National Inventory Report

Emissions of greenhouse gases in Iceland from 1990 to 2018

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

2020

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

Publication ID: **UST-2020:06**
Cover photo: Goðafoss Waterfall, Iceland. Photo by Trevor Cole on Unsplash

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
Jón Guðmundsson, Agricultural University of Iceland
Arnór Snorrason, Icelandic Forest Research
Jóhann Þórsson, Soil Conservation Service of Iceland
Leone Tinganelli, Soil Conservation Service of Iceland

Reykjavík, 15.04.2020

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 1990-2018. 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), with major contributions by the Agricultural University of Iceland (AUI – Landbúnaðarháskóli Íslands), the Icelandic Forest Service (IFS - Skógræktin), and the Soil Conservation Service of Iceland (SCSI – Landgræðsla ríkisins) for the chapters concerning Land-Use, Land-Use Change and Forestry (LULUCF and KP-LULUCF)

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, 15.04.2020

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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
NF_3	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
SiO_2	Quartz
SO_2	Sulphur Dioxide
SO_2e	Sulphur Dioxide Equivalents
SOC	Soil Organic Carbon
SSPP	Systematic sampling of permanent plots
SWD	Solid Waste Disposal
SWDS	Solid Waste Disposal Sites
t/t	Tonne per Tonne
TJ	Terajoule
TOW	Total Organics in Wastewater
UNFCCC	United Nations Framework Convention on Climate Changes

Global Warming Potentials (GWP) of Greenhouse Gases

Greenhouse gas	Chemical formula	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 is expected to be published in spring/summer 2020.

The Kyoto Protocol commits Annex I Parties[2] to individual, legally binding targets for their greenhouse gas emissions. Iceland's obligations according to the Kyoto Protocol have been and are as follows:

[1] Aðgerðaáætlun í loftslagsmálum 2018-2030: https://www.stjornarradid.is/verkefni/umhverfi-og-natturuvernd/loftslagsmal/adgerdaaaetlun/

[2] The industrialized countries listed in Annex I to the Convention, which committed to returning their greenhouse-gas emissions to 1990 levels by the year 2000 as per Article 4.2 (a) and (b). They have also accepted emissions targets for the period 2008-12 as per Article 3 and Annex B of the Kyoto Protocol. http://unfccc.int/essential_background/glossary/items/3666.php

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

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)
- Sulfur 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 2018 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.

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

A summary of Iceland's national emissions for selected years between 1990 and 2018 is presented in Table ES. 1. LULUCF is the largest sector, with emissions of more than double the combined emissions from the other sectors across the time series. Total GHG emissions (excluding LULUCF) increased by approximately a third from 1990 to 2018. 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.

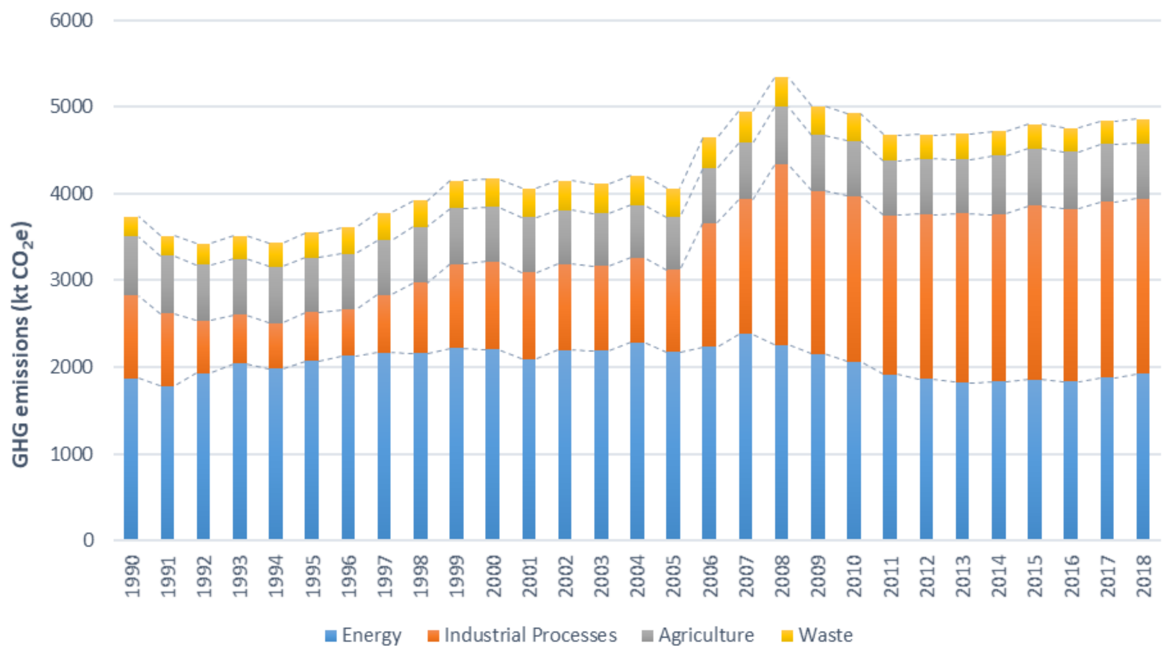

Figure ES. 1 Emissions of GHG by sector, without LULUCF, from 1990 to 2018 in kt CO_2e

Table ES. 1 Total GHG emissions by source since 1990 (kt CO2e).

	1990	1995	2000	2005	2010	2015	2017	2018	Changes ´90-´18	Changes ´17-´18
1 Energy	1,869	2,070	2,205	2,173	2,063	1,859	1,878	1,920	3%	2%
2 Industrial Processes	958	565	1,010	952	1,911	1,998	2,026	2,026	112%	0%
3 Agriculture	678	629	632	605	631	659	666	635	-6%	-5%
4 Land Use, Land Use Change and Forestry	9,344	9,260	9,238	9,242	9,262	9,141	9,053	9,010	-4%	0%
5 Waste	227	288	325	330	324	283	265	276	22%	4%
Total emissions without LULUCF	**3,733**	**3,551**	**4,171**	**4,059**	**4,929**	**4,800**	**4,836**	**4,857**	**30%**	**0.4%**
Total emissions with LULUCF	**13,076**	**12,811**	**13,409**	**13,302**	**14,191**	**13,941**	**13,889**	**13,867**	**6%**	**-0.2%**

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 2020 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 will end 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 2019 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[4] 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 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.

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

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 – which will be repealed as per 1 January 2021) into the European Economic Area Agreement) in October.

1.1.4 Climate change strategies

A climate change strategy was adopted by the Icelandic government in February 2007. The Ministry for the Environment formulated the strategy in close collaboration with the ministries of Transport and Communications, Fisheries, Finance, Agriculture, Industry and Commerce, Foreign Affairs and the Prime Minister's Office. 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 new Climate Change Action Plan. The action plan has two main goals; achieving the emission reductions of the Paris Agreement for 2030 and reaching carbon-neutrality for Iceland in 2040. To reach these goals the action plan has set forth 34 actions which mostly focus on electrification of the transport sector and increased efforts in afforestation, revegetation and wetland restoration. Unlike the action plan from 2010, this action plan is funded with 49 million Euros over the time period 2019-2023. Of those 49 million Euros, 29 million will go to increased efforts in afforestation, revegetation and wetland restoration, 11 million will go to infrastructure for electric vehicles and 9 million will go towards other projects, such as innovation and research projects, improved GHG inventory, international collaboration and education. An update to the 2018 Action Plan is expected to be published in spring 2020.

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 89% 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. 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 and the Icelandic Forest Service of Iceland in collaboration with the Agricultural University of Iceland (AUI). The EA reports to the Convention and to the EU. The Act specifies which institutions are obligated to collect data necessary for the GHG inventory and report it to the EA; 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). Both the Act and Regulation are to be updated soon, to reflected changes in responsibilities of various data providers. The list below shows the main institutions which provided data for this year's submission, followed by information on which sector they are contributing data to:

- The Soil Conservation Service of Iceland (SCSI - *Landgræðslan*): LULUCF; KP-LULUCF.
- The Icelandic Forest Service (IFS - *Skógræktin*): LULUCF; KP-LULUCF.
- The Agricultural University of Iceland (AUI – *Landbúnaðarháskóli Íslands*) (LULUCF; Agriculture)
- The National Energy Authority (NEA - *Orkustofnun*) (Energy; Industrial Processes and Product Use (IPPU))
- The Icelandic Transport Authority (*Samgöngustofa*): Energy
- Statistics Iceland (*Hagstofa Íslands*) (Energy, IPPU, Agriculture)
- The Icelandic Food and Veterinary Authority (*Matvælastofnun*): Agriculture
- The Icelandic Agricultural Advisory Centre (*Ráðgjafarmiðstöð landbúnaðarins*): Agriculture
- The Icelandic Recycling Fund (*Úrvinnslusjóður*): IPPU
- The Icelandic Medicines Agency (*Lyfjastofnun*): IPPU

Figure 1.1 illustrates the flow of information and allocation of responsibilities.

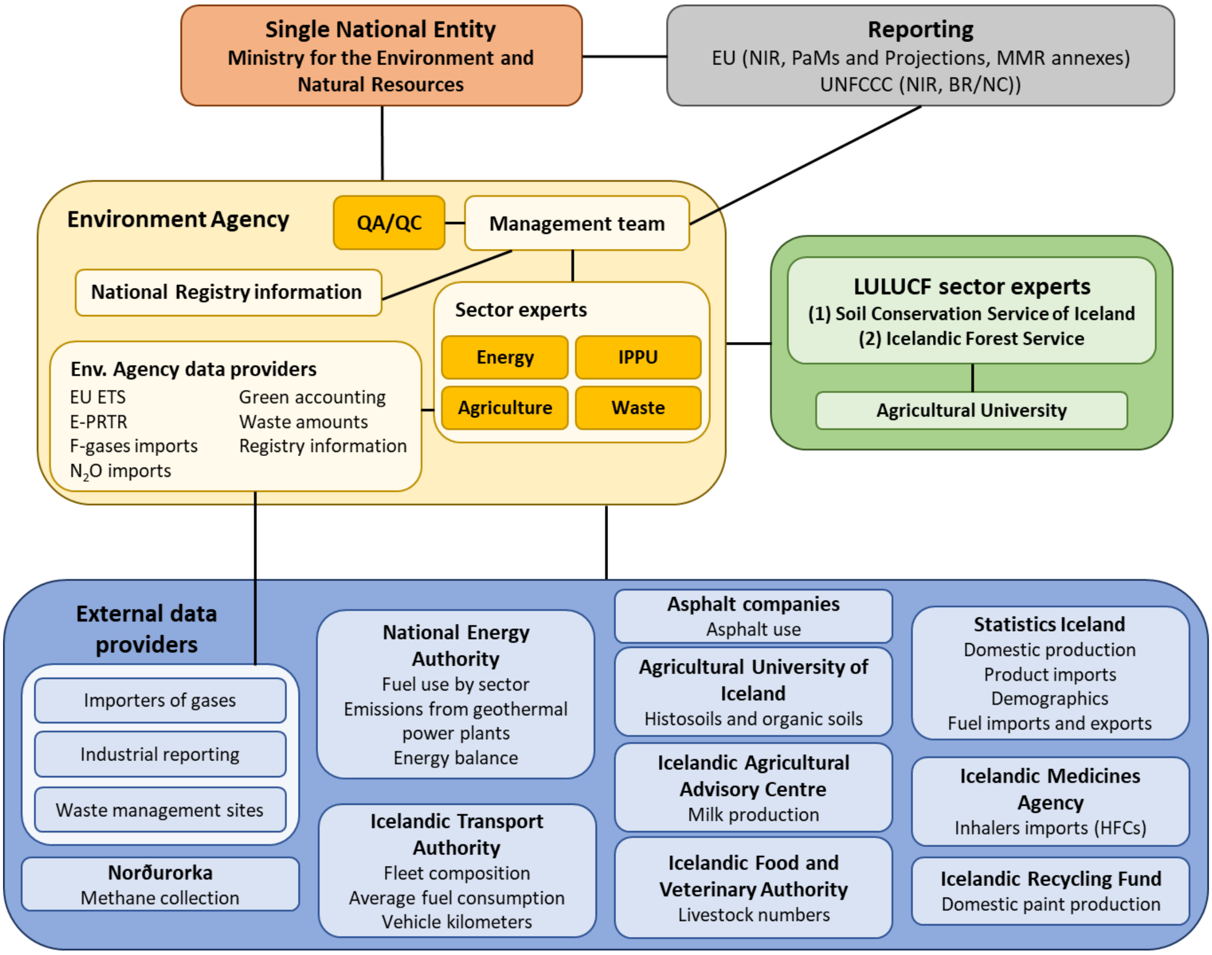

Figure 1.1 Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the UNFCCC.

