National Inventory Report

Emissions of greenhouse gases in Iceland from 1990 to 2019

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

2021

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

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Authors:
Nicole Keller, Environment Agency of Iceland
Martina Stefani, Environment Agency of Iceland
Sigríður Rós Einarsdóttir, Environment Agency of Iceland
Ásta Karen Helgadóttir, Environment Agency of Iceland
Rafn Helgason, Environment Agency of Iceland
Hera Guðlaugsdóttir, Environment Agency of Iceland
Arnór Snorrason, Icelandic Forest Service
Leone Tinganelli, Soil Conservation Service of Iceland
Jóhann Þórsson, Soil Conservation Service of Iceland

Reykjavík, 15.04.2021

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 1990-2019. 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 article 7.1 of the Monitoring Mechanism Regulation (MMR, Regulation No 525/2013) and relevant articles and annexes in the implementing Regulation No 749/2014.

Environment Agency of Iceland, Reykjavík, 15.04.2021

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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 to 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 managed by the Soil Conservation Service of Iceland (SCSI) and the Icelandic Forest Service (IFS), with contributions from the Agricultural University of Iceland (AUI). 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.

The Kyoto Protocol commits Annex I Parties to individual, legally binding targets for their greenhouse gas emissions. Iceland's obligations according to the Kyoto Protocol have been and are as follows:

- 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.

[1] Aðgerðaáætlun í loftslagsmálum 2018-2030: https://www.stjornarradid.is/verkefni/umhverfi-og-natturuvernd/loftslagsmal/adgerdaaaetlun/
2 Aðgerðaáætlun í loftslagsmálum til 2030: 2. útgafa https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Adgerdaaetlun%20i%20loftslagsmalum%20onnur%20utgafa.pdf

- 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.
- The second commitment period of the Kyoto Protocol ran for eight years, from 2013 to 2020 inclusive. 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 40% 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 40% 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) by 29% in 2030 relative to the 2005 emission level[4].

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 2019 is shown in Figure ES. 1. Emissions from the Energy sector and Industrial Processes each contribute approximately 80% of 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 2019 is presented in Table ES. 1. LULUCF is the largest sector, with emissions of more than double the combined

[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)

emissions from the other sectors across the time series. Total GHG emissions (excluding LULUCF) increased by approximately a third from 1990 to 2019. 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.

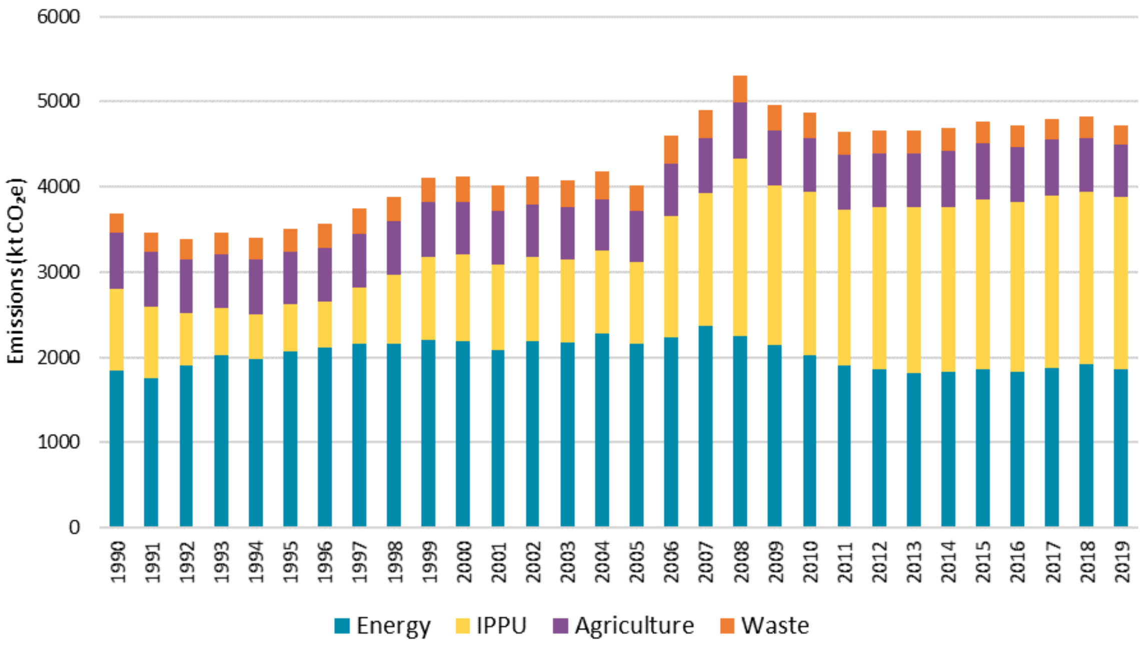


Figure ES.1 Emissions of GHG by sector, without LULUCF, from 1990 to 2019 in kt CO_2e

Table ES. 1 Emissions of GHG by sector, without LULUCF, from 1990 to 2019 in kt CO_2e

	1990	1995	2000	2005	2010	2015	2018	2019	Change ’90-´19	Change ´18-´19
1 Energy	1,849	2,061	2,191	2,164	2,029	1,852	1,913	1,855	0.3%	-3.0%
2 Industrial Processes	958	565	1,010	951	1,911	1,998	2,023	2,024	111%	0.09%
3 Agriculture	657	617	624	603	630	653	632	619	-5.8%	-2.1%
4 Land Use, Land Use Change and Forestry	9,192	9,161	9,184	9,233	9,294	9,204	9,106	9,072	-1.3%	-0.4%
5 Waste	219	270	302	304	296	261	255	224	2.3%	-12%
Total without LULUCF	3,683	3,513	4,127	4,022	4,866	4,764	4,823	4,722	28%	-2.1%
Total with LULUCF	12,875	12,674	13,311	13,255	14,160	13,968	13,929	13,794	7.1%	-1.0%

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_2 emissions falling under Decision 14/CP.7 during CP1 were 5,912,964 tonnes CO_2. Therefore, in order to comply with its goal for CP1, Iceland reported 3,257,140 tonnes of the CO_2 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 2020 for the second commitment period (CP2). There were no annual external transactions made and at the end of the reported year there were no units in the 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 to article 7.1 of the MMR (Regulation 512/2013) and relevant articles and annexes in the Implementing Regulation 749/2014.

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 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. 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 525/2013 shall be binding upon Iceland. This includes for instance Commission Implementing

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

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 40% 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 40% 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) by 29% in 2030 relative to the 2005 emission level.

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. This includes the LULUCF Regulation (Regulation (EU) 2018/84), 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) into the European Economic Area Agreement).

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 for the years 2018-2030; an updated version of the action plan was released in June 2020 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 action plan has set forth 48 actions which mostly focus on electrification of the transport sector and increased efforts in afforestation, revegetation and wetland restoration. This action plan is funded with 43 million Euros over the time period 2019-2023. Of those 49 million Euros, 25 million will go to increased efforts in afforestation, revegetation and wetland restoration, 9 million will go to infrastructure for electric vehicles and 8 million will go towards other projects, such as innovation and research projects, improved GHG inventory, international collaboration and education.

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

- Emissions from generation of electricity and from space heating are very low owing to the use of renewable energy sources (geothermal and hydropower).
- Approximately 90% of emissions from the Energy sector stem from mobile sources (transport, mobile machinery and commercial fishing vessels; excluding international aviation and navigation).
- Emissions from the Land Use, Land Use Change and Forestry (LULUCF) sector are relatively 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.

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 the Act the Environment Agency of Iceland (EA), an agency under the auspices of the Ministry for the Environment and Natural Resources, carries the overall responsibility for the national inventory. EA compiles and maintains the GHG emission inventory, except for LULUCF 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 scheduled to be updated soon, amongst other things to reflected changes in responsibilities of various data providers.

The UNFCCC national focal points are within the Ministry for the Environment and Natural Resources (Mrs. Helga Bardadóttir) and are responsible for approving the final inventory before its submission to the UNFCCC.

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

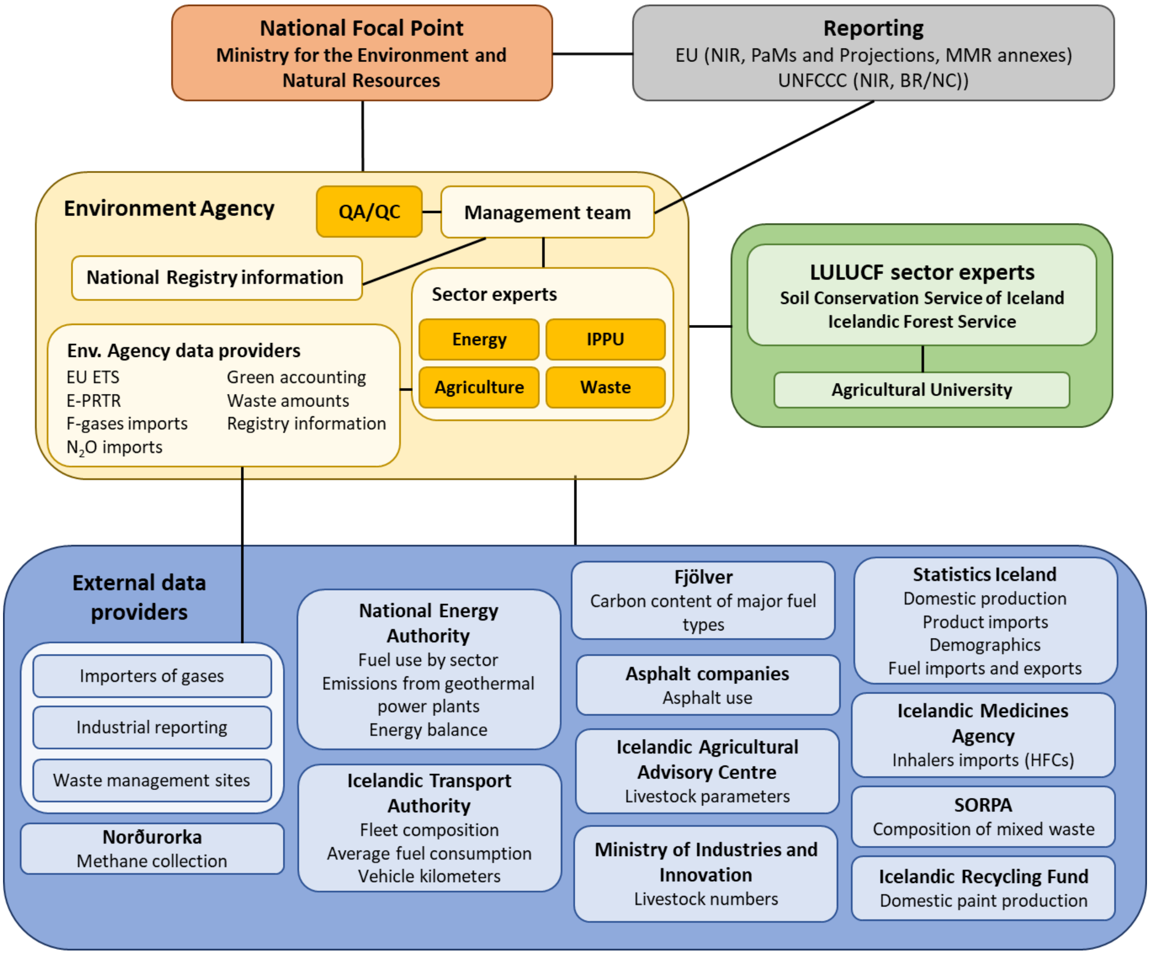


Figure 1.1 Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the UNFCCC.

1.2.2 National legislation

1.2.2.1 *The Climate Change Act No 70/2012*

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

- Reducing GHG emissions efficiently and effectively,
- To increase carbon sequestration from the atmosphere,
- Promoting mitigation to the consequences of climate change, and
- To create conditions 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[6] 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.

Regulation No 520/2017 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.

Work to implement this regulation is seen as a continuous requirement, and further specific and ongoing meetings with various agencies responsible for data supply to the EA are planned to enhance collaboration and improve workflows; furthermore, the regulation is scheduled to be updated in 2021, in order to take into consideration new reporting requirements linked to Regulation (EU) 2018/1999, and the associated Commission Implementing Regulation (EU) 2020/1208. In particular, Commission Implementing Regulation (EU) 2020/1208 established stricter rules on the establishment, operation and functioning of the National inventory system[7], elements of 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 would be coordinated by the EA and be composed of representatives from the Soil Conservation Service, the Forestry Service, the Ministry

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

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

for the Environment 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.

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 the Icelandic Forest Service provides information on forests, afforestation and harvested wood products. The AUI assesses other land use categories on the basis of its own geographical database and other available supplementary land use information.

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. Only few country-specific emission factors are available at this time.

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

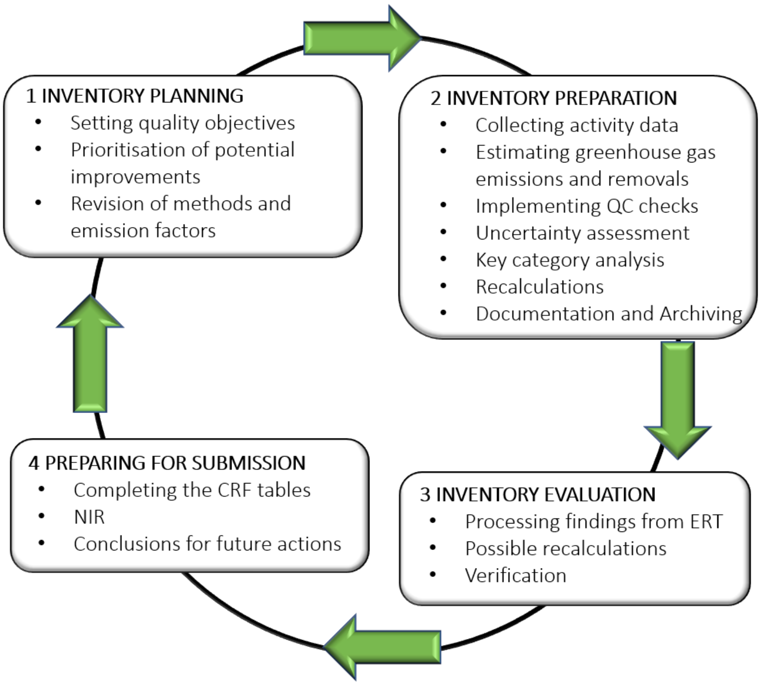


Figure 1.2 Iceland´s annual inventory cycle.

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 review. 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 for the Environment and Natural Resources, 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 2012 running on a separate server. Both servers are running Windows Server 2012 R2.

Each staff member at EA 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 2012 R2. EA´s virtual servers are running on IBM BladeCenter.

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 Sauðákrókur (a town in northern Iceland) and the disaster recovery room storing off-site backups is in Reykjavík city (located in south western 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.
- General QA/QC: during Aether's visit to Iceland in 2019, Aether provided an overview of the general concepts of QA/QC, and the QA/QC plan presented in this submission has largely been developed in collaboration with Aether.
- Participation in capacity building activities proposed by the EU (Yearly sector-specific capacity-building webinars).
- 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.

1.3.5 Capacity and staffing

Additional funding was recently allocated by the Icelandic government to the Environment Agency 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. This brings the capacity of the inventory team to a total of 7.5 positions. 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 as submitted to the EU and the UNFCCC, as well as on the annual air pollutant inventory reported to the Convention on Long-range transport of atmospheric pollutants (CLRTAP).

One full-time person was added to the SCSI LULUCF inventory team in 2020 and increased emphasis was put on the field campaign by hiring temporal staff over the summer months. Plans are to add one additional full-time position at the SCSI in 2021. A 50% position was added at the Icelandic Forest Service for the inventory work in 2019.

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 LULCUF 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 2019	Trend
Energy (CRF sector 1)					
1A2	Fuel combustion - Manufacturing Industries and Construction	CO_2	✓		✓
1A3b	Road Transportation	CO_2	✓	✓	✓
1A4c	Agriculture/Forestry/Fishing	CO_2	✓	✓	✓
1B2d	Fugitive Emissions from Fuels - Other (Geothermal)	CO_2		✓	✓
IPPU (CRF sector 2)					
2C2	Ferroalloys Production	CO_2	✓	✓	✓
2C3	Aluminium Production	CO_2		✓	✓
2C3	Aluminium Production	PFCs	✓		✓
2F1	Refrigeration and Air Conditioning	Aggregate F-gases		✓	
Agriculture (CRF sector 3)					
3A1	Enteric Fermentation - Cattle	CH_4		✓	
3A2	Enteric Fermentation - Sheep	CH_4		✓	
3D1	Direct N_2O Emissions from Managed Soils	N_2O	✓	✓	
Land use, Land use change and Forestry (CRF sector 4)					
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 2019	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	✓	✓	✓
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 inventory 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.

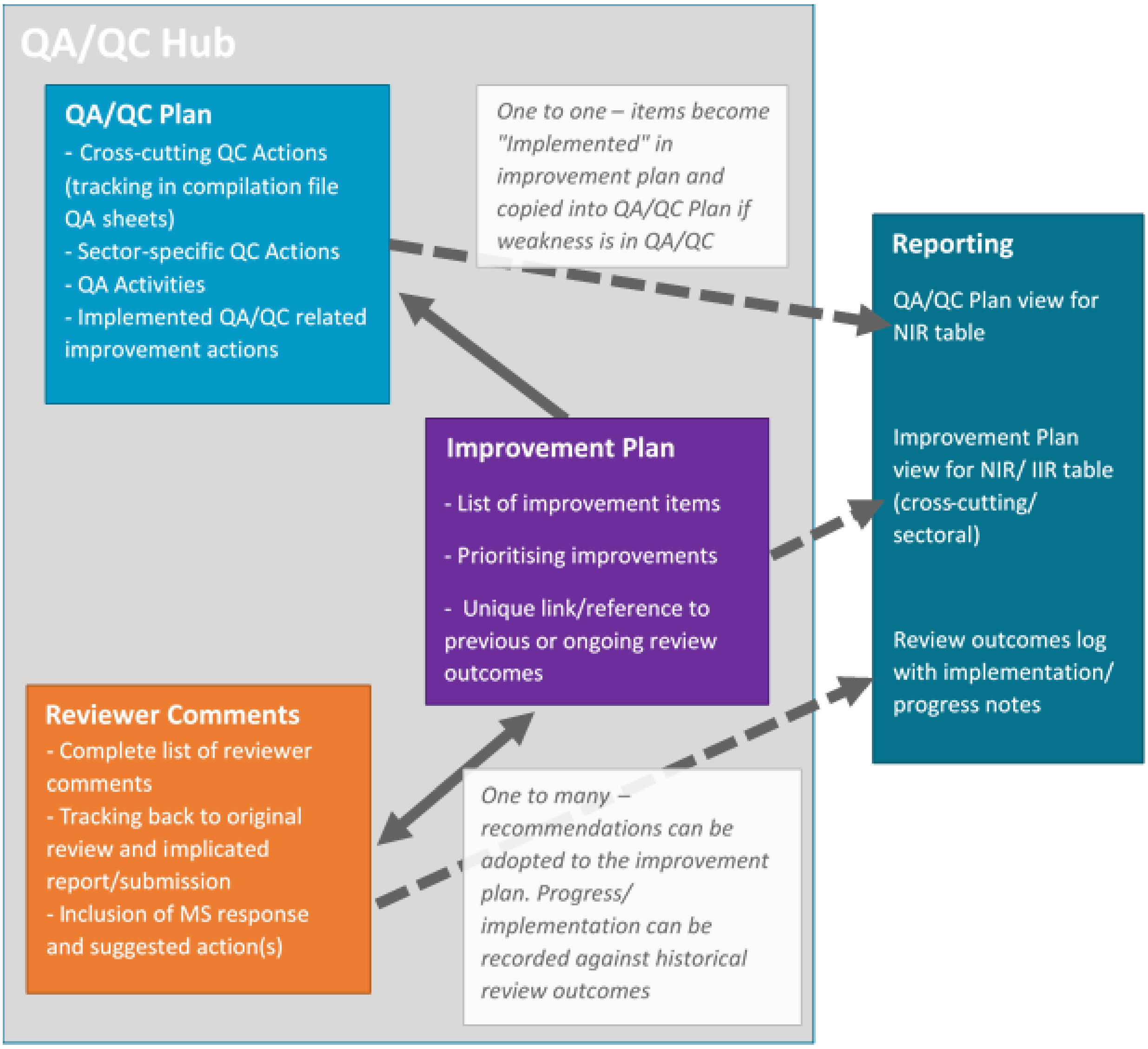


Figure 1.3 Schematic overview of the elements included in the QA/QC hub

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

In the past, the Icelandic inventory team has operated with sectoral lead individuals, supported by a inventory manager. This has been effective at delivering a primarily complete inventory to the required reporting obligations. During the 2018/19 cycle, Iceland made minor alterations to its inventory team roles and responsibilities. The changes were made to reflect the growing importance and prioritization of effectively managing and reporting on inventory QA/QC activities. The ambition is to ensure that Iceland's national inventory reporting be not only complete, but shown to be timely, accurate and transparent, whilst future proofing the inventory against known limitations e.g. due to loss of institutional memory (through staff turnover) and economic / staff capacity.

At a simple level, the inventory will now operate under the inventory project manager. The project manager has overall responsibility for the completion of QA/QC activities and improvements planning. The roles and key responsibilities are outlined below:

- Inventory project manager: overall responsibility for the accurate and timely production and submission of the inventory, according to the rules and deadlines specified in relevant domestic and international legislation; The inventory project manager 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.
- Data manager - responsible for making sure that data acquisition, processing and entry into the CRF portal is done timely
- QC manager - responsible for the annual design and timely implementation of QC activities.
- Sectoral experts - sectoral experts are the main knowledge holders on individual inventory sectors. They are responsible for completion of day-to-day data processing and QC activities. Each sector comprises 2 to 3 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.

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. Furthermore, 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.

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"), 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.

The quality manager 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.

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 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.

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 implemented, 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 1.3 Uncertainties 2019

	With LULUCF		Without LULUCF	
	Uncertainty 2019 [%]	Trend [%]	Uncertainty 2019 [%]	Trend [%]
CO_2	5%	4%	0.03%	0.1%
CH_4	29%	1%	0.1%	0.1%
N_2O	0.1%	0.01%	0.5%	0.1%
HFCs	0.02%	0.1%	0.2%	0.7%
PFCs	0.0004%	0.01%	0.004%	0.2%
SF_6	0.0000004%	0.0000005%	0.000003%	0.00001%
Total GHG	**58.2%**	**17.8%**	**8.7%**	**10.9%**

The total inventory uncertainty is 58% and the trend uncertainty estimate for this submission is 18%. When excluding LULUCF the trend uncertainty is 11% and the total inventory uncertainty is 9 % as can be seen in Table 1.3.

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 2019. With regard to sectoral coverage, all sources considered to be above the threshold of significance[8] are reported. The only instance where the notation key "NE" (Not Estimated) is used is for CH_4 and N_2O emissions from paraffin wax use, due to the lack of available emission factors in the 2006 IPCC Guidelines.

[8] 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 is from gases released from animals (enteric fermentation), a digestive process in herbivores which emits CH_4, and manure management (from the management of animal manure) which contains and emits CH_4 and N_2O. The methods of storage and treatment of manure (the animal waste management systems (AWMS)) 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, this sector focuses on the different carbon pools (areas where carbon is stored). These include living biomass (growing vegetation within an agreed definition), dead organic matter, soil organic matter and harvested wood products. Removals occur through carbon sequestration (absorption of carbon from the atmosphere by growing vegetation), emissions are dominated by wood removals (harvesting and fuelwood), natural disturbances (fires, natural disasters, pests and disease) and land management practices (e.g. ploughing cropland and disturbing the land for settlements etc.). 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[9], 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).

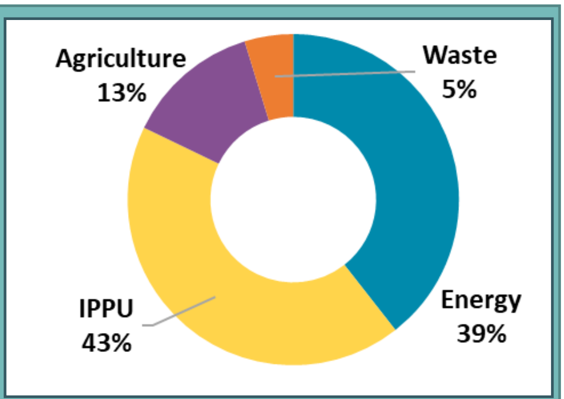
Iceland also reports emissions from indirect GHGs, this includes:

- 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.

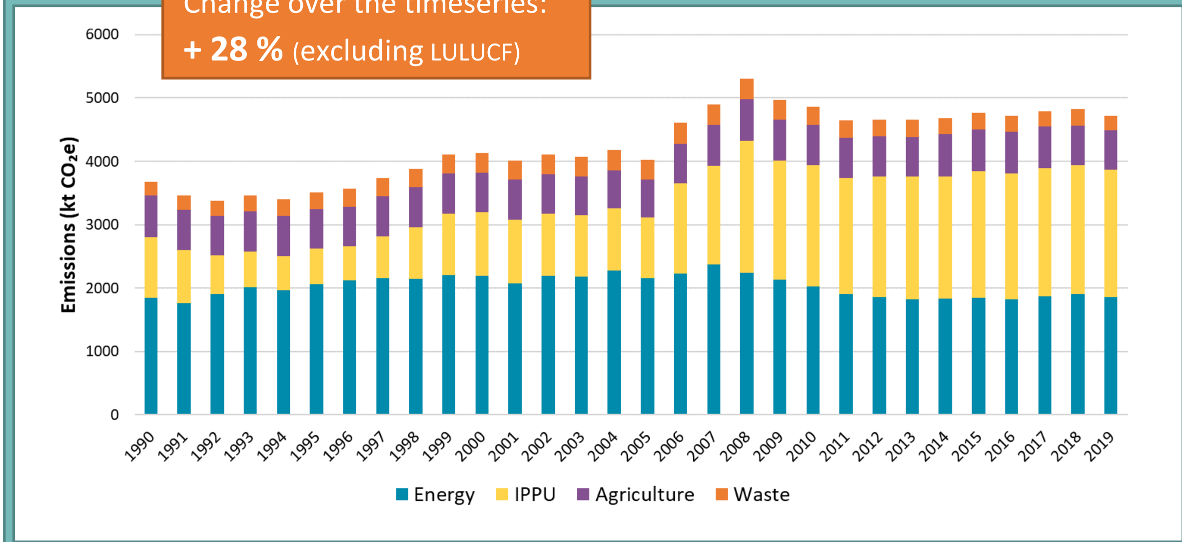
The emission trends from indirect GHGs are presented separately in Section 2.2.

[9] 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.



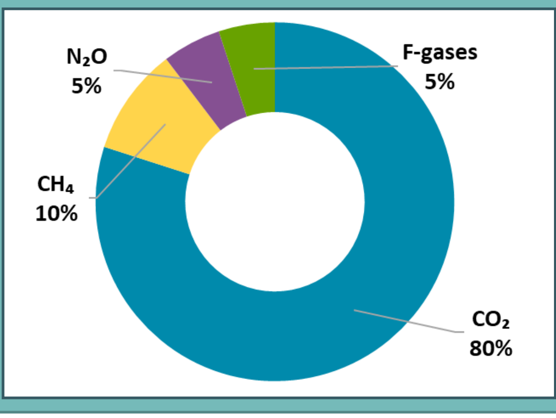
Change over the timeseries:
+ 28 % (excluding LULUCF)



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 CO_2 emissions have increased by almost two thirds. 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 CO_2 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	2018	2019	Changes ´90-´19	Changes ´18-´19
1 Energy	1,849	2,061	2,191	2,164	2,029	1,852	1,913	1,855	0.3%	-3.0%
2 Industrial Processes	958	565	1,010	951	1,911	1,998	2,023	2,024	111%	0.09%
3 Agriculture	657	617	624	603	630	653	632	619	-5.8%	-2.1%
4 Land Use, Land Use Change and Forestry (LULUCF)	9,192	9,161	9,184	9,233	9,294	9,204	9,106	9,072	-1.3%	-0.4%
5 Waste	219	270	302	304	296	261	255	224	2.3%	-12%
Total without LULUCF	**3,683**	**3,513**	**4,127**	**4,022**	**4,866**	**4,764**	**4,823**	**4,722**	**28%**	**-2.1%**
Total with LULUCF	**12,875**	**12,674**	**13,311**	**13,255**	**14,160**	**13,968**	**13,929**	**13,794**	**7.1%**	**-1.0%**
Memo items	240	241	466	427	380	830	1,540	1,171	388%	-24%

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.

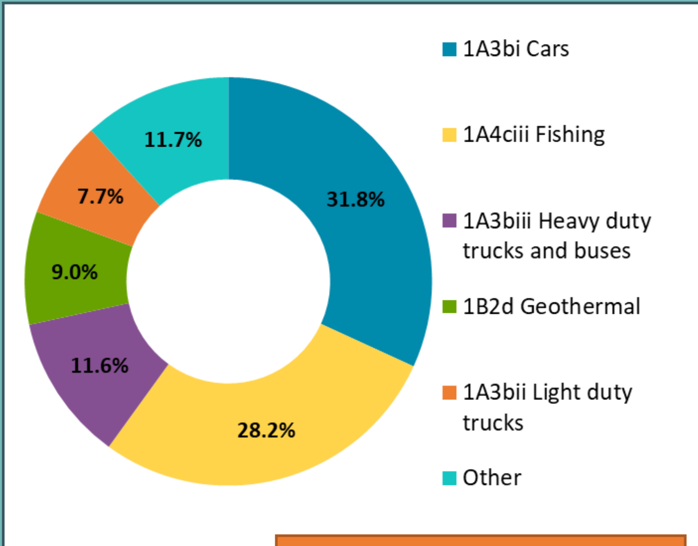
Table 2.2 Emissions of GHG gases by gas for the reported time series (without LULUCF) (kt CO_2e).

GHG	1990	1995	2000	2005	2010	2015	2018	2019	Changes ´90-´19	Changes ´18-´19	% Total in latest year
CO_2	2,228	2,467	2,932	2,976	3,625	3,536	3,663	3,551	59%	-3%	75%
CH_4	602	629	657	647	655	630	609	569	-5%	-6%	12%
N_2O	357	343	343	311	306	313	307	296	-17%	-4%	6%
PFCs	495	69	150	31	172	104	76	97	-80%	27%	2%
HFCs	0.3	3.4	44	56	105	180	163	207	60129%	27%	4%
SF_6	1.1	1.2	1.3	2.5	4.7	1.6	3.3	2.0	82%	-39%	0%
Total	**3,683**	**3,513**	**4,127**	**4,023**	**4,866**	**4,764**	**4,822**	**4,722**	**28%**	**-2%**	**100%**

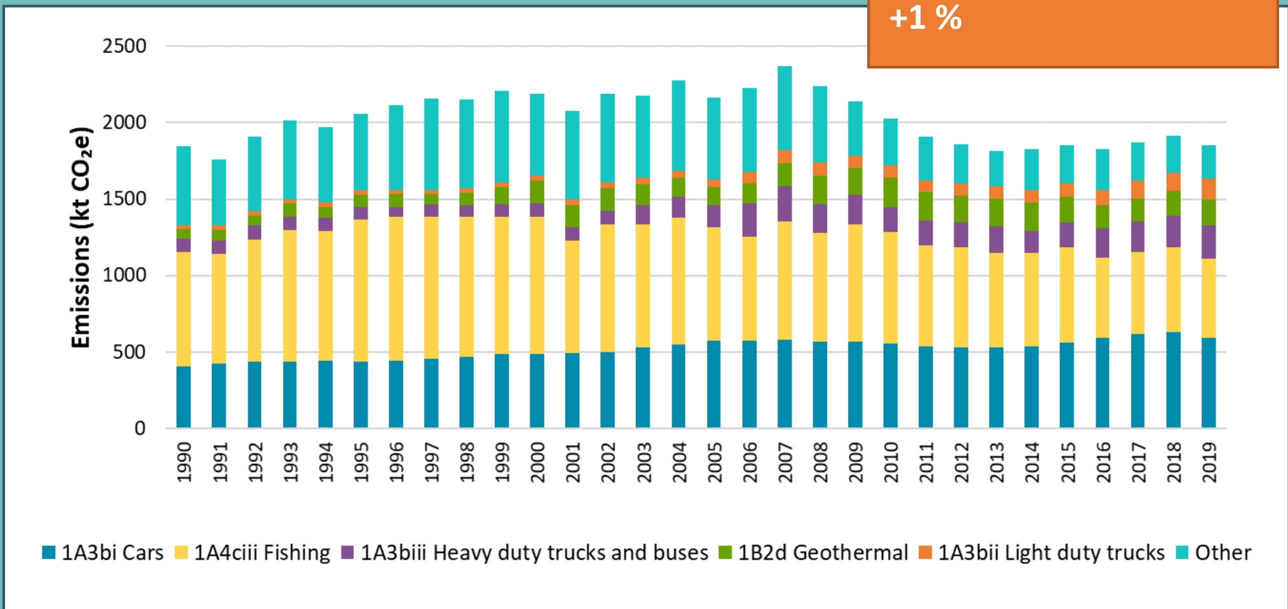
2.1.1 Energy (CRF sector 1)

39 % 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: **+1 %**



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.

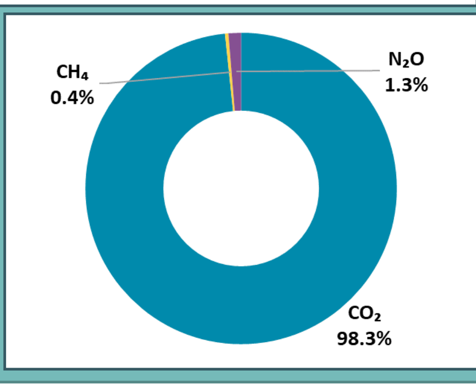


Figure 2.2 Overview of emissions from the Energy sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year

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 decrease 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 3-4% 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 is 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.

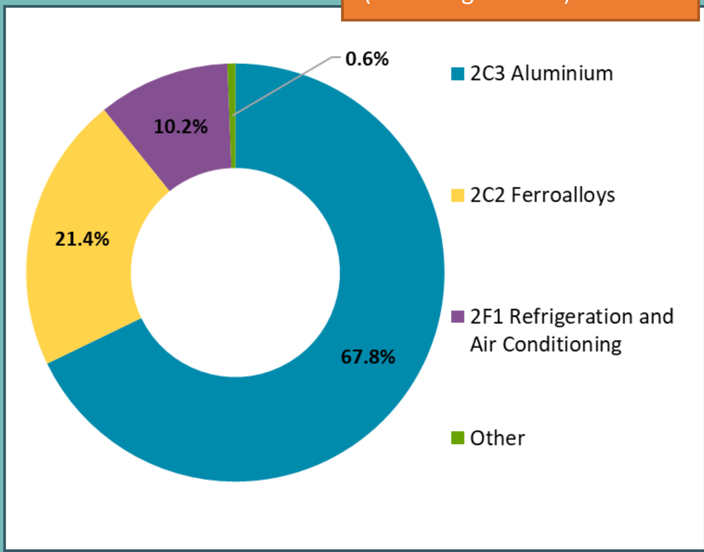
Table 2.3 Total GHG emissions from the Energy sector for the reported time series (kt CO_2e).

Energy Sector	1990	1995	2000	2005	2010	2015	2018	2019	Changes ´90-´19	Changes ´18-´19
1A1 Energy industries	13.5	18.8	11.2	8.0	14.0	4.2	2.4	5.0	-63%	110%
1A2 Manufacturing industry and construction	373	383	446	426	203	180	150	91	-76%	-40%
1A3 Transport	617	618	649	816	863	868	1,040	1,034	67%	-0.6%
1A3a Domestic Aviation	33.6	30.3	28.5	26.2	21.3	20.6	24.8	28.0	-17%	13%
1A3b Road transport	523	550	608	767	806	820	971	952	82%	-2.0%
1A3d Navigation	60.4	37.7	12.7	22.7	35.5	26.8	43.8	53.5	-11%	22%
1A4 Other Sectors (fishing)	783	956	925	765	740	632	560	557	-29%	-0.5%
1A4a Commercial/institutional	8.1	7.8	6.8	5.0	1.7	2.1	0.7	1.2	-85%	68%
1A4b Residential Stationary	28.3	22.2	21.4	13.2	8.5	6.0	7.5	7.1	-75%	-4.8%
1A4diii Fishing	746	926	897	746	730	624	552	522	-30%	-5.4%
1A5 Other	0.1	1.6	4.6	29.0	14.0	0.2	0.5	1.7	1284%	222%
1B2 Fugitive Emissions from Fuels (incl. Geothermal energy)	62	83	155	120	195	168	160	167	169%	4.5%
1B2d Geothermal	62	82	154	119	194	167	159	166	170%	4.6%
Total emissions (kt CO_2e)	**1,849**	**2,061**	**2,191**	**2,164**	**2,029**	**1,852**	**1,913**	**1,855**	**0.3%**	**-3.0%**
International aviation (memo)	221	238	411	425	380	680	1,296	965	336%	-26%
International navigation (memo)	19.0	3.4	54.7	1.8	0.3	150	244	207	986%	-15%
CO_2 from biomass (memo)	NO	NO	NO	1	2	43	59	58	-	1%

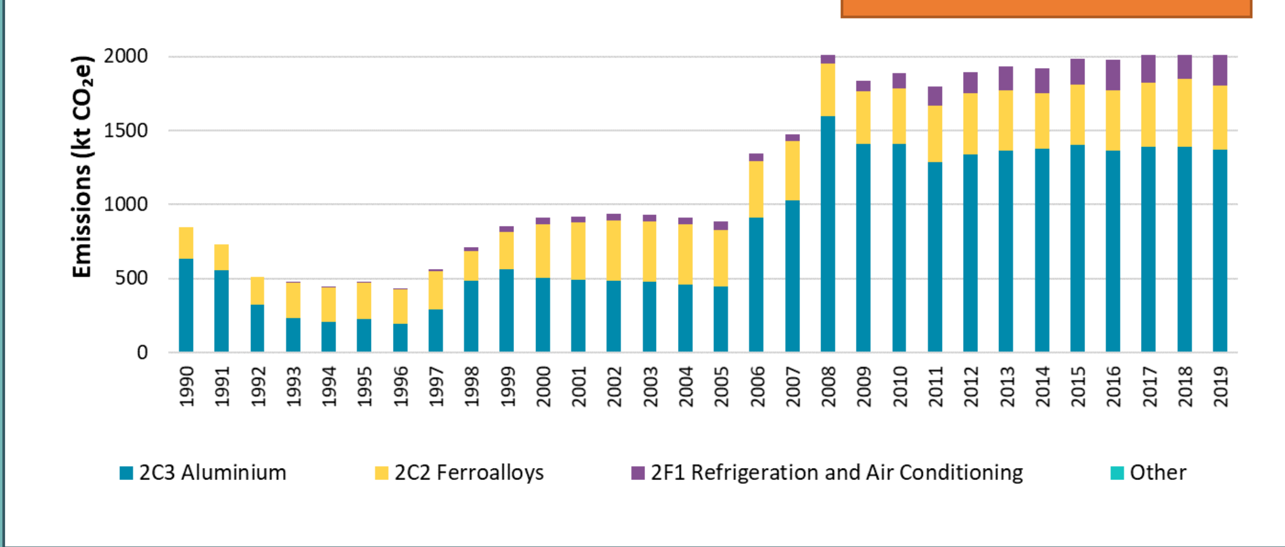
2.1.2 Industrial Processes and Product Use (CRF sector 2)

43 % 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: **+111 %**



Large part of the GHG emissions are 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.

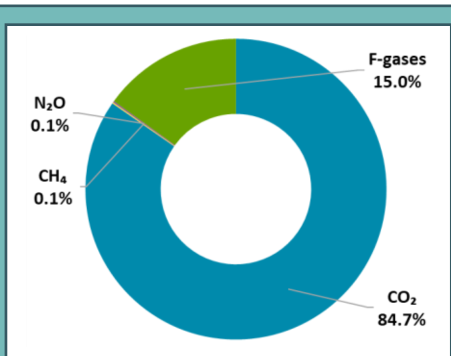


Figure 2.3 Overview of emissions from the IPPU sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year

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, perfluorocarbon (PFC) and hydrofluorocarbons (HFCs). 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. HFCs are used as substitutes for ozone depleting substances (ODS) in refrigeration systems.

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)

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, or by 104.7% 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, thus emissions from this subsector are expected to increase in coming years.

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 down 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 since then. 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 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	2018	2019	Changes ´90-´19	Changes ´18-´19
2A Mineral products	52	38	65	55	10	0.7	0.9	1.0	-98%	5.7%
2B Chemical industry	47	41	18	NO	NO	NO	NO	NO	NA	NA
2C Metal production	844	469	868	828	1,781	1,807	1,846	1,806	114%	-2.2%
2D Non-Energy Products from Fuels and Solvent Use	6.8	7.4	7.4	6.9	5.1	5.7	6.2	5.6	-18%	-10.4%
2F Product Uses as Substitutes for Ozone Depleting Substances	0.3	3.4	44	56	105	180	163	207	60147%	27%
2G Other Product Manufacture and Use	7.2	5.8	6.3	6.5	8.6	4.9	6.3	4.9	-33%	-23%
Total	**958**	**565**	**1,010**	**951**	**1,911**	**1,998**	**2,023**	**2,024**	**111%**	**0.1%**

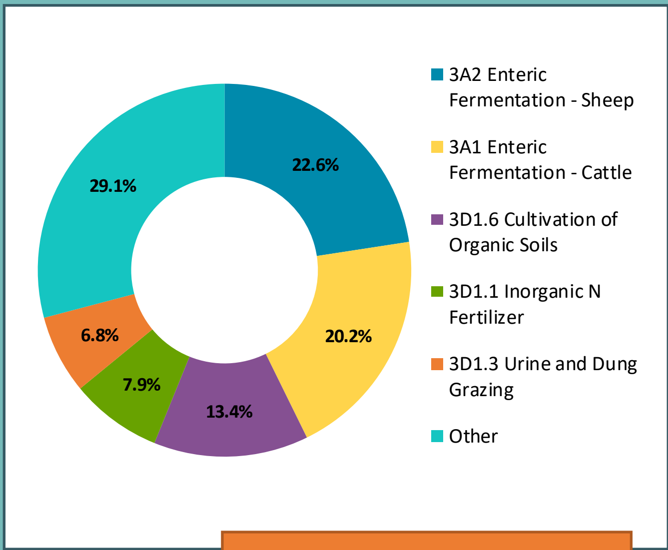
Table 2.5 Total HFC, PFC and SF_6 emissions from F gas consumption (kt CO_2e).

GHG	1990	1995	2000	2005	2010	2015	2018	2019	Change ´90-´19	Change ´18-´19
HFCs	0.3	3.4	44	56	105	180	163	207	60129%	27%
PFCs	495	69	150	31	172	104	76	97	-80%	27%
SF_6	1.1	1.2	1.3	2.5	4.7	1.6	3.3	2.0	82%	-39%

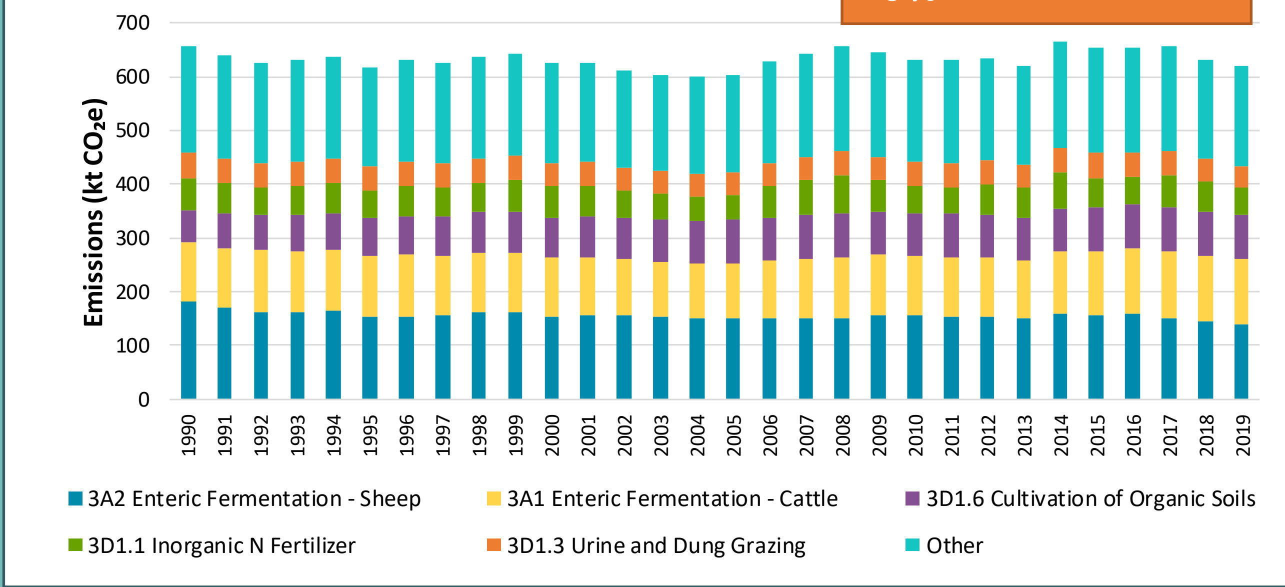
2.1.3 Agriculture (CRF sector 3)

13 % of total emissions (excluding LULUCF)

Emissions are dominated by agricultural soils and enteric fermentation across the time series. Approximately 60% of emissions from enteric fermentation are from cattle, the next most significant livestock categories are sheep and horses.



Change over the timeseries: **- 6 %**



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.

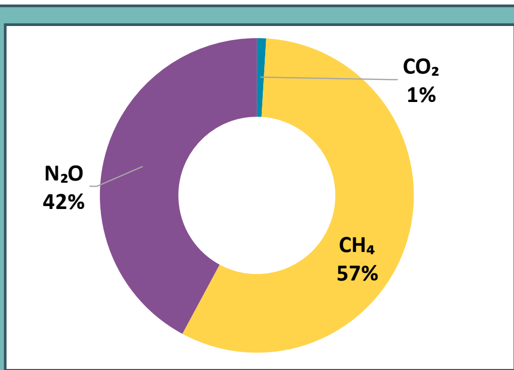


Figure 2.4 Overview of emissions from the agriculture sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year

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.

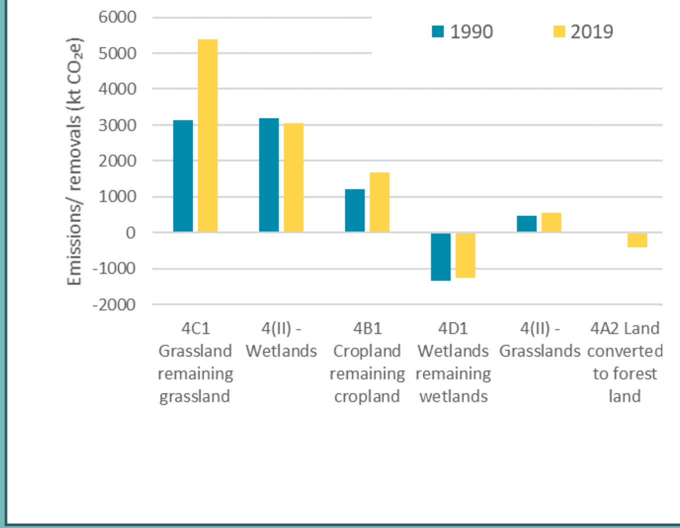
Table 2.6 GHG emissions from agriculture sector for the reported time series (kt CO_2e).

Agriculture Sector	1990	1995	2000	2005	2010	2015	2018	2019	Changes ´90-´19	Changes ´18-´19
3A Enteric Fermentation	326	303	298	289	303	314	301	297	-9.1%	-1.5%
3B Manure management	82	75	75	72	75	78	76	74	-9.4%	-2.4%
3D Agricultural Soils	248	239	252	238	250	257	252	242	-2.4%	-3.8%
3G Liming	0.46	0.0001	0.04	1.8	0.3	2.1	1.6	3.7	700%	137%
3H Urea Application	0.06	0.06	0.07	0.07	0.13	0.2	0.02	0.22	301%	966%
3I Other C-containing fertilizers	NE	NE	NE	2.3	1.7	1.2	1.6	1.9	NA	21%
Total	**657**	**617**	**624**	**603**	**630**	**653**	**632**	**619**	**-5.8%**	**-2.1%**

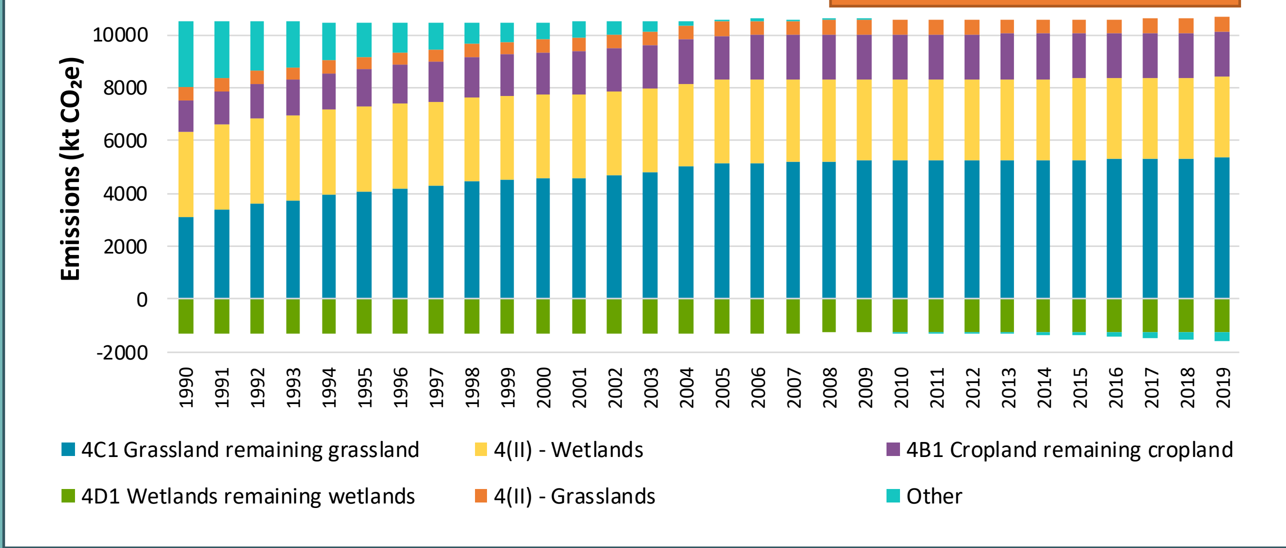
2.1.4 Land Use, Land-Use Change and Forestry (LULUCF, CRF sector 4)

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: **-1 %**



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

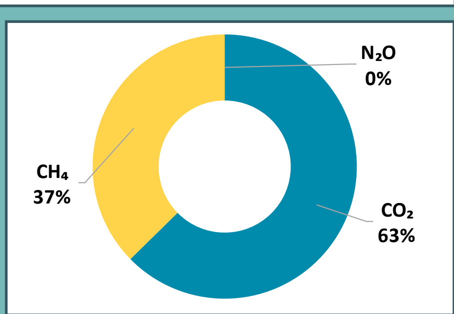


Figure 2.5 Overview of emissions and removals from the LULUCF sector, from top to bottom: (1) absolute emission and removals by subsector for the latest year, (2) emission and removals by subsector over the time series and (3) absolute emissions and removals by gas for the latest year

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.

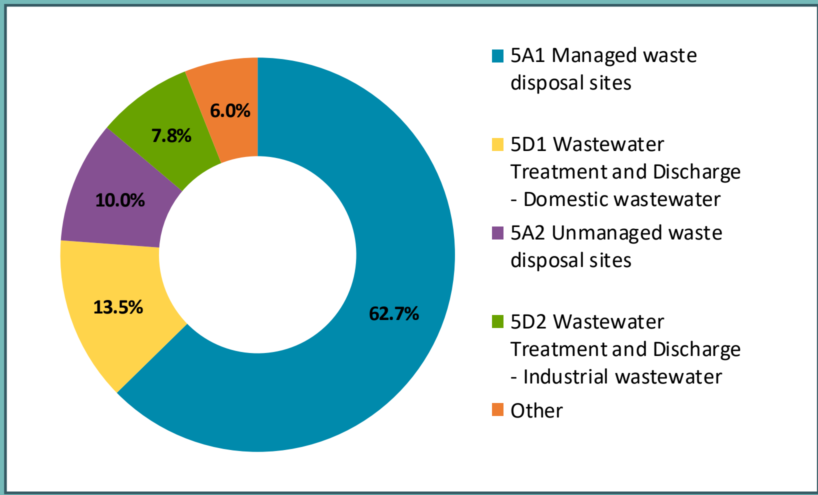
Table 2.7 GHG emissions and removals from the LULUCF sector for the reported time series (kt CO_2e).

LULUCF Sector	1990	1995	2000	2005	2010	2015	2018	2019	Changes ´90-´19	Changes ´18-´19
4A Forest Land	-43	-67	-102	-153	-208	-313	-403	-446	932%	11%
4B Cropland	1,975	1,962	1,949	1,936	1,923	1,911	1,904	1,901	-3.7%	-0.1%
4C Grassland	5,372	5,375	5,455	5,572	5,755	5,789	5,800	5,809	8.1%	0.2%
4D Wetlands	1,872	1,877	1,864	1,845	1,818	1,810	1,799	1,802	-3.7%	0.2%
4E Settlements	16	13	18	35	5.8	5.9	5.9	5.9	-64%	0.0%
4F Other Land	NA,NE	NA,NE	NA,NE	NA,NE	NE,NA	NE,NA	NE,NA	NE,NA	NA	NA
4G Harvested Wood Products	NO,NA	NO,NA	0.0004	-0.0002	-0.03	-0.12	-0.15	-0.03	NA	-81%
Total	**9,192**	**9,161**	**9,184**	**9,233**	**9,294**	**9,204**	**9,106**	**9,072**	**-1.3%**	**-0.4%**

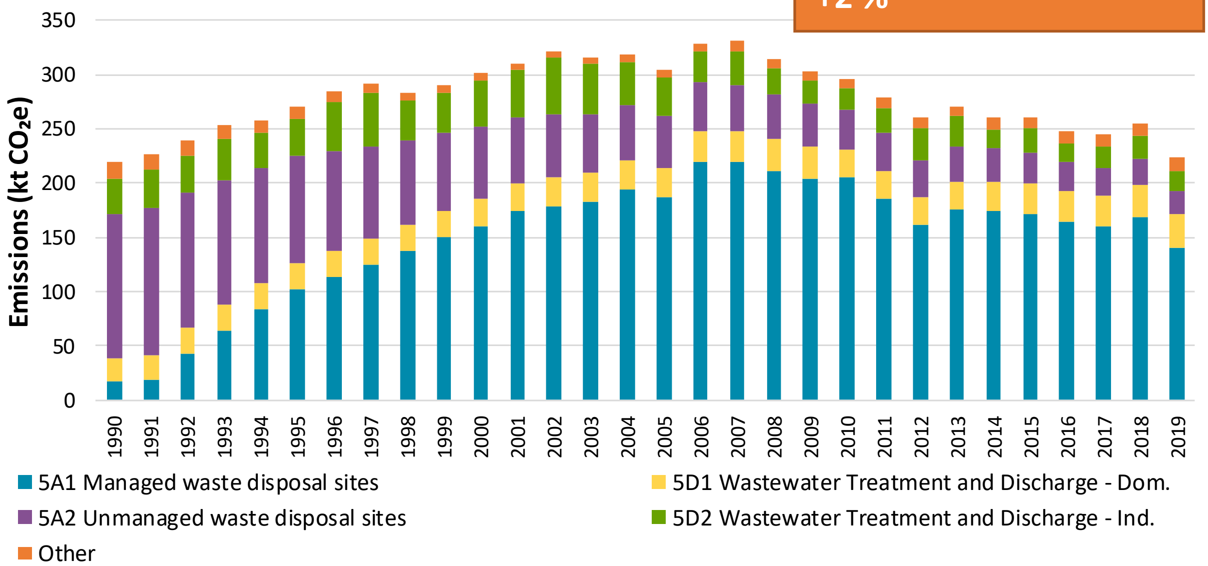
2.1.5 Waste (CRF sector 5)

5 % of total emissions (excluding LULUCF)

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.



Change over the timeseries: **+2 %**



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

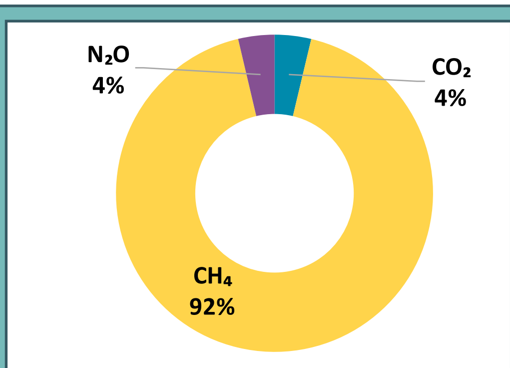


Figure 2.6 Overview of emissions from the waste sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year

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	2018	2019	Changes ´90-´19	Changes ´18-´19
5A Solid Waste Disposal	150	201	227	234	243	200	193	163	8.8%	-16%
5B Biological Treatment of Solid Waste	NO	0.3	0.3	0.9	2.6	3.7	4.1	4.1	NA	-0.6%
5C Incineration and Open Burning of Waste	15	10	6.0	5.5	6.5	7.1	6.8	9.4	-38%	37%
5D Wastewater Treatment and Discharge	55	59	68	64	45	50	51	48	-12%	-6.3%
Total	**219**	**270**	**302**	**304**	**296**	**261**	**255**	**224**	**2.2%**	**-12%**

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[10]. 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 sources 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 aluminium production.

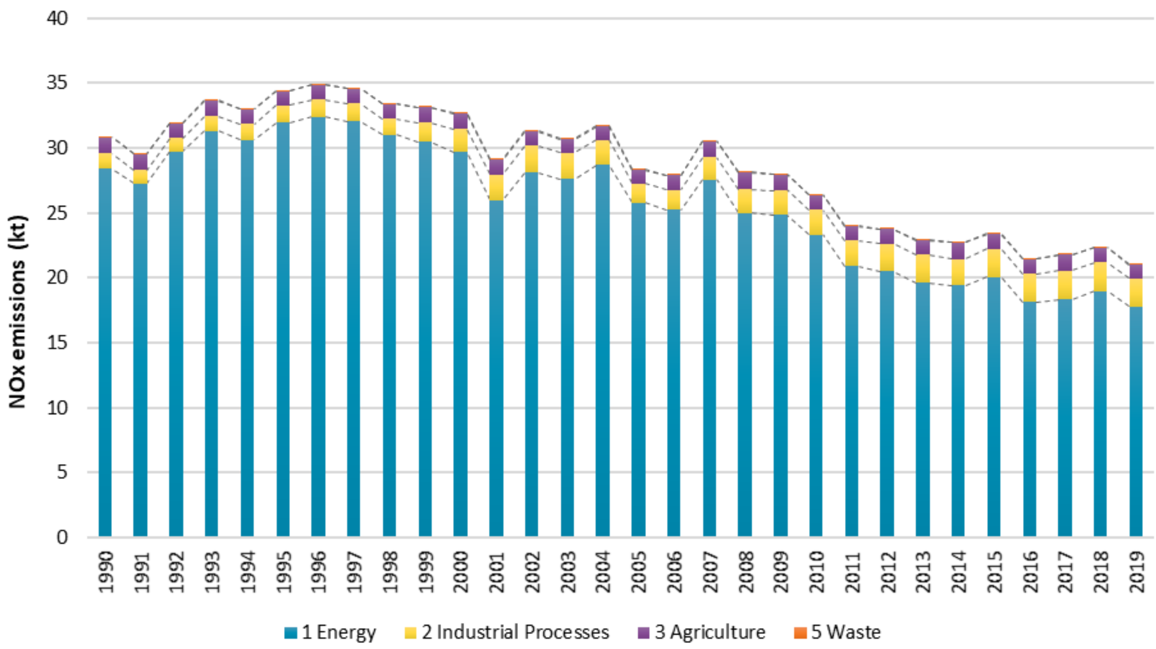


Figure 2.7 Emissions of NOX by sector for the reported time series (kt).

2.2.2 Non-Methane Volatile Organic Compounds (NMVOC)

The main sources of NMVOCs are the Energy sector, followed by Agriculture and Industrial processes 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.

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

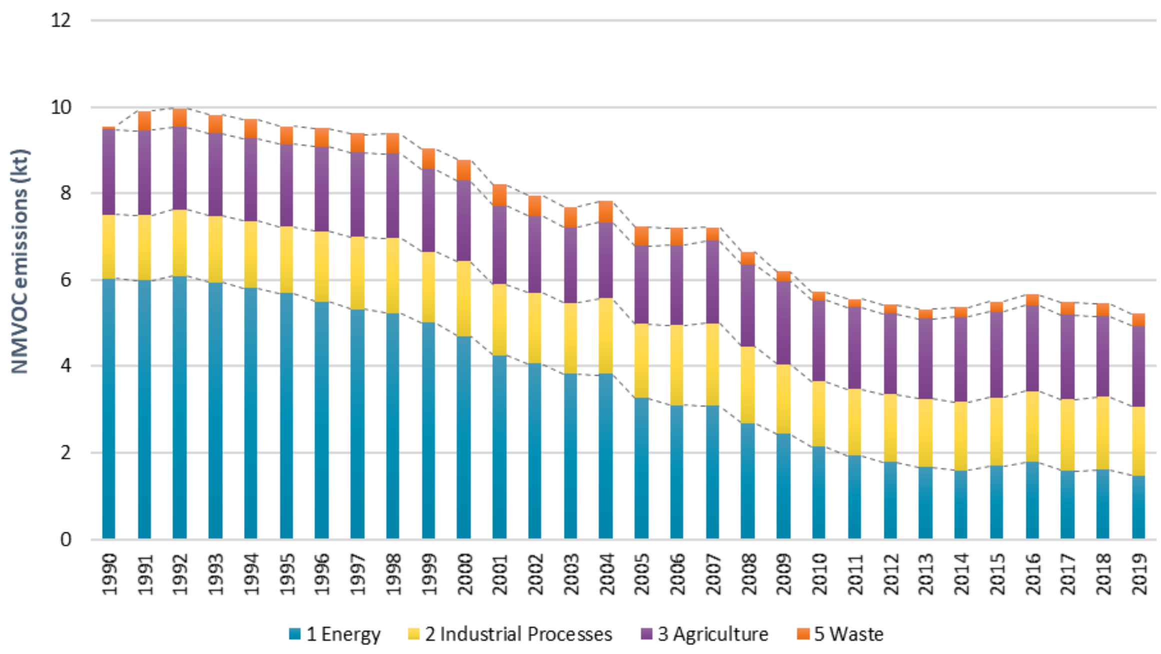


Figure 2.8 Emissions of NMVOC by sector for the reported time series (kt).

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

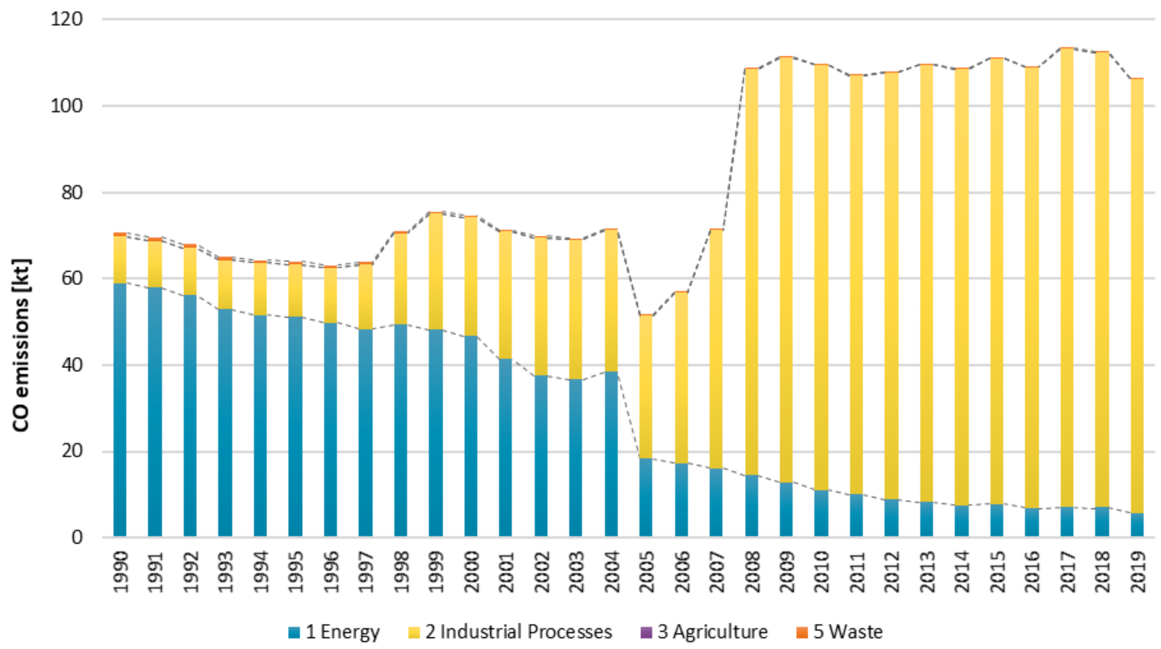


Figure 2.9 Emissions of CO by sector for the reported time series (kt).

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.

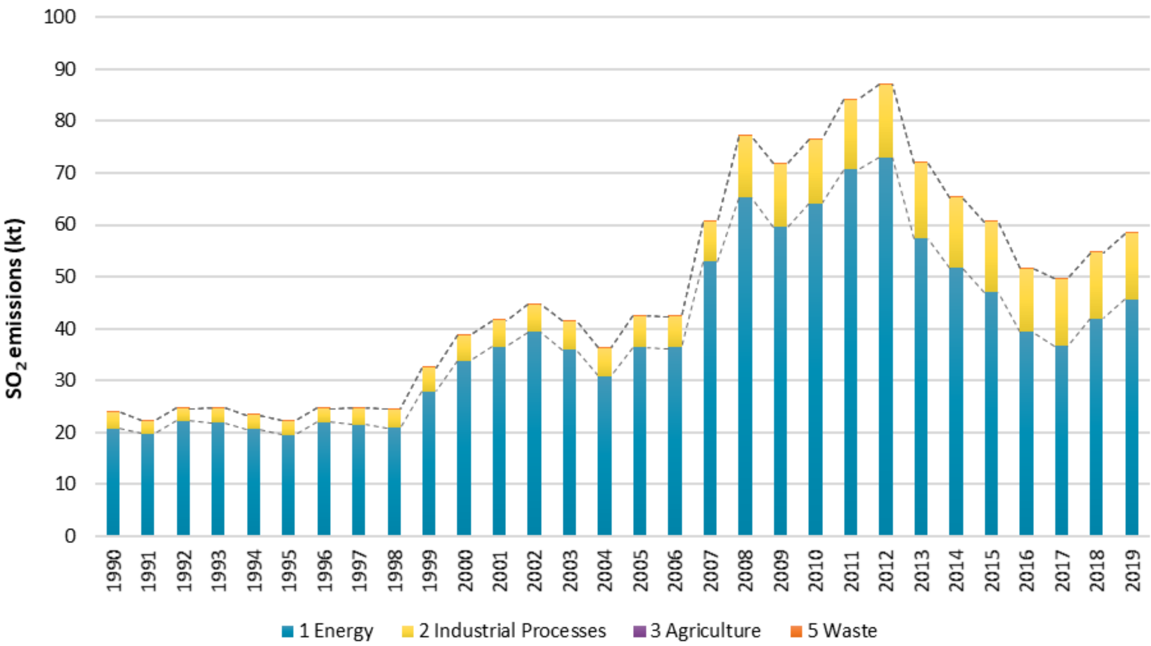


Figure 2.10 Emissions of S (sulphur) by sector for the reported time series (kt SO_2e).

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 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. A summary of the energy sector is provided below together with references to the method statement which are included in Section 3.3.

Table 3.1 Energy method summary

1 Energy Greenhouse Gas Source and Sink Categories	Estimated Gases	% Total Emissions*	Key Categories	Tier/ NK	MS reference	Notes
A. Fuel Combustion Activities						
1. Energy Industries						
a. Public electricity and heat production	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	0.1	N	T1	1	
b. Petroleum Refining		-	N	NO	-	
c. Manufacture of Solid Fuels and Other Energy Industries		-	N	NO	-	
2. Manufacturing Industries and Construction						
a. Iron and Steel	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	0.04	Y	T1	2	1A2 combined is a key category
b. Non-Ferrous Metals	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	0.2	Y	T1	2	1A2 combined is a key category
c. Chemicals	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	-	Y	T1	2	Not occurring since 2004.
d. Pulp, Paper and Print		-	N	NO	-	
e. Food Processing, Beverages and Tobacco	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	0.3	Y	T1	2	1A2 combined is a key category
f. Non-Metallic Minerals	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	0.01	Y	T1	2	1A2 combined is a key category
g. Transport Equipment	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	1.2	Y	T1	2	1A2 combined is a key category
3. Transport						
a. Domestic Aviation	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	0.6	Y	T1	3	
b.i. Cars		12.5	Y		4	

1 Energy Greenhouse Gas Source and Sink Categories	Estimated Gases	% Total Emissions*	Key Categories	Tier/ NK	MS reference	Notes
b.ii. Light duty trucks	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	3.0		T2, T3		1A3b combined is a key category
b.iii. Heavy duty trucks and buses		4.6				
b.iv. Motorcycles		0.1				
b.v. Other		-	N	NO	-	
c. Railways		-	N	NO	-	
d. Water-borne Navigation	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	1.1	N	T1	5	
e. Other Transportation		-	N	IE	-	Fuel use and emissions associated ground activities in airports are marked as IE and are included in subsector 1A2gvii “off-road vehicles and other machinery”
4. Other Sectors						
a. Commercial/Institutional	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	0.03	N	T1	6	
b. Residential		0.2	Y	T1	6	
ci. Agriculture		-	N	NO		
cii. Forestry		0.6	N	T1	2	
ciii. Fishing	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	11	Y	T1	5	
5. Non-specifed						
a. Stationary	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	0.04	N	T1	2	Unspecified categories for all fuels from the NEA
b. Mobile		-	N	NO	-	
c. Multilateral Operations		-	N	NO	-	
B. Fugitive emissions from fuels						
1. Solid Fuels						
a. Coal mining and handling			N	NO	-	
b. Uncontrolled combustion and burning coal dumps			N	NO	-	
c. Fuel transformation			N	NO	-	
2. Oil and Natural Gas						
a. Oil	CO_2, CH_4, NMVOC	-	N	T1	7	
b. Natural Gas Systems	-	-	N	NO	-	
d. Geothermal	CO_2, CH_4, SO_2	3.5	Y	T1	8	

1 Energy Greenhouse Gas Source and Sink Categories	Estimated Gases	% Total Emissions*	Key Categories	Tier/ NK	MS reference	Notes
3. Other emissions from Energy Production						
Other emissions from Energy Production		-	N	NO	-	
C. Carbon dioxide Transport and Storage						
1. Transport of CO_2		-	N	NO	-	
2. Injection and Storage		-	N	NO	-	
3. Other		-	N	NO	-	
Memo items:						
International bunkers						
International aviation	CO_2, CH_4, N_2O, NO_X, CO, NMVOC, SO_2	-	N	T1	3	
Navigation		-	N	T1	5	
Multilateral operations		-	N	-	-	
CO_2 emissions from biomass	CO_2	-	N	T1	-	
CO_2 captured		-	N	-	-	

*Note: NK = notation key, MS = method statement, T = tier, * percentage of total emissions without LULUCF in the most recent inventory year, ** Square root of the sum of the contribution to variance by category in the latest year*

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. Activity data is provided by the National Energy Authority (NEA), which collects data from the oil companies on fuel sales by sector. In all calculations, the oxidation factor was set to the default value of 1.

