
D. Wetlands	-1068.86	2869.45	NO,NA						1800.59
E. Settlements	18.28	NE,NA	0.01						18.28
F. Other land	NA	0.00	0.00						0.00
G. Harvested wood products	-0.01								-0.01
H. Other	IE	IE	IE						IE
5. Waste	6.06	290.61	6.38						303.05
A. Solid waste disposal	NO,NA	242.79							242.79
B. Biological treatment of solid waste		1.27	0.91						2.18
C. Incineration and open burning of waste	6.06	0.37	0.26						6.69
D. Waste water treatment and discharge		46.18	5.21						51.39
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	0.08	2.92						354.15
Aviation	343.01	0.06	2.86						345.92
Navigation	8.15	0.02	0.06						8.23
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									4969.12
Total CO_2 equivalent emissions with land use, land-use change and forestry									14202.02
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 2022 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)]	9438.62	4028.73	306.04	111.32	171.66	4.66	NO	NO	14061.03
1. Energy	1985.36	9.35	24.95						2019.66
A. Fuel combustion (sectoral approach)	1795.71	4.29	24.95						1824.95
1. Energy industries	8.38	0.05	0.15						8.58
2. Manufacturing industries and construction	84.15	0.13	0.27						84.55
3. Transport	959.50	2.38	18.73						980.61
4. Other sectors	729.76	1.71	5.76						737.23
5. Other	13.93	0.01	0.03						13.98
B. Fugitive emissions from fuels	189.64	5.07	NO,NA						194.71
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	189.64	5.07	NA,NO						194.71
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1623.27	2.59	3.88	111.32	171.66	4.66	NO	NO	1917.39
A. Mineral industry	10.40								10.40
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1607.25	2.56	NO	NO	171.66	NO	NO	NO	1781.47
D. Non-energy products from fuels and solvent use	5.59	NA	NA						5.59
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				111.32	0.00	NO	NO	NO	111.32
G. Other product manufacture and use	0.02	0.04	3.88		NO	4.66			8.60
H. Other	NA	NA	NA						NA
3. Agriculture	2.09	359.57	269.77						631.43
A. Enteric fermentation		303.06							303.06
B. Manure management		56.51	19.43						75.95
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	250.34						250.34
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.30								0.30
H. Urea application	0.13								0.13
I. Other carbon-containing fertilizers	1.66								1.66
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5822.00	3373.22	0.90						9196.11
A. Forest land	-296.30	0.68	0.76						-294.87
B. Cropland	1875.75	94.48	NO,NA						1970.23
C. Grassland	5306.74	411.31	0.14						5718.19
D. Wetlands	-1067.84	2866.75	0.00						1798.90
E. Settlements	3.68	NE,NA	0.01						3.68
F. Other land	NA	NA	NA						NA
G. Harvested wood products	-0.03								-0.03
H. Other	IE	IE	IE						IE
5. Waste	5.91	284.00	6.54						296.45
A. Solid waste disposal	NO,NA	242.69							242.69
B. Biological treatment of solid waste		1.52	1.09						2.61
C. Incineration and open burning of waste	5.91	0.35	0.25						6.51
D. Waste water treatment and discharge		39.43	5.20						44.63
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	3.14						380.35
Aviation	376.89	0.07	3.14						380.09
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									4864.92
Total CO_2 equivalent emissions with land use, land-use change and forestry									14061.03
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 2022 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)	9291.96	4008.19	302.79	136.25	74.52	3.05	NO	NO	13816.76
1. Energy	1867.26	7.94	22.83						1898.03
A. Fuel combustion (sectoral approach)	1687.74	3.93	22.83						1714.50
1. Energy industries	6.43	0.04	0.12						6.59
2. Manufacturing industries and construction	98.34	0.15	0.31						98.80
3. Transport	915.50	2.17	17.17						934.84
4. Other sectors	660.59	1.55	5.21						667.35
5. Other	6.90	0.01	0.02						6.92
B. Fugitive emissions from fuels	179.51	4.01	NO,NA						183.52
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	179.51	4.01	NA,NO						183.52
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1617.76	2.67	3.99	136.25	74.52	3.05	NO	NO	1838.24
A. Mineral industry	20.14								20.14
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1591.77	2.63	NO	NO	74.52	NO	NO	NO	1668.92
D. Non-energy products from fuels and solvent use	5.82	NO,NA	NO,NA						5.82
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				136.25	0.01	NO	NO	NO	136.26
G. Other product manufacture and use	0.02	0.04	3.99		NO	3.05			7.10