1.2.2 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, a 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 authority 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[5] 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. Work is still under way to implement this regulation, and further meetings with various agencies responsible for data supply to the EA are planned for the year 2020 to enhance collaboration and improve workflows.

Regulation No 520/2017 implements EU Regulation No (EU) 525/2013[6] 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.

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. 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.

[5] https://www.reglugerd.is/reglugerdir/eftir-raduneytum/umhverfis--og-audlindaraduneyti/nr/0520-2017
[6] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R0525

- 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 and afforestation. 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 the2006 IPCC Guidelines for National Greenhouse Gas Inventories and IPCC Good Practice Guidance for LULUCF, since limited information is available from measurements of emissions in Iceland.

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

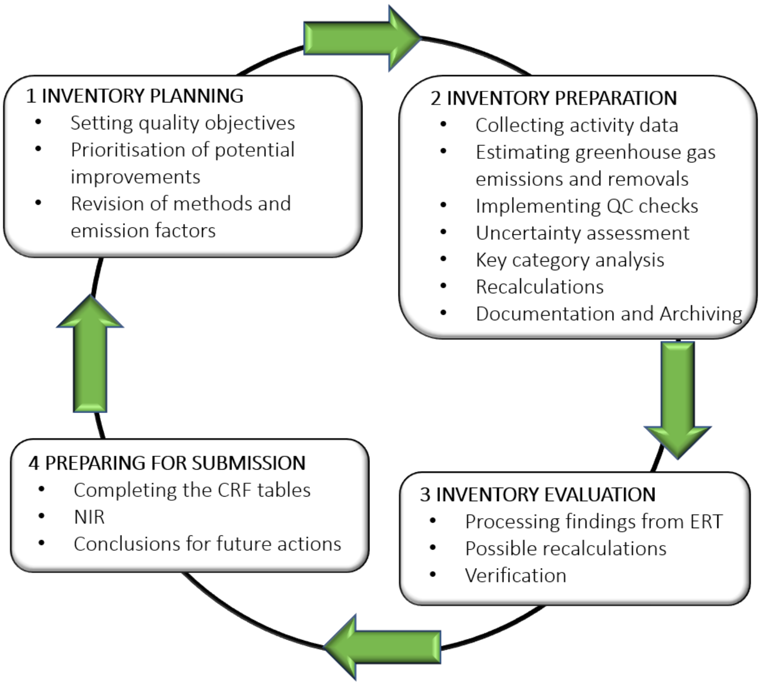

Figure 1.2 Iceland´s annual inventory cycle.

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 director of the EA and 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. 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 archiving process has improved over the last years, i.e. the origin of data dating years back cannot always be found out. The land use database IGLUD is stored on a server of the Agricultural University of Iceland (AUI). All other data used in LULUCF as well as spread sheets containing calculations are stored there as well. This excludes data regarding Forestry and Revegetation which is stored on servers of the Icelandic Forest Service and Soil Conservation Service of Iceland, respectively.

1.3.4 Training and capacity-building activities for inventory compilers

Capacity building activities can be split into three categories:

- Training by the consulting company which has been helping staff at the Environment Agency for several years (Aether ltd.). Examples from the last couple of 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 refrigerents 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: When a new staff member started in 2018 and took over the Agriculture sector, she had a half a day training by the consultant on the basics of estimating emissions from Agriculture, including practicalities of the excel files and imports into CRF. Furthermore, updates of the Agriculture sector that took place for this submission were done in collaboration with 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 managment.
  - General QA/QC: during Aether's visit to Iceland last spring, Aether provided an overview of the general concepts of QA/QC, and the QA/QC plan presented in this submission has largely been developped in collaboration with Aether.

- Participation in capacity building activities proposed by the EU (Yearly sector-specific capacity-buiding 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 Planned improvements

Additional funding was 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 period 2021-2030 (for instance, the Effort Sharing Regulation No 2018/842 and the Governance Regulation No 2018/1999). The Environment Agency used the funding to hire a new staff member to work on the inventories (GHG and air pollutants), who started working early February 2020. The plan is to fund another position within the inventory group, which will hopefully be filled in the fall of 2020. This will ensure more time allocated to each sector, which is expected to allow for more time for QA/QC activities.

No additional staff was added to the LULUCF inventory team at The Soil Conservation Service of Iceland between the 2019 and the 2020 submission, whereas ½ position was added at the Icelandic Forest Service for the inventory work. However, the two agencies have recently made a request to the Government for additional funding for measurements and calculations linked to the LULUCF sector (in particular due to the implementation of EU Regulation 2018/841). One position was added at the Soil Conservation Service in February 2020, and both institutions responsible for the LULUCF calculations are hoping to obtain additional capacity in 2020 or 2021.

1.4 Key Category Analysis

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

The results of the key category analysis including 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.

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

IPCC source category		Gas	Level 1990	Level 2018	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)					
2A1	Cement Production	CO_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) Cropland	Emissions and removals from drainage and rewetting	CH_4	✓		
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 2018	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.

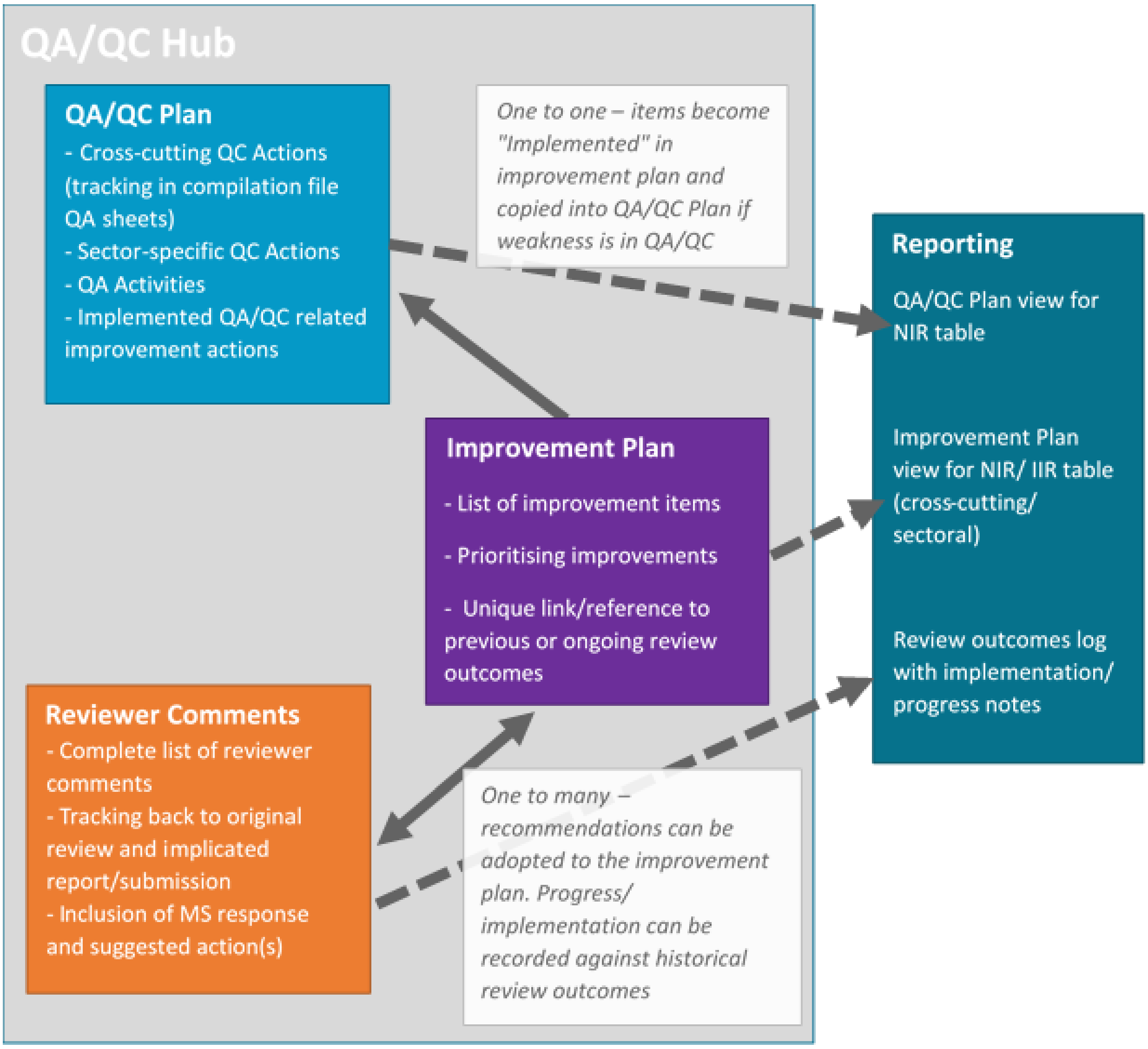

Figure 1.3 Schematic overview of the elements included in the QA/QC hub

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 an 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 QA/QC manager. The QA/QC manager has overall responsibility for the completion of QA/QC activities and improvements planning. It will also be the role of the QA/QC manager to ensure that sectoral leads and seconds (see below definitions) have documented their assigned activities in accordance with the requirements laid out under the QA/QC Hub. The roles and key responsibilities are outlined below:

- QA/QC manager - overall responsibility for the annual design of QA/QC and improvements activities.
- Sectoral lead - the sectoral lead is the main knowledge holder on individual inventory sectors. They are responsible for completion of day-to-day QC activities.
- Sectoral second - each inventory sector has an identified 'second'. The role of the second is to provide support to the sectoral lead and to protect institutional memory. The second has specific QC activities assigned to them at key milestones in the annual inventory cycle.

Table 1.3 below defines the key responsibilities of the three above roles in relation to inventory planning, improvements and QA/QC. Specific, detailed QA/QC activities are identified within the QA/QC Hub. Detailed activities include completion of internal QC lists, and other standard procedures that inventory compilers are expected to evidence as part of their compilation.