Emissions from Road Transport are estimated using COPERT 5.4.36. which uses a tier 3 methodology to estimate N_2O and CH_4 emissions, and a tier 2 methodology to estimate CO_2 emissions. This is the first submission where a tier 2 method has been used to estimate CO_2 emissions from road transport because Iceland has now made measurements on the carbon content in fossil fuels used. A more detailed description can be found in chapter 3.3.4, Method Statement 4: Road Transport.

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 this 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 is 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 (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.

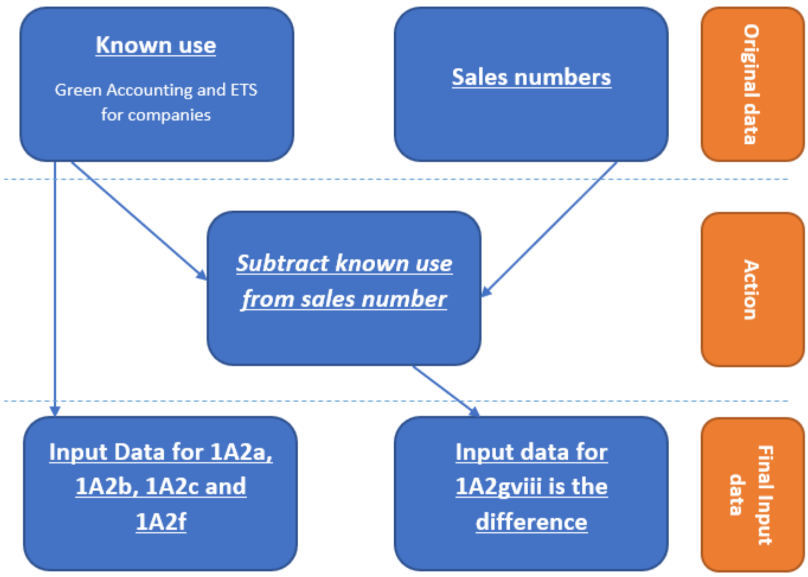


Figure 3.1 Description of adjustments in input data for IPCC category 1A2

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.

3.1.2 Key category analysis

The key categories for 1990, 2019 and 1990-2019 trend in the Energy sector are as follows (compared to total emissions without LULUCF):

Table 3.2 Key category analysis for the Energy sector

IPCC source category		Gas	Level 1990	Level 2019	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	✓	✓	✓
1A4b	Residential Combustion	CO_2			✓
1A4c	Agriculture/Forestry/Fishing	CO_2	✓	✓	✓
1B2d	Fugitive Emissions from Fuels - Other (Geothermal)	CO_2	✓	✓	✓

3.1.3 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
- 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.

3.1.4 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.
- It is planned to assess the use of the Eurocontrol dataset for estimating emissions from the aviation 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 Statistics Iceland to obtain this data.
- It is planned to send the Energy chapter for review by national stakeholders.

3.2 Cross-Cutting Issues

3.2.1 Sectoral versus 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 3.1.1for 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.

3.2.2 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.

3.3 Method Statements

3.3.1 Method Statement 1: Energy Industries

MS 1: Energy Industries (1A1ai & 1A1aiii)
Relevant Categories
1A1ai: Electricity Generation 1A1aiii: Heat Plants
Relevant Gases
CO_2; SO_2; CH_4
Relevant fuels, activities
Hydropower, Geothermal energy, Fuel combustion and Wind power
Background
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 has to 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 3.3), 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 3.3 Electricity production in Iceland (GWh).

	1990	1995	2000	2005	2010	2015	2018	2019
Hydropower	4,159	4,677	6,350	7,015	12,592	13,781	13,813	13,462
Geothermal	283	288	1,323	1,655	4,465	5,003	6,010	6,018
Fuel combustion	5.6	8.4	4.4	7.8	1.7	3.9	1.9	2.7
Wind power	0	0	0	0	0	11	4	7
Total	**4,447**	**4,974**	**7,678**	**8,678**	**17,059**	**18,799**	**19,829**	**19,490**

Note: Emissions from hydropower reservoirs are included in the LULUCF sector and emissions from geothermal power plants are reported in sector 1B2d (see Method Statement 8).

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.

Data sources

Activity data

1A1ai: Electricity Generation: Activity data for whole timeseries is sales numbers for fuel sold for electricity production from the NEA. In 2019 approx. 0.02% of the electricity in Iceland was produced with fuel combustion. Activity data for fuel combustion and the resulting emissions are given in Table 3.4.

Table 3.4 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e.), from electricity production.

	1990	1995	2000	2005	2010	2015	2018	2019
Gas/Diesel oil (kt)	1.300	1.091	1.065	0.021	1.01	1.19	0.742	1.24
Residual fuel oil (kt)	NO	NO	NO	NO	NO	NO	NO	NO
Biomethane (kt)	NO	NO	NO	0.294	NO	NO	NO	NO
Biodiesel (kt)	NO	NO	NO	NO	NO	NO	0.016	NO
Emissions (kt CO_2e)	**4.15**	**3.49**	**3.40**	**0.068**	**3.23**	**3.79**	**2.38**	**3.96**

1A1aiii: Heat Plants: Activity data for heat production with fuel combustion and waste incineration and the resulting emissions are given in Table 3.5. 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 3.5 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e.) from heat production

	1990	1995	2000	2005	2010	2015	2018	2019
Gas/Diesel oil	NO	NO	NO	NO	NO	NO	NO	0.326
Residual fuel oil	2.99	3.08	0.122	0.195	NO	0.137	NO	NO
Biodiesel	NO	NO	NO	NO	NO	NO	NO	0.018
Solid waste	NO	4.65	6.05	5.95	8.11	NO	NO	NO
Emissions (kt CO_2e)	**9.37**	**15.3**	**7.78**	**7.89**	**10.79**	**0.430**	**NO**	**1.044**

Emission Factors

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 oil is used the IEF is considerably higher than in normal 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 and biodiesel 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.

The CO_2 emission factor for waste incineration was calculated using Tier 2 methodology and default values from the 2006 Guidelines. 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.

SO_2 is calculated from the S-content of the fuels. CH_4 is based on the default for large diesel fuel engines (3 kg/TJ). Default emission factors (EFs) were used where EFs are missing. Emission factors are presented in Table 3.6 along with the sulphur content of the fossil fuels.

Table 3.6 Emission factors for CO_2 from fuel combustion and S-content of fossil fuels for 2019

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t fuel]	S-content [%]
Gas/Diesel oil	43.1*	20.2	1	3.18	0.2%
Residual Fuel Oil	40.4	21.1	1	3.13	1.8%
Biomethane	50.4	14.9	1	2.75	-
Biodiesel	43.5	19.3	1	3.08	-
Solid waste	10	38.5[1]	1	1.24[1]	0.1%

*Note: * Country-specific value, [1] Mean values. Annual values vary depending on fossil carbon content of waste incinerated.*

Method approach

The calculation of direct greenhouse gases for the sources covered by this MS is:
Iceland Emissions = EF x AD
The sources of emission factors and activity data are summarised under “key data sources” above. The activity data are taken from NEA, noting the exceptions set out under Assumptions & observations, below.

Method Changes

Yes, for 1990-2002

Assumptions & observations

Activity data for the years 1990 - 2002 has been reassessed by the EA, following the same methodology which was used for 2003 and onwards in last submission.

Recalculation
Yes
Recalculation justification & summary of change
1A1ai: Electricity Generation: Recalculations were performed for this sector for the time period 1990-2002. This was due to the review of the activity data which now includes fuel sold instead of calculated fuel use based on kWh produced. This changed the amount of diesel used for electricity production, as well as added residual fuel oil for some years. This recalculation caused at maximum a ±0.5 kt CO_2e change in emissions depending on the years between 1990-2002 between the current submission and last submission, which amounts to <0.05% of total emissions from energy. *1A1aiii: Heat Plants:* Recalculations were performed for this sector for the time period 1996-2002. This was due to the review of the activity data which now includes fuel sold. This changed the amount of residual fuel oil used in heat plants. This recalculation caused at maximum a ±0.25 kt CO_2e change in emissions depending on the years between 1996-2002 between the current submission and last submission, which amounts to approximately 0.01% of total emissions from energy.
Improvements
Activity data from the NEA was refined to include a further separation of activity data in the context of energy production, where we have a more detailed separation between fuel used for house heating and for electricity production, which did not exist before 2019.
QA/QC processes
See section 3.1.2
Time series consistency issues
In the years before 2019 activity data for house heating and electricity production was separated by expert judgement from the NEA but for 2019 (and onwards) this is separated in the sales statistics.
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.
Verification
No verification has been undertaken.

3.3.2 Method Statement 2: Manufacturing Industries and Construction & Other (1A5)

MS 2: Manufacturing Industries and Construction (1A2 & 1A4cii) & Other (1A5)
Relevant Categories
1A2: Manufacturing Industries and Construction: Table 3.7 shows the structure of the CRF sector 1A2, and the industries included in the various subcategories. *1A4cii Agriculture - Off-road vehicles and other machinery:* - This category was previously reported under 1A2gvii but will be estimated separately from 2019. *1A5a: Stationary, Other:* Note that 1A5b and 1A5c do not occur in Iceland.

Table 3.7 Overview of 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
1A2g	Other	(see subcategories below)
1A2gv	Construction	IE (1990-2018, included in 1Agvii Off-road vehicles and other machinery), Construction from 2019
1A2gvii	Off-road vehicles and other machinery	All off-road machinery for 1990-2018 (including from agriculture/forestry subsectors)
1A2gviii	Other	All production that is not attributed to any of the other 1A2 subcategories.

Relevant Gases

CO_2, CH_4, N_2O

Relevant fuels, activities

Stationary and mobile combustion. Gas/diesel oil, residual fuel oil, LPG, waste oil, petroleum coke, other bituminous coal and biodiesel.

Background

1A2: Manufacturing Industries and Construction: 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). Additional information is provided in Annex 7.

1A4cii Agriculture - Off-road vehicles and other machinery: This category is reported as IE for 1990-2018 and is included in 1A2gvii. From 2019 the sales statistics will separate fuel sold for off-road vehicles and other machinery in agriculture, and therefore this sector is now being reported.

1A5a: Stationary, Other: For this submission sector 1A5 is being reported for the first time for the timeseries 2003-2018 as part of the review of the energy input data (see method statement 2). For previous submissions these emissions have been 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, were 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.

Data sources

Activity data

Activity data for mobile combustion in these sectors is provided by the NEA.

1A2: Manufacturing Industries and Construction: 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 is possible to distinguish between off-road vehicles in agriculture and construction from the inventory year 2019 onwards.

For this submission, category 1A2gvii off-road vehicles and other machinery includes all emissions derived from fuels sold to off-road machinery for 1990-2018, including Construction (1A2gv), ***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). The latter three categories are marked as "IE" in the CRF reporter for 1990-2018 and are all included under 1A2gvii. For 2019 Construction (1A2gv) and Agriculture/Forestry/Fishing: Off-road vehicles and other machinery (1A4cii) are reported separately but transport activities not reported under road transport such as ground activities in airports and harbours (1A3eii) are still reported under 1A2gvii.

Emissions are calculated by multiplying energy use with a pollutant specific emission factor.
Table 3.8 and

Table 3.9 show the fuel sales statistics for the various fuel types used in Sector 1A2:

Table 3.8 Fuel use (in kt) and emissions (GHG, in kt CO_2e) from stationary combustion in the manufacturing industry (1A2).

	1990	1995	2000	2005	2010	2015	2018	2019
Gas/Diesel oil	5.07	1.28	9.09	15.35	6.83	7.22	4.12	4.35
Residual fuel oil	55.90	56.17	46.15	25.01	14.92	10.18	5.79	2.68
LPG	0.41	0.31	0.86	0.93	1.05	0.81	1.04	1.52
Other bituminous coal	18.60	8.65	13.26	9.91	3.65	NO	NO	NO
Petroleum coke	NO	NO	NO	8.13	NO	0.028	0.037	0.039
Waste oil	NO	4.99	6.04	1.82	1.36	1.59	1.25	0.70
Emissions (kt CO_2e)	**238.4**	**216.7**	**226.2**	**185.3**	**84.5**	**61.9**	**37.9**	**28.7**

Table 3.9 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from mobile combustion in the construction industry (1A2gv), Agriculture (1A4cii) and other (1A2gvii).

	1990	1995	2000	2005	2010	2015	2018	2019
Gas/Diesel oil	38.0	46.7	61.9	67.8	32.2	33.1	31.4	24.8
Other Kerosene	NO	NO	NO	0.022	1.171	0.157	0.027	0.029
Biofuels	NO	NO	NO	NO	NO	NO	0.028	0.028
Emissions (kt CO_2e)	**135.1**	**166.2**	**220.1**	**241.1**	**118.7**	**118.2**	**112.3**	**88.6**

1A5a: Stationary, Other: All fuel categorised as “Other” in sales statistics without any explanation of which sector it is used in, were allocated to CRF category 1A5. For the timeseries 1990-2002 these fuels are still attributed to CRF category 1A2gvii (see Table 3.10).

Table 3.10 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from sector 1A5 Other

	1990	1995	2000	2005	2010	2015	2018	2019
Gas/Diesel oil	NO	0.458	1.39	8.93	2.73	NO	NO	0.393
Residual Fuel oil	0.039	0.052	0.067	NO	1.63	NO	NO	0.075
Other kerosene	NO	NO	NO	0.151	0.047	0.029	0.030	0.064
LPG	NO	NO	NO	NO	NO	0.032	0.144	NO
Biodiesel	NO	NO	NO	NO	NO	NO	0.040	0.022
Biomethane	NO	NO	NO	NO	NO	NO	0.045	NO
Emissions (kt CO_2e)	**0.122**	**1.63**	**4.64**	**29.01**	**13.98**	**0.19**	**0.53**	**1.69**

Emission factors

The CO_2 emission factors used reflect the average carbon content of fossil fuels and have been taken from the 2006 IPCC Guidelines. CH_4 and N_2O emission factors are the default values for stationary combustion (Table 2.2, Volume 2, Chapter 2 of the 2006 IPCC guidelines), and the default values for mobile combustion in Industry (Table 3.3.1, Volume 2, Chapter 3 of the 2006 IPCC Guidelines). Sulphur contents are the maximum allowed according to the legislation in place concerning fuel quality. NCV, carbon contents as well as emission factors are presented in Table 3.11 (stationary combustion) and Table 3.12 (mobile combustion). From 2017 onwards NCV for gas/diesel oil is country specific based on measurements taken of fuel imported during the most recent inventory year.

For biofuels NCV’s are weighted averages taken from Proof of Sustainability documents provided to the NEA by biofuel suppliers, and CO_2 emission factors are the default values from Table 1.4, Volume 2, Chapter 1 of the 2006 IPCC Guidelines. CH_4 and N_2O emission factors were assumed to be the same for biofuels and their fossil fuel equivalent due to lack of more accurate biofuel-specific data.

Table 3.11 Emission factors for CO_2, CH_4 and N_2O from stationary combustion reported under 1A2/1A5a

	NCV [TJ/kt]	Carbon Content [t C/TJ]	Fraction oxidized	CO_2 EF [t/TJ]	CH_4 EF [kg/TJ]	N_2O EF [kg/TJ]
Gas/Diesel oil	43.1	20.2	1	74.1	70	13.9
Residual fuel oil	40.4	21.1	1	77.4	74	14.9
LPG	47.3	17.2	1	63.1	1	0.1
Other kerosene	43.8	19.6	1	71.9	10	0.6
Other bituminous coal	25.8	25.8	1	94.6	10	1.5
Petroleum coke	32.5	26.6	1	97.5	3	0.6
Waste oil	40.2	20.0	1	73.3	3	0.6
Biodiesel	43.5	19.3	1	70.8	69	13.8
Biomethane	50.4	14.9	1	54.6	1	0.1

Table 3.12 Emission factors for CO_2, CH_4 and N_2O from mobile combustion reported under 1A2 and 1A4cii

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/TJ fuel]	CH_4 EF [kg CH_4/TJ fuel]	N_2O EF [kg N_2O/TJ fuel]
Gas/Diesel Oil	43.2	20.2	1	74.1	4.14	28.5
Biodiesel	43.6	19.3	1	70.8	4.10	28.2
Other Kerosene	43.8	19.6	1	71.9	4.10	28.1

Method approach

Tier 1 - The emissions are calculated by multiplying energy use with a pollutant specific emission factor.

Method Changes

No

Assumptions & observations

Some assumptions and adjustments are made according to Figure 3.1 Description of adjustments in input data for IPCC category 1A2

Recalculation

Yes

Recalculation justification & summary of change

1A2 Manufacturing Industries and Construction: Some recalculations were done for this category:

- For 1990-2002 some fuels were moved from 1A2gvii to 1A5 because of lack of reference of where these fuels were used. This does not increase the total emissions from the energy sector.
- For previous submission electrode waste from the cement factory was reported un 1A2f. However, it was concluded for this submission that this activity data was for electrode waste which was exported as waste but not used for combustion. Therefore, electrode waste was removed from the inventory. This caused recalculations for 1990-2001 and 2007-2010.

1A2f Non-metallic minerals	1990	1993	1995	1998	2000	2007	2010
2020 v1 submission	50.7	39.1	37.5	51.3	56.4	63.2	10.7
2021 submission	47.8	36.3	36.5	50.0	51.0	61.5	9.2
Change relative to 2020 submission	**-5.8%**	**-7.2%**	**-2.8%**	**-2.7%**	**-9.6%**	**-2.8%**	**-13.6%**

1A5a: Stationary, Other: For previous submission this sector was reported as IE for 1990-2002. Now these years have been estimated and account for 0.1 kt CO_2e in 1990 and 19.8 kt CO_2e in 2002. This does not increase the total emissions from the energy sector as these emissions were accounted under 1A2gvii in previous submissions.

Improvements

Work with the NEA to attribute fuels from 1A5 into appropriate categories.

QA/QC processes

See section 3.1.2

Time series consistency issues

Categories 1A2v Construction and 1A4cii Agriculture - Off-road vehicles and other machinery are reported as IE for 1990-2018 and are included in 1A2gvii Other Off-road machinery and vehicles. From 2019 and onwards 1A2gv and 1A4cii are reported separately, as sales data became available.

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.

Verification

No verification has been undertaken.

3.3.3 Method Statement 3: Aviation

MS 3: Aviation (1A3a & 1D1a)

Relevant Categories

1A3a: Domestic Aviation
1D1a: International Aviation (memo)

Relevant Gases

CO_2, CH_4, N_2O

Relevant fuels, activities

Jet kerosene, aviation gasoline

Background

Domestic aviation (1A2a) includes flights departing from and subsequently landing in Iceland. Flights to or from destinations other than Iceland are included in International Aviation (Memo Item, 1D1a). Flights, that would be accounted under military operations in 1A5b are not occurring in Iceland as there is no Icelandic military.

Data sources

1A3: Domestic Aviation: Total use of jet kerosene and gasoline is based on the NEA's annual sales statistics for fossil fuels sold for domestic flights. Activity data for fuel sales and the resulting emissions are given in Table 3.13.

Table 3.13 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from domestic aviation.

	1990	1995	2000	2005	2010	2015	2018	2019
Jet kerosene	8.92	8.41	7.87	7.39	6.07	5.99	7.45	8.44
Gasoline	1.68	1.13	1.10	0.87	0.65	0.50	0.35	0.37
Emissions (kt CO_2e)	**33.62**	**30.27**	**28.48**	**26.23**	**21.32**	**20.62**	**24.79**	**27.99**

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 in Table 3.14.

Table 3.14 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from international aviation

	1990	1995	2000	2005	2010	2015	2018	2019
Jet kerosene	69.4	74.6	129.2	133.2	119.5	213.7	407.5	303.3
Gasoline	0.20	0.18	0.03	0.40	0.01	0.01	NO	NO
Emissions (kt CO_2e)	**221**	**238**	**411**	**425**	**380**	**680**	**1296**	**965**

The emission factors for greenhouse gases are taken from the 2006 IPCC Guidelines and are presented in Table 3.15 as tonne of gas per tonne of fuel. Emission factors for NO_X, NMVOC and CO are taken from EMEP/EEA 2016 guidebook, Table 3.3. Emissions of SO_2 are calculated from S-content in the fuels.

Table 3.15 Emission factors for CO_2 and other pollutants for aviation

Fuel	NCV [TJ/kt]	Carbon Content	Fraction oxidised	Emission factor [t/t fuel]					
				CO_2	NO_X	CH_4	NMVOC	CO	N_2O
Jet kerosene	44.10	19.50	1	3.15	0.004	2.E-05	0.019	1.20	0.00009
Gasoline	44.30	19.10	1	3.10	0.004	2.E-05	0.019	1.20	0.00009

Method approach

Emissions are calculated by using Tier 1 methodology, thus multiplying energy use with a pollutant specific emission factor.

Method Changes

No

Assumptions & observations

No assumptions or observations

Recalculation

Yes

Recalculation justification & summary of change

1A3a Domestic aviation: Recalculations were done for this sector as a part of the activity data review for 1990-2002 which caused an increase in emissions in the range of 0.3 kt CO_2e to 1.6 kt CO_2e. This did not cause an increase in emissions for the total energy sector because this was kerosene fuel that had previously been reported under 1A4.

1D1a International Aviation: Small recalculation was done for Jet kerosene for 2018. The NEA revised their sales statistics which decrease the emissions from the sector by 7.7 kt CO_2e, which amounts to 0.6% of the 2020 emissions from the sector.

Improvements

Planned improvement for the next submission involve moving emission estimates from aviation to the Tier 2 methodology in future submissions if possible and to assess the use of Eurocontrol data from 2005. The main limitations preventing Iceland from switching to using Eurocontrol data include yet unexplained discrepancies between fuel sales statistics from the NEA and Eurocontrol, as well as the issue of ensuring the time series consistency for the time period before 2005 (first Eurocontrol data available).

QA/QC processes

See section 3.1.2

Time series consistency issues

No timeseries issues for GHGs

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.

Verification

No verification has been undertaken.

3.3.4 Method Statement 4: Road Transport

MS 4: Road Transport (1A3b)

Relevant Categories

1A3b: Road Transport:

- 1A3bi Cars
- 1A3bii Light duty trucks
- 1A3biii Heavy duty trucks and buses
- 1A3biv Motorcycles

Relevant Gases

CO_2, CH_4, N_2O

Relevant fuels, activities

Gasoline, diesel, biogasoline, biodiesel, biomethane and hydrogen.

Background

This sector includes all emissions from road transport vehicles.

Data sources

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 3.16.

Table 3.16 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from road transport

	1990	1995	2000	2005	2010	2015	2018	2019
Gasoline	127.8	135.6	142.6	156.7	148.2	132.5	127.1	118.7
Diesel oil	36.6	36.9	47.5	83.5	106.4	126.4	178.9	180.9
Biogasoline/Bioethanol	NO	NO	NO	NO	NO	1.9	6.1	6.2
Biodiesel	NO	NO	NO	NO	NO	11.9	15.3	14.9
Biomethane	NO	NO	0.006	0.039	0.595	2.18	1.38	1.49
Hydrogen	NO	NO	NO	0.00001	0.002	NO	0.001	0.0009
Emissions (kt CO_2e)	**523.1**	**550.4**	**608.2**	**767.1**	**806.5**	**820.4**	**971.4**	**952.0**

All of the biogasoline in Iceland is bioethanol and does therefore not include any fossil carbon (Sempos, 2018). 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 2017-2019 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 the whole time series.

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

Method approach

Emissions from Road Transportation are estimated using COPERT 5.4.36. 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.

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.

Method Changes

No

Assumptions & observations

No assumptions or observations to report

Recalculation

Yes

Recalculation justification & summary of change

For this submission a measurement of country specific carbon content in fuels which was applied to the whole time series, replacing the default carbon content, which caused recalculation for CO_2. For this submission a 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. A summary of the recalculation for each greenhouse gas and the total emissions can be seen in Table 3.17.

Table 3.17 Summary of road transport recalculations done for this submission

	1990	1995	2000	2005	2010	2015	2017	2018
				CO_2 (kt CO_2e)				
2020 v1 submission	520	545	601	761	806	820	944	969
2021 submission	512	537	593	751	797	811	935	961
Change	-8	-8	-9	-10	-9	-9	-9	-9
				CH_4 (kt CO_2e)				
2020 v1 submission	6	5	4	3	2	2	1	1
2021 submission	6	5	4	3	2	2	2	2
Change	0.1	0.1	0.04	0.03	0.03	0.1	0.1	0.1
				N_2O (kt CO_2e)				

2020 v1 submission	5	8	11	12	6	6	7	8
2021 submission	6	8	12	13	7	8	9	9
Change	0.6	0.6	0.7	1.1	1.3	1.5	1.4	1.4
				Total				
2020 v1 submission	530	558	616	776	815	827	953	979
2021 submission	523	550	608	767	806	820	945	971
Total change	-7	-8	-8	-9	-8	-7	-8	-7
Total change (%)	-1.3%	-1.4%	-1.3%	-1.1%	-1.0%	-0.8%	-0.8%	-0.7%

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.

Improvements

For future submissions further collaboration with the Road traffic directorate 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 2020 to get a comparative value.

QA/QC processes

See section 3.1.2

Time series consistency issues

No timeseries issues

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.

Verification

No verification has been undertaken.

3.3.5 Method Statement 5: Navigation & Fishing

MS 5: Navigation (1A3d & 1D1b) & Fishing (1A4ciii)

Relevant Categories

1A3d: Domestic Navigation
1D1b: International Navigation (memo)
1A4ciii: Fishing

Relevant Gases

CO_2, CH_4, N_2O

Relevant fuels, activities

Gas/diesel oil, residual fuel oil, biodiesel

Background

1A3d Domestic Navigation: This sector includes all vessels of all flags which purchase fuel in Iceland and sail between two Icelandic harbours.
1D1b International Navigation (memo): This sector includes all vessels of all flags which purchase fuel in Iceland and sail internationally from an Icelandic harbour.
1A4ciii Fishing: The GHG emissions from the agriculture, forestry and fishing subsector (1A4c) are high, due to the fact that fishing is one of the main industries in Iceland; fishing was estimated to account for close to 99% of the 1A4 sector's total.

Data sources

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, as well as the resulting emissions are given in Table 3.18.

Table 3.18 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from national navigation

	1990	1995	2000	2005	2010	2015	2018	2019
Gas/Diesel oil	11.7	7.0	3.4	6.2	8.5	7.9	8.5	11.9
Residual fuel oil	7.2	4.8	0.5	0.9	2.6	0.4	5.2	4.8
Biodiesel	NO	NO	NO	NO	NO	NO	NO	0.001
Emissions (kt CO_2e)	**60.4**	**37.7**	**12.7**	**22.7**	**35.5**	**26.8**	**43.8**	**53.5**

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 3.19. 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 3.19 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from international navigation

	1990	1995	2000	2005	2010	2015	2018	2019
Gas/Diesel oil	5.9	1.1	15.0	0.1	NO	33.6	42.3	45.2
Residual fuel oil	0.05	NO	2.0	0.44	0.08	13.2	34.0	19.3
Emissions (kt CO_2e)	**19.0**	**3.4**	**54.7**	**1.8**	**0.3**	**149.8**	**244.1**	**206.8**

Note: Fuel use in 1990 was approximated using average fuel use distribution for the years 1995 to 1999.

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 and the resulting emissions are given in Table 3.20.

Table 3.20 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from the fishing sector

	1990	1995	2000	2005	2010	2015	2018	2019
Gas/Diesel oil	199.9	231.8	256.9	199.9	158.3	142.5	136.2	136.6
Residual fuel oil	32.6	57.2	22.3	32.6	69.9	52.4	35.3	25.8
Biodiesel	NO	NO	NO	NO	NO	0.094	NO	0.034
Emissions (kt CO_2e)	**746.4**	**926.4**	**896.9**	**746.4**	**729.9**	**624.2**	**551.7**	**522.2**

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 3.21.

Table 3.21 Emission factors for CO_2, CH_4 and N_2O for ocean-going ships

	NCV [TJ/kt]	C EF [t C/TJ]	Fraction oxidised	EF CO_2 [t CO_2/t]	EF N_2O [kg N_2O/TJ]	N_2O EF [kg N_2O/t]	EF CH_4 [kg CH_4/TJ]	EF CH_4 [kg CH_4/t]
Gas/Diesel Oil	43.1*	20.2	1	3.19	2	0.086	7	0.30
Residual fuel oil	40.4	21.1	1	3.13	2	0.081	7	0.28
Biodiesel	43.5	19.3	1	3.09	0.6	0.026	10	0.44

**: Country specific NCV value annually since 2017*

Method approach

Emissions are calculated by multiplying fuel use with a GHG-specific emission factor.

Method Changes

No

Assumptions & observations

No assumptions or observations to report

Recalculation

Yes

Recalculation justification & summary of change

1A3d: Domestic Navigation: Small recalculation for 2010 due to a revised residual fuel used for that year. This caused an increase of emissions by 0.2 kt CO_2e

1D1b: International Navigation: Small recalculation for 1990-1994 as a part of the activity data revisions for 1990-2002. These recalculations decrease the emissions from this sector by 0.2 - 0.5 kt CO_2e

1A4ciii: Fishing: Small recalculation for 2010 due to a revised residual fuel used for that year. This caused an increase of emissions by 2.3 kt CO_2e which amounts to 0.3% of the fishing sectors emissions for that year.

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.

QA/QC processes
See section 3.1.2
Time series consistency issues
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.
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.
Verification
No verification has been undertaken.

3.3.6 Method Statement 6: Commercial / Institutional and Residential Fuel Combustion

MS 6: Commercial / Institutional (1A4a) and Residential Fuel Combustion (1A4b)
Relevant Categories
Commercial / Institutional (1A4a) and Residential Fuel Combustion (1A4b)
Relevant Gases
CO_2, CH_4, N_2O
Relevant fuels, activities
Gas/diesel oil, waste oil, LPG and solid waste.
Background
Since Iceland relies largely on its renewable energy sources, fuel use for residential, commercial, and institutional heating is low and GHG emissions from subsectors 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.
Data sources
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 and the resulting emissions are given in Table 3.22 and Table 3.23 respectively.

Table 3.22 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from the commercial/institutional sector (1A4a).

	1990	1995	2000	2005	2010	2015	2018	2019
Gas/Diesel oil	1.8	1.6	1.6	1.0	0.30	0.30	0.15	0.291
LPG	0.78	0.83	0.46	0.50	0.17	0.37	0.08	0.095
Solid waste	NO	0.45	0.58	0.58	0.35	NO	NO	NO
Emissions (kt CO_2e)	**8.1**	**7.8**	**6.8**	**5.0**	**1.7**	**2.1**	**0.72**	**1.22**

Table 3.23 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from the residential sector (1A4b).

	1990	1995	2000	2005	2010	2015	2018	2019
Gas/Diesel oil	8.82	6.94	6.03	3.24	1.34	0.99	0.85	0.66
LPG	NO	NO	0.72	0.93	1.42	0.93	1.58	1.67
Emissions (kt CO_2e)	**28.3**	**22.2**	**21.4**	**13.2**	**8.5**	**6.0**	**7.5**	**7.1**

Emission factors:

The CO_2 emission factors used are based on the default NCV and carbon content of fossil fuels. They are taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The CH_4 and N_2O emission factors are default values for Commercial/Institutional and Residential fuel use as given in Tables 2.4 and 2.5 of the 2006 IPCC guidelines, Vol 2, Chap. 2.

The emission factor for waste incineration was calculated using Tier 2 methodology and default values from the 2006 IPCC Guidelines. Therefore, the waste amounts incinerated are dissected into eleven categories. The dry matter content, total, and fossil carbon fractions are calculated separately for each waste category and then added up. In years that have higher fractions of fossil carbon containing waste categories such as plastics the EF is higher than in other years since the EF is related to the total amount of waste incinerated. CO_2 EF varied between 0.44 and 0.69 t CO_2 per tonne waste (cf. chapter 7.4.3). The IEF for the sector 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.

Table 3.24 Emission factors for CO_2, CH_4 and N_2O in the residential, commercial and institutional sector

	NCV [TJ/kt]	CO_2 EF [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Gas/diesel oil	43.2	74.1	10	0.6
LPG	47.3	63.1	5	0.1
Solid waste	10.0	38.5	24	6

Method approach

The emissions from this sector are calculated by multiplying energy use with a pollutant specific emission factor.

Method Changes

No

Assumptions & observations

No assumptions or observations to report

Recalculation

Yes

Recalculation justification & summary of change

1A4ai Commercial/Institutional: Recalculations were done for this sector as a part of the activity data review for 1990-2002. The recalculations for 1990-1993 decreased the emissions by 7 - 11 kt CO_2e. This was due to waste oil being reported in previous submissions for those years. When the activity data was reviewed for this submission, no reference for this waste oil was found and it is not included in the official sales statistics from the NEA. Therefore, this fuel was removed from the inventory. This decreased the emissions from the 1A4ai sector by 48-57% for 1990-1993.

1A4bi Residential Stationary: Due to the review of all activity data for 1990-2002 there were recalculations for this sector for this submission. The emissions from this sector decreased by 0.01 - 3.4 kt CO_2e. However, in 2018 emissions from the sector increased by 0.16 kt CO2e due to a revision in input data from the NEA. This is related to methodological changes of allocation between house heating and heating for swimming pools.

Improvements

No improvements are currently planned.

QA/QC processes

See section 3.1.2

Time series consistency issues

No time series consistency issues to report

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.

Verification

No verification has been undertaken

3.3.7 Method Statement 7: Fugitive Emissions from Fuels

MS 7: Fugitive Emissions from Fuels (1B2a5)

Relevant Categories

1B2a5: Distribution of Oil Products

Relevant Gases

CO_2, CH_4, N_2O, NMVOC

Relevant fuels, activities

Distribution of gasoline, jet kerosene, gas/diesel oil, residual fuel oil and LPG

Background

This sector includes emissions that come from the distribution of liquid fuels in Iceland.

Data sources

CO_2 and CH_4 emissions from distribution of oil products are estimated by multiplying the total imported fuel with emission factors. The emission factors are taken from Table 4.2.4 in the 2006 IPCC GL. For liquid fuels the CO_2 EF is 2.3E-06 kt per 1000 m^3 and the CH_4 EF is 2.5E-05 kt per 1000 m^3 transported by tanker truck. For LPG the CO_2 EF is 4.3E-4 kt per 1000 m^3 and the N_2O EF is 2.2E-09 kt per 1000 m^3 of LPG. Data on total import of fuels is taken from Statistics Iceland. Activity data and resulting emissions are provided in Table 3.25.

Table 3.25 Fuel use (in kt) and resulting GHG emissions (in kt CO_2e) from distribution of oil products.

	1990	1995	2000	2005	2010	2015	2018	2019
Gasoline	129.4	132.2	153.4	164.2	144.5	139.6	134.0	122.8
Jet Kerosene	78.7	72.3	146.5	139.4	120.4	218.3	422.9	277.5
Gas/Diesel oil	335.8	309.3	427.9	418.2	292.3	342.1	369.5	392.9
Residual Fuel Oil	106.0	151.9	64.1	62.9	93.1	105.3	119.2	57.2
LPG	1.3	1.3	1.7	2.5	2.6	2.6	2.6	3.0
Emissions (kt CO_2e)	**0.49**	**0.50**	**0.60**	**0.60**	**0.49**	**0.61**	**0.80**	**0.65**

Method approach

CO_2 and CH_4 emissions from distribution of oil products are estimated by multiplying the total imported fuel with emission factors.

Method Changes

No

Assumptions & observations

No assumptions or observations to report

Recalculation

No

Recalculation justification & summary of change

No recalculations were performed for this subcategory.

Improvements

No improvements planned

QA/QC processes

See section 3.1.2

Time series consistency issues

No time series consistency issues to report

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.

Verification

No verification has been undertaken.

3.3.8 Method Statement 8: Geothermal Energy

MS 8: Geothermal Energy (1B2d)

Relevant Categories

1B2d: Geothermal Energy

Relevant Gases

CO_2, CH_4 (in CO_2e) and H_2S emissions (in SO_2e)

Relevant fuels, activities

Energy production by geothermal energy

Background

This category includes emissions from all geothermal power plants in Iceland, including (as of 2018) 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% of the total electricity production in 2018). Small amounts of methane and considerable quantities of sulphur in the form of hydrogen sulphide (H_2S) are emitted from geothermal power plants.

Data sources

The National Energy Authority of Iceland (NEA – Orkustofnun in Icelandic), 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 1969-2018 were published on 26.03.2019 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 (Orkustofnun, 2019).

Table 3.26 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 3.26 Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2010	2015	2018	2019
Electricity production (GWh)	283	288	1,323	1,655	4,465	5,003	6,010	6,018
CO_2 emissions (kt)	61	82	153	118	190	163	156	163
Methane emissions (kt CO_2e)	0.2	0.2	0.9	1.1	4.6	3.9	2.5	3.1
Sulphur emissions (as SO_2, kt)	13	11	26	30	59	42	38	42

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 (in Icelandic) "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 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, i.e., currently Þeistareykir, 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 was measured in 2010, 2011 and 2012. Older measurements exist for the years 1995 to 1997. Based on the measurements from 1995 to 1997 and 2010 an average methane emission factor was calculated and used for the years where no information has been provided. The methane emissions for those years (1995, 1996, 1997 and 2010) range from 35.5 to 55.8 kg/GWh, with an average of 45.7 kg/GWh.
Two power plants, Hellisheiði and Svartsengi, report emissions that have been adjusted to reflect specific capture and recycling/injection projects:

- 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). In 2012, 55 t CO_2 were captured, injected and mineralized in the ground. In 2014, 2015, 2016, 2017, 2018 and 2019, the amount of CO_2 captured and reinjected was 2381 t, 3911 t, 6644 t, 10168 t, 12200 t and 9700 t respectively. A sister project, SulFix, consists of separating H2S from the steam and also reinjecting the gas into the subsurface and mineralizing on contact with the basalt host rock.
- 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 both used as fuel in Iceland and is exported (Carbon Recycling International, 2018).

Method Changes

No

Assumptions & observations

It should be noted that the geothermal power plants produce both electricity and hot water for district heating. As it stands, there is no disaggregation between the emissions related to electricity production vs. district heating, however this will be investigated in the future in collaboration with the geothermal power plant operators.

Recalculation

No

Recalculation justification & summary of change

No recalculations were performed for this subcategory.

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.

QA/QC processes

See section 3.1.2

Time series consistency issues

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).)
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.
Verification
No verification has been undertaken.

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 Industrial Processes sector accounted for 43% of the GHG emissions in Iceland in 2019. The dominant category within the Industrial Process sector is metal production, which accounted for 92% of the sector's emissions in 2019. Close to 100% 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 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". In response to a question raised during the 2019 UNFCCC desk review Iceland collected further information about the non-occurrence of emissions due to the use of NF_3. The Chemical Team of the Environment Agency confirms 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, 2019 and 1990-2019 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, 2019 and trend (excluding LULUCF).

IPCC source category		Gas	Level 1990	Level 2019	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]	NE	NA	NA	NA	NA	NA	NA	NA	NA
2A4d Mineral Wool, Ferrosilicon production	E, IE[2]	NA	NA	NA	NA	NA	NE	E	NE	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)	IE[4]	IE[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	NE	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	NE	E
2C4 Magnesium Production	NOT OCCURRING									
2C5 Lead Production	NOT OCCURRING									
2C6 Zinc Production	NOT OCCURRING									
2C7 Other	NOT OCCURRING									

	Greenhouse gases						Indirect greenhouse gases			
Sector	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NO_x	CO	NMVOC	SO_2
2D Non-Energy Products from Fuels and Solvent Use										
2D1 Lubricant Use	E	NA	NA	NA	NA	NA	NA	NA	NE	NA
2D2 Paraffin Wax Use	E	NE	NE	NA	NA	NA	NA	NA	NE	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
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	NE	NE	E	NE
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	NE
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									

Note: [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.
- 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 recommended by an expert at the cement plant. This ratio is close to the average proportion for the years 2003 and 2004.

The production at the cement plant decreased slowly from 2000 - 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	EF_{cl}	CF_{ckd}	CO_2 emissions [kt]
1990	114,100	96,985	63%	0.495	107.5%	51.6
1991	106,174	90,248	63%	0.495	107.5%	48.0
1992	99,800	84,830	63%	0.495	107.5%	45.1
1993	86,419	73,456	63%	0.495	107.5%	39.1
1994	80,856	68,728	63%	0.495	107.5%	36.5
1995	81,514	69,287	63%	0.495	107.5%	36.8
1996	90,325	76,776	63%	0.495	107.5%	40.8
1997	100,625	85,531	63%	0.495	107.5%	45.5
1998	117,684	100,031	63%	0.495	107.5%	53.2
1999	133,647	113,600	63%	0.495	107.5%	60.4
2000	142,604	121,213	63%	0.495	107.5%	64.4
2001	127,660	108,511	63%	0.495	107.5%	57.7
2002	84,684	71,981	63%	0.495	107.5%	38.3
2003	75,314	60,403	63%	0.495	107.5%	32.1
2004	104,829	93,655	63%	0.495	107.5%	49.8
2005	126,123	99,170	63%	0.495	110%	53.9
2006	147,874	112,219	63%	0.495	110%	61.0
2007	148,348	114,668	64%	0.501	110%	63.2
2008	126,070	110,240	63.9%	0.502	110%	60.8
2009	59,290	51,864	63.9%	0.502	108%	28.1
2010	33,389	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 CO_2 emission factor for clinker (EF_{cl}) is thus 0.495 from 1990-2006, 0.501 in 2007, 0.502 in 2008 and 2009, 0.497 in 2010 and 0.504 in 2011.The correction factor for cement kiln dust (CF_{ckd}) was 107.5% for all years from 1990 to 2004, 110% from 2005 - 2008 and 108% in 2009 and 2010. In 2011 the CF_{ckd} correction factor was 110%. 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.

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 very 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 2000 and mineral wool production.

Emissions from the mineral wool plant were 0.96 kt CO_2e in 2019. Fluctuations in GHG emissions reflect fluctuations in annual production.

Uncertainties

The uncertainty on activity data was calculated to be 7.9%% using equation 3.1 from Chapter 3 in the IPCC 2006 guidelines and 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 8%. The complete uncertainty analysis is shown in Annex 2.

Category-specific recalculations

No category-specific recalculations were done for this submission.

Category-specific planned improvements

No improvements are currently planned for this category.

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 1990-2004. 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 3.3.8 Method Statement 8 - Geothermal Energy on geothermal energy production.

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.

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 1%, leading to a combined uncertainty of 5.1%. The complete uncertainty analysis is shown in Annex 2.

Category-specific recalculations

No category-specific recalculations were done for this submission.

Category-specific planned improvements

No improvements are currently planned for this category.

4.3.10.2 ***Fertilizer Production***

Category description

A fertilizer production plant was operational until it exploded in 2001. In the early days of the factory, only one type of fertilizer was produced (a nitrogen fertilizer), whereas at the end of its production phase it was producing over 20 different types of fertilizers. CO_2 and CH_4 emissions are considered insignificant, as the fertilizer plant used H2 produced on-site by electrolysis.

Methodology

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

Uncertainties and time-series consistency–

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.

Category-specific recalculations

No category-specific recalculations were done for this submission.

Category-specific planned improvements

No improvements are currently planned for this category.

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 2016 EMEP/EEA Guidebook (European Environment Agency, 2016).

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 26.9%. The complete uncertainty analysis is shown in Annex 2.

Category-specific recalculations

No category-specific recalculations were done for this submission.

Category-specific planned improvements

No improvements are currently planned for this category.

4.4.2 Ferroalloys Production (CRF 2C2)

Category description

As of 2019, 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.

CO_2 emissions from this category amounted to 429.8 kt CO_2e in 2019 corresponding to an increase of 106% from the 1990 emissions.

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	2018	2019
Electrodes, casings and paste	3.8	3.9	5.7	6.0	4.8	5.3	5.2	5.0
Carbon blocks	-	-	-	-	-	0.1	0.2	0.3
Anthracite/coking coal	45.1	52.4	73.2	86.9	96.1	115.1	144.3	142.4
Coke oven coke	24.9	30.1	46.6	42.6	30.3	30.9	21.3	21.2
Charcoal	-	-	-	2.1	-	-	0.7	3.4
Wood	16.7	7.7	16.2	15.6	11.3	27.2	57.8	78.1
Limestone	-	-	0.5	1.6	0.5	2.2	1.9	1.8
FeSi, silicon metal production	62.8	71.4	108.7	111	102.2	117.9	122.2	119.4
Emissions (kt CO_2e)	**210.4**	**245.7**	**365.3**	**379.6**	**372.3**	**403.9**	**455.4**	**431.4**

Plant and year specific emission factors for CO_2 are based on the carbon content of the reducing agents, the electrodes. 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. Carbon content of coal (anthracite), coke-oven coke and charcoal are based on routine measurements of each lot at the 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. The carbon content of the electrodes is measured by the producer of the electrodes. Carbon content of wood is taken from a Norwegian report (SINTEF. Data og informasjon om skogbruk og virke, Report OR 54.88). The carbon contents of raw materials and products are presented in Table 4.5. 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 3.13 tonne CO_2 per tonne Ferrosilicon in 1998, to 3.66 tonne CO_2 per tonne Ferrosilicon in 2005. 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).

Table 4.5 Carbon content of raw material for ferroalloy production

	1990	1995	2000	2005	2010	2015	2018	2019
Electrodes	94.0%	94.0%	94.0%	94.0%	94.0%	96.0%	95.0%	94.5%
Coal (Anthracite)	74.8%	74.8%	79.0%	75.5%	74.8%	71.8%	69.9%	64.7%
Coke oven coke	78.8%	78.8%	76.6%	73.8%	80.8%	70.4%	76.1%	76.1%
Charcoal	-	-	-	80.9%	-	-	85.6%	78.4%
Wood chips	48.7%	48.7%	48.7%	48.7%	48.7%	50.0%	50.0%	50.0%

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 0.7% of the emissions from ferroalloy production.

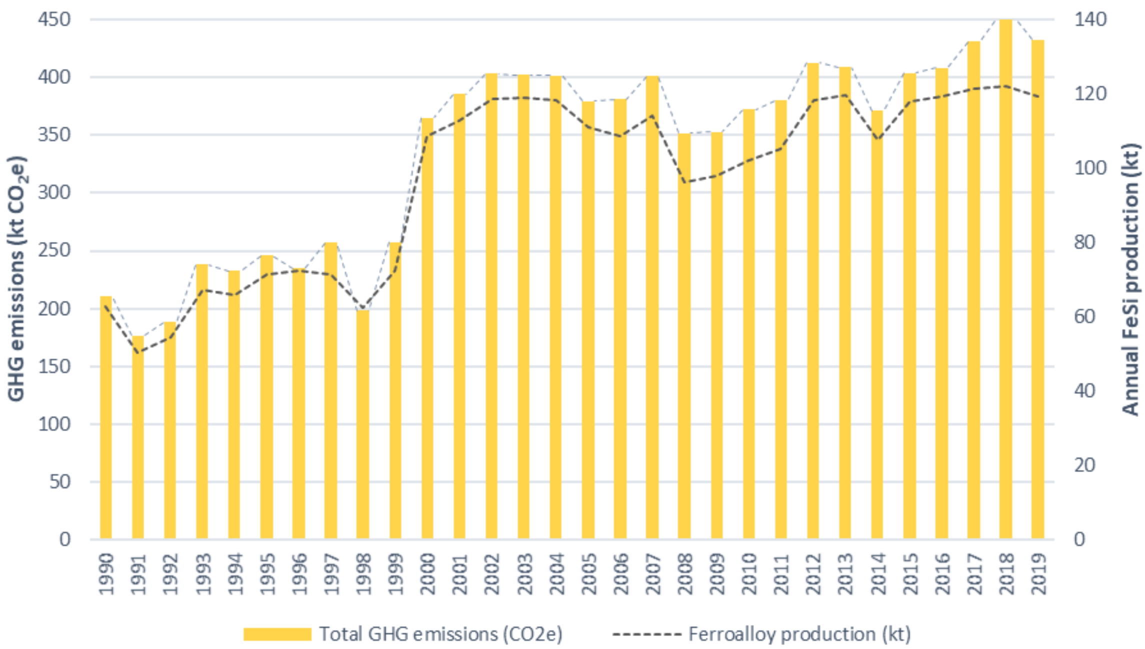


Figure 4.1 Total GHG emissions (CO_2 and CH_4) from the Ferroalloy production, and annual production (kt)

Uncertainties and time-series consistency

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%. The complete uncertainty analysis is shown in Annex 2.

The IEF fluctuates over the time series depending on the consumption of different reducing agents and electrodes (3.13 – 3.70 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

No recalculations have been performed between the 2020 and 2021 submissions.

Category-specific planned improvements

No improvements are currently planned for this category.

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 3 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 4.6 and are displayed in Figure 4.2.

Table 4.6 Aluminium production, CO_2 and PFC emissions, IEF for CO_2 and PFC 1990-2019.

	1990	1995	2000	2005	2010	2015	2018	2019
Primary aluminium production [kt]	87.8	100.2	226.4	272.5	818.9	857.3	876.0	835.7
CO_2 emissions [kt]	139.2	154.0	353.0	417.1	1237.6	1299.6	1313.9	1276.1
PFC emissions [kt CO_2e]	494.6	69.4	149.9	30.8	171.7	103.7	76.4	97.0
CO_2 [t/t Al]	1.6	1.5	1.6	1.5	1.5	1.5	1.5	1.5
PFC [t CO_2e/t Al]	5.6	0.7	0.7	0.1	0.2	0.1	0.1	0.1
Total Emissions [kt CO_2e]	**633.9**	**223.3**	**502.8**	**447.9**	**1409.2**	**1403.2**	**1390.3**	**1373.1**

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. In 2013 to 2019 the information comes from submitted data from the operators under the EU ETS. The weighted average carbon content of the electrodes ranges from 97.9% to 98.7%.

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, with a slight increasing trend since 2011 (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 in 2019 have risen by 116% since 1990 although a slight decrease in emissions (-1,7%) occur in 2019 compared to 2018.

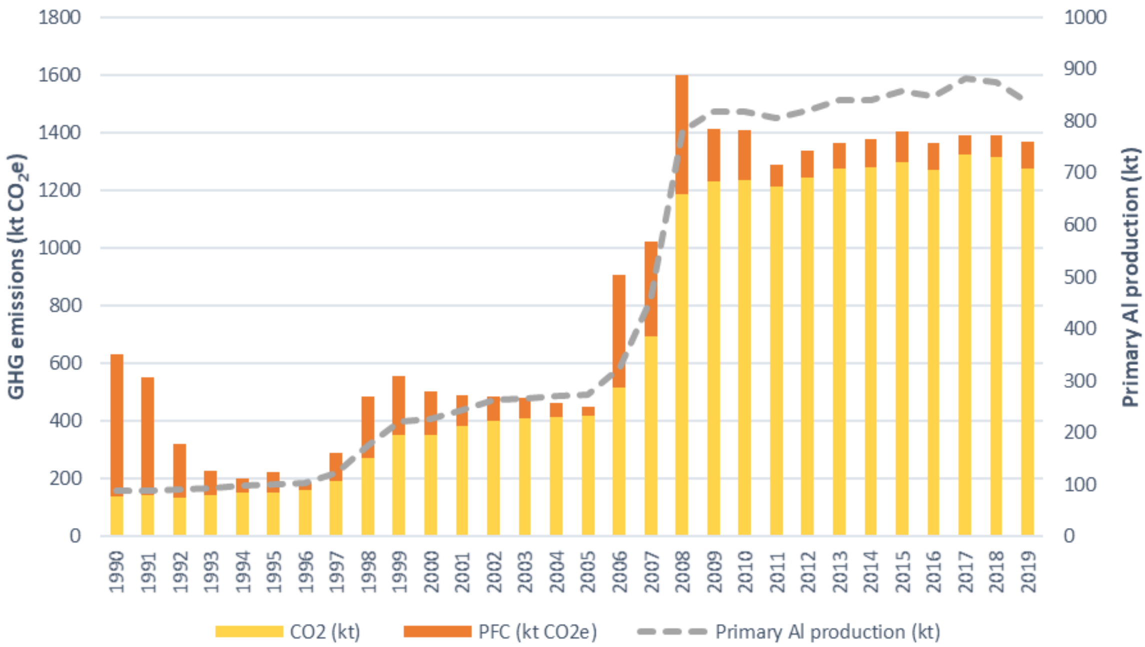


Figure 4.2 GHG emissions (CO_2 and PFC) from primary Al production, and annual production (kt).

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%. For PFC the activity data has also 1.5% uncertainty and the emission factor uncertainty is 30%, following the suggestion of the 2006 IPCC Guidelines for Tier 3. This leads to a combined uncertainty of 15%. The complete uncertainty analysis is shown in Annex 2.

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.

4.4.4 **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. NMVOC are possibly also emitted, but there is no default methodology currently available to estimate those 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_2 in 1990, the emissions decreased to 1.87 kt CO_2 in 2009. Since 2010, the emissions have been rather stable between 2.07 kt and 2.54 kt CO_2.

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 50.34%. The complete uncertainty analysis is shown in Annex 2.

Category-specific recalculations

No category-specific recalculations were done for this submission.

Category-specific planned improvements

There are no improvements planned in this category.

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). Activity data for this category is limited and planned improvements are discussed below.

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 “NE“ in the CRF tables.

The emissions from Paraffin Wax Use have been estimated to be 0.17 kt CO_2 in 1990 and 0.29 kt CO_2 in 2019.

Methodology

CO_2 Emissions from paraffin wax use are calculated using equation 5.4 (Tier 1) 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. The proportion of paraffin candles used is assumed to be 66%, taken from the Norwegian Inventory Report for 2015 as the activity data available in Iceland does not distinguish between paraffin candles and others.

Activity data for the production of candles is missing. 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. Activity data for paraffin production is missing but is considered insignificant based on expert judgement.

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 100.3%. The complete uncertainty analysis is shown in Annex 2.

Category-specific recalculations

No category-specific recalculations were done for this submission.

Category-specific planned improvements

For future submissions, it is planned to keep improving the collection of activity data for all sources of paraffin wax use in Iceland. Activity data should furthermore distinguish between paraffin candles and other types of candles.

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 2016 EMEP/EEA 2016 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.

Total CO_2 from2D3 categories including CO_2 arising from the oxidation of NMVOCs amounted to 3.2 kt CO_2 in 2019. An overview of the emissions from the individual subcategories is given in Table 4.7 and is shown in Figure 4.3.

Methodology

NMVOC emissions are estimated according to the 2016 EMEP/EEA air pollutant emission inventory guidebook (European Environment Agency, 2016), 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 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).

Category-specific recalculations

No category-specific recalculations were done for this submission.

Category-specific planned improvements

Collaboration is underway with Statistics Iceland to review data collection pertaining to this category, in order to ensure complete reporting of solvent use.

4.5.3.1 *Road Paving with Asphalt (CRF 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 EMEP/EEA emission inventory guidebook (2016). Emissions of SO_2, NO_X and CO are expected to originate mainly from combustion and are therefore not estimated here but accounted for under sector 1A2f. In 1990 the NMVOC emissions for Road Paving with Asphalt were 2.76 t NMVOC, in 2019 3.97 t NMVOC, corresponding to an increase of 44% with a decrease of 4% between 2018 and 2019.

4.5.3.2 *Coating Applications (2D3d)*

The EMEP/EEA guidebook (EMAP/EEA, 2016) 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. 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. No category-specific recalculations were done for this submission.

4.5.3.3 *Degreasing and Dry Cleaning (2D3e, 2D3f)*

The 2016 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.

Emissions from dry cleaning were calculated using the Tier 2 emission factor for open-circuit machines provided by the EMEP/EEA guidebook. Activity data for calculation of NMVOC emissions is the amount of textile treated annually, which is assumed to be 0.3 kg/head (European Environment Agency, 2016) and calculated using demographic data. The NMVOC emission factor for open-circuit machines is 177 g/kg textile treated. Since all dry-cleaning machines used in Iceland are conventional closed-circuit PER machines, the emission factor was reduced using the respective 2016 EMEP/EEA guidebook reduction default value of 0.89.

In 1990 the NMVOC emissions for Degreasing were 76.2 t NMVOC, in 2019 58.2 t NMVOC, corresponding to a decrease of 23%. For Dry-cleaning the NMVOC were 1.5 t NMVOC in 1990 and 2.1 t NMVOC in 2019, corresponding to an increase of 40%.

4.5.3.4 *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 2016 EMEP/EEA 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 (2019), 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.

In 1990 the NMVOC emissions for paint manufacturing were 15.6 t NMVOC, in 2019 0.5 t NMVOC, corresponding to a decrease of 97%.

4.5.3.5 *Other Use of Solvent and related activates (2D3a, 2D3h, 2D3i)*

NMVOC emissions from other domestic solvent use (2D3a) were calculated using the EMEP/EEA guidebook (EMAP/EEA, 2016) emission factor of 1.8 kg/inhabitant/year. In 1990 the NMVOC emissions for domestic solvent use were 460.6 t NMVOC, in 2019 655.4 t NMVOC, corresponding to an increase of 42%.

NMVOC emissions for printing (2D3h) were calculated using the 2016 EMEP/EEA guidebook Tier 1 emission factor of 500g/kg ink used. Import data on ink was received from Statistics Iceland (Statistics Iceland, 2019). In 1990 the NMVOC emissions for printing were 77.5 t NMVOC, in 2019 125.9 t NMVOC, corresponding to an increase of 62%.

Emissions from wood preservation (2D3i) were calculated using the 2016 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 1990 the NMVOC emissions for Wood preservation were 8.7 t NMVOC, in 2019 47.7 t NMVOC, corresponding to an increase of 448%.

4.5.3.6 *Urea based catalytic converters*

For the current submission it was possible to estimate the emissions deriving from the use of urea-based additives for diesel vehicles and allocate them to the right 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 5.8). Customs Iceland has been contacted to correct the error in the registration which will take place starting from 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. This amount was then subtracted from the amount registered by Customs Iceland. 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 and 44/12. The so obtained emissions are 0.6 kt CO_2e for the year 2019 and were 0.01 kt CO_2e in 2008, the first year in which this activity is reported.

4.5.3.7 *Emissions of Sector 2D3*

Figure 4.3 and Table 4.7 show NMVOC emissions from the sector 2D3 from 1990-2019. NMVOC emissions increased by 10% between 1990 and 2019 and decreased by 3% between 2018 and 2019.

Table 4.7 NMVOC emissions (in kt) from all sub-categories, and total emissions from subsector 2D3 in kt CO_2e).

	1990	1995	2000	2005	2010	2015	2018	2019
2D3a Domestic solvent use	0.4606	0.4823	0.5100	0.5398	0.5732	0.5986	0.6426	0.6554
2D3b Road paving with asphalt	0.0028	0.0028	0.0052	0.0054	0.0038	0.0031	0.0041	0.0040
2D3d Coating applications	0.5086	0.5474	0.5601	0.3424	0.2887	0.3183	0.3806	0.2927
2D3e Degreasing	0.0762	0.0568	0.0853	0.0576	0.0380	0.0463	0.0549	0.0582
2D3f Dry cleaning	0.0015	0.0016	0.0017	0.0018	0.0019	0.0019	0.0021	0.0021
2D3g Paint manufacturing	0.0156	0.0156	0.0122	0.0054	0.0032	0.0033	0.0050	0.0005
2D3h Printing	0.0775	0.1091	0.1982	0.3051	0.1888	0.2067	0.1499	0.1259
2D3i Wood preservation	0.0087	0.0187	0.0254	0.0859	0.0309	0.0265	0.0327	0.0477
Total NMVOC [kt]	1.15	1.23	1.40	1.34	1.13	1.20	1.27	1.19
Total CO_2e [kt]	**2.53**	**2.71**	**3.07**	**2.95**	**2.48**	**2.65**	**2.80**	**2.61**

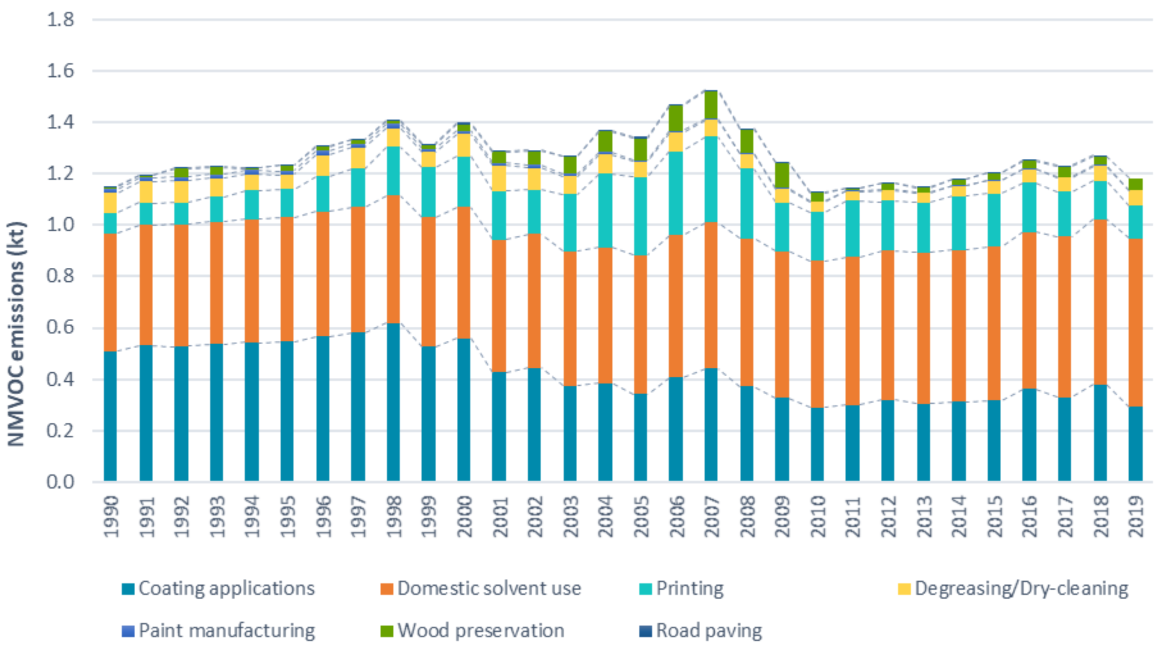


Figure 4.3 NMVOC emissions from all subgroups of Sector 2D3, other non-energy products from fuels and solvent use.

4.5.3.8 *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 and the total combined uncertainty of all emission factors used is 66.67% leading to a combined uncertainty for emission factor and activity data of 66.7%. 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 4.11. 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 (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 4.8 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 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. 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. 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 commonly 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.

Emissions from Refrigeration and Air Conditioning amounted to 206 kt CO_2e in the most recent inventory year, or approximately 10% of the emissions originating from the IPPU sector. It is a significant sector in Iceland, as it is by far the largest source 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 (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 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:

- $ECH_{arge,t}$= 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

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

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

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

Where:

- $E_eN_{d\text{-}of\text{-}life,t}$= 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 7.2) 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 F-gases used to refill reefers (for 2F1d Transport).
- The Transport Authority (Samgöngustofa) which provides numbers of first registrations of cars (for 2F1e Mobile ACs) and country of previous registation 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)
- 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 from a) to d) 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:
    - 15% Commercial Refrigeration
    - 20% Industrial Refrigeration
    - 65% Transport minus Reefers.

The percentages of use derive from surveys carried out periodically among service providers and importers of F-gases. In 2019 this survey was repeated and 33% of the participants responded confirming the results from the previous survey. Figure 4.4 gives an overview of the imported bulk amounts of F-gases between 1990-2019 as registered by the Chemical Team of the Environment Agency. 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).

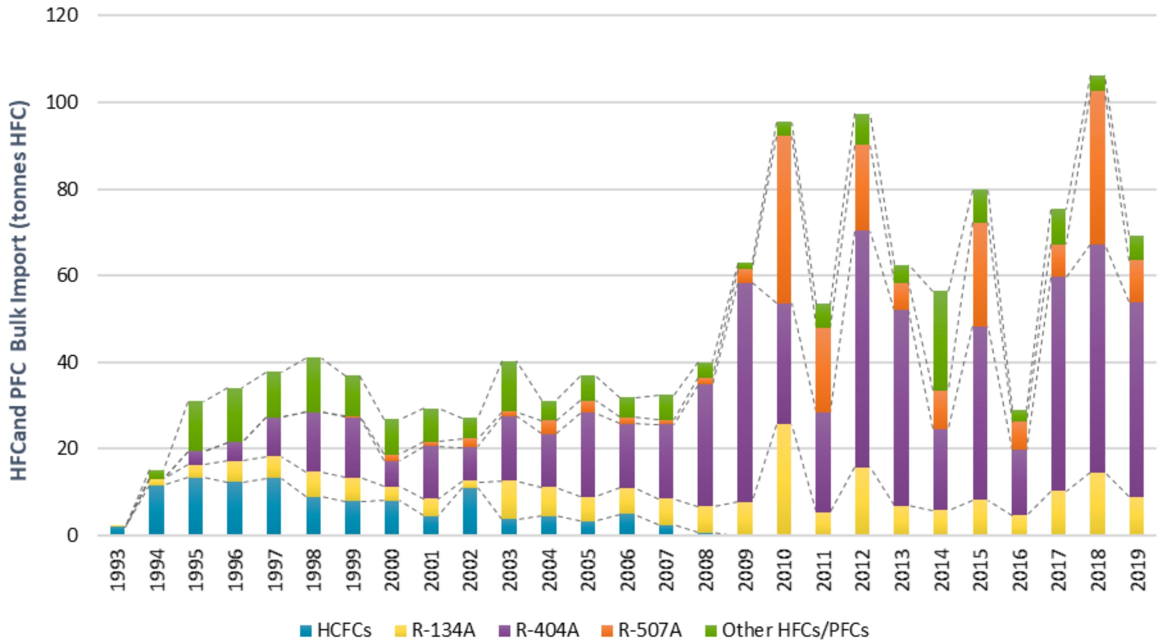


Figure 4.4 Quantity of F-gases imported in bulk to Iceland between 1993 and 2019

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 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

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 N_2 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 today (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% in 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 4.9. 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 4.9 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	5	NE	NO	15%	NE
Transport ref.: fishing vessels	NE	7	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%

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

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 reefers and MACs. 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 amounted to 206 kt CO_2e in 2019. Emissions disaggregated to constituents are shown in Table 4.10.

Table 4.10 HFC and PFC emissions for all individual compounds, recalculated into kt CO_2e using AR4 GWPs.

	1990	1995	2000	2005	2010	2015	2018	2019
HFC-23	NO	NO	NO	0.035	0.009	0.007	0.052	0.068
HFC-32	NO	NO	0.005	0.016	0.061	0.106	0.306	0.317
HFC-125	NO	0.800	18.848	19.787	37.749	66.821	58.385	73.929
HFC-134a	NO	1.732	5.622	10.086	15.594	23.268	30.295	35.768
HFC-143a	NO	0.170	18.663	24.696	50.805	88.252	73.169	95.910
HFC152a	NO	0.0084	0.0667	0.0213	0.0225	0.0040	0.0011	NO
HFC-227ea	NO	NO	NO	0.108	0.023	0.330	0.302	0.362
Total HFC in CO_2e [kt]	NO	2.71	43.21	54.75	104.26	178.79	162.51	206.35
C_2F_6 (PFC-116)	NO	NO	NO	0.0032	0.0009	0.0084	0.0522	0.0000
C_2F_8 (PFC-218)	NO	NO	NO	NO	0.0006	0.0002	NO	NO
Total PFC in CO_2e [kt]	NO	NO	NO	0.0032	0.0015	0.0086	0.0522	0.0000
Total HFC+PFC in CO_2e [kt]	**NO**	**2.71**	**43.21**	**54.75**	**104.27**	**178.80**	**162.56**	**206.35**

Figure 4.5 shows the total emissions (assembly emissions, lifetime emissions and disposal emissions) expressed as kt CO_2e from Refrigeration and Air Conditioning. 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. Commercial refrigeration, industrial refrigeration and mobile air conditioning contribute approximately equal parts in 2019 to the overall emissions.

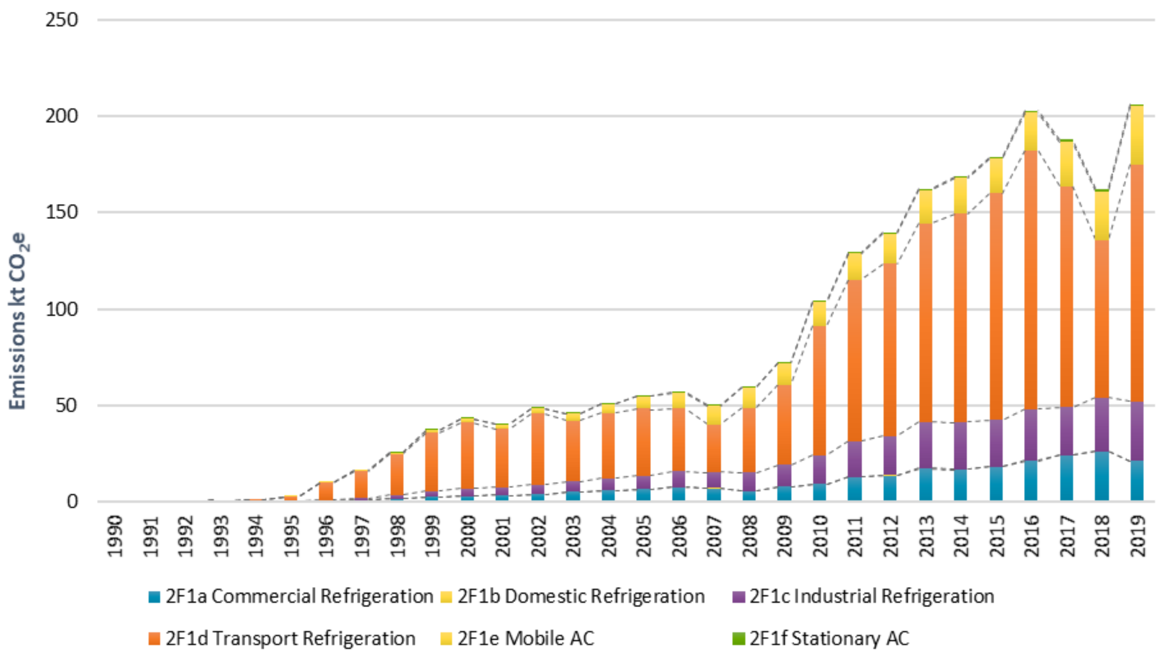


Figure 4.5 Total F-gas emissions from Refrigeration and Air Conditioning, split by subcategories and in kt CO_2e.