H. Other	NA	NA	NA						NA
3. Agriculture	2.60	360.81	268.54						631.95
A. Enteric fermentation		302.59							302.59
B. Manure management		58.23	19.56						77.79
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	248.98						248.98
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.90								0.90
H. Urea application	0.15								0.15
I. Other carbon-containing fertilizers	1.54								1.54
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry (1)	5797.79	3371.51	0.91						9170.22
A. Forest land	-323.42	0.69	0.77						-321.96
B. Cropland	1875.42	94.46	NO,NA						1969.88
C. Grassland	5308.95	412.28	0.14						5721.36
D. Wetlands	-1066.82	2864.08	NO,NA						1797.27
E. Settlements	3.68	NE,NA	0.01						3.69
F. Other land	NA	NA	NA						NA
G. Harvested wood products	-0.03								-0.03
H. Other	IE	IE	IE						IE
5. Waste	6.55	265.26	6.51						278.32
A. Solid waste disposal	NO,NA	221.37							221.37
B. Biological treatment of solid waste		1.43	1.02						2.45
C. Incineration and open burning of waste	6.55	0.33	0.26						7.14
D. Waste water treatment and discharge		42.12	5.24						47.36
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	0.19	3.90						475.22
Aviation	421.51	0.07	3.51						425.10
Navigation	49.62	0.11	0.39						50.12
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									4646.54
Total CO_2 equivalent emissions with land use, land-use change and forestry									13816.76
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 2022 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)]	9284.79	3982.39	309.46	141.73	94.00	5.35	NO	NO	13817.72
1. Energy	1820.31	7.00	22.05						1849.36
A. Fuel combustion (sectoral approach)	1648.26	3.73	22.05						1674.03
1. Energy industries	7.73	0.04	0.11						7.87
2. Manufacturing industries and construction	83.36	0.11	0.24						83.71
3. Transport	903.01	2.04	16.53						921.58
4. Other sectors	654.08	1.54	5.17						660.78
5. Other	0.09	0.00	0.00						0.09
B. Fugitive emissions from fuels	172.05	3.28	NO,NA						175.33
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	172.05	3.28	NA,NO						175.33
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1660.64	3.00	3.90	141.73	94.00	5.35	NO	NO	1908.61
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	2.96	NO	NO	94.00	NO	NO	NO	1751.28
D. Non-energy products from fuels and solvent use	5.77	NO,NA	NO,NA						5.77
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				141.73	0.00	NO	NO	NO	141.74
G. Other product manufacture and use	0.03	0.04	3.90		NO	5.35			9.31
H. Other	NA	NA	NA						NA
3. Agriculture	3.58	355.18	276.29						635.05
A. Enteric fermentation		299.58							299.58
B. Manure management		55.60	19.28						74.87
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	257.02						257.02
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	1.80								1.80
H. Urea application	0.03								0.03
I. Other carbon-containing fertilizers	1.75								1.75
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5793.92	3369.66	0.94						9164.53
A. Forest land	-334.06	0.71	0.79						-332.56
B. Cropland	1875.09	94.44	NO,NA						1969.54
C. Grassland	5314.99	413.25	0.15						5728.39
D. Wetlands	-1065.75	2861.26	NO,NA						1795.51
E. Settlements	3.70	NE,NA	0.01						3.71
F. Other land	NA	0.00	0.00						0.00
G. Harvested wood products	-0.06								-0.06
H. Other	IE	IE	IE						IE
5. Waste	6.35	247.55	6.28						260.17
A. Solid waste disposal	NO,NA	195.93							195.93
B. Biological treatment of solid waste		1.12	0.80						1.92
C. Incineration and open burning of waste	6.35	0.33	0.23						6.90
D. Waste water treatment and discharge		50.18	5.25						55.43
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	0.13	3.87						469.46
Aviation	441.72	0.08	3.68						445.48
Navigation	23.75	0.05	0.18						23.99
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									4653.19
Total CO_2 equivalent emissions with land use, land-use change and forestry									13817.72
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 2022 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)]	9261.51	3982.76	303.32	172.32	88.17	3.23	NO	NO	13811.30
1. Energy	1785.16	7.53	21.30						1813.99
A. Fuel combustion (sectoral approach)	1612.02	3.54	21.30						1636.86
1. Energy industries	4.39	0.01	0.03						4.43
2. Manufacturing industries and construction	74.46	0.13	0.25						74.85
3. Transport	914.80	1.95	16.14						932.90
4. Other sectors	617.60	1.45	4.87						623.92
5. Other	0.76	0.00	0.00						0.77