Table 1.3 Key responsibilities for the various roles involved in the inventory preparation

Role	Responsibility	Outcome
QA/QC Manager	Collates review recommendations into QA/QC Hub	QA/QC Hub list of review outcomes updated and removed of duplicates
	Organises inventory team planning meeting	Review recommendations carried through to improvement plan and prioritized
	Identifies budget constraints and opportunities	Improvement plan updated to reflect feasibility of actions. Completion deadlines revised
	Inventory sign off	Ensures that all compilation files show complete QA/QC documentation as defined in the QA/QC Hub
	Cross-cutting improvements and QA/QC	Responsible for carrying through cross-cutting QA/QC and improvement items that are promoted in the QA/QC Hub
Sectoral lead	Implementing sectoral improvements	Translates information in QA/QC hub into specified actions for new / updated data gathering
	Draft compilation	Completes and documents standard QC activities as defined in the QA/QC Hub
	Sectoral uncertainties	Uncertainties values in uncertainties calculator updated where sector-specific improvements have been made
	Recalculations	All sectoral recalculation checks complete with reasons for change
	QA/QC documentation	QA/QC Hub maintained and documented for agreed sector-specific QA/QC activities.
Sectoral second	Implementing sectoral improvements	Conducts detailed secondary QC where improvements are implemented
	Draft compilation	Ensures that all QA/QC records within compilation files are completed by sectoral lead
	Sectoral uncertainties	Checks file for annual update
	Recalculations	Sense checks and approves recalculations and reasons for change
	QA/QC documentation	Conducts sector-specific QA/QC in partnership with sector lead

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.

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

The results of the checks are prioritised in terms of their contribution to total GHG emissions and the magnitude of the flagged issue.

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 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?

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 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 NOx, 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 new QC procedures mentioned above. In the year 2020 the inventory team at the EA is expected to grow, and more time will be spent on finalising and fully implementing the new QA/QC procedures. A review and possible expansion of sector-specific QA and QC activities is planned for the 2021 submission. In the future, it is also planned to fully document the results of QC activities for each sector and providing evidence of such activities by including screenshots of the Q Comments tool discussed under 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

Uncertainty estimates are an essential element of a complete inventory and are used to prioritise efforts to improve the accuracy of the inventory. Here, the uncertainty analysis is according to Approach 1 of the 2006 Guidelines (Table 3.2, Vol. 1, Chapter 3) where different gases are reviewed separately as CO_2e. Total base and current years´ emissions within a GHG sector, category or subcategory are used in the calculations as well as corresponding uncertainty estimate values for activity data and emission factors used in emission calculations. When including LULUCF, the overall trend uncertainty estimate for this submission is 18.6%, whereas the uncertainty in total inventory is 40.1%. When looking at the uncertainty analysis without LULUCF, the trend uncertainty is 8.2%, and the uncertainty in total inventory is 7.9%.

The complete uncertainty analysis can be found in Annex 2.

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 2018. With regard to sectoral coverage, all sources considered to be above the threshold of significance[7] 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.

[7] 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 Gas Emissions

2.1 Emission Trends in Aggregated GHG Emissions

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_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur 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.

Total amounts of GHGs emitted in Iceland during the period 1990 to the most recent inventory year are presented in the following tables and figures, expressed in terms of contribution by gas and source. Figure 2.1 presents emission figures by UNFCCC sector excluding LULUCF. Table 2.1 presents emission figures for GHGs for all sectors, in kt CO_2 equivalents (CO_2e).

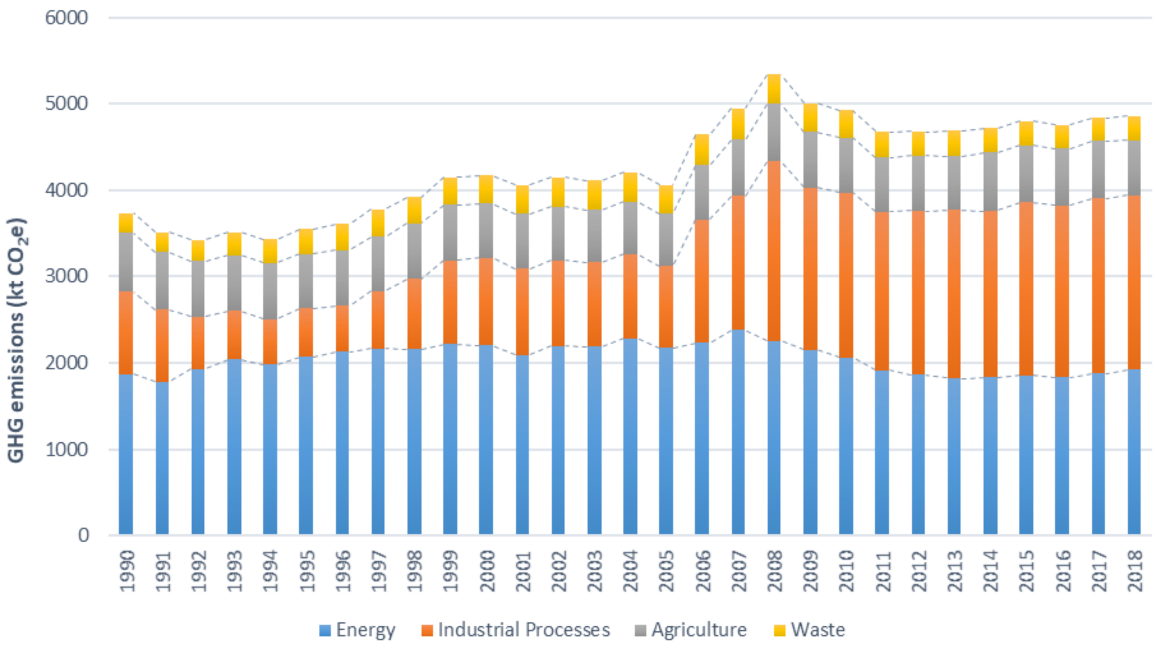

Figure 2.1 Emissions of GHG by UNFCCC sector, without LULUCF, for the reported time series (kt CO_2e).

Table 2.1 Emissions of GHG by sector in Iceland for the reported time series (kt CO_2e).

	1990	1995	2000	2005	2010	2015	2017	2018	Changes ´90-´18	Changes ´17-´18
1 Energy	1,869	2,070	2,205	2,173	2,063	1,859	1,878	1,920	3%	2.2%
2 Industrial Processes	958	565	1,010	952	1,911	1,998	2,026	2,026	112%	0.0%
3 Agriculture	678	629	632	605	631	659	666	635	-6%	-4.7%
4 Land Use, Land Use Change and Forestry (LULUCF)	9,344	9,260	9,238	9,242	9,262	9,141	9,053	9,010	-4%	-0.5%
5 Waste	227	288	325	330	324	283	265	276	22%	4.1%
Total emissions without LULUCF	**3,733**	**3,551**	**4,171**	**4,059**	**4,929**	**4,800**	**4,836**	**4,857**	**30%**	**0.4%**
Total emissions with LULUCF	**13,076**	**12,811**	**13,409**	**13,302**	**14,191**	**13,941**	**13,889**	**13,867**	**6%**	**-0.2%**

Total GHG emissions (excluding LULUCF) increased by approximately a third since 1990. In the most recent inventory year, Industrial Processes were the largest contributor of GHG emissions in Iceland (without LULUCF), followed by Energy, Agriculture, and Waste. The contribution of Industrial Processes to total net emissions (without LULUCF) has more than doubled over the time series, overtaking emissions from the Energy sector in 2012 (Figure 2.1).

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 5% higher than in 2011, yet still 19% 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. Emissions increased between 2017 and 2018 by 0.3% when considering the total emissions without LULUCF.

The increase in GDP since 1990 explains the general growth in emissions together with population growth (37% increase between 1990 and 2018). This has resulted in higher emissions from most sources, but in particular from **transport** and the **construction sector**.

In 2018, **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 2018 total emissions from the aluminium sector were 13% lower than in 2008 due to reduced PFC emissions from the sector.

2.1.1 Energy (CRF sector 1)

The Energy sector in Iceland is unique in many ways. 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. The cool climate and sparse population call for high energy use for space heating and transport. In addition, 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 percentage change in the various source categories in the Energy sector between 1990 and 2018, compared with 1990, is illustrated in Figure 2.2.

Table 2.2 shows the distribution of emissions in 2017 by different source categories. The relative contributions of the various source categories to the total emissions of the Energy sector are shown in Figure 2.2.

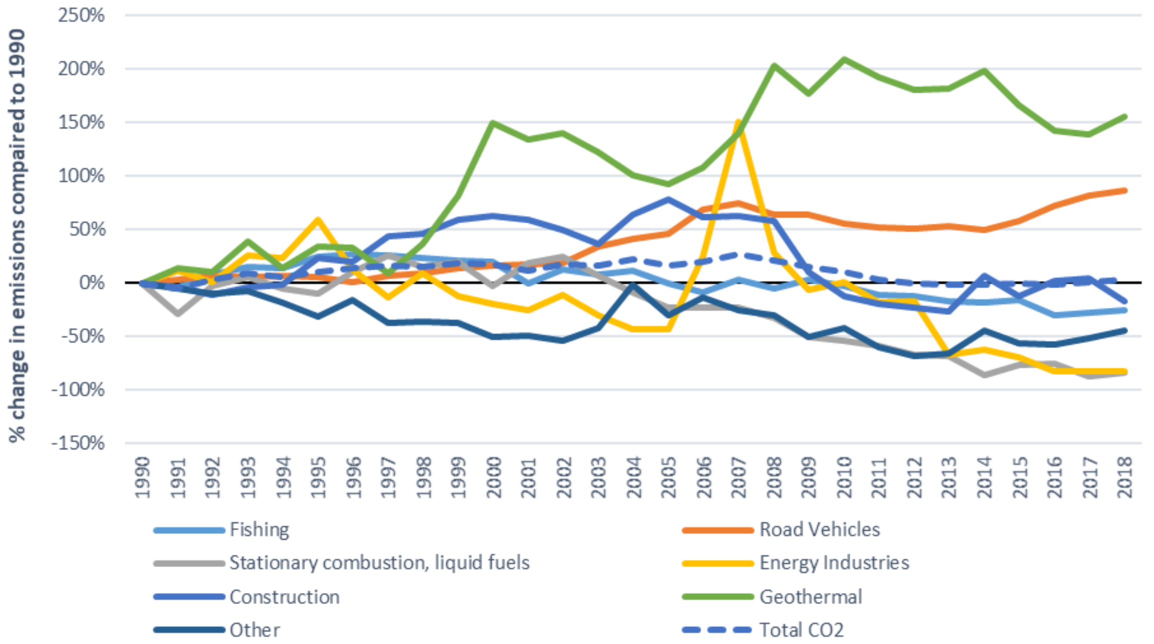

Figure 2.2 Percentage changes in GHG emissions for source categories in the Energy sector compared to 1990, for the reported time series.