As can be seen in Figure 4.4, an 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). Therefore, imported blends in 2012 are decommissioned 7 years later, increasing the total emissions in 2019 compared to 2018.

Uncertainties

The activity data uncertainty for all subcategories of sector 2F1 was derived by analizing 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 28.5% and the total uncertainty, activity data and emission factors combined, is 104%.

Details about the retrieval of the uncertainty factors are summarized in Table 4.11. They can also be found in Annex 2.

Table 4.11 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				58.9%	
	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				35.8%	
	AD Uncertainty					50%
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				71.5%	
	AD Uncertainty					100%
2F1d Transport ref.	Lifetime EF	7	6	9	21%	
	Initial Em.	2	0.2	1	20%	
	Operation Em.	20	15	50	88%	
	Recovery Effic.	70	0	70	50%	
	Combined EF Uncertainty				40.6%	
	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.	No first fills in Iceland				
	Combined EF Uncertainty				28.0%	
	AD Uncertainty					100%
2F1f Stationary air-con.	Lifetime EF	1	10	20	42%	
	Initial Em.	1	0.2	1	40%	
	Operation Em.	3	1	10	150%	
	Recovery Effic.	75	0	80	53%	
	Combined EF Uncertainty				60.7%	
						100%

Recalculations and improvements

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 reacalculations for 2016-2018 of HFC emissions from 2F1e. The effects of these recalculations can be seen in Table 4.12 Recalculations for 2F1e between 2020 v1 and 2021 submissions

Table 4.12 Recalculations for 2F1e between 2020 v1 and 2021 submissions

2F1e Mobile AC	2015	2016	2017	2018
2020 v1 submission kt CO_2e	17.75	20.10	24.95	29.13
2021 submission kt CO_2e	17.75	19.49	22.91	25.35
Change, kt CO_2e	0.0	0.6	2.0	3.8
Change relative to 2020	0.0%	-3%	-8%	-13%

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.

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)

Icelandic regulation no. 834/2010 on fluorinated greenhouse gases bans the production, import, and sale of aerosols products containing HFCs with the exception of HFCs used metered dose inhalers (MDIs). Emissions from 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 2019 were approx. 0.92 kt CO_2e.

Uncertainties

The combined uncertainty of HFC emissions from MDIs are assumed to be 7%, with an activity data uncertainty of 5% and an emission factor uncertainty of 5%. The complete uncertainty analysis is shown in Annex 2.

Recalculations

New 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.

These recalculations can be seen in Table 4.13.

Table 4.13 Recalculations for 2F4 between 2020 and 2021 submissions

2F4 Aerosols	1990	1995	2000	2005	2010	2015	2017	2018
2020 v1 submission kt CO_2e	0.345	0.721	0.758	0.810	0.843	0.881	0.952	0.933
2021 submission kt CO_2e	0.344	0.720	0.756	0.810	0.843	0.866	0.954	0.937
Change, kt CO_2e	-0.0009	-0.0019	-0.0020	-0.00002	-0.0001	-0.0145	0.0018	0.0038
Change relative to 2020 v1	0.0%	-0.3%	-0.3%	0.0%	0.0%	-1.6%	0.2%	0.4%

Planned improvements

There are no category-specific improvements planned for future submissions.

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 the 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[11]. Based on this information the amount “Remaining in products at decommissioning” and the resulting emissions “from disposal” and the “recovery” is reported as “NO”.

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

Emissions

SF_6 emissions amounted to 87.5 kg (2.0 kt CO_2e) in 2019. Emissions increased by 82% since 1990. However, this increase is less than proportional compared to the net increase in SF_6 nameplate capacity since 1990.

Figure 4.6 shows the evolution of SF_6 in switchgear and the associated emissions due to leakage. 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.

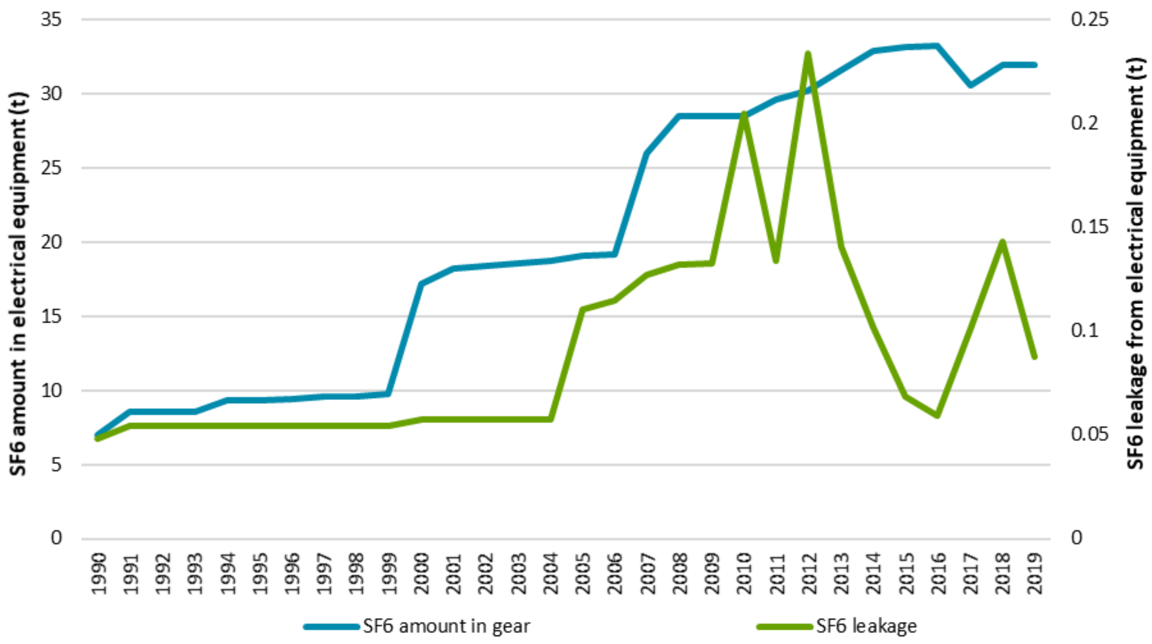


Figure 4.6 Total SF_6 amounts contained in and SF_6 leakage from electrical equipment (tonnes).

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.

Recalculations and planned improvements

No reculations were done for this category.

4.8.2 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), or 91-98%. Minor uses of N_2O in Iceland comprise its use as fuel oxidant in auto racing and in fire extinguishers (CRF subsector 2G3b). In addition, following a request during the 2019 UNFCCC desk review, the emissions from the use of aerosol cans of cream have been added in the current submission.

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 for 2015-2019 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 2015- 2019, 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

$$EN_2O\ (t) = \Sigma i\ \{ [0.5 \bullet Ai(t) + 0.5 \bullet Ai(t\text{-}1)] \bullet EFi \}$$

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

4.8.2.1 *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 2019 (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.

4.8.2.2 *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 for the first time. 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 (720 t CO_2e) and 1.57 t N_2O (467 t CO_2e) in 2019.

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 and the emission factor uncertainty is 5% giving a combined uncertainty factor of 7.8%. The complete uncertainty analysis is shown in Annex 2.

Recalculations and Planned improvements

No recalculations were performed for the current submission and no improvements are planned.

4.8.3 Other: Tobacco combustion and Fireworks Use (CRF 2G4)

4.8.3.1 *Tobacco*

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 2016 guidebook.

Emissions

As can be seen in Figure 4.7, Tobacco consumption in Iceland has been steadily decreasing since 1990, with the 2019 imports (214 t) approximately 62% of the 1990 imports (561 t). Accordingly, the GHG emissions have also decreased by 62%, with 0.045 kt CO_2e CH_4 and 0.011 kt CO_2e N_2O in 1990 and 0.017 kt CO_2e CH_4 and 0.004 kt CO_2e N_2O in 2019. NO_X decreased from 1.01 t in 1990 to 0.39 t in 2019, NMVOC decreased from 2.7 t in 1990 to 1 t in 2019, and CO decreased from 30.9 t in 1990 to 12 t in 2019.

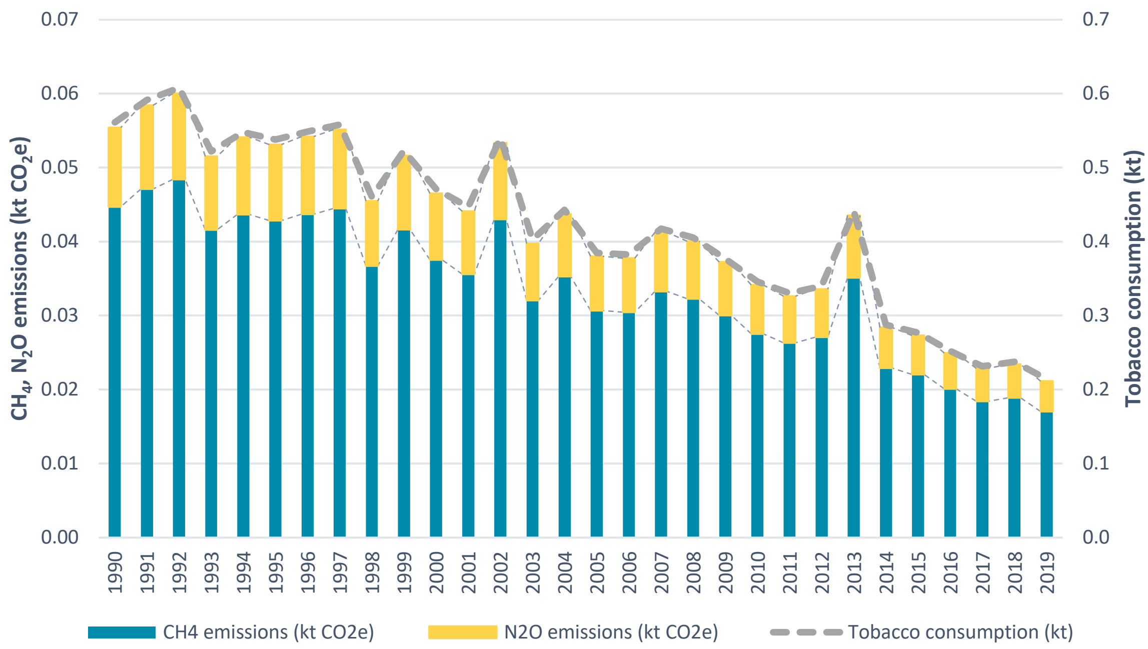


Figure 4.7 Tobacco import and GHG emissions (kt CO_2e) from tobacco use.

Recalculations and planned improvements

No category-specific recalculations were done for the current submission, and no improvements are currently planned for this category.

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 and 50% for N_2O and are chosen in analogy to the Danish NIR 2020. The combined uncertainty for each greenhouse gas is 50.04%. 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 2016 EMEP/EEA Guidebook.

Emissions

Total fireworks use has been gradually increasing since the early 1990's, with associated increase in emissions (Figure 4.8). 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 2019. The main contributor to GHG emissions from fireworks is N_2O, with about 90% of total emissions (when calculated in CO_2e).

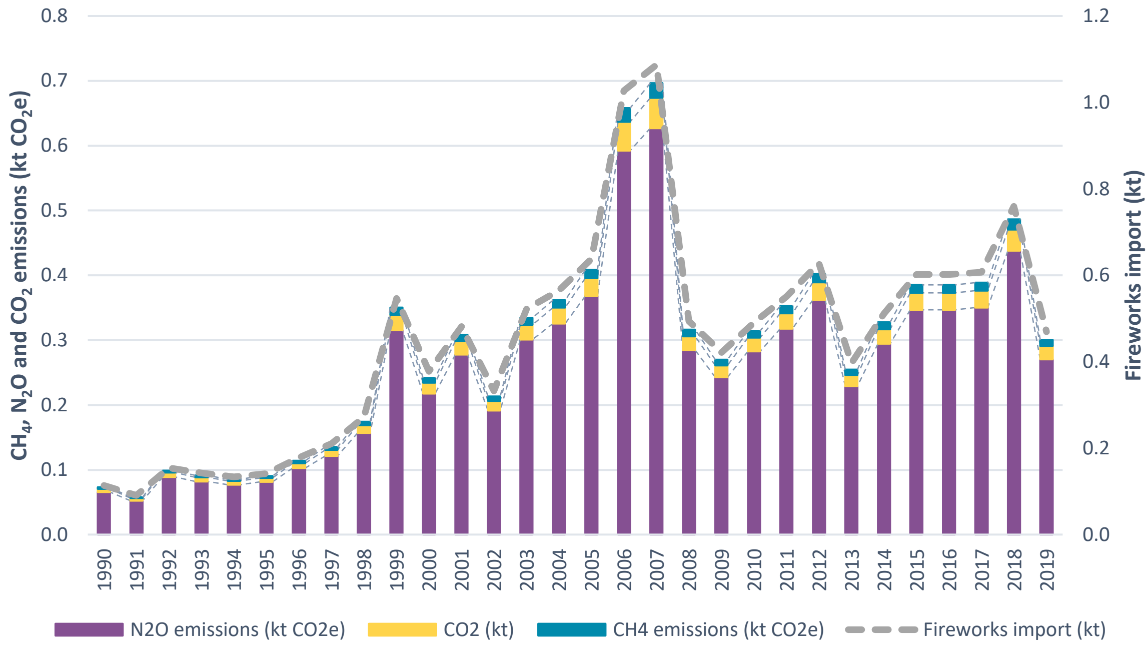


Figure 4.8 Fireworks import and GHG emissions (kt CO_2e) from firework use.

Recalculations and planned improvements

No category-specific recalculations were done for the current submission, and no improvements are currently planned for this category.

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 2020. The combined uncertainty for each greenhouse gas is 50.04%.

4.9 Other (CRF 2H)

4.9.1 Overview

In this sector emissions are reported from the Food and Beverages industry (CRF sector 2H2). Only NMVOC emissions are considered to be significant in this industry. The emission calculations include production of fish, meat, poultry, animal feed, coffee, bread and other breadstuff, beer and other malted beverages.

4.9.2 Methodology

NMVOC emissions were calculated using the default Tiers 2 emission factors from the 2016 EMEP/EEA guidebook. Production statistics were obtained by Statistics Iceland for beer, fish, meat and poultry for the whole time series, apart from beer production in 2017 for which figures were not available from Statistics Iceland, and the same value as for 2016 was used. Statistics for coffee roasting and animal feed were available for the years 2005 to 2014. Production statistics were extrapolated for the years 1990 to 2004. Further production of bread, cakes and biscuits was estimated from consumption figures.

4.9.3 Emissions

In 2019 NMVOC emissions were estimated at 0.4 kt, which represents a 26% increase from the 1990 levels. Figure 4.9 shows the various subcategories contributing to the emissions from the food and beverage production industry. Fish, bread and animal feed are by far the largest contributors to the NMVOC emissions from this subsector. Iceland's inventory does not include CO_2 emission from NMVOC emission oxidation from this subsector.

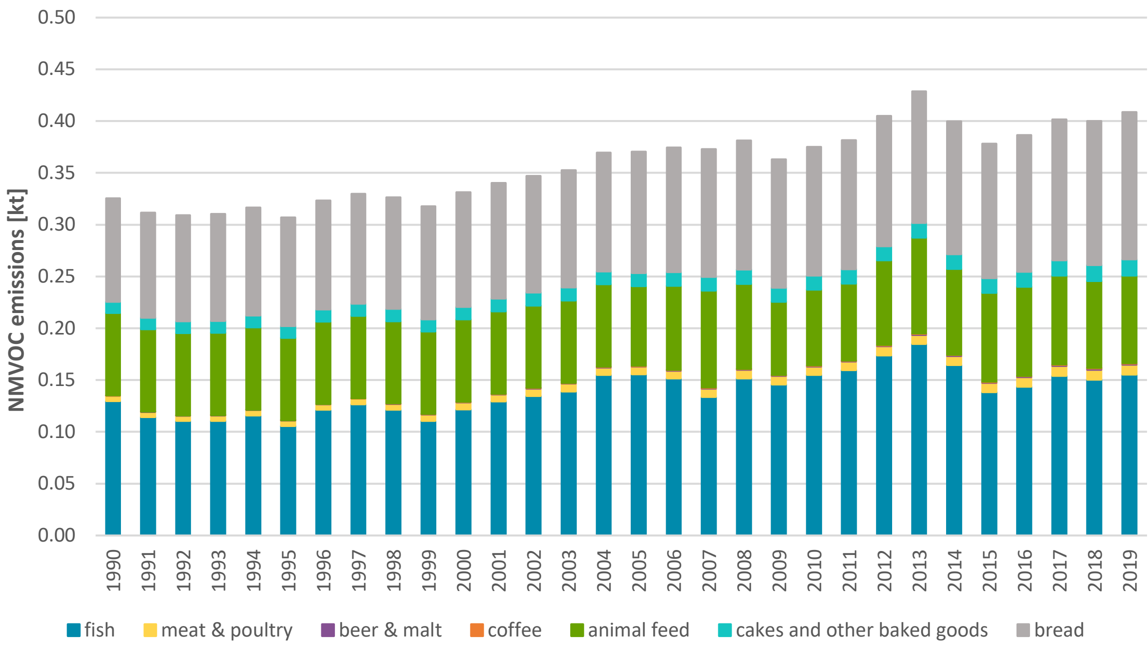


Figure 4.9 NMVOC emissions (in kt NMVOC) for various food and beverage processing.

4.9.4 Recalculations and Planned Improvements

No category-specific recalculations were done for the current submission and for future submissions it is planned to improve the quality of input data.

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 619 kt CO_2e in the year 2019 and were 6% below the 1990 level (Table 5.1). Emissions of CH_4 account for 57%, N_2O for 42% 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. 85% 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 2021 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 2020 EU Comprehensive review. In addition, the 2019 EMEP/EEA Air Pollutant Emissions Inventory Guidebook was applied to the calculations for the first time, determining changes especially in the nitrogen flow model used to calculate emissions of N_2O in 3B Manure Management.

Table 5.1 Emission of GHG in the agricultural sector in Iceland 1990-2019 in kt CO_2e

	1990	1995	2000	2005	2010	2015	2018	2019
CH_4	385	359	353	342	359	372	358	352
N_2O	271	258	271	257	269	277	271	261
CO_2	0.52	0.06	0.12	4	2	3	3	6
Total	**657**	**617**	**624**	**603**	**630**	**653**	**632**	**619**
Emission reduction (year-base year)/base year		-6%	-5%	-8%	-4%	-1%	-4%	-6%

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, 2019 and 1990-2019 trend in the Agriculture sector are as follows (compared to total emissions without LULUCF):

Table 5.2 Key source analysis for Agriculture, 1990, 2019 and trend (excluding LULUCF)

IPCC source category		Gas	Level 1990	Level 2019	Trend
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	✓	✓	

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	
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.

5.1.5 Planned Improvements

In 2019 the IPCC Guidelines used as a basis for the estimation of the emissions has been updated. 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 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 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 Industries and Innovation (MII)	www.government.is /ministries/ministry-of-industries-and-innovation/	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 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

Data provider	Website	Data/information
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 Industries and Innovation (MII) 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 MII 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 numbers directly from there.

This data collection method leads to one issue, namely that young animals that live less than one year and are 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 and RML, written information, 2020).
- The number of piglets was calculated with data on piglets per sow and year (Farmers Association of Iceland, written information, 2012).
- The number of kids was calculated with information on birth rates received from Iceland´s biggest goat farmer (Þorvaldsdóttir, oral information, 2012).
- The number of foals missing in the census as well as hen, duck and turkey chickens were added with information received from the association of slaughter permit holders and poultry slaughterhouses.

For animals with a life span less than one year, annual average animal places (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.

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

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 5.6. While differences are small for some species, they are considerably higher for sheep and poultry (57% and 275%, respectively). The number of swine is eleven times higher in the NIR than in the national census (Statistics Iceland, 2020)[12]. Lambs are not reported in Statistics Iceland or in the MII autumn reports and therefore calculated through the equation 10.1 from the 2006 IPCC Guidelines. The same applies for the animal category swine, where only adult females and males are reported in Statistics Iceland and in MII; using the age of slaughter obtained by the slaughter association of Iceland, the annual average population of piglets is calculated and the notable differences between the two counts as shown in Table 5.6 is explained. Animal categories changed over time, as in Statistics Iceland 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 derive 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 MII, even though they are not reported on the website of Statistics Iceland. The annual livestock census is a 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 5.5 Age at slaughter for young animals with a live span of less than one year used for calculating AAP

Animal type	Age at slaughter
Lambs	4.5 months
Piglets	5.9 months (1990) – 4.5 months (2010)
Foals	5 months
Kids	5 months
Chickens (hens)	1.1 months
Chickens (ducks)	1.7 months
Chickens (turkeys)	2.6 months

Table 5.6 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	2018	2019
Mature dairy cattle	Statistics Iceland	32,246	30,428	27,066	24,538	25,711	27,386	26,386	26,217
	NIR	31,604	30,428	27,066	24,488	25,379	27,441	26,477	26,217
Other Mature Cattle	Statistics Iceland	…	…	949	1,355	1,672	2,049	2,640	2,891
	NIR	645	737	953	1,355	1,608	2,049	2,640	2,891
Ewes	Statistics Iceland	445,513	458,341	465,777	454,950	374,266	374,863	344,452	328,290
	NIR	445,185	372,222	373,240	360,119	372,672	373,278	344,795	328,881
Lambs	Statistics Iceland	…	…	…	…	….	…	…	…
	NIR	312,801	261,163	263,750	256,227	271,156	272,279	225,572	216,237

[12] https://statice.is/statistics/business-sectors/agriculture/live-stock-and-field-crops/

Animal category	Source	1990	1995	2000	2005	2010	2015	2018	2019
Swine	Statistics Iceland	3,116	3,726	3,862	3,982	3,615	3,550	3,323	3,155
	NIR	29,768	30,746	32,242	39,350	38,032	42,542	40,278	38,314
Laying hens	Statistics Iceland	214,936	164,402	193,097	166,119	173,419	238,000	253,763	205,079
Poultry	NIR	669,280	353,214	531,853	765,860	630,258	706,067	866,435	889,848

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). MII is in the process of setting up a better system by linking Worldfengur, the studbook of origin for the Icelandic horse[13] 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 during the past two years and it will take some more time to be fully reliable. Nevertheless, there is no legal obligation for horse owners to report the number of horses as there are no 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 them as the sum of two thirds of animals registered at MII (bustofn.is) and one third registered in the studbook after consulting with Jón Baldur Lorange, advisor at the office for agricultural affairs at MII and manager of the studbook Worldfengur (Table 5.7).

Table 5.7 Comparison of registered horses in the autumn census of IFVA and the studbook Worldfengur for 2014-2019 and calculated livestock numbers to be used in this submission

Source	2014	2015	2016	2017	2018	2019
MII (bustofn.is)	67,997	67,417	67,239	64,816	53,453	55,198
Studbook (worldfengur.com)	97,693	97,941	97,955	96,840	96,689	93,733
Calculated for NIR	77,896	77,592	77,478	75,491	67,865	70,612

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: heifers, male animals from the age of 12 to 27 months and young cows from the age of 12 months to 18 months and calves (males and females up to 12 months of age). The emissions

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

are calculated separately for each of these subcategories and then summed in the category "growing cattle" in CRF.

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 5.8 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 5.8. 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

Note: [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 5.9 shows national parameters that were used to calculate gross energy intake for cattle in 2019. Not all parameters have been constant over the last three decades. The ones that have changed during that time period are days on stall, days on pasture, kg milk per day.

Table 5.9. Animal performance data used in calculation of gross energy intake for cattle in 2019. (NA: Not applicable, NO: Not occurring)

	Mature dairy cattle	Other mature cattle	Heifers	Steers for producing meat	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

Note: Steers are not allowed outside. The young cows inside the category are grazing on pasture for 120 days. Average for cows and steers, not weighted.

Table 5.10 shows national parameters that were used to calculate gross energy intake for sheep in 2019.

Table 5.10 Animal performance data used in calculation of gross energy intake for sheep for 2019. 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

Note: [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.

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 2019 per cow is 6416 kg with 4.25% fat and 3.41% protein.

	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	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 was 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 5.11 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 5.11 Dry matter digestibility, digestible energy and ash content of cattle and sheep feed in 2019

	DMD (%)	DE (%)	Ash in feed (%)
Mature dairy cattle	72.00	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 5.1 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 257 MJ/day in 2019. 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 6.3 t in 2019.

Feed digestibility is constant in Iceland for all other cattle types 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.

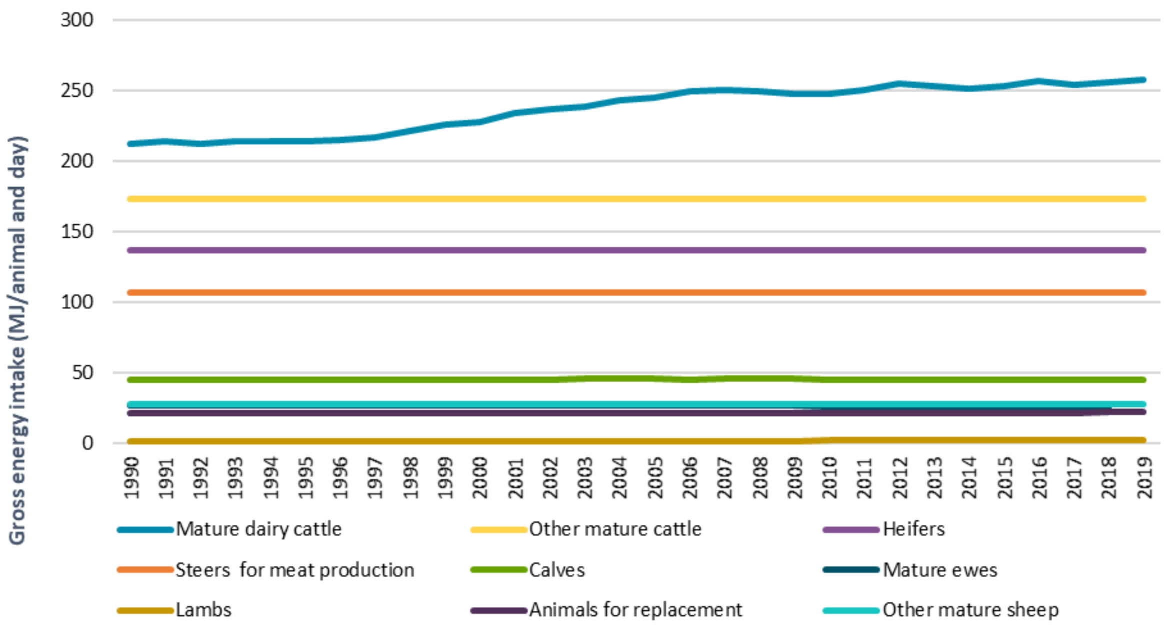


Figure 5.1 Gross energy intake (MJ/day) for cattle and sheep subcategories from 1990-2019.

5.2.4 Recalculations

Animal characterization update

In response to an issue raised during the 2020 EU Comprehensive Review (EMRT-ID IS-3A-2020-0004) the gross energy (GE) for mature dairy cattle has been interpolated from 2013-2017 to avoid a step change between 2017 and 2018 as in the previous 2020 submission. For the past submission, feed digestibility data as well as other animal characterization parameters were updated in collaboration with the Icelandic Agricultural Advisory Centre (RML, written communication, 2020; see NIR 2020). The previous data collection referred to the year 2012 and the new data to the year 2018. Revising the GE for dairy cattle impacts on corresponding 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).

Table 5.12 Recalculation of the gross energy (MJ/day) for mature dairy cattle 2013-2018 (interpolation to avoid step change as in 2020 v1 submission

Mature dairy cattle	2013	2014	2015	2016	2017	2018
2020 v1 submission	256	257	261	269	269	256
2021 submission	253	251	253	257	254	256
Change relative to 2020 submission	-1%	-2%	-3%	-4%	-5%	0%

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 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.

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 5.13). 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 5.13 Default emission factors (kg CH_4/head/year) used for Tier 1 calculations

Livestock category	Source	2019
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 0. These values together with the default values of the methane conversion rate from the IPCC 2006 Guidelines and reported in Table 5.14 were used to calculate emission factors for methane emissions from enteric fermentation by applying Equation 10.21. Table 5.15 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 5.14 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	0.065	0.065	0.045

Table 5.15 Country specific emission factors (kg CH_4/head/year) for cattle and sheep, calculated based on Equation 10.21 (IPCC, 2006)

Livestock category	2019
Mature dairy cattle	109.7
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 5.16 are solely based on fluctuations in population size. The population size of mature dairy cattle has decreased by 17% between 1990 and 2019. Methane emissions, however, have increased by 0.5% from 2.86 kt to 2.88 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

5.17 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 calves population is much higher than heifers and steers for producing meet 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 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 proportionate decrease in population size, emissions from mature ewes decreased by 27% between 1990 and 2019 (from 5.05 to 3.7 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 2019 compared to 1990 (by 2%), the methane emissions are fairly constant therefore 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 11.8 kt in 2019, or by 9% (Table 5.16).

Table 5.16 Methane emissions from enteric fermentation from agricultural animals in t methane

Livestock category	1990	1995	2000	2005	2010	2015	2018	2019
Mature dairy cattle	2,860	2,770	2,629	2,552	2,681	2,955	2,890	2,875
Other mature cattle	48	54	70	100	119	151	195	213
Heifers	267	746	371	393	386	418	351	380
Steers for producing meat	817	700	903	694	858	899	1,066	1,049
Calves	388	268	346	351	387	429	441	425
Mature ewes	5,043	4,217	4,228	4,092	4,045	4,054	3,844	3,666
Other mature sheep	158	148	144	134	144	141	139	131
Animals for replacement	845	695	756	786	872	834	720	726
Lambs	1,231	1,028	1,038	1,000	1,132	1,154	1,054	1,011
Swine	45	46	48	59	57	64	60	57
Horses	1,330	1,444	1,361	1,379	1,419	1,430	1,255	1,304
Goats	2	3	3	3	5	7	11	11
Fur animals	5	4	4	4	4	5	2	1
Poultry	14	7	11	16	13	14	18	18
Total CH_4 emissions (t)	**13,053**	**12,129**	**11,913**	**11,561**	**12,122**	**12,554**	**12,046**	**11,868**
Emission reduction (year-base year)/base year		-7.1%	-8.7%	-11.4%	-7.1%	-3.8%	-7.7%	-9.1%

Table 5.17 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	2018	2019
Population heifers	4,579	12,781	6,361	6,728	6,620	7,157	6,011	6,504
Population steers for meat production	17,957	15,379	19,848	15,250	18,873	19,757	23,445	23,066
Population calves	20,118	13,874	17,916	18,149	20,029	22,372	23,000	22,217

Growing Cattle	1990	1995	2000	2005	2010	2015	2018	2019
Weighted average Body weight (BW) kg	237.4	274.2	252.2	243.8	245.4	242.6	244.4	246.8
Weighted average digestible energy (DE) %	69.9	69.2	69.5	69.8	69.7	69.8	69.6	69.6
Weighted average gross energy (GE) MJ/day	81.0	95.6	86.1	84.0	84.1	83.1	83.1	84.0
Sum CH_4 emissions (kt)	**1.47**	**1.71**	**1.62**	**1.44**	**1.63**	**1.75**	**1.858**	**1.854**
IEF	34.52	40.76	36.71	35.83	35.84	35.41	35.42	35.80

5.3.3 Recalculations

The recalculations of the gross energy (GE) explained in paragraph 5.2.4 for mature dairy cattle lead to recalculations in the methane emission factor and therefore in the methane emissions for the years 2013-2017. The changes show an average decrease of 3% for the years 2013-2017 (Table 5.18). There are no recalculations for the methane emissions from enteric fermentation for the year 2018.

Table 5.18 Comparison between the 2020 v1 submission and the 2021 submission for mature dairy cattle for the years 2013-2017

Mature dairy cattle	2013	2014	2015	2016	2017
2020 v1 submission	2.595	2.863	3.055	3.017	3.062
2021 submission	2.566	2.799	2.955	2.886	2.898
Change relative to 2020 submission	-1.1%	-2.2%	-3.3%	-4.3%	-5.4%

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 apply this uncertainty also to the animal classes in 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 40.3% 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 5.19 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 5.19 Tier 1 default emission factors for methane emissions from manure management.

Livestock category	Source	2019
Swine	Table 10.14 2006 IPCC	6.0
Horses	Table 10.15 2006 IPCC	1.09
Goats	Table 10.15 2006 IPCC	0.12
Minks, foxes	Table 10.16 2006 IPCC	0.7
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

$$VS = \left[GE * \left(1 - \frac{DE\%}{100}\right) + \boldsymbol{UE * GE}\right] * \left[\left(\frac{\boldsymbol{1 - ASH}}{\boldsymbol{18.45}}\right)\right]$$

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 5.20.

Table 5.20 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) / 0.17 (2)	same as for cattle
		Cattle		Sheep	
Maximum methane producing capacity of manure - Bo	Tables 10A-4, 10A-9, 2006 IPCC	0.24		0.19	

Note: (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 (0.17) than PRP (0.01) or solid storage (0.02), 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 5.21).

Table 5.21 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 5.22. Mature dairy cows and steers have the highest emission factors for methane from manure management.

Table 5.22 Emission factors values and range for the tier 2 calculations of methane emissions from manure management.

Livestock category	Emission factor 2019	Emission factor range 1990-2019	Source
	(kg CH_4/head year)	(kg CH_4/head year)	
Mature dairy cattle	30.83	29.23-34.05	LPS
Other mature cattle	3.01		LPS
Heifers	12.04		LPS
Steers for producing meat	13.03		LPS
Calves	4.86	4.86-4.96	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 5.22 above, 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 ewes 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 2.36 kt in 1990 to 2.22 kt in 2019 or by 6%.

Table 5.23 Methane emissions from manure management in tonnes.

Livestock category	1990	1995	2000	2005	2010	2015	2018	2019
Mature dairy cattle	928	893	838	808	840	882	813	808
Other mature cattle	2	2	3	4	5	6	8	9
Heifers	55	154	77	81	80	86	72	78
Steers for producing meat	234	200	259	199	246	257	306	301
Calves	99	68	88	89	98	109	112	108
Mature ewes	488	408	409	396	391	392	372	355
Other mature sheep	15	14	14	13	14	14	13	13
Animals for replacement	82	67	73	76	84	81	70	70
Lambs	26	22	22	21	24	24	22	21
Swine	179	184	193	236	228	255	242	230
Horses	81	87	82	84	86	87	76	79
Goats	0	0	0	0	0	0	0	0
Fur animals (minks and foxes)	32	26	28	25	27	32	13	10
Rabbits	0	0	0	0	0	0	0	0
Poultry	142	105	127	107	99	86	156	141
Total CH_4 from manure management (t)	**2362**	**2231**	**2213**	**2139**	**2223**	**2313**	**2275**	**2223**
Emission reduction (year-base year)/base year		-6%	-6%	-9%	-6%	-2%	-4%	-6%

5.4.4 Recalculations

For mature dairy cattle the update of the gross energy (GE) for 2013-2017 as described in paragraph 5.2.4 influences the calculation of the volatile solid excretion rates (VS).

The CH_4 emissions from Manure Management show recalculations of minus 3% in 2013 up to minus 13% in 2017 as shown in Table 5.24. There are no recalculations affecting the methane emissions from manure management for the year 2018.

Table 5.24 Comparison of CH_4 emissions in kt from Manure Management between 2020 v1 submission and 2021 submission for mature dairy cattle, years 2013-2017

Mature dairy cattle	2013	2014	2015	2016	2017
2020 v1 submission	0.814	0.897	0.958	0.946	0.960
2021 submission	0.792	0.850	0.882	0.848	0.837
Change relative to 2020 submission	-3%	-5%	-8%	-10%	-13%

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) 22.9%, 3B2 (sheep) 32.4%, 3B3 (swine) 32%, 3B4 (all other animals) 64.6%. 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 (chapter 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 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 in 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 omission occurs 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 2019 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 during the past twenty years and are summarized Table 5.21.

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

Table 5.25 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 by the Tier 2 approach, and those animal categories for which the Nex rate has been calculated on a more disaggregated level and reported as a weighted average in relation to the population data (growing cattle, horses, poultry).

The calculation method for the Nex rate for mature dairy cattle followes 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_iN_{take}= the daily N intake per head of animal category, kg N/animal/day
- $N_{rete}N_{tio}N_{\_frac}$= 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:

- NiNtake= 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

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

Where:

- NreteNtioN= 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 5.25 Nitrogen excretion rates defaults, animal weight and Nex for the time series 1990-2019

Livestock category	Nex default (kg N/1000 kg animal mass/day)	animal weight (kg)	1990	1995	2000	2005	2010	2015	2018	2019
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	weighed average from heifers, steers, calves		29	29	33	33	33	33	34	30
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

Livestock category	Nex default (kg N/1000 kg animal mass/day)	animal weight (kg)	1990	1995	2000	2005	2010	2015	2018	2019
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 and foals		28	28	28	28	27	27	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
Broilers	1.10	4	2	2	2	2	2	2	2	2
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 2018 = 471.3 kg and in the years between interpolated linearly (see section 5.2.4).

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 5.26.

Table 5.26 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	243	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	150	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	0.22	0.11	0	0.0001
					solid	0.24	0.29	0.01	0.01
Goats	0.5	0	1	201	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
Broilers	0.7	0	1	365	solid	0.21	0.3	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 5.26) 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 expresses as proportions of TAN in manures 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. As an example, sheep have a default housing period of 30 (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 and further information 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 34 tonnes N_2O in 2019 and 44 tonnes in 1990 (-22%).

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 2019. This is because the emission factor is twenty times lower for liquid systems than for solid storage. The majority of emissions originated from the solid storage of sheep manure (79% in 2019), followed by solid storage of horse manure (6%), poultry manure (3%), and fur animal manure (0.3%).

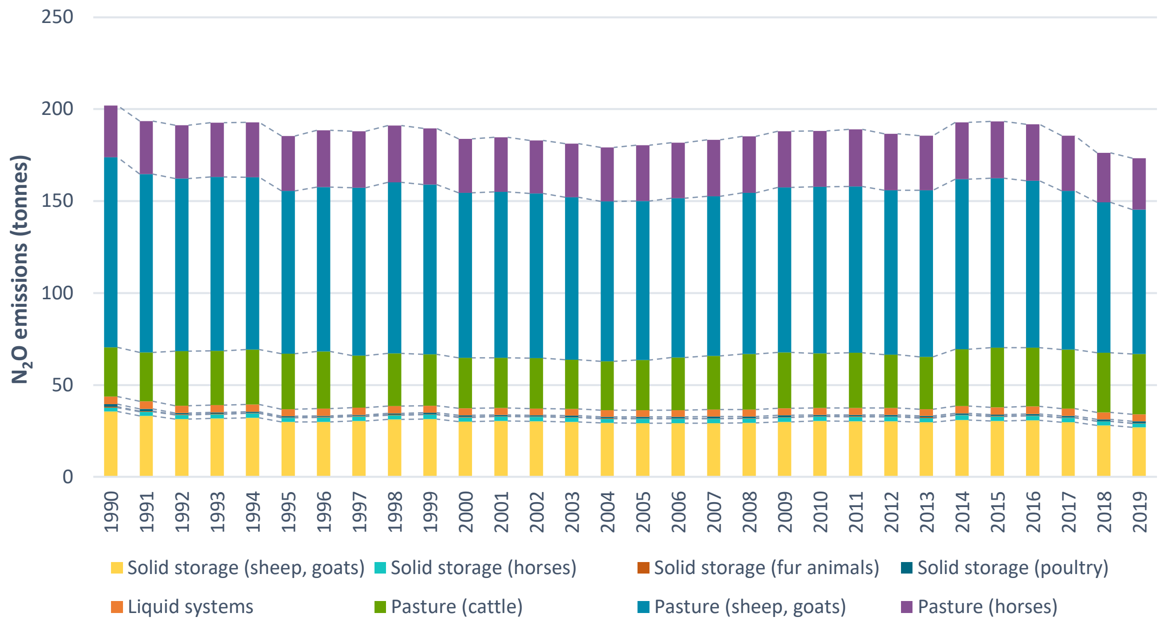


Figure 5.2 N_2O emissions from manure management in t N_2O

Figure 5.2 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 2019 N_2O emissions from manure spread on pasture by livestock amounted to 139 tonnes. Emissions from sheep manure were 79 tonnes, emissions from horse manure were 28 tonnes, and emissions from cattle manure amounted to 33 tonnes N_2O.

Indirect emission from manure management due to the losses of volatilization of N resulted in a total of 28 tonnes N_2O for 2019, decreasing by 14% from 32 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.

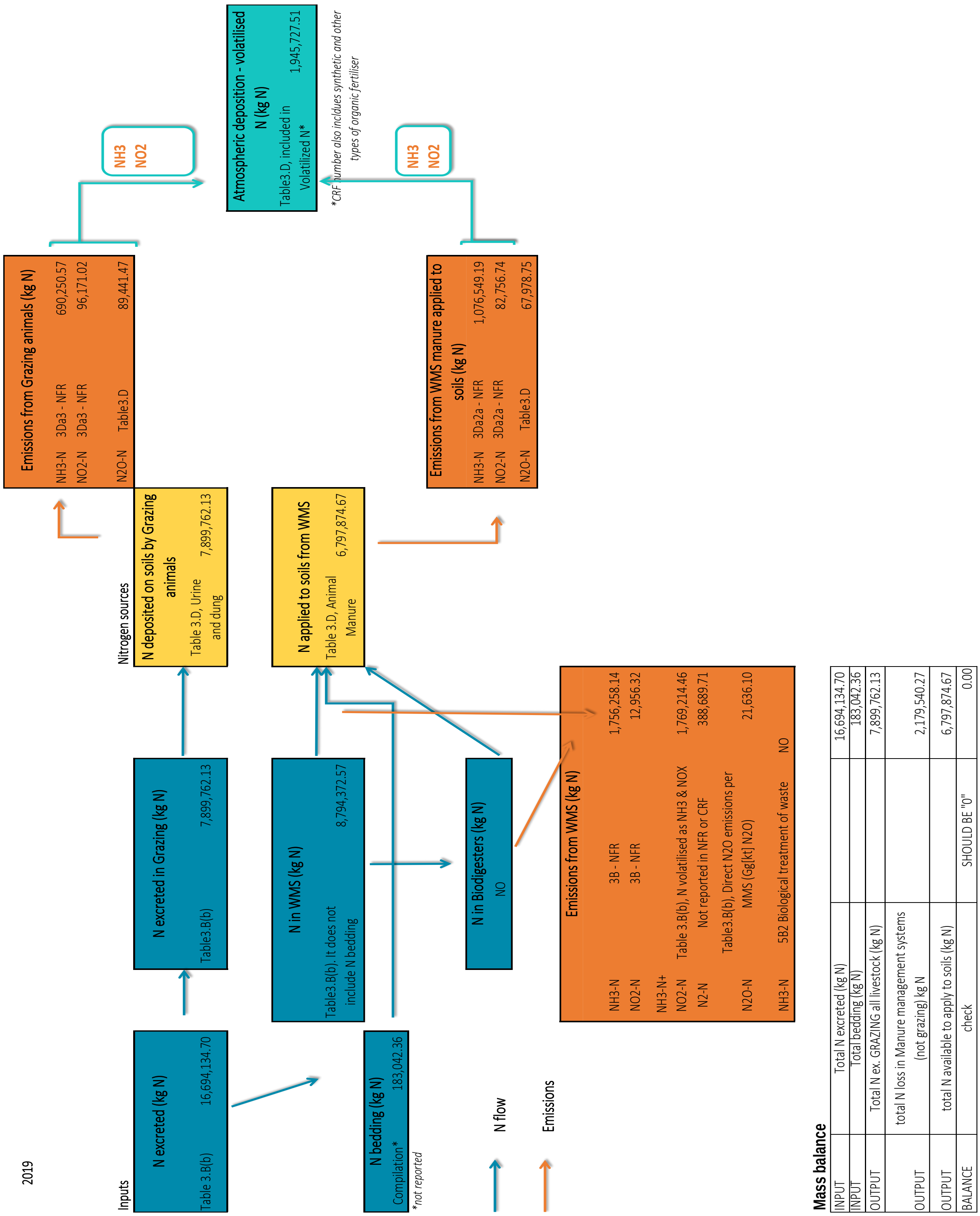


Figure 5.3 Complete Nitrogen flow applied to the categories 3B Manure Management and 3D Agricultural soils for the year 2019. Biodigesters are not occurring in Iceland. In Atmospheric Deposition – volatilized CRF includes also synthetic and other types of organic fertilizers. NFR refers to the reporting of air pollutants under CLTRAP (NH_3 and NO_X).

5.5.6 Recalculations

For the current 2021 submission, parameters, e.g. emission factors used in the N-flow methodology were updated from the 2016 EMEP/ EEA Air Pollution Inventory Guidebook to its newest 2019 edition. In particular, emission factors for the NH_3-N emissions in the different stages of manure management systems (housing, storage, application and grazing) and for the manure types slurry and solid changed for some animal categories. Some emission factors increased, some decreased and some remained unchanged. The emission factors for N_2O, NO and N_2 are unchanged compared to the 2016 edition of the EMEP/EEA Guidebook. This implies recalculations for the N_2O emissions of all animal categories and for the whole times series 1990-2018. The total recalculations for the subsector 3B2 N_2O emissions from Manure Management are reported in Table 5.27 and there is an average decrease of N_2O emissions of about 3.7% over the whole time series.

In order to explain the recalculations better, the direct and indirect N_2O emissions from Manure Management are reported in Table 5.28 and Table 5.29. The change in emission factors and parameters used in the N-flow tool determine an average increase of 0.8% of direct N_2O emissions and an average decrease of 8.9% of indirect emissions.

Table 5.27 Total N_2O emissions from Manure Management (3B) from the 2020 v1 submission compared to the current submission

	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission kt N_2O	0.07893	0.06696	0.06810	0.06585	0.06781	0.06965	0.06565
2021 submission kt N_2O	0.07588	0.06456	0.06559	0.06344	0.06529	0.06702	0.06344
Change relative to 2020 submission	-3.9%	-3.6%	-3.7%	-3.6%	-3.7%	-3.8%	-3.4%

Table 5.28 Direct N_2O emissions from Manure Management (all livestock categories) compared to the 2020 v1 submission

	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission kt N_2O	0.04332	0.03660	0.03708	0.03602	0.03728	0.03763	0.03487
2021 submission kt N_2O	0.04373	0.03939	0.03738	0.03631	0.03755	0.03781	0.03517
Change relative to 2020 submission	0.9%	7.6%	0.8%	0.8%	0.7%	0.5%	0.9%

Table 5.29 Indirect N_2O emissions from Manure Management compared to the 2020 v1 submission

	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission kt N_2O	0.03560	0.03036	0.03102	0.02983	0.03053	0.03202	0.03078
2021 submission kt N_2O	0.03215	0.02771	0.02821	0.02713	0.02774	0.02921	0.02827
Change relative to 2020 submission	-9.7%	-8.8%	-9.1%	-9.0%	-9.1%	-8.8%	-8.2%

When looking at the main animal categories (Table 5.30), cattle and sheep, the change in emission factors determine on average and on the whole time series a decrease in emissions of 5% for cattle and an increase of 0.8% for sheep. The biggest changes occur for the animal category poultry, with an average increase of 23% in N_2O emissions compared to the previous submission. This is explained by the change of emission factor for NH_3-N for housing, which decreased by half from 0.41 to 0.20 for solid manure; in addition the emission factors of NH_3-N for solid manure for broilers also decreased from 0.28 to 0.21. All emission factors are given as a proportion of TAN and detailed information about the methodology applied can be retrieved in the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019. In addition, the update of the gross energy calculation for mature dairy cattle (2013-2017) contributes also to recalculations (see 5.2.4).

Table 5.30 Recalculations for the animal categories cattle, sheep and poultry

Cattle kt N_2O	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission	0.0026	0.0026	0.0025	0.0023	0.0025	0.0027	0.0027
2021 submission	0.0025	0.0025	0.0024	0.0022	0.0023	0.0025	0.0025
Change relative to 2020 submission	-5%	-5%	-5%	-5%	-5%	-7%	-5%
Sheep kt N_2O							
2020 v1 submission	0.0369	0.0310	0.0312	0.0302	0.0315	0.0314	0.0289
2021 submission	0.0372	0.0312	0.0315	0.0305	0.0318	0.0317	0.0292
Change relative to 2020 submission	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%
Poultry kt N_2O							
2020 v1 submission	0.0012	0.0004	0.0007	0.0008	0.0005	0.0006	0.0008
2021 submission	0.0014	0.0006	0.0009	0.0009	0.0006	0.0007	0.0010
Change relative to 2020 submission	18%	27%	22%	19%	22%	19%	23%

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 47.5% for horses to 59.7% for poultry. The emission factor uncertainty is assigned to be 100% for all animal categories at 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) 100.6%, 3B22 (sheep) 103%, 3B23 (swine) 100.6%, 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

There are no improvements planned for this category.

5.6 Rice Cultivation (CRF 3C)

This activity is not occurring in Iceland.

5.7 Direct N_2O Emissions from Managed Soils (CRF 3D1)

Nitrous oxide (N_2O) is produced naturally in soils through the microbial processes of nitrification and denitrification. The following agricultural activities lead to N_2O emissions and are described in this chapter:

- application of inorganic N fertilizer
- application of organic N fertilizer (animal manure, sewage sludge and 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:

- $N_2O_{Direct\ -N}$ = 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 the 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 (F_SN)*

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 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 inspection of food, fertilizers and seeds, animal diseases and prevention of them and relative changes. The Environment Agency receives a detailed list of the inorganic fertilizers 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[14]. Table 5.31 reports the nitrogen content in inorganic fertilizers and the associated N_2O emissions from 1990-2019. Due to the nature of the import system, which registers imports during one solar year, stockpiling of fertilizers can occur, e.g. when one shipment comes late in autumn and won't be used during the same years. This explains the irregular shape of the imports, with periodic peaks (Figure 5.4). 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 5.31 Nitrogen applied in inorganic fertilizers to soils and the associated emissions, 1990-2019

	1990	1995	2000	2005	2010	2015	2018	2019
N content in inorganic N fertilizer, kt N	12.47	11.20	12.68	9.78	10.88	11.65	11.74	10.38
N_2O emissions, kt N_2O	0.20	0.18	0.20	0.15	0.17	0.18	0.18	0.16

5.7.2.2 *Organic N Fertilizer (F_ON)*

Animal Manure Applied to Soils

Animal manure nitrogen available from storage for application as a fertilizer is calculated through from 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 at 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 5.32).

Table 5.32 Nitrogen input from animal manure, both slurry and solid, applied to soils and associated N_2O emissions

	1990	1995	2000	2005	2010	2015	2018	2019
N input - slurry, kt N	4.47	4.16	4.09	3.91	4.13	4.32	4.18	4.09
N input - solid, kt N	3.64	2.92	3.04	2.94	2.98	3.01	2.80	2.71
N_2O emissions, kt N_2O	0.128	0.111	0.112	0.116	0.112	0.115	0.110	0.107

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

Sewage Sludge Applied to Soils

The regulations 799/1999 (Regulation about handling 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 to the use in agriculture, such as fertilizer for areas to produce forage for animals. Currently in Iceland, few municipalities are using sewage sludge as an organic fertilizer for land reclamation purposes in collaboration with the Soil Conservation Service of Iceland[15]. 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. These data 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 5.33 the emissions from the application of sewage sludge are low, with 0.75 t N_2O in 2019.

Table 5.33 Nitrogen content of sewage sludge 2013-2019 and associated N_2O emissions

	1990	1995	2012	2013	2014	2015	2018	2019
N in sewage sludge, t N	NO	NO	1.44	1.92	0.96	0.81	15.52	4.75
N_2O emissions, t N_2O	NO	NO	0.0226	0.0302	0.0151	0.0127	0.2439	0.0747

Other Organic Fertilizers Applied to Soils

Research carried out during 2020 has shown that there are other organic fertilizers applied to soils and for the first time the emissions from this subcategory has been added to the inventory. Also in this case the information derives from an unpublished report of the Soil Conservation Service of Iceland (Magnus H. Johannsson, e-mail May 2020) reporting type and quantity of organic fertilizers used from 2009-2019 for land reclamation purposes and related N-contents. In addition, compost produced by one company in Iceland with a high N-content has been added to this subcategory. Table 5.34 shows the N-content and associated N_2O emissions from this category, reaching 2.93 t N_2O in 2019.

Table 5.34 Nitrogen content of other organic fertilizers, added for the first time in this submission and associated N_2O emissions

	1990	1995	2000	2009	2010	2015	2018	2019
N in other organic fertilizers sludge, t N	NO	NO	NO	59	103	163	180	186
N_2O emissions, t N_2O	NO	NO	NO	0.93	1.62	2.56	2.83	2.93

[15] https://www.land.is/english/

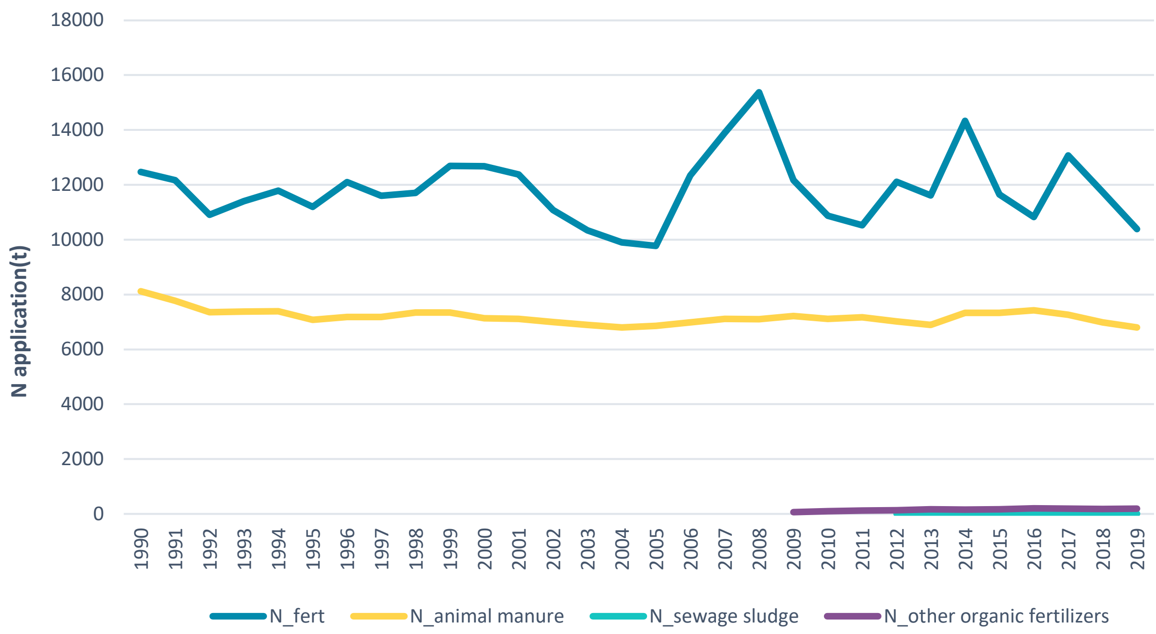


Figure 5.4 Amounts of nitrogen from synthetic and organic fertilizer (animal manure and sewage sludge) applied to soils, t

5.7.2.3 *Urine and Dung Deposited by Grazing Animals (F_{PRP})*

N deposited from animals at pasture, range and paddock is also determined by the N-flow approach described in section 5.5. The amount of days animals spend outside are collected for the livestock characterization 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 5.35).

Table 5.35 Nitrogen deposited by grazing animals (pasture, range and paddock) and associated N_2O emissions, 1990-2019

	1990	1995	2000	2005	2010	2015	2018	2019
N excretion, grazing, kt N	9.37	8.49	8.43	8.31	8.67	8.80	8.03	7.90
N_2O emissions, kt N_2O	**0.161**	**0.148**	**0.146**	**0.144**	**0.151**	**0.155**	**0.142**	**0.141**

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

There are four 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 are 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 Residue/crop ratio, dry matter fraction and nitrogen fraction, the IPCC default values are used. Dry matter fraction defaults, though, do 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 below in Figure 5.5.

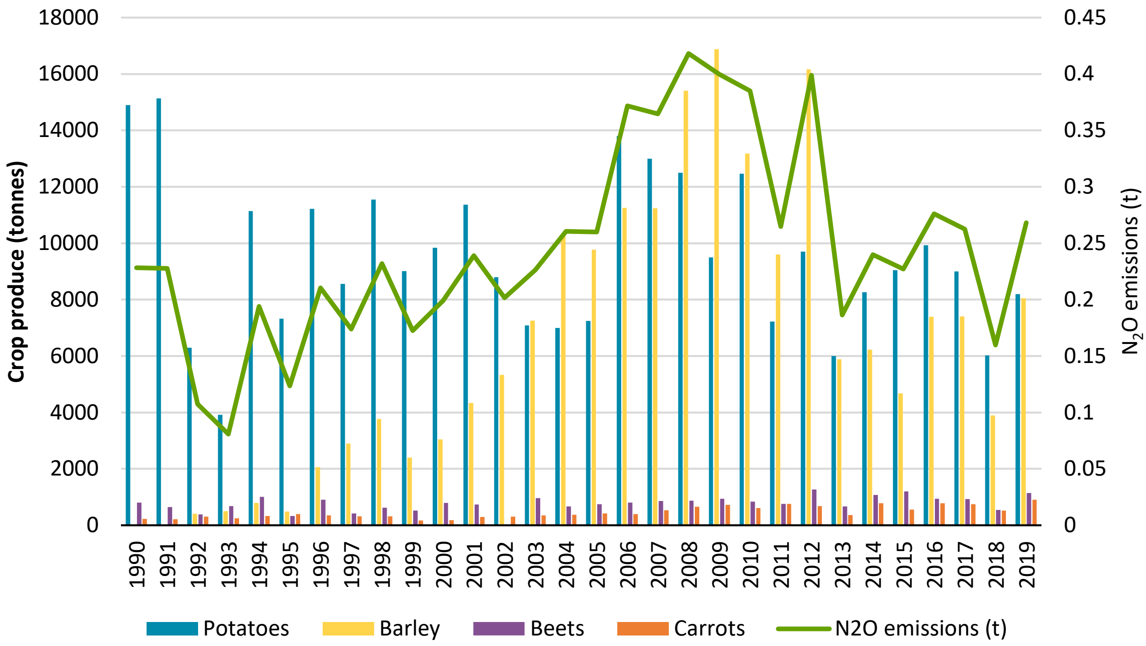


Figure 5.5 Crop produce and associated N_2O emissions in t for 1990-2019.

The amount of nitrogen in crop residues returned to soils was lowest in 1993, when it amounted to roughly 5 tonnes and highest in 2008 when it amounted to roughly 27 tonnes. It has to be noted, however, that there is a very large difference in scale between amounts of nitrogen in crop residues returned to soils and N amounts in synthetic fertilizer 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 *Mineralization/Immobilization 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 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 5.36.

Table 5.36 Area of organic soils in kha and associated N_2O emissions, 1990-2019

	1990	1995	2000	2005	2010	2015	2018	2019
Organic soils-histosols	65	65	64	64	63	63	63	63
Drained organic soils-grasslands	150	2	219	247	251	253	256	258
Total area	215	2	283	311	315	316	319	320
N_2O emissions, kt N_2O	**0.205**	**0.236**	**0.251**	**0.270**	**0.272**	**0.273**	**0.275**	**0.276**

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 5.37. For urine and dung deposited by grazing animals two emission factors are used according to 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 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). 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. 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 problem.

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 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.

Table 5.37 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 689 t of N_2O in 2019 which is the same level of emissions in 1990. Main fluctuations are due to the import and use of synthetic N-fertilizers as can be seen in Figure 5.6.

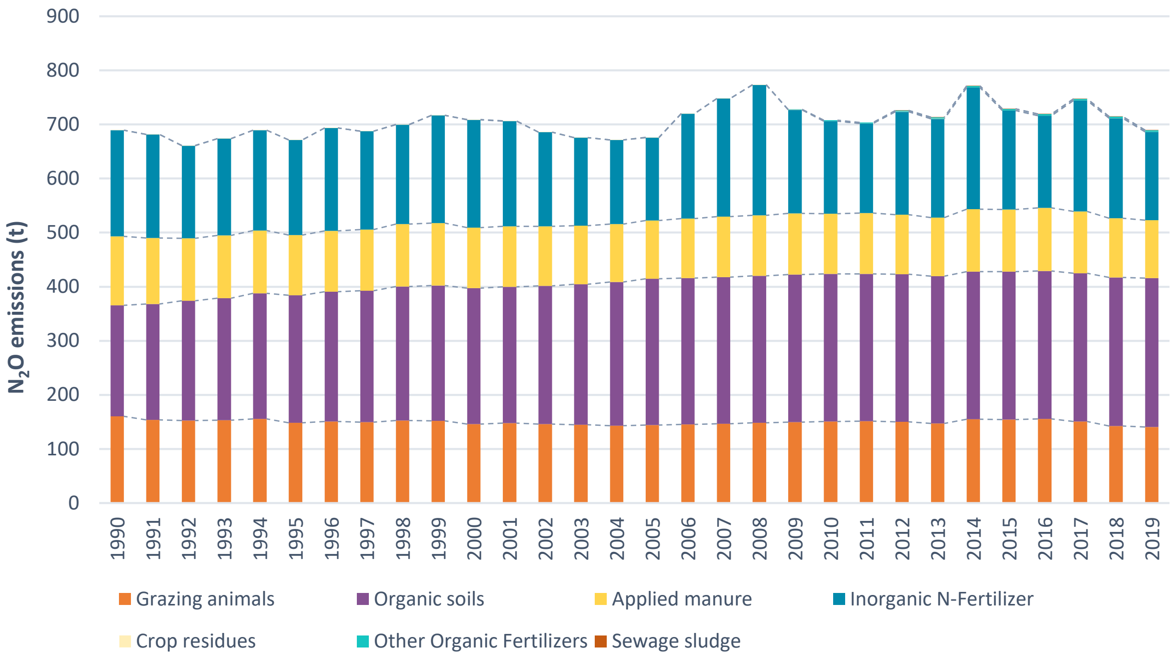


Figure 5.6 Direct N_2O emissions from Agricultural soils (t).

5.7.5 Recalculations

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). Table 5.38 shows the entities of these recalculations showing a decrease for the first decade of the time series and then a slight increase of emissions up to +1.1% in 2018 compared to the 2020 v1 submission.

Table 5.38 Recalculations of the direct emissions from Managed agricultural soils (CRF 3D1)

kt N_2O	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission	0.753	0.702	0.725	0.674	0.704	0.725	0.707
2021 submission	0.689	0.683	0.709	0.676	0.708	0.729	0.715
Change relative to 2020 submission	-8.4%	-2.8%	-2.2%	0.3%	0.6%	0.5%	1.1%

Regarding the Organic N fertilizers, changes in the N-flow calculations (chapter 5.5) lead to recalculations in the emissions occurring from animal manure applied to soils (Table 5.39) for the whole timeseries producing an average increase of 2% in emissions. Emissions from the use of sewage sludge as organic fertilizer has been estimated for the first time in the inventory submission 2020 and for the current submission the activity data was updated and completed by newer information. In addition, N_2O emissions from other organic fertilizer has been estimated this year.

Table 5.39 Recalculations for Animal Manure applied to soils

kt N_2O	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission	0.12445	0.10867	0.10949	0.10520	0.10910	0.11391	0.10749
2021 submission	0.12756	0.11114	0.11206	0.10767	0.11169	0.11515	0.10972
Change relative to 2020 submission	2.5%	2.3%	2.3%	2.4%	2.4%	1.1%	2.1%

Recalculations in the category Urine and dung deposited by grazing animals derive from the changes in the livestock characterization for mature dairy cattle as explained in chapter 5.2.4 and chapter 5.5. These changes concern only the years 2013-2017 and show a small decrease in emissions as can be seen in Table 5.40.

Table 5.40 Recalculations for Urine and Dung deposited by grazing animals

kt N_2O	2013	2014	2015	2016	2017
2020 v1 submission	0.1473	0.1558	0.1556	0.1572	0.1527
2021 submission	0.1470	0.1551	0.1546	0.1558	0.1510
Change relative to 2020 submission	-0.2%	-0.4%	-0.7%	-0.9%	-1.1%

Recalculations in the subcategory Cultivated organic soils have two origins: first, the area calculations have changed due to improvements in the LULUCF sector (Chapter 6) and second, 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. The use of 0.96 kg N_2O-N/ha/yr was a typo in the emission estimation files. As can be seen from Table 5.41 the recalculation shows a decrease of 24% for 1990 and an increase of 1% for 2018.

Table 5.41 Recalculations of the emissions from cultivated organic soils.

kt N_2O	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission	0.271	0.269	0.269	0.271	0.274	0.273	0.272
2021 submission	0.205	0.236	0.251	0.270	0.272	0.273	0.275
Change relative to 2020 submission	-24%	-12%	-7%	0%	-1%	0%	1%

5.7.6 Uncertainties

The activity data uncertainties vary according to the used activity data. For 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 241.7%, 3D13 Urine and dung deposited by grazing animals 240.8%, 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

For future submissions, it is planned to compare the national fertilizer statistics against international data, as suggested by the review teams during the 2019 reviews. It is aimed to improve the gathering of data pertaining to sewage sludge by setting up a direct communication channel with the involved municipalities. At the moment, the emissions from sewage sludge applied for land reclamation are not deducted from the emissions of sewage sludge occurring in the waste chapter because the calculation methodology does not allow for it. This issue will be solved for the next submission. Efforts will be made to assure the completeness of the inventory by improving the research of the use of other organic fertilizers in the country.

5.8 Indirect N_2O 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 amount 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 run-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. These data are calculated in section 5.7. From 1990 to 2019, volatilized nitrogen from agricultural inputs diminished by 9% or from 2400 t in 1990 to 2178 t in 2019.

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% (FracLEACH-H). This amount has diminished by 16% from 8993 tonnes in 1990 to 7586 tonnes in 2019.

5.8.3 Emission factors

Table 5.42 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 5.42 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
$Frac_{LEA}CH_{-H}$		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 1990-2019 - after conversion from nitrogen to nitrous oxide - is shown in Figure 5.7. N_2O emissions amounted to 124 tonnes N_2O in 2019, which is 3% 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 fertilizer application caused an increase of indirect N_2O emissions from agricultural soils above the 1990 level.

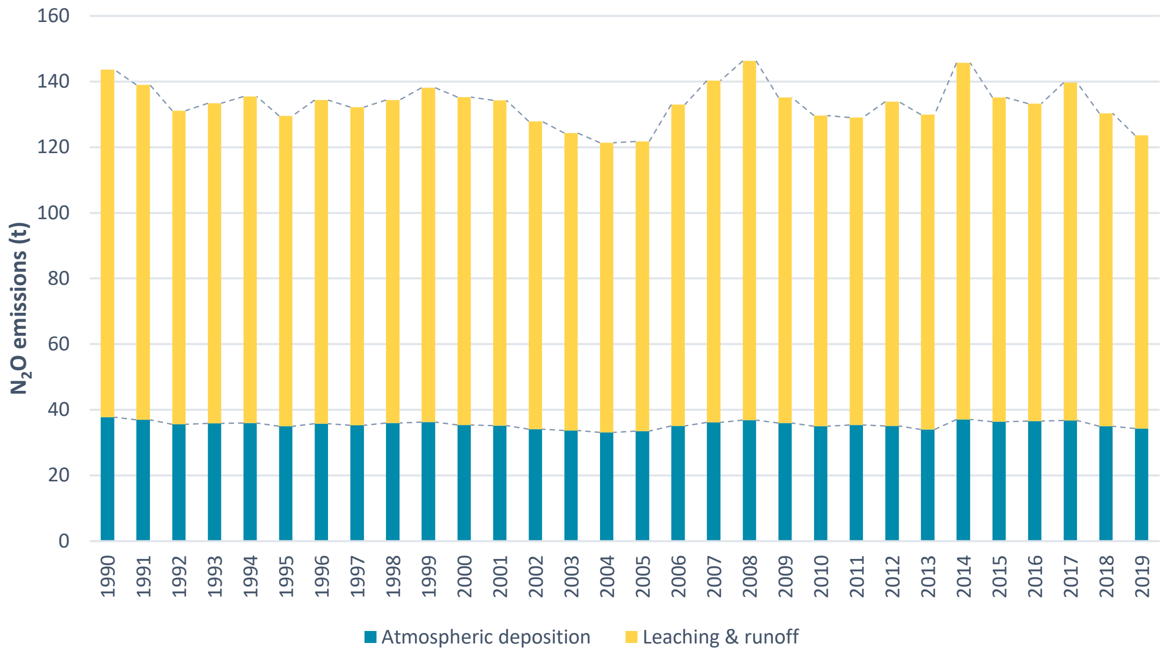


Figure 5.7 Indirect N_2O emissions from agricultural soils.

5.8.5 Recalculations

Indirect N_2O emissions are calculated starting from the amount of N applied to soils under various forms. Therefore, all 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 also in the indirect emissions from agricultural soils (3D2). Detailed informations about the recalculations performed in the sector Manure Management are to be found in chapter 5.2.4.

Table 5.43 and Table 5.44 show the recalculations in this category. The drop in emissions deriving from atmospheric deposition is due to the use of the updated emissions for NO_X and NH_3 calculated through the 2019 EMEP/EEA methodology instead of using FracGasf from IPCC 2006. The proportion of synthetic N volatilised as NH_3 and NO is only about 0.022, compared to the 0.1 assumed with IPCC2006 FracGasf. However, it's not surprising that Iceland has a low figure, given that not much urea is used in Iceland, combined with the cool climate and normal pH soils. The default of FracGasf = 0.1 assumes 50% of N applied is urea, and this is an average across many warmer climates and higher pH soils. Changes in Nitrogen leaching and run-off are due to the update of activity data for sewage sludge and the addition of other organic fertilizers as explained in chapter 5.7.2.2.