B. Fugitive emissions from fuels	173.14	3.99	NO,NA						177.13
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	173.14	3.99	NA,NO						177.13
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1686.64	3.03	3.45	172.32	88.17	3.23	NO	NO	1956.83
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	2.99	NO	NO	88.16	NO	NO	NO	1771.50
D. Non-energy products from fuels and solvent use	5.72	NO,NA	NO,NA						5.72
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				172.32	0.00	NO	NO	NO	172.33
G. Other product manufacture and use	0.02	0.04	3.45		NO	3.23			6.73
H. Other	NA	NA	NA						NA
3. Agriculture	2.89	346.30	271.00						620.19
A. Enteric fermentation		292.90							292.90
B. Manure management		53.40	18.92						72.32
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	252.08						252.08
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	1.08								1.08
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	1.75								1.75
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5781.43	3367.87	0.97						9150.27
A. Forest land	-352.80	0.71	0.79						-351.30
B. Cropland	1874.77	94.42	NO,NA						1969.19
C. Grassland	5320.59	414.24	0.17						5735.00
D. Wetlands	-1064.71	2858.49	NO,NA						1793.79
E. Settlements	3.65	NE,NA	0.01						3.66
F. Other land	NA	NA	NA						NA
G. Harvested wood products	-0.07								-0.07
H. Other	IE	IE	IE						IE
5. Waste	5.39	258.02	6.61						270.02
A. Solid waste disposal	NO,NA	208.11							208.11
B. Biological treatment of solid waste		1.50	1.07						2.57
C. Incineration and open burning of waste	5.39	0.33	0.25						5.97
D. Waste water treatment and discharge		48.09	5.29						53.37
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	0.27	4.77						581.69
Aviation	498.57	0.09	4.16						502.81
Navigation	78.08	0.18	0.62						78.88
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									4661.03
Total CO_2 equivalent emissions with land use, land-use change and forestry									13811.30
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 2022 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]	9199.24	3991.95	328.56	170.28	99.03	2.39	NO	NO	13791.43
1. Energy	1771.91	7.91	23.10						1802.92
A. Fuel combustion (sectoral approach)	1588.96	3.37	23.10						1615.42
1. Energy industries	5.13	0.01	0.01						5.15
2. Manufacturing industries and construction	31.83	0.05	0.10						31.98
3. Transport	935.72	1.86	18.17						955.74
4. Other sectors	613.63	1.44	4.80						619.88
5. Other	2.66	0.01	0.01						2.67
B. Fugitive emissions from fuels	182.95	4.54	NA,NO						187.50
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	182.95	4.54	NA,NO						187.50
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1655.13	2.73	3.19	170.28	99.03	2.39	NO	NO	1932.75
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	2.69	NO	NO	99.03	NO	NO	NO	1750.48
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				170.28	0.00	NO	NO	NO	170.28
G. Other product manufacture and use	0.02	0.03	3.19		NO	2.39			5.63
H. Other	NA	NA	NA						NA
3. Agriculture	2.22	369.57	294.05						665.83
A. Enteric fermentation		311.38							311.38
B. Manure management		58.20	20.01						78.21
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	274.03						274.03
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.54								0.54
H. Urea application	0.14								0.14
I. Other carbon-containing fertilizers	1.53								1.53
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [1]	5762.88	3366.09	1.00						9129.97
A. Forest land	-376.71	0.72	0.81						-375.19
B. Cropland	1874.43	94.41	NO,NA						1968.84
C. Grassland	5324.90	415.22	0.18						5740.29
D. Wetlands	-1063.37	2855.74	0.01						1792.37
E. Settlements	3.71	NE,NA	0.01						3.72
F. Other land	NA,NE	NA	NA						NA,NE
G. Harvested wood products	-0.07								-0.07
H. Other	IE	IE	IE						IE
5. Waste	7.09	245.65	7.23						259.96
A. Solid waste disposal	NO,NA	204.59							204.59
B. Biological treatment of solid waste		2.01	1.44						3.45
C. Incineration and open burning of waste	7.09	0.34	0.41						7.84
D. Waste water treatment and discharge		38.70	5.37						44.08
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	651.25	0.27	5.40						656.91
Aviation	580.71	0.10	4.84						585.65
Navigation	70.53	0.16	0.56						71.26
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									4661.46
Total CO_2 equivalent emissions with land use, land-use change and forestry									13791.43
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.