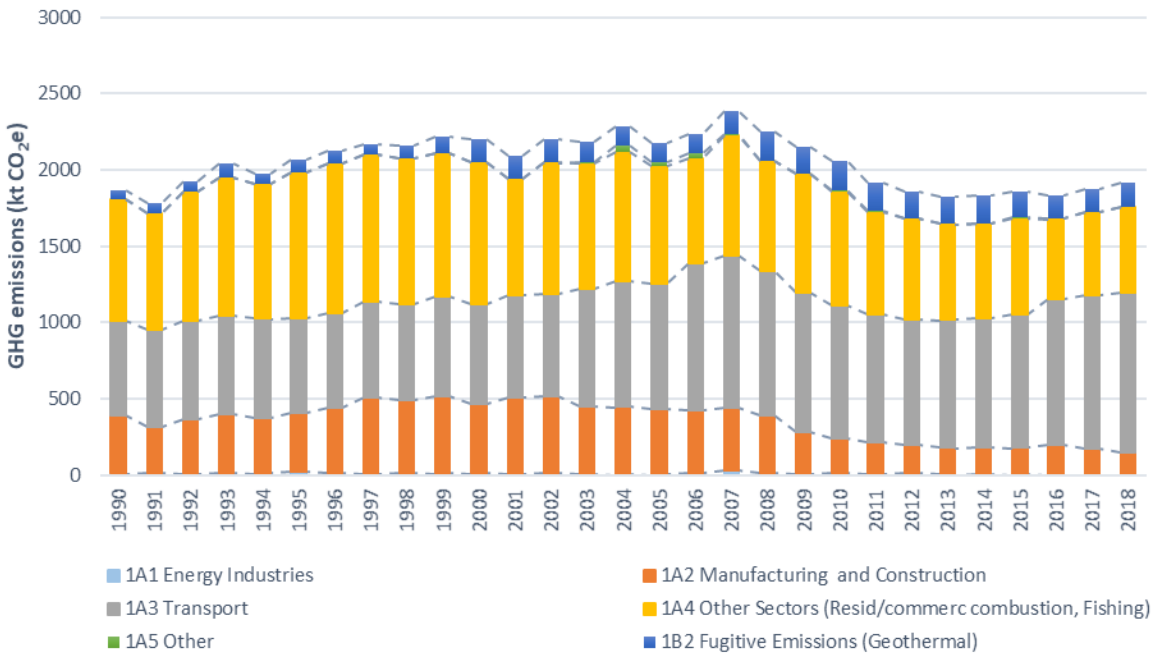

Figure 2.3 Total GHG emissions in Energy sector for the reported time series (kt CO_2e).

Table 2.2 Total GHG emissions from fuel combustion in the Energy sector for the reported time series (kt CO_2e).

Energy Sector	1990	1995	2000	2005	2010	2015	2017	2018	Change ´90-18	Change ´17-´18
1A1 Energy industries	14	22	11	8	14	4.2	2.3	2.4	-83%	2.0%
1A2 Manufacturing industry and construction	377	384	456	426	231	175	172	150	-60%	-12.7%
1A3 Transport	623	625	657	825	871	875	1,008	1,047	68%	3.9%
1A4 Other Sectors	794	955	926	765	738	632	546	560	-30%	2.6%
1A5 Other	NO,IE	NO,IE	NO,IE	29	14	6	0.2	0.7	NA	305.8%
1B2 Fugitive Emissions from Fuels (incl. Geothermal energy)	62	83	155	120	195	168	150	160	158%	6.7%
Total emissions (kt CO_2e)	**1,869**	**2,070**	**2,205**	**2,173**	**2,063**	**1,859**	**1,878**	**1,920**	**3%**	**2.2%**

2.1.1.1 Fuel Combustion

Emissions from fuel combustion in the Energy sector accounted for 40% of the total GHG emissions in Iceland in 2018. Emissions from transport have significantly increased since 1990 (by 68%), whilst emissions from energy industries, fishing and manufacturing industries and construction have decreased (-83%, -30% and -60%, resp.). 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 0.1% of the sector's total emissions in 2018). 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 55% 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 down. 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, which has increased by 83% since 1990, 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. Also, the Icelandic population has grown by 37% from 1990 to 2018. 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 2015. The 2018 road emissions are 7% higher than the 2007 peak. 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. 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 decreased again reaching 1990 levels in 2001. Emissions increased again by 10% between 2001 and 2002. In 2003 emissions again reached the 1990 level. Emissions remain below 1990 levels, however there are large annual variations due to the inherent nature of fisheries.

2.1.1.2 Geothermal Energy

Emissions from geothermal energy utilization accounts for 3.2% of the total GHG emissions in Iceland in 2018. Iceland relies heavily on geothermal energy for space heating (over 90% of the homes) and electricity production (27% of the total electricity production). Table 2.3 shows the emissions from geothermal energy from 1990 to 2018. Electricity production using geothermal power increased 21-fold during this period from 283 to 6010 GWh, 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.

Table 2.3 Emissions from geothermal energy for the reported time series (kt CO_2e).

	1990	1995	2000	2005	2010	2015	2017	2018	Change ´90-´18	Change ´17-´18
Geothermal energy	62	82	154	119	194	167	149	159	158%	-7%

2.1.1.3 Distribution of oil products

Emissions from distribution of oil products are a minor source in Iceland (below 1 kt CO_2e)

2.1.1.4 International Bunkers

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 and can be seen in Table 2.4.

In 2018 GHG emissions from ships and aircrafts in international traffic bunkered in Iceland amounted to a total of 1,547 kt CO_2e. GHG emissions from marine and aviation bunkers have more than quadrupled since 1990. Foreign commercial fishing vessels dominate the fuel consumption from marine bunkers.

Table 2.4 GHG emissions from international aviation and international water-borne navigation for the reported time series (kt CO_2e).

	1990	1995	2000	2005	2010	2015	2017	2018	Change ´90-´18	Change ´17-´18
1D1a International aviation	221	238	411	425	380	680	1156	1304	489%	13%
1D1b International navigation	20	3.4	55	1.8	0.3	150	214	244	1152%	14%
Total GHG emissions	241	241	466	427	380	830	1371	1548	543%	13%

2.1.2 Industrial Processes (CRF sector 2)

Production of raw materials is the main source of industrial process related emissions for both CO_2 and other GHGs such as N_2O and PFCs. Emissions also occur as a result of the consumption of HFCs as substitutes for ozone depleting substances and SF_6 from electrical equipment. The Industrial Process sector is the sector largest contributor to national GHG emissions after LULUCF. Emissions from Industrial Process have increased over the time series primarily due to the expansion of energy-intensive industry, such as aluminium smelting and ferroalloy production as can be seen in Figure 2.4 and Table 2.5, emissions from industrial processes decreased from 1990 to 1996, mainly because of a decrease in PFC emissions. Increased production capacity has led to an increase in industrial process emissions since 1996, especially after 2005 as the production capacity in the aluminium industry has increased.

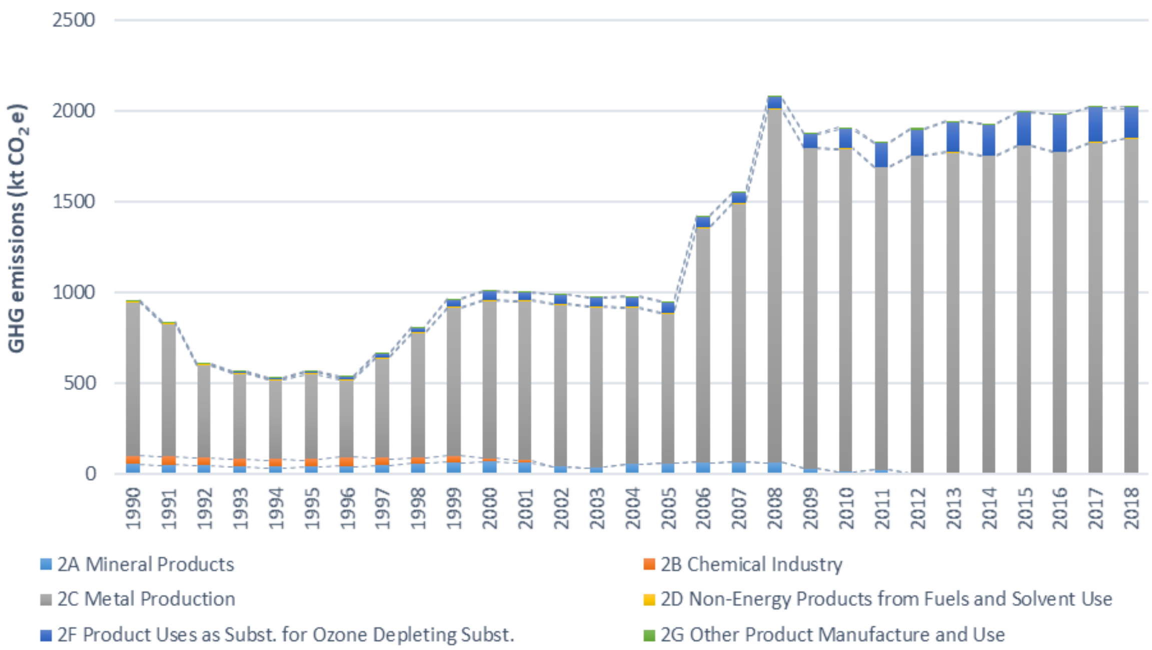

Figure 2.4 Total GHG emissions in the Industrial Process sector for the reported time series (kt CO_2e).

Table 2.5 GHG emissions from Industrial Processes for the reported time series (kt CO_2e).

Industry Sector	1990	1995	2000	2005	2010	2015	2017	2018	Change ´90-´18	Change ´17-´18
2A Mineral products	52	38	65	55	10	0.7	0.9	0.9	-98%	0.3%
2B Chemical industry	47	41	18	NO	NO	NO	NO	NO	NA	NA
2C Metal production	844	469	868	828	1,781	1,807	1,824	1,846	119%	1.2%
2D Non-Energy Products from Fuels and Solvent Use	6.8	7.4	7.4	6.9	5.1	5.5	5.1	5.6	-17%	9.1%
2F Product Uses as Substitutes for Ozone Depleting Substances	0.3	3.4	44	56	105	180	191	167	48381%	-12.4%
2G Other Product Manufacture and Use	7.2	5.8	6.3	6.6	8.6	4.8	4.8	6.2	-14%	30.2%
Total GHG emissions	**958**	**565**	**1,010**	**952**	**1,911**	**1,998**	**2,026**	**2,026**	112%	0.0%

The most significant category within the Industrial Processes sector is metal production, which accounts for approximately 90% of the sector's emissions in recent years:

- **Aluminium production** is the main source within the metal production category, accounting for 69% of the total Industrial Processes emissions in 2018. 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. From 1990 to 1996 PFC emissions were reduced by 94%. Because of the expansion of the existing aluminium plant in 1997 and the establishment of a second aluminium plant in 1998, emissions increased again 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.
- No HFC/PFC's were routinely used for refrigeration before 1993 and the only HFC's reported before then is HFC-134 in Metered Dose Inhalers, therefore the increase since 1990 is very large.

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 shell sand 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 started in 1993 and have increased steadily since then. 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. The process of retrofitting older refrigeration systems and replacing ODS as refrigerants is still on-going which means that the size of the refrigerant bank is still increasing, causing an accelerated increase of emissions since 2008. The amount of HFCs emitted by mobile air conditioning units in vehicles has also been increasing steadily. Very minor amounts of PFC's 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 2.6). The peak in leakage in 2010 was caused by two unrelated accidents during which the SF_6 contained in equipment leaked into the atmosphere.

Table 2.6 Total HFC, PFC and SF_6 emissions from F gas consumption (kt CO_2e) for the reported time series.

	1990	1995	2000	2005	2010	2015	2017	2018	Change ´90-´18	Change ´17-´18
HFCs	0.35	3.4	44	56	105	180	191	167	48366%	-12%
PFCs	NO	NO	NO	0.0032	0.0015	0.0086	0.027	0.052	NA	91%
SF_6	1.1	1.2	1.3	2.5	4.7	1.6	2.3	3.3	197%	41%

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 this 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.

2.1.3 Agriculture (CRF sector 3)

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. The only other factor that has had 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 2.5 and Table 2.7).