Table 5.43 Recalculations for indirect N_2O emissions, Atmospheric deposition

Atmospheric deposition kt N_2O	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission	0.046	0.041	0.042	0.040	0.042	0.043	0.041
2021 submission	0.038	0.035	0.035	0.034	0.035	0.036	0.035
Change relative to 2020 submission	-18%	-16%	-16%	-16%	-16%	-16%	-15%

Table 5.44 Recalculations for indirect N_2O emissions, N leaching and run-off

Nitrogen leaching and run-off kt N_2O	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission	0.105	0.094	0.099	0.088	0.093	0.098	0.094
2021 submission	0.106	0.095	0.100	0.088	0.095	0.099	0.095
Change relative to 2020 submission	1%	1%	1%	1%	1%	1%	1%

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

No improvements are currently planned for this category.

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[i] burning is not permitted, but farmers and landowners of land, where agriculture is practiced, can apply for a permit for burning between 1 April and 1 May each year provided the purpose is justified. The district commissioner can, after consultation with the Ministry of the Environment and Natural Resources, set a different date for burning which, however, needs to be within the period of 15 March and 15 May each year. It is however 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[16]. 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 collected from 1990-2018. Table 5.45 reports the results from the enquiry carried out during the year 2019. Currently not enough activity data are 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 and estimation for the next submission.

Table 5.45 Data collection regarding the occurrence of field burning of agricultural residues

District	
Suðurnes (SW)	No permit given 1990-2018
Höfuðborgarsvæðið (Capital area)	No permit given 1990-2018
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 1990-2018
Suðurland (S)	
Vestmannaeyjar (Westman Islands)	No permit given 1990-2018

5.11 CO_2 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

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

Equation 11.13
Annual CO_2 emissions from lime 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 fertilizers containing chalk or dolomite. Although the ratio of calcifying materials is low in these fertilizers 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 however not available before 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.

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 last submission were therefore updated by deducting the amount of urea sold as SCR-additives which have been directly collected from the oil distributing companies (Figure 5.8). From 2020 onwards there are different custom numbers and this issue should not be of concern anymore.

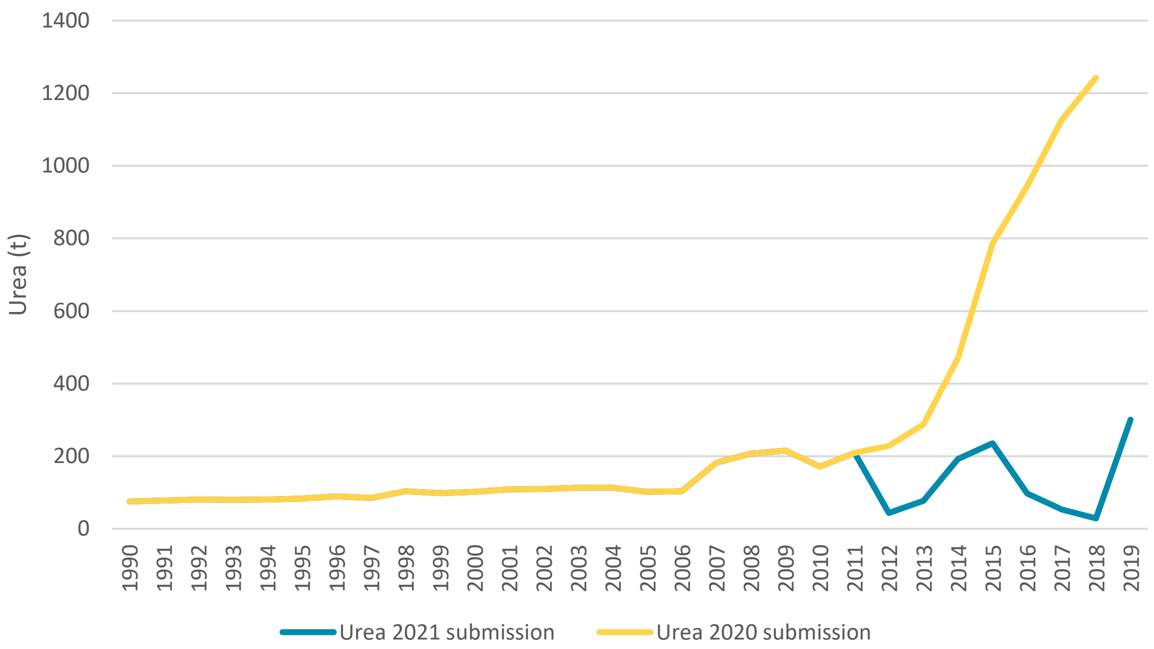


Figure 5.8 Import data of urea fertilizers 1990-2019, comparison between 2021 and 2020 submission

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 derive from distributor sales numbers. No activity data are available from 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 3.7 kt in 2019, CO_2 and emissions from Dolomite are 0.02 kt (CRF 3G). CO_2 emissions from Urea are 0.22 kt (CRF 3H) and Other carbon containing fertilisers (shellsand) 1.95 kt (CRF 3I). Other (CRF 3J) is not occurring for the timeseries. Figure 5.9 reports the CO_2 emissions from the whole time series available in the current inventory. For the years 1990-2002/03 activity data for liming and shellsand application are not available.

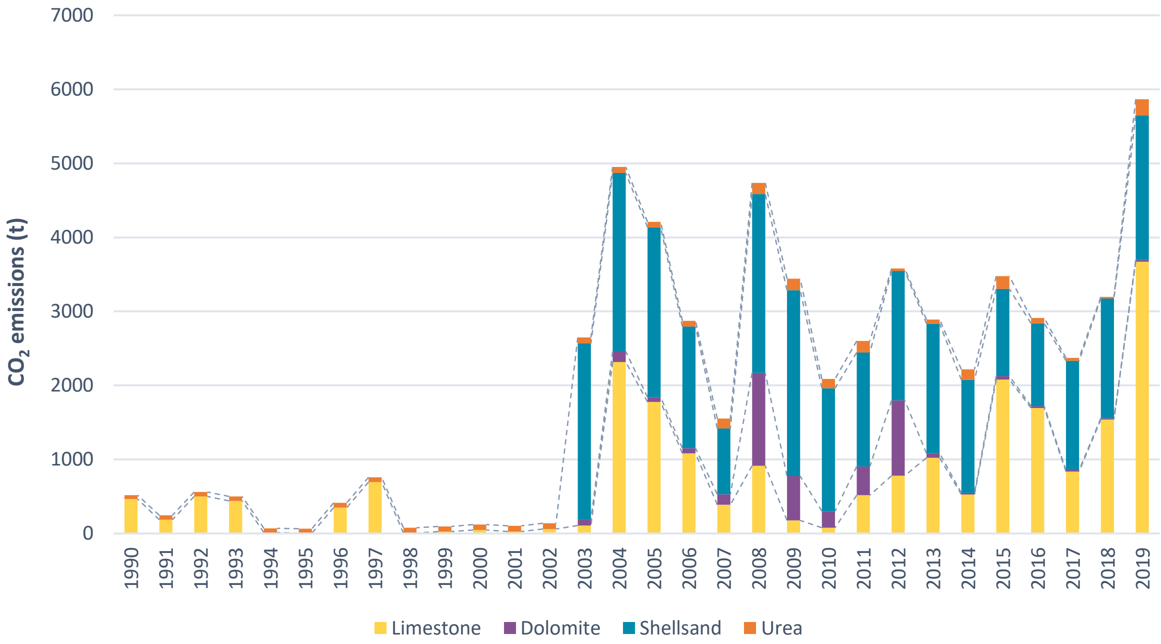


Figure 5.9 CO_2 emissions from liming (limestone and dolomite), urea application and other carbon containing fertilizers (shell sand).

5.11.5 Recalculations

In the current submission, recalculations were carried out for liming (3G) and urea application (3H). It was possible to complete the time series for liming, application of calcium carbonate and the data source is from Statistics Iceland. Recalculations occur for the years 1990-2018 and changes range from -82% up to +105% in emissions as reported in Table 5.46. For the application of dolomite the activity data was updated for the years 2013-2018 due to an error detected in data collection and recalculations show an average decrease of 97% (Table 5.47). In 3H-urea application the deduction of the amounts of urea imported as additives for selective catalytic converters in diesel vehicles lead to an average decrease in emissions of 81% for the years 2012-2018 (Figure 5.8, Table 5.48).

Table 5.46 Recalculations for emissions deriving from the application of limestone for 1990-2018

3G1 Limestone (kt CO_2)	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission	NE	NE	NE	1.17	0.42	1.02	3.36
2021 submission	0.0001	0.185	0.044	1.78	0.08	2.08	1.54
Change relative to 2020 submission				52%	-82%	105%	-54%

Table 5.47 Recalculations for emissions deriving from the application of dolomite for 2013-2018

3G2 Dolomite (kt CO_2)	2013	2014	2015	2016	2017	2018
2020 v1 submission	1.02	1.02	1.02	1.02	1.02	0.52
2021 submission	0.06	0.02	0.04	0.02	0.02	0.02
Change relative to 2020 submission	-94%	-98%	-96%	-98%	-98%	-96%

Table 5.48 Recalculations for emissions deriving from the application of urea for 2012-2018

3H Urea application (kt CO_2)	2012	2013	2014	2015	2016	2017	2018
2020 v1 submission	0.17	0.21	0.35	0.58	0.69	0.83	0.91
2021 submission	0.03	0.06	0.14	0.17	0.07	0.04	0.02
Change relative to 2020 submission	-81%	-73%	-59%	-70%	-90%	-95%	-98%

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

It is planned to continue to improve the activity data collection.

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 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) 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.

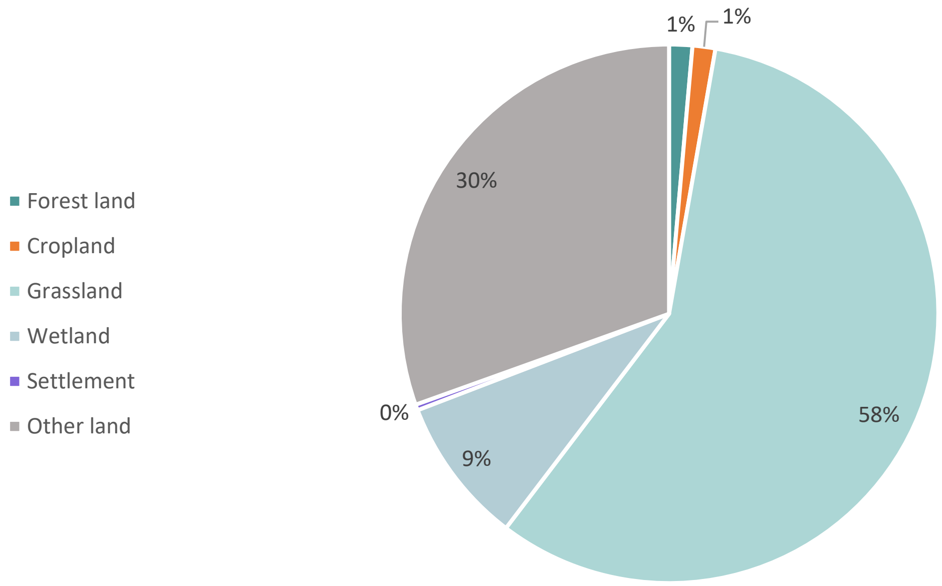


Figure 6.1 Relative size of land use categories in Iceland according to IGLUD land use map 2019 and other land use estimates available for the reporting.

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.

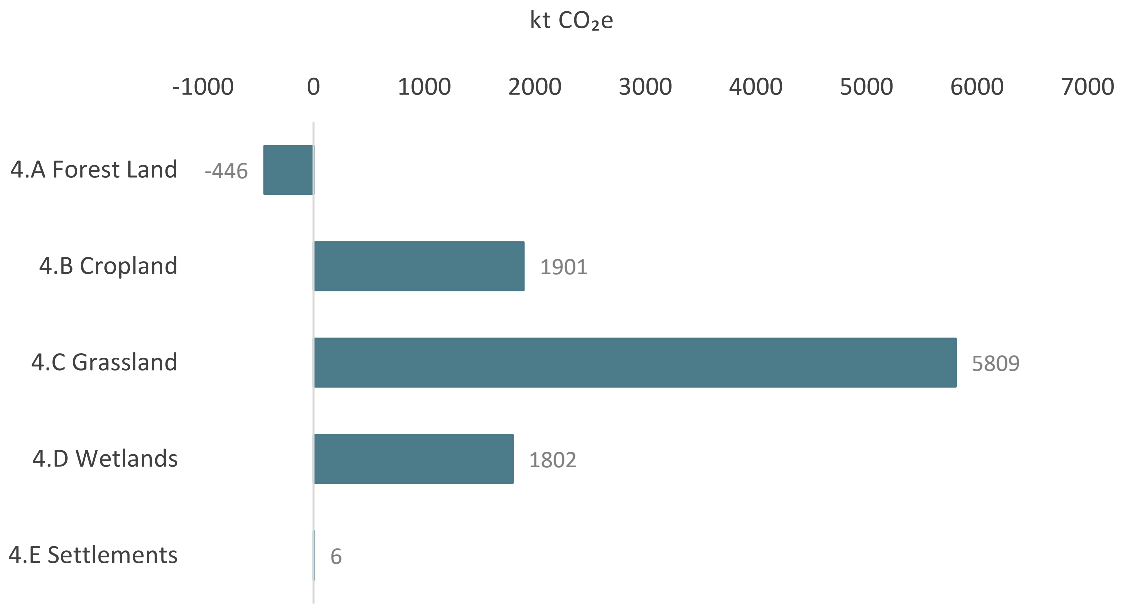


Figure 6.2. The net emissions/removals of land use categories (kt CO_2e) in 2019. Emissions from Other land (4F) and Harvested wood products 4(G)are not included in this graph. Since last year's submission, the N_2O emissions from Cropland management of organic soils are reported under the Agricultural sector and are not included here.

The total gross emissions reported is 11,506.6 kt CO_2e and is dominated 73.8% by 8,486.3 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 25.0% or 2,871.7 kt CO_2e, is methane emission 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 51.7% or 1,258.0 kt CO_2, to biomass and SOC in revegetation 27.7%or 674.6 kt CO_2, and to biomass and SOC in forest 18.6% or 453.7 kt CO_2. Other contributing components total of 3.9% 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 this sector has increased from 9,009.8 kt CO_2e to 9,072.3 kt CO_2e. New area estimate of some land-use categories is included in this submission explains most of the changes.

The CRF tables are prepared through new version of the CRF reporter (version 6.0.6). The information on all categories has the same structure as in the 2019 submission.

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 ares), and maps on revegetation from 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 as described in Guðmundsson et al. (2010).

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). 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.

The introduction of HMI as base map in IGLUD has many advantages. One of the most obvious is that it provides data for more detailed stratification of land cover with 64 terrestrial land cover types, instead of 6 or 12 classes in IFD. The methodology applied in these two classification projects are different. In the IFD, the classification method was supervised classification adjusted to ground truth sampling points to reach reasonable certainty. In the HMI, the classification is automatic ISODATA (Lillesand, Kiefer, & Chipmann, 2004) and classes correlated to on ground classification. The HMI classes and their categorization to LULUCF land use can be found in the 2019 submission.

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 is still some discrepancy 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 2019. 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 2019. Accordingly, the category Birch woodland < 2 m is ordered lower in the IGLUD compilation hierarchy.

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, subsided from the government, obtained from the Icelandic Agricultural Advisory Centre (IAAC). The current submission also includes additional data now available from RI (including abandoned cropland).

Map of Settlements is based on data from NLSI's IS 50V dataset as in last year's submission. The summary of GIS processing of this particular map layer can be found in the 2019 submission.

The introduction of HMI map layers as base map for IGLUD land use map improves it considerably. There are also some disadvantages caused by some of the map layers included in HMI-not based on the original classification to habitat type. The category Settlement is in HMI composed differently from the IS50 NLSI map layers than the previous Settlement layer included in last submission, land use map. The HMI map layer "Constructed, industrial and other artificial habitats" includes towns and villages, and roads with 5 or 10 m buffer zone from central line. In the HMI version (2016), airports from IS50 are missing and the coastline is in some cases drawn differently than in previous IGLUD versions. In last submission, the IGLUD map layer for roads was with 15 and 10 m buffer zone on primary and secondary roads. Accordingly, the Settlement map layer (airports) from last submission is included in the compilation process.

These discrepancies don´t have any notable effects on calculation of emission or removal for these categories.

Table 6.1 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 1990-2019	Not HMI category	Not HMI category/	3
	Cultivated forest before 1990	Not HMI category	Not HMI category/	4
	Natural Birch forest	Not HMI category	Not HMI category/	5
Cropland	Harvested croplands 2019	Not HMI category	Not HMI category/	12
	Harvested croplands 2018	Not HMI category	Not HMI category/	13
	Harvested croplands 2017	Other land types	Not HMI category/	14
	Cropland other (1)	Other land types	Not HMI category/	15
	Cropland inactive (fallow) (2)	Other land types	Not HMI category/	16
Grassland	Revegetated land SCSI before 1990	Not HMI category	Not HMI category/	6
	Revegetated land SCSI 1990 -2019	Not HMI category	Not HMI category/	7
	Farmers revegetation before 1990	Not HMI category	Not HMI category/	8
	Farmers revegetation 1990-2019	Not HMI category	Not HMI category/	9
	Natural Birch shrubland	Not HMI category	Not HMI category/	11

Land use category	Subcategories	Habitat type class	Habitat type/or other map layer	Compilation hierarchy
	Croplands	Other land types	L14.2 Other land types	17
	Grassland on drained soils	Not HMI category	Not HMI category/	20
	Other Grassland	Fell fields, moraines and sands	L1.6 Icelandic inland dunes	21
		Exposed aeolian soils	L2.1 Icelandic exposed andic soils	22
		River plains	L4.2 Icelandic braided river plains	23
		Moss lands	L5.3 Moss and lichen fjell fields	24
		Lava fields	L6.4 Icelandic lava field shrub heaths	25
		Coastal lands	L7.1 Icelandic sand beach perennial communities	26
			L7.4 Northern fixed grey dunes	27
			L7.7 Atlantic sea-cliff communities	28
		Grasslands	L9.1 Icelandic Carex bigelowii grasslands	29
			L9.2 Insular Nardus-Galium grasslands	30
			L9.3 Wavy hair-grass grasslands	31
			L9.4 Boreal tufted hairgrass meadows	32
			L9.5 Icelandic Festuca grasslands	33
			L9.6 Boreo-subalpine Agrostis grasslands	34
			L9.7 Northern boreal Festuca grasslands	35
		Heathlands	L10.1 Icelandic Racomitrium grass heaths	36
			L10.2 Arctic Dryas heaths	37
			L10.3 Icelandic Carex bigelowii heaths	38
			L10.4 Icelandic Empetrum Thymus grasslands	39
			L10.5 Icelandic lichen Racomitrium heaths	40
			L10.6 North Atlantic boreo-alpine heaths	41
			L10.7 Oroboreal moss-dwarf willow snowbed communities	42
			L10.8 North Atlantic Vaccinium-Empetrum-Racomitrium heaths	43

Land use category	Subcategories	Habitat type class	Habitat type/or other map layer	Compilation hierarchy
			L10.9 Icelandic Salix lanata/S. phylicifolia scrub	44
			L10.10 Oroboreal willow scrub	45
		Woodlands	L11.1-3 subclasses of Birch wood	46
		Other land types	L14.3 Mixed forestry plantations	47
		Other land types	L14.4 Land reclamation forb fields	48
Wetland	Reservoirs	Reservoirs Landsvirkjun &AUI	Not HMI category	1
	Lakes	Standing waters	V1	18
	Rivers	Running waters	V2	19
	Coastal wetlands	Coastal lands	L7.5 Atlantic lower shore communities	49
			L7.6 Icelandic Carex lyngbyei salt meadows	50
	Mires and fens	Wetlands	L8.1 Philonotis-Saxifraga stellaris springs	51
			L8.2 Icelandic stiff sedge fens	52
			L8.3 Cottonsedge marsh-fens	53
			L8.4 Juncus arcticus meadows	54
			L8.5 Boreal black sedge-brown moss fens (high altitude)	55
			L8.6 Boreal black sedge-brown moss fens (low altitude)	56
			L8.7 Aapa mires	57
			L8.8 Palsa mires	58
			L8.9 Icelandic black sedge-brown moss fens	59
			L8.10 Icelandic Carex rariflora alpine fens	60
			L8.11 Common cotton-grass fens	61
			L8.12 Icelandic black sedge-brown moss fens	62
			L8.13 Basicline bottle sedge quaking mires	63
			L8.14 Icelandic Carex lyngbyei fens	64
	Geothermal wetland	Geothermal lands	L12.1 Geothermal wetlands	65
Settlement	Settlement	Other land types	L14.1 Constructed, industrial and other artificial habitats	10

Land use category	Subcategories	Habitat type class	Habitat type/or other map layer	Compilation hierarchy
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	66
			L1.2 Sparsely- or un-vegetated habitats on mineral substrates not resulting from recent ice activity	67
			L1.3 Oroboreal Carex bigelowii-Racomitrium moss-heaths	68
			L1.4 Glacial moraines with very sparse or no vegetation	69
			L1.5 Volcanic ash and lapilli fields	70
		Screes and cliffs	L3.1 Icelandic talus slopes	71
			L3.2 Icelandic Salix herbacea screes	72
			L3.3 Icelandic Alchemilla screes	73
		River plains	L4.1 Unvegetated or sparsely vegetated shores	74
		Moss lands	L5.1 Boreal moss snowbed communities	75
			L5.2 Icelandic Racomitrium ericoides heaths	76
		Lava fields	L6.1 Barren Icelandic lava fields	77
			L6.2 Icelandic lava field lichen heaths	78
			L6.3 Icelandic lava field moss heaths	79
		Coastal lands	L7.2 Upper shingle beaches with open vegetation	80
			L7.3 Atlantic embryonic dunes	81
		Geothermal lands	L12.2 Geothermal heathlands	82
			L12.3 Geothermal alpine habitats	83
			L12.4 Geothermal bare grounds	84
	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 6.2 below.

Table 6.2 Key Categories for LULUCF: 1990, 2019, and 1990-2019 trend.

IPCC source category			Level 1990	Level 2019	Trend
LULUCF (CRF sector 4)					
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 6.3 below presents the sources and sinks not estimated in this submission.

Table 6.3 Sources and sinks where emission/removals are not estimated in present submission.

Source/sink	Land use category	Component	GHG NE
Carbon stock changes	Grassland remaining Grassland		
	Natural birch shrub land	Dead organic matter	CO_2
Carbon stock changes	Grassland converted to Other Wetland	Living biomass	CO_2
		Dead organic matter	CO_2
Carbon stock changes	Settlement remaining Settlement		
		Living biomass	CO_2
		Dead organic matter	CO_2
		Mineral soil	CO_2
		Organic soil	CO_2
Carbon stock changes	Land converted to Settlement		
	All other grassland converted to Settlement	Living biomass-gain	CO_2
		Mineral soil	CO_2
Biomass burning	Controlled burning all categories except Forest land		CO_2, CH_4, N_2O

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 v2013 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 the current submission a new sub-category has been added. This is the sub-category „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 now 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 below; they are also available at the AUI website http://www.lbhi.is/vefsja.

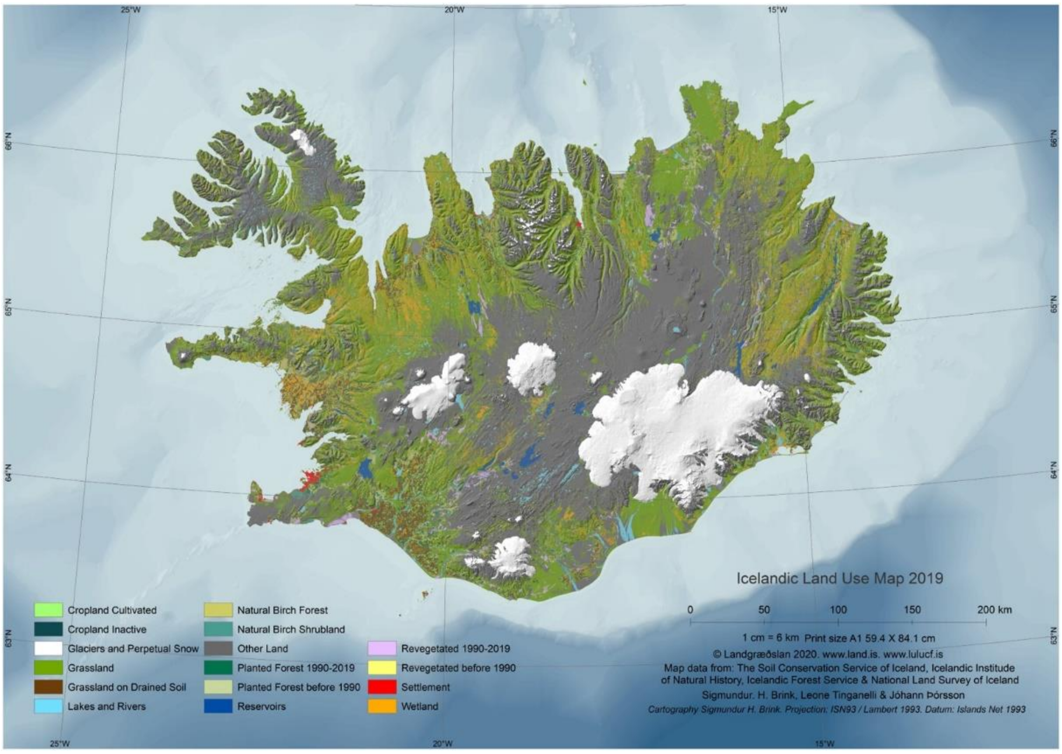


Figure 6.3 The land use map of IGLUD prepared for the year 2019.

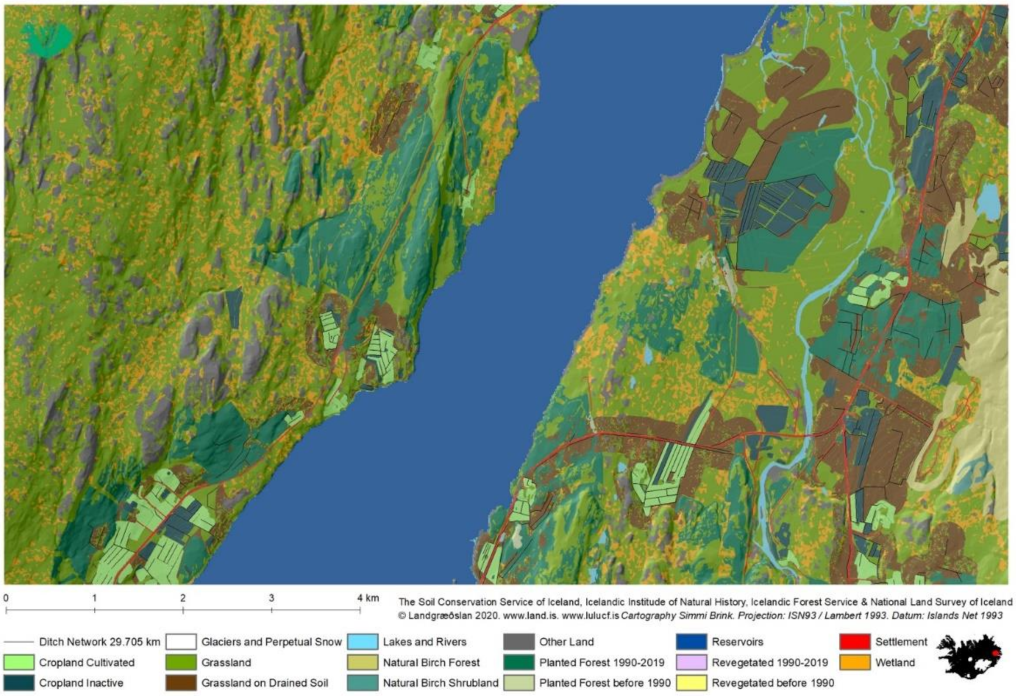


Figure 6.4 Enlargement of land use map for the year 2019, emphasizing the different Forest land subcategories.

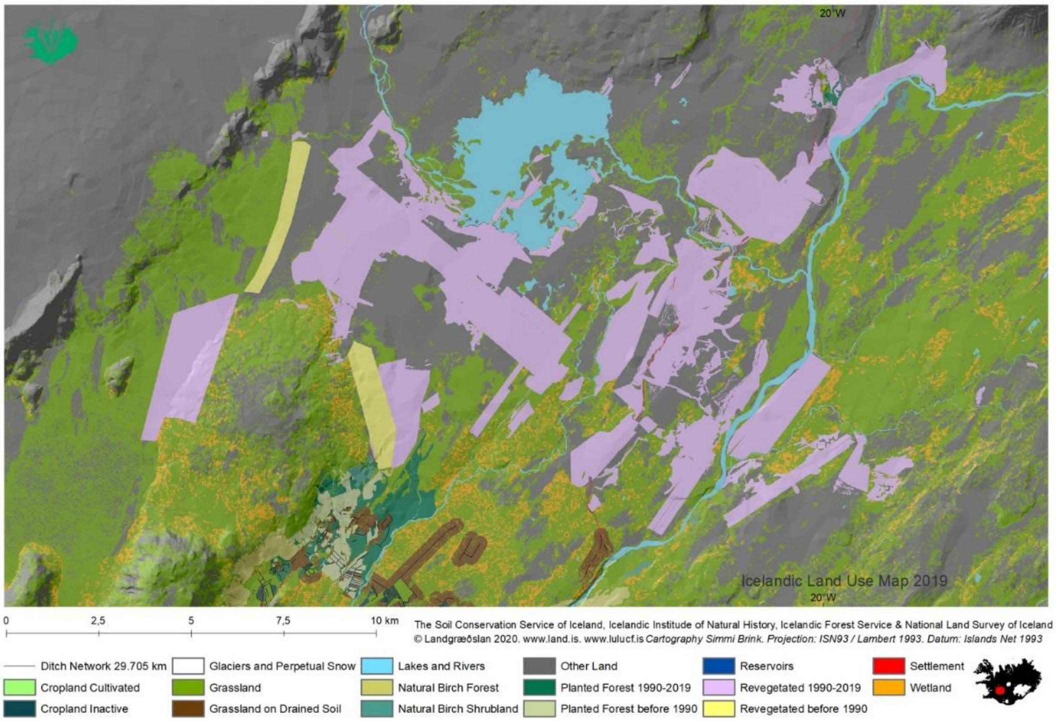


Figure 6.5 Enlargement of land use for the year 2019, emphasizing the Revegetation areas.

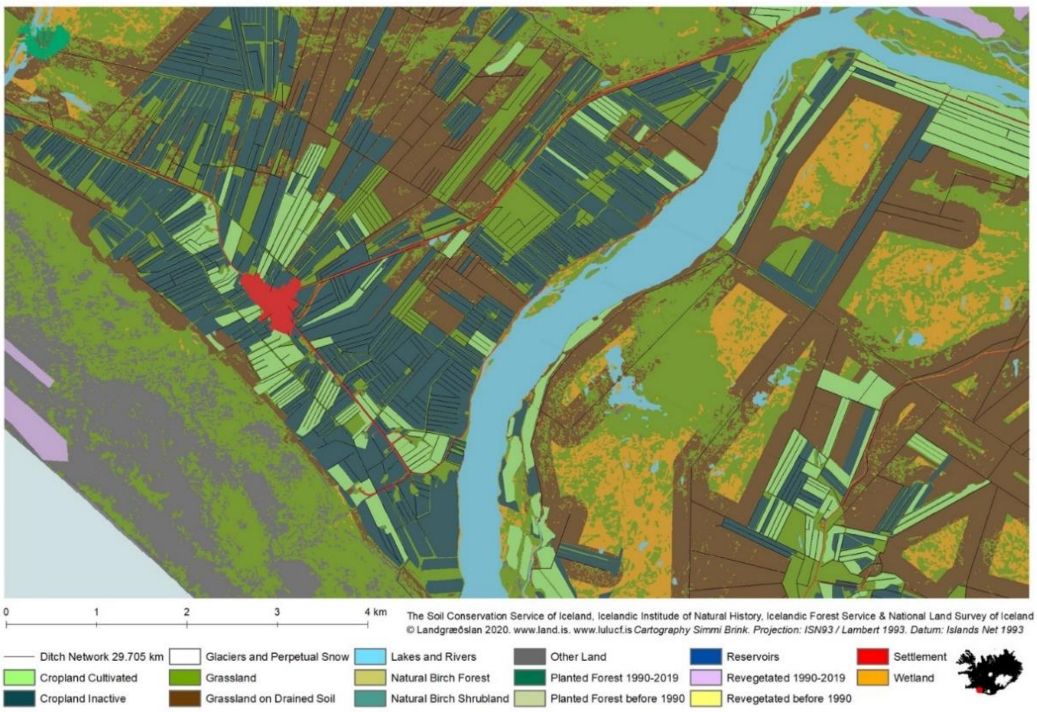


Figure 6.6 Enlargement of land use map for the year 2019, emphasizing the subcategory Grassland on drained soils and Cropland inactive.

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[17], 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.

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.

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 Table 6.4.

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

Table 6.4 Land use map area transfer matrix showing area transfer 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 [kha]	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								8,110	990							
FL NB																
CL																
GL. drained																
GL. Nb. shrub																
RV before. “90																
RV since. “90																
G a		1,294			1,705	138,262								742		
GL w g		158			208	16,877								91		
Gr a OL															9,644	
WL.O				28,021												
WL. L&R																
WL. Reserv.																
Settlements																
OL eG & G a							23,003			2,275,614						
Glaciers																
Other																
Other estimate	43,995	98,482	140,460	283,471	56,099	159,500	144,490							35,426		
Map area	53,095	97,029	140,460	255,450	54,186	4,361	121,487	2,806,810	342,623	2,262,256	653,495	217,937	59,366	34,593	2,100,420	1,033,133
Difference	9,100	-1,452		-28,021	-1,913	-155,139	-23,003							-833		
Corrected area	43,995	98,482	140,460	283,471	56,099	159,500	144,490	2,672,918	326,279	2,252,611	625,475	217,937	59,366	35,426	2,087,062	1,033,133
Total area [ha]																10,236,702

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

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).

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. , 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. 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.

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 to 150.65 kha in the 2010-2014 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 was 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 and 2017. 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 were 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 IPCC Guidelines for National Greenhous Gas Inventories Volume 4 Agriculture, Forestry and Other Land Use (AFOLU) (IPCC, 2006). Historical area of CF is 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).

C-stock changes in biomass of NBF are estimated with same method as in last year submission. In 1987 a tree data sampling was conducted i.a. to estimate the biomass of NBW in Iceland (Jónsson T. H., 2004). These data have now been used to estimate the woody C-stock of the natural birch woodland in 1987. The new estimate considers treeless areas inside the woodland that are measured to be 35% for shrubland (under 2 m at maturity) and 19% for forest in the sample plot inventory of 2005-2011 (Snorrason & Jónsson. In manuscript). 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 estimates 763 kt C (±93 kt SE) with average of 5.56 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 840 kt C (±95 kt SE) with average of 6.10 t C ha^{-1}. The C-stock in the forest and the shrub part of the natural birch woodland was estimated to 658 kt C with an average of 7.38 t C $_{ha-1}$ and 183 kt C with average of 3.76 t C ha^{-1} respectively. The net increase in the tree biomass C-stock between 1987 and 2007 (the midyear of the 2005-2011 inventory) turned out to be significant with mean annual net C-stock removal to tree biomass of 3.58 kt C and which is reported as annual biomass gain for the category of Natural birch forest older than 50 years. 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 AFOLU (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.

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 2005-2019. 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 6.5). The most accurate estimates are for 2007-2018 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 2018 the estimate is forwarded one year respectively, compared to the midvalue for 2017. 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

2019 was calibrated by the average difference between midvalues and forwarded values of the years 2008-2018 which was 0.85. In next submission a midvalue estimate build on measurement years 2017-2021 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 6.5 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
	2019		2016-2020
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; 2014; 2015; 2016; Gunnarsson & Brynleifsdóttir (2017; 2019) (Elefsen & Brynleifsdóttir, 2020; Jóhannesdóttir Þ., 2020). Most of the cultivated forests in Iceland are relatively young, only 32% are older than 20 years, and clear cutting is very rare. As an example, in the year of 2016 only 2 ha of forest were clear cut, 49 ha were commercial thinned and 162 ha pre commercial thinned (Gunnarsson & Brynleifsdóttir, 2017). 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 too 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 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 (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 AFOLU (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 IPCC Wetlands supplement (IPCC, 2014)). Newly published research of Eddy Covariance CO_2 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 as done in this submission.

Indirect CO_2 emission from drained organic soil which is a off-site emission via waterborne carbon losses is too 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 IPCC Wetlands supplement (IPCC, 2014). Bjarnardottir et al. 2021 did too measure the waterborne carbon losses with the result of 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 IPCC Wetlands supplement, assuming that average ditches width is 2.5 and average distance between ditches 50 m. The drained area is thus divided between ditches (5%) and drained land (95%). 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 IPCC 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).

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 much lower than systematic sample errors and not significant in an uncertainty estimate of C-stock change.

The estimate of C-stock in living biomass of the trees is mostly 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).

The NFI and the special inventory of deforestation have greatly improved the quality of the carbon stock change estimates. The same can be stated in the case of new approach to estimate the net change of C-stock in biomass of the natural birch woodland. By comparing two national estimates from two different times, errors caused by the difficulty of estimating natural mortality are eliminated.

Because of the design of the NFI it is possible to estimate realistic uncertainties by calculating statistical error of the estimates. Error estimates for all data sources and calculation processes has currently not been conducted but are planned in the near future. Currently, error estimates are available for the area of cultivated forest, and the biomass C-stock of the natural birch woodland at two different times as already stated. As the sample in the cultivated forest is much bigger than the sample in the natural birch woodland (769 plots compared to 210 plots in the natural birch woodland) one should expect a considerably lower relative statistical error of the biomass C-stock of cultivated forest then for the natural birch woodland.

6.5.1.4 *Category-specific recalculations*

As described above the emission/removal estimate for forest land has been slightly 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 the years 2017 and 2018 due to new data from NFI measurements in 2019 and 2020. Estimates for the natural birch forest are built on the same methodology as in last year´s submission and are unchanged.

6.5.1.5 *Category-specific planned improvements*

Data from NFI are used for the 13th 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 (2019) as well as in the 1990-2019 trend.

Four categories are defined as Land Converted to Forest Land:

4.A.2.2: Grassland Converted to Forest land

3. Afforestation 1 - 50 years old – Cultivated forest
4. Afforestation 1 – 50 years old – Natural birch forest

4.A.2.5: Other Land Converted to Forest land

5. Afforestation 1 - 50 years old – Cultivated forest
6. 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.

Categories 1 and 3 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.

Category 2 and 4 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 – 2019.

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. For the NBF expansion since 1989 a linear regression between biomass per area unit in trees on measurement plots in natural birch woodland and measured age of sample trees (N=147, $P < 0.0001$) is used to measure net annual C-stock change (Snorrason & Jónsson, In manuscript).

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, 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}. 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 various species and ages ranging from 32 to 54 years. 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 these two researches 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, 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. Further description of indirect CO_2 emission and CH_4 and N_2O emission as in similar categories in Forest remaining forest. 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. 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.

6.5.2.3 *Uncertainties and time-series consistency*

See discussion in Chapter 6.5.1 Forest Land Remaining Forest Land (CRF 4A1).

6.5.2.4 *Category-specific recalculations*

See discussion in Chapter 6.5.1 Forest Land Remaining Forest Land (CRF 4A1).

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 2019) as well as in 1990-2019 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 2019submission, 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 new map layer through the IGLUD processing, taking into account the order of compilation applied, is 140.46 kha compared to 187.30 kha in previous IGLUD map layer. This increase in map area is not interpreted as increase 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 140.46kha, whereof 62.75 kha is estimated as organic soil. The reported area is a product of the primary time series for new cultivation, drainage of wetland for cultivation, and Cropland abandonment. The time series 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. For this submission "Cropland remaining Cropland" has been subdivided in two new subcategories: "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 88.83 kha whereof 38.99 kha is organic soil.

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 46.37 kha whereof 21.03 kha is organic soil.

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. In that study increase in %C in top 0-5cm was observed, but in 5-20 cm depth there was a small decrease in % C. Assuming bulk density of soil 0.7 g cm_{-3} EF (CS) was calculated as -0.17 t C ha^{-1} yr^{-1}. Andosol is the main soil type in Iceland which has high carbon store capacity. If the land prior to cultivation did not have carbon saturated to cultivation potential, in those cases the carbon content could raise significantly which also explains high EF (CS) for mineral soils. 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 60.02 kha. These organic soils are estimated to lose -474.14kt C. The consequent emission is estimated as 1691.44 kt CO_2.

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 50×50m grid of randomly selected polygons of the Cropland mapping unit. Preliminary results from this sampling effort show similar ratio of organic soils. The uncertainty for the mapped area of Cropland on organic soil is for this submission assumed 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 1990–2019 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). The uncertainty associated to C change factors for Cropland remaining Cropland in 2019 is 14.21% 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*

Except for the subdivision of Cropland remaining in Cropland in two new subcategories i.e., "Cropland active" and "Cropland inactive (Fallow)" and the creation of two new time series for these two new subcategories as described above in chapter 6.6.1.1, there are no category specific recalculations for this category.

6.6.1.6 *Category-specific planned improvements*

A new map of cultivated land has been prepared by the Registers Iceland (Þjóðaskrá Íslands). 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 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 2019) as well as in 1990-2019 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 was 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 does IFR estimates the area, of this category, as deforestation activity.

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. 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 above ground biomass, including litter and standing dead, for Grassland below 200 m height above sea level and for Wetland below 200m, is 1.27 kg C m-2 and 1.80 kg C m-2 respectively.

The losses in biomass following conversion of land to Cropland are estimated 4.06 kt C, whereof 1.61 kt C is from Grassland converted and 2.45 kt C from Wetland converted. The CO_2 emission is thus 14.88, 5.89 and 8.99 kt CO_2 respectively. Gains are estimated for the area converted to Cropland the year before assuming biomass after one year of growth to be 2.1 t C ha^{-1}. The total gain in biomass for land converted to Cropland is thus estimated as 0.55 kt C, with 0.27 kt C from Grassland converted and 0.29 kt C from Wetland converted. The CO_2 removal of the gain is 2.03, 0.98, and 1.05 kt CO_2 respectively.

Organic soils of land converted Cropland are reported in two categories i.e., Forest land converted to Cropland, and Wetland converted to Cropland 0.01 kha, and 2.72 kha respectively. These organic soils are estimated to annually lose 0.09 kt C and 21.47 kt C in the same order. The consequent emission is estimated as 0.34 kt CO_2 and 78.72 kt CO_2. 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.

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.

Uncertainty estimates for C-stock change factors for the period 1990–2019 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 2019 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 recalculation was performed for this category.

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 emission 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 34 map layers as emerging form the compilation process for the IGLUD Land use map, 28 of them originating from the HMI map. For this year´s 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 5896.35 kha. 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 in this year´s 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 last year´s 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, for this year´s submission the time series for "Other Grassland" is disaggregated in two new time series, i. e., "Grazing areas" and " Grassland without grazing". This time series disaggregation was 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 was 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 2019) as well as in 1990-2019 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 23.60kha whereof 6.07kha 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 has slightly increased between 1987 and 2007 although the mean annual net change is very low (0.02 t C ha^{-1} yr^{-1}). 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}) (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 – 2019.

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 6.1) are excluded a priory. The land in this category is e.g., land dominated by grasses, woodland small bushes other than birch (Betula pubescens), 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, lichens and or 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 2647.10 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 323.13 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 5.86kha. 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 6.4).

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 ditches excavated available until 1993 (Hagstofa Íslands (Statistics Iceland), 1997; Óskarsson, 1998) and from 1993 to 2008 from personal records of agricultural consultant in one region (Kristján Bjarndal Jónsson, personal communication) 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 map layer “Grassland on drained soils” was prepared by AUI from the 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 J. S., 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 251.44 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. The C-stock changes of “Revegetated land older than 60 years” and “Other Grassland” are presently estimated as not occurring.

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. Carbon stock changes in living biomass of other subcategories of Grassland remaining Grassland i.e. “Revegetation older than 60 years”, “Wetland drained for more than 20 years”, “Cropland abandoned for more than 20 years”, and “Other Grassland” are reported as not occurring based on Tier 1 method for Grassland remaining Grassland.

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 presently not estimated, and for other subcategories of Grassland remaining Grassland changes in that pool is reported as not occurring based on Tier 1.

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. Changes in carbon stock in mineral soils of land under other subcategories of Grassland remaining Grassland are reported as not occurring in line with Tier 1 method. The Tier 1 methodology gives by default no changes if land use, management and input (FLU, FMG, and FI) are unchanged over a period.

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 IPCC 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 6.6.

Table 6.6. 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	258.01	-1,467.98	5,371.63
Cropland abandoned for more than 20 years	6.07	-34.61	126.89
Natural birch shrubland (N.b.s)- old	0.26	-0.09	-3.34
N.b.s.- recently expanded into Other Grassland	0.25	-0.09	-6.92
Wetland drained for more than 20 years	251.44	-1,433.18	5,255.00
Land converted to Grassland	26.44	-150.69	534.57
Cropland converted to Grassland	4.37	-24.93	73.42
Wetland converted to Grassland	22.06	-125.77	461.15
Total	284.45	-1,618.67	5,260.49

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.

Changes in C stock of living biomass and dead organic matter of the category Grassland remaining Grassland are reported as not occurring (Tier 1) except for living biomass of Natural birch shrubland. The CO_2 emissions from mineral soils of Grassland remaining Grassland are also reported as not occurring following Tier 1 assumption of steady stock. Uncertainty estimates for C-stock change factors for the period 1990–2019 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 49.60% 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*

Two new time series are created based on the time series "Other Grassland": "Grazing areas" and "Grassland without grazing". A new time series for the subcategory "Grazing areas on Other Land" (not classified as Grassland) is created based on time series for "Other Land" and added in Grassland remaining Grassland. Detailed information regarding the revisions made in "Grassland remaining Grassland" are described in the chapter 6.7.1. Category description. The emission is recalculated accordingly.

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 6,544.291 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 year’s submission.

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 in this year´s 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 1990-2019 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 10.46 kha with 4.37 kha on organic soil.

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 22.06 kha and the whole area assumed to be on organic soil. 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 is 307.25 kha, with 159.50 kha as revegetation before 1990, 144.49 kha as revegetation since 1990, and 3.26 kha as other land converted to Natural birch shrubland.

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 2020 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 – 2019.

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 of all subcategories of “Land converted to Grassland” are estimated, except for “Revegetation since 1990- (areas) protected from grazing”, and “Revegetation since 1990 – (areas with) limited grazing allowed” as the SCSI is currently surveying all revegetation areas initiated from that year.

Carbon stock changes in living biomass are estimated for all categories of Land converted to Grassland where conversion is reported to occur, with the exception noted above. 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 living biomass of this category is estimated 5.54 kt C in 2019, consequently removing 20.30 kt CO_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 as 18.03 kt C and thereby removing 66.09 kt CO_2 from the atmosphere. This increase is divided to three subcategories; Revegetation before 1990 9.09 kt C (33.34 kt CO_2), Revegetation since 1990-protected from grazing 5.66 kt C (20.74 kt CO_2), and Revegetation since 1990-limited grazing allowed 2.58 kt C (9.46 kt CO_2). The carbon stock in living biomass of the fourth subcategory "Other land converted to Natural birch shrubland" is estimated in the NFI to have increased to 0.70 kt C removing 2.56 kt CO_2 from the atmosphere.

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 carbon stock in dead organic matter of that category is estimated to have increased to 0.46 kt C in the year 2019 and accordingly removing 1.68 kt CO_2 from the atmosphere.

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 not occurring consequent with no changes in living biomass.

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 (chapter 6.6.2.2). The loss from mineral soils of Cropland converted to Grassland is reported as 0.63 kt C and consequently emitting 2.32 kt CO_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. Increase in carbon stock of mineral soils of revegetated land is estimated as 157.62 kt C, removing 577.93 kt CO_2 from the atmosphere. This increase is divided on three subcategories, "Revegetation before 1990" 81.82 kt C (300.02 kt CO_2), "Revegetation since 1990 – protected from grazing" 50.91 kt C (186.69 kt CO_2), "Revegetation since 1990- limited grazing allowed" 23.21 kt C (85.10 kt CO_2). The changes in carbon stock in mineral soils of the fourth subcategory of "Other land converted to Grassland", "Other land converted to Natural birch shrubland" is estimated applying same CS emission (removal) factor as used for revegetation categories. The increase in mineral soil of this subcategory is estimated as 1.67kt C and to have removed 6.12kt CO_2 from the atmosphere.

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= 5.7 t C ha^{-1} yr^{-1}. The area, C-stock changes and comparable CO_2 emission is summarized in Table 6.6.

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 1990–2019 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 84.42% 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*

The time series for area of "Wetland converted to Grassland" is revised according to revised estimate of the total area of map layer "Grassland on drained soils". Emissions of all pools depending on that area are recalculated accordingly. The area for Revegetation since 1990 protected from grazing back to 2012 is revised and emissions accordingly recalculated.

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.

For this year’s submission an update of one of reclamation areas has been made, i.e., "Revegetation since 1990 limited controlled grazing allowed". Nevertheless, the update only concerns reclamation occurred after 1990. 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 2021 this year.

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 2019) as well as in 1990-2019 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 902.90kha. 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: 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. The area estimate is based on reservoir mapping and available data on inundated land.

Lakes and rivers: The area estimation of this category is described in chapter 6.2..

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 625.65 kha compared to 657.08 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 2019 and in trend 1990-2019.

Carbon stock changes in living biomass and dead organic matter: No changes of C-stocks in living biomass or dead organic matter are reported. 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.

Carbon stock changes in soils: 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.

No changes in C-stocks of soils or other pools are estimated for the category “Refilled lakes and ponds”.

The changes in soils of the categories “Intact mires”, and “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). The total removal reported is 1261.73 kt CO_2 and 1.74 kt CO_2, respectively.

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 1990–2019 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*

The time series for intact mires is revised according to new estimate of the category in the revised IGLUD land use map. All emissions are recalculated accordingly.

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*

See description of Wetland remaining wetland

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 6.7).

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”.

Table 6.7 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

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 include: 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 1990–2019 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 121.07% 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*

The time series for the area of intact mires is revised according to the new IGLUD land use map categorizing much larger area as intact mire than in previous submission. The emissions based on the categories area are revised accordingly.

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*

Time series of the basal area of all buildings in towns and villages is applied as index on changes in total area of towns and villages on one hand and all other area included as Settlements on the other hand. It is assumed that both the ratios between basal area and total area of towns and villages and basal area and other settlements have been stable since 1990. Two time-series of land converted to Settlements area available: “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 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 these time series. 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 15.82 kha and other settlements 19.78 kha in the inventory year. The total area reported in this submission is 35.60 kha. The estimated total area is revised from previous submission. In the new HMI map Settlement is approached in slightly different way than in the previous IGLUD land use maps. The main difference is that more roads are included in the HMI map. This has no effect on the emission reported for the category.

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*

Country-wise updated records of the area included as towns and villages is not available, beside IS-50 maps. Changes in IS-50V mapped area have not been converted to time series. The uncertainty of the methods used for estimating area has not been checked. The category "Other settlements" in IGLUD land use map consist mostly of roads and other transportation structure. The roads in the IS 50 database are linear features representing the centreline of the road. To allocate area to roads a 15m buffer zone was added. The actual area covered by that categories has not been controlled the uncertainty is although not considered high.

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*

No recalculations are performed for this category.

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 does 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 settlements. It is assumed that this deforestation is included in Settlements maps, although comparison of maps has not been carried out.

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" 0.05 kha, "Natural birch shrubland converted to Settlement" is reported for the year 2019 as 0.01 kha, and "All other Grassland subcategories converted to Settlement", 0.18 kha.

According to the 2006 AFOLU IPCC 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.

The carbon stock changes reported are -1.68 kt C or 6,14 kt CO_2 emitted from the category “all other grassland converted to Settlement”.

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 1990–2019 have been assessed following Approach 1 of 2006 IPCC 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 the total area is revised the time series for “All other Grassland converted to Settlement” is modified accordingly and emission recalculated.

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%. For this year´s submission "Other land" area decreases significantly from 5314.54 kha reported in 2020 submission to 3120.19 kha as large part of this category is reported as Grassland remainin 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” are derivate form 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 fourth 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[18] the annual unofficial report of the Iceland Forest Association does contain data about sawnwood production from 1996 to 2019 (See Table 6.8); Gunnarsson E., 2010; 2011; 2012; 2013; 2014; 2015; 2016; Gunnarsson & Brynleifsdóttir (2017); (Elefsen & Brynleifsdóttir, 2020; Jóhannesdóttir Þ., 2020).

Table 6.8 Annual wood production (in m^3 on bark) and sawnwood production (in m^3) in 1996 to 2019

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

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

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.

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.

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 2019 and CH_4 in trend 1990- 2019.

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.

Off-site CO_2 emission via waterborne losses from drained inland soils: Off-site CO_2 emission is calculated according to Tier 1 applying equation 2.4 in the 2013 wetland Supplement. For the three categories of organic Cropland soils, the emission calculated is 16.15 kt CO_2 for organic soils of

"Cropland remaining Cropland", 0.01 kt CO_2 for soils of "Forest land converted to Cropland" and 1.20 kt CO_2 for soils of Wetland converted to Cropland.

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 $EFCH_4\_laNd$ = 0 and $EFCH_4\_ditCH$ = 1,165 kg CH_4 ha^{-1} yr^{-1} from table 2.3 and 2.4 in 2013 wetland supplement respectively. The emission reported is 3.66 kt CH_4 or 91.38 kt CO_2e total for all three categories with organic soils. 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.

Rewetted soils under Cropland: 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).

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 CO_2 emission via waterborne losses from drained Grassland soils is calculated according to Tier 1 using EF = 0.12 t C ha^{-1} yr^{-1} from table 2.2 in 2013 wetland supplement. The total emission for Grassland is estimated as 125.00kt CO_2. The disaggregation of these numbers to the subcategories involved is shown in Table 6.9.

Table 6.9 Drained soils, estimated off- site CO_2 emission of Grassland categories/subcategories.

Category/subcategory	Drained "organic" soils [kha]	Off-site CO2 emission [kt CO2]
Grassland remaining Grassland	258.01	113.36
Cropland abandoned for more than 20 years	6.07	2.67
Natural birch shrubland (N.b.s)- old	0.26	0.03
N.b.s.- recently expanded into Other Grassland	0.25	0.03
Wetland drained for more than 20 years	251.44	110.63
Land converted to Grassland	26.44	11.63
Cropland converted to Grassland	4.37	1.92
Wetland converted to Grassland	22.06	9.71
Total	**284.45**	**125.00**

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. 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 CH_4 emission and removal from drained Grassland is calculated according to T1 applying $EFCH_4$_land = 1.4 and $EFCH_4$_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. The total emission reported is 16.92kt CH_4 or 423.03 kt CO_2e. Of this emission 16.55kt CH_4 is reported from the ditches while only 0.37kt CH_4 is reported from the drained land. The disaggregation of these numbers to emission from drained land and ditches of the subcategories involved is shown in Table 6.10.

Table 6.10 Drained soils, estimated CH_4 emission from drained land and ditches of Grassland categories/subcategories.

Category/subcategory	Drained "organic" soils [kha]	CH_4 land [kt CH_4]	CH_4 ditches [kt CH_4]	CH_4 total	
				[kt CH_4]	[kt CO_2e]
Grassland remaining Grassland	258.01	0.34	15.01	15.35	383.65
Cropland abandoned for more than 20 years	6.07	0.01	0.35	0.36	9.04
Natural birch shrubland (N.b.s)- old	0.26	0.00	0.00	0.00	0.05
N.b.s.- recently expanded into Other Grassland	0.25	0.00	0.00	0.00	0.05
Wetland drained for more than 20 years	251.44	0.33	14.65	14.98	374.51
Land converted to Grassland	26.44	0.04	1.54	1.58	39.38
Cropland converted to Grassland	4.37	0.01	0.25	0.26	6.51
Wetland converted to Grassland	22.06	0.03	1.29	1.31	32.87
Total	**284.45**	**0.37**	**16.55**	**16.92**	**423.03**

Rewetted soils under Grassland: 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.

N_2O emission from drained inland soils: For the 2020 submission the emission of N_2O 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 CO_2 emission and CH_4 emission from wet organic soils.

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. The reported emission is 0.29kt CO_2, 183.52kt CO_2, 0.03kt CO_2, and 0.25kt CO_2 for these categories in the above order.

CH_4 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. Emission factors applied for CH_4 from reservoirs are listed in Table 6.7. Estimated CH_4 emission from reservoirs is 0.41 kt CH_4 (10.16 kt CO_2e).

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. The reported emissions are 114.29, 0.02, and 0.16 kt CH_4 for “Intact mires”, “Refilled lakes and ponds”, and “Rewetted organic soils” respectively. This is equivalent to 2857.14, 0.53, and 3.91 kt CO_2e, in the same order.

N_2O 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.

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.

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

6.14.2 Methodology

Methodology for Forest land has already been described in Chapter 6.5.1.2 above.

6.14.3 Uncertainties and time-series consistency

The uncertainties and time-series consistency are as described for the relevant land use category.

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 category specific recalculations are performed for this category.

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 0.66and 0.03 t N_2O or 0.20 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; “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]

The area burned each year 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 CO_2 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%.

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 of all land use categories is reported as not estimated because there are not enough data to report biomass burning as not occurring, except for forest land where it is reported as not occurring.

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.

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), wastewater treatment and discharge (5D), and other waste treatment (5E).

For most of the 20th century solid waste disposal sites (SWDS) in Iceland were numerous, small, and located close to the locations of waste generation. Therefore, waste did not have to be transported long distances for disposal. In Reykjavik, waste was landfilled in smaller SWDS before 1967. That year the waste disposal site in Gufunes was set into operation and most of the waste from the capital's population was landfilled there.

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

Before 1990, three waste incinerators were opened in Keflavík, Húsavík and Ísafjörður. In total they burned around 15,000 tonnes of waste annually. They operated at low or varying temperatures and the energy produced was not utilized. Proper waste incineration in Iceland started in 1993 with the commissioning of the incineration plant in Vestmannaeyjar, an archipelago to the south of Iceland. Six more incineration plants were commissioned until 2006. In the beginning of 2012, a total of four waste incinerators were still operating. Some of the incineration plants recovered the burning energy and used it for either public or commercial heat production. By the end of 2012 all incineration plants except one (Kalka in Reykjanesbær) had closed; therefore, emissions from the single plant are reported from 2013. Open burning of waste was banned in 1999 and is non-existent today. The last place to burn waste openly was the island of Grímsey which stopped doing so in 2010.

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

Reliable data about waste composition does not exist until recent years. In 1991 the waste management company Sorpa ltd. started serving the capital area and has gathered data on waste composition of landfilled waste since 1999. Since 2014 all waste operators in Iceland have had to report data on the amount of waste landfilled, incinerated and recycled. Also, Sorpa ltd. reports data on waste composition each year.

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

Clinical waste has been incinerated in incinerators either at hospitals or at waste incineration plants. Kalka is currently the only incineration plant in Iceland treating clinical waste.

The trend has been toward managed SWDS as municipalities have increasingly cooperated with each other on running waste collection schemes and operating joint landfill sites. This has resulted in larger SWDS and enabled the shutdown of a number of small sites. The majority of landfilled waste is disposed of in managed SWDS. Recycling of waste has increased due to efforts made by the government, local municipalities, recovery companies and others. Composting started in the mid-1990s and has been gradually increasing since then. Over recent years, composting has become a publicly known waste treatment option and a number of composting facilities have been commissioned.

Wastewater treatment in Iceland consists mainly of basic treatment with subsequent discharge into the sea. The majority of the Icelandic population (approximately 90%) lives by the coast. The coast is a non-problem area with regard to eutrophication, as Iceland is surrounded by an open sea with strong currents and frequent storms. This leads to effective mixing. About 64% of the population lives in the greater Reykjavík area and most of the larger industries are located within the area, mostly by the coast. In recent years, more advanced wastewater treatments have been commissioned in some smaller municipalities. Their share of total wastewater treatment, however, does not exceed 2%.

Table 7.1 Emissions from the waste sector, kt CO_2e

		1990	1995	2000	2005	2010	2015	2018	2019
5A Solid waste disposal	CH_4	149.7	154.8	227.2	234.4	242.7	200.1	192.8	162.9
5B Biological treatment of solid waste	CH_4	NO	NO	0.2	0.5	1.5	2.1	2.4	2.4
5B Biological treatment of solid waste	N_2O	NO	NO	0.1	0.4	1.1	1.5	1.7	1.7
5C Incineration and open burning of waste	CH_4	6.1	6.0	2.6	0.4	0.4	0.3	0.3	0.4
5C Incineration and open burning of waste	N_2O	1.7	1.7	0.7	0.3	0.3	0.3	0.3	0.6
5C Incineration and open burning of waste	CO_2	7.3	7.2	2.7	4.7	5.9	6.5	6.2	8.4
5D Waste water treatment and discharge	CH_4	50.0	52.9	62.9	58.8	39.4	44.6	45.3	41.9
5D Waste water treatment and discharge	N_2O	4.6	4.6	5.1	4.7	5.2	5.4	5.7	5.9
5 E Other		NO	NO	NO	NO	NO	NO	NO	NO
5 Waste	**Total**	**219.4**	**227.2**	**301.6**	**304.3**	**296.4**	**260.9**	**254.9**	**224.2**

7.1.1 Methodology

The emission estimates of GHGs from the waste sector in Iceland is based on methodologies suggested by the 2006 IPCC Guidelines. The methodologies are described under each of the CRF categories.

7.1.2 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. Three examples for these inconsistencies are the amount of timber burned in bonfires on New Year’s Eve, the amount of landfilled manure and waste from metal production.

Until 2011 the amount of material burned annually in bonfires had been estimated to be up to 6 kt. Beginning with the year 2012 year the amount was calculated as follows: first the material (mainly unpainted timber) that went into one of the country's largest bonfires was weighed 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 in 2018. The result was projected back in time using expert judgement.

7.1.3 Key Category Analysis

The key sources for 1990, 2019 and the 1990-2019 trend in the Waste sector are as follows (compared to total emissions excluding LULUCF):

Table 7.2 Key source categories for Waste (excluding LULUCF).

IPCC source category		Level 1990	Level 2019	Trend
Waste (CRF 5)				
5A1 Managed Waste Disposal	CH4		✓	✓
5A2 Unmanaged Waste Disposal	CH4	✓		✓
5D2 Industrial Wastewater Treatment	CH4	✓		✓

7.1.4 Completeness

Table 7.3 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 7.3 Waste - - completeness (E: estimated, NE: not estimated, NA: not applicable).

	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

	Direct GHG			Indirect GHG		
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 (5B2)	NO	NO	NO	NO	NO	NO
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	NE	NE	NE
Industrial Wastewater (CRF 5D2)	NA	E	IE[2]	NE	NE	NE
Other (5E)	NO	NO	NO	NO	NO	NO

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

N_2O emissions from Solid Waste Disposal Sites (CRF 5A1 and CRF 5A2) are not applicable since the IPCC 2006 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 IPCC 2006 Guidelines do not require their reporting.

7.1.5 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. 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 methodology for calculating methane from solid waste disposal on land is according to 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) has compiled data on total amounts of waste generated since 1995. This data is published by Statistics Iceland (2018). 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 data 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 estimations on 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. Data on methane recovery and flaring is based on data provided by operators to the European Pollutant Release and Transfer Register (E-PRTR).

Waste generation before 1995 was 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 7.3). 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 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 (more on this in Chapter 7.2.2).

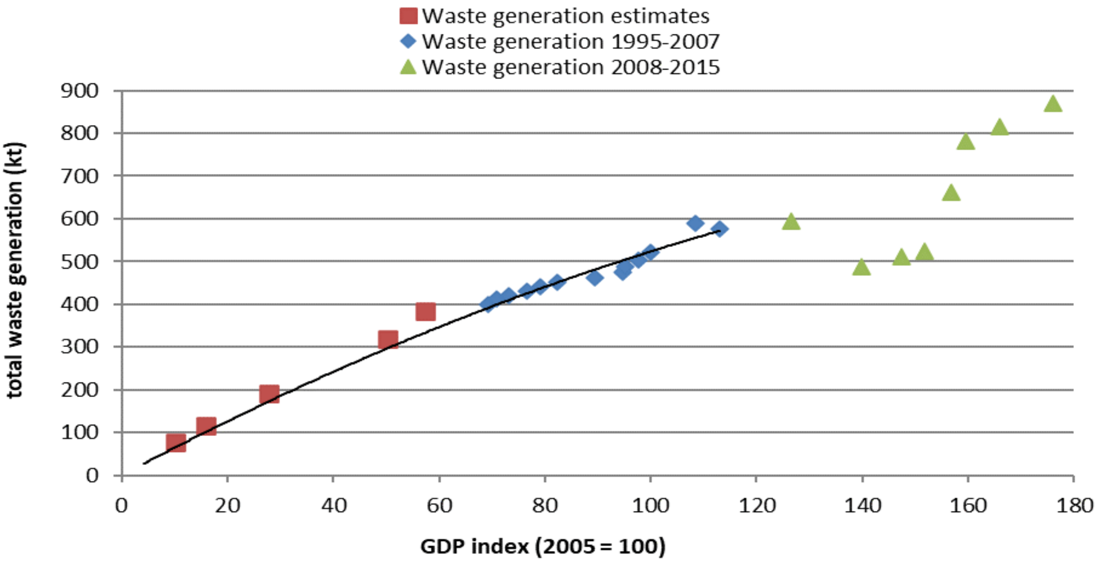


Figure 7.1 Correlation between waste generation and GDP index in Iceland used for waste generation estimates before 1995.

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 started 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 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 the population of Akureyri burned before the opening of the new landfill were 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 1990-2019 are shown in Figure 7.3 and Figure 7.3.

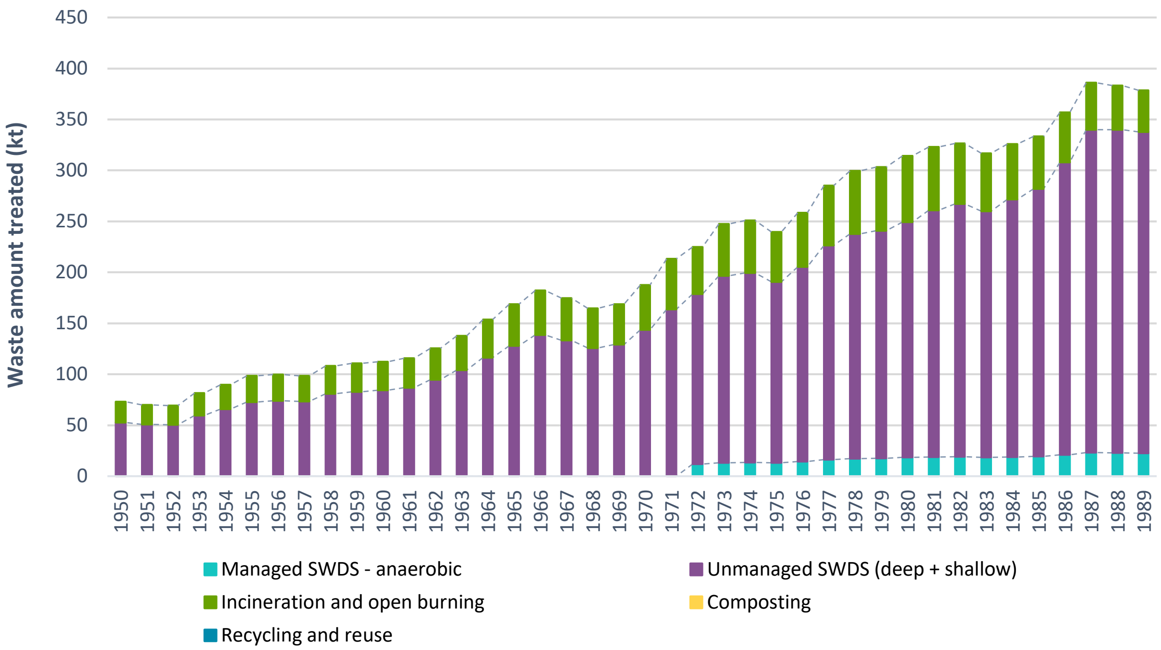


Figure 7.2 Waste amount and allocation to incineration/open burning, solid waste disposal, recycling and composting 1950-1989

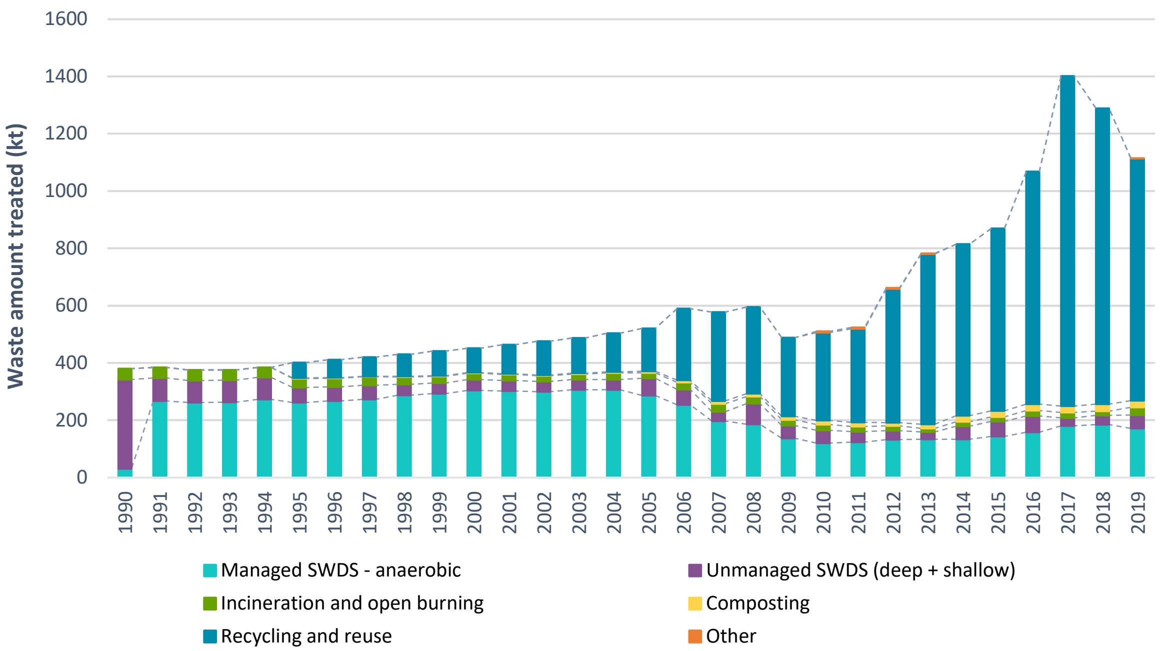


Figure 7.3 Waste amount and allocation to incineration/open burning, solid waste disposal, recycling and composting 1990-2019

In accordance with the 2006 GL 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”).