2015

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2015
Submission 2022 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)]	9275.41	3995.66	313.45	163.33	103.69	1.59	NO	NO	13853.13
1. Energy	1816.21	8.01	23.59						1847.82
A. Fuel combustion (sectoral approach)	1653.08	3.46	23.59						1680.13
1. Energy industries	4.20	0.00	0.01						4.22
2. Manufacturing industries and construction	61.57	0.10	0.21						61.88
3. Transport	963.88	1.89	18.45						984.22
4. Other sectors	623.23	1.47	4.93						629.63
5. Other	0.19	0.00	0.00						0.19
B. Fugitive emissions from fuels	163.14	4.56	NA,NO						167.69
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	163.14	4.56	NA,NO						167.69
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1707.70	2.98	3.23	163.33	103.69	1.59	NO	NO	1982.53
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	2.95	NO	NO	103.69	NO	NO	NO	1807.45
D. Non-energy products from fuels and solvent use	6.14	NO,NA	NO,NA						6.14
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				163.33	0.01	NO	NO	NO	163.34
G. Other product manufacture and use	0.03	0.03	3.23		NO	1.59			4.88
H. Other	NA	NA	NA						NA
3. Agriculture	3.48	373.11	278.20						654.79
A. Enteric fermentation		313.84							313.84
B. Manure management		59.27	19.91						79.18
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	258.29						258.29
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	2.13								2.13
H. Urea application	0.17								0.17
I. Other carbon-containing fertilizers	1.18								1.18
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5741.56	3364.38	1.18						9107.11
A. Forest land	-401.12	0.72	0.81						-399.58
B. Cropland	1874.21	94.39	NO,NA						1968.60
C. Grassland	5327.18	416.31	0.31						5743.80
D. Wetlands	-1062.31	2852.95	0.04						1790.69
E. Settlements	3.72	NE,NA	0.01						3.73
F. Other land	NA	0.00	0.00						0.00
G. Harvested wood products	-0.12								-0.12
H. Other	IE	IE	IE						IE
5. Waste	6.46	247.18	7.25						260.89
A. Solid waste disposal	NO,NA	200.15							200.15
B. Biological treatment of solid waste		2.13	1.52						3.65
C. Incineration and open burning of waste	6.46	0.34	0.30						7.10
D. Waste water treatment and discharge		44.56	5.43						49.99
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	0.46	6.80						828.92
Aviation	673.99	0.12	5.62						679.73
Navigation	147.66	0.35	1.18						149.19
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									4746.02
Total CO_2 equivalent emissions with land use, land-use change and forestry									13853.13
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 2022 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)]	9201.68	3984.88	311.47	181.24	91.86	1.34	NO	NO	13772.47
1. Energy	1791.19	6.78	25.25						1823.23
A. Fuel combustion (sectoral approach)	1642.23	3.25	25.25						1670.74
1. Energy industries	2.37	0.00	0.01						2.38
2. Manufacturing industries and construction	59.87	0.08	0.17						60.12
3. Transport	1058.66	1.94	20.95						1081.55
4. Other sectors	521.17	1.23	4.13						526.53
5. Other	0.16	0.00	0.00						0.16
B. Fugitive emissions from fuels	148.96	3.53	NO,NA						152.49
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	148.96	3.53	NO,NA						152.49
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1684.33	3.03	2.61	181.24	91.86	1.34	NO	NO	1964.42
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	2.99	NO	NO	91.84	NO	NO	NO	1772.14
D. Non-energy products from fuels and solvent use	6.22	NO,NA	NO,NA						6.22
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				181.24	0.02	NO	NO	NO	181.27
G. Other product manufacture and use	0.03	0.03	2.61		NO	1.34			4.02
H. Other	NA	NA	NA						NA
3. Agriculture	2.91	378.50	275.19						656.59
A. Enteric fermentation		318.06							318.06
B. Manure management		60.44	20.17						80.60
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	255.02						255.02
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	1.72								1.72