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

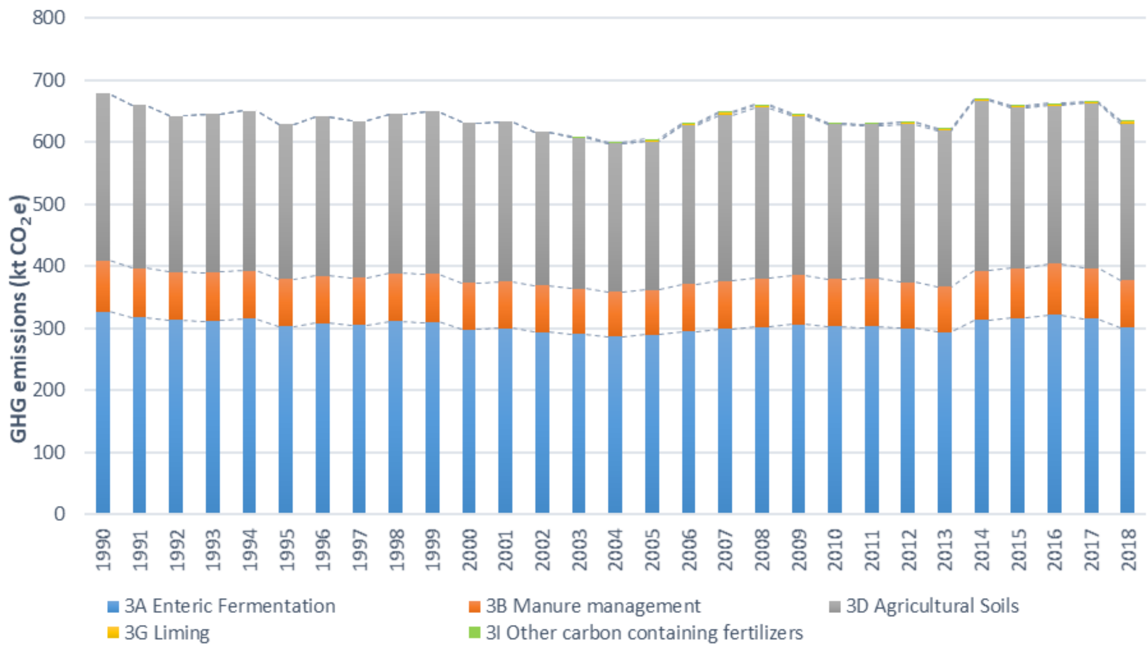

Figure 2.5 GHG emissions from agriculture sector for the reported time series (kt CO_2e).

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

Agriculture Sector	1990	1995	2000	2005	2010	2015	2017	2018	Change ´90-´18	Change ´17-´18
3A Enteric Fermentation	326	303	298	289	303	316	315	301	-7.7%	-4.4%
3B Manure management	83	76	76	73	76	80	82	76	-7.4%	-6.9%
3D Agricultural Soils	269	250	258	239	250	258	265	251	-6.8%	-5.4%
3G Liming	NE	NE	NE	1.2	0.6	2.0	1.7	3.9	NA	131%
3H Urea Application	0.06	0.06	0.07	0.07	0.13	0.6	0.8	0.9	1557%	10%
3I Other C-containing fertilizers	NE	NE	NE	2.3	1.7	1.2	1.5	1.6	NA	9.5%
Total GHG emissions	**678**	**629**	**632**	**605**	**631**	**659**	**666**	**635**	**-6.4%**	**-4.7%**

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

Net emissions from the LULUCF sector in Iceland are high; the sector had the highest net emissions 1990-2018. Both emissions from sources and removals by sinks are reported for this sector. A large part of the absolute value of emissions from the sector in 2018 was from grassland, wetlands and cropland. The net contribution of the main land use categories is summarized in Figure 2.6 below.

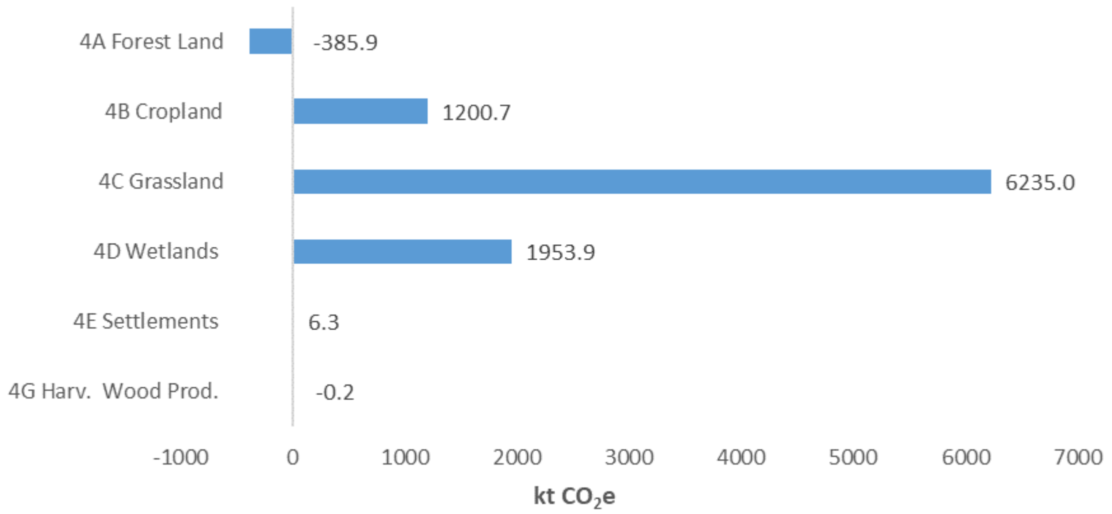

Figure 2.6 Net emissions/removals from the LULUCF land use categories (kt CO_2e)

Net emissions (emissions – removals) in the sector have slightly decreased over the time period, as can be seen in Table 2.8. Emission increase from Grassland is explained by drainage of wetland, converting Wetlands to Grassland, which is 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.

Table 2.8 GHG emissions from the LULUCF sector from 1990 to 2017 (kt CO_2e).

LULUCF Sector	1990	1995	2000	2005	2010	2015	2017	2018	Change ´90-´18	Change ´17-´18
4A Forest Land	-43	-66	-101	-152	-207	-311	-383	-386	807%	0.8%
4B Cropland	1946	1813	1679	1546	1413	1280	1227	1201	-38%	-2.2%
4C Grassland	5389	5467	5623	5815	6076	6201	6242	6235	16%	-0.1%
4D Wetlands	2027	2032	2019	1999	1973	1964	1961	1954	-4%	-0.4%
4E Settlements	24	14	19	35	6	6	6	6	-74%	0.1%
4F Other Land	NA,NE	NA,NE	NA,NE	NA,NE	NO,NA, NE	0.003	0.002	NE,NA	NA	NA
4G Harvested Wood Products	NO,NA	NO,NA	0.0004	-0.0002	-0.03	-0.12	-0.09	-0.1502	NA	59.2%
Net emissions LULUCF	**9344**	**9260**	**9238**	**9242**	**9262**	**9141**	**9053**	**9010**	**-4%**	**-0.5%**

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.

2.1.5 Waste (CRF sector 5)

Emissions from the Waste sector accounted for 5.7% of total GHG emissions in 2018. Approximately 80% of these emissions were methane 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 presented in Figure 2.7and Table 2.9, and is dominated by:

- An increase in **Solid Waste Disposal** (SWD) emissions between 1990 and 2007. This increase 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 2007 is caused by a decrease in SWD emissions which is due to a rapidly decreasing share of waste landfilled since 2005 and by an increase in methane recovery at SWDS. The total increase of SWD emissions between 1990 and 2018 amounted to 36%. Despite the downward trend, there was again an increase in emissions from SWDs between 2017 and 2018 due to an increased amount of waste going to SWDs in 2018.

- **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.

- A halving of emissions from **waste incineration** between 1990 and 2018 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.

- Emissions from **composting (5B)** have been steadily increasing from 1995 when composting started. Between 1995 and 2018 composting emissions increased 12-fold due to increasing amounts of waste composted.

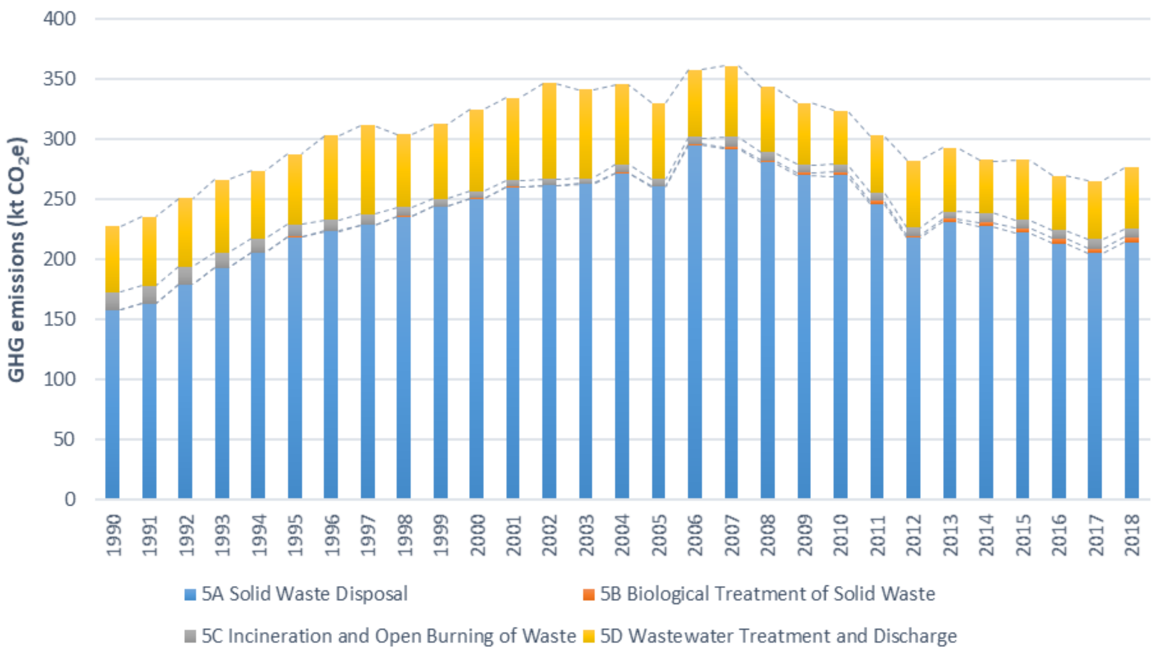

Figure 2.7 GHG emissions of the waste sector for the reported time series (kt CO_2e).

Table 2.9 GHG emissions from the waste sector for the reported time series (kt CO_2e).

Waste Sector	1990	1995	2000	2005	2010	2015	2017	2018	Change ´90-´18	Change ´17-´18
5A Solid Waste Disposal	158	219	251	260	270	222	205	214	36%	4.4%
5B Biological Treatment of Solid Waste	NO, NA	0.3	0.3	0.9	2.6	3.7	3.7	4.1	NA	11%
5C Incineration and Open Burning of Waste	15	10	6.0	5.5	6.5	7.1	7.8	6.9	-54%	-11%
5D Wastewater Treatment and Discharge	55	59	68	64	45	50	49	51	-6%	5.2%
Total emissions	**227**	**288**	**325**	**330**	**324**	**283**	**265**	**276**	**22%**	**4.1%**

2.2 Emission Trends by Gas

All values in this chapter refer to Iceland´s total GHG emissions without LULUCF. As shown in Figure 2.8, the largest contributor by far to total GHG emissions 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 (Figure 2.9).

Table 2.10 Emissions of GHG gases by gas for the reported time series (without LULUCF) (kt CO_2e).