Waste allocation is mainly based the following events:

- 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 the aforementioned 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 before had gone to the SWDS Selfoss plus waste of surrounding municipalities. Based on 2006 GL 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 GL 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 GL criteria and landfill gas measurements (Kamsma & Meyles, 2003); (Júlíusson, 2011).
- Until 2004 the fractions of waste landfilled 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 7.4 shows the development of landfill waste management practice shares since 1950.

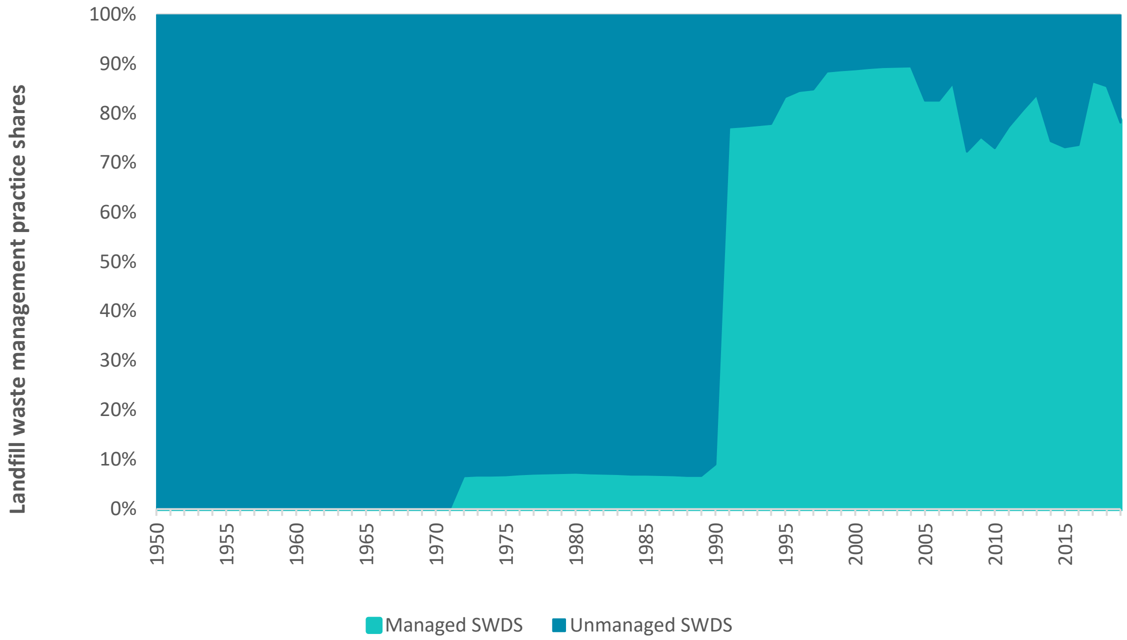


Figure 7.4 Waste management practice shares of total waste disposed of in managed and unmanaged SWDS.

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 Incineration 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 Table 7.4 for Managed Solid Waste Disposal Sites and in Table 7.5 for Unmanaged Waste Disposal Sites. The composition amounts are subject to changes as streamlining of the WStatR to IPCC categorization processes have been revised for future submission.

Table 7.4 Waste composition amounts for Managed Waste Disposal Sites (CRF 5A1a), in kt

Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industrial	Total
1950	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1953	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1954	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1955	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1956	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1957	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1960	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1961	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1962	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1965	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1966	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1969	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1972	5.2	0.4	1.7	0.4	0.3	0.0	0.2	3.0	0.7	11.9
1973	5.7	0.5	2.0	0.4	0.3	0.0	0.2	3.4	0.8	13.3
1974	5.7	0.5	2.0	0.5	0.3	0.0	0.2	3.5	0.8	13.5
1975	5.5	0.4	2.0	0.4	0.3	0.0	0.2	3.5	0.8	13.1
1976	5.9	0.5	2.2	0.5	0.4	0.0	0.3	3.8	0.8	14.4
1977	6.6	0.5	2.5	0.5	0.4	0.0	0.3	4.4	0.9	16.2
1978	6.9	0.6	2.7	0.6	0.4	0.0	0.3	4.7	1.0	17.2
1979	6.9	0.6	2.8	0.6	0.4	0.0	0.3	4.8	1.0	17.6
1980	7.2	0.6	3.0	0.6	0.5	0.0	0.3	5.1	1.1	18.4
1981	7.1	0.6	3.1	0.6	0.5	0.1	0.3	5.4	1.1	18.9
1982	6.9	0.6	3.2	0.6	0.5	0.2	0.3	5.7	1.1	19.2
1983	6.3	0.6	3.2	0.6	0.5	0.2	0.3	5.7	1.1	18.4
1984	6.2	0.6	3.3	0.6	0.5	0.3	0.3	6.0	1.1	19.0
1985	6.1	0.7	3.4	0.7	0.5	0.4	0.3	6.4	1.1	19.6
1986	6.3	0.7	3.8	0.7	0.5	0.5	0.4	7.1	1.2	21.2
1987	6.5	0.8	4.2	0.8	0.6	0.7	0.4	7.9	1.3	23.1
1988	6.0	0.8	4.2	0.8	0.6	0.8	0.4	8.1	1.3	22.9
1989	5.6	0.8	4.2	0.8	0.6	0.8	0.4	8.2	1.3	22.7

Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industrial	Total
1990	7.2	1.0	5.8	1.0	0.8	1.3	0.5	11.5	1.8	30.9
1991	62.2	9.0	50.2	8.9	6.8	11.1	4.7	99.4	15.4	267.6
1992	60.9	8.9	49.1	8.8	6.6	10.8	4.6	97.3	15.0	262.0
1993	61.2	8.9	49.4	8.8	6.6	10.9	4.6	97.8	15.1	263.3
1994	63.4	9.2	51.1	9.1	6.9	11.3	4.8	101.3	15.6	272.7
1995	60.8	8.8	49.1	8.7	6.6	10.8	4.6	97.1	15.0	261.6
1996	62.0	9.0	50.1	8.9	6.7	11.0	4.7	99.1	15.3	267.0
1997	63.5	9.2	51.2	9.1	6.9	11.3	4.8	101.4	15.7	273.1
1998	66.8	9.7	53.9	9.6	7.3	11.9	5.1	106.7	16.5	287.5
1999	68.0	9.9	54.9	9.8	7.4	12.1	5.1	108.7	16.8	292.8
2000	70.7	10.3	57.0	10.2	7.7	12.6	5.3	112.9	17.4	304.0
2001	70.2	10.2	56.7	10.1	7.6	12.5	5.3	112.3	17.3	302.3
2002	69.5	10.1	56.1	10.0	7.6	12.4	5.3	111.1	17.2	299.2
2003	71.1	10.3	57.4	10.2	7.7	12.6	5.4	113.6	17.5	305.8
2004	71.1	10.3	57.4	10.2	7.7	12.6	5.4	113.7	17.6	306.1
2005	66.4	9.7	53.6	9.5	7.2	11.8	5.0	106.1	16.4	285.8
2006	58.9	8.6	47.6	8.5	6.4	10.5	4.5	94.2	14.5	253.6
2007	32.7	12.1	39.8	13.1	5.8	7.1	5.0	61.8	19.5	197.0
2008	43.1	2.7	44.6	6.5	7.1	8.2	3.1	69.3	1.6	186.4
2009	40.1	2.0	17.2	4.8	7.1	9.0	2.8	52.4	1.2	136.5
2010	32.1	1.2	25.6	1.5	2.5	8.6	1.8	46.6	0.2	120.2
2011	46.5	1.6	25.7	2.3	3.1	8.7	1.9	29.7	4.1	123.7
2012	51.4	4.5	23.1	2.7	2.8	7.3	1.6	36.4	2.2	132.1
2013	63.6	4.5	9.3	3.6	3.7	9.5	2.0	36.1	0.8	133.2
2014	62.2	0.8	13.5	1.2	3.3	8.2	2.2	37.6	4.1	133.1
2015	66.2	2.4	13.6	3.5	4.5	8.2	2.9	39.4	2.4	143.2
2016	68.7	2.4	17.3	5.1	5.8	8.6	2.5	44.4	3.7	158.4
2017	61.6	0.0	36.9	17.9	5.5	3.3	2.4	47.9	4.5	180.0
2018	52.0	0.0	40.8	19.9	5.1	4.3	2.4	54.3	6.3	185.1
2019	54.2	0.7	28.5	31.6	4.1	6.8	1.3	38.6	5.2	170.9

The total waste amounts from 2008 for this type of Solid Waste Disposal Site is in-line with official waste statistics. From 1995-2008, official data exists for the total amounts landfilled; however, this data is not disaggregated for the Solid Waste Disposal type (managed/unmanaged). The waste type amounts shown in the table may be subject to changes in future submission due to streamlining of allocation procedures when transforming data from WStatR categories into IPCC categories.

Table 7.5 Waste composition amounts for Unmanaged Waste Disposal Sites (CRF 5A2), in kt

Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industrial	Total
1950	29.2	1.8	5.0	1.8	1.3	0.0	0.9	9.9	3.0	52.8
1951	27.8	1.7	4.9	1.7	1.3	0.0	0.9	9.6	2.9	50.8
1952	27.4	1.7	5.0	1.7	1.3	0.0	0.9	9.8	2.9	50.6
1953	31.9	2.0	6.0	2.0	1.5	0.0	1.0	11.7	3.4	59.6
1954	35.0	2.2	6.8	2.2	1.7	0.0	1.2	13.1	3.8	66.0
1955	38.2	2.5	7.7	2.4	1.8	0.0	1.3	14.7	4.2	72.8
1956	38.4	2.5	8.0	2.5	1.9	0.0	1.3	15.2	4.2	73.9
1957	37.7	2.5	8.1	2.5	1.9	0.0	1.3	15.3	4.2	73.4
1958	41.2	2.7	9.1	2.7	2.0	0.0	1.4	17.1	4.6	80.9
1959	41.8	2.8	9.5	2.8	2.1	0.0	1.5	17.8	4.8	82.9
1960	41.9	2.8	9.9	2.8	2.1	0.0	1.5	18.3	4.8	84.2
1961	42.9	2.9	10.4	2.9	2.2	0.0	1.5	19.2	5.0	87.0
1962	46.1	3.2	11.5	3.2	2.4	0.0	1.7	21.2	5.4	94.7
1963	50.2	3.5	12.9	3.5	2.6	0.0	1.8	23.6	6.0	104.2
1964	55.4	3.9	14.7	3.9	2.9	0.0	2.0	26.7	6.7	116.4
1965	60.3	4.3	16.5	4.3	3.2	0.0	2.3	29.8	7.3	128.1
1966	64.5	4.7	18.2	4.6	3.5	0.0	2.4	32.7	8.0	138.6
1967	61.3	4.5	17.8	4.5	3.4	0.0	2.3	31.8	7.6	133.2
1968	57.2	4.3	17.1	4.2	3.2	0.0	2.2	30.5	7.2	125.9
1969	58.0	4.4	17.9	4.3	3.3	0.0	2.3	31.6	7.4	129.1
1970	63.7	4.9	20.2	4.8	3.6	0.0	2.5	35.6	8.2	143.5
1971	71.8	5.5	23.4	5.5	4.1	0.0	2.9	41.2	9.4	163.8
1972	72.2	5.6	24.3	5.6	4.2	0.0	2.9	42.4	9.6	166.9
1973	78.4	6.2	27.1	6.1	4.6	0.0	3.2	47.2	10.5	183.5
1974	78.5	6.3	27.9	6.2	4.7	0.0	3.3	48.5	10.7	186.1
1975	74.0	6.0	27.1	5.9	4.5	0.0	3.1	46.8	10.2	177.7
1976	78.6	6.5	29.6	6.4	4.8	0.0	3.4	51.0	11.0	191.2
1977	85.3	7.1	33.0	7.0	5.3	0.0	3.7	56.7	12.1	210.3
1978	88.3	7.5	35.2	7.4	5.6	0.0	3.9	60.2	12.7	220.7
1979	88.2	7.5	36.1	7.5	5.6	0.0	3.9	61.6	12.8	223.2
1980	90.0	7.8	37.9	7.7	5.8	0.0	4.1	64.4	13.3	231.0
1981	90.5	8.2	40.3	8.1	6.1	1.0	4.3	69.8	13.9	242.1
1982	88.8	8.4	41.9	8.3	6.3	2.0	4.4	73.8	14.2	248.0
1983	82.7	8.2	41.4	8.1	6.1	3.0	4.2	74.1	13.9	241.6
1984	82.5	8.5	43.8	8.4	6.4	4.2	4.4	79.8	14.5	252.6
1985	81.6	8.9	46.1	8.8	6.6	5.4	4.6	85.3	15.1	262.3
1986	84.7	9.7	51.1	9.6	7.2	7.1	5.0	96.0	16.5	286.9
1987	88.5	10.7	57.2	10.6	8.0	9.2	5.6	108.8	18.2	316.7
1988	83.6	10.7	58.0	10.6	8.0	10.5	5.6	111.9	18.2	317.0
1989	78.2	10.6	58.4	10.5	8.0	11.7	5.5	114.1	18.1	315.1

Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industrial	Total
1990	72.3	10.5	58.4	10.4	7.9	12.9	5.5	115.6	17.9	311.2
1991	18.5	2.7	14.9	2.7	2.0	3.3	1.4	29.5	4.6	79.4
1992	17.8	2.6	14.4	2.6	1.9	3.2	1.3	28.5	4.4	76.7
1993	17.7	2.6	14.3	2.5	1.9	3.1	1.3	28.3	4.4	76.1
1994	18.0	2.6	14.5	2.6	2.0	3.2	1.4	28.8	4.5	77.6
1995	12.2	1.8	9.8	1.8	1.3	2.2	0.9	19.5	3.0	52.4
1996	11.4	1.7	9.2	1.6	1.2	2.0	0.9	18.2	2.8	49.1
1997	11.4	1.7	9.2	1.6	1.2	2.0	0.9	18.2	2.8	48.9
1998	8.7	1.3	7.0	1.3	0.9	1.6	0.7	13.9	2.2	37.6
1999	8.7	1.3	7.0	1.2	0.9	1.5	0.7	13.8	2.1	37.2
2000	8.8	1.3	7.1	1.3	1.0	1.6	0.7	14.1	2.2	38.0
2001	8.5	1.2	6.9	1.2	0.9	1.5	0.6	13.6	2.1	36.7
2002	8.3	1.2	6.7	1.2	0.9	1.5	0.6	13.3	2.1	35.8
2003	8.4	1.2	6.8	1.2	0.9	1.5	0.6	13.4	2.1	36.2
2004	8.3	1.2	6.7	1.2	0.9	1.5	0.6	13.3	2.1	35.9
2005	14.0	2.0	11.3	2.0	1.5	2.5	1.1	22.4	3.5	60.2
2006	12.4	1.8	10.0	1.8	1.3	2.2	0.9	19.8	3.1	53.4
2007	11.9	0.7	3.3	0.3	0.3	0.6	0.1	13.5	1.3	32.0
2008	16.0	10.0	5.8	1.1	0.8	1.0	3.5	28.5	4.9	71.7
2009	14.2	4.6	2.1	0.5	0.7	1.1	1.2	16.9	3.7	45.0
2010	11.7	2.3	2.9	0.9	0.5	1.0	0.5	21.9	2.9	44.6
2011	14.2	2.7	3.2	0.8	0.5	1.1	0.7	9.3	3.8	36.4
2012	13.0	0.2	2.4	1.7	0.4	0.8	0.9	10.7	1.6	31.7
2013	11.4	0.8	1.0	1.2	0.5	1.0	1.0	6.9	2.1	25.9
2014	5.6	0.1	0.8	0.3	0.2	0.5	0.4	37.0	0.9	45.8
2015	5.0	0.3	1.0	0.3	0.3	0.6	0.3	43.9	1.1	52.6
2016	3.9	0.1	1.0	0.5	0.3	0.5	0.2	48.9	1.3	56.8
2017	3.1	0.0	1.6	0.9	0.2	0.1	0.4	20.5	1.5	28.3
2018	3.1	0.0	2.0	1.1	0.2	0.2	1.1	22.6	1.2	31.5
2019	3.3	0.1	1.6	9.4	0.2	0.4	1.0	29.4	2.3	47.7

The total waste amounts from 2008 for this type of Solid Waste Disposal Site is in-line with official waste statistics. From 1995-2008, official data exists for the total amounts landfilled; however, this data is not disaggregated for the Solid Waste Disposal type (managed/unmanaged). The waste type amounts shown in the table may be subject to changes in future submission due to streamlining of allocation procedures when transforming data from WStatR categories into IPCC categories.

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 was used to attribute the mixed waste categories to the ten waste categories listed above. This was 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 2010. 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 have undergone changes during the same time period: many categories that have been recorded separately during the last five years had been included in the mixed waste category before 2005, thus multiplying the amount recorded as mixed waste. Also, for the time period from 1995-2004 the EA data does not permit 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 7.6.

Table 7.6 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 the 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 following:

- Amounts of waste metals, paper, plastics and rubber that have been exported for treatment by other 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 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 GL:

EQUATION 3.1

$$CH_4\ emissions = (\Sigma x\ CH_4\ generated_{x,T} - R_t) * (1 - OX_T)$$

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 nr. 738/2003 on waste management practices it is a requirement that managed landfills are covered to prevent air and smell pollution and access to birds and vermin. In Iceland the majority of landfills use a combination of soil and wood chips, 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 will be 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 7.7.

Table 7.7 Emission factors and parameters used to calculate methane generated.

Emission factors/parameters	Values
Degradable organic carbon in the year of deposition (DOC)	Table 7.8
Fraction of DOC that can decompose (DOCf)	0.5
Methane correction factor for anaerobic decomposition (MCF)	Table 7.9
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 7.8
Half-life time of waste in years (y)	Table 7.8
Delay time in months	6

DOC, k, and y (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 7.8.

Table 7.8 Degradable organic carbon (fraction), methane generation rate and half-life time (years) 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	0.1	0.1	0.09	0.185	NA
h	4	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 with DOC, DOCf, and the methane correction factor results in the mass of decomposable DOC deposited annually (DDOCm).

The default methane correction factors for SWDS types 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 GL for the three SWDS types used are shown in Table 7.9. 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, its 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 7.9 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 GL to calculate DDOC accumulated and decomposed are shown below:

EQUATION 3.4

DDOC accumulated in SWDS at the end of year T

$$DDOCma_T = DDOC\ md_T + (DDOCma_{T-1} * e^{-k})$$

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)

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).

7.2.4 Emissions

7.2.4.1 *Methane recovery*

Recovery of landfill gas occurs at two sites in Iceland; Álfsnes which has served the capital area since 1996 and Glerárdalur which is an old SWDS which is not used for landfilling anymore. Data on the amount of landfill gas recovered from Álfsnes stems from the operator Sorpa ltd. (Hjarðar, written communication) and data reported under 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 stems from the operator, Norðurorka.

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 0). 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 0). Figure 7.5 gives an overview of the annual methane amounts segregated by utilization.

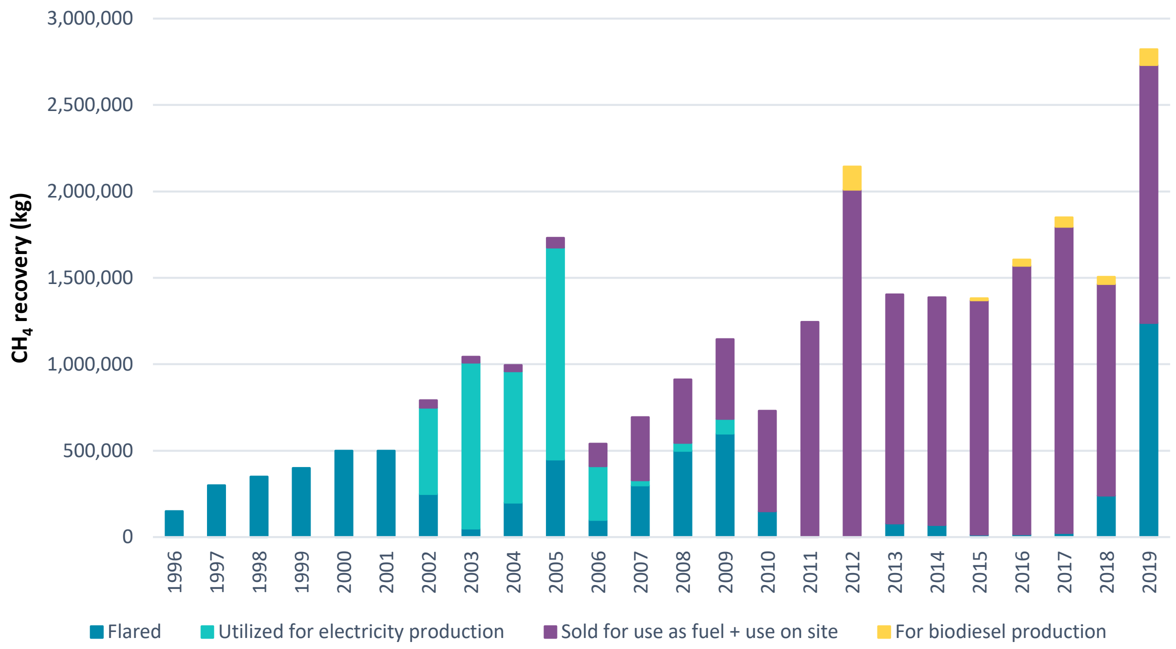


Figure 7.5 Methane recovery (CRF 5A1a) at Álfsnes and Glerárdalur SWDS's (kg CH_4).

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 and were estimated at 6.5 kt in 2019. This equals an increase of 9% between 1990 and 2019.

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 7.6. 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 2019 86% 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 can be found in the 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.

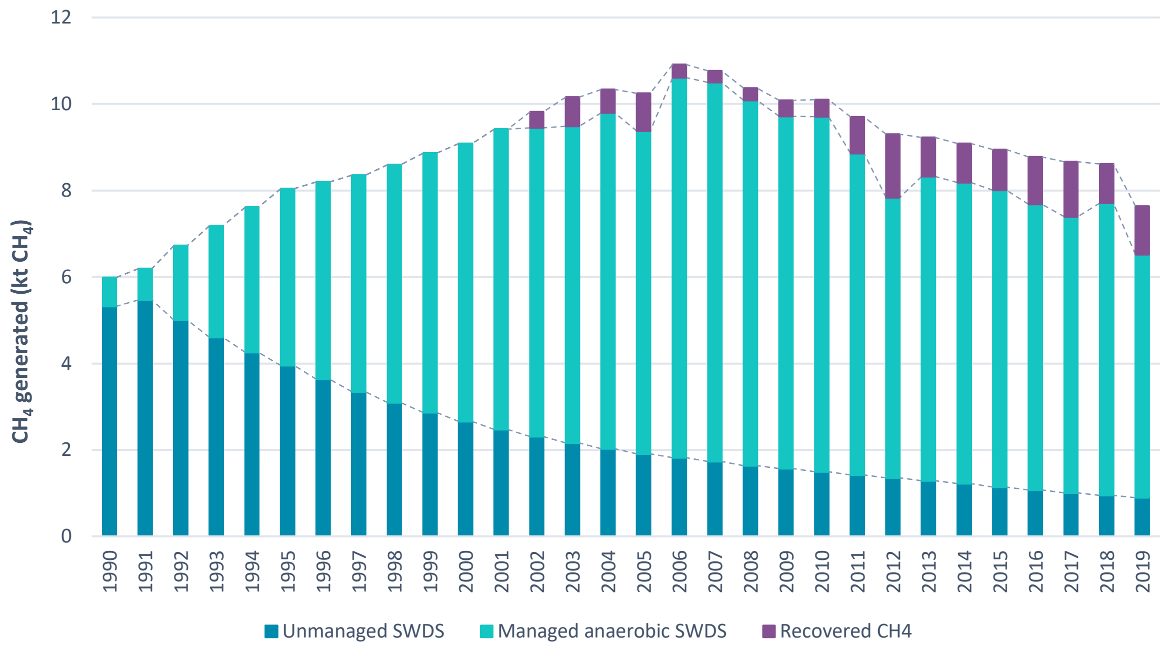


Figure 7.6 Methane generation estimates and recovery from Solid Waste Disposal sites since 1990.

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 results slightly higher 52.2%. The emission factor uncertainty is based on the uncertainty values from Table 3.5 of the 2006 IPCC Guidelines and was calculated using Equation 3.1 of the same guidelines (vol. 1, chapter 3) and is 42.72% and 41.23% respectively.

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 2021 submission the the oxidation factor has been updated from the previously used value of 0 to 0.1. This issue has been pointed out during the 2020 EU Comprehensive Review. 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 to birds and vermin. In Iceland the majority of landfills use a combination of soil and wood chips as cover, except for a few exceptions which use sand and gravel. Therefore, as pointed out by the reviewers, an oxidation factor of 0.1 is more appropriate.

This leads to recalculations for the whole time series under 5A1 Managed SWDS and the emissions are 11% lower in the current submission.

Table 7.10 Recalculations due to the updated oxidation factor in Managed SWDS (5A1)

5A1 CH_4 (kt)	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission	0.76	4.60	7.24	8.42	9.24	7.71	7.59
2021 submission	0.67	4.09	6.43	7.47	8.21	6.86	6.76
Change relative to 2020 submission	-11%	-11%	-11%	-11%	-11%	-11%	-11%

During the 2020 EU Comprehensive review it was furthermore pointed out that the DOC value for Industrial waste was not appropriate for the type of waste reported under industrial waste. Therefore, this value has been reviewed as well as the categorisation of industrial waste. Now this category comprises (1) non-hazardous residues from waste treatment and (2) mixed construction and demolition waste. Both categories (1) and (2) are present in managed waste, but detailed data which shows the split between the two categories is only available back to 2014. 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 appopriate DOC (Table 2.5 from the IPCC Guidelines) to calculate a weighted DOC for managed industrial waste: (72%*0.15)+(28%*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.

Table 7.11 Change of DOC for Industrial Waste for both managed and unmanaged SWDS.

Industrial Waste - DOC	Managed SWDS	Unmanaged SWDS
2020 v1 submission	0.15	0.15
2021 submission	0.1195	0.04

The total recalculations for the changes of both oxidation factor and DOC for industrial waste are shown in Table 7.12 and determine a change of -5% in 1990 and -10% in 2018.

Table 7.12 Recalculations for 5A due to the oxidation factor (5A1) and the DOC for industrial waste (5A1, 5A2)

5A CH_4 (kt)	1990	1995	2000	2005	2010	2015	2018
2020 v1 submission	6.31	8.74	10.02	10.42	10.80	8.90	8.57
2021 submission	5.99	8.04	9.09	9.38	9.71	8.01	7.71
Change relative to 2020 submission	-5%	-8%	-9%	-10%	-10%	-10%	-10%

7.2.7 Planned Improvements

Generally, there is a need for further improvements in the type of data being collected to use in the IPCC FOD model. This is a part of the improvement plan for this sector. Adding information on the parameters used in the estimation of CH_4 emissions from SWD and a collection of detailed information on landfill gas utilization (e.g. energy content of recovered gas, place of utilization) are planned for future submissions.

7.3 Biological Treatment of Solid Waste: Composting (CRF 5B)

Composting on a noteworthy scale has been practiced in Iceland since the mid-1990s. Data collection regarding the amount of waste composted started in 1995. Composted waste mainly includes 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 is mixed together. 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 for the future as is evident by the recent commissioning of composting facilities in Sauðárkrókur and Eyjafjörður (2009) in northern Iceland as well as of smaller facilities elsewhere in Iceland.

7.3.1 Methodology

Estimation of CH_4 and N_2O emissions from composting are calculated using the Tier 1 method of the 2006 GL. CO_2 emissions from Composting are not applicable since the IPCC 2006 Guidelines do not require their reporting.

7.3.2 Activity Data

There exists data about the amount of waste composted since 1995. Table 7.13 shows the amount of composted waste in Iceland since 1995. The amount composted is estimated to be between 2 and 3 kt annually until 2004. Since 2005 this amount has increased by roughly 2 kt per year and was 24 kt in 2019. There exists data on the composition of waste composted since 2007. In 2019 the main waste types composted were food waste, garden and park waste, slaughterhouse waste, and wood. The Tier 1 method, however, makes no use of waste composition data.

Table 7.13 Waste amounts composted since 1990.

	1990	1995	2000	2005	2010	2015	2018	2019
Waste amount composted (kt)	NO	2	2	5	15	21	24	24

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 GL default emission factors are (on a wet weight basis):

- 4 g CH_4/kg waste treated
- 0.24 g N_2O/kg waste treated (from the 9th Corrigenda for the 2006 IPCC guidelines)

7.3.4 Emissions

CH_4 emissions from composting amounted to 0.095 kt CH_4 or 2.39 kt CO_2e in 2019. N_2O emissions amounted to 0.006 kt N_2O or 1.71 kt CO_2e in 2019. The waste composted and emission trend since 1990 is shown in Figure 7.7.

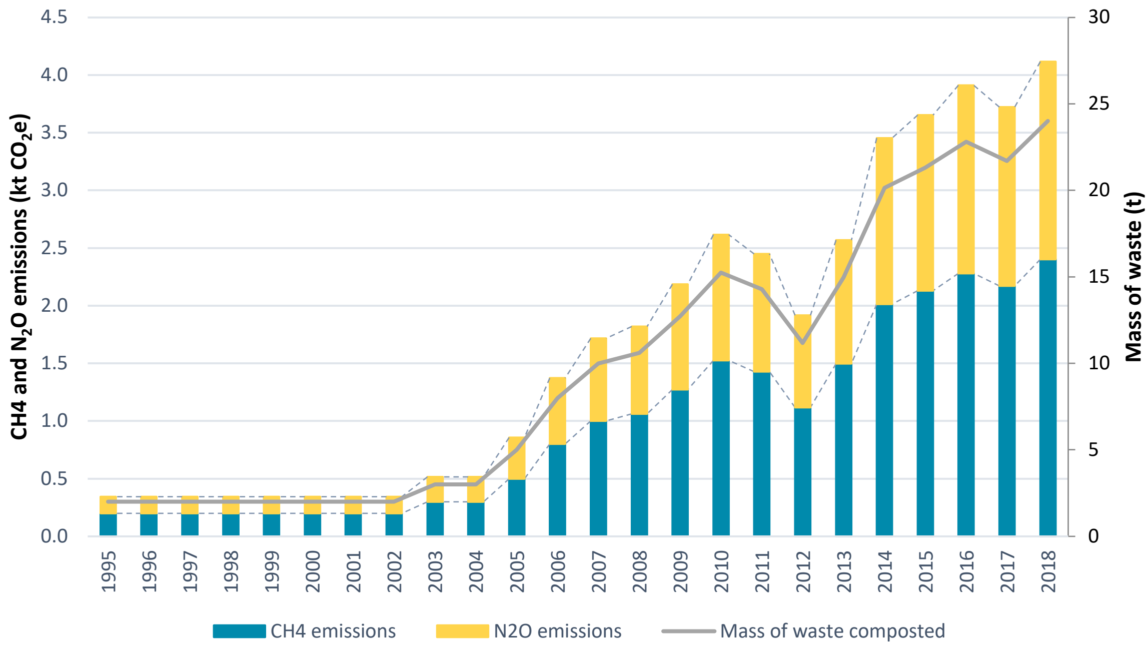


Figure 7.7 Mass of waste composted and estimated CH_4 and N_2O emissions (kt CO_2e)

7.3.5 Uncertainties

Uncertainty for emissions from composting was calculated using value ranges from the 2006 GL (table 4.). The uncertainty of CH_4 emissions from composting is 113% (with an activity data uncertainty of 100% and emission factor uncertainty of 52%). The N_2O uncertainty for emissions from composting is 159% (with activity data uncertainty of 150% and emission factor uncertainty of 52%). The complete uncertainty analysis is shown in Annex 2.

7.3.6 Recalculations

No recalculations were done for the 2020 submission for biological treatment of solid waste.

7.3.7 Planned Improvements

No specific improvements are planned for biological treatment of solid waste.

7.4 Waste Incineration and Open Burning of Waste (CRF 5C)

This chapter deals with incineration and open burning of waste. Open burning of waste includes historic combustion in nature and open dumps as well as combustion at incineration plants that do not control the combustion air to maintain adequate temperatures and do not provide sufficient residence time for complete combustion. Proper incineration plants on the other hand are characterised by creating conditions for complete combustion. Therefore, the burning of waste in historic incineration plants that did not ensure conditions for complete combustion was allocated to open burning of waste. The allocation has influence on CO_2, CH_4 and N_2O emission factors.

Open burning of waste is further divided into open burning of waste and bonfires. They differ from each other (from an emission point of view) in the composition of waste categories burned. Open burning of waste is used to incinerate a waste mix whereas bonfires contain only wood waste. Because wood does not contain any fossil carbon, CO_2 emissions from bonfires are not included in national totals.

The only emissions currently arising from 5C2 are from new year´s eve bonfires. After stricter regulations and inspections of bonfires were adopted around the year 2000, their number has significantly decreased, the bonfires have grown smaller, and only unpainted wood is allowed to be used. 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.

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 (5C).

The amount of waste burned in open pits decreased rapidly since the early 1990s, when more than 30 kt of waste were burned. Between 2005 and 2010 there was only one plant burning waste in open pits, on the island of Grímsey. It is assumed that around 45 tonnes of waste were burned there annually. The amount of material burned in bonfires has also decreased from around 4.3 kt in 1990 to 1.7 kt in 2019. 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.

Total GHG emissions from waste incineration and open burning of waste decreased from 15.1 kt CO_2e in 1990 to 9.4 kt CO_2e in 2019.

7.4.1 Methodology

The methodology for calculating CO_2 emissions from waste incineration is according to 2006 GL Tier 2a methodology. The methodologies for calculating methane and nitrous oxide emissions are in accordance with the 2006 GL Tier 1 methods.

Consistent with the 2006 Guidelines, only CO_2 emissions resulting from oxidation during incineration and open burning of carbon in waste of fossil origin (e.g. in plastics) are considered net emissions and therefore included in the national CO_2 emissions estimate. The CO_2 emissions from combustion of biomass materials contained in the waste (e.g. food and wood waste) are biogenic emissions and therefore not included in national total emission estimates. 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.

NO_X, CO, NMVOC, and SO_2 emissions are estimated in accordance with the EMEP/EEA Guidebook 2016.

7.4.2 Activity Data

7.4.2.1 *Amount of waste incinerated*

Methodology for activity data generation was inherited from the Icelandic submission to CLRTAP. 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 bonfires on New Year was calculated by weighing the wood of a sample bonfire and correlating the weight to the more readily measurable parameters pile height and diameter. These parameters were recorded for the majority of all bonfires and added up. The result was projected back in time using expert judgement. The amounts of waste incinerated are based on actual data from the incineration sites since 2004. The marginal amounts incinerated between 2001 and 2004 are based on expert judgement. The amounts of waste incinerated are shown in Figure 7.8.

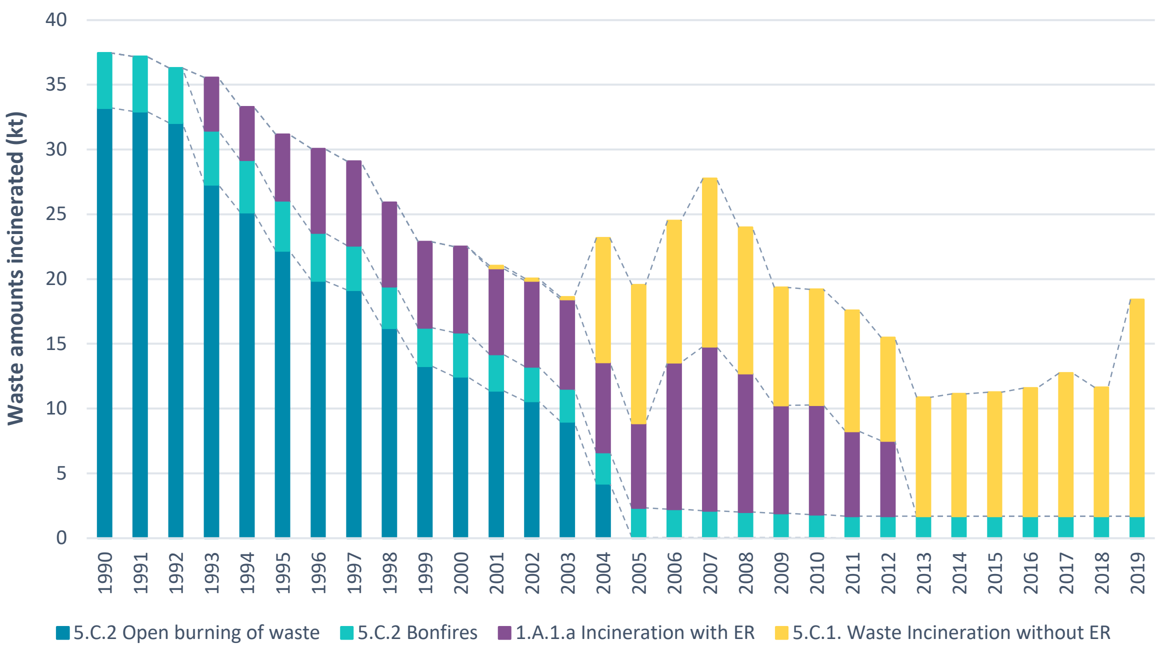


Figure 7.8 Amounts of waste incinerated with and without energy recovery, burned openly and amount of wood burned in bonfires 1990-2019.

Figure 7.8 shows that waste was only burned openly (here this includes waste incinerators with low/varying combustion temperatures) and in bonfires during the 1990s. A small incineration plant operated in Tálknafjörður in northwest Iceland from 2001-2004. The incineration plant Kalka in southwest Iceland, which started operation in 2004, is the only incineration plant in Iceland as of 2014 and onwards.

7.4.2.2 *Composition of waste incinerated*

There exists data on the composition of waste incinerated since 2005. A fraction of this data is in the form of separate waste categories whereas another fraction is in the form of mixed waste categories. The mixed waste categories were divided into separate categories using the study by Sorpa ltd. for

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. By including the separate waste categories, however, the special function of some of the incineration plants – such as destruction of clinical and hazardous waste - are taken into account. Thus, it was possible to allocate waste, along with their weight fractions from 2005 and onwards, to one of 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 was defined for the SWDS chapter. In this context it excludes plastics, rubber and hazardous waste.

This data exists only for waste incineration and for the years from 2005 and onwards. For want of data from 1990-2004, weighted average fractions from 2005-2011 were applied to the period before 2005, i.e. to both incineration and open burning of waste (waste incineration plants often succeeded 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).

7.4.3 Emission Factors

7.4.3.1 *CO_2 emission factors*

CO_2 emissions were calculated using equation 5.3 from the 2006 GL (see below). 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 5.3

$$CO_2\ emissions = MSW * \Sigma j\ (WF_j * dm_j * CF_j * FCF_j * OF_j) * 44/12$$

Where:

- CO_2 emissions = CO_2 emissions in inventory year, kt/yr
- MSW = total amount of municipal solid waste as wet weight incinerated or open-burned, kt/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 GL 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. This is shown exemplary for the year 2019 in Table 7.14.

Table 7.14 Calculation of fossil carbon amount incinerated in 2019 (for all incineration subcategories under 5C).

	Mass of incinerated waste (tonnes)	Fraction of incinerated waste	(f) Dry matter	(f) Carbon in dry matter	(f) Fossil carbon in total carbon	Fossil carbon (tonnes)
Paper	2,779	0.14	0.9	0.46	0.01	1.6
Textiles	362	0.02	0.8	0.5	0.2	0.5
Wood	4,484	0.23	0.85	0.5	0	0.0
Garden	60	0.00	0.4	0.49	0	0.0
Diapers	603	0.03	0.4	0.7	0.1	0.5
Food	3,376	0.17	0.4	0.38	0	0.0
Inert	2,304	0.12	0.9	0.03	1	7.2
Plastics	2,531	0.13	1	0.75	1	241.5
Hazardous	1,254	0.06	0.5	NA	0.275	10.9
Clinical	398	0.02	0.65		0.25	1.3
Rubber	217	0.01	0.84	0.10	0.2	0.0
Sludge plus manure	660	0.03	0.4	0.45	0	0.0
Industrial solid waste	864	0.04	0.4	0.38	0	0.0
Sum	**19,890**	**1.00**				**263.6**

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 were 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 GL. 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,2016), 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 where 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 7.9. Total GHG emissions estimates have decreased from 15.1 kt CO_2e in 1990 to 9.4 kt CO_2e in 2019. 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 0.39 kt CO_2e in 2019 and N_2O emissions have decreased from 1.7 kt CO_2e in 1990 to 0.63 kt CO_2e in 2019.

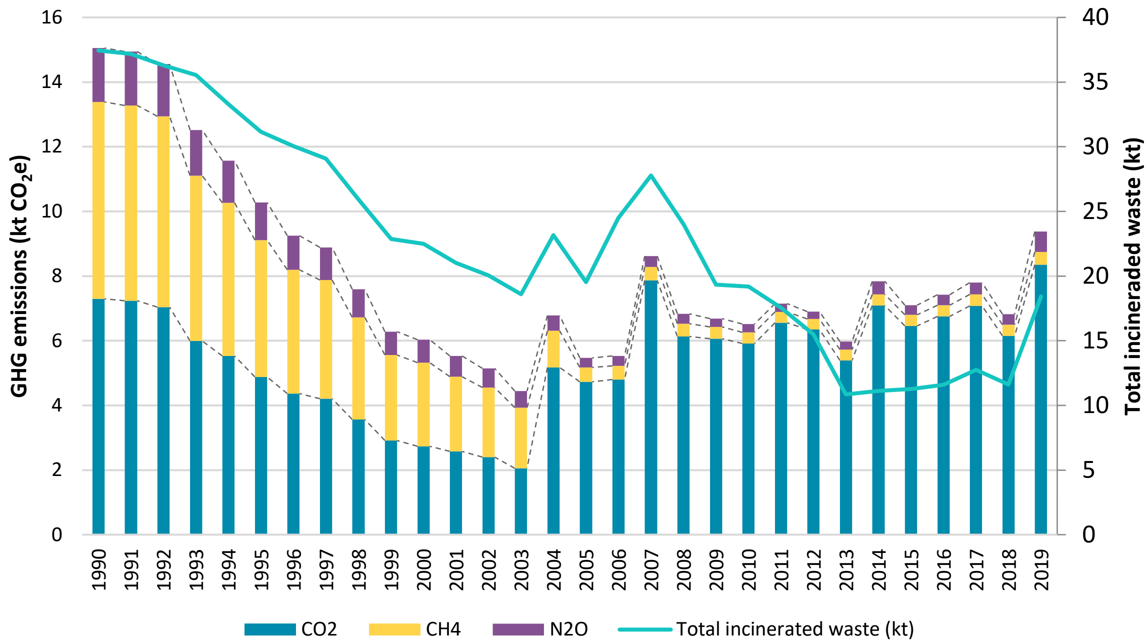


Figure 7.9 Emission estimates from incineration and open burning of waste since 1990

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 2019. 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 was set to 1 because emissions from industrial wastewater are calculated separately. The default BOD5 value for Canada, Europe, Russia and Oceania was used, 60 g per person per day (table 6.4). Between 1990 and 2019 annual TOW increased proportionally to population from 5.6 kt to 7.8 kt.

EQUATION 6.3

$$TOW = P \cdot BOD \cdot 0.001 \cdot I \cdot 365$$

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 7.3 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	2018	2019
Population (n)	253,785	266,978	279,049	293,577	317,630	329,100	348,450	356,991
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)	5.56	5.85	6.11	6.43	6.96	7.21	7.63	7.82

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

$$TOW_i = P_i \cdot W_i \cdot COD_i$$

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 CODi value for fish processing, 2.5 kg/m^3 (table 6.9 of the 2006 IPCC GL), was used. For fish processing Wi 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 amount of processed fish was only available from 1992 and onwards. Therefore, amount 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	2018	2019
Processed fish (kt)	1371.06	1376.39	1704.74	1253.83	729.44	1104.93	1077.88	877.57
COD generated (kt COD/yr)	44.56	44.73	55.40	40.75	23.71	35.91	35.03	28.52

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 GL:

EQUATION 6.8

$$N_{EFFLUENT} = (P * protein * F_{NPR} * F_{NON\text{-}COM} * F_{IND\text{-}COM}) - N_{SLUDGE}$$

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
- $F_{NON\text{-}CON}$ = factor for non-consumed protein added to the wastewater
- $F_{IND\text{-}COM}$ = factor for industrial and commercial co-discharged protein into the sewer system
- N_{SLUDGE} = nitrogen removed with sludge, kg N/yr

Fraction of nitrogen in protein, factor for non-consumed protein added to wastewater, and factor for industrial and commercial co-discharged protein are 2006 GL 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
$F_{NON\text{-}CON}$	1.1	1-1.5	The default value of 1.1 for countries with no garbage disposal was selected.
$F_{IND\text{-}COM}$	1.25	1-1.5	Default value used

Other parameters influencing the nitrogen amount of 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 (Bo) and the methane correction factor (MCF), see Equation 6.2 of the 2006 IPCC Guidelines.

EQUATION 6.2

$$EF_j = B_0 \cdot MCF_j$$

Where:

- EF_j = emission factor, kg CH_4 /kg BOD
- j = each treatment/discharge pathway or system
- B_0 = 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 GL). 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 ow MSW and population of Iceland since 1990.

		MCF	1990	1995	2000	2005	2010	2015	2018	2019
Not known		0.5	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	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02
	No treatment	0.1	0.75	0.72	0.49	0.31	0.22	0.23	0.23	0.23
Collected - treated systems	Primary treatment	0.1	0.02	0.03	0.26	0.39	0.57	0.50	0.50	0.50
	Secondary treatment	0	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
	Tertiary treatment	0	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Uncollected Septic tank	Urban	0.5	0.03	0.05	0.05	0.09	0.06	0.00	0.00	0.00
	Rural	0.5	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	348,450	356,991

Total CH_4 emissions from domestic wastewater were calculated with equation 6.1 from the 2006 IPCC Guidelines.

EQUATION 6.1

$$CH_4\ emissions = (\Sigma_{i,j}(U_i * T_{i,j} * EF_j)) * (TOW - S) - R$$

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 and R is set to 0 as well as 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

$$EF_j = B_0 \cdot MCF_j$$

Where:

- EF_j = emission factor, kg CH_4 /kg BOD
- j = each treatment/discharge pathway or system
- B_0 = maximum CH_4 production capacity, kg CH_4/kg COD
- MCF_j = methane correction factor (fraction)

The default maximum CH_4 production capacity (Bo) for industrial wastewater, 0.25 kg CH_4/kg COD, was applied (2006 IPCC GL). Eight wastewater discharge pathways exist in Iceland. They are shown for industrial wastewater in Table 7.20 along with 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	2018	2019
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	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
	Tertiary treatment	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

$$CH_4\ emissions = \Sigma_i\ ((\ TOW_i - S_i\ ) * EF_i - R_i)$$

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 GL 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 (CH_4)*

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 7.9 Methane emissions and total organics in domestic wastewater in Iceland since 1990. CH_4 emissions from domestic wastewater were 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 ready.

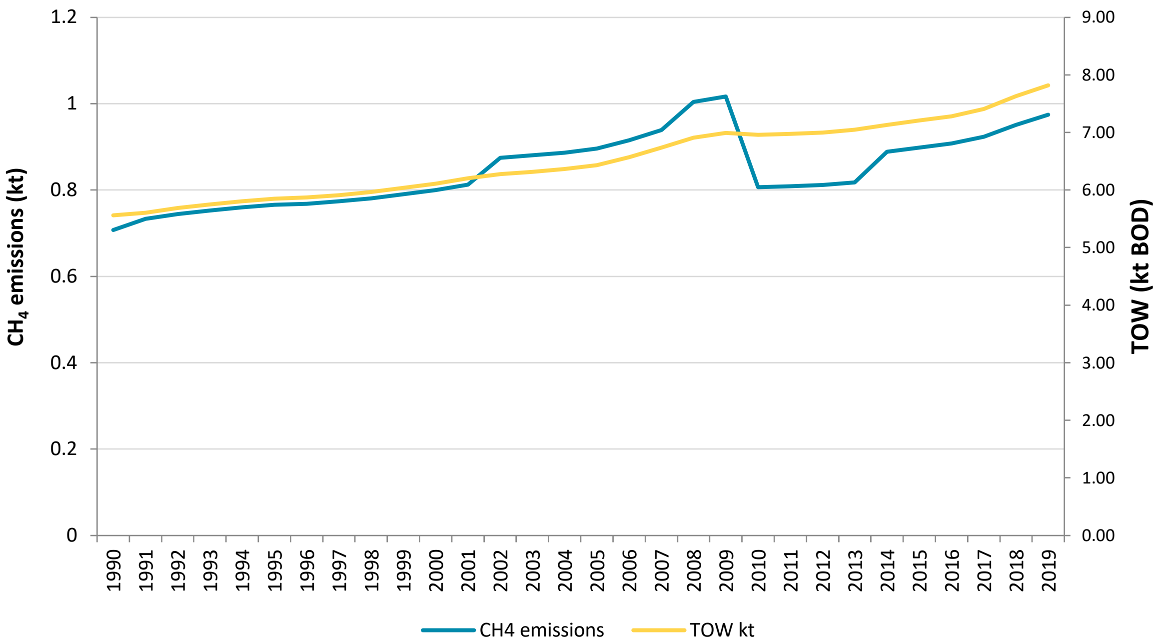


Figure 7.10 Methane emissions and total organics in domestic wastewater in Iceland since 1990.

Industrial wastewater

The correlation between chemical oxygen demand and methane emissions from industrial wastewater discharge can be seen in Figure 7.10 Methane emissions and total organics in industrial wastewater in Iceland since 1990. CH_4 emissions from industrial wastewater were 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.

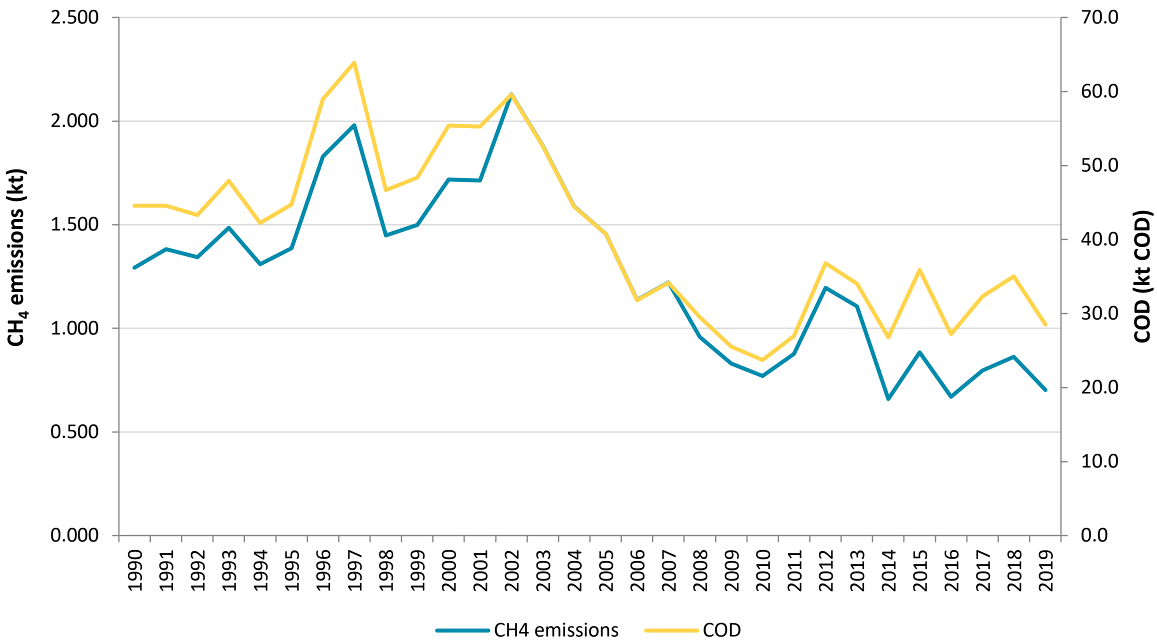


Figure 7.11 Methane emissions and total organics in industrial wastewater in Iceland since 1990.

7.5.4.2 ***Nitrous Oxide (N_2O)***

In order to estimate N_2O emissions from wastewater effluent, $N_{EFFLUENT}$ was calculated using equation 6.8 from the 2006 GL. 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 7.17 shows the amount of sludge removed and $N_{EFFLUENT}$ calculated using equation 6.8 from the 2006 GL. 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.

Table 7.21 Amount of sludge removed and N in effluent

	1990	1995	2000	2005	2010	2015	2018	2019
Sludge removed (kt DC)	6.0	5.5	6.0	4.9	3.9	3.2	3.5	2.4
N in effluent (kt N/year)	2.0	2.1	2.2	2.0	2.2	2.3	2.5	2.5

The resulting emissions are shown in Figure 7.12. Emissions rose from 0.015 kt in 1990 to 0.02 in 2019, or by 30%. The main driver behind this development was a 41% increase of population during the same time. The drop in emissions in 2002 was due to a new dietary survey which showed a decreased in protein intake (Steingrímsdóttir, Þorgeirsdóttir, & Ólafsdóttir, 2002).

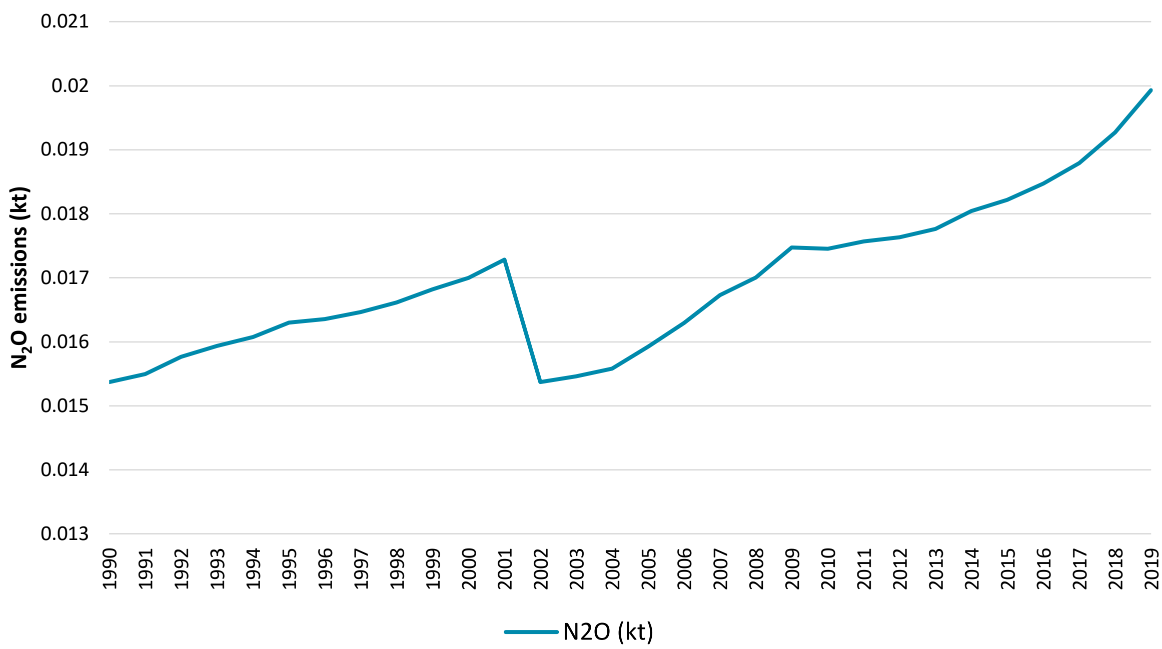


Figure 7.12 Emission estimates for N_2O from wastewater effluent since 1990.

7.5.5 Uncertainties

The activity data uncertainty was calculated to be 38.7% for CH4 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 for N_2O emissions is based on values from the 2006 IPCC Guidelines. and is 39% while the emission factor uncertainty is calculated using the ranges given in Table 6.11 of the 2006 IPCC Guidelines and amounts to 2495% giving a combined uncertainty of 2495.3%. The complete uncertainty analysis is shown in Annex 2.

7.5.6 Recalculations

No recalculations were performed for the current submission.

7.5.7 Planned Improvements

It is planned to add further background information on sludge removal (e.g. amount and N content) to improve the transparency on in which category the resulting emissions are accounted for.

Adding further emissions from industrial wastewater and updating the factor for non-consumed protein in wastewater treatment and discharge is on the improvement plan for future submissions.

A new survey on the diet of people in Iceland is planned and the data on the average protein intake of the population will be updated when the results from that survey will be published.

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 (2018) 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 2021 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. Some of the recalculations were due to potentially significant issues as identified in the 2020 EU comprehensive review (see below), 3 of which lead to revised estimates submitted by Iceland during the review, and approved by the expert review team. The effect of these recalculations is documented in chapter 10.2.1 below.

Table 10.1 and Table 10.2 below show the difference between the total emissions in the 2021 submission and the 2020 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 2021 submission compared to the 2020 resubmission, kt CO_2e (without LULUCF).

Inventory year	2020 submission	2021 submission	Change (kt)	Change (%)
1990	3,733	3,683	-50	-1.3%
1995	3,551	3,513	-38	-1.1%
2000	4,171	4,127	-44	-1.1%
2005	4,059	4,023	-37	-0.9%
2010	4,929	4,866	-63	-1.3%
2015	4,800	4,764	-36	-0.7%
2017	4,836	4,795	-40	-0.8%
2018	4,857	4,822	-35	-0.7%

Table 10.2 Total emissions according to the 2021 submission compared to the 2020 resubmission, kt CO_2e (with LULUCF).

Inventory year	2020 submission	2021 submission	Change (kt)	Change (%)
1990	13,076	12,875	-201	-1.5%
1995	12,811	12,674	-137	-1.1%
2000	13,409	13,311	-99	-0.7%
2005	13,302	13,256	-46	-0.3%
2010	14,191	14,160	-31	-0.2%
2015	13,941	13,966	25	0.2%
2017	13,889	13,931	42	0.3%
2018	13,867	13,928	61	0.4%

10.2 2020 Reviews

10.2.1 EU Comprehensive review

In 2020, in addition to the yearly "EU step 1 review checks"[19], the Icelandic inventory underwent a comprehensive review by the EU/EFTA as was required by Art. 4 of Regulation (EU) 2018/842 (so-called Effort-sharing regulation - ESR)[20]. The comprehensive review addressed the emissions falling under the scope of the aforementioned regulation, that is, excluding EU ETS emissions (covered by Directive 2003/87/EC) as well as LULUCF emissions and removals. The expert review team (ERT) specifically focussed on emissions of the years 2005, 2016, 2017 and 2018, as these emissions were then used to determine the volume of annual emission allocations (AEAs) for the years 2021-2030 as provided for in Art. 4 of the ESR. The review was conducted according to Art. 32 of Regulation (EU) 749/2014, with checks as listed in Art. 19 of Regulation (EU) 525/2013.

During the review, three issues were deemed to exceed the threshold of significance for the Icelandic inventory, and Iceland provided the expert review team (ERT) revised estimates for those three issues (1 in IPPU (F-gases), 1 in agriculture and 1 in waste). The revised estimates were accepted by the ERT and used in the calculations to determine Iceland's AEAs. The revised methodologies were all used in this submission. Detailed information on these three issues as per the Final Review Report received by Iceland in August 2020 can be found in Annex 5 of this report, including Iceland’s explanations on the current status of the issues. The table below shows the impact of the revised estimates on the 2020 submission.

[19] cf. Art. 29, Commission Implementing Regulation (EU) 749/2014

[20] as added to the EEA Agreement with Joint Committee Decision nr. 269/2019.

Table 10.3 Effect of recalculations as performed during the EU comprehensive review (kt CO_2e)

Data/Source category	Reference/Comment ID	2005 Emission estimates	2016 Emission estimates	2017 Emission estimates	2018 Emission estimates
Total GHG emissions	As submitted to EU 15/03/2020	4059.5	4754.6	4835.5	4857.0
Total GHG emissions after comprehensive review	Including revised estimates	4033.5	4725.8	4804.3	4831.7
Total difference		-26.0	-28.8	-31.2	-25.3
Revised estimates					
2.F.1 Refrigeration and Air Conditioning, HFCs	IS-2F1-2020-0002	-	-0.6	-2.0	-3.8
3.A Enteric fermentation, CH_4, N_2O	IS-3A-2020-0004	-	-6.9	-8.6	-
5.A Solid Waste Disposal, CH_4	IS-5A-2020-0005	-26.0	-21.4	-20.6	-21.5

10.2.2 UNFCCC review

The Icelandic inventory was not reviewed by UNFCCC in 2020.

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 2020 and the 2021 submission amounting to -7 kt CO_2e for the year 2018 and -18 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:

- Activity data for 1990-2002 was revised with the purpose of making it more transparent and consistent with official sales statistics from the National Energy Authority. These were the same revisions that were done for 2003-2018 for last submission.
- For this submission measurements of carbon content in fossil fuels used in road transport were done. With this country-specific value emissions from road transport are now estimated using T2 methodology and this caused recalculations for the whole timeseries.

10.3.2 Industrial Processes and Products Use (CRF sector 2)

For the current inventory a new category 2D3- urea based additives in catalytic converters was added for the first time to the inventory for the time series 2008-2019.

Recalculations occurred for the use of F-gases, in the sectors 2F1 and 2F4a:

- In light of the 2020 EU Comprehensive review, it was asked to revise the emissions from 2F1e MACs as the emissions deemed to be too high. 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 leads to recalculations for the years 2016-2018.

- Data on import of MDIs containing R-227ea from 2014. This caused a small increase in emissions for 2014-2018. In addition, activity data (amount of HFC in each MDI) was updated due to improved data collection leading to small recalculations.

10.3.3 Agriculture (CRF sector 3)

In light of the 2020 EU Comprehensive review, one revised estimate for animal characterization parameters leads to recalculations for methane emissions. The N-flow methodology used for estimating N_2O emissions in the categories 3B and 3D was updated to the latest emission factors as proposed in the 2019 EMEP EEA air pollutant inventory guidebook leading to recalculations. Smaller recalculations occur due to the update of activity data for organic fertilizers, areas for the cultivation of organic soils (3D), activity data for liming and urea application (3G, 3H). Further details can be found under each subsector and are summarized here below:

- The gross energy (GE) for mature dairy cattle has been interpolated from 2013-2017 to avoid a step change between 2017 and 2018. Revising the GE for dairy cattle impacts on corresponding emissions in: 3A Enteric Fermentation (CH_4), 3B Manure Management (CH_4, N_2O) and 3D Agricultural Soils (N_2O) For the current 2021 submission, parameters, e.g. emission factors used in the N-flow methodology were updated from the 2016 EMEP/ EEA air pollution inventory guidebook to its newest 2019 edition. In particular, emission factors for the NH_3-N emissions in the different stages (housing, storage, application and grazing) and for the manure types slurry and solid changed for some animal categories. This leads to changes in 3B but also in 3D such as for Animal Manure Applied to Soils (3D12a) and Indirect Emissions (3D2).
- The activity data for sewage sludge in organic fertilizers (3D12b) was updated due to better research and a new emission category, other organic fertilizers (compost, bone meal in category 3D12c) was added for completeness.
- Recalculations in the subcategory Cultivated organic soils (3D16) have two origins: first, the area calculations have changed due to improvements in the LULUCF sector and second, 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.
- It was possible to complete the time series for liming (3G), application of calcium carbonate and the data source is from Statistics Iceland. Recalculations occur for the years 1990-2018. For the application of dolomite, the activity data was updated for the years 2013-2018 due to an error detected in data collection.
- In 3H-urea application the deduction of the amounts of urea imported as additives for selective catalytic converters in diesel vehicles lead to recalculations for the years 2012-2018.

10.3.4 LULUCF (CRF sector 4)

Recalculations have been done to the LULUCF sector between the 2020 and 2021 submission, mostly due to revised area estimation. The effect of the recalculations on the emissions from the sector are shown in Table 10.4. Further explanations for the subsectors are also explained below.

Table 10.4 Total emissions from LULUCF according to the 2021 submission compared to the 2020 submission, kt CO_2e.

Inventory year	2020 submission	2021 submission	Difference (kt CO_2e)	Difference (%)
1990	9,344	9,192	-151	-1.6%
1995	9,260	9,161	-99	-1.1%
2000	9,238	9,184	-54	-0.6%
2005	9,242	9,233	-9	-0.1%
2010	9,262	9,293	32	0.3%
2015	9,141	9,202	61	0.7%
2017	9,053	9,135	82	0.9%
2018	9,010	9,106	96	1.1%

Forest land (4A)
The emission/removal estimate for forest land has been slightly 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.

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.

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)
The total area of Settlements has been revised due to the revised estimate of the total area of the map layer of "Cropland". 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.

Other Land (4F)

No emissions are reported under this category.

Harvested wood products (4G)

A calculation error in last year submission was found and recalculation halved the C-stock of HWP in this year submission compared to last year submission.

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 2021 submission, the main recalculations in the waste chapter were done in the chapter Solid Waste Disposal (5A). The following changes have been made in light of the recommendations of the 2020 EU Comprehensive review:

- 5A1 - Managed Solid Waste Disposal Sites: The oxidation factor was updated from the previously used value of 0 to 0.1 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 to birds and vermin. In Iceland, the majority of landfills use a combination of soil and wood chips as cover, except for a few exceptions which use sand and gravel. Therefore, as pointed out by the reviewers, an oxidation factor of 0.1 is more appropriate.
- 5A1 - Managed Solid Waste Disposal Sites: The DOC value used was deemed not appropriate for industrial waste. The value was changed from 0.15 to 0.1195.
- 5A2 - Unmanaged Solid Waste Disposal Sites: As for Managed SWDS, the DOC value for industrial waste was updated from 0.15 to 0.04.

All details regarding the above-mentioned recalculations can be found in chapter 7.2.6.

10.3.6 KP-LULUCF (CRF Sector 7)

As explained in Chapter 6.4 and above in Chapter 10 are data on area in CF slightly revised. This will lead to revision on area dependent stock changes. Emission/removal factors used are unchanged (See further explanation in chapter 0).

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 2020 submission was reviewed during EU's comprehensive review process, according to Art. 29 and 32 of Commission Implementing Regulation (EU) No 749/2014 (see also chapter 10.2.1). The most recent UNFCCC review took place in September 2019. In the tables below we document the status of implementation of Iceland's ARR 2019, which was published on 19 March 2020.

The main improvements implemented in the inventory compilation for the 2021 submission were the measurements of country specific carbon content in fossil fuels in road transport which move emissions estimate of CO_2 from that sector to T2 methodology. Furthermore, following the EU comprehensive review, changes were made to the waste sector (change in oxidation factor for managed SWDS and DOC for industrial waste).

Tables Table 10.5- Table 10.10 show the status of implementation of each general recommendation for each sector listed in the 2019 Assessment Report (Report on the individual review of the annual submission of Iceland submitted in 2019 - FCCC/ARR/2019/ISL).

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. Sector-Specific Implemented and Planned Improvements, Including in Response to the Review Process

The table below shows the status of implementation of each general recommendation listed in the 2019 Assessment Report.

Table 10.5 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 in the NIR
General	Ensure that one organization has a full understanding of the complete energy balance and can compile a transparent and complete energy balance	FCCC/ARR/2019/ ISL /G.1	This has been resolved. Annex 3 of the NIR shows the energy balance for the most recent inventory year.	Annexes
General	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	FCCC/ARR/2019/ ISL /G.2	In progress	Chapter 14
General	Report in the annual submission any changes in its national system in accordance with decision 15/CMP.1, annex, chapter I.F, and/or further relevant decisions of the CMP.	FCCC/ARR/2019/ ISL /G.3	Resolved. Information on changes in the national system are reported in Chapter 13.	Chapter 13
General	The ERT recommends that Iceland 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 involved institutions (e.g. Agricultural University of Iceland, IFR and the Ministry of Environment and Natural Resources) and the changes in the national system resulting from such implementation (if any).	FCCC/ARR/2019/ ISL /G.4	A table has been added to Chapter 13 (Table 13.2) describing the status of implementation of Regulation 520/2017 for each article of the Regulation.	Chapter 13

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
General	The ERT recommends that Iceland include in the NIR complete information on efforts made by the Party 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.	FCCC/ARR/2019/ ISL /G.5	Additional information was added to Chapter 1, there in particular to sections 1.3.4 (Training and capacity-building activities) and 1.3.5 (capacity and staffing).	Chapter 1
General	The ERT recommends that Iceland 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.	FCCC/ARR/2019/ ISL /G.6	This has been addressed in Section 1.5, which has been expanded since last submission.	Chapter 1
General	The ERT commends Iceland for its efforts to improve the uncertainty analysis by using the 2006 IPCC Guidelines and recommends that Iceland present the results obtained through the use of the 2006 IPCC Guidelines in the next annual submission.	FCCC/ARR/2019/ ISL /G.7	An overview of the uncertainty analysis is included in Chapter 1.6, and Annex 2 shows the complete uncertainty analysis, with and without LULUCF.	Paragraph 1.6; Annex 2.
General - National system	The ERT recommends that Iceland 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.	FCCC/ARR/2019/ ISL /G.8	Information on this has been added to the NIR, chapters 1.2, 1.3 and 1.5.	Chapter 1
General - National system	The ERT encourages Iceland to include in the NIR information on its efforts to archive information at a single location as part of its inventory management in line with decision 19/CMP.1, annex, paragraph 17, in conjunction with decisions 3/CMP.11 and 4/CMP.11.	FCCC/ARR/2019/ ISL /G.9	This will be considered for future submissions.	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
General - Art.3.14 of the KP	The ERT recommends that the Party, in its annual submission, 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.	FCCC/ARR/2019/ ISL /G.10	Updated information has been added to Chapter 15.	Chapter 15
General - QA/QC	The ERT recommends that Iceland use the 2006 IPCC Guidelines as the only guidelines for QA/QC procedure and for assessing completeness. The ERT further recommends that Iceland remove all outdated references to earlier IPCC guidelines from the NIR in order to improve the transparency and comparability of its NIR.	FCCC/ARR/2019/ ISL /G.11	We confirm that Iceland uses the 2006 IPCC guidelines as the only guidelines for QA/QC procedure and for assessing completeness. We have removed all outdated references to earlier IPCC guidelines from the NIR.	
General - recalculations	The ERT recommends that Iceland improve its reporting on recalculations, particularly for the agriculture and LULUCF sectors, by clearly documenting and justifying recalculations and clearly indicating the reason for the changes compared with previously submitted inventories (e.g. error correction, statistical reason) in the NIR in line with the UNFCCC Annex I inventory reporting guidelines, annex I, paragraphs 44 and 45. The ERT also recommends that the Party 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. Further, the ERT encourages the Party to include in the NIR explanations of the impact of the recalculations on the AD and emission trend at the category and sectoral level.	FCCC/ARR/2019/ ISL /G.12	Extensive descriptions of recalculations were added to the Agriculture chapter. QC plans are being developed and improved to assure consistent reporting of recalculations between NIR and CRF, and explanations on the impact of recalculations on trends will be added in future submissions.	
General - further improvements	The ERT encourages Iceland to establish clearer linkages between its improvement plans and QA/QC findings. The ERT also encourages the Party to include timelines and report on the progress of its improvement plans in the NIR.	FCCC/ARR/2019/ ISL /G.13	The new QA/QC procedures are still being implemented. Iceland plans to include timelines and report on progress of the improvement plan as an annex to the NIR in future submissions.	