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	1.12								1.12
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5716.49	3362.54	0.96						9079.99
A. Forest land	-424.51	0.73	0.81						-422.97
B. Cropland	1873.55	94.37	NO,NA						1967.92
C. Grassland	5325.12	417.12	0.13						5742.37
D. Wetlands	-1061.35	2850.33	NO,NA						1788.98
E. Settlements	3.71	NE,NA	0.01						3.72
F. Other land	NA	NA	NA						NA
G. Harvested wood products	-0.04								-0.04
H. Other	IE	IE	IE						IE
5. Waste	6.75	234.03	7.46						248.24
A. Solid waste disposal	NO,NA	191.97							191.97
B. Biological treatment of solid waste		2.28	1.63						3.91
C. Incineration and open burning of waste	6.75	0.35	0.33						7.43
D. Waste water treatment and discharge		39.43	5.50						44.93
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	0.59	9.11						1111.07
Aviation	916.88	0.16	7.64						924.68
Navigation	184.50	0.43	1.46						186.39
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									4692.48
Total CO_2 equivalent emissions with land use, land-use change and forestry									13772.47
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 2022 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)]	9280.22	3971.25	322.45	172.78	67.99	2.73	NO	NO	13817.42
1. Energy	1832.42	6.43	26.57						1865.42
A. Fuel combustion (sectoral approach)	1685.94	3.13	26.57						1715.64
1. Energy industries	2.33	0.00	0.01						2.34
2. Manufacturing industries and construction	31.25	0.06	0.12						31.42
3. Transport	1115.45	1.79	22.21						1139.45
4. Other sectors	536.75	1.27	4.24						542.26
5. Other	0.17	0.00	0.00						0.17
B. Fugitive emissions from fuels	146.48	3.31	NO,NA						149.79
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	146.48	3.31	NO,NA						149.79
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1759.73	3.16	2.42	172.78	67.99	2.73	NO	NO	2008.80
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	3.13	NO	NO	67.98	NO	NO	NO	1823.88
D. Non-energy products from fuels and solvent use	6.03	NO,NA	NO,NA						6.03
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				172.78	0.01	NO	NO	NO	172.79
G. Other product manufacture and use	0.03	0.03	2.42		NO	2.73			5.20
H. Other	NA	NA	NA						NA
3. Agriculture	2.38	370.50	284.95						657.84
A. Enteric fermentation		311.01							311.01
B. Manure management		59.50	19.68						79.18
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	265.28						265.28
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	0.87								0.87
H. Urea application	0.04								0.04
I. Other carbon-containing fertilizers	1.48								1.48
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5678.60	3360.85	1.01						9040.45
A. Forest land	-462.91	0.73	0.82						-461.36
B. Cropland	1873.43	94.35	NO,NA						1967.78
C. Grassland	5324.80	418.12	0.17						5743.09
D. Wetlands	-1060.33	2847.64	0.01						1787.32
E. Settlements	3.71	NE,NA	0.01						3.71
F. Other land	NA	0.00	0.00						0.00
G. Harvested wood products	-0.09								-0.09
H. Other	IE	IE	IE						IE
5. Waste	7.08	230.31	7.51						244.90
A. Solid waste disposal	NO,NA	184.80							184.80
B. Biological treatment of solid waste		2.17	1.55						3.72
C. Incineration and open burning of waste	7.08	0.36	0.36						7.80
D. Waste water treatment and discharge		42.98	5.60						48.57
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	0.69	11.23						1369.90
Aviation	1146.71	0.20	9.56						1156.47
Navigation	211.27	0.49	1.67						213.43
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									4776.97
Total CO_2 equivalent emissions with land use, land-use change and forestry									13817.42
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 2022 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)]	9314.59	3968.77	307.57	191.29	76.43	3.91	NO	NO	13862.56
1. Energy	1875.89	6.46	24.34						1906.69
A. Fuel combustion (sectoral approach)	1719.42	3.15	24.34						1746.91
1. Energy industries	2.37	0.00	0.01						2.38
2. Manufacturing industries and construction	37.80	0.07	0.13						38.01