	1990	1995	2000	2005	2010	2015	2017	2018	Change ´90-´18	Change ´17-´18
CO_2	2248	2477	2946	2986	3660	3545	3615	3675	63%	1.7%
CH_4	611	646	680	673	682	656	637	630	3.2%	-1.1%
N_2O	378	354	349	312	306	313	322	306	-19%	-5.2%
PFCs	495	69	150	31	172	104	68	76	-85%	12%
HFCs	0.35	3.43	44	56	105	180	191	167	48366%	-12%
SF_6	1.1	1.2	1.3	2.5	4.7	1.6	2.3	3.3	197%	41%
Total emissions	**3733**	**3551**	**4171**	**4059**	**4929**	**4800**	**4836**	**4857**	**30%**	**0.4%**

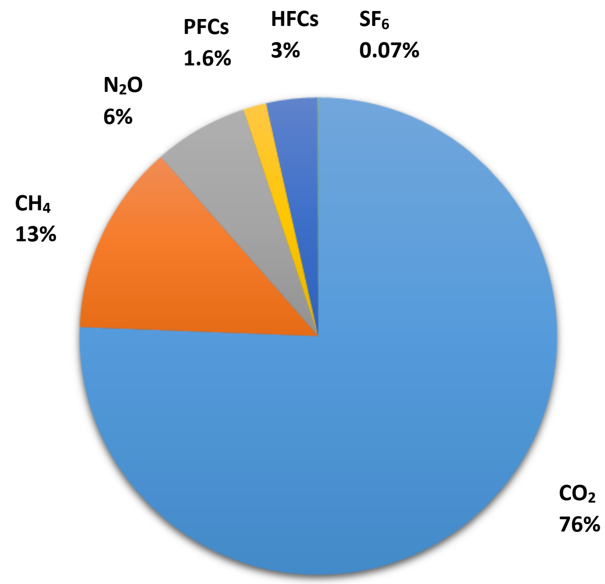

Figure 2.8 Distribution of emissions of GHGs by gas in 2018 (without LULUCF).

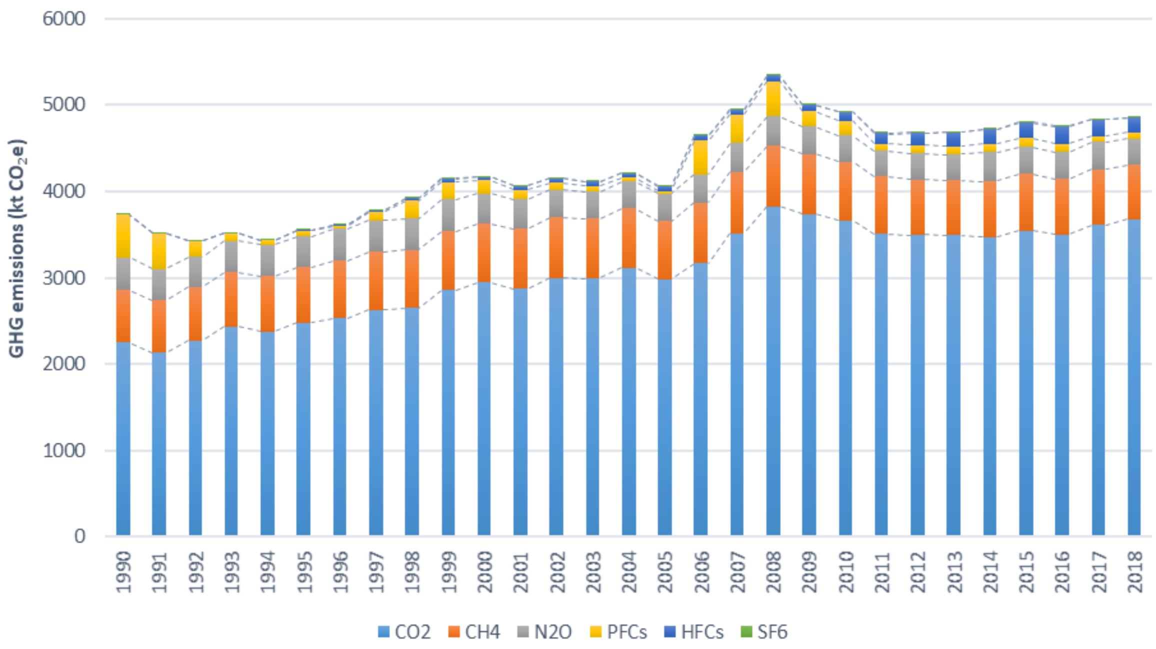

Figure 2.9 Emissions of GHGs by gas for the reported time series (kt CO_2e)

2.2.1 Carbon Dioxide (CO_2)

Industrial processes, road transport and commercial fishing are the three main sources of CO_2 emissions in Iceland. Since emissions from electricity generation and space heating are low, as they are generated from renewable energy sources, emissions from stationary combustion are dominated by industrial sources. Thereof, the fishmeal industry is by far the largest user of fossil fuels. Emissions from mobile sources in the construction sector are also significant (though much lower from 2008 onwards). Emissions from geothermal energy exploitation are also considerable. Other sources consist mainly of emissions from non-road transport and waste incineration.

Since 1990, Iceland´s total CO_2 emissions have increased by almost two thirds. This trend in increasing emission is dominated by:

- **Industrial processes** which has seen the greatest in emissions due to the expansion of the metal production sector, in particular the aluminium 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. In 2018 the total production amounted to 879,135 tonnes of aluminium.
- Emissions from **geothermal energy utilization** have significantly increased (Figure 2.2) due to an increase in electricity production, which increased 18-fold between 1990 and 2018.
- **Road transport** CO_2 emissions have increased by 87% since 1990, owing to increases in population, number of cars per capita, more mileage driven, and an increase in the share of larger vehicles.

Annual emissions have seen an overall decline since 1990 from the following sectors:

- Total CO_2 emissions from **commercial fishing** declined by over a quarter in 2018 compared to 1990.
- Annual emissions from **construction** rose until 2009 when emissions fell below 1990 levels. This is mainly due to changes in the cement industry where production had been slowly decreasing since 1990. The sole cement plant ceased operation in late 2011.

Emissions from both **domestic flights** and **navigation** have declined since 1990.

2.2.2 Methane (CH_4)

Agriculture and waste treatment have been the main sources of methane emissions since 1990. The main methane source in the agriculture sector is enteric fermentation, and the main source in the waste sector is solid waste disposal on land.

Methane emissions from agriculture have decreased slightly since 1990 due to a decrease in livestock population. Emissions from waste, on the other hand, have increased by over half over the time series.

2.2.3 Nitrous Oxide (N_2O)

Agriculture is the main source of N_2O emissions in Iceland. Direct and indirect N_2O emissions from agricultural soils were the most prominent emission contributors, followed by emissions from manure management systems.

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. 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.

2.2.4 Perfluorocarbons (PFCs)

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 PFC218. PFC emissions from the aluminium industry were 76 kt CO_2e in 2018, whereas emissions of PFCs from refrigeration and air conditioning equipment were 0.052 kt CO_2e in 2018.

Total PFC emissions decreased by 84% in the period of 1990-2018. The emissions decreased steadily from 1990 to 1996 with the exception of 1995, as can be seen from Figure 2.10.

At that time one aluminium plant was operating in Iceland. PFC emissions per tonne of aluminium are generally high during start up and usually rise during expansion. The emissions therefore rose again due to the expansion of the plant in 1997 and the establishment a new plant in 1998. The emissions showed a steady downward trend between 1998 and 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. The PFC emissions rose significantly in 2006 due to an expansion of one of the facilities. A new aluminium plant was established in 2007 and reached full production capacity in 2008. The decline in PFC emissions in 2009, 2010 and 2011 was achieved through improved process control as the processes have become more stable after a period of start-up in both plants. In December 2010, a rectifier was damaged in fire at one of the plants. This led to increased PFC emissions leading to higher emissions at the plant in 2010 than in 2009. On average 0.1 t of PFC (in CO_2e) are emitted for each produced t of aluminium from the years 2010-2018.

To a very small extent PFCs have also been used as refrigerants. C_2F_6 has been used in refrigeration and air conditioning equipment since 2001 (0.001 to 0.014 kt CO_2e per year) and C_3F_8 was used in refrigeration and air conditioning equipment for the first time in 2009.

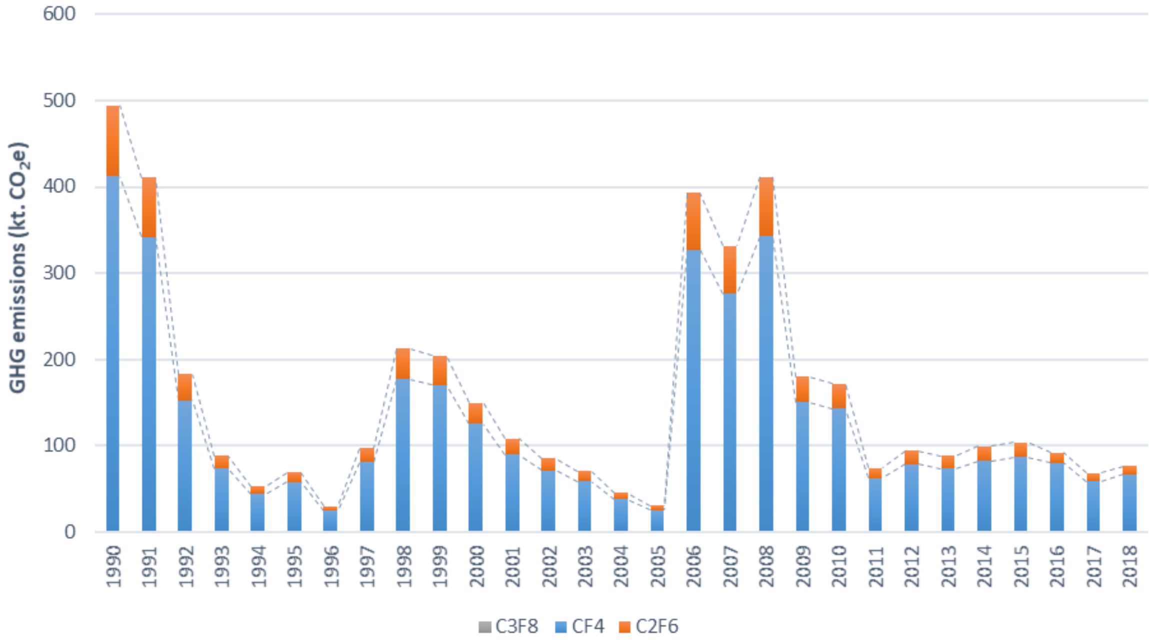

Figure 2.10 Emissions of PFCs for the reported time series (kt CO_2e).

2.2.5 Hydrofluorocarbons (HFCs)

HFCs are used as substitutes for ozone depleting substances (ODS) in refrigeration systems. Total HFC emissions have significantly increased compared to 1990 levels. The import of HFCs started in 1993 and increased until 2016 in response to the phase-out of ODS like chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). Import numbers decreased strongly in 2011, causing only a slight decrease in emissions due to the time lag between refrigerant use and leakage. Refrigeration and air-conditioning were by far the largest sources of HFC emissions and the fishing industry plays an eminent role. Figure 2.11 presents the emissions trend of HFC species.