10.5.1 Energy (CRF Sector 1)

For this submission the EA had measurements done on the carbon content in fossil fuels used in road transport in Iceland to obtain a country-specific emission factor for CO_2 emissions from road transport. The EA also performed a comprehensive review of the input data for the energy sector for 1990-2002 in collaboration with the NEA. For future submissions the EA will work on harmonising energy data processing between various organisations (such as EA, the National Energy Authority and Statistics Iceland) and updating the NIR text. Iceland also plans to look into how the Eurocontrol dataset can be used to estimate aviation GHG emissions.

Table 10.6 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 in the NIR
1.	Report information on electrode consumption, steam coal consumption and petroleum coke consumption that provide justification for significant inter-annual changes and gaps in the time series of fuel consumption and associated emissions	FCCC/ARR/2019 /ISL /E.1	Resolved. Electrodes have been removed from the energy sector as these were not used for energy, these were electrode waste which is exported. Steam coal was an error in translation, it is now reported as other bituminous coal in sector 1A2f. This was used for cement production, which stopped operating in 2012 and has therefore not been reported since then. Petroleum coke was also use in cement production 2004-2007 and since 2013 small amount of petroleum coke has been used in mineral wool production. Both cement and mineral wool production is reported in 1A2f	Energy Chapter
1.	Provide transparent information in cases where GHG emissions have been accounted for elsewhere and the notation key "IE" (included elsewhere) is used to report such emissions	FCCC/ARR/2019 /ISL /E.2	This has been implemented. / Done	Energy Chapter
1.	Provide more transparent information on the modification methodologies used when re-categorizing the data received from the National Energy Authority of Iceland (NEA)	FCCC/ARR/2019 /ISL /E.3	This has been implemented. / Done	Energy Chapter
1.	The ERT recommends that Iceland reassess the uncertainty values for AD and EFs used to carried out the uncertainty evaluation and archive the relevant supporting information in accordance with decision 19/CMP.1, and implement the provision from its regulation 520/2017 on the joint work of EA	FCCC/ARR/2019 /ISL /E.4	Resolved. AD uncertainty values were confirmed by the NEA, whereas default EF uncertainties are taken from the 2006 IPCC guidelines.	Energy Chapter

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	and NEA regarding the uncertainty analysis.			
1.	The ERT recommends that Iceland correct the several errors and omissions in the national inventory, such as the omission of oxidation factors in the emission estimates, incorrect allocation of fuels, incorrect use of EFs for diesel oil used in the transportation sector, inconsistent use of NCV and carbon content for steam coal, missing emissions and emission capture from geothermal power plants, and missing use of charcoal. The ERT also encourages Iceland to develop and implement category-specific QC procedures for key categories and for those categories in which significant methodological changes and/or revisions have occurred in the energy sector.	FCCC/ARR/2019 /ISL /E.5	All of these issues were resolved, apart from the missing use of charcoal. New QC procedures are being implemented.	Energy Chapter
1.AB	Correct the apparent consumption in units of energy for the entire time series by using an appropriate conversion factor and report the corrected estimates in CRF table 1.A(c).	FCCC/ARR/2019 /ISL /E.6	This has been implemented. / Done	Energy Chapter
1.AB	Estimate and report stock changes of liquid (gasoline, jet kerosene, gas/diesel oil, residual fuel oil and liquefied petroleum gas) and solid (other bituminous coal) fuels in CRF table 1.A(b) for the entire time series.	FCCC/ARR/2019 /ISL /E.7	This has been implemented. / Done	Energy Chapter
1.AB	The ERT recommends that Iceland report estimates for the apparent energy consumption (excluding non-energy use, reductants and feedstocks) of liquid and solid fuels for the entire time series in CRF table 1.A(c)	FCCC/ARR/2019 /ISL /E.8	This has been implemented. / Done	Energy Chapter
1.AB	The ERT recommends that Iceland report the correct amount of carbon excluded from anthracite use in CRF table 1.A(d) for the calculation of CO_2 emissions from fuel combustion activities under the reference approach.	FCCC/ARR/2019 /ISL /E.9	This has been implemented / Done	Energy Chapter
1.	The ERT recommends that Iceland develop country-specific fuel properties (NCVs and carbon	FCCC/ARR/2019 /ISL /E.10	This has been implemented. / Done	Energy Chapter

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	content of fuels) that would allow it to use the tier 2 approach for key categories in line with the 2006 IPCC Guidelines.			
1.	The ERT recommends that Iceland update the oxidation factor values reported in the NIR in accordance with the oxidation factor values used to estimate CO_2 emissions from fuel combustion activities of liquid and solid fuels.	FCCC/ARR/2019 /ISL /E.11	This has been implemented / Done	Energy Chapter
1.	The ERT recommends that Iceland 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. The ERT also recommends that Iceland archive all relevant information regarding the selection of AD, EFs and associated parameters (e.g. NCV) used to estimate the emissions.	FCCC/ARR/2019 /ISL /E.12	Resolved. The values for steam coal have now been replaced by IPCC default values for petroleum coke: After investigating the issue for waste electrodes it was concluded that these are not used for energy in Iceland but are exported. Therefore, waste electrodes have been removed from the inventory.	Energy Chapter
1.A.2.	The ERT recommends that Iceland assess the use of the CH_4 and N_2O EFs that are reported as examples in the 2006 IPCC Guidelines, and use tier 1 IPCC default values if it is not possible to explain how the non-default CH_4 and N_2O EFs defined in the 2006 IPCC Guidelines represent average conditions in Iceland.	FCCC/ARR/2019 /ISL /E.13	The EFs have been replaced by the IPCC default EFs / Done	Energy Chapter
1.A.3.b	Use a consistent methodology for the division of vehicle groups and conduct recalculations for the earlier years of the time series (1990–2005)	FCCC/ARR/2019 /ISL /E.14	We have implemented the use of COPERT which uses a consistent methodology for the whole timeseries.	
1.A.3.b	The ERT recommends that Iceland update the NIR with the CH_4 and N_2O EFs used for estimating emissions from diesel oil in road transportation. The ERT further encourages the Party to develop and implement category-specific QC checks.	FCCC/ARR/2019 /ISL /E.15	Iceland has updated the EFs used for calculating CH_4 and N_2O emissions from road transport by implementing COPERT for the whole timeseries / Done	Energy Chapter
1.A.3.b	The ERT recommends that Iceland undertake an evaluation of the use of CH_4 collected from waste yards in road transportation and consider estimating and reporting the emissions associated with the use of CH_4 in road transportation,	FCCC/ARR/2019 /ISL /E.16	For the 2018 submission Iceland included emissions from CH_4 collected from landfill sites and sold as fuel for vehicles. / Done	Energy Chapter

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	avoiding potential double counting with the waste sector.			
1.A.3.e	The ERT recommends that Iceland report transparent information on emissions from off-road and ground activities occurring in airports that have been accounted elsewhere	FCCC/ARR/2019 /ISL /E.17	For the 2019 emissions sales statistics for off road machinery was separated between construction (1A2gv), agriculture (1A4cii) and other (1A2gvii). All off-road transportation for 1990-2018 is reported under 1A2gvii / Done	Energy Chapter
1.A.4.	The ERT recommends that Iceland collect AD on the consumption of charcoal, estimate its emissions, report the corresponding CO_2 emissions as a memo item and include the non-CO_2 emissions in the corresponding CRF table and national totals.	FCCC/ARR/2019 /ISL /E.18	Iceland is aware that charcoal is being used for grilling in the country, however data on this activity has not been obtained. Work is in progress in collaboration with Statistics Iceland in order to obtain suitable data.	
1.B.2.d.	The ERT recommends that Iceland 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.	FCCC/ARR/2019 /ISL /E.19	Some information was added to section 3.8.2.2. Further information, including translations of part of the 2009 report and updated information, will provided in future submissions.	Energy Chapter
1.B.2.d.	The ERT recommends that Iceland 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.	FCCC/ARR/2019 /ISL /E.20	Additional information about this was added to section 3.8.2.1	Energy Chapter
1.B.2.d.	The ERT recommends that Iceland identify the main drivers for the trend in CO_2 and CH_4 emissions (e.g. power plants, geothermal fields) and investigate why geothermal electricity is being produced with decreasing levels of CO_2 emissions per GWh since 1993, and report its findings in the NIR.	FCCC/ARR/2019 /ISL /E.21	Additional information about the main drivers for the trend in GHG emissions from geothermal power plants was added to Chapter 3.8.2.2 of the NIR	Energy Chapter
1.AB electrode s	The ERT recommends that the Party 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 CO_2 emissions	FCCC/ARR/2019 /ISL /E.22	Electrodes are now reported as NO in the reference approach	CRF

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	resulting from the two approaches across the time series. The ERT also recommends that the planned recalculation for the reference approach is explained in the next NIR.			
1.A.3.b.i	The ERT recommends that Iceland revise the AD for fuel consumption for road transportation using consistent approach across the entire time series. The ERT notes that consistent reporting in the road transportation sector, particularly for cars, could be ensured for example, by applying the splicing techniques (overlapping) included in the 2006 IPCC Guidelines (vol. 1, chap. 5) to the AD used across the time series. The ERT also recommends that when applying the recalculation, the Party clearly 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 (see ID# G.12 in table 6). Further, the ERT encourages the Party to include in the NIR explanations for the impact of the recalculations on the AD and emission trend, particularly in those cases where the impact is not uniform across the time series.	FCCC/ARR/2019 /ISL /E.23	Not relevant anymore because now we use COPERT	Energy Chapter
1	The ERT encourages Iceland to develop and implement category-specific QC procedures for key categories and for energy sector categories in which significant methodological changes and/or revisions have occurred and report on them in the next NIR.	FCCC/ARR/2019 /ISL /E.24	Additional information on QC was added to Chapter 3.1.4 on sector specific QA/QC, as well as planned improvements (Chapter 3.1.5 - see also answer to recommendation #E.25 below).	
1	The ERT encourages the Party to develop a prioritized improvement plan for the energy sector that takes into consideration any previous recommendations and the results of the key category analysis and the uncertainty analysis.	FCCC/ARR/2019 /ISL /E.25	An improvement plan was made for the energy sector, as can be seen in Section 3.1.5. This plan takes into consideration previous recommendations, including whether the recommendations were found in three consecutive reviews, as well as the KCA. The uncertainty analysis will be taken into consideration for the improvement plan in the future. See also chapter 1.5.5 on general	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
			improvements to the improvement plans.	
1.AB Reference Approach	The ERT recommends that Iceland report the results of the data analysis by NEA in the NIR and ensure the use consistent AD for the inventory estimates across the time series. The ERT encourages the Party to improve the energy balance as planned and report on the improvements in the next NIR.	FCCC/ARR/2019 /ISL /E.26	In progress, in collaboration with the NEA.	
1.AB Jet Kerosene	The ERT recommends that the Party correctly report consumption of and CO_2 emissions from jet kerosene in CRF table 1.A(b).	FCCC/ARR/2019 /ISL /E.27	Resolved	
1.AB Peat	The ERT recommends that the Party report on peat consistently between the sectoral and reference approach.	FCCC/ARR/2019 /ISL /E.28	Resolved. it was confirmed by Statistics Iceland that peat is solely used for non-energy purposes, mostly gardening.	
1. Comparison with international data	The ERT recommends that the Party enhance the collaboration among NEA, IEA and relevant national authorities to resolve the errors detected in the data, and report correctly in table 1.A(b) (1) the production of waste (non-biomass fraction) for the entire time series, (2) the export of liquid fuel for the time-series and (3) stock changes for coke oven/gas coke between 2007 and 2012 and make corrections in emissions.	FCCC/ARR/2019 /ISL /E.29	Issue (1) has been resolved, issues (2) and (3) have not been resolved and are being considered by the NEA.	
1.AD	The ERT recommends that the Party 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 entire time series.	FCCC/ARR/2019 /ISL /E.30	Not resolved	
1.AA	The ERT recommends that the Party report information on AD and emissions for the information item “waste incineration with energy recovery” in CRF table 1.A(a)s4.	FCCC/ARR/2019 /ISL /E.31	Resolved	
1.A.3.b.i biomass	The ERT recommends that the Party explain in the NIR any significant inter-annual and trend changes of the AD, emissions and implied emissions factors for CH_4 and N_2O related to the use of gasoline for passenger cars.	FCCC/ARR/2019 /ISL /E.32	Resolved with the use of COPERT.	
1.A.3.b.i biomass	The ERT recommends that the Party, clearly explain any significant inter-annual changes in the AD used for biomass and provide	FCCC/ARR/2019 /ISL /E.33	Partly resolved. We have yet to add explanation about inter annual changes in IEFs.	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	information on the EFs used for biofuels to justify any significant inter-annual changes in the biomass IEFs.			
1.A.3.b.i biomass	The ERT recommends that the Party update the N_2O EF for biogasoline and ensure that the EF choice is well documented and justified in the NIR.	FCCC/ARR/2019 /ISL /E.34	Resolved with the use of COPERT.	
1.A.3.e	The ERT recommends that the Party further investigate the possibility of separately estimating and reporting fuel consumption by splitting it into ground activities at airports and harbours (1.A.3.e.ii), agriculture and forestry (1.A.4.c.ii) and manufacturing industries and construction (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.	FCCC/ARR/2019 /ISL /E.35	For the 2019 emissions sales statistics for off road machinery was seperated between construction (1A2gv), agriculture (1A4cii) and other (1A2gvii). All off-road transportation for 1990-2018 is reported under 1A2gvii / Resolved	
1.D.1	The ERT encourages the Party to enhance the collaboration among NEA, IEA and relevant national authorities to resolve the errors detected in the data, and report accurately AD for bunker fuel across the time series, particularly in relation to liquid fuels for marine bunkers for 1990–2012 and liquid fuels for international aviation for 1991, 1985–1997 and 2003–2006.	FCCC/ARR/2019 /ISL /E.36	Addressing. This is being investigated by the NEA and hopefully resolved for the next submission.	

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 the input data split from importers and end-users of refrigerants and to keep improving the input data quality for the sector non-energy products from fuels and solvent use, including paraffin wax and candles.

Table 10.7 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 in the NIR
2.	The ERT recommends that Iceland 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)	FCCC/ARR/2019 /ISL /I.1	NK added for 2A3, 2B1, 2B3, 2B7, 2E, 2F2, 2F3, 2F5 and 2F6. / Done as far as CRF Reporter allows (CRF Reporter won't allow notation keys to be uploaded for some of the F gases).	IPPU Chapter
2	The ERT recommends that Iceland determine whether there are other uses of carbonates in the country that might not be reflected in the current official records, including the use of carbonates in, for example, the construction industry, ceramics, agriculture and environmental pollution control, and estimate the corresponding emissions if they occur.	FCCC/ARR/2019 /ISL /I.2	All imported goods are registered by the Directorate of Customs and subsequently by Statistics Iceland. Therefore, no industrial use of carbonates are reported. If carbonates are imported, e.g. for manufacturing artistic ceramics, the quantity is very small and negligible. Added to the NIR, section 4.2.4.4/Done	IPPU Chapter
2.F	The ERT recommends that Iceland 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).	FCCC/ARR/2019 /ISL /I.3	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.	IPPU Chapter
2.F.1	The ERT recommends that Iceland revise its estimates of HFC-23 emissions from manufacturing of commercial refrigeration.	FCCC/ARR/2019 /ISL /I.4	Calculations for 2F1 have been revisited and new estimation files created. /Done	IPPU Chapter

CRF category / issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section in the NIR
2.G.1	The ERT recommends that Iceland obtain clear information about the recovery of SF_6 emissions from electrical equipment and revise its emission estimates as necessary	FCCC/ARR/2019 /ISL /I.5	Iceland got its first SF_6 equipment (220 V) in 1981 for one power station. At the same time some 66 kV equipment was imported. These installations are still in use and have not been taken down yet which explains why there are no disposal emissions nor information on recovery. This information was added in section 4.8.1.2. / done.	IPPU Chapter
2	The ERT recommends that Iceland include in the NIR an explanation, based on the information provided during the review, for the non-occurrence of NF_3 emissions in the country.	FCCC/ARR/2019 /ISL /I.7	Information has been added in section 4.1.1.	IPPU Chapter
2.C.3	The ERT encourages Iceland to include in the NIR the information that there are two aluminium producers in the country, but they do not use F-gases because one uses a salt-flux process to avoid oxidation and the other uses slag as a cover for oxidation when the raw material melts.	FCCC/ARR/2019 /ISL /I.8	Information has been added in section 4.4.4.	IPPU Chapter
2.D.2	The ERT recommends that the Party carry out the planned improvement and revise the AD, if appropriate, and to report on any improvements in the quality of the data on paraffin wax use in the NIR.	FCCC/ARR/2019 /ISL /I.9	The AD of paraffin wax use has been updated.	IPPU Chapter
2.D.2	The ERT recommends that the Party carry out the planned improvement and include the production of candles to improve completeness of the estimates of the category.	FCCC/ARR/2019 /ISL /I.10	The vast majority of the candles used in Iceland are imported (and are therefore accounted for), and only candles produced by very small local crafts workshops might be missing from the estimates. The emissions will most certainly be below the threshold of significance, however, this will be considered for future submissions.	IPPU Chapter
2.F.1	The ERT recommends that Iceland 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.	FCCC/ARR/2019 /ISL /I.11	The calculations of the 2F sector have been completely updated and revised for the current submission. 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	IPPU Chapter

CRF category / issue	Review recommendation	Review report/ paragraph	MS response / status of implementation	Chapter/ section in the NIR
			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). Explanations on how emissions of F-gases are calculated can be found in chapter 4.7.	
2.G.3	The ERT recommends that the Party include estimates for N_2O emissions from whipped cream containers.	FCCC/ARR/2019 /ISL /I.12	This information has been added in chapter 4.8.2	IPPU Chapter

10.5.3 Agriculture (CRF Sector 3)

Iceland is collaborating with the Icelandic Agricultural Advisory Centre (RML) to update livestock productivity data, such as the digestible energy content of feed, gross energy intake and deriving parameters, on a regular basis.

Comments and suggestions received during the 2019 reviews which could not be addressed during the current submission will be tackled in future submissions.

Table 10.8 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 in the NIR
3.	The ERT recommends that Iceland include detailed explanations of the AD, EFs and emission trends for all categories, including for young cattle population and for N_2O emissions from synthetic N fertilizer applied to agricultural soils	FCCC/ARR/2019/ ISL / A.1	This has been added in the current NIR, see section 5.2.1, tables 5.6, 5.17 and section 5.7.2.1, table 5.31.	Agriculture Chapter
3.	The ERT recommends that Iceland 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 cases where the 2006 IPCC Guidelines prescribe the use of average animal populations, include additional information on how it has converted the animal numbers from Statistics Iceland to average animal populations.	FCCC/ARR/2019/ ISL / A.2	This has been added in the current NIR: Comparison with animal numbers from Statistics Iceland Table 5.6; estimation methodology for AAP in section 5.2.1.	Agriculture Chapter

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
3.	The ERT recommends that Iceland update its 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 its improvement plan to update the productivity data at regular intervals.	FCCC/ARR/2019/ ISL / A.3	Animal characterization data have been updated for mature dairy cattle for the year 2018 and for lambs 2003-2018, mature ewes 2018. Work is underway to improve and validate all livestock characterization data used in the inventory. Further information can be found in 5.2, 5.2.4.	Agriculture Chapter
3.	The ERT recommends that Iceland report weighted average AD for feed intake, typical animal mass, VS excretion rates and Nex rates in the CRF tables and in the NIR, as used in the calculations.	FCCC/ARR/2019/ ISL / A.4	Feed characteristics are found in Annex 7. Tables 5.9 and 5.10, 5.11, 5.27 report the rest of the requested information in the current NIR.	Agriculture Chapter
3.A.4	The ERT recommends that Iceland correct the CH_4 and N_2O emission estimates from other livestock based on the correct number of horses for the years 2013–2015 and avoid any underestimation of emissions for this subcategory.	FCCC/ARR/2019/ ISL / A.5	This has been resolved. Find further information in chapter 5.2.1, Horses and table 5.7 in the current NIR.	Agriculture Chapter
3.A.1	The ERT recommends that Iceland update the CH_4 EF reported in the NIR to the CH_4 EF used to estimate CH_4 emissions from enteric fermentation from cattle.	FCCC/ARR/2019/ ISL / A.6	This has been updated. / Done	Agriculture Chapter
3.A.1	The ERT recommends that Iceland report information on and emissions from growing cattle under the subcategory growing cattle instead of the subcategory other mature cattle.	FCCC/ARR/2019/ ISL / A.7	Information on emissions from growing cattle has been moved to the subcategory growing cattle / Done	Agriculture Chapter
3.A.2	The ERT recommends that Iceland update the CH_4 EF reported in the NIR to the CH_4 EF used to estimate CH_4 emissions from enteric fermentation from sheep.	FCCC/ARR/2019/ ISL / A.8	This has been updated. / Done	Agriculture Chapter
3.A.3	The ERT recommends that Iceland include in the NIR information to support the use of an MCF based on the Revised 1996 IPCC Guidelines or apply the default factor from the 2006 IPCC Guidelines for estimating CH_4 emissions from enteric fermentation from swine.	FCCC/ARR/2019/ ISL / A.9	This has been updated. / Done	Agriculture Chapter
3.A.4	The ERT recommends that Iceland include in the NIR information to support the use of an MCF based on the Revised 1996 IPCC Guidelines or apply the default factors from the 2006 IPCC Guidelines for estimating CH_4 emissions from enteric	FCCC/ARR/2019/ ISL / A.10	This has been updated. / Done	Agriculture Chapter

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	fermentation from horses and poultry.			
3.B	The ERT recommends that Iceland include in the NIR information on the circumstances under which the country-specific N excretion data have been estimated	FCCC/ARR/2019/ ISL / A.11	The calculations for the Nex rate were changed and detailed explanations are given in section 5.5.2.	Agriculture Chapter
3.B	The ERT recommends that Iceland 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 UNECE and under the Convention.	FCCC/ARR/2019/ ISL / A.12	The text has been updated in the current NIR, see chapter 5.5. A diagram (Figure 5.3) was added to improve the understanding of the N-flow.	Agriculture Chapter
3.B	The ERT recommends that Iceland correct its N_2O emission estimates by using the total amount of N excreted in the different manure management systems.	FCCC/ARR/2019/ ISL / A.13	We apply the EMEP/EEA methodology for the N_2O estimation from 3 B Manure Management, so no correction is required.	Agriculture Chapter
3.B	The ERT recommends that Iceland correct its N_2O emission estimates from manure management systems by using the default N_2O EFs from the 2006 IPCC Guidelines or provide additional information that supports the use of other N_2O EFs that may be more representative of manure management systems in Iceland.	FCCC/ARR/2019/ ISL / A.14	The N-flow methodology from the EMEP EEA air pollutant inventory guidebook is fully consistent with the Emission Factors from the 2006 IPCC Guidelines. Please find further explanations in the agriculture chapter.	Agriculture Chapter
3.B.1	The ERT recommends that Iceland update the Nex rate for mature dairy cattle, in particular for 2000 onwards, in accordance with the best available knowledge and current production rates.	FCCC/ARR/2019/ ISL / A.15	This has been updated by changing calculations.	Agriculture Chapter
3.B	The ERT recommends that Iceland correct the average Nex rates reported in CRF table 3.B(b) so that they reflect the actual Nex rates used for estimating N_2O emissions from manure management.	FCCC/ARR/2017/ ISL / A.16	Resolved /Done	Agriculture Chapter
3.B.5	The ERT recommends that Iceland estimate indirect N_2O emissions from manure management (3.B.5), including N_2O emissions from nitrogen volatilized as ammonia and NO_X and from nitrogen lost through leaching and run-off, and report the relevant background data in the next GHG inventory submission, 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	FCCC/ARR/2019/ ISL / A.17	Resolved	Agriculture Chapter

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	UNFCCC Annex I inventory reporting guidelines			
3.D.a.2	The ERT recommends that Iceland improve the completeness of its inventory by collecting information on sewage sludge and other organic fertilizers applied to soils and estimating 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	FCCC/ARR/2019/ ISL / A.18	This has been added to the NIR, see chapter 5.7.2.2	Agriculture Chapter
3.D.a.2.a	The ERT recommends that Iceland correct the estimates of animal manure applied to soils and the corresponding emissions for the subcategory 3.D.a.2.a reported in CRF table 3.D, taking into account any updates to the population of horses and the Nex rates for mature dairy cattle, as well as updates to the total amount of N excreted in different manure management systems.	FCCC/ARR/2019/ ISL / A.19	Resolved	Agriculture Chapter
3.D.a.5	The ERT recommends that Iceland improve the completeness of its inventory by estimating N_2O 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	FCCC/ARR/2019/ ISL / A.20	This has been partially addressed by adding the chapter 5.7.2.5 -in progress.	Agriculture Chapter
3.D.a.6	The ERT recommends that Iceland include in the NIR a comparison of the country-specific N_2O EF for the cultivation of histosols with peer-reviewed studies	FCCC/ARR/2019/ ISL / A.21	This has been now added in Annex 8 and in section 5.7.2.6	Agriculture Chapter
3.D.a.6	The ERT recommends that Iceland correct the misallocation of N_2O emissions by moving the N_2O 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/2019/ ISL / A.22	This has been now added in section 5.7.2.6	Agriculture Chapter
3.D.b.1	The ERT recommends that Iceland make a thorough examination of its N flow to estimate emissions from N volatilized from atmospheric deposition reported in CRF table 3.D and consider including in the NIR a	FCCC/ARR/2019/ ISL / A.23	A figure has been added to explain better the relations of the N-flow between chapters 3B and 3D and the different N-compounds (Figure 5.3)	Agriculture Chapter

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	table with the overall mass balance of N, including information on N volatilized as NO_X, nitric oxide and N_2O.			
3.F	The ERT recommends that Iceland include in the NIR additional information on the non-occurrence of field burning of agricultural crop residues activity	FCCC/ARR/2019/ ISL / A.24	Information about the occurrence of field burning practices have been added in chapter 5.10. However, the collected data does not allow at the moment an estimation of the emissions. Work in progress.	Agriculture Chapter
3	The ERT recommends that the Party clearly 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), while ensuring consistent reporting on recalculations between CRF tables and NIR.	FCCC/ARR/2019/ ISL / A.25	Detailed explanations for recalculations performed for the current submission are to be found in the NIR.	Agriculture Chapter
3.A.1 Cattle - CH_4	The ERT encourages the Party to include detailed and transparent information in the NIR on all factors affecting the recalculations of respective emissions from a given category (see also ID# A.25 above).	FCCC/ARR/2019/ ISL / A.26	Detailed explanations for recalculations performed for the current submission are to be found in the NIR.	Agriculture Chapter
3.B - N_2O	The ERT encourages the Party to include a discussion on the impact of the recalculations on the emission trend at the category, sectoral and national total level, as appropriate, in line with paragraph 43 of the UNFCCC Annex I inventory reporting guidelines.	FCCC/ARR/2019/ ISL / A.27	Detailed explanations for recalculations performed for the current submission are to be found in the NIR.	Agriculture Chapter
3.B.1 Cattle - N_2O	The ERT recommends that the Party correct the reporting of the AD for growing cattle across the time series (see also ID# G.12).	FCCC/ARR/2019/ ISL / A.28	Detailed explanations for recalculations performed for the current submission are to be found in the NIR.	Agriculture Chapter
3.A - CH_4 - CH_4	The ERT encourages the Party to try to obtain parameters from peer-reviewed studies and/or include in the NIR information showing the verification of the data used for the estimates (e.g. by comparing the parameters with those used by Parties with similar conditions).	FCCC/ARR/2019/ ISL / A.29	This will be considered for future submissions	
3.A.1 Cattle - CH_4	The ERT recommends that Iceland justify the appropriateness of the current parameters and/or update the input parameters and	FCCC/ARR/2019/ ISL / A.30	No livestock parameters for "Other mature cattle" were updated for the 2020 submission, work is nevertheless underway to	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	consequently the CH_4 EF for future submissions, as planned.		update these parameters for future submissions.	
3.A.1 Cattle - CH_4	The ERT recommends that Iceland 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. The ERT also recommends that the Party include a section in the NIR that explains how the Party has ensured time-series consistency for the estimates in the category.	FCCC/ARR/2019/ ISL / A.31	This issue has been addressed and numbers for Other Mature cattle extrapolated from Mature Dairy cattle, see paragraphs 5.2.1 and 5.2.4 in the current NIR.	Chapter 5.2
3.A.1 Cattle - CH_4	The ERT recommends that the Party justify the low CH_4 IEF reported for growing cattle and explain any significant changes in the animals covered by this subcategory that would affect the CH_4 IEF trend.	FCCC/ARR/2019/ ISL / A.32	A table showing the population composition for growing cattle and the relative emissions, with the IEF, is added in NIR, table 5.17 under Chapter 5.3.2. In the years calves populations are big, the IEF is accordingly lower and lower than the IPCC default range.	Chapter 5.3
3.A.1 Cattle - CH_4	The ERT recommends that the Party revise the explanation of CH_4 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.	FCCC/ARR/2019/ ISL / A.33	This has been resolved, equations for all net energy requirements are now referenced to the IPCC 2006 guidelines. Information about the performed recalculations can be found in the NIR, chapter 5.2.4.	Chapter 5.2
3.B.1 Cattle - N_2O	The ERT recommends that Iceland update the NIR with the revised information on the estimation method and the input parameters used in the N_2O estimates for mature dairy cattle across the time series.	FCCC/ARR/2019/ ISL / A.34	This issue has been resolved and detailed explanations can be found in section 5.5.6 of the NIR.	Chapter 5.5.6
3.B.2 Sheep - CH_4	The ERT recommends that the Party correct the volatile solids values and recalculate emissions from sheep for the entire times series, transparently documenting the change in the NIR. The ERT believes that future ERTs should consider this issue further to ensure that there is no underestimation of emissions. Further, the ERT encourages the Party to verify the updated EFs against the IPCC default values and the IEFs reported by other Parties, including information on the results of the check under the QA/QC and verification section for the category.	FCCC/ARR/2019/ ISL / A.35	The reason for the high EF is that around 19% of manure from adult sheep is assumed to be kept as slurry, which has a much higher MCF (0.17) than PRP (0.01) or solid storage (0.02). The Tier 1 EF of 0.19 kg CH_4/head/year assumes that all manure is managed in solid systems. This information has been added in the NIR, section 5.4.2.	Chapter 5.4

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
3.B.5 indirect N_2O	The ERT encourages Iceland to take steps to define an appropriate FracleachMS value 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.	FCCC/ARR/2019/ ISL / A.36	We will consider this for future submissions.	
3.D.a.1 - N_2O	The ERT recommends that Iceland 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.	FCCC/ARR/2019/ ISL / A.37	This information has been added to the NIR, chapter 5.7.2.1.	Chapter 5.7
3.D.a.6 - N_2O	The ERT recommends that the Party include in the NIR the explanation for the low country-specific N_2O EF for cultivated organic soils provided during the review.	FCCC/ARR/2019/ ISL / A.38	This information has been added in the NIR, section 5.7.3 and in the Annex 9.	Chapter 5.7
3.G - CO_2	The ERT recommends that the Party 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, the ERT recommends that Iceland justify this in the NIR and include explanations of the allocation in CRF table 9.	FCCC/ARR/2019/ ISL / A.39	This information and emission estimates have been added to the NIR chapter 5.11.	Chapter 5.11
3.I - CO_2	The ERT recommends that the Party report CO_2 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, the ERT recommends that Iceland justify this in the NIR and include explanations of the allocation in CRF table 9.	FCCC/ARR/2019/ ISL / A.40	This information and emission estimates have been added to the NIR chapter 5.11.	Chapter 5.11

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 11th 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 Register 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 6,679 kt CO_2e making that component the far largest identified anthropogenic source of GHG in Iceland. For the year 2016 the emission reported in this submission is 6,655 kt CO_2e compared to 8,489 kt CO_2e in last year’s submission showing the effects of this submission’s implemented improvements. 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 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.

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 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 still reported as one unit. 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 2019 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 2020 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 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 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.

Table 10.9 Status of implementation in the LULUCF sector in response to UNFCCC´s review process.

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
4	The ERT recommends that Iceland enhance the transparency of the information in the NIR on the uncertainty analysis	FCCC/ARR/2019 /ISL/L.1	The Party welcomes the recommendation which will be taken into consideration in future submissions	LULUCF Chapter
4.	The ERT recommends that Iceland 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.	FCCC/ARR/2019 /ISL/L.2	No improvement has been made regarding this issue for 2021 submission. The solution of this issue remains in progress. However, Iceland estimates	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
			that at the least part of this issue will be resolved for the 2022 submission.	
4.	The ERT recommends that Iceland 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.	FCCC/ARR/2019 /ISL/L.3	Resolved	
4 Land represent ation	The ERT recommends that Iceland, rather than increasing the quantity of information provided, 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	FCCC/ARR/2019 /ISL/L.4	The Party welcomes the recommendation which will be taken into consideration in future submissions	LULUCF Chapter
4 Land represent ation	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.	FCCC/ARR/2019 /ISL/L.5	No improvements have been made for 2021 submission. Efforts will be made to improve this issue in future submissions.	
4 Land represent ation	Continue to update land use cover maps and revise the land representation time series and, if appropriate, create land-use subcategories that could better reflect the actual land cover and use to ensure adequate and consistent data over time, including specifying which IPCC approach is used for land representation by providing explanations in the NIR.	FCCC/ARR/2019 /ISL/L6	Land use cover maps have been updated for the 2021 submission. Two new subcategories in "Cropland remaining Cropland" and three in "Grassland remaining Grassland" have been created for 2021 submission. Iceland will further improve this issue in future submissions.	
4.	Provide an additional description of the processes by which the CSCs and associated emissions and removals are estimated, including tables with raw data and intermediate outputs stratified by year and forest type	FCCC/ARR/2019 /ISL/L.7	No improvement has been made regarding this issue for the 2021 submission. Iceland will take this issue into consideration in future submissions.	LULUCF Chapter
4.A	The ERT recommends that Iceland 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	FCCC/ARR/2019 /ISL/L.8	No improvement has been made regarding this issue for the 2021 submission. Iceland will take this issue into consideration in future submissions.	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	9 of why these pools could not be estimated.			
4.A.1	The ERT recommends that Iceland estimate and report carbon-stock changes in mineral soils under forest land remaining forest land	FCCC/ARR/2019 /ISL/L.9	Resolved. A Tier 1 approach is used for the pool and it is assumed to be zero, as explained also in the NIR.	LULUCF Chapter
4.A:2	Include transparent information in the NIR on the carbon stock in the land-use categories used in Iceland.	FCCC/ARR/2019 /ISL/L.10	Regarding the issue of the value 12.7 t C/ha used for land-use conversion to cropland, please consult information added in in NIR 2020 under the Annex 8: Justification of use of country-specific N_2O emission factor for cultivation of organic soils (histosols)	
4.A.2	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.	FCCC/ARR/2019 /ISL/L11	Regarding this issue Icelandic reesarch results do show loss of C in other biomass than trees with Afforestation in the conversion period of 50 years. See chapter 6.5.2.2 Methodology on page 1161 and reference: Sigurðsson, B., Magnússon, B., Elmarsdóttir, A., & Bjarnadóttir, B. (2005). Biomass and composition of understory vegetation and the forest floor carbon stock across Siberian larch and mountain birch chronosequences in Iceland. Annals of Forest Sciences, 62(8), 881-888.	
4.B.1	The ERT recommends that Iceland estimate and report carbon-stock changes in mineral soils under cropland remaining cropland	FCCC/ARR/2019 /ISL/L.12	Resolved	LULUCF Chapter
4.B.2	Estimate the area of forest land and other land that was converted to cropland before 1990 and report these values under the appropriate categories.	FCCC/ARR/2019 /ISL/L.13	No improvements have been made for 2021 submission. Efforts will be made to improve this issue in future submissions.	LULUCF Chapter

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
4.B.2	The ERT recommends that Iceland ensure the equivalence of climatic, historical and edaphic conditions when analyzing 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	FCCC/ARR/2019 /ISL/L.14	No improvement has been made regarding this issue for the 2021 submission. Iceland will take this issue into consideration in future submissions.	LULUCF Chapter
4.C	Prepare estimates for the emissions from degraded areas of grassland	FCCC/ARR/2019 /ISL/L.15	Improvements have been made to locate degraded areas of Grassland since 2020 submission. However, estimations of the emissions from these areas will be conducted in future submissions.	LULUCF Chapter
4.C.1	The ERT recommends that Iceland estimate and report carbon-stock changes in mineral soils under grassland remaining grassland for “Natural birch shrubland – old” and “Revegetated land older than 60 years”	FCCC/ARR/2019 /ISL/L.16	No improvements have been made regarding this issue for 2021 submission. Recommendation is noted and will be included under planned improvements for future submissions.	LULUCF Chapter
4.C.2	The ERT recommends that Iceland revise its CO_2 estimates form land converted to grassland using updated measured data on carbon sequestration in soils, especially for other land converted to grassland, and include in the NIR, in a 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.	FCCC/ARR/2019 /ISL/L.17	The Party is working to improve this issue.	
4.D.2	The ERT recommends that Iceland estimate and report carbon-stock changes in mineral soils under land converted to other wetlands	FCCC/ARR/2019 /ISL/L.18	No improvements have been made regarding this issue for 2021 submission. Recommendation is noted and will be included under planned improvements for future submissions.	LULUCF Chapter
4.D.2.3	The ERT recommends that Iceland 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 from 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	FCCC/ARR/2019 /ISL/L.19	Resolved	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	organic soils are reported separately in the CRF tables.			
4.E.2	The ERT recommends that Iceland estimate and report carbon-stock changes in mineral soils under land converted to settlements	FCCC/ARR/2019 /ISL/L.20	No improvements are made for 2021 submission. Recommendation is noted and will be included under planned improvements of the category.	LULUCF Chapter
4(II)	The ERT recommends that Iceland correct its N_2O emission estimates by using the default N_2O EFs from the Wetlands Supplement or provide additional information that supports the use of other N_2O EFs that may be more representative of its specific conditions. In addition, the ERT encourages the Party to use the Wetlands Supplement in preparing its annual inventories for future annual submissions.	FCCC/ARR/2019 /ISL/L.21	At the moment no progress has been made for this issue. However, in future Iceland will evaluate the two options for future submissions.	
4 (III)	The ERT recommends that Iceland estimate direct N_2O emissions from nitrogen mineralization associated with the loss of soil carbon resulting from lands converted to settlements for the entire time series of the GHG inventory 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	FCCC/ARR/2019 /ISL/L.22	No improvements have been made regarding estimation of direct N_2O emissions from nitrogen mineralization associated with the loss of soil carbon resulting from lands converted to settlements for the period prior to 2004. Emission are only reported for the period 2004 to 2019. Recommendation is noted and will be included under planned improvements for future submissions.	LULUCF Chapter
4(IV)	The ERT recommends that Iceland estimate and report indirect N_2O emissions from managed soils, excluding those from agricultural lands that are reported in CRF table 3.D, and, in those cases 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 in CRF table 9.	FCCC/ARR/2019 /ISL/L.23	Information regarded notation key "IE" is provided in the documentation box of the CRF table 4(IV), in CRF table 9, and in chapter 6.16 Indirect N_2O Emissions from Managed Soils (CRF(IV)) in NIR 2021. Regarding estimation of indirect N_2O emissions from other managed soils than those reported in CRF 3.D, the Party will take the ERT recommendation into consideration for future submissions.	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
4(V)	The ERT recommends that Iceland correct the use of notation keys to report on emissions from biomass burning in CRF table 4(V).	FCCC/ARR/2019 /ISL/L.24	Resolved	
4 Land representation	The ERT recommends that Iceland improve the transparency of AD reporting by providing information on the uncertainties related to habitat type classification, especially in relation to separating wetlands from grassland and other land.	FCCC/ARR/2019 /ISL/L.25	No improvements have been made for 2021 submission. The Party appreciates the recommendation and will take it into consideration for future submissions.	
4.C.1 - CO_2	The ERT recommends that Iceland 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.	FCCC/ARR/2019 /ISL/L.26	Resolved The EF reported for NBS in NIR 2020 section 6.7.1.2 was corrected from 5.7 t C/ha/year to 0.37 t C/ha/year	
4.D - CO_2 and CH_4	The ERT encourages Iceland to transparently report the effect of recalculations related to the AD of wetlands and to the removals of emissions, as it did in NIR section 6.8.2.5, but also to include information on the effects of recalculations on emissions and removals, for example, in a tabular format, and on the trend at category and sectoral level.	FCCC/ARR/2019 /ISL/L.27	No additional information in tabular format has been added for 2021 submission. The Party will consider the ERT encouragement for future submissions.	
4(I)	The ERT recommends that Iceland check the EF used for inorganic fertilizers, revise it, if appropriate and report any recalculations made for N_2O emissions from inorganic fertilizers on forest land.	FCCC/ARR/2019 /ISL/L.28	Resolved. These errors have been corrected in last year's submission (2020)	
4(II) - CO_2, CH_4 and N_2O	The ERT recommends that Iceland check and revise, if appropriate, the EFs for CO_2 and CH_4 on 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).	FCCC/ARR/2019 /ISL/L.29	Resolved. These errors have been corrected in last year's submission (2020)	
4. General	The ERT recommends that Iceland improve its QA/QC plan to avoid discrepancies in cross references between NIR sections and to ensure that section numbering is correct.	FCCC/ARR/2019 /ISL/L.30	Resolved. Link in section "6.6.2.1 Category description" regarded to "area estimates by Icelandic Forest Research" has been uppdated in NIR 2020	
4. General	The ERT recommends that Iceland provide transparent information in the NIR section discussing the land transition matrix on the use of the	FCCC/ARR/2019 /ISL/L.31	No additional discussions are added in NIR 2021. Information regarded the use of nk "IE" is available in	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	notation key “IE” where areas have been accounted for elsewhere.		CRF table 4.1 documentation box.	
4. Land representation – CO_2, CH_4 and N_2O	The ERT recommends that Iceland 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 and may lead to recalculations of areas.	FCCC/ARR/2019 /ISL/L.32	No improvements have been made since 2020 submission. The Party will consider the ERT recommendation for future submissions.	
4.A – CO_2	The ERT recommends that Iceland provide transparent information in CRF table 9 for the notation key “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# L.8 and KL.17 below). The ERT further encourages the Party to include the explanatory information also in the documentation box to CRF table 4.A.	FCCC/ARR/2019 /ISL/L.33	Resolved. The Party has changed "NE" notation to "NA" notation for litter in FrF.	
4.B.1 – CO_2	The ERT recommends that Iceland provide information to justify the high EF for mineral soils in the next annual submission.	FCCC/ARR/2019 /ISL/L.34	"Andosol is the main soil type in Iceland which has high carbon store capacity. If the land prior to cultivation did not have carbon saturated to cultivation potential, in those cases the carbon content could raise significantly which also explains high EF (CS) for mineral soils. Changes in SOC of organic soils are calculated according to Tier 1 applying equation 2.3 in the 2013 Wetlands supplement" (See section 6.6.1.2 Methodology in NIR 2021).	
4.B.2 – CO_2	The ERT recommends that to improve the transparency of the reporting, the Party provide an explanation of notation key “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.	FCCC/ARR/2019 /ISL/L.35	Resolved	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
4.C – CO_2	The ERT recommends that Iceland explain the use of notation key “IE” for each subcategory and pool in CRF table 9 in the reporting of grassland CSCs in DOM and soil and consider adding explanatory information to the documentation box to CRF table 4.C.	FCCC/ARR/2019 /ISL/L.36	Resolved	
4.C.1 – CO_2	The ERT recommends that Iceland improve 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 of why estimates could not be produced for this pool for 1990–2015 and by reporting “NA” for the instances where CSCs are assumed to be in equilibrium (i.e. zero).	FCCC/ARR/2019 /ISL/L.37	The Party uppdated notation key in Grassland mineral soils for "Revegetation older than 60 years" for CSC in mineral soils i.e., from NE to NA for the period 1990-2015 in 2020 submission. Additional explanations regarding this issue are also provided in "Revegetation older than 60 years" Node comment" in 2021 inventory.	
4.D.1 – CO_2	The ERT recommends that Iceland develop for managed wetlands a country-specific methodology that would allow it to use the tier 2 approach for key categories in line with the 2006 IPCC Guidelines.	FCCC/ARR/2019 /ISL/L.38	No improvements have been made regarding this issue for this year submission (2021). The Party welcomes the recommendation which will be taken into consideration in future submissions.	
4.D.2.2 – CO_2 and CH_4	The ERT commends Iceland on its transparent reporting of the EFs and AD under land converted to wetlands for reservoirs. The ERT encourages Iceland to complete the information on the area of flooded land and to compile information on the ice-free period for individual reservoirs or regions to be applied with corresponding EFs.	FCCC/ARR/2019 /ISL/L.39	The Party welcomes the encouragement. However, no improvements have been made regarding this issue for this year submission (2021). As the Party already has indicated during previous reviews, there are major difficulties in gathering data related to this issue. This is not a priority issue. Nevertheless, Iceland will try to improve this issue for future submissions.	
4(III)– N_2O	The ERT recommends that Iceland transparently report the reasons for carbon accumulation on cropland soils, especially on mineral soils converted to cropland (see ID#s L.34 and A.20).	FCCC/ARR/2019 /ISL/L.40	"Andosol is the main soil type in Iceland which has high carbon store capacity. If the land prior to cultivation did not have carbon saturated to cultivation potential, in those cases the carbon content could raise significantly which also explains high EF (CS) for	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
			mineral soils. Changes in SOC of organic soils are calculated according to Tier 1 applying equation 2.3 in the 2013 Wetlands supplement" (See section 6.6.1.2 Methodology in NIR 2021).	
4(V) – CO_2, CH_4 and N_2O	The ERT recommends that Iceland include estimates for the emissions from biomass burning on cropland and grassland over the entire time series and if not implemented, include information on the use of notation key “NE” used (both in the NIR and CRF tables) as to why these pools could not be estimated (see ID# L.24 on correcting the use of notation keys).	FCCC/ARR/2019 /ISL/L.41	For this year´s submission, the Party has changed in CRF tables NK for the emissions from biomass burning on cropland and grassland from NE to NA over the entire time series except for years where wildfire episodes occurred.	
4(KP)	The ERT recommends that Iceland improve the transparency of its reporting by providing information on how harvesting or forest disturbance that is followed by the re-establishment of a forest is distinguished from deforestation	FCCC/ARR/2019 /ISL/KL.1	Resolved This information has been included.	KP-LULUCF Chapter
4(KP)	The ERT recommends that Iceland include in the NIR country-specific information on the associated forest management and afforestation and reforestation and background levels of emissions associated with annual disturbances, and information on margin and how to avoid the expectation of net credits or net debits during the commitment period, including through the use of a margin.	FCCC/ARR/2019 /ISL/KL.2	No improvement has been made regarding this issue for the 2021 submission. Iceland will take this issue into consideration in future submissions.	KP-LULUCF Chapter
4(KP)	The ERT, acknowledging the information provided by the Party during the review, recommends that Iceland report information clearly demonstrating that emissions by sources and removals by sinks resulting from forest management 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	FCCC/ARR/2019 /ISL/KL.3	No improvement has been made regarding this issue for the 2021 submission. Iceland will take this issue into consideration in future submissions.	KP-LULUCF Chapter
4(KP).A.1	Provide an additional description of the process by which the CSCs and associated emissions and removals are estimated, including tables with raw data and intermediate outputs stratified by year and forest type	FCCC/ARR/2019 /ISL/KL.6	No improvement has been made regarding this issue for the 2021 submission. Iceland will take this issue into consideration in future submissions.	KP-LULUCF Chapter

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
4(KP).A.2	Recalculate the CSCs 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)	FCCC/ARR/2019 /ISL/KL.8	No improvement has been made regarding this issue for the 2021 submission. Iceland will take this issue into consideration in future submissions.	KP-LULUCF Chapter
4(KP).B.1	The ERT recommends that Iceland provide the technical correction to the FMRL in the next GHG inventory submission	FCCC/ARR/2019 /ISL/KL.9	Resolved. Iceland provided a technical correction to the FMRL as reported it in the 2018 NIR. Information on this can be found in this NIR, section 11.5.3.	
4(KP)	The ERT recommends that Iceland 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.	FCCC/ARR/2019 /ISL/KL.4	No improvement has been made regarding this issue for the 2021 submission. Iceland will take this issue into consideration in future submissions.	
4(KP)	The ERT recommends that Iceland 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 ERT encourages Iceland to indicate in the NIR that technical corrections to the FMRL are expected to be carried out before the end of the second commitment period.	FCCC/ARR/2019 /ISL/KL.5	No improvement has been made regarding this issue for the 2021 submission. An updated FMRL will be submitted in next year submission.	
4(KP) Afforestat ion Reforestat ion	The ERT recommends that Iceland 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.	FCCC/ARR/2019 /ISL/KL.7	Resolved. NA has been changed to NO in the HWP pool under AR in CRF table 4(KP-I)C.	
4(KP) Forest managme nt	The ERT recommends that Iceland 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).	FCCC/ARR/2019 /ISL/KL.10	No improvement has been made regarding this issue for the 2021 submission. Iceland will take this issue into consideration in future submissions.	
4(KP) revegetati on	The ERT recommends that Iceland revise its estimates of carbon stock in living and dead biomass as well as carbon stock in soils in revegetated areas and revise its estimates of carbon sequestration in revegetated land for the whole time series.	FCCC/ARR/2019 /ISL/KL.11	No improvement has been made regarding this issue for the 2021 submission. However, survey strategy has currently been revised to address this issue.	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
4(KP) HWP	The ERT recommends that Iceland 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).	FCCC/ARR/2019 /ISL/KL.12	Resolved. In Chapter 11.6 it is described in detail how statistics for domestic HWP are reported and published in the Journal of the Icelandic Forest Association every year. These reports give the overview of the domestic production of sawnwood which is the only HWP produced from Icelandic timber. They are used in the calculation of the HWP pool originating from Icelandic timber and its removal/emission	
KP - FM - CO_2	The ERT recommends that Iceland report transparently in the NIRs any recalculations for FM (including changes in EFs for the pools, e.g. on mineral and organic soils).	FCCC/ARR/2019 /ISL/KL.13	Recommendation taken into consideration	
KP - FM - CO_2	The ERT recommends that Iceland provide information on any changes in data and methods from previous submissions, including those resulting from a detected error, in future annual submissions.	FCCC/ARR/2019 /ISL/KL.14	Recommendation taken into consideration	
KP - General (KP-LULUCF activities)	The ERT encourages the Party to include this information in the NIR on harvesting and clear-cut regulations, which are based on licences, to improve the transparency of the reporting.	FCCC/ARR/2019 /ISL/KL.15	Resolved. The Party included this information to NIR2020 as NIR2021. See Chapter 6.5.	
KP - AR – CO_2	The ERT recommends that Iceland 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).	FCCC/ARR/2019 /ISL/KL.16	Resolved. The reference was corrected in NIR 2020. Correction included in NIR 2021.	
KP - AR – CO_2	The ERT recommends that the Party improve the transparency of the reporting by indicating in the NIR that the average EF of data from two research projects for litter on AR includes both natural birch forests and cultivated forests.	FCCC/ARR/2019 /ISL/KL.17	The Party welcomes the recommendation which will be taken into consideration in future submissions	
KP - Deforestation – C and N_2O	The ERT recommends that the Party report the AD, CSC and related N_2O emissions from the category to avoid underestimating the emissions. If this is not possible, the ERT recommends that the Party provide information that justifies the use of notation key “NE”	FCCC/ARR/2019 /ISL/KL.18	Resolved. The Party has estimated N_2O emission by Tier 1 EF in the 2021 submission	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/ section in the NIR
	for AD and CSC related to N_2O emissions from mineralization and immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils in lands subject to deforestation and in the NIR in the next annual submission and consider providing information in the documentation box to CRF table 4(KP-II)3.			
KP - FM – CO_2	The ERT recommends that Iceland report estimates for CSC in 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). If "NE" is reported, the ERT encourages the Party to include an accompanying explanation in the documentation box to CRF table 4(KP-I)B.1.	FCCC/ARR/2019 /ISL/KL.19	The Party welcomes the recommendation which will be taken into consideration in future submissions	
KP - FM – CO_2	The ERT recommends that Iceland 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.	FCCC/ARR/2019 /ISL/KL.20	The ERT recommendation have been taken into consideration	
KP - FM – CO_2	The ERT recommends that the Party provide the revised technical correction to the FMRL, as planned, before the end of the commitment period.	FCCC/ARR/2019 /ISL/KL.21	The Party has planned to provide revised technical correction in the 2022 submission.	
KP - FM – CO_2	The ERT recommends that, in accordance with paragraph 12 of decision 6/CMP.9, the Party report in the CRF accounting table the FM cap as established in the initial report.	FCCC/ARR/2019 /ISL/KL.22	Resolved. This was fixed in the 15. April 2020 submission as well in the 2021 submission.	
KP - HWP – CO_2	The ERT recommends that Iceland improve the comparability of its reporting by including harvest data (e.g. m3 or kt C) for FM in column D of CRF table 4(KP-I)C on CSC in the HWP pool and report the data consistently with NIR table 11.2.	FCCC/ARR/2019 /ISL/KL.23	Resolved. The party added harvest data to the 4(KP-I9 table in the 2020 submission as well as 2021 submission.	

10.5.5 Waste (CRF Sector 5)

Table 10.10 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 in the NIR
5.	The ERT recommends that Iceland use the notation key "NA" in the NIR when reporting information on the following GHGs and subcategories: N_2O emissions from managed waste disposal sites (5.A.1); N_2O emissions from unmanaged waste disposal sites (5.A.2); CO_2 emissions from biological treatment of solid waste (5.B); CO_2 emissions from domestic wastewater (5.D.1); and CO_2 emissions from industrial wastewater (5.D.2).	FCCC/ARR/ 2019/ISL/ W.1	Notation keys for the relevant categories have been changed; CO_2 emissions have been changed to "NO" in accordance with comment W.5 and N_2O emissions have been change to "NA". This can be seen in table 7.2. / Done	Waste chapter - 7.1.4 Completeness, table 7.2
5.A	Include information in the NIR on the amount of waste deposited in solid waste disposal sites, categorized by type of waste, for the entire time series	FCCC/ARR/ 2019/ISL/ W.2	Resolved. Information is presented in tables 7.3 and 7.4 in the NIR.	Waste Chapter - 7.2.2.3 Waste categories
5.A	The ERT recommends that Iceland ensure the transparency of its reporting by presenting in the NIR information on how the methane generation rate and half-life time for construction and demolition waste were chosen	FCCC/ARR/ 2019/ISL/ W.3	Resolved. The waste amounts for construction and demolition waste were moved to "industrial waste" in the IPCC FOD model, i.e. Using default IPCC values for industrial waste. Partly due to this issue, a new IPCC FOD model was constructed from scratch for the 2018 submission with significant recalculations and changes in data and parameters. These recalculations were explained in the 2018 submission and information has been updated in chapter 7.2 in the NIR.	Waste Chapter - 7.2 Solid Waste Disposal
5.A	The ERT recommends that Iceland report CO_2 emissions from the subcategories anaerobic managed waste disposal sites (5.A.1.a), unmanaged waste disposal sites (5.A.2) and uncategorized waste disposal sites (5.A.3) 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	FCCC/ARR/ 2019/ISL/ W.4	The activity of waste burning on landfill sites is non-occurring in Iceland as a means of waste management practice. Notation key has been changed to "NO" for 5.A.1. and 5.A.2, and explanations provided. / Done	Waste Chapter
5.B.1	Estimate N_2O emissions from composting using the default N_2O EF for composting given in the 9th	FCCC/ARR/ 2019/ISL/ W.5	Resolved. Explained in section 7.3.3. of the NIR.	Waste Chapter - Section 7.3.3

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	corrigenda for the 2006 IPCC Guidelines.			
5.D	The ERT recommends that Iceland 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	FCCC/ARR/ 2019/ISL/ W.6	Resolved. Explained in section 7.5.4.2 and information provided in table 7.15.	Waste Chapter - 7.5.4.2. Nitrous Oxide, table 7.15
5.D	The ERT recommends that Iceland investigate the issue of the protein intake further and report on any new results for N_2O emissions from human sewage based on the yearly per capita protein intake	FCCC/ARR/ 2019/ISL/ W.7	Resolved. Documentation provided during review and information provided in section 7.5.2.2. of the NIR.	Waste Chapter
5.D	The ERT recommends that Iceland improve the transparency of its reporting by providing in the NIR the information used to estimate emissions from wastewater treatment and discharge, that is, population of the country, protein consumption and total organic matter in the wastewater, for the entire time series, and by ensuring this information is consistent between the NIR and the CRF tables	FCCC/ARR/ 20179/ISL/ W.8	Resolved. Information updated in chapter 7.5 in the NIR.	Waste Chapter - 7.5.2 Activity data, table 7.12
5.D.2	The ERT recommends that Iceland correct the use of notation keys in the NIR to report CH_4 emissions from industrial wastewater and encourages Iceland to investigate the possibility to report CH_4 emissions from industrial wastewater and domestic wastewater separately	FCCC/ARR/ 2019/ISL/ W.9	Resolved. Notation keys are now consistent and supporting information is provided in section 7.5.2.1.	Waste Chapter - 7.5.2.1 Activity data
5.A.1 - CO_2, CH_4 and N_2O	The ERT recommends that the Party 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). The ERT also recommends that the Party improve its explanation for the allocation of emissions from landfill gas in the inventory (NIR, section 7.2.4.1).	FCCC/ARR/ 2019/ISL/ W.11	Resolved. CRF codes added in the figure title.	
5.A - CH_4	The ERT recommends that the Party document and provide in the NIR all the parameters used in the estimation of CH_4 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 waste model.	FCCC/ARR/ 2019/ISL/ W.12	Resolved. Activity data is included in an annex.	

CRF category/ issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
5.A - CH_4	The ERT recommends that the Party investigate the composition of both municipal solid waste and industrial waste and reconsider the separate estimation of emissions from industrial waste. The ERT also recommends that the Party report the 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.	FCCC/ARR/ 2019/ISL/ W.13	Partly resolved. An explanation of the current reporting is provided in the NIR, and AD is provided in tables 7.3 and 7.v. Iceland is currently unable to further separate the estimation of emissions from MSW and industrial waste. This may be revisited in the future	
5.A.1 - CH_4	The ERT recommends that the Party 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.	FCCC/ARR/ 2019/ISL/ W.14	Resolved. This has been updated in table 7.7. in the NIR.	Table 7.7
5.D - CH_4	The ERT recommends that the Party 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.	FCCC/ARR/ 2019/ISL/ W.15	Resolved. This has been updated and emissions from domestic and industrial wastewater are now calculated separately. Details on the updated methodology and recalculations can be found in chapter 7.5 in the NIR.	
5.D.1 - N_2O	The ERT encourages Iceland to continue to work on implementing country-specific surveys on protein consumption in Iceland and report on their results in the NIR.	FCCC/ARR/ 2019/ISL/ W.16	This will be included in the workflow for waste data collection.	

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 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.

Revegetation

Revegetation in KP is defined as conversion of other land to grassland, resulting from land reclamation activities that have occurred since 1990.

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 to 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 in 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 1990-2019. 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.

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 2021 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 of 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.

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; 2014; 2015; 2016; Gunnarsson & Brynleifsdóttir (2017; 2019) (Elefsen & Brynleifsdóttir, 2020) (Jóhannesdóttir Þ., 2020)) 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, 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 AFOLU (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 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.

11.3.1.2 ***Revegetation***

The SCSI maintains the National Inventory on Revegetation Areas database based on 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. 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. 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 is 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 fourth 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[21], the annual unofficial report of the Iceland Forest Association does contain data about sawnwood production (Gunnarsson E., 2010; 2011; 2012; 2013; 2014; 2015; 2016; Gunnarsson & Brynleifsdóttir (2017; 2019) (Elefsen & Brynleifsdóttir, 2020) (Jóhannesdóttir Þ., 2020)). 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 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 2017 and 2018 have also been slightly revised on basis of new annual NFI data from 2019 and 2020. See further explanations in Chapter 6.5. above.

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

11.3.2.5 *Uncertainty estimates*

An error estimate is available for the area of afforestation and FM of cultivated forest. Relative error of area of CF is ±4%. Area error for NBF is lower.

Uncertainty estimates for revegetation are available both for EF and area. Both are estimated with ±10% uncertainty.

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

No reportable natural disturbance has been detected in Afforestation since 1990. No historical data of natural disturbance events of forest under AR does exist so 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) is not possible or should be defined as 0 (zero) or 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.

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 the 2018 submission (Environment Agency of Iceland, 2018) and 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)

New approach to estimate the change in the carbon stock of natural birch forest was conducted soon after the reference level was accepted. The approach was two folded:

1. To use countrywide inventory of the natural birch woodland from 1987 with tree measurements sufficient to estimate biomass stock in trees and compare it to biomass estimates of a systematic plot sample inventory done in the period of 2005-2011. Differences in biomass stock between these two estimates would either lead to mean annual removal of Carbon or emission in this 20 years period. First results of this work were reported in the Icelandic NIR and CRF submitted in 2013. Net annual removal was estimated to 3.432 Gg (kt) C (12.582 Gg CO_2) both in year 2010 and 2011. Same figure for 2010 in the 2012 submission done with the previous method was much higher or 24.18 Gg C (88.66 Gg CO_2). **The figure 13.138 is used as a new annual estimate for Net Removal of CO_2 into C-stock of Natural Birch Forest.**

2. To remap natural birch woodland and make an estimate of the area changes over 20 years period. The remapping took place in 2010-2014.

No other emissions or removal than from change in tree biomass stock from the NBF was estimated in the FMRL. Emission from drained organic soils was estimated and reported in the 2018 submission both CO_2, N_2O and CH_4. Consequently, this emission was added to the Technical correction (TC) of the FMRL. All NBF older than 1990 are defined as Forest remaining forest. CS estimation of removal of CO_2 to litter and mineral soil in these forests has not been done so they were as in the CRF reported as NO.

The area and the age structure of cultivated forest (CF) has been updated, both on mineral and organic soil since the estimation of FMRL. The area of CF was estimated 5.772 kha in FMRL but is in the 2018 submission reported 5.869 kha so the changes are minimal (1.7%). Nevertheless, it had small effect on the removals/emission to/from soil and litter. Moreover, has new emission factors for drained organic soils effect on emission of CO_2 and N_2O. CH_4 emission from drained organic soil was not estimated in the FMRL but were estimated and added to the TC calculation as for the NBF. CS removals factors for litter and mineral soil were the same as used in FMRL but area changes in total and between afforestation categories together with small alteration in age classification did lead to considerable reduction in removal from soil (13.3% reduction for the period 2013-16) and litter (7.1% reduction for the period 2013-16). These reduction rates were used to estimate TC for these sinks.

Removals to biomass in cultivated forest did too change although the estimate methodology was unchanged. Cultivated forest did grow faster than projected in the FMRL (9.7% more removal than projected in the FMRL for the period 2013-16). The reason is unclear but one of the explanations was slightly decreased harvest rates from the level projected in the FMRL (7.0% decrease in harvest rate for the period 2011-16).

In the FMRL the harvest level of 2010 was set as BAU level and projected unchanged to 2020. Real harvest rate for the period 2011-2016 turned out to be slightly lower than projected in FMRL.

These two last factors are the factors of FM that are totally or partially affected by managerial decisions of stakeholder. Changes from the projection in the FMRL were therefore not added to the TC.

Effect of harvest wood products (HWP) was not estimated in the Icelandic FMRL and all wood removals were assumed to be instantly oxidised. Iceland did estimate C-stock changes in HWP for the first time in the 2017 submission. HWP C-stock change estimation was conducted for the predicted level of wood removal of the FMRL and added to the TC. Predicted volume input to the domestic sawnwood pool, which is the only HWP pool of domestic wood production in Iceland, was 49.6 m^3(the level of the year 2010), only 1.2% of the total wood removal in that year. The remaining harvested wood pool was assumed to be oxidised instantly.

Table 11.2 below gives an overview of categories of sources and sinks in FMRL and their technical correction.

Table 11.2 Sources and sinks in the FMRL and their technical correction (TC)

Sources and sinks in Gg CO_2 e	FMRL	New estimate	TC
Net removals from biomass stocks in Natural Birch Forest	-88.952	-13.138	75.814
CO_2 emissions from organic soils in Natural Birch Forest	NE	0.114	0.114
N_2O emissions from organic soils in Natural Birch Forest	NE	0.017	0.017
CH_4 emissions from organic soils in Natural Birch Forest	NE	0.015	0.015
CO_2 emissions from organic soils in Cultivated Forest	0.229	0.472	0.243
N_2O emissions from organic soils in Cultivated Forest	0.114	0.072	-0.043
CH_4 emissions from organic soils in Cultivated Forest	NE	0.064	0.064
Removals to litter in Cultivated Forest	-1.893	-1.759	0.134
Removals to mineral soil in Cultivated Forest	-4.865	-4.218	0.647
Removals to biomass in Cultivated Forest	-62.921	NA	NA
Emission from harvest of wood	3.935	NA	NA
Removals to Harvested Wood Products	NE	-0.059	-0.059
Sum	-154.352		76.948

The technical correction is not updated in this year's submission. Further technical correction will be done in the 2022 submission when stock changes in NBF between first (2005-2011) and second (2015-2020) SSPI has been estimated and published.

11.5.4 Information related to the natural disturbance provision under Article 3.4

No reportable natural disturbance events have been detected in forest under FM. No historical data of natural disturbance events of forest under FM does exist so 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) is not possible or should be defined 0 (zero) or not occurring (NO); the same applies to revegetation.

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.

11.6 Harvested Wood Products

Emissions/removals related to harvested wood products (HWP) are estimated for the fourth 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 1996 to 2016 (Table 11.3) (Gunnarsson E., 2010; 2011; 2012; 2013; 2014; 2015; 2016; Gunnarsson & Brynleifsdóttir (2017; 2019) (Elefsen & Brynleifsdóttir, 2020) (Jóhannesdóttir Þ., 2020)).

Table 11.3 Annual wood production (in m^3 on bark) and sawnwood production (in m^3) in 1996 to 2019).

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

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.

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 2020: 56 EU ETS accounts, thereof 9 Operator holding accounts, 35 Aircraft operator holding accounts, 10 Verifier accounts, 1 National holding account and 1 Party holding account. Iceland's AAUs were 0 tonnes of CO_2e, on December 31, 2020.

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 2020. Iceland´s Standard Electronic Format (SEF) reports for 2020, for the second commitment period, are reported with the CRF data and NIR, and will be made available at the UNFCCC website[22]. 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

[22] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10116.php

nature of the project and the emission savings resulting from it. Only projects using renewable energy were eligible, and only where this use of renewable energy resulted in a reduction in GHG emissions per unit of production. The use of best environmental practice (BEP) and best available technology (BAT) was also 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

		2008	2009	2010	2011	2012	CP1
Total RMUs from KP-LULUCF	RMUs	255,721	275,233	307,305	337,879	366,624	1,542,761
Available assigned amount	AAUs	3,960,490	3,980,002	4,012,074	4,042,648	4,103,716	20,098,931
Emissions from Annex A sources	t CO_2e	5,021,786	4,779,267	4,646,161	4,441,127	4,467,730	23,356,071
Difference AAU - Annex A emissions	t CO_2e	1,061,296	799,265	634,087	398,479	364,014	3,257,140
Emissions falling under Decision 14/CP.7	t CO_2e	1,134,704	1,178,389	1,197,398	1,184,753	1,217,720	5,912,964
Emissions falling under Decision 14/CP.7 reported under national totals	t CO_2e	73,408	379,124	563,311	786,274	853,706	2,655,824
Emissions falling under Decision 14/CP.7 not reported under national totals	t CO_2e	1,061,296	799,265	634,087	398,479	364,014	3,257,140

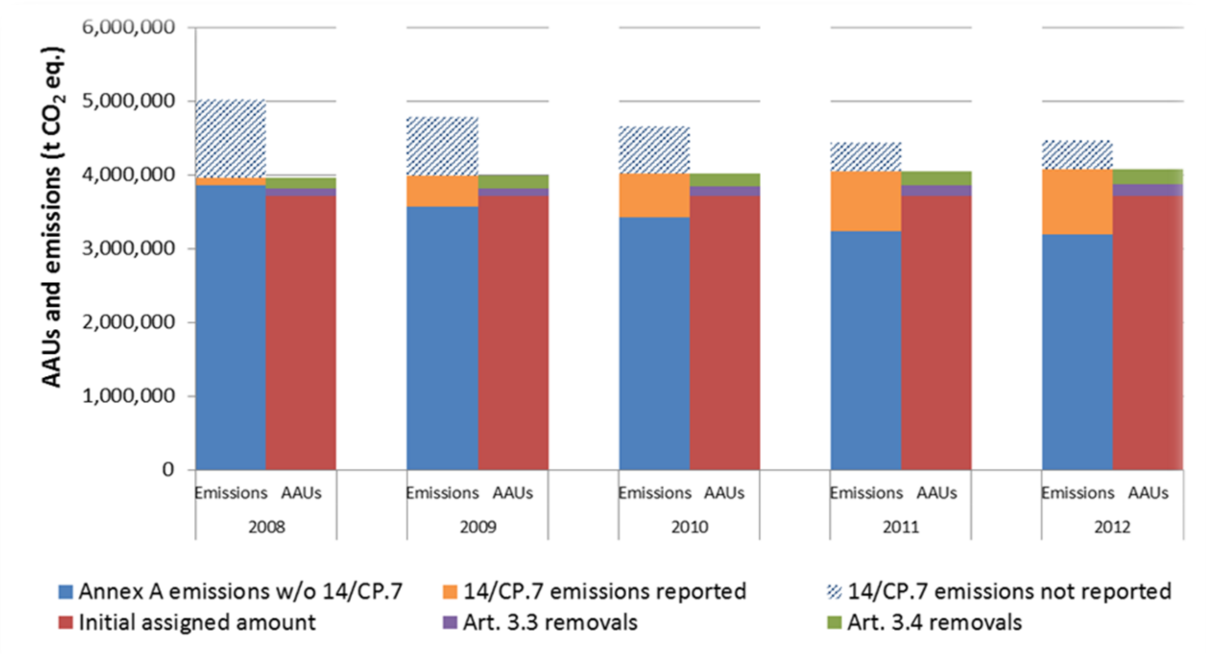


Figure 12.1 Summary of Kyoto accounting for CP1

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[23]). 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

[23] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015D1339&from=EN

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.