3. Transport	1129.07	1.78	19.83						1150.68
4. Other sectors	549.65	1.30	4.37						555.32
5. Other	0.52	0.00	0.00						0.53
B. Fugitive emissions from fuels	156.46	3.32	NO,NA						159.78
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	156.46	3.32	NO,NA						159.78
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1773.72	3.19	2.94	191.29	76.43	3.91	NO	NO	2051.48
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	3.16	NO	NO	76.39	NO	NO	NO	1845.66
D. Non-energy products from fuels and solvent use	6.67	NO,NA	NO,NA						6.67
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				191.29	0.04	NO	NO	NO	191.34
G. Other product manufacture and use	0.03	0.03	2.94		NO	3.91			6.91
H. Other	NA	NA	NA						NA
3. Agriculture	3.20	359.32	271.58						634.10
A. Enteric fermentation		301.10							301.10
B. Manure management		58.23	18.86						77.09
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	252.71						252.71
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	1.56								1.56
H. Urea application	0.02								0.02
I. Other carbon-containing fertilizers	1.62								1.62
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5655.64	3358.87	0.97						9015.48
A. Forest land	-490.96	0.74	0.82						-489.40
B. Cropland	1873.10	94.33	NO,NA						1967.43
C. Grassland	5329.19	419.06	0.13						5748.38
D. Wetlands	-1059.24	2844.74	NO,NA						1785.50
E. Settlements	3.72	NE,NA	0.01						3.72
F. Other land	NA	NA	NA						NA
G. Harvested wood products	-0.15								-0.15
H. Other	IE	IE	IE						IE
5. Waste	6.15	240.92	7.75						254.82
A. Solid waste disposal	NO,NA	192.83							192.83
B. Biological treatment of solid waste		2.40	1.72						4.12
C. Incineration and open burning of waste	6.15	0.35	0.33						6.83
D. Waste water treatment and discharge		45.34	5.71						51.05
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*									
Memo items: [(2)]									
International bunkers	1525.25	0.78	12.62						1538.65
Aviation	1285.04	0.22	10.71						1295.98
Navigation	240.21	0.56	1.91						242.67
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			NE,NA						
Indirect CO_2 [(3)]	NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4847.09
Total CO_2 equivalent emissions with land use, land-use change and forestry									13862.56
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.

2019

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2019
Submission 2022 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]	9208.52	3927.13	295.51	202.64	97.05	2.27	NO	NO	13733.13
1. Energy	1820.17	6.57	21.88						1848.61
A. Fuel combustion (sectoral approach)	1657.06	2.79	21.88						1681.72
1. Energy industries	4.99	0.01	0.01						5.01
2. Manufacturing industries and construction	51.33	0.08	2.70						54.11
3. Transport	1060.29	1.44	13.02						1074.76
4. Other sectors	538.77	1.26	6.13						546.16
5. Other	1.69	0.00	0.00						1.69
B. Fugitive emissions from fuels	163.11	3.78	NO,NA						166.89
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	163.11	3.78	NO,NA						166.89
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1711.87	3.25	2.81	202.64	97.05	2.27	NO	NO	2019.90
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	3.23	NO	NO	97.00	NO	NO	NO	1805.08
D. Non-energy products from fuels and solvent use	6.04	NO,NA	NO,NA						6.04
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				202.64	0.05	NO	NO	NO	202.69
G. Other product manufacture and use	0.02	0.03	2.81		NO	2.27			5.13
H. Other	NA	NA	NA						NA
3. Agriculture	5.87	353.89	261.59						621.34
A. Enteric fermentation		296.66							296.66
B. Manure management		57.23	18.35						75.57
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	243.24						243.24
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	3.70								3.70
H. Urea application	0.22								0.22
I. Other carbon-containing fertilizers	1.95								1.95
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[1]	5662.26	3356.89	0.97						9020.12
A. Forest land	-491.58	0.74	0.83						-490.00