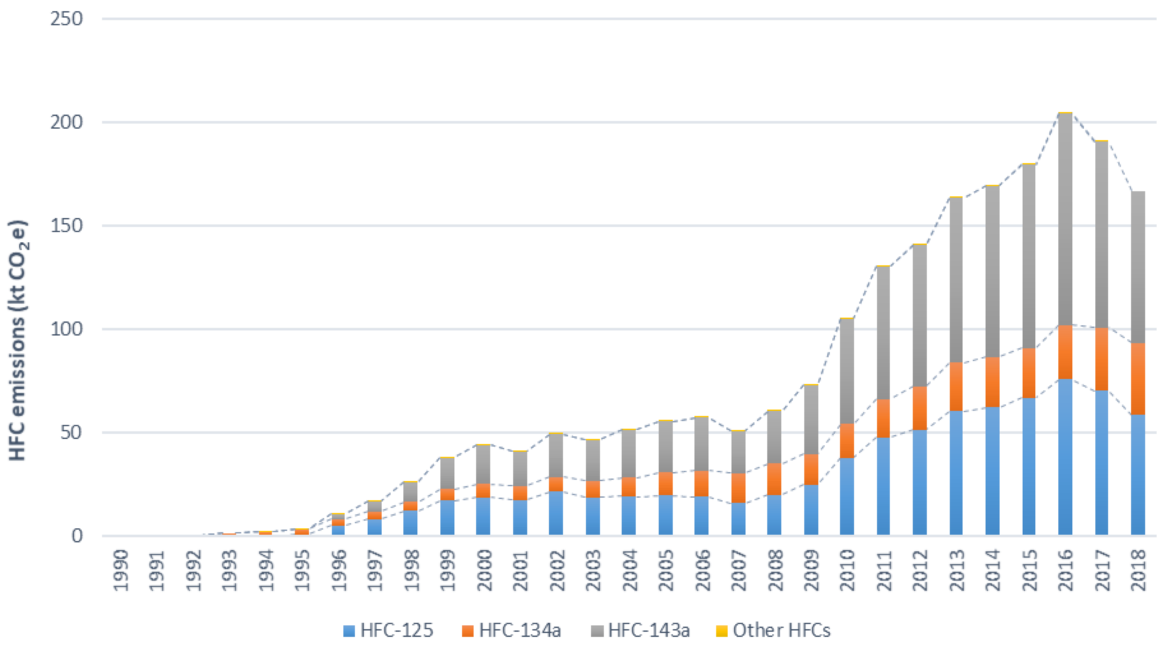

Figure 2.11 Emissions of HFCs for the reported time series (kt CO_2e).

2.2.6 Sulphur Hexafluoride (SF_6)

The sole source of SF_6 emissions in Iceland is leakage from electrical equipment. Emissions have more than doubled in 2018 compared to 1990 (Figure 2.12). This increase reflects the expansion of the Icelandic electricity distribution system since 1990 which is accompanied by an increase in SF_6 used in high voltage gear.

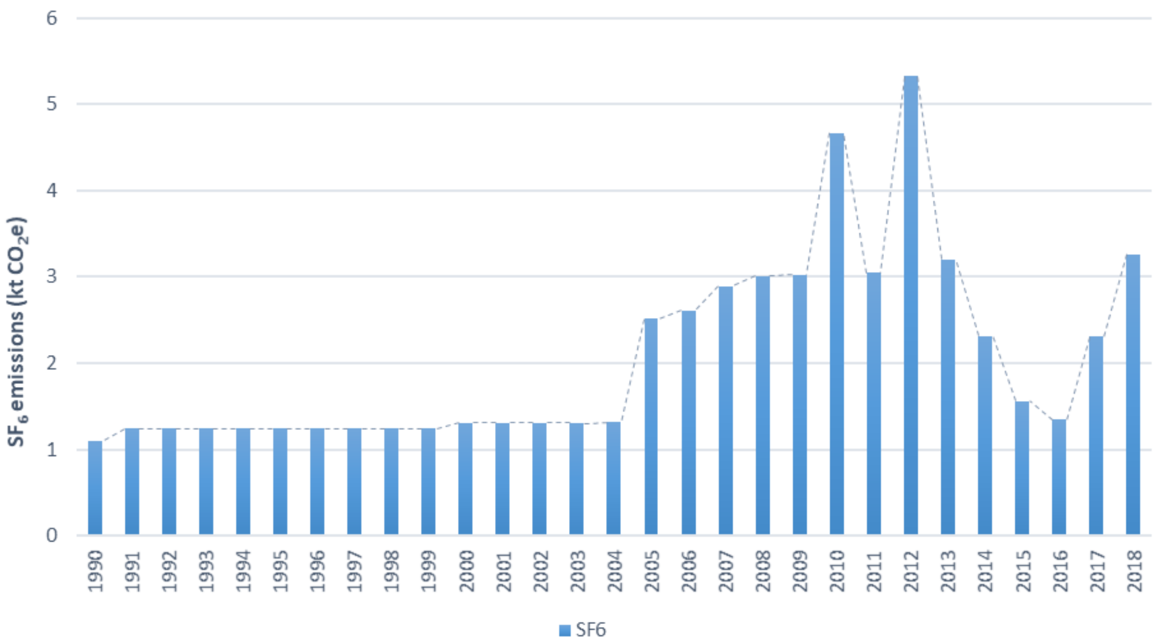

Figure 2.12 Emissions of SF_6 for the reported time series (kt CO_2e).

2.3 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.

2.3.1 Nitrogen Oxides (NOx)

The main sources of NO_x in Iceland is the Energy sector, as can be seen in Figure 2.13. 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.

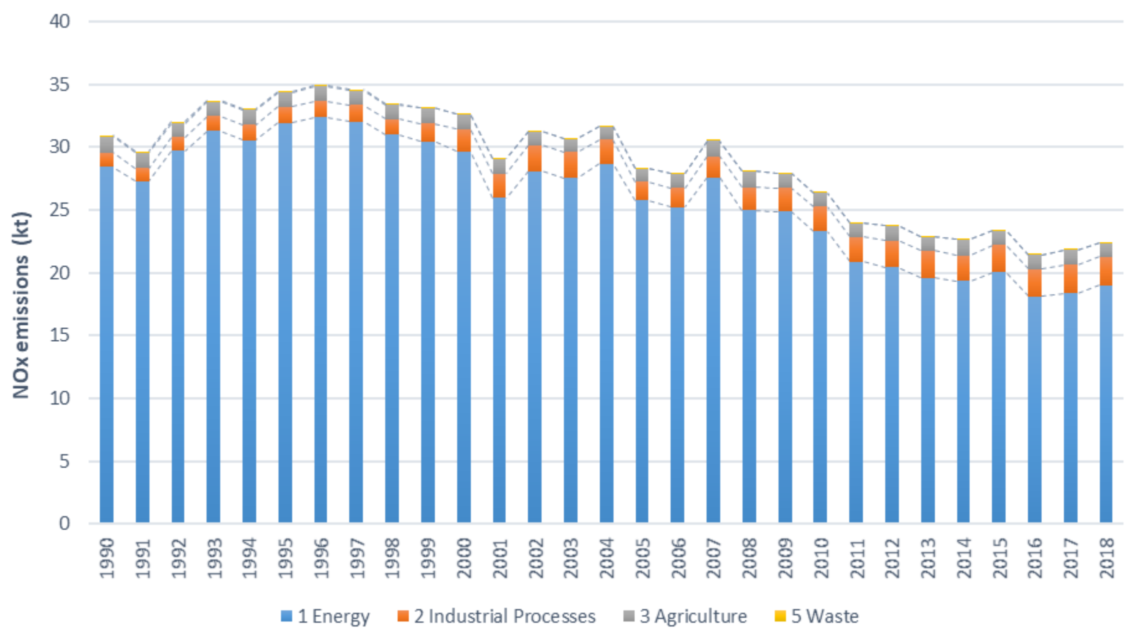

Figure 2.13 Emissions of NO_x by sector for the reported time series (kt).

2.3.2 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 2.14. 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.

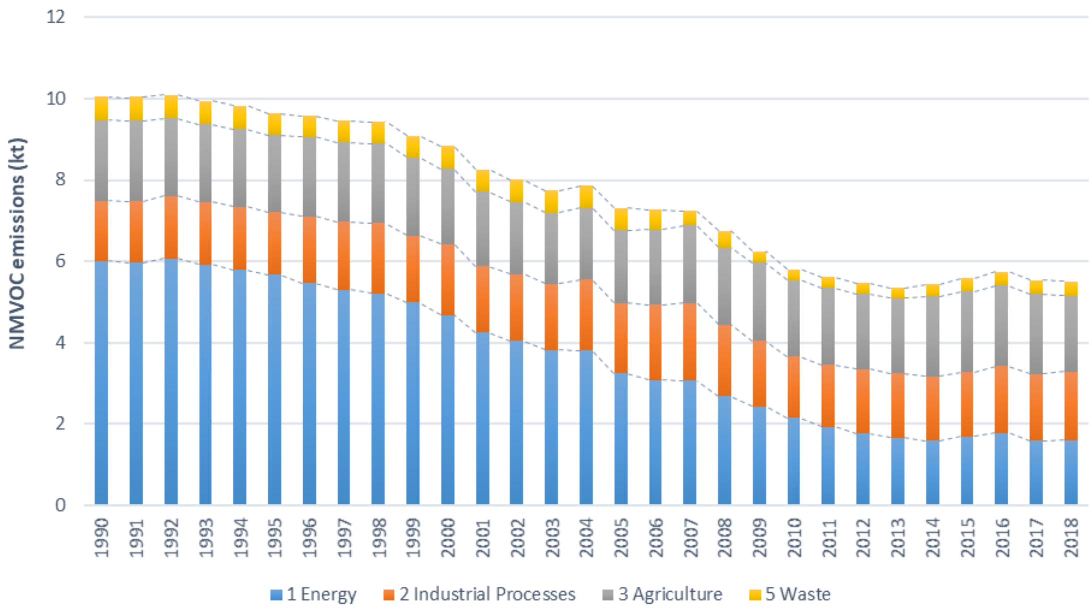

Figure 2.14 Emissions of NMVOC by sector for the reported time series (kt).

2.3.3 Carbon Monoxide (CO)

Industrial Processes are the most prominent contributors to CO emissions in Iceland, as can be seen in Figure 2.15. 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.

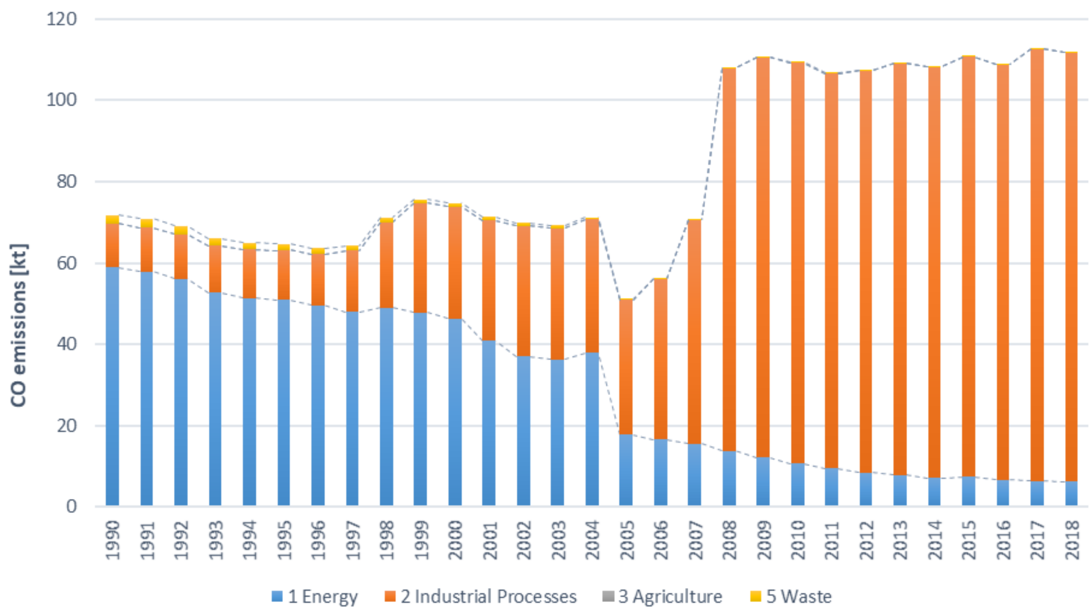

Figure 2.15 Emissions of CO by sector for the reported time series (kt).