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 2020, 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 2020, 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

The following account types in the registry did not contain any units:

- Party holding account
- Voluntary cancellation account CP1

Iceland submitted the SEF tables for the first time in April 2014 for the issued Kyoto Protocol units in 2013 and the 2020 SEF tables for second commitment period were submitted in March 2021. The Kyoto Protocol party holding account did not hold any units relevant for the second commitment period at the end of reported year 2020.

12.3 Discrepancies and Notifications

No discrepancies or notifications have occurred in relation to Iceland's accounting of Kyoto units in 2020.

Table 12.2 Discrepancies and notifications in 2020.

Annual Submission Item	Reporting Information
15/CMP.1 Annex 1.E paragraph 12: List of discrepant transactions	No discrepant transaction occurred in 2020
15/CMP.1 Annex 1.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2020
15/CMP.1 Annex 1.E paragraph 15: List of non-replacements	No non-replacements occurred in 2020
15/CMP.1 Annex 1.E paragraph 16: List of invalid units	No invalid units exist as of 31 December 2020
15/CMP.1 Annex 1.E paragraph 17: Actions and changes to address discrepancies	No discrepant transactions occurred in 2020

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/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/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:

$$\begin{aligned}&\text{90\% of Iceland's assigned amount}\\&= 0.9 \times 15{,}327{,}217 \text{ tonnes } CO_2 \text{ equivalent}\\&= 13{,}794{,}495 \text{ tonnes } CO_2 \text{ equivalent.}\end{aligned}$$

or,

$$\begin{aligned}&\text{100\% of } 8 \times \text{(the national total in the most recently reviewed inventory)}\\&= 8 \times 4{,}765{,}830 \text{ tonnes } CO_2 \text{ equivalent}\\&= 38{,}126{,}638 \text{ tonnes } CO_2 \text{ equivalent}\end{aligned}$$

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 2020.

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 76,950 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 first seven years of the second commitment period.

Table 12.4 Calculated RMUs (in t CO_2e) from Art. 3.3 and Art. 3.4 activities for the first seven years of CP2.

	2013	2014	2015	2016	2017	2018	2019
Article 3.3							
A.1 Afforestation/ Reforestation	-184,007	-204,409	-224,860	-244,456	-281,298	-309,735	-356,099
A.2 Deforestation	155	111	647	248	467	462	462
Article 3.4							
B.1 Forest Management	-4,213	-7,533	-11,251	-14,971	-16,675	-16,976	-13,578
B.4 Revegetation	-221,837	-228,277	-235,607	-209,109	-211,879	-228,740	-216,365
Total RMUs	-409,902	-440,109	-471,071	-468,288	-509,386	-554,988	-585,580

13 Information on Changes in National System

No changes have been made in the National System since the 2020 submission. However, implementation and application of Regulation 520/2017 (see below) is still ongoing and several improvements are planned in this regard.

The Regulation on data collection and information from institutions related to Iceland´s inventory on greenhouse gas emissions and removal of carbon from the atmosphere No 520/2017[24] was adopted in June 2017 and is based on the Climate Change Act No 70/2012. It implements EU Regulation No 525/2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level to climate change and delegated Acts.

Act No 70/2012 establishes the national system for the estimation of greenhouse gas emissions by sources and removals by sinks, a national registry, emission permits and establishes the legal basis for installations and aviation operators participating in the EU ETS. Article 6 of Act No 70/2012 addresses Iceland´s greenhouse gas inventory. It states that the Environment Agency (EA) compiles Iceland´s GHG inventory in accordance with Iceland´s international obligations. Act No 70/2012 defines the form of relations between the EA and other bodies concerning data handling.

Based on the Act the Regulation further elaborates the institutions obligations on the manner and deadlines for data submission necessary for Iceland´s GHG inventory. Table 13.1 contains a short summary of the Regulation, and

Table 13.2 shows a summary of the status of implementation of the various articles of the Regulation.

Table 13.1 Table with a summary of each article in the Icelandic Regulation No 520/2017.

Article nr.	Comments	Chapter
1	Scope of the regulation - Regulation on institutions data collection and information for Iceland‘s Inventory on greenhouse gas emissions and removals No 520/2017. – Implements MMR (Regulation (EU) No 525/2013 and delegated Acts).	Chapter 1 - General
2	Definitions – wording used in Regulation defined	
3	Guidelines- Everything should be according to the IPCC GL - EA shall provide information/guidance on where GL can be found.	
4	The EA´s role. The EA shall have overview/supervision and is responsible for the inventory. Even though each institution under chapter 3 of the Regulation (article 7-11) is responsible for the data provided/they submit. The EA collects the data in cooperation with other institutions in accordance to this regulation and produces the NIR in accordance to the UNFCCC requirements.	
5	Reporting and deadlines because of joint fulfilment. The EA shall report according to CP2 KP requirements as well as the EU Regulations (MMR)	

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

Article nr.	Comments	Chapter
6	Information from the NEA - The NEA shall collect the information that is needed for the Energy sector of the Inventory. Before 15th of May the NEA shall submit approximated data to the EA and final data before 30th of September. The data shall be on: a) Energy balance in accordance to the International Energy Agency's handbook. b) Energy Account with trend analysis c) Information on geothermal energy. The information shall be submitted in a standardized format that the EA provides. The following information shall also be included: trends in fuel use, data collection, QAQC, uncertainty assessment and change of data back to 1990. The NEA shall in cooperation with the EA ensure that the data and procedures fulfil the IPCC guidelines. Information on how the differentiation between domestic and international use of fuel is done. Uncertainty assessment and QAQC checks shall be done in cooperation with the EA.	Chapter 2 - Information on Energy
7	Institutions cooperation on data collection on LULUCF- The AUI shall in cooperation with the Soil Conservation Service of Iceland and Icelandic Forest Service/research write the LULUCF chapter in the NIR based on the IPCC	Chapter 3 - Information on LULUCF
8	Information from the AUI - writes the chapter on land use, changed land use and removals in the NIR and submits all the data except data related to forests, forestry and soil conservation. Approximated data shall be submitted before 15th of July. Data collection and data quality shall at least fulfil the requirements of the IPCC GL. Uncertainty assessment shall be in accordance to the IPCC GL.	
9	Information from the Icelandic Forest Service/Research - The Research part of the Forest Service shall deliver approximated information (according to points a and b) before 1st of July to the AUI and the finalised information (according to points a and b) before 1st of October. Data/information according to point a, b, c and d shall be put into the CRF before 1st of December each year. a) Area and geographical information related to forests, divided by land use according to the IPCC GL back to 1990 b) Area and geographical location of forests and forest activities that fall under KP. Art. 3.3 and 3.4 for each year from 2008. c) Estimation on GHG emissions and removals for categories connected to forestry. Information shall be in accordance to the UNFCCC and Kyoto Protocol. d) Relevant chapters in the NIR. - Data collection, data quality and uncertainty assessment shall be according to the IPCC GL. Where applicable the GL on LULUCF shall be used.	
10	Information from the Soil Conservation Service - The Soil Conservation Service shall deliver approximated information (according to points a and b) before 1st of July to the AUI and the finalised information (according to points a and b) before 1st of October. Data/information according to point a, b, c and d shall be put into the CRF before 1st of December each year. a) Area and geographical information related to soil, divided by land use according to the IPCC GL back to 1990 b) Area and geographical location of soil reclamation type that fall under KP. Art.3.4 for each year from 2008. c) Estimation on GHG emissions and removals for categories connected to soil. Information should be in accordance to the UNFCCC and Kyoto Protocol. d) Relevant chapters in the NIR. - Data collection, data quality and uncertainty assessment shall be according to the IPCC GL. Where applicable, the GL on LULUCF shall be used.	
11	The AUI, Soil Conservation Service of Iceland and Icelandic Forest Service/research right - the institutions and employee´s names shall be on the NIR.	
12	Information from the Icelandic Food and Veterinary Authority - The Icelandic Food and Veterinary Authority shall submit the following data about the year before to the EA before 15th of May each year. A) Livestock numbers (here all the different species listed). B) Amount of nitrogen in imported manure fertilizers in fertilizers in addition to a calcined substance in imported fertilizers. The data shall be submitted in a standardized format provided by the EA. The EA is allowed to request any information needed for the inventory.	Chapter 4 on Agriculture

Article nr.	Comments	Chapter
13	Information from the Agricultural University of Iceland (AUI) - The AUI shall no later than the 1st of November submit data to the EA on the area of drained fields that contain organic soil and N_2O emissions. The AUI shall assist the EA with the evaluation of the following: a) digestibility (further elaborated in the Regulation) b) Amount of nitrogen in manure from cattle and sheep (further elaborated in the Regulation).c) Division of manure for each livestock type by methodology by treatment of the manure. The EA is allowed to request any information needed for the inventory.	
14	Information from Statistics Iceland - Statistic Iceland shall no later than the 15th of May submit the following information: a) GDP B) Production of asphalt C) Production of food and beverages D) Harvesting of vegetables and cereals. E) Import of solvents and products containing solvents. F) The number of imported refrigerators broken down by country. G) Import and export of fuel. H) Import and export of wood products. The EA is allowed to request any information needed for the inventory.	Chapter 5 - Other information
15	Information from the Icelandic Transport Authority - The Icelandic Transport Authority shall submit to the EA, no later than 15th of May each year, information on: registration, driving, fuel use and emission control equipment in cars. The data should be sorted and submitted in the format the EA requires.	
16	Information from the Icelandic Recycling fund - The Recycling fund should submit data to the EA before the 15th of May about: production and import of paint and ink the year before. The EA has permission to ask/require any information needed for the inventory.	
17	Information from the Directorate of Customs - The EA can require the Directorate of Customs to submit data on import and export of products, as well as information about the importer that are needed for the inventory.	
18	Information from the EA to other institutions - The EA should, no later than 30th of May, submit data to the NEA about the following (related to the year before): Information on fuel use from Industry. B) Information on amount and energy content from waste incinerations with heat recovery.	
19	Data handling and information - Data and information should not be used for other purposes than for the inventory. Data providers shall inform the EA if any data is confidential.	Chapter 6 - Paragraph on information and use of the information
20	Agreements on more detailed information and deviations - The institutions mentioned in this regulation are allowed to make agreements to further elaborate the collaboration and requirements in this regulation.	
21	Requests for further data - The EA can request institutions, companies and private business sector about data or information that they have and the EA needs to do the inventory.	
22	Implementation - The EU MMR 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.	Chapter 7 - implementation
23	Cost - each institution in this regulation shall bear the cost of the work due to this regulation	Chapter 8 - Final paragraph
24	Right of appeal - any disagreement can be appeal to the Minister.	
25	Legal base and entry into force - This Regulation is based on Act 70/2012.	

Table 13.2 Status of implementation of the articles of Regulation 520/2017

Article nr.	Status of implementation
Art. 1 - 5	Have been implemented
Art. 6	Not entirely implemented. Work is ongoing between EA and the NEA, including splitting fuel sales statistics into IPCC subcategories, explanation of trends in fuel sales, changes in time series from 1990, uncertainties as well as information on QA/QC conducted by the NEA.
Art. 7 to 10	The institutional arrangements were changed the 2020 inventory cycle, with the main responsibility of data acquisition and emission calculations pertaining to the LULUCF sector now with the Iceland Forestry Service and the Soil Conservation Service of Iceland (Instead of the main responsible institution being the Agricultural University of Iceland). This change was approved by the parliament in June 2019 with the approval of amendments to the Climate Change Act No. 70/2012. Following the change to Act 70/2012, Regulation 520/2017 will need to be revised in order to reflect the changes in the law. The timeline for rewriting Regulation 520/2017 has not been established yet.
Art. 12 and 13	These articles have not been completely implemented. Work is needed with the two institutions concerned (Icelandic Food and Veterinary Authority and Agricultural University of Iceland) to reassess how the arrangements should be, and this will be reflected in the rewriting of the Regulation mentioned above.
Art. 14	Mostly implemented
Art. 15	The Icelandic Transport Authority is currently only providing the list of all vehicles registered in year y-1, and number of km driven by each vehicle that was submitted to an official vehicle inspection that year. It is planned to meet with the ITA to discuss how to obtain a more complete dataset, including information on vehicle emission control technologies, uncertainties and QA/QC procedures conducted by the Authority.
Art. 16 and 17	Mostly implemented, though work is underway to refine data collection procedures from the Directorate of Customs.

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 2020. Note that the 2020 SIAR confirms that previous recommendations have been implemented and included in the annual report.

Table 14.1 Changes in the National Registry in 2020.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	None
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	There has been a new EUCR release (version 11.5) after version 8.2.2 (the production version at the time of the last Chapter 14 submission). Due to the new release, some changes were applied to the database. The updated database 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 version 11.5 compared with version 8.2.2 of the national registry are presented in Annex B. It is to be noted that each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and are carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The use of soft tokens for authentication and signature was introduced for the registry end users.
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

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[25], 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.

[25] 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”

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834/2010 Reglugerð um flúoraðar gróðurhúsalofttegundir – “Regulation on fluorinated greenhouse gases”

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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, 2019 level and 1990-2019 trend assessment without LULUCF, and Table A4, A5 and A6 show the 1990 level, 2019 level and 1990-2019 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 in kt CO_2e, excluding LULUCF.

IPCC code	IPCC category	Gas	1990 Emissions (kt CO_2e)	Level assessment (%)	Cumulative total of level (%)
1A4c	Agriculture/Forestry/Fishing	CO_2	738.8	20.06%	20.06%
1A3b	Road Transport	CO_2	511.7	13.90%	34.0%
2C3	Metal Production: Aluminium	C_2F_6	82.4	13.43%	47.39%
1A2	Manufacturing and Construction	CO_2	358.4	9.73%	57.12%
2C2	Metal Production: Ferroalloys	CO_2	208.8	5.67%	62.79%
3D1	Agricultural Soils	N_2O	205.4	5.58%	68.36%
3A2	Enteric Fermentation: Sheep	CH_4	182.0	4.94%	73.31%
2C3	Metal Production: Aluminium	CO_2	139.2	3.78%	77.09%
5A2	Unmanaged waste disposal sites	CH_4	132.9	3.61%	80.69%
3A1	Enteric Fermentation: Cattle	CH_4	109.5	2.97%	83.67%
1B2d	Fugitive Emissions	CO_2	61.4	1.67%	85.3%
1A3d	Navigation	CO_2	59.8	1.62%	86.96%
2A1	Mineral Products: Cement	CO_2	51.6	1.40%	88.4%
2B5	Chemical Industry: Carbide Production	N_2O	46.5	1.26%	89.6%
3D2	Agricultural Soils: Indirect	N_2O	42.8	1.16%	90.78%
3A4	Enteric Fermentation: Other	CH_4	33.8	0.92%	91.70%
1A3a	Domestic Aviation	CO_2	33.3	0.91%	92.61%
3B1	Manure Management: Cattle	CH_4	32.9	0.89%	93.50%
5D2	Wastewater Treatment and Discharge: Industrial wastewater	CH_4	32.3	0.88%	94.38%
1A4b	Residential Stationary	CO_2	28.1	0.76%	95.14%

Table A1. 2 Key category analysis approach 1 level for 2019 in kt CO_2e, excluding LULUCF.

IPCC code	IPCC category	Gas	2019 Emissions (kt CO_2e)	Level assessment (%)	Cumulative total of level (%)
2C3	Metal Production: Aluminium	CO_2	1276.1	27.02%	27.02%
1A3b	Road Transport	CO_2	940.5	19.9%	46.9%
1A4c	Agriculture/Forestry/Fishing	CO_2	540.5	11.45%	58.38%
2C2	Metal Production: Ferroalloys	CO_2	429.8	9.10%	67.49%
2F1	Refrigeration and Air Conditioning	HFC	206.4	4.37%	71.85%
3D1	Agricultural Soils	N_2O	205.4	4.35%	76.21%
1B2d	Fugitive Emissions	CO_2	163.1	3.5%	79.7%
5A1	Managed waste disposal sites	CH_4	140.5	2.97%	82.63%
3A2	Enteric Fermentation: Sheep	CH_4	138.4	2.93%	85.56%
3A1	Enteric Fermentation: Cattle	CH_4	123.6	2.62%	88.18%
2C3	Metal Production: Aluminium	C_2F_6	97.0	2.05%	90.23%
1A2	Manufacturing and Construction	CO_2	84.3	1.78%	92.02%
1A3d	Navigation	CO_2	53.0	1.12%	93.14%
3D2	Agricultural Soils: Indirect	N_2O	36.8	0.78%	93.92%
3A4	Enteric Fermentation: Other	CH_4	33.4	0.71%	94.63%
3B1	Manure Management: Cattle	CH_4	32.6	0.69%	95.32%

Table A1. 3 Key category analysis approach 1 1990-2019 trend assessment in kt CO_2e, excluding LULUCF.

IPCC code	IPCC Category	Gas	Base Year (1990) Estimate $E_{x,0}$ (kt CO_2e)	Current Year (2019) 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	1276.1	29.8%	29.4%	29.4%
2C3	Metal Production: Aluminium	C_2F_6	494.6	97.0	14.6%	14.4%	43.8%
1A4c	Agriculture/Forestry/Fishing	CO_2	738.8	540.5	11.0%	10.9%	54.6%
1A2	Manufacturing and Construction	CO_2	358.4	84.3	10.2%	10.0%	64.7%
1A3b	Road Transport	CO_2	511.7	940.5	7.7%	7.6%	72.3%
2C2	Metal Production: Ferroalloys	CO_2	208.8	429.8	4.4%	4.3%	76.6%
5A2	Unmanaged waste disposal sites	CH_4	132.9	22.4	4.0%	4.0%	80.6%
5A1	Managed waste disposal sites	CH_4	16.8	140.5	3.2%	3.2%	83.8%
3A2	Enteric Fermentation: Sheep	CH_4	182.0	138.4	2.6%	2.5%	86.3%
1B2d	Fugitive Emissions	CO_2	61.4	163.1	2.3%	2.3%	88.6%
2A1	Mineral Products: Cement	CO_2	51.6	0.0	1.8%	1.8%	90.4%
2B5	Chemical Industry: Carbide Production	N_2O	46.5	0.0	1.6%	1.6%	92.0%
3D1	Agricultural Soils	N_2O	205.4	205.4	1.6%	1.6%	93.5%
1A4b	Residential Stationary	CO_2	28.1	7.1	0.8%	0.8%	94.3%
5D2	Wastewater Treatment and Discharge: Industrial wastewater	CH_4	32.3	17.6	0.6%	0.6%	94.9%
1A3d	Navigation	CO_2	59.8	53.0	0.6%	0.6%	95.6%

Table A1. 4 Key Category analysis approach 1 Level Assessment for 1990 in kt CO_2e, including LULUCF.

IPCC code	IPCC category	Gas	1990 Emissions /Removals (kt CO_2e)	Level assessment (%)	Cumulative total of level (%)
4C1	Grassland	CO_2	3130.2	20.1%	20.1%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	3002.6	19.2%	39.3%
4C2	Grassland	CO_2	1757.0	11.3%	50.5%
4D1	Wetlands	CO_2	1323.8	8.5%	59.0%
4B1	Cropland	CO_2	1216.7	7.8%	66.8%
1A4c	Agriculture/Forestry/Fishing	CO_2	738.8	4.7%	71.6%
4B2	Cropland	CO_2	634.8	4.1%	75.6%
1A3b	Road Transport	CO_2	511.7	3.3%	78.9%
2C3	Metal Production: Aluminium	C_2F_6	494.6	3.2%	82.1%
4(II) - Grasslands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	374.0	2.4%	84.5%
1A2	Manufacturing and Construction	CO_2	358.4	2.3%	86.8%
2C2	Metal Production: Ferroalloys	CO_2	208.8	1.3%	88.1%
3D1	Agricultural Soils	N_2O	205.4	1.3%	89.4%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	192.9	1.2%	90.6%
3A2	Enteric Fermentation: Sheep	CH_4	182.0	1.2%	91.8%
2C3	Metal Production: Aluminium	CO_2	139.2	0.9%	92.7%
5A2	Unmanaged waste disposal sites	CH_4	132.9	0.9%	93.6%
4(II) - Grasslands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	110.5	0.7%	94.3%
3A1	Enteric Fermentation: Cattle	CH_4	109.5	0.7%	95.0%
4(II) - Cropland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	94.8	0.6%	95.6%

Table A1. 5 Key category analysis approach 1 level for 2019 in kt CO_2e, including LULUCF

IPCC code	IPCC category	Gas	2019 Emissions/ Removals (kt CO_2e)	Level assessment (%)	Cumulative total of level (%)
4C1	Grassland	CO_2	5371.6	30.8%	30.8%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	2871.7	16.5%	47.3%
4B1	Cropland	CO_2	1691.4	9.7%	57.0%
2C3	Metal Production: Aluminium	CO_2	1276.1	7.3%	64.3%
4D1	Wetlands	CO_2	1259.0	7.2%	71.5%
1A3b	Road Transport	CO_2	940.5	5.4%	76.9%
1A4c	Agriculture/Forestry/Fishing - Stationary	CO_2	540.5	3.1%	80.0%
2C2	Metal Production: Ferroalloys	CO_2	429.8	2.5%	82.5%
4(II) - Grasslands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	423.0	2.4%	84.9%
4A2	Forest land	CO_2	413.3	2.4%	87.3%
2F1	Refrigeration and Air Conditioning	HFC	206.4	1.2%	88.5%
3D1	Agricultural Soils	N_2O	205.4	1.2%	89.7%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	184.1	1.1%	90.7%
1B2d	Fugitive Emissions	CO_2	163.1	0.9%	91.7%
5A1	Managed waste disposal sites	CH_4	140.5	0.8%	92.5%
3A2	Enteric Fermentation: Sheep	CH_4	138.4	0.8%	93.2%
4(II) - Grasslands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	125.0	0.7%	94.0%
3A1	Enteric Fermentation: Cattle	CH_4	123.6	0.7%	94.7%
4C2	Grassland	CO_2	111.1	0.6%	95.3%

Table A1. 6 Key category analysis approach 1 1990-2019 trend assessment in kt CO_2e, including LULUCF.

IPCC code	IPCC Category	Gas	Base Year (1990) Estimate Ex,0 (kt CO_2e)	Current Year (2019) Estimate Ex,t (kt CO_2e)	Trend Assessment Tx,t	Contribution to Trend (%)	Cumulative Total of trend (%)
4C1	Grassland	CO_2	3130.2	5371.6	12.0%	20.2%	20.2%
4C2	Grassland	CO_2	1757.0	111.1	11.9%	19.9%	40.0%
2C3	Metal Production: Aluminium	CO_2	139.2	1276.1	7.2%	12.0%	52.1%
4B2	Cropland	CO_2	634.8	90.9	4.0%	6.6%	58.7%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	3002.6	2871.7	3.1%	5.2%	63.9%
2C3	Metal Production: Aluminium	C_2F_6	494.6	97.0	2.9%	4.9%	68.8%
4A2	Forest land	CO_2	27.9	413.3	2.4%	4.1%	72.9%
1A3b	Road Transport	CO_2	511.7	940.5	2.4%	4.0%	76.8%
4B1	Cropland	CO_2	1216.7	1691.4	2.1%	3.6%	80.4%
1A2	Manufacturing and Construction	CO_2	358.4	84.3	2.0%	3.4%	83.8%
1A4c	Agriculture/Forestry/Fishing	CO_2	738.8	540.5	1.8%	3.1%	86.9%
4D1	Wetlands	CO_2	1323.8	1259.0	1.4%	2.4%	89.2%
2C2	Metal Production: Ferroalloys	CO_2	208.8	429.8	1.3%	2.1%	91.3%
5A2	Unmanaged waste disposal sites	CH_4	132.9	22.4	0.8%	1.4%	92.7%
5A1	Managed waste disposal sites	CH_4	16.8	140.5	0.8%	1.3%	94.0%
1B2d	Fugitive Emissions	CO_2	61.4	163.1	0.6%	1.0%	95.0%

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 58%. 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)	2019 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)	CO2	4.14	3.95	5%	5%	7.1%	4.1E-10	2.3E-06	2.2E-05	4.8E-10
1A1aiii	Public electricity and heat production (heat plants)	CO2	9.34	1.04	5%	5%	7.1%	2.9E-11	3.5E-05	5.7E-06	1.3E-09
1A2a	Iron and Steel	CO2	0.36	1.76	2%	5%	5.2%	4.5E-11	2.7E-06	2.9E-06	1.6E-11
1A2b	Non-Ferrous Metals	CO2	13.50	8.38	2%	5%	5.2%	1.0E-09	1.2E-05	1.4E-05	3.3E-10
1A2c	Chemicals	CO2	7.43	0.00	5%	5%	7.1%	0.0E+00	1.6E-05	0.0E+00	2.4E-10
1A2e	Food Processing, Beverages and Tobacco	CO2	128.24	15.24	5%	5%	7.1%	6.1E-09	2.4E-04	8.4E-05	6.4E-08
1A2f	Non-metallic minerals	CO2	47.42	0.54	5%	5%	7.1%	7.7E-12	9.9E-05	3.0E-06	9.8E-09
1A2g	Other manufacturing industries and Constructions	CO2	161.49	58.36	5%	5%	7.1%	9.0E-08	2.3E-04	3.2E-04	1.6E-07
1A3a	Domestic Aviation	CO2	33.34	27.76	5%	5%	7.1%	2.0E-08	1.7E-05	1.5E-04	2.4E-08
1A3b	Road Transport	CO2	511.75	940.48	5%	3%	5.7%	1.5E-05	4.3E-04	5.2E-03	2.7E-05
1A3d	Domestic Water - borne Navigation	CO2	59.83	52.99	5%	5%	7.1%	7.4E-08	2.2E-05	2.9E-04	8.6E-08
1A4a	Commercial/Institutional	CO2	8.05	1.21	5%	5%	7.1%	3.9E-11	1.5E-05	6.7E-06	2.7E-10
1A4b	Residential	CO2	28.10	7.08	5%	5%	7.1%	1.3E-09	4.6E-05	3.9E-05	3.7E-09
1A4c	Agriculture/Fishing	CO2	738.76	540.53	5%	5%	7.1%	7.7E-06	5.1E-04	3.0E-03	9.1E-06
1A5a	Other - stationary	CO2	0.12	1.69	5%	5%	7.1%	7.5E-11	3.2E-06	9.3E-06	9.7E-11
1B2a5	Oil - Distribution of oil products	CO2	0.00	0.00	5%	5%	7.1%	6.0E-16	3.6E-09	2.6E-08	7.0E-16
1B2d	Other emission from Energy Production	CO2	61.36	163.10	10%	10%	14.1%	2.8E-06	4.0E-04	1.8E-03	3.4E-06
2A1	Cement Production	CO2	51.56	0.00	2%	30%	30%	0.0E+00	7.0E-04	0.0E+00	4.9E-07
2A4d	Other: Mineral Wool Production	CO2	0.70	0.96	8%	2%	8%	3.1E-11	1.3E-07	8.3E-06	6.9E-11
2B10	Other: Silica production	CO2	0.36	0.00	7%	1%	7%	0.0E+00	1.6E-07	0.0E+00	2.7E-14
2C1	Metal Production - Iron and steel	CO2	0.00	0.00	10%	25%	27%	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2C2	Metal Production - Ferroalloys	CO2	208.80	429.81	2%	2%	2%	4.4E-07	1.3E-04	7.1E-04	5.2E-07

	IPCC Category	Gas	1990 emissions (kt CO_2e)	2019 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
2C3	Metal Production - Aluminium Production	CO2	139.21	1276.06	2%	2%	2%	3.9E-06	7.2E-04	2.1E-03	5.0E-06
2D1	Lubricants	CO2	4.06	2.07	5%	50%	50%	5.7E-09	4.4E-05	1.1E-05	2.1E-09
2D2	Paraffin wax use	CO2	0.17	0.29	5%	100%	100%	4.3E-10	4.6E-06	1.6E-06	2.4E-11
2D3	Solvents	CO2	2.53	3.20	2%	67%	67%	2.4E-08	1.7E-05	7.0E-06	3.5E-10
2G4fw	Other: Fireworks	CO2	0.00	0.02	2%	50%	50%	5.4E-13	3.3E-07	4.5E-08	1.1E-13
3G	Liming	CO2	0.46	3.70	50%	0%	50%	1.8E-08	0.0E+00	2.0E-04	4.1E-08
3H	Urea application	CO2	0.06	0.22	50%	0%	50%	6.4E-11	0.0E+00	1.2E-05	1.5E-10
3I	Other Carbon Containing Fertilizers	CO2	0.00	1.95	50%	0%	50.0%	5.0E-09	0.0E+00	1.1E-04	1.2E-08
4(II)	Cropland	CO2	28.65	27.61	20%	41%	45.9%	8.5E-07	3.0E-05	6.1E-04	3.7E-07
4(II)	Grasslands	CO2	110.50	125.00	20%	52%	55.6%	2.5E-05	2.7E-04	2.8E-03	7.6E-06
4(II)	Wetlands	CO2	192.89	184.10	20%	37%	42.4%	3.2E-05	2.1E-04	4.1E-03	1.6E-05
4A1	Forest Land Remaining Forest Land	CO2	-15.61	-35.00	14%	10%	17.2%	1.9E-07	8.2E-05	5.4E-04	3.0E-07
4A2	Land Converted to Forest Land	CO2	-27.89	-413.26	5%	10%	11.2%	1.1E-05	1.7E-03	2.3E-03	7.9E-06
4B1	Cropland Remaining Cropland	CO2	1216.70	1691.44	20%	14%	24.5%	9.1E-04	2.6E-03	3.7E-02	1.4E-03
4B2	Land Converted to Cropland	CO2	634.84	90.95	20%	29%	35.2%	5.4E-06	7.3E-03	2.0E-03	5.8E-05
4C1	Grassland Remaining Grassland	CO2	3130.22	5371.63	20%	50%	53.5%	4.4E-02	4.9E-02	1.2E-01	1.6E-02
4C2	Land Converted to Grassland	CO2	1756.98	-111.14	20%	84%	86.8%	4.9E-05	8.1E-02	2.4E-03	6.6E-03
4D1	Wetlands Remaining Wetlands	CO2	-1323.76	-1258.99	20%	40%	44.6%	1.7E-03	2.8E-03	2.8E-02	7.8E-04
4D2	Land Converted to Wetlands	CO2	0.50	5.47	20%	121%	122.7%	2.4E-07	3.4E-04	1.2E-04	1.3E-07
4E2	Land Converted to Settlements	CO2	16.39	5.87	5%	150%	150.1%	4.1E-07	9.3E-04	3.2E-05	8.7E-07
5C	Incineration and Open Burning of waste	CO2	7.30	8.36	52%	40%	65.6%	1.6E-07	1.9E-05	4.8E-04	2.3E-07
1A1ai	Public electricity and heat production (electricity generation)	CH4	0.00419	0.00400	5%	100%	100.1%	8.5E-14	1.8E-08	2.2E-08	8.2E-16
1A1aiii	Public electricity and heat production (heat plants)	CH4	0.00906	0.00111	5%	100%	100.1%	6.5E-15	4.6E-07	6.1E-09	2.2E-13
1A2a	Iron and Steel	CH4	0.00036	0.00110	2%	100%	100.0%	6.4E-15	4.1E-08	1.8E-09	1.7E-15
1A2b	Non-Ferrous Metals	CH4	0.01239	0.00778	2%	100%	100.0%	3.2E-13	2.8E-07	1.3E-08	8.0E-14
1A2c	Chemicals	CH4	0.00720	0.00000	5%	100%	100.1%	0.0E+00	4.2E-07	0.0E+00	1.8E-13

	IPCC Category	Gas	1990 emissions (kt CO_2e)	2019 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1A2e	Food Processing, Beverages and Tobacco	CH4	0.12432	0.01534	5%	100%	100.1%	1.2E-12	6.4E-06	8.4E-08	4.1E-11
1A2f	Non-metallic minerals	CH4	0.12191	0.00052	5%	100%	100.1%	1.4E-15	7.1E-06	2.8E-09	5.0E-11
1A2g	Other manufacturing industries and Constructions	CH4	0.20941	0.07890	5%	100%	100.1%	3.3E-11	7.7E-06	4.3E-07	6.0E-11
1A3a	Domestic Aviation	CH4	0.00585	0.00486	5%	100%	100.1%	1.2E-13	6.6E-08	2.7E-08	5.1E-15
1A3b	Road Transport	CH4	5.58056	1.26533	5%	219%	219.1%	4.1E-08	5.5E-04	7.0E-06	3.1E-07
1A3d	Domestic Water - borne Navigation	CH4	0.13910	0.12369	5%	100%	100.1%	8.1E-11	1.1E-06	6.8E-07	1.7E-12
1A4a	Commercial/Institutional	CH4	0.02394	0.00370	5%	100%	100.1%	7.2E-14	1.2E-06	2.0E-08	1.4E-12
1A4b	Residential	CH4	0.09485	0.01698	5%	100%	100.1%	1.5E-12	4.6E-06	9.3E-08	2.1E-11
1A4c	Agriculture/Fishing	CH4	1.73522	1.24651	5%	100%	100.1%	8.2E-09	3.1E-05	6.9E-06	9.9E-10
1A5a	Other - stationary	CH4	0.00012	0.00226	5%	100%	100.1%	2.7E-14	1.2E-07	1.2E-08	1.5E-14
1B2a5	Oil - Distribution of oil products	CH4	0.48687	0.64406	5%	100%	100.1%	2.2E-09	8.0E-06	3.5E-06	7.6E-11
1B2d	Other emission from Energy Production	CH4	0.19546	3.14039	10%	25%	26.9%	3.8E-09	4.1E-05	3.5E-05	2.9E-09
2C2	Metal Production - Ferroalloys	CH4	1.56979	2.80375	2%	10%	10.1%	4.2E-10	6.7E-06	4.6E-06	6.6E-11
2G4tob	Other: Tobacco	CH4	0.04704	0.02672	2%	50%	50.0%	9.4E-13	6.1E-07	5.9E-08	3.8E-13
3A1	Enteric Fermentation - Cattle	CH4	109.48763	123.56049	5%	40%	40.3%	1.3E-05	2.4E-04	6.8E-04	5.2E-07
3A2	Enteric Fermentation - Sheep	CH4	181.95354	138.35262	5%	40%	40.3%	1.6E-05	1.1E-03	7.6E-04	1.8E-06
3A3	Enteric Fermentation - Swine	CH4	1.11630	1.43676	5%	40%	40.3%	1.8E-09	6.5E-06	7.9E-06	1.0E-10
3A4	Enteric Fermentation – Other Livestock	CH4	33.76413	33.35724	13%	80%	81.1%	3.9E-06	7.1E-05	4.9E-04	2.4E-07
3B1	Manure Management - Cattle	CH4	32.93380	32.60168	11%	20%	22.9%	2.9E-07	1.7E-05	4.0E-04	1.6E-07
3B2	Manure Management - Sheep	CH4	15.27850	11.47657	25%	20%	32.4%	7.3E-08	5.0E-05	3.2E-04	1.1E-07
3B3	Manure Management - Swine	CH4	4.46520	5.74703	11%	30%	32.0%	1.8E-08	2.0E-05	7.1E-05	5.4E-09
3B4	Manure Management – Other Livestock	CH4	6.37364	5.74363	24%	60%	64.6%	7.3E-08	2.9E-05	1.5E-04	2.4E-08
4(II) -	Cropland	CH4	94.83100	91.37599	20%	50%	54.2%	1.3E-05	1.9E-04	2.0E-03	4.1E-06
4(II) - s	Grassland	CH4	374.01996	423.02902	20%	63%	66.4%	4.2E-04	1.3E-03	9.3E-03	8.9E-05
4(II) -	Wetlands	CH4	3002.58107	2871.74552	20%	259%	259.3%	2.9E-01	3.5E-02	6.3E-02	5.2E-03

	IPCC Category	Gas	1990 emissions (kt CO_2e)	2019 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 (%)
5A1	Managed waste disposal sites	CH4	16.79481	140.47333	52%	43%	67.3%	4.7E-05	3.8E-03	8.0E-03	7.9E-05
5A2	Unmanaged waste disposal sites	CH4	132.93743	22.41939	52%	41%	66.5%	1.2E-06	3.4E-03	1.3E-03	1.4E-05
5B	Biological treatment of solid waste	CH4	0.00000	2.38649	52%	100%	112.7%	3.8E-08	1.7E-04	1.4E-04	4.9E-08
5C	Incineration and Open Burning of waste	CH4	6.08558	0.39035	52%	100%	112.7%	1.0E-09	4.4E-04	2.2E-05	1.9E-07
5D2	Wastewater Treatment and Discharge Industrial Wastewater	CH4	32.30562	17.55859	39%	58%	70.0%	8.0E-07	6.9E-04	7.5E-04	1.0E-06
5D1	Wastewater Treatment and Discharge Domestic Wastewater	CH4	17.69012	24.35649	59%	58%	82.8%	2.1E-06	2.5E-04	1.6E-03	2.6E-06
1A1aiii	Public electricity and heat production (electricity generation)	N2O	0.02	0.00	5%	100%	100.1%	3.7E-14	1.5E-06	1.5E-08	2.1E-12
1A1ai	Public electricity and heat production (heat plants)	N2O	0.01	0.01	5%	100%	100.1%	4.8E-13	7.0E-08	5.3E-08	7.6E-15
1A2a	Iron and Steel	N2O	0.00	0.00	2%	100%	100.0%	2.3E-14	8.8E-08	3.5E-09	7.7E-15
1A2b	Non-Ferrous Metals	N2O	0.03	0.02	2%	100%	100.01%	1.7E-12	8.9E-07	3.0E-08	8.0E-13
1A2c	Chemicals	N2O	0.02	0.00	5%	100%	100.1%	0.0E+00	1.3E-06	0.0E+00	1.7E-12
1A2e	Food Processing, Beverages and Tobacco	N2O	0.30	0.04	5%	100%	100.1%	7.1E-12	2.0E-05	2.0E-07	4.0E-10
1A2f	Non-metallic minerals	N2O	0.22	0.00	5%	100%	100.1%	8.0E-15	1.7E-05	6.8E-09	2.8E-10
1A2g	Other manufacturing industries and Constructions	N2O	14.01	6.40	5%	100%	100.1%	2.2E-07	6.1E-04	3.5E-05	3.7E-07
1A3a	Domestic Aviation	N2O	0.28	0.23	5%	200%	200.1%	1.1E-09	9.0E-06	1.3E-06	8.2E-11
1A3b	Road Transport	N2O	5.78	10.25	5%	188%	188.0%	2.0E-06	5.8E-04	5.6E-05	3.3E-07
1A3d	Domestic Water - borne Navigation	N2O	0.47	0.42	5%	200%	200.1%	3.7E-09	1.1E-05	2.3E-06	1.3E-10
1A4a	Commercial/Institutional	N2O	0.01	0.00	5%	100%	100.1%	3.0E-14	9.8E-07	1.3E-08	9.5E-13
1A4b	Residential	N2O	0.07	0.01	5%	100%	100.1%	2.9E-13	4.7E-06	4.1E-08	2.2E-11
1A4c	Agriculture/Fishing	N2O	5.91	6.85	5%	200%	200.1%	9.9E-07	9.5E-05	3.8E-05	1.0E-08
1A5a	Other - stationary	N2O	0.00	0.00	5%	100%	100.1%	9.5E-14	2.9E-07	2.3E-08	8.4E-14
1B2a5	Oil - Distribution of oil products	N2O	0.00	0.00	5%	0%	5.0%	1.7E-22	0.0E+00	2.0E-11	4.0E-22
2B10	Other: Fertilizer production	N2O	46.49	0.00	7%	40%	40.6%	0.0E+00	1.4E-03	0.0E+00	2.0E-06

	IPCC Category	Gas	1990 emissions (kt CO_2e)	2019 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	N2O	5.30	2.07	6%	5%	7.8%	1.4E-10	1.3E-05	1.4E-05	3.6E-10
2G3b	N2O from Product Uses: Other	N2O	0.72	0.47	6%	5%	7.8%	7.1E-12	1.1E-06	3.1E-06	1.1E-11
2G4tob	Other: Tobacco	N2O	0.08	0.27	2%	50%	50.0%	1.0E-10	7.1E-06	6.0E-07	5.1E-11
3B1	Manure Management: Cattle	N2O	0.74	0.75	11%	100%	100.6%	3.0E-09	1.7E-06	9.3E-06	8.9E-11
3B25	Manure Management: Indirect	N2O	9.58	8.28	100%	400%	412.3%	6.2E-06	5.3E-04	9.1E-04	1.1E-06
3B2	Manure Management: Sheep	N2O	11.09	8.33	25%	100%	103.2%	3.9E-07	2.5E-04	2.3E-04	1.2E-07
3B3	Manure Management: Swine	N2O	0.00	0.00	11%	100%	100.6%	0.0E+00	0.0E+00	0.0E+00	0.0E+00
3B4	Manure Management: Other Livestock	N2O	1.21	1.05	24%	200%	201.4%	2.3E-08	3.4E-05	2.8E-05	1.9E-09
3D1.1	Inorganic N Fertilizers	N2O	58.41	48.61	5%	233%	233.4%	6.8E-05	2.2E-03	2.7E-04	5.0E-06
3D1.2	Organic N Fertilizers	N2O	38.01	32.73	63%	233%	241.6%	3.3E-05	1.3E-03	2.3E-03	6.8E-06
3D1.3	Urine and Dung Deposited by Grazing Animals	N2O	47.86	41.88	57%	233%	240.1%	5.3E-05	1.5E-03	2.6E-03	9.1E-06
3D1.4	Crop Residues	N2O	0.07	0.08	100%	233%	253.9%	2.2E-10	1.4E-06	8.8E-06	7.9E-11
3D1.5	Mineralization Associated with Loss/gain of Soil Organic Carbon	N2O	0.00	0.00	0%	0%	0.0%	0.0E+00	0.0E+00	0.0E+00	0.0E+00
3D1.6	Cultivation of organic soils	N2O	61.08	82.14	20%	200%	201.0%	1.4E-04	2.6E-03	1.8E-03	1.0E-05
3D2.1	Indirect N2O Emissions	N2O	11.24	10.20	100%	400%	412.3%	9.3E-06	5.0E-04	1.1E-03	1.5E-06
4(V) -	Wetlands	N2O	0.00	0.00	0%	0%	0.0%	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5B	Biological Treatment of Solid Waste	N2O	0.00	1.71	52%	150%	158.7%	3.9E-08	1.9E-04	9.8E-05	4.6E-08
5C	Incineration and Open Burning of Waste	N2O	1.67	0.63	52%	100%	112.7%	2.6E-09	8.5E-05	3.6E-05	8.6E-09
5D2	Wastewater Treatment and Discharge Industrial Wastewater	N2O	0.00	0.00	39%	2495%	2495.7%	1.2E-04	0.0E+00	3.8E-04	1.5E-07
5D1	Wastewater Treatment and Discharge Domestic Wastewater	N2O	4.58	5.94	59%	2495%	104.0%	2.4E-04	2.4E-05	2.3E-02	5.2E-04
2F1	Refrigeration and Air Conditioning	HFC	0.00	206.35	100%	28%	104.0%	2.4E-04	4.4E-03	2.3E-02	5.4E-04
2F4	Aerosols	HFC	0.34	0.92	10%	10%	14.1%	8.9E-11	4.2E-06	1.0E-05	1.2E-10

	IPCC Category	Gas	1990 emissions (kt CO_2e)	2019 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
2C3	Metal Production - Aluminium Production	PFC	494.64	97.00	3%	30%	30.1%	4.5E-06	9.4E-03	3.2E-04	8.8E-05
2F1	Refrigeration and Air Conditioning	PFC	0.00	0.06	100%	28%	104.0%	2.3E-11	1.4E-06	6.9E-06	5.0E-11
2G1	Electrical Equipment	SF6	1.10	1.99	30%	30%	42.4%	3.8E-09	1.9E-05	6.6E-05	4.7E-09
	Total emissions		12843.17	13765.54							
	Total Uncertainties		% Uncertainty in total inventory (including LULUCF):					58%	Trend uncertainty:		17.8%

Table A2. 2 Uncertainty Analysis excluding LULUCF

	IPCC Category	Gas	1990 emissions (kt CO_2e)	2019 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)	CO2	4.14	3.95	5%	5%	7.1%	3.50E-09	1.8E-05	7.6E-05	6.1E-09
1A1aiii	Public electricity and heat production (heat plants)	CO2	9.34	1.04	5%	5%	7.1%	2.43E-10	1.5E-04	2.0E-05	2.3E-08
1A2a	Iron and Steel	CO2	0.36	1.76	2%	5%	5.2%	3.79E-10	8.9E-06	1.0E-05	1.8E-10
1A2b	Non-Ferrous Metals	CO2	13.50	8.38	2%	5%	5.2%	8.57E-09	6.1E-05	4.8E-05	6.0E-09
1A2c	Chemicals	CO2	7.43	0.00	5%	5%	7.1%	0.00E+00	6.5E-05	0.0E+00	4.2E-09
1A2e	Food Processing, Beverages and Tobacco	CO2	128.24	15.24	5%	5%	7.1%	5.21E-08	1.0E-03	2.9E-04	1.1E-06
1A2f	Non-metallic minerals	CO2	47.42	0.54	5%	5%	7.1%	6.53E-11	4.3E-04	1.0E-05	1.8E-07
1A2g	Other manufacturing industries and Constructions	CO2	161.49	58.36	5%	5%	7.1%	7.64E-07	1.1E-03	1.1E-03	2.4E-06
1A3a	Domestic Aviation	CO2	33.34	27.76	5%	5%	7.1%	1.73E-07	1.2E-04	5.3E-04	3.0E-07
1A3b	Road Transport	CO2	511.75	940.48	5%	3%	5.7%	1.30E-04	1.0E-03	1.8E-02	3.3E-04
1A3d	Domestic Water - borne Navigation	CO2	59.83	52.99	5%	5%	7.1%	6.30E-07	1.9E-04	1.0E-03	1.1E-06
1A4a	Commercial/Institutional	CO2	8.05	1.21	5%	5%	7.1%	3.30E-10	7.3E-05	2.3E-05	5.8E-09
1A4b	Residential	CO2	28.10	7.08	5%	5%	7.1%	1.13E-08	2.3E-04	1.4E-04	7.2E-08
1A4c	Agriculture/Fishing	CO2	738.76	540.53	5%	5%	7.1%	6.55E-05	3.4E-03	1.0E-02	1.2E-04
1A5a	Other - stationary	CO2	0.12	1.69	5%	5%	7.1%	6.37E-10	1.4E-05	3.2E-05	1.2E-09
1B2a5	Oil - Distribution of oil products	CO2	0.00	0.00	5%	5%	7.1%	5.07E-15	7.6E-09	9.1E-08	8.4E-15
1B2d	Other emission from Energy Production	CO2	61.36	163.10	10%	10%	14.1%	2.39E-05	1.4E-03	6.3E-03	4.1E-05
2A1	Cement Production	CO2	51.56	0.00	2%	30%	30.1%	0.00E+00	3.8E-03	0.0E+00	1.5E-05
2A4d	Other: Mineral Wool Production	CO2	0.70	0.96	8%	2%	8.0%	2.66E-10	1.6E-08	2.9E-05	8.4E-10
2B5	Other: Silica production	CO2	0.36	0.00	7%	1%	7.1%	0.00E+00	9.1E-07	0.0E+00	8.2E-13
2C1	Metal Production - Iron and steel	CO2	0.00	0.00	10%	25%	26.9%	0.00E+00	0.0E+00	0.0E+00	0.0E+00
2C2	Metal Production - Ferroalloys	CO2	208.80	429.81	2%	2%	2.1%	3.73E-06	3.8E-04	2.5E-03	6.3E-06

	IPCC Category	Gas	1990 emissions (kt CO_2e)	2019 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
2C3	Metal Production - Aluminium Production	CO2	139.21	1276.06	2%	2%	2.1%	3.29E-05	3.1E-03	7.4E-03	6.4E-05
2D1	Lubricants	CO2	4.06	2.07	5%	50%	50.3%	4.87E-08	2.5E-04	4.0E-05	6.5E-08
2D2	Paraffin wax use	CO2	0.17	0.29	5%	100%	100.2%	3.68E-09	1.7E-05	5.5E-06	3.2E-10
2D3	Solvents	CO2	2.53	3.20	2%	67%	66.7%	2.04E-07	3.8E-05	2.5E-05	2.0E-09
2G4fw	Other: Fireworks	CO2	0.00	0.02	2%	50%	50.0%	4.62E-12	1.4E-06	1.6E-07	2.0E-12
3G	Liming	CO2	0.46	3.70	50%	0%	50.0%	1.53E-07	0.0E+00	7.1E-04	5.0E-07
3H	Urea application	CO2	0.06	0.22	50%	0%	50.0%	5.46E-10	0.0E+00	4.2E-05	1.8E-09
3I	Other Carbon Containing Fertilizers	CO2	0.00	1.95	50%	0%	50.0%	4.26E-08	0.0E+00	3.7E-04	1.4E-07
5C	Incineration and Open Burning of waste	CO2	7.30	8.36	52%	40%	65.6%	1.35E-06	1.0E-06	1.7E-03	2.8E-06
1A1ai	Public electricity and heat production (electricity generation)	CH4	0.00	0.00	5%	100%	100.1%	7.19E-13	1.6E-07	7.7E-08	3.1E-14
1A1aiii	Public electricity and heat production (heat plants)	CH4	0.01	0.00	5%	100%	100.1%	5.56E-14	1.8E-06	2.1E-08	3.3E-12
1A2a	Iron and Steel	CH4	0.00	0.00	2%	100%	100.0%	5.43E-14	1.3E-07	6.3E-09	1.8E-14
1A2b	Non-Ferrous Metals	CH4	0.01	0.01	2%	100%	100.0%	2.71E-12	1.3E-06	4.5E-08	1.6E-12
1A2c	Chemicals	CH4	0.01	0.00	5%	100%	100.1%	0.00E+00	1.6E-06	0.0E+00	2.6E-12
1A2e	Food Processing, Beverages and Tobacco	CH4	0.12	0.02	5%	100%	100.1%	1.06E-11	2.5E-05	2.9E-07	6.1E-10
1A2f	Non-metallic minerals	CH4	0.12	0.00	5%	100%	100.1%	1.20E-14	2.7E-05	9.9E-09	7.4E-10
1A2g	Other manufacturing industries and Constructions	CH4	0.21	0.08	5%	100%	100.1%	2.80E-10	3.1E-05	1.5E-06	9.9E-10
1A3a	Domestic Aviation	CH4	0.01	0.00	5%	100%	100.1%	1.06E-12	3.6E-07	9.3E-08	1.4E-13
1A3b	Road Transport	CH4	5.58	1.27	5%	219%	219.1%	3.45E-07	2.2E-03	2.4E-05	4.8E-06
1A3d	Domestic Water - borne Navigation	CH4	0.14	0.12	5%	100%	100.1%	6.88E-10	7.0E-06	2.4E-06	5.5E-11
1A4a	Commercial/Institutional	CH4	0.02	0.00	5%	100%	100.1%	6.15E-13	4.6E-06	7.1E-08	2.2E-11
1A4b	Residential	CH4	0.09	0.02	5%	100%	100.1%	1.30E-11	1.8E-05	3.3E-07	3.2E-10

	IPCC Category	Gas	1990 emissions (kt CO_2e)	2019 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 (%)
1A4c	Agriculture/Fishing	CH4	1.74	1.25	5%	100%	100.1%	6.99E-08	1.5E-04	2.4E-05	2.2E-08
1A5a	Other - stationary	CH4	0.00	0.00	5%	100%	100.1%	2.30E-13	4.1E-07	4.3E-08	1.7E-13
1B2a5	Oil - Distribution of oil products	CH4	0.49	0.64	5%	100%	100.1%	1.86E-08	1.7E-05	1.2E-05	4.3E-10
1B2d	Other emission from Energy Production	CH4	0.20	3.14	10%	25%	26.9%	3.21E-08	1.4E-04	1.2E-04	3.5E-08
2C2	Metal Production - Ferroalloys	CH4	1.57	2.80	2%	10%	10.1%	3.60E-09	2.0E-05	1.6E-05	6.4E-10
2G4tob	Other: Tobacco	CH4	0.05	0.03	2%	50%	50.0%	8.02E-12	2.7E-06	2.1E-07	7.1E-12
3A1	Enteric Fermentation - Cattle	CH4	109.49	123.56	5%	40%	40.3%	1.11E-04	1.6E-04	2.4E-03	5.7E-06
3A2	Enteric Fermentation - Sheep	CH4	181.95	138.35	5%	40%	40.3%	1.39E-04	5.6E-03	2.7E-03	3.9E-05
3A3	Enteric Fermentation - Swine	CH4	1.12	1.44	5%	40%	40.3%	1.50E-08	1.1E-05	2.8E-05	8.9E-10
3A4	Enteric Fermentation – Other Livestock	CH4	33.76	33.36	13%	80%	81.1%	3.28E-05	9.8E-04	1.7E-03	3.8E-06
3B1	Manure Management - Cattle	CH4	32.93	32.60	11%	20%	22.9%	2.50E-06	2.4E-04	1.4E-03	2.0E-06
3B2	Manure Management - Sheep	CH4	15.28	11.48	25%	20%	32.4%	6.20E-07	2.7E-04	1.1E-03	1.3E-06
3B3	Manure Management - Swine	CH4	4.47	5.75	11%	30%	32.0%	1.52E-07	3.4E-05	2.5E-04	6.2E-08
3B4	Manure Management – Other Livestock	CH4	6.37	5.74	24%	60%	64.6%	6.18E-07	2.1E-04	5.3E-04	3.3E-07
5A1	Managed waste disposal sites	CH4	16.79	140.47	52%	43%	67.3%	4.00E-04	1.1E-02	2.8E-02	9.0E-04
5A2	Unmanaged waste disposal sites	CH4	132.94	22.42	52%	41%	66.5%	9.97E-06	1.1E-02	4.5E-03	1.5E-04
5B	Biological treatment of solid waste	CH4	0.00	2.39	52%	100%	112.7%	3.24E-07	5.2E-04	4.8E-04	5.0E-07
5C	Incineration and Open Burning of waste	CH4	6.09	0.39	52%	100%	112.7%	8.68E-09	1.5E-03	7.8E-05	2.1E-06
5D2	Wastewater Treatment and Discharge Industrial Wastewater	CH4	32.31	17.56	39%	58%	70.0%	6.77E-06	2.6E-03	2.6E-03	1.3E-05
5D1	Wastewater Treatment and Discharge Domestic Wastewater	CH4	17.69	24.36	59%	58%	82.8%	1.83E-05	4.6E-04	5.5E-03	3.0E-05
1A1aiii	Public electricity and heat production (electricity generation)	N2O	0.02	0.00	5%	100%	100.1%	3.16E-13	5.0E-06	5.1E-08	2.5E-11

	IPCC Category	Gas	1990 emissions (kt CO_2e)	2019 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 (heat plants)	N2O	0.01	0.01	5%	100%	100.1%	4.09E-12	4.8E-07	1.8E-07	2.7E-13
1A2a	Iron and Steel	N2O	0.00	0.00	2%	100%	100.0%	1.97E-13	2.4E-07	1.2E-08	5.8E-14
1A2b	Non-Ferrous Metals	N2O	0.03	0.02	2%	100%	100.0%	1.48E-11	3.5E-06	1.0E-07	1.2E-11
1A2c	Chemicals	N2O	0.02	0.00	5%	100%	100.1%	0.00E+00	4.4E-06	0.0E+00	2.0E-11
1A2e	Food Processing, Beverages and Tobacco	N2O	0.30	0.04	5%	100%	100.1%	6.01E-11	6.9E-05	7.0E-07	4.7E-09
1A2f	Non-metallic minerals	N2O	0.22	0.00	5%	100%	100.1%	6.80E-14	5.6E-05	2.4E-08	3.2E-09
1A2g	Other manufacturing industries and Constructions	N2O	14.01	6.40	5%	100%	100.1%	1.84E-06	2.2E-03	1.2E-04	4.9E-06
1A3a	Domestic Aviation	N2O	0.28	0.23	5%	200%	200.1%	9.62E-09	4.3E-05	4.4E-06	1.8E-09
1A3b	Road Transport	N2O	5.78	10.25	5%	188%	188.0%	1.66E-05	1.4E-03	2.0E-04	2.1E-06
1A3d	Domestic Water - borne Navigation	N2O	0.47	0.42	5%	200%	200.1%	3.19E-08	6.0E-05	8.1E-06	3.7E-09
1A4a	Commercial/Institutional	N2O	0.01	0.00	5%	100%	100.1%	2.54E-13	3.4E-06	4.6E-08	1.1E-11
1A4b	Residential	N2O	0.07	0.01	5%	100%	100.1%	2.49E-12	1.6E-05	1.4E-07	2.6E-10
1A4c	Agriculture/Fishing	N2O	5.91	6.85	5%	200%	200.1%	8.42E-06	4.3E-05	1.3E-04	1.9E-08
1A5a	Other - stationary	N2O	0.00	0.00	5%	100%	100.1%	8.05E-13	8.7E-07	8.1E-08	7.6E-13
1B2a5	Oil - Distribution of oil products	N2O	0.00	0.00	5%	0%	5.0%	1.48E-21	0.0E+00	7.0E-11	4.9E-21
2B5	Other: Fertilizer production	N2O	46.49	0.00	7%	40%	40.6%	0.00E+00	4.8E-03	0.0E+00	2.4E-05
2G3a	N2O from Product Uses: Medical Applications	N2O	5.30	2.07	6%	5%	7.8%	1.18E-09	4.7E-05	4.8E-05	4.5E-09
2G3b	N2O from Product Uses: Other	N2O	0.72	0.47	6%	5%	7.8%	5.99E-11	4.4E-06	1.1E-05	1.4E-10
2G4tob	Other: Tobacco	N2O	0.08	0.27	2%	50%	50.0%	8.47E-10	2.1E-05	2.1E-06	4.3E-10
3B1	Manure Management: Cattle	N2O	0.74	0.75	11%	100%	100.6%	2.57E-08	2.8E-05	3.2E-05	1.8E-09
3B25	Manure Management: Indirect	N2O	9.58	8.28	100%	400%	412.3%	5.23E-05	2.8E-03	3.2E-03	1.8E-05
3B2	Manure Management: Sheep	N2O	11.09	8.33	25%	100%	103.2%	3.32E-06	1.1E-03	8.2E-04	1.9E-06
3B3	Manure Management: Swine	N2O	0.00	0.00	11%	100%	100.6%	0.00E+00	0.0E+00	0.0E+00	0.0E+00
3B4	Manure Management: Other Livestock	N2O	1.21	1.05	24%	200%	201.4%	2.00E-07	1.8E-04	9.6E-05	4.1E-08

	IPCC Category	Gas	1990 emissions (kt CO_2e)	2019 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	N2O	58.41	48.61	5%	233%	233.4%	5.77E-04	1.1E-02	9.3E-04	1.2E-04
3D1.2	Organic N Fertilizers	N2O	38.01	32.73	63%	233%	241.6%	2.80E-04	6.8E-03	7.9E-03	1.1E-04
3D1.3	Urine and Dung Deposited by Grazing Animals	N2O	47.86	41.88	57%	233%	240.1%	4.54E-04	8.3E-03	9.1E-03	1.5E-04
3D1.5	Crop Residues	N2O	0.00	0.00	0%	0%	0.0%	0.00E+00	0.0E+00	0.0E+00	0.0E+00
3D1.6	Mineralization Associated with Loss/gain of Soil Organic Carbon	N2O	61.08	82.14	20%	200%	201.0%	1.22E-03	4.1E-03	6.3E-03	5.6E-05
3D2.1	Cultivation of organic soils	N2O	11.24	10.20	100%	400%	412.3%	7.93E-05	3.1E-03	3.9E-03	2.5E-05
3D2.2	Indirect N2O Emissions	N2O	31.58	26.64	100%	500%	509.9%	8.28E-04	1.3E-02	1.0E-02	2.8E-04
5B	Biological Treatment of Solid Waste	N2O	0.00	1.71	52%	150%	158.7%	3.29E-07	6.1E-04	3.4E-04	4.9E-07
5C	Incineration and Open Burning of Waste	N2O	1.67	0.63	52%	100%	112.7%	2.24E-08	3.3E-04	1.3E-04	1.3E-07
5D2	Wastewater Treatment and Discharge Industrial Wastewater	N2O	0.00	0.00	39%	2495%	2495.3%	0.00E+00	0.0E+00	0.0E+00	0.0E+00
5D1	Wastewater Treatment and Discharge Domestic Wastewater	N2O	4.58	5.94	59%	2495%	2495.7%	9.85E-04	2.5E-03	1.3E-03	8.3E-06
2F1	Refrigeration and Air Conditioning	HFC	0.00	206.35	100%	28%	104.0%	2.06E-03	1.4E-02	7.9E-02	6.5E-03
2F4	Aerosols	HFC	0.34	0.92	10%	10%	14.1%	7.60E-10	1.3E-05	3.5E-05	1.4E-09
2C3	Metal Production - Aluminium Production	PFC	494.64	97.00	3%	30%	30.1%	3.84E-05	3.4E-02	1.1E-03	1.2E-03
2F1	Refrigeration and Air Conditioning	PFC	0.00	0.06	100%	28%	104.0%	1.93E-10	4.9E-06	2.4E-05	6.1E-10
2G1	Electrical Equipment	SF6	1.10	1.99	30%	30%	42.4%	3.21E-08	4.8E-05	2.3E-04	5.5E-08
	Total emissions		3682.84	4722.27							
	Total Uncertainties		% Uncertainty in total inventory (excluding LULUCF):					8.7%		Trend uncertainty:	10.1%

Annex 3: National Energy Balance for the year 2019

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 960 TJ, which is 4.2% of the total energy consumption in Iceland in 2019. The biggest discrepancies in fuel use are in residual fuel oil. This discrepancy will be further analysed with the agencies that provide the data.

Table A3. 1 National Energy Balance for 2019

2019 Unit = TJ	Gasoline	Jet Kerosene	Gas Diesel Oil	Residual Fuel Oil	LPG	Bitumen	Lubricants	Petroleum Coke	Other oil	Anthracite	Coke oven Gas	Natural Gas (Dry)	Solid Biomass	Landfill gas
Indigenous Production	-	-	-	-	-	-	-	-	-	-	-	-	-	51
Imports	5,375	12,859	16,933	2,311	142	607	142	245	0.0	3,994	300	0.1	0	-
Exports	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Bunkers	-	13,376	1,948	781	-	-	-	-	-	-	-	-	-	-
Stock Change	-10	-887	-442	-497	-	-	-	-	-	-	-	-	-	-
Primary Energy Supply	5,385	370	15,427	2,027	142	607	142	245	0.0	3,994	300	0.1	0	51
Non-Energy Use of Fuels						607	142	245		3,994	300	0.1	0	
Available Final Energy Consumption	**5,385**	**370**	**15,427**	**2,027**	**142**	**0**	**0**	**0**	**0.0**	**0**	**0**	**0**	**0**	**51**
1A1ai - Electricity generation	-	-	53	-	-	-	-	-	-	-	-	-	-	-
1A1aiii - Heat Plants	-	-	14	-	-	-	-	-	-	-	-	-	-	-
1A2a - Iron and Steel	-	-	9	-	18	-	-	-	-	-	-	-	-	-
1A2b - Non-ferrous Metals	-	-	27	73	12	-	-	-	-	-	-	-	-	-
1A2e - Food processing, beverages and tobacco	-	-	78	36	-	-	-	-	-	-	-	-	-	-
1A2f - Non-metallic minerals (mineral wool)	-	-	6	-	-	-	-	-	-	-	-	-	-	-
1A2gv Construction	-	-	444	-	-	-	-	-	-	-	-	-	-	-
1A2gvii - Off-road vehicles and mobile machinery	-	1	307	-	-	-	-	-	-	-	-	-	-	-
1A2gviii - Other industry	-	-	-	-	42	-	-	-	-	-	-	-	-	-
1A3a - Domestic Aviation	16	372	-	-	-	-	-	-	-	-	-	-	-	-
1A3b - Road Transport	5,213	-	7,795	-	-	-	-	-	-	-	-	-	-	75
1A3d - Domestic Navigation	-	-	512	195	-	-	-	-	-	-	-	-	-	-
1A4ai - Commercial/Institutional - Stationary combustion	-	-	13	-	4	-	-	-	-	-	-	-	-	-
1A4bi - Residential - Stationary combustion	-	-	28	-	79	-	-	-	-	-	-	-	-	-
1A4ci - Stationary Agriculture	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-
1A4cii Off Road in agriculture	-	-	320	-	-	-	-	-	-	-	-	-	-	-
1A4ciii - Fishing	-	-	5,887	1,044	-	-	-	-	-	-	-	-	-	-
1A5 - Other	-	3	17	3	-	-	-	-	-	-	-	-	-	-
Final Energy Consumption	**5,229**	**376**	**15,510**	**1,350**	**155**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**75**

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	4694.4	1812.7	38.6%	
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	3635.6	1812.7	49.9%	

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	1661.0	NA	NA	
1.A Fuel combustion activities, stationary combustion [4]	CO_2	90.5	10.9	12.0%	
1.A.1 Energy industries	CO_2	5.0	NA		
1.A.1.a Public electricity and heat production	CO_2	5.0	NA		
1.A.1.b Petroleum refining	CO_2	NO	NO		
1.A.1.c Manufacture of solid fuels and other energy industries	CO_2	NO	NO		
Iron and steel total (1.A.2, 1.B, 2.C.1) [5]	CO_2	431.6	1.8	0.4%	includes Ferroalloy/Silicon production
1.A.2. Manufacturing industries and construction	CO_2	84.3	10.9	12.9%	
1.A.2.a Iron and steel	CO_2	1.76	1.76	100.0%	
1.A.2.b Non-ferrous metals	CO_2	8.38	8.52	101.8%	Small differences due to slightly different NCV values used by ETS companies vs. inventory
1.A.2.c Chemicals	CO_2	NO	NO		
1.A.2.d Pulp, paper and print	CO_2	NO	NO		
1.A.2.e Food processing, beverages and tobacco	CO_2	15.2	0.5	3.5%	
1.A.2.f Non-metallic minerals	CO_2	0.5	NA		
1.A.2.g Other	CO_2	58.4	0.03900	0.1%	
1.A.3. Transport	CO_2	1021.2	NA		
1.A.3.e Other transportation (pipeline transport)	CO_2	NO	NO		
1.A.4 Other sectors	CO_2	548.8	NA		
1.A.4.a Commercial / Institutional	CO_2	1.2	NA		
1.A.4.c Agriculture/ Forestry / Fisheries	CO_2	540.5	NA		
1.B Fugitive emissions from Fuels	CO_2	163.1	NA		
1.C CO_2 Transport and storage	CO_2	NO	NO		
1.C.1 Transport of CO_2	CO_2	NO	NO		

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.2 Injection and storage	CO_2	NO	NO		
1.C:3 Other 2.A Mineral products	CO_2	NO	NO		
2.A Mineral products	CO_2	1.0	NA		
2.A.1 Cement Production	CO_2	NO	NO		
2.A.2. Lime production	CO_2	NO	NO		
2.A.3. Glass production	CO_2	NO	NO		
2.A.4. Other process uses of carbonates	CO_2	1.0	NA		
2.B Chemical industry	CO_2	NO	NO		
2.B.1. Ammonia production	CO_2	NO	NO		
2.B.3. Adipic acid production (CO_2)	CO_2	NO	NO		
2.B.4. Caprolactam, glyoxal and glyoxylic acid production	CO_2	NO	NO		
2.B.5. Carbide production	CO_2	NO	NO		
2.B.6 Titanium dioxide production	CO_2	NO	NO		
2.B.7 Soda ash production	CO_2	NO	NO		
2.B.8 Petrochemical and carbon black production	CO_2	NO	NO		
2.C Metal production	CO_2	1705.9	1705.9	100.0%	
2.C.1. Iron and steel production	CO_2	NO	NO		
2.C.2 Ferroalloys production	CO_2	429.8	429.8	100.0%	
2.C.3 Aluminium production	CO_2	1276.1	1276.1	100.0%	
2.C.4 Magnesium production	CO_2	NO	NO		
2.C.5 Lead production	CO_2	NO	NO		
2.C.6 Zinc production	CO_2	NO	NO		
2.C.7 Other metal production	CO_2	NO	NO		

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 (in 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	
2.B.3. Adipic acid production	N_2O	NO	NO	NA	
2.B.4. Caprolactam, glyoxal and glyoxylic acid production	N_2O	NO	NO	NA	

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 (in 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	97.00	97.00	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, the Icelandic inventory underwent a comprehensive review by the EU/EFTA as was required by Art. 4 of Regulation (EU) 2018/842 (so-called Effort-sharing regulation - ESR)[26]. The comprehensive review addressed the emissions falling under the scope of the aforementioned regulation, that is, excluding EU ETS emissions (covered by Directive 2003/87/EC) as well as LULUCF emissions and removals.

A Final Review Report was received by Iceland in August 2020. Three issues were deemed to exceed the threshold of significance for the Icelandic inventory. The table below shows the status of implementation of each recommendation that was listed in the report.

Table A5. 1 Responses to recommendations listed in the review report resulting from the EU Step 2 review.

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
2F1 Refrigeration and Air Conditioning, HFCs, 2017-2018	For HFC-134a emissions in category 2F1e Mobile Air Conditioning the TERT noted that there may be an over-estimation of the emissions due to assumption of too high number of vehicles using refrigerants with GWP higher than 150. In response to a question raised during the review, Iceland explained that new data from car importers and from the Icelandic Transport Authority had become available. Iceland provided revised estimates for the years 2016, 2017 and 2018 taking into account that the share of cars with R1234yf (low GWP) is increasing. The TERT agreed with the revised estimate provided by Iceland. The TERT recommends that Iceland include the revised estimate in its next submission.	IS-2F1-2020-0002	This has been implemented as submitted in the revised estimate	3.4.2 Road Transport (CRF 1A3b)
3A Enteric Fermentation, CH_4, 2018	For Gross Energy for 3A Enteric Fermentation from Dairy Cattle, the TERT noted that there was a step change between 2017 and 2018. In response to a question raised during the review, Iceland explained that this was because new data was available, but interpolation had not been used across the time series. Iceland provided revised estimates for 2016 and 2017 and stated that it will be included in the next submission. The TERT agreed with the revised estimate provided by Iceland. The TERT recommends that Iceland include the revised estimate in its next submission.	IS-3A-2020-0004	This has been implemented as submitted in the revised estimate	Energy chapter

[26] as added to the EEA Agreement with Joint Committee Decision nr. 269/2019.