B. Cropland	1872.76	94.31	NO,NA						1967.07
C. Grassland	5335.57	420.03	0.13						5755.73
D. Wetlands	-1058.13	2841.81	NO,NA						1783.67
E. Settlements	3.72	NE,NA	0.01						3.73
F. Other land	NA	NA	NA						NA
G. Harvested wood products	-0.08								-0.08
H. Other	IE	IE	IE						IE
5. Waste	8.36	206.54	8.26						223.16
A. Solid waste disposal	NO,NA	161.85							161.85
B. Biological treatment of solid waste		2.39	1.71						4.09
C. Incineration and open burning of waste	8.36	0.39	0.63						9.37
D. Waste water treatment and discharge		41.92	5.93						47.84
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*									
Memo items:[2]									
International bunkers	1159.90	0.64	9.60						1170.14
Aviation	956.38	0.17	7.97						964.52
Navigation	203.52	0.48	1.63						205.63
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	58.06								58.06
CO_2 captured	9.70								9.70
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NE,NA						
Indirect CO_2 [3]	NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4713.01
Total CO_2 equivalent emissions with land use, land-use change and forestry									13733.13
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 2022 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)]	8980.23	3946.97	295.69	197.70	95.64	3.15	NO	NO	13519.40
1. Energy	1633.89	6.71	18.04						1658.63
A. Fuel combustion (sectoral approach)	1459.01	2.41	18.04						1479.46
1. Energy industries	1.78	0.00	0.00						1.78
2. Manufacturing industries and construction	43.64	0.06	1.44						45.14
3. Transport	876.38	1.11	9.77						887.25
4. Other sectors	536.86	1.24	6.82						544.93
5. Other	0.36	0.00	0.00						0.36
B. Fugitive emissions from fuels	174.87	4.30	NO,NA						179.17
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	174.87	4.30	NO,NA						179.17
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1683.75	3.07	2.83	197.70	95.64	3.15	NO	NO	1986.15
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	3.04	NO	NO	95.58	NO	NO	NO	1775.23
D. Non-energy products from fuels and solvent use	6.22	NO,NA	NO,NA						6.22
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				197.70	0.07	NO	NO	NO	197.77
G. Other product manufacture and use	0.02	0.03	2.83		NO	3.15			6.03
H. Other	NA	NA	NA						NA
3. Agriculture	5.49	347.49	265.34						618.31
A. Enteric fermentation		291.29							291.29
B. Manure management		56.20	17.82						74.02
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	247.52						247.52
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NE,NA	NO,NE,NA						NO,NE,NA
G. Liming	3.86								3.86
H. Urea application	0.19								0.19
I. Other carbon-containing fertilizers	1.43								1.43
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5651.36	3357.39	1.00						9009.76
A. Forest land	-511.78	0.75	0.84						-510.19
B. Cropland	1872.42	94.31	0.02						1966.76
C. Grassland	5344.88	421.00	0.14						5766.01
D. Wetlands	-1057.96	2841.33	0.00						1783.38
E. Settlements	3.83	NE,NA	0.01						3.84
F. Other land	NA	0.00	0.00						0.00
G. Harvested wood products	-0.04								-0.04
H. Other	IE	IE	IE						IE
5. Waste	5.76	232.30	8.48						246.54
A. Solid waste disposal	NO,NA	187.07							187.07
B. Biological treatment of solid waste		3.14	2.22						5.36
C. Incineration and open burning of waste	5.76	0.07	0.22						6.04
D. Waste water treatment and discharge		42.03	6.04						48.07
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*									
Memo items:[(2)]									
International bunkers	338.55	0.23	2.80						341.58
Aviation	261.36	0.05	2.18						263.59
Navigation	77.19	0.18	0.62						77.99
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	53.10								53.10
CO_2 captured	11.70								11.70
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NE,NA						
Indirect CO_2 [(3)]	NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4509.64
Total CO_2 equivalent emissions with land use, land-use change and forestry									13519.40
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.