2.3.4 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 2.16.

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.

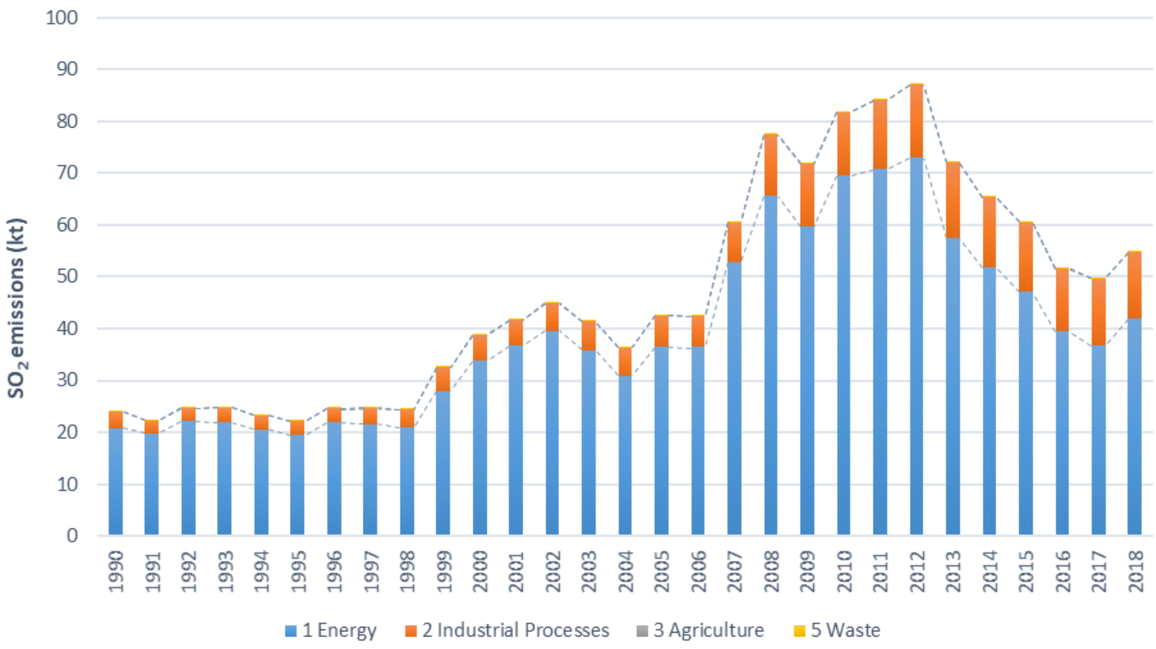

Figure 2.16 Emissions of S (sulphur) by sector for the reported time series (kt SO_2e).

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. The total GHG emissions from the energy sector in Iceland were estimated to 1,920 kt CO_2e in 2018. The 1990 emissions were estimated to be 1,869 kt CO_2e and the emissions from the energy sector in the most recent year reported are 2.7% above the 1990 level. From reported sources of GHG emissions, fisheries and road transport are the sector's largest single contributors and estimated to account for around 80% of the total GHG emissions in the energy sector in 2018. CO_2 emissions account for 98.4% of the total GHG emissions in the energy sector while CH_4 and N_2O account for the rest.

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, as per recommendation of previous review teams, as well as during the UNFCC's in-country review in 2017.

For this submission, emissions from Road Transportation are estimated using COPERT 5.3.0. which uses a tier 3 methodology to estimate N_2O and CH_4 emissions, and a tier 1 methodology to estimate CO_2 emissions. This is the first submissions where COPERT has been used which improved the methodology for emissions from road transport significantly. A more detailed description can be found in chapter 3.4.2 Road Transportation (CRF 1A3b).

For the 2020 submission a comprehensive review was performed on how the fuels sales data from the NEA is attributed to IPCC sectors. For this 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. Therefore, the attributing of fuels to IPCC categories for 1990-2002 has not been changed, but for the next submission it is planned to perform a similar review of the sales statistics for the earlier time series.

1990-2002 methodology

For the years 1990-2002, the division of fuel sales by sector did not match the 2006 IPCC sectors, thus the EA has developed a method to attribute fuel consumption to the various IPCC categories. This applies for the sectors 1A1 Energy industries, 1A2 Manufacturing industry and 1A4a and b Commercial/Residential combustion. The adjustment is done in the following way for gasoil: Fuel consumption needed for the known electricity production with fuels is calculated (1A1a – electricity production), assuming 34% efficiency of the diesel engines. The values calculated are compared with the fuel sales for the category 10X60 Energy industries (nomenclature from the NEA). Fuel consumption attributed to 1A2a Iron and Steel, 1A2b Non-ferrous metals and one company under 1A2f non-metallic minerals is taken from the ETS reports submitted by the ferroalloy, aluminium and mineral wool companies. The rest of the fuel consumption is then attributed as follows:

- In years where there is less fuel sale to energy industries than would be needed for the electricity production, the fuel needed to compensate is taken from the category 10X90

Other; and if that is not sufficient from the category 10X40 House heating and swimming pools.

- In years where there is a surplus, the extra fuel is added to the category 10X40 House heating and swimming pools.
- NEA has estimated the fuel use by swimming pools (1A4a), but it should be noted that the majority of swimming pools in Iceland have geothermal water. The estimated fuel use values are given in the lower table of Annex 7. These values are subtracted from the adjusted 10X40 category, and the rest is attributed to 1A4c – Residential.
- For years where there is still fuel in the category 10X90 Other, this is added to the 10X5X Industry. This is the fuel use in 1A2 – Industry.

Tables explaining this attribution are in Annex 7, where the values obtained from the NEA are shown, and the adjustment methodology for residual fuel oil is explained.

2003-2018 methodology

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

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

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

- It is assumed that Green Accounting reports (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.

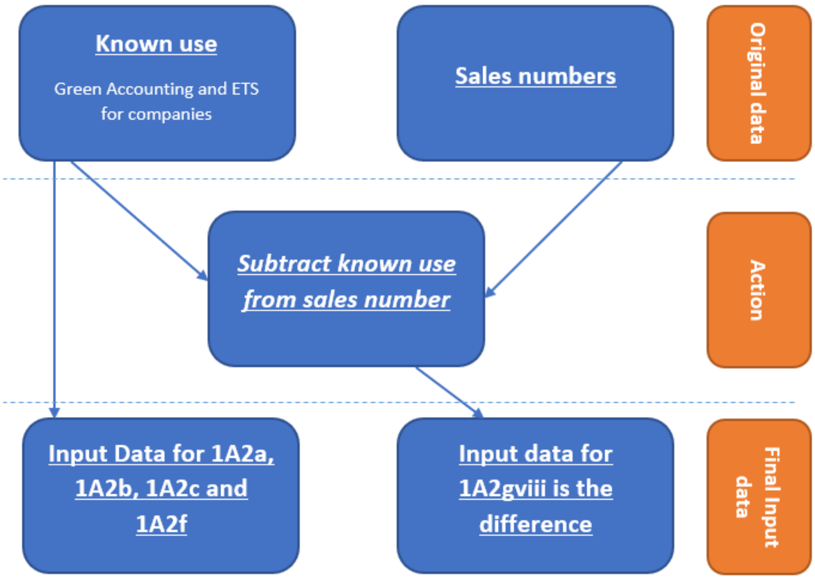

Figure 3.1 Description of adjustments in input data for IPCC category 1A2

In the sales statistics received from the NEA there are unspecified categories for all fuels, labelled as "Other". For previous submissions these fuels have been attributed to 1A2gviii Other Industry, however there is insufficient justification for that attribution because the location of use of these fuels is unknown. Therefore, for this input data review, these fuels were attributed to IPCC category 1A5, which Iceland has not been reporting previously. This only applies to 2003-2018 for this submission. For the next submission a similar methodology will be used to attribute fuels for 1990-2002 but until then 1A5 will be reported as IE for those years. 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 (KCA)

The key sources for 1990, 2018 and 1990-2018 trend in the Energy sector are as follows (compared to total emissions without LULUCF):

Table 3.1 Key Categories for Energy 1990, 2018 and trend (excluding LULUCF).

IPCC source category			Level 1990	Level 2018	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 Completeness

Table 3.2 gives an overview of the IPCC source categories included in this chapter and presents the status of emission estimates from all sub-sources in the Energy sector.

Table 3.2 Energy - completeness (E: estimated, NE: not estimated, NA: not applicable).

	Greenhouse gases						Other gases			
Sector	**CO_2**	**CH_4**	**N_2O**	**HFC**	**PFC**	**SF_6**	**NO_x**	**CO**	**NMVOC**	**SO_2**
1A1 Energy industries										
1A1a Public electricity and heat production	E	E	E	NA	NA	NA	E	E	E	E
1A1b Petroleum refining	**NOT OCCURING**									
1A1c Manufacture of Solid Fuels	**NOT OCCURING**									
1A2 Manufacturing Industries and Construction										
1A2a Iron and Steel	E	E	E	NA	NA	NA	E	E	E	E
1A2b Non-ferrous metals	E	E	E	NA	NA	NA	E	E	E	E
1A2c Chemicals (1990-2004)	E	E	E	NA	NA	NA	E	E	E	E
1A2d Pulp, paper and print	**NOT OCCURING**									
1A2e Food Processing, Beverages and Tobacco	E	E	E	NA	NA	NA	E	E	E	E
	Greenhouse gases						**Other gases**			
Sector	**CO_2**	**CH_4**	**N_2O**	**HFC**	**PFC**	**SF_6**	**NO_x**	**CO**	**NMVOC**	**SO_2**
1A2f Non-metallic minerals	E	E	E	NA	NA	NA	E	E	E	E
1A2g Other	E	E	E	NA	NA	NA	E	E	E	E
1A3 Transport										
1A3a Domestic aviation	E	E	E	NA	NA	NA	E	E	E	E
1A3b Road Transportation	E	E	E	NA	NA	NA	E	E	E	E
1A3d Railways	**NOT OCCURING**									
1A3d Domestic navigation	E	E	E	NA	NA	NA	E	E	E	E
1A3e Other Transportation	**NOT OCCURING**									
1A4 Other Sectors										
1A4a Commercial/Institutional	E	E	E	NA	NA	NA	E	E	E	E
1A4b Residential	E	E	E	NA	NA	NA	E	E	E	E
1A4c Agriculture/Forestry/Fisheries	E	E	E	NA	NA	NA	E	E	E	E
1A5 Other										
1A5a Stationary (2003-2018)	E	E	E	NA	NA	NA	E	E	E	E
1A5a Mobile	**NOT OCCURING**									
1B Fugitive Emissions from Fuels										
1B1 Solid Fuels	**NOT OCCURING**									
1B2 Oil and Natural Gas	E	E	NA	NA	NA	NA	NA	NA	E	NA
1B2d Geothermal Energy	E	E	NA	NA	NA	NA	NA	NA	NA	E
1D International Transport										
1D1a International Aviation	E	E	E	NA	NA	NA	E	E	E	E
1D1b International Navigation	E	E	E	NA	NA	NA	E	E	E	E

3.1.4 Source Specific QA/QC Procedures

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

- Identify and document discrepancies between the sectoral approach and the reference approach
- Cross-checks with data from the NEA (as sent to the IEA) and Statistics Iceland (as reported from