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
5A Solid Waste Disposal, CH4, 1990-2018	For CH4 emissions from 5A Solid Waste Disposal for all years the TERT noted that in Iceland, industrial waste is mainly composed of two categories in managed landfills (non-hazardous residues from waste treatment and Construction and Demolition (C&D) waste), and only of C&D waste in unmanaged landfills. Nevertheless, a Degradable Organic Carbon (DOC) value corresponding to food industry waste (0.15) is applied (IS-5A-2020-0005). The TERT also noted that the Oxidation Factor value (OX) used by Iceland for managed landfills is 0 although the OX value should have been 0.1 as recommended in Table 3.2 of Volume 5, Chapter 3 of the 2006 IPCC Guidelines for managed landfills covered with oxidising material (IS-5A-2020-0003). In response to a question raised during the review, Iceland agreed with these observations and provided a revised estimate for all applicable years including 2005, 2016, 2017 and 2018 that resolves both observations. In addition, the amount of disposed waste per IPCC waste categories has been corrected by Iceland. The TERT agreed with the revised estimate provided by Iceland. The TERT recommends that Iceland include the revised estimate in its next submission.	IS-5A-2020-0005	This has been implemented as submitted in the revised estimate	Chapter 4.5

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[27],[28]		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

[27] Jóhannes Sveinbjörnsson og Grétar H. Harðarson, 2008. Þungi og átgeta íslenskra mjólkurkúa. Fræðaþing landbúnaðarins: 336-344
[28] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

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[29]	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,[30]	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

[29] Jóhannes Sveinbjörnsson og Bragi L. Ólafsson, 1999. Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi. Ráðunautafundur 1999: 204-217.

[30] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

Table A7. 4 Values used in Calculation of Digestible Energy of Feed: Steers

1. Steers[31],[32]	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[33]	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

[31] Jóhannes Sveinbjörnsson og Bragi L. Ólafsson, 1999. Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi. Ráðunautafundur 1999: 204-217.
[32] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers
[33] Grétar H. Harðarson, Eiríkur Þórkelsson og Jóhannes Sveinbjörnsson, 2007. Uppeldi kálfa: Áhrif kjarnfóðurs með mismiklu tréni á vöxt og heilbrigði kálfa. Fræðaþing landbúnaðarins 2007: 234-239

Table A7. 6 Values used in Calculation of Digestible Energy of Feed: Sheep

1. Sheep, stallfed[34]	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[35]	**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[36]	**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[37,38]	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

[34] Jóhannes Sveinbjörnsson, 2013: Fóðrun og fóðurþarfir sauðfjár. Kafli 4 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.
[35] Jóhannes Sveinbjörnsson, 2013: Fóðuröflun og beit á ræktað land. Kafli 5 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.
[36] Ólafur Guðmundsson, 1987: Átgeta búfjár og nýting beitar. Ráðunautafundur 1987: 181-192
[37] Ólafur Guðmundsson, 1987: Átgeta búfjár og nýting beitar. Ráðunautafundur 1987: 181-192
[38] Stefán Sch. Thorsteinsson og Sigurgeir Thorgeirsson, 1989: Winterfeeding, housing and management. P. 113-145 í: Reproduction, nutrition and growth in sheep. Dr. Halldór Pálsson memorial publication. (Eds. Ólafur R. Dýrmundsson and Sigurgeir Thorgeirsson). Agricultural Research Institute and Agricultural Society, Iceland)

2. Lambs, after-weaning[39],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)) *09752 *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

[39] Jóhannes Sveinbjörnsson, 2013: Fóðuröflun og beit á ræktað land. Kafli 5 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 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, 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, 2015).

The Icelandic soil classification system distinguishes three main soil types: **Vitrisols, Andosols**, and **Histosols** (Arnalds, 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, 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, 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, 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 ($(Al_2O_3)(SiO_2)1.3\bullet2.5(H_2O)$), Imogolite ($Al_2SiO_3(OH)_4$), Ferrihydrite ($Fe^{3+}2O_3\bullet0.5(H_2O)$) and Halloysite ($Al_2Si_2O_5(OH)_4$)[40]. 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, 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, 2015). The clay minerals all have large reactive surface areas and the cation exchange capacity rises with increasing pH (Arnalds, 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, 2015). The aeolian input in Iceland is not

[40] 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, 2015).

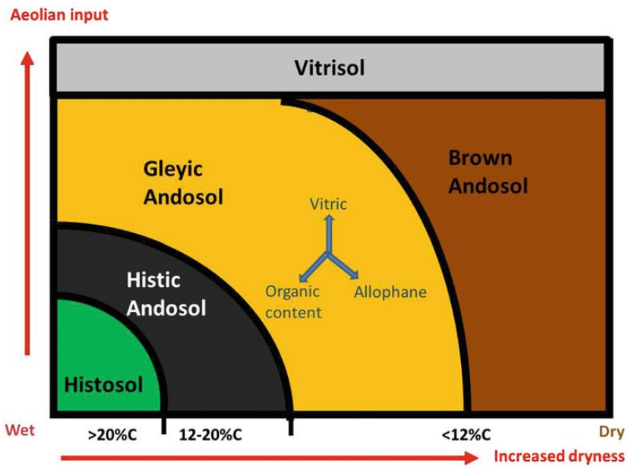

Figure A8. 1 Classification of Icelandic Andosols together with Vitrisols (soils of the desert) and Histosols (wetland soils), determined by the aeolian input and the drainage conditions. The amount of soil carbon is also given, separating Histosols (20%) from Andosols, (Arnalds, 2015).

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, 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, 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, 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)

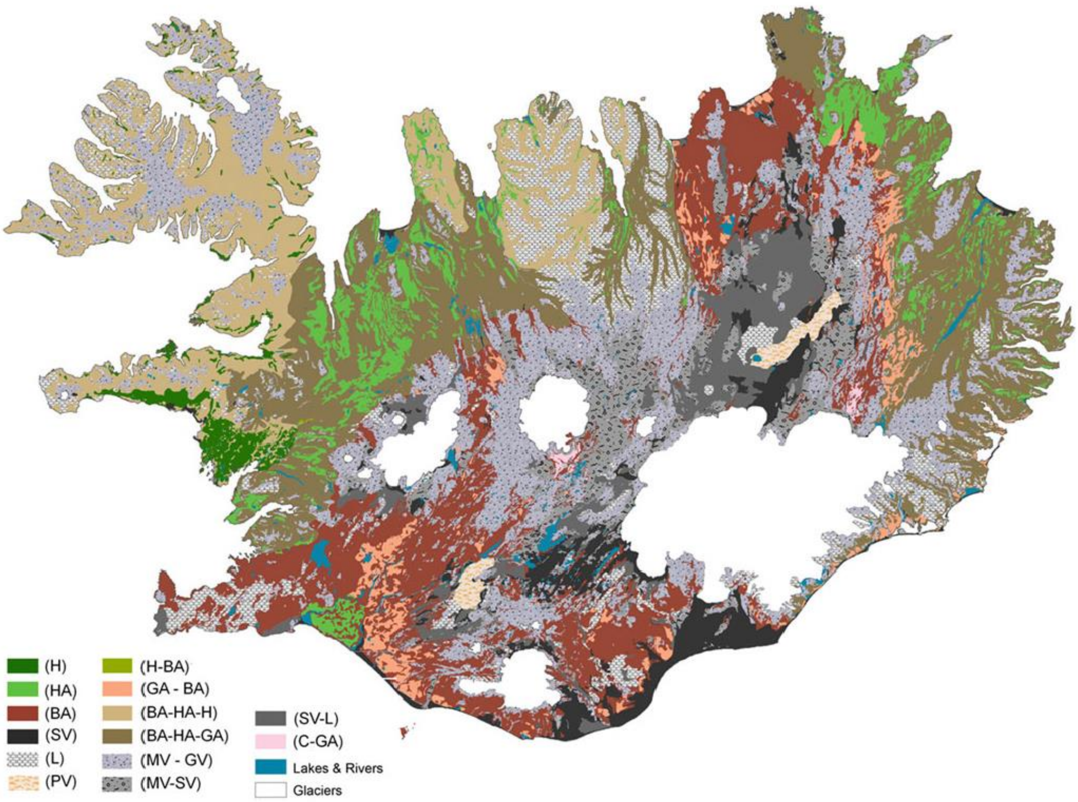

Figure A8. 2 General soil map of Iceland (Arnalds, 2015), based on Arnalds & Oskarsson, (2009). H: Histosol, HA: Histic Andosol, GA: Gleyic Andosol, BA: Brown Andosol, MV: Cambic Vitrisol, GV: Gravelly Vitrisol, SV: Sandy Vitrisol, PV: Pumice Vitrisol, L: Leptosol, C: Cryosol

Cultivation of Organic Soils in Iceland

According to the IPCC 2006 Guidelines, Volume 4 (AFOLU), Chapter 11[41], 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

[41] IPCC 2006 Guidelines, Volume 4, Agriculture, Forestry and Other Land Use.

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, 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

Icelandic inland wetlands cover an area of about 9000 km^2 and represent around 19.4% of vegetated surfaces (Arnalds et al., 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 et al., 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 et al., 2016; Arnalds, 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 et al., 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 et al., 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 et al., 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 et al., 2016).

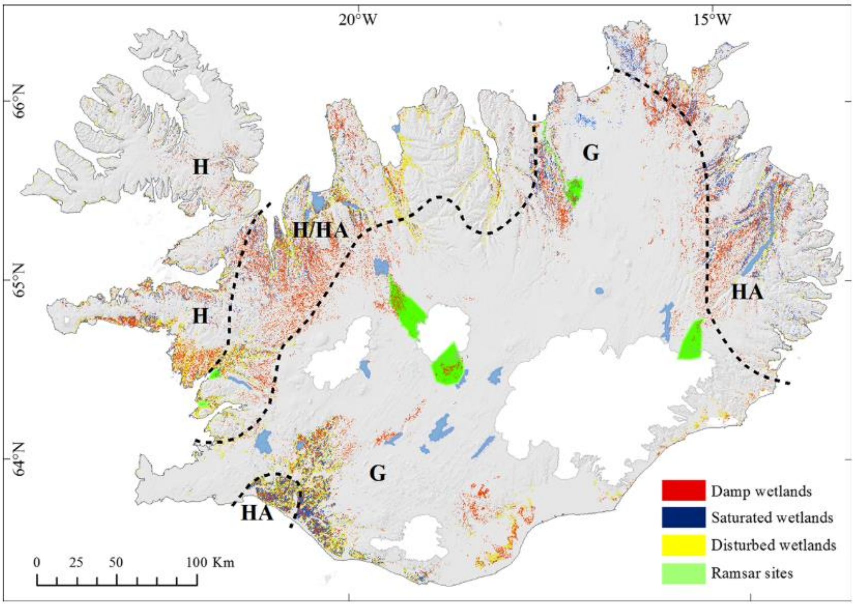

Figure A8. 3 Inland wetlands in Iceland. H: Histosols, HA: Histic Andosols, G: Gleyic Andosols. In green the Ramsar sites are shown. Large water bodies are light blue, in white are the main glaciers (Arnalds et al., 2016).

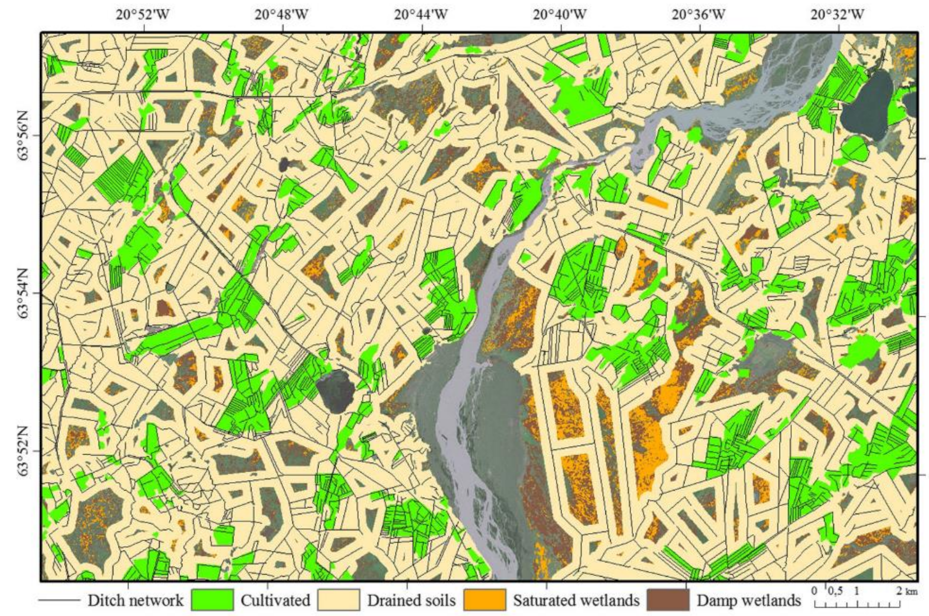

Figure A8. 4 South Iceland, close to the river Þjórsá. The black lines show the system of ditches created to drain the wetlands. Of the drained soils, only the green patches are cultivated as hay fields (Arnalds et al., 2016).

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[42] 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, 2008).

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.

[42] 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 (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 (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 et al. (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) [43]. These numbers derive directly from the experiments of Guðmundsson (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, 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 et al. (2016) show in a flooding experiment how the oxidation of Fe(II) is coupled to denitrification and therefore low N_2O emissions from paddy soils. The presence of ferrihydrite in Icelandic soils is clearly a sign of the oxidation process of iron, a consequence of the aeolian input of volcanic parent material.

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 fore

[43] 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 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).

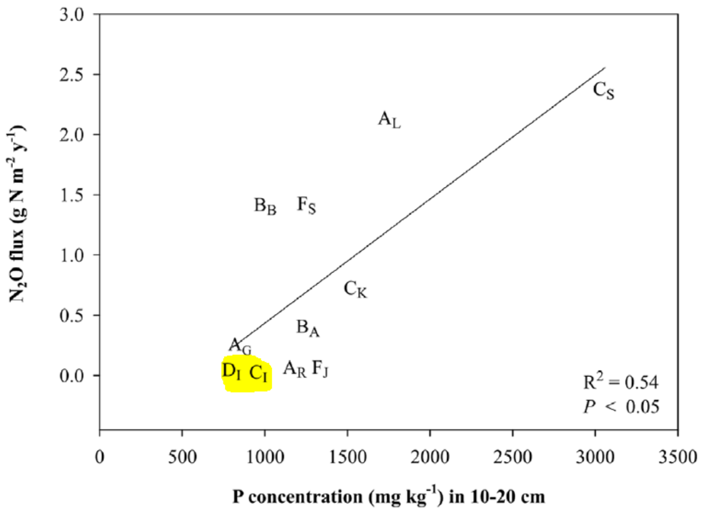

Fig. 4. Correlation between N_2O emissions (g N m^{-2} y^{-1}) *in situ* and the content of total P (mg kg^{-1}) in soil at the depth of 10–20 cm.

Figure A8. 5 Correlation between N2O 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).

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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	0.8	
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	2.8

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	0.141	29.2	1.8	5.0	1.8	1.3	0.0	0.9	9.9	3.0
1951	0.144	27.8	1.7	4.9	1.7	1.3	0.0	0.9	9.6	2.9
1952	0.147	27.4	1.7	5.0	1.7	1.3	0.0	0.9	9.8	2.9
1953	0.149	31.9	2.0	6.0	2.0	1.5	0.0	1.0	11.7	3.4
1954	0.153	35.0	2.2	6.8	2.2	1.7	0.0	1.2	13.1	3.8
1955	0.156	38.2	2.5	7.7	2.4	1.8	0.0	1.3	14.7	4.2
1956	0.159	38.4	2.5	8.0	2.5	1.9	0.0	1.3	15.2	4.2
1957	0.163	37.7	2.5	8.1	2.5	1.9	0.0	1.3	15.3	4.2
1958	0.167	41.2	2.7	9.1	2.7	2.0	0.0	1.4	17.1	4.6
1959	0.170	41.8	2.8	9.5	2.8	2.1	0.0	1.5	17.8	4.8
1960	0.174	41.9	2.8	9.9	2.8	2.1	0.0	1.5	18.3	4.8
1961	0.177	42.9	2.9	10.4	2.9	2.2	0.0	1.5	19.2	5.0
1962	0.181	46.1	3.2	11.5	3.2	2.4	0.0	1.7	21.2	5.4
1963	0.184	50.2	3.5	12.9	3.5	2.6	0.0	1.8	23.6	6.0
1964	0.187	55.4	3.9	14.7	3.9	2.9	0.0	2.0	26.7	6.7
1965	0.191	60.3	4.3	16.5	4.3	3.2	0.0	2.3	29.8	7.3
1966	0.194	64.5	4.7	18.2	4.6	3.5	0.0	2.4	32.7	8.0
1967	0.197	61.3	4.5	17.8	4.5	3.4	0.0	2.3	31.8	7.6
1968	0.200	57.2	4.3	17.1	4.2	3.2	0.0	2.2	30.5	7.2
1969	0.203	58.0	4.4	17.9	4.3	3.3	0.0	2.3	31.6	7.4
1970	0.204	63.7	4.9	20.2	4.8	3.6	0.0	2.5	35.6	8.2
1971	0.205	71.8	5.5	23.4	5.5	4.1	0.0	2.9	41.2	9.4
1972	0.207	72.2	5.6	24.3	5.6	4.2	0.0	2.9	42.4	9.6
1973	0.211	78.4	6.2	27.1	6.1	4.6	0.0	3.2	47.2	10.5
1974	0.214	78.5	6.3	27.9	6.2	4.7	0.0	3.3	48.5	10.7
1975	0.217	74.0	6.0	27.1	5.9	4.5	0.0	3.1	46.8	10.2
1976	0.219	78.6	6.5	29.6	6.4	4.8	0.0	3.4	51.0	11.0
1977	0.221	85.3	7.1	33.0	7.0	5.3	0.0	3.7	56.7	12.1
1978	0.223	88.3	7.5	35.2	7.4	5.6	0.0	3.9	60.2	12.7
1979	0.225	88.2	7.5	36.1	7.5	5.6	0.0	3.9	61.6	12.8
1980	0.227	90.0	7.8	37.9	7.7	5.8	0.0	4.1	64.4	13.3
1981	0.229	90.5	8.2	40.3	8.1	6.1	1.0	4.3	69.8	13.9
1982	0.232	88.8	8.4	41.9	8.3	6.3	2.0	4.4	73.8	14.2
1983	0.236	82.7	8.2	41.4	8.1	6.1	3.0	4.2	74.1	13.9
1984	0.238	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	0.241	81.6	8.9	46.1	8.8	6.6	5.4	4.6	85.3	15.1
1986	0.242	84.7	9.7	51.1	9.6	7.2	7.1	5.0	96.0	16.5
1987	0.244	88.5	10.7	57.2	10.6	8.0	9.2	5.6	108.8	18.2
1988	0.248	83.6	10.7	58.0	10.6	8.0	10.5	5.6	111.9	18.2
1989	0.252	78.2	10.6	58.4	10.5	8.0	11.7	5.5	114.1	18.1
1990	0.254	72.3	10.5	58.4	10.4	7.9	12.9	5.5	115.6	17.9
1991	0.256	18.5	2.7	14.9	2.7	2.0	3.3	1.4	29.5	4.6
1992	0.260	17.8	2.6	14.4	2.6	1.9	3.2	1.3	28.5	4.4
1993	0.262	17.7	2.6	14.3	2.5	1.9	3.1	1.3	28.3	4.4
1994	0.265	18.0	2.6	14.5	2.6	2.0	3.2	1.4	28.8	4.5
1995	0.267	12.2	1.8	9.8	1.8	1.3	2.2	0.9	19.5	3.0
1996	0.268	11.4	1.7	9.2	1.6	1.2	2.0	0.9	18.2	2.8
1997	0.270	11.4	1.7	9.2	1.6	1.2	2.0	0.9	18.2	2.8
1998	0.272	8.7	1.3	7.0	1.3	0.9	1.6	0.7	13.9	2.2
1999	0.276	8.7	1.3	7.0	1.2	0.9	1.5	0.7	13.8	2.1
2000	0.279	8.8	1.3	7.1	1.3	1.0	1.6	0.7	14.1	2.2
2001	0.283	8.5	1.2	6.9	1.2	0.9	1.5	0.6	13.6	2.1
2002	0.287	8.3	1.2	6.7	1.2	0.9	1.5	0.6	13.3	2.1
2003	0.288	8.4	1.2	6.8	1.2	0.9	1.5	0.6	13.4	2.1
2004	0.291	8.3	1.2	6.7	1.2	0.9	1.5	0.6	13.3	2.1
2005	0.294	14.0	2.0	11.3	2.0	1.5	2.5	1.1	22.4	3.5
2006	0.300	12.4	1.8	10.0	1.8	1.3	2.2	0.9	19.8	3.1
2007	0.308	11.9	0.7	3.3	0.3	0.3	0.6	0.1	13.5	1.3
2008	0.315	16.0	10.0	5.8	1.1	0.8	1.0	3.5	28.5	4.9
2009	0.319	14.2	4.6	2.1	0.5	0.7	1.1	1.2	16.9	3.7
2010	0.318	11.7	2.3	2.9	0.9	0.5	1.0	0.5	21.9	2.9
2011	0.318	14.2	2.7	3.2	0.8	0.5	1.1	0.7	9.3	3.8
2012	0.320	13.0	0.2	2.4	1.7	0.4	0.8	0.9	10.7	1.6
2013	0.322	11.4	0.8	1.0	1.2	0.5	1.0	1.0	6.9	2.1
2014	0.326	5.6	0.1	0.8	0.3	0.2	0.5	0.4	37.0	0.9
2015	0.329	5.0	0.3	1.0	0.3	0.3	0.6	0.3	43.9	1.1
2016	0.333	3.9	0.1	1.0	0.5	0.3	0.5	0.2	48.9	1.3
2017	0.338	3.1	0.0	1.6	0.9	0.2	0.1	0.4	20.5	1.5
2018	0.348	3.1	0.0	2.0	1.1	0.2	0.2	1.1	22.6	1.2
2019	0.357	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 1990-2019

1990

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2021 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)	7948.90	4073.08	357.03	0.34	494.64	1.10	NO,NA	NO,NA	12875.10
1. Energy	1813.22	8.75	27.13						1849.10
A. Fuel combustion (sectoral approach)	1751.86	8.07	27.13						1787.06
1. Energy industries	13.48	0.01	0.03						13.53
2. Manufacturing industries and construction	358.43	0.48	14.58						373.48
3. Transport	604.91	5.73	6.53						617.17
4. Other sectors	774.91	1.85	5.99						782.76
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	407.39	1.62	52.58	0.34	494.64	1.10	NO,NA	NO,NA	957.67
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	6.76	NE,NA	NE,NA						6.76
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	385.37	270.87						656.76
A. Enteric fermentation		326.32							326.32
B. Manure management		59.05	22.61						81.66
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	248.26						248.26
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.46								0.46
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5720.48	3471.53	0.18						9192.19
A. Forest land	-43.44	0.10	0.11						-43.23
B. Cropland	1880.20	94.83	NO,NA						1975.03
C. Grassland	4997.70	374.02	0.07						5371.79
D. Wetlands	-1130.37	3002.58	NO,NA						1872.21
E. Settlements	16.39	NE,NA	NO,NE,IE,NA						16.39
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	238.29	0.08	1.98						240.35
Aviation	219.44	0.04	1.83						221.31
Navigation	18.85	0.04	0.15						19.04
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						
Indirect CO_2 (3)	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3682.90
Total CO_2 equivalent emissions with land use, land-use change and forestry									12875.10
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 2021 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)]	7829.97	4072.53	349.48	0.69	410.61	1.24	NO,NA	NO,NA	12664.53
1. Energy	1725.58	8.63	26.39						1760.60
A. Fuel combustion (sectoral approach)	1655.63	8.04	26.39						1690.05
1. Energy industries	15.08	0.01	0.04						15.13
2. Manufacturing industries and construction	281.92	0.39	13.76						296.07
3. Transport	616.08	5.86	6.85						628.79
4. Other sectors	742.42	1.77	5.73						749.92
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	372.99	1.31	50.54	0.69	410.61	1.24	NO,NA	NO,NA	837.38
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	6.63	NE,NA	NE,NA						6.63
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			6.84
H. Other	NA	NA	NA						NA
3. Agriculture	0.24	374.72	266.04						641.00
A. Enteric fermentation		316.86							316.86
B. Manure management		57.86	21.49						79.35
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	244.54						244.54
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.18								0.18
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5723.92	3474.21	0.24						9198.37
A. Forest land	-44.90	0.14	0.16						-44.59
B. Cropland	1878.19	94.71	NO,NA						1972.90
C. Grassland	4997.70	374.48	0.08						5372.27
D. Wetlands	-1123.47	3004.87	NO,NA						1881.40
E. Settlements	16.39	NE,NA	NO,NE,IE,NA						16.39
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	228.94	0.06	1.91						230.90
Aviation	221.77	0.04	1.85						223.66
Navigation	7.17	0.02	0.06						7.25
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						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3466.17
Total CO_2 equivalent emissions with land use, land-use change and forestry									12664.53
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 2021 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)	7970.42	4080.21	334.68	0.70	183.04	1.24	NO,NA	NO,NA	12570.30
1. Energy	1871.12	8.93	26.69						1906.74
A. Fuel combustion (sectoral approach)	1803.50	8.28	26.69						1838.47
1. Energy industries	14.08	0.01	0.03						14.13
2. Manufacturing industries and construction	337.22	0.42	12.98						350.61
3. Transport	626.40	5.88	7.29						639.57
4. Other sectors	825.01	1.96	6.39						833.36
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	376.25	1.41	45.22	0.70	183.04	1.24	NO,NA	NO,NA	607.86
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	6.77	NE,NA	NE,NA						6.77
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	370.06	256.14						626.76
A. Enteric fermentation		313.02							313.02
B. Manure management		57.03	20.10						77.13
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	236.04						236.04
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.50								0.50
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5715.46	3473.56	0.31						9189.33
A. Forest land	-49.50	0.20	0.22						-49.08
B. Cropland	1875.57	94.60	NO,NA						1970.16
C. Grassland	4996.07	374.94	0.09						5371.11
D. Wetlands	-1123.07	3003.82	NO,NA						1880.75
E. Settlements	16.39	NE,NA	NO,NE,IE,NA						16.39
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	214.82	0.06	1.79						216.67
Aviation	203.42	0.04	1.70						205.15
Navigation	11.40	0.03	0.09						11.52
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						
Indirect CO_2 (3)	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3380.97
Total CO_2 equivalent emissions with land use, land-use change and forestry									12570.30
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.

1993

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1993
Submission 2021 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)]	8134.21	4093.68	343.31	1.58	88.24	1.24	NO,NA	NO,NA	12662.27
1. Energy	1979.57	8.90	28.79						2017.27
A. Fuel combustion (sectoral approach)	1894.20	8.25	28.79						1931.24
1. Energy industries	17.23	0.03	0.10						17.36
2. Manufacturing industries and construction	364.46	0.46	14.02						378.93
3. Transport	626.90	5.65	7.77						640.32
4. Other sectors	884.16	2.10	6.91						893.17
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	425.19	1.73	47.23	1.58	88.24	1.24	NO,NA	NO,NA	565.21
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	7.02	NE,NA	NE,NA						7.02
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			6.21
H. Other	NA	NA	NA						NA
3. Agriculture	0.50	369.42	260.80						630.72
A. Enteric fermentation		312.72							312.72
B. Manure management		56.70	20.22						76.92
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	240.59						240.59
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.44								0.44
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5722.95	3472.89	0.33						9196.17
A. Forest land	-54.65	0.21	0.23						-54.21
B. Cropland	1872.98	94.48	NO,NA						1967.46
C. Grassland	4996.10	375.41	0.09						5371.60
D. Wetlands	-1122.68	3002.79	NO,NA						1880.11
E. Settlements	31.20	NE,NA	NO,NE,IE,NA						31.20
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	213.98	0.08	1.78						215.83
Aviation	195.45	0.03	1.63						197.11
Navigation	18.52	0.04	0.15						18.72
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						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3466.10
Total CO_2 equivalent emissions with land use, land-use change and forestry									12662.27
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 2021 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)]	8059.56	4100.73	349.09	2.03	52.53	1.24	NO,NA	NO,NA	12565.19
1. Energy	1932.82	8.70	29.50						1971.01
A. Fuel combustion (sectoral approach)	1862.70	8.03	29.50						1900.22
1. Energy industries	17.09	0.03	0.09						17.22
2. Manufacturing industries and construction	346.20	0.44	14.22						360.86
3. Transport	629.73	5.49	8.38						643.60
4. Other sectors	869.58	2.06	6.80						878.44
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	426.28	1.70	47.09	2.03	52.53	1.24	NO,NA	NO,NA	530.87
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	6.93	NE,NA	NE,NA						6.93
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	371.79	266.06						637.91
A. Enteric fermentation		315.20							315.20
B. Manure management		56.59	20.23						76.82
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	245.82						245.82
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.01								0.01
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5694.87	3471.73	0.35						9166.95
A. Forest land	-57.57	0.22	0.25						-57.10
B. Cropland	1870.41	94.36	NO,NA						1964.77
C. Grassland	4996.25	376.11	0.10						5372.46
D. Wetlands	-1122.01	3001.04	NO,NA						1879.03
E. Settlements	7.78	NE,NA	NO,NE,IE,NA						7.78
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	231.16	0.08	1.92						233.16
Aviation	213.41	0.04	1.78						215.23
Navigation	17.75	0.04	0.14						17.93
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						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3398.24
Total CO_2 equivalent emissions with land use, land-use change and forestry									12565.19
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1995

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1995
Submission 2021 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)]	8157.69	4098.87	343.62	3.43	69.36	1.24	NO,NA	NO,NA	12674.22
1. Energy	2018.49	8.57	34.02						2061.08
A. Fuel combustion (sectoral approach)	1936.25	7.87	34.02						1978.15
1. Energy industries	18.67	0.04	0.11						18.83
2. Manufacturing industries and construction	364.74	0.45	17.68						382.88
3. Transport	604.44	5.13	8.81						618.38
4. Other sectors	946.77	2.25	7.42						956.43
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	443.68	1.83	45.01	3.43	69.36	1.24	NO,NA	NO,NA	564.55
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	7.44	NE,NA	NE,NA						7.44
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	359.02	258.02						617.10
A. Enteric fermentation		303.23							303.23
B. Manure management		55.79	19.24						75.03
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	238.78						238.78
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.00								0.00
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5690.59	3470.12	0.40						9161.11
A. Forest land	-67.19	0.26	0.30						-66.63
B. Cropland	1867.82	94.24	NO,NA						1962.06
C. Grassland	4997.64	377.03	0.11						5374.78
D. Wetlands	-1121.08	2998.58	NO,NA						1877.50
E. Settlements	13.40	NE,NA	NO,NE,IE,NA						13.40
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	239.27	0.05	1.99						241.32
Aviation	235.92	0.04	1.97						237.93
Navigation	3.35	0.01	0.03						3.39
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						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3513.11
Total CO_2 equivalent emissions with land use, land-use change and forestry									12674.22
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 2021 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)]	8210.93	4118.98	359.58	10.65	29.64	1.24	NO,NA	NO,NA	12731.03
1. Energy	2074.76	8.47	34.57						2117.79
A. Fuel combustion (sectoral approach)	1993.49	7.69	34.57						2035.75
1. Energy industries	16.77	0.05	0.13						16.94
2. Manufacturing industries and construction	407.23	0.48	17.26						424.97
3. Transport	595.25	4.84	9.57						609.66
4. Other sectors	973.85	2.32	7.61						983.78
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	443.04	1.86	52.29	10.65	29.64	1.24	NO,NA	NO,NA	538.73
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	7.40	NE,NA	NE,NA						7.40
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			6.21
H. Other	NA	NA	NA						NA
3. Agriculture	0.41	364.24	266.23						630.88
A. Enteric fermentation		307.87							307.87
B. Manure management		56.37	19.47						75.84
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	246.76						246.76
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.35								0.35
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5688.36	3470.52	0.42						9159.29
A. Forest land	-71.38	0.28	0.31						-70.78
B. Cropland	1865.20	94.12	NO,NA						1959.33
C. Grassland	4998.14	377.84	0.11						5376.09
D. Wetlands	-1118.72	2998.27	NO,NA						1879.55
E. Settlements	15.11	NE,NA	NO,NE,IE,NA						15.11
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	290.37	0.09	2.41						292.87
Aviation	271.24	0.05	2.26						273.55
Navigation	19.12	0.05	0.15						19.32
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						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3571.74
Total CO_2 equivalent emissions with land use, land-use change and forestry									12731.03
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.

1997

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1997
Submission 2021 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)]	8307.90	4120.25	353.79	16.89	97.08	1.24	NO,NA	NO,NA	12897.15
1. Energy	2111.31	8.23	38.92						2158.47
A. Fuel combustion (sectoral approach)	2044.46	7.44	38.92						2090.82
1. Energy industries	11.64	0.04	0.12						11.80
2. Manufacturing industries and construction	474.95	0.58	20.77						496.30
3. Transport	606.58	4.56	10.55						621.69
4. Other sectors	951.26	2.26	7.48						961.00
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	502.25	1.83	44.44	16.89	97.08	1.24	NO,NA	NO,NA	663.74
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	7.29	NE,NA	NE,NA						7.29
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	360.77	263.92						625.45
A. Enteric fermentation		305.43							305.43
B. Manure management		55.35	19.54						74.89
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	244.37						244.37
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.69								0.69
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5689.37	3467.93	0.45						9157.75
A. Forest land	-78.27	0.29	0.33						-77.64
B. Cropland	1862.63	94.01	NO,NA						1956.63
C. Grassland	5006.14	379.29	0.12						5385.55
D. Wetlands	-1117.21	2994.33	NO,NA						1877.13
E. Settlements	16.07	NE,NA	NO,NE,IE,NA						16.07
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	330.12	0.14	2.74						333.00
Aviation	291.83	0.05	2.43						294.31
Navigation	38.29	0.09	0.31						38.69
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						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3739.40
Total CO_2 equivalent emissions with land use, land-use change and forestry									12897.15
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.

1998

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1998
Submission 2021 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)]	8332.65	4115.99	354.65	26.31	212.33	1.24	NO,NA	NO,NA	13043.18
1. Energy	2103.82	8.15	40.01						2151.98
A. Fuel combustion (sectoral approach)	2020.10	7.14	40.01						2067.25
1. Energy industries	13.67	0.04	0.12						13.83
2. Manufacturing industries and construction	447.76	0.57	20.95						469.28
3. Transport	609.67	4.27	11.54						625.49
4. Other sectors	944.01	2.25	7.39						953.65
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	530.10	1.60	39.53	26.31	212.33	1.24	NO,NA	NO,NA	811.13
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	7.43	NE,NA	NE,NA						7.43
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	5.09		NO	1.24			6.38
H. Other	NA	NA	NA						NA
3. Agriculture	0.08	368.13	268.64						636.85
A. Enteric fermentation		311.29							311.29
B. Manure management		56.84	20.03						76.87
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	248.61						248.61
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.00								0.00
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5695.09	3464.15	0.50						9159.74
A. Forest land	-86.79	0.34	0.37						-86.08
B. Cropland	1860.04	93.89	NO,NA						1953.93
C. Grassland	5020.34	381.34	0.12						5401.81
D. Wetlands	-1114.85	2988.59	NO,NA						1873.74
E. Settlements	16.36	NE,NA	NO,NE,IE,NA						16.36
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	389.58	0.18	3.23						392.99
Aviation	337.80	0.06	2.82						340.67
Navigation	51.78	0.12	0.41						52.32
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						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3883.44
Total CO_2 equivalent emissions with land use, land-use change and forestry									13043.18
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1999

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1999
Submission 2021 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)]	8549.80	4118.15	363.66	37.98	204.17	1.24	NO,NA	NO,NA	13275.00
1. Energy	2158.41	8.31	42.33						2209.04
A. Fuel combustion (sectoral approach)	2047.13	6.94	42.33						2096.40
1. Energy industries	11.32	0.04	0.12						11.48
2. Manufacturing industries and construction	471.85	0.59	22.91						495.34
3. Transport	631.06	4.08	12.00						647.14
4. Other sectors	928.52	2.22	7.29						938.03
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	678.97	1.86	40.01	37.98	204.17	1.24	NO,NA	NO,NA	964.23
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	6.98	NE,NA	NE,NA						6.98
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	366.52	274.92						641.53
A. Enteric fermentation		310.02							310.02
B. Manure management		56.50	20.12						76.62
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	254.80						254.80
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.02								0.02
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5709.41	3459.75	0.53						9169.69
A. Forest land	-93.15	0.36	0.40						-92.39
B. Cropland	1857.52	93.77	NO,NA						1951.29
C. Grassland	5038.74	383.62	0.13						5422.49
D. Wetlands	-1112.36	2982.00	NO,NA						1869.64
E. Settlements	18.66	NE,NA	NO,NE,IE,NA						18.66
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	402.14	0.16	3.34						405.64
Aviation	363.01	0.06	3.03						366.10
Navigation	39.13	0.09	0.31						39.54
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						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4105.31
Total CO_2 equivalent emissions with land use, land-use change and forestry									13275.00
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2000

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2000
Submission 2021 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)]	8661.57	4110.73	343.20	43.96	149.89	1.31	NO,NA	NO,NA	13310.67
1. Energy	2140.49	8.09	42.72						2191.30
A. Fuel combustion (sectoral approach)	1987.34	6.58	42.72						2036.64
1. Energy industries	11.03	0.04	0.12						11.18
2. Manufacturing industries and construction	422.45	0.55	23.28						446.28
3. Transport	633.55	3.81	12.09						649.45
4. Other sectors	915.69	2.18	7.22						925.09
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	788.79	2.76	22.84	43.96	149.89	1.31	NO,NA	NO,NA	1009.56
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	7.35	NE,NA	NE,NA						7.35
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	353.16	271.12						624.39
A. Enteric fermentation		297.84							297.84
B. Manure management		55.32	19.55						74.87
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	251.57						251.57
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.04								0.04
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5729.44	3453.82	0.61						9183.87
A. Forest land	-103.47	0.42	0.47						-102.57
B. Cropland	1854.97	93.65	NO,NA						1948.62
C. Grassland	5068.64	386.65	0.14						5455.42
D. Wetlands	-1109.00	2973.10	NO,NA						1864.10
E. Settlements	18.30	NE,NA	NO,NE,IE,NA						18.30
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	461.47	0.20	3.83						465.50
Aviation	407.33	0.07	3.40						410.80
Navigation	54.14	0.13	0.43						54.70
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						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4126.80
Total CO_2 equivalent emissions with land use, land-use change and forestry									13310.67
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 2021 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)	8608.03	4117.12	338.48	41.10	108.04	1.31	NO,NA	NO,NA	13214.08
1. Energy	2029.74	7.59	41.70						2079.03
A. Fuel combustion (sectoral approach)	1885.97	6.06	41.70						1933.73
1. Energy industries	10.62	0.04	0.12						10.77
2. Manufacturing industries and construction	455.05	0.60	22.89						478.54
3. Transport	644.29	3.61	12.68						660.58
4. Other sectors	756.24	1.80	5.96						764.00
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	831.00	2.87	20.21	41.10	108.04	1.31	NO,NA	NO,NA	1004.53
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	6.45	NE,NA	NE,NA						6.45
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				41.10	0.00	NO	NO	NO	41.10
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	355.45	269.99						625.54
A. Enteric fermentation		299.54							299.54
B. Manure management		55.91	19.42						75.33
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	250.58						250.58
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.02								0.02
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry (1)	5744.60	3450.08	0.66						9195.34
A. Forest land	-109.18	0.46	0.51						-108.20
B. Cropland	1852.49	93.53	NO,NA						1946.02
C. Grassland	5089.85	388.77	0.14						5478.77
D. Wetlands	-1106.66	2967.31	NO,NA						1860.65
E. Settlements	18.09	NE,NA	NO,NE,IE,NA						18.09
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	2.58	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	408.11	0.20	3.38						411.69
Aviation	348.78	0.06	2.91						351.75
Navigation	59.33	0.14	0.48						59.94
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						
Indirect CO_2 (3)	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4018.74
Total CO_2 equivalent emissions with land use, land-use change and forestry									13214.08
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.

2002

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2002
Submission 2021 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)]	8765.30	4117.88	313.59	49.32	85.51	1.31	NA,NO	NA,NO	13332.91
1. Energy	2140.45	7.57	41.46						2189.48
A. Fuel combustion (sectoral approach)	1993.03	6.03	41.46						2040.53
1. Energy industries	11.50	0.04	0.12						11.66
2. Manufacturing industries and construction	458.92	0.58	21.50						480.99
3. Transport	647.88	3.37	13.04						664.29
4. Other sectors	852.12	2.03	6.75						860.90
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	848.30	3.02	4.36	49.32	85.51	1.31	NA,NO	NA,NO	991.82
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	6.69	NE,NA	NE,NA						6.69
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				49.32	0.01	NO	NO	NO	49.33
G. Other product manufacture and use	0.01	0.05	4.36		NO	1.31			5.74
H. Other	NA	NA	NA						NA
3. Agriculture	0.14	348.67	261.75						610.56
A. Enteric fermentation		294.12							294.12
B. Manure management		54.55	19.20						73.75
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	242.55						242.55
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.06								0.06
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NE								NE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5774.02	3444.88	0.70						9219.59
A. Forest land	-118.48	0.49	0.55						-117.43
B. Cropland	1850.02	93.41	NO,NA						1943.44
C. Grassland	5123.35	391.72	0.15						5515.22
D. Wetlands	-1103.62	2959.25	NO,NA						1855.63
E. Settlements	22.74	NE,NA	NO,NE,IE,NA						22.74
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	2.40	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	395.00	0.26	3.27						398.52
Aviation	309.54	0.05	2.58						312.18
Navigation	85.46	0.20	0.69						86.35
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						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4113.32
Total CO_2 equivalent emissions with land use, land-use change and forestry									13332.91
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 2021 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)	8758.35	4104.42	308.18	46.55	70.48	1.31	NA,NO	NA,NO	13289.29
1. Energy	2131.03	7.32	40.30						2178.65
A. Fuel combustion (sectoral approach)	1994.68	5.83	40.30						2040.81
1. Energy industries	9.63	0.04	0.11						9.79
2. Manufacturing industries and construction	422.61	0.53	19.71						442.85
3. Transport	741.95	3.32	13.97						759.24
4. Other sectors	813.18	1.93	6.49						821.59
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	849.17	3.02	4.32	46.55	70.48	1.31	NA,NO	NA,NO	974.85
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	6.36	NE,NA	NE,NA						6.36
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				46.55	0.01	NO	NO	NO	46.56
G. Other product manufacture and use	0.02	0.04	4.32		NO	1.31			5.70
H. Other	NA	NA	NA						NA
3. Agriculture	2.65	344.12	257.47						604.23
A. Enteric fermentation		290.56							290.56
B. Manure management		53.56	19.02						72.58
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	238.45						238.45
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)	5773.46	3441.65	0.75						9215.86
A. Forest land	-129.31	0.53	0.60						-128.18
B. Cropland	1847.56	93.29	NO,NA						1940.85
C. Grassland	5137.71	393.55	0.15						5531.41
D. Wetlands	-1101.74	2954.28	NO,NA						1852.53
E. Settlements	19.25	NE,NA	NO,NE,IE						19.25
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	351.98	0.10	2.93						355.02
Aviation	332.67	0.06	2.77						335.50
Navigation	19.32	0.05	0.15						19.51
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.59								0.59
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 (3)	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4073.43
Total CO_2 equivalent emissions with land use, land-use change and forestry									13289.29
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.

2004

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2021 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)	8893.14	4096.22	309.87	51.46	45.48	1.31	NA,NO	NA,NO	13397.49
1. Energy	2226.08	7.50	44.68						2278.26
A. Fuel combustion (sectoral approach)	2103.18	5.88	44.68						2153.73
1. Energy industries	7.89	0.04	0.11						8.04
2. Manufacturing industries and construction	418.51	0.57	23.47						442.55
3. Transport	794.00	3.24	14.33						811.57
4. Other sectors	837.23	1.99	6.66						845.88
5. Other	45.54	0.05	0.11						45.69
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	872.91	3.01	4.05	51.46	45.48	1.31	NA,NO	NA,NO	978.22
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	7.14	NE,NA	NE,NA						7.14
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				51.46	0.00	NO	NO	NO	51.47
G. Other product manufacture and use	0.02	0.05	4.05		NO	1.31			5.44
H. Other	NA	NA	NA						NA
3. Agriculture	4.95	339.48	255.04						599.48
A. Enteric fermentation		286.73							286.73
B. Manure management		52.76	18.76						71.51
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	236.28						236.28
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)	5784.03	3438.09	0.78						9222.90
A. Forest land	-135.28	0.55	0.61						-134.12
B. Cropland	1845.05	93.18	NO,NA						1938.22
C. Grassland	5149.02	395.45	0.16						5544.63
D. Wetlands	-1099.72	2948.92	NO,NA						1849.20
E. Settlements	24.96	NE,NA	0.00						24.96
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	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	400.58	0.12	3.33						404.03
Aviation	379.62	0.07	3.16						382.85
Navigation	20.96	0.05	0.17						21.17
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.43								0.43
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 (3)	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4174.60
Total CO_2 equivalent emissions with land use, land-use change and forestry									13397.49
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 2021 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)]	8775.70	4079.71	311.94	55.56	30.76	2.52	NO	NO	13256.19
1. Energy	2111.55	7.14	45.19						2163.88
A. Fuel combustion (sectoral approach)	1993.40	5.40	45.19						2043.98
1. Energy industries	7.81	0.04	0.11						7.96
2. Manufacturing industries and construction	400.60	0.52	25.32						426.44
3. Transport	799.34	3.03	13.70						816.07
4. Other sectors	756.74	1.79	5.98						764.51
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	855.86	2.82	3.89	55.56	30.76	2.52	NO	NO	951.41
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	6.87	NE,NA	NE,NA						6.87
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				55.56	0.00	NO	NO	NO	55.56
G. Other product manufacture and use	0.03	0.04	3.89		NO	2.52			6.48
H. Other	NA	NA	NA						NA
3. Agriculture	4.21	342.50	256.65						603.35
A. Enteric fermentation		289.03							289.03
B. Manure management		53.47	18.91						72.38
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	237.74						237.74
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)]	5799.35	3433.12	0.81						9233.28
A. Forest land	-154.73	0.57	0.64						-153.51
B. Cropland	1842.62	93.06	NO,NA						1935.67
C. Grassland	5173.70	398.10	0.17						5571.96
D. Wetlands	-1096.88	2941.39	NO,NA						1844.51
E. Settlements	34.65	NE,NA	0.00						34.65
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						426.57
Aviation	421.23	0.07	3.51						424.81
Navigation	1.74	0.00	0.01						1.76
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.92								0.92
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4022.91
Total CO_2 equivalent emissions with land use, land-use change and forestry									13256.19
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2006

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2006
Submission 2021 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)]	9019.31	4109.32	327.95	57.39	392.79	2.61	NO	NO	13909.37
1. Energy	2180.37	7.78	38.34						2226.49
A. Fuel combustion (sectoral approach)	2052.94	5.36	38.34						2096.64
1. Energy industries	17.16	0.07	0.20						17.43
2. Manufacturing industries and construction	381.33	0.50	22.98						404.81
3. Transport	942.34	3.15	9.66						955.15
4. Other sectors	685.31	1.61	5.43						692.36
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	964.88	2.77	4.13	57.39	392.79	2.61	NO	NO	1424.57
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	7.64	NE,NA	NE,NA						7.64
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				57.39	0.00	NO	NO	NO	57.39
G. Other product manufacture and use	0.04	0.05	4.13		NO	2.61			6.84
H. Other	NA	NA	NA						NA
3. Agriculture	2.87	350.76	273.39						627.03
A. Enteric fermentation		294.56							294.56
B. Manure management		56.20	19.12						75.32
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	254.27						254.27
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)]	5866.39	3430.15	6.35						9302.89
A. Forest land	-161.04	0.60	0.67						-159.78
B. Cropland	1840.21	92.95	0.02						1933.18
C. Grassland	5237.02	407.44	4.53						5648.99
D. Wetlands	-1091.87	2929.16	1.13						1838.41
E. Settlements	42.07	NE,NA	0.00						42.07
F. Other land	NA,NE	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	516.61	0.13	4.30						521.03
Aviation	499.40	0.09	4.16						503.65
Navigation	17.20	0.04	0.13						17.38
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.47								0.47
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4606.48
Total CO_2 equivalent emissions with land use, land-use change and forestry									13909.37
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 2021 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)	9398.60	4101.41	334.98	50.85	331.39	2.89	NO	NO	14220.12
1. Energy	2324.00	8.55	39.21						2371.76
A. Fuel combustion (sectoral approach)	2176.63	5.46	39.21						2221.30
1. Energy industries	34.52	0.09	0.26						34.87
2. Manufacturing industries and construction	379.92	0.55	23.20						403.67
3. Transport	977.83	2.98	9.59						990.40
4. Other sectors	777.52	1.82	6.15						785.49
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	1162.67	2.91	4.60	50.85	331.39	2.89	NO	NO	1555.31
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	7.16	NE,NA	NE,NA						7.16
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				50.85	0.00	NO	NO	NO	50.85
G. Other product manufacture and use	0.05	0.06	4.60		NO	2.89			7.59
H. Other	NA	NA	NA						NA
3. Agriculture	1.55	356.47	284.25						642.28
A. Enteric fermentation		298.84							298.84
B. Manure management		57.63	19.46						77.09
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	264.80						264.80
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)	5902.51	3415.63	0.88						9319.02
A. Forest land	-168.78	0.61	0.68						-167.49
B. Cropland	1837.84	92.82	NO,NA						1930.65
C. Grassland	5279.88	407.09	0.19						5687.16
D. Wetlands	-1086.29	2915.12	NO,NA						1828.83
E. Settlements	39.86	NE,NA	0.01						39.86
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	523.00	0.12	4.35						527.47
Aviation	511.03	0.09	4.26						515.38
Navigation	11.97	0.03	0.09						12.09
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.56								0.56
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 (3)	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4901.10
Total CO_2 equivalent emissions with land use, land-use change and forestry									14220.12
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2008

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2008
Submission 2021 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]	9742.14	4080.31	341.77	60.43	411.39	3.01	NO	NO	14639.05
1. Energy	2196.27	8.04	37.03						2241.34
A. Fuel combustion (sectoral approach)	2010.33	4.92	37.03						2052.28
1. Energy industries	17.70	0.07	0.20						17.96
2. Manufacturing industries and construction	350.38	0.51	22.41						373.30
3. Transport	923.62	2.67	8.78						935.07
4. Other sectors	711.52	1.67	5.64						718.82
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	1604.31	2.45	4.10	60.43	411.39	3.01	NO	NO	2085.69
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	6.40	NE,NA	NE,NA						6.40
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				60.43	0.01	NO	NO	NO	60.44
G. Other product manufacture and use	0.02	0.04	4.10		NO	3.01			7.17
H. Other	NA	NA	NA						NA
3. Agriculture	4.74	359.78	293.52						658.04
A. Enteric fermentation		301.85							301.85
B. Manure management		57.93	19.33						77.26
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	274.18						274.18
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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]	5930.69	3407.42	0.99						9339.11
A. Forest land	-172.84	0.63	0.71						-171.50
B. Cropland	1835.49	92.70	NO,NA						1928.18
C. Grassland	5329.63	411.30	0.26						5741.18
D. Wetlands	-1081.63	2902.79	0.02						1821.19
E. Settlements	20.06	NE,NA	0.01						20.06
F. Other land	NA,NE	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	474.99	0.18	3.93						479.10
Aviation	427.40	0.07	3.56						431.04
Navigation	47.59	0.11	0.37						48.06
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	1.02								1.02
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 [3]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									5299.94
Total CO_2 equivalent emissions with land use, land-use change and forestry									14639.05
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 2021 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)]	9637.27	4071.00	318.24	73.11	180.05	3.02	NO	NO	14282.70
1. Energy	2102.47	7.51	30.32						2140.30
A. Fuel combustion (sectoral approach)	1932.35	4.66	30.32						1967.34
1. Energy industries	12.94	0.05	0.15						13.14
2. Manufacturing industries and construction	249.03	0.34	15.60						264.97
3. Transport	896.79	2.47	8.50						907.76
4. Other sectors	768.75	1.80	6.07						776.62
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	1615.71	2.49	3.59	73.11	180.05	3.02	NO	NO	1877.98
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	4.90	NE,NA	NE,NA						4.90
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				73.11	0.00	NO	NO	NO	73.12
G. Other product manufacture and use	0.02	0.04	3.59		NO	3.02			6.67
H. Other	NA	NA	NA						NA
3. Agriculture	3.44	364.49	277.01						644.94
A. Enteric fermentation		306.14							306.14
B. Manure management		58.35	19.69						78.03
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	257.32						257.32
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)]	5909.60	3405.89	0.93						9316.42
A. Forest land	-186.47	0.66	0.74						-185.08
B. Cropland	1833.17	92.58	NO,NA						1925.75
C. Grassland	5336.59	412.30	0.19						5749.09
D. Wetlands	-1080.54	2900.35	NO,NA						1819.81
E. Settlements	6.86	NE,NA	0.01						6.86
F. Other land	NA,NE	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						354.16
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	1.20								1.20
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4966.28
Total CO_2 equivalent emissions with land use, land-use change and forestry									14282.70
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 2021 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)]	9512.89	4058.73	306.60	105.11	171.66	4.66	NO	NO	14159.65
1. Energy	1993.84	9.32	26.13						2029.28
A. Fuel combustion (sectoral approach)	1804.20	4.25	26.13						1834.57
1. Energy industries	13.82	0.05	0.15						14.02
2. Manufacturing industries and construction	190.47	0.24	12.45						203.16
3. Transport	853.34	2.23	7.71						863.27
4. Other sectors	732.65	1.71	5.78						740.14
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	1622.81	2.59	3.88	105.11	171.66	4.66	NO	NO	1910.71
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	5.13	NE,NA	NE,NA						5.13
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				105.11	0.00	NO	NO	NO	105.11
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	358.65	269.09						629.82
A. Enteric fermentation		303.06							303.06
B. Manure management		55.59	19.46						75.04
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	249.63						249.63
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)]	5888.24	3404.18	0.96						9293.38
A. Forest land	-209.88	0.67	0.75						-208.46
B. Cropland	1830.87	92.46	NO,NA						1923.32
C. Grassland	5340.98	413.43	0.20						5754.60
D. Wetlands	-1079.51	2897.62	0.00						1818.11
E. Settlements	5.83	NE,NA	0.01						5.83
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	1.63								1.63
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4866.27
Total CO_2 equivalent emissions with land use, land-use change and forestry									14159.65
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2011

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2011
Submission 2021 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)	9365.73	4037.92	303.27	130.46	74.52	3.05	NO	NO	13914.94
1. Energy	1874.87	7.91	23.95						1906.73
A. Fuel combustion (sectoral approach)	1695.35	3.90	23.95						1723.20
1. Energy industries	11.30	0.04	0.12						11.46
2. Manufacturing industries and construction	195.56	0.26	11.47						207.29
3. Transport	818.38	2.04	7.13						827.54
4. Other sectors	663.23	1.55	5.22						670.00
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	1617.30	2.67	3.99	130.46	74.52	3.05	NO	NO	1831.98
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	5.36	NE,NA,NO	NE,NA,NO						5.36
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				130.46	0.01	NO	NO	NO	130.46
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	359.59	267.84						630.03
A. Enteric fermentation		302.59							302.59
B. Manure management		57.00	19.61						76.61
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	248.23						248.23
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)	5864.41	3402.49	0.97						9267.88
A. Forest land	-237.05	0.69	0.77						-235.59
B. Cropland	1828.56	92.34	NO,NA						1920.90
C. Grassland	5345.58	414.54	0.20						5760.32
D. Wetlands	-1078.47	2894.92	NO,NA						1816.45
E. Settlements	5.84	NE,NA	0.01						5.84
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	471.25	0.19	3.90						475.35
Aviation	421.51	0.07	3.51						425.10
Navigation	49.74	0.11	0.39						50.25
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	3.64								3.64
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 (3)	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4647.06
Total CO_2 equivalent emissions with land use, land-use change and forestry									13914.94
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.

2012

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2012
Submission 2021 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]	9357.64	4012.19	309.94	140.74	94.00	5.32	NO	NO	13919.84
1. Energy	1826.72	6.97	23.19						1856.88
A. Fuel combustion (sectoral approach)	1654.67	3.69	23.19						1681.55
1. Energy industries	11.38	0.04	0.11						11.53
2. Manufacturing industries and construction	177.09	0.21	10.97						188.27
3. Transport	809.36	1.91	6.93						818.19
4. Other sectors	656.76	1.54	5.18						663.47
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	1660.18	3.00	3.90	140.74	94.00	5.32	NO	NO	1907.14
A. Mineral industry	0.51								0.51
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	5.31	NE,NA,NO	NE,NA,NO						5.31
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				140.74	0.00	NO	NO	NO	140.75
G. Other product manufacture and use	0.03	0.04	3.90		NO	5.32			9.29
H. Other	NA	NA	NA						NA
3. Agriculture	3.58	354.01	275.57						633.17
A. Enteric fermentation		299.58							299.58
B. Manure management		54.43	19.32						73.75
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	256.25						256.25
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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]	5860.81	3400.66	1.00						9262.48
A. Forest land	-247.62	0.70	0.79						-246.13
B. Cropland	1826.25	92.22	NO,NA						1918.46
C. Grassland	5353.78	415.67	0.21						5769.67
D. Wetlands	-1077.40	2892.07	NO,NA						1814.67
E. Settlements	5.85	NE,NA	0.01						5.86
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						260.18
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	465.48	0.13	3.87						469.47
Aviation	441.72	0.08	3.68						445.48
Navigation	23.76	0.05	0.18						24.00
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	6.26								6.26
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 [3]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4657.36
Total CO_2 equivalent emissions with land use, land-use change and forestry									13919.84
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.

2013

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2013
Submission 2021 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)]	9331.63	4013.01	303.83	163.38	88.17	3.20	NO	NO	13903.21
1. Energy	1788.26	7.47	22.50						1818.24
A. Fuel combustion (sectoral approach)	1615.12	3.49	22.50						1641.11
1. Energy industries	4.93	0.01	0.03						4.96
2. Manufacturing industries and construction	164.63	0.20	10.54						175.37
3. Transport	824.77	1.83	7.07						833.67
4. Other sectors	620.03	1.45	4.87						626.35
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	1686.18	3.03	3.45	163.38	88.17	3.20	NO	NO	1947.41
A. Mineral industry	0.55								0.55
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	5.26	NE,NA,NO	NE,NA,NO						5.26
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				163.38	0.00	NO	NO	NO	163.38
G. Other product manufacture and use	0.02	0.04	3.45		NO	3.20			6.71
H. Other	NA	NA	NA						NA
3. Agriculture	2.89	345.59	270.23						618.71
A. Enteric fermentation		292.90							292.90
B. Manure management		52.69	18.93						71.62
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	251.30						251.30
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)]	5848.91	3398.89	1.03						9248.82
A. Forest land	-266.22	0.71	0.79						-264.72
B. Cropland	1823.93	92.10	NO,NA						1916.03
C. Grassland	5361.62	416.81	0.23						5778.66
D. Wetlands	-1076.34	2889.27	NO,NA						1812.93
E. Settlements	5.98	NE,NA	0.01						5.99
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						270.03
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						53.38
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	576.86	0.27	4.77						581.90
Aviation	498.57	0.09	4.16						502.81
Navigation	78.29	0.18	0.62						79.09
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	13.15								13.15
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4654.39
Total CO_2 equivalent emissions with land use, land-use change and forestry									13903.21
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.

2014

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2014
Submission 2021 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)]	9286.24	4021.95	331.59	169.60	99.03	2.32	NO	NO	13910.72
1. Energy	1795.28	7.91	26.83						1830.03
A. Fuel combustion (sectoral approach)	1612.32	3.37	26.83						1642.53
1. Energy industries	5.13	0.01	0.01						5.15
2. Manufacturing industries and construction	161.18	0.21	14.95						176.34
3. Transport	827.46	1.70	7.06						836.22
4. Other sectors	615.90	1.44	4.80						622.15
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	1654.67	2.73	3.19	169.60	99.03	2.32	NO	NO	1931.54
A. Mineral industry	0.55								0.55
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	5.34	NE,NA,NO	NE,NA,NO						5.34
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				169.60	0.00	NO	NO	NO	169.60
G. Other product manufacture and use	0.02	0.03	3.19		NO	2.32			5.56
H. Other	NA	NA	NA						NA
3. Agriculture	2.22	368.65	293.27						664.13
A. Enteric fermentation		311.38							311.38
B. Manure management		57.27	20.04						77.31
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	273.23						273.23
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)]	5826.98	3397.01	1.06						9225.06
A. Forest land	-289.96	0.72	0.80						-288.44
B. Cropland	1821.62	91.98	NO,NA						1913.59
C. Grassland	5364.72	417.70	0.24						5782.66
D. Wetlands	-1075.00	2886.61	0.01						1811.62
E. Settlements	5.68	NE,NA	0.01						5.69
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						259.97
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	5.38						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	630.39	0.26	5.23						635.88
Aviation	559.59	0.10	4.66						564.35
Navigation	70.80	0.16	0.56						71.53
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	18.26								18.26
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4685.66
Total CO_2 equivalent emissions with land use, land-use change and forestry									13910.72
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.

2015

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2015
Submission 2021 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)]	9341.89	4025.09	314.29	179.65	103.70	1.56	NO	NO	13966.17
1. Energy	1819.05	7.98	25.15						1852.17
A. Fuel combustion (sectoral approach)	1655.91	3.42	25.15						1684.48
1. Energy industries	4.20	0.00	0.01						4.22
2. Manufacturing industries and construction	167.52	0.21	12.32						180.05
3. Transport	858.17	1.74	7.89						867.80
4. Other sectors	625.84	1.47	4.93						632.23
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	1707.23	2.98	3.24	179.65	103.70	1.56	NO	NO	1998.36
A. Mineral industry	0.72								0.72
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	5.67	NE,NA,NO	NE,NA,NO						5.67
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				179.65	0.01	NO	NO	NO	179.66
G. Other product manufacture and use	0.03	0.03	3.24		NO	1.56			4.85
H. Other	NA	NA	NA						NA
3. Agriculture	3.48	371.67	277.42						652.57
A. Enteric fermentation		313.84							313.84
B. Manure management		57.83	19.97						77.80
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	257.45						257.45
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.12								2.12
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)]	5805.67	3395.27	1.24						9202.18
A. Forest land	-314.09	0.72	0.81						-312.56
B. Cropland	1819.40	91.86	NO,NA						1911.26
C. Grassland	5368.54	418.90	0.37						5787.81
D. Wetlands	-1073.93	2883.79	0.04						1809.91
E. Settlements	5.87	NE,NA	0.01						5.88
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	822.27	0.46	6.80						829.53
Aviation	673.99	0.12	5.62						679.73
Navigation	148.28	0.35	1.18						149.80
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	43.27								43.27
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4763.99
Total CO_2 equivalent emissions with land use, land-use change and forestry									13966.17
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 2021 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)]	9267.75	4014.25	312.31	203.86	91.86	1.34	NO	NO	13891.38
1. Energy	1793.89	6.77	26.84						1827.50
A. Fuel combustion (sectoral approach)	1644.93	3.24	26.84						1675.01
1. Energy industries	2.37	0.00	0.01						2.38
2. Manufacturing industries and construction	182.92	0.23	14.29						197.43
3. Transport	935.88	1.77	8.42						946.07
4. Other sectors	523.61	1.23	4.13						528.97
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	1683.87	3.03	2.62	203.86	91.86	1.34	NO	NO	1986.58
A. Mineral industry	0.77								0.77
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	5.76	NO,NE,NA	NO,NE,NA						5.76
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				203.86	0.02	NO	NO	NO	203.88
G. Other product manufacture and use	0.03	0.03	2.62		NO	1.34			4.02
H. Other	NA	NA	NA						NA
3. Agriculture	2.91	377.02	274.37						654.30
A. Enteric fermentation		318.06							318.06
B. Manure management		58.96	20.23						79.19
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	254.14						254.14
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)]	5780.33	3393.41	1.02						9174.76
A. Forest land	-337.50	0.73	0.81						-335.96
B. Cropland	1816.76	91.74	NO,NA						1908.50
C. Grassland	5368.20	419.81	0.20						5788.20
D. Wetlands	-1072.95	2881.13	NO,NA						1808.18
E. Settlements	5.87	NE,NA	0.01						5.87
F. Other land	NE,NA	NA	NA						NE,NA
G. Harvested wood products	-0.04								-0.04
H. Other	IE	IE	IE						IE
5. Waste	6.75	234.03	7.46						248.25
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						44.94
E. Other	NA	NO	NO						NO,NA
6. Other ***(as specified in summary 1.A)***	NO	NO	NO	NO	NO	NO	NO	NO	NO

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
Memo items:[(2)]									
International bunkers	1102.00	0.59	9.11						1111.70
Aviation	916.88	0.16	7.64						924.68
Navigation	185.13	0.43	1.46						187.02
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	45.41								45.41
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4716.62
Total CO_2 equivalent emissions with land use, land-use change and forestry									13891.38
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 2021 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)]	9347.25	4001.15	323.05	188.88	68.01	2.31	NO	NO	13930.64
1. Energy	1836.15	6.43	27.93						1870.52
A. Fuel combustion (sectoral approach)	1689.68	3.10	27.93						1720.71
1. Energy industries	2.33	0.00	0.01						2.34
2. Manufacturing industries and construction	157.25	0.21	14.55						172.00
3. Transport	989.60	1.62	9.14						1000.36
4. Other sectors	540.33	1.27	4.24						545.84
5. Other	0.17	0.00	0.00						0.17
B. Fugitive emissions from fuels	146.48	3.33	NO,NA						149.81
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	146.48	3.33	NO,NA						149.81
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1759.28	3.16	2.43	188.88	68.01	2.31	NO	NO	2024.05
A. Mineral industry	0.90								0.90
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	5.57	NO,NE,NA	NO,NE,NA						5.57
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				188.88	0.03	NO	NO	NO	188.91
G. Other product manufacture and use	0.03	0.03	2.43		NO	2.31			4.79
H. Other	NA	NA	NA						NA
3. Agriculture	2.37	369.46	284.11						655.94
A. Enteric fermentation		311.01							311.01
B. Manure management		58.45	19.71						78.16
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	264.41						264.41
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.86								0.86
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)]	5742.37	3391.80	1.07						9135.23
A. Forest land	-376.00	0.73	0.82						-374.45
B. Cropland	1814.65	91.62	NO,NA						1906.27
C. Grassland	5369.92	420.91	0.23						5791.06
D. Wetlands	-1071.97	2878.53	0.01						1806.57
E. Settlements	5.86	NE,NA	0.01						5.87
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						48.58
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	1358.84	0.69	11.23						1370.76
Aviation	1146.71	0.20	9.56						1156.47
Navigation	212.13	0.49	1.67						214.29
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	49.71								49.71
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE						
Indirect CO_2 [(3)]	NO,NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4795.42
Total CO_2 equivalent emissions with land use, land-use change and forestry									13930.64
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 2021 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)]	9386.75	3989.75	308.12	163.45	76.44	3.26	NO	NO	13927.76
1. Energy	1880.78	6.44	25.66						1912.88
A. Fuel combustion (sectoral approach)	1724.32	3.12	25.66						1753.10
1. Energy industries	2.37	0.00	0.01						2.38
2. Manufacturing industries and construction	138.47	0.18	11.61						150.26
3. Transport	1028.68	1.64	9.67						1039.99
4. Other sectors	554.28	1.30	4.37						559.94
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	1773.25	3.19	2.94	163.45	76.44	3.26	NO	NO	2022.53
A. Mineral industry	0.91								0.91
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	6.20	NO,NE,NA	NO,NE,NA						6.20
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				163.45	0.05	NO	NO	NO	163.50
G. Other product manufacture and use	0.03	0.03	2.94		NO	3.26			6.27
H. Other	NA	NA	NA						NA
3. Agriculture	3.19	358.02	270.70						631.91
A. Enteric fermentation		301.14							301.14
B. Manure management		56.88	18.90						75.78
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	251.80						251.80
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)]	5723.37	3381.18	1.03						9105.57
A. Forest land	-404.68	0.73	0.82						-403.13
B. Cropland	1812.33	91.50	NO,NA						1903.82
C. Grassland	5377.63	421.96	0.20						5799.78
D. Wetlands	-1067.62	2866.99	NO,NA						1799.37
E. Settlements	5.87	NE,NA	0.01						5.88
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	7.79						254.86
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	5.74						51.08
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*									

Memo items: [(2)]									
International bunkers	1526.65	0.78	12.62						1540.05
Aviation	1285.04	0.22	10.71						1295.98
Navigation	241.60	0.56	1.91						244.07
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	58.58								58.58
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NE						
Indirect CO_2 [(3)]	NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4822.19
Total CO_2 equivalent emissions with land use, land-use change and forestry									13927.76
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.

2019

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2019
Submission 2021 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)	9234.88	3956.14	297.06	207.27	97.06	1.99	NO	NO	13794.41
1. Energy	1824.13	6.56	24.23						1854.91
A. Fuel combustion (sectoral approach)	1661.02	2.77	24.23						1688.02
1. Energy industries	4.99	0.01	0.01						5.01
2. Manufacturing industries and construction	84.28	0.10	6.45						90.84
3. Transport	1021.23	1.39	10.90						1033.52
4. Other sectors	548.83	1.27	6.86						556.96
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	1712.40	2.83	2.81	207.27	97.06	1.99	NO	NO	2024.37
A. Mineral industry	0.96								0.96
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1705.87	2.80	NO	NO	97.00	NO	NO	NO	1805.67
D. Non-energy products from fuels and solvent use	5.55	NO,NE,NA	NO,NE,NA						5.55
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				207.27	0.06	NO	NO	NO	207.34
G. Other product manufacture and use	0.02	0.03	2.81		NO	1.99			4.85
H. Other	NA	NA	NA						NA
3. Agriculture	5.87	352.28	260.71						618.85
A. Enteric fermentation		296.71							296.71
B. Manure management		55.57	18.42						73.99
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	242.29						242.29
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,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)	5684.13	3386.89	1.03						9072.06
A. Forest land	-447.78	0.74	0.83						-446.21
B. Cropland	1810.00	91.38	NO,NA						1901.37
C. Grassland	5385.49	423.03	0.20						5808.71
D. Wetlands	-1069.41	2871.75	NO,NA						1802.33
E. Settlements	5.87	NE,NA	0.01						5.88
F. Other land	NA	NA	NA						NA
G. Harvested wood products	-0.03								-0.03
H. Other	IE	IE	IE						IE
5. Waste	8.36	207.58	8.27						224.22
A. Solid waste disposal	NO,NA	162.89							162.89
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	5.94						47.86
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*									
Memo items:(2)									
International bunkers	1161.06	0.64	9.60						1171.30
Aviation	956.38	0.17	7.97						964.52
Navigation	204.68	0.48	1.63						206.79
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	57.93								57.93
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites									
Indirect N_2O			NE						
Indirect CO_2 (3)	NE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4722.35
Total CO_2 equivalent emissions with land use, land-use change and forestry									13794.41
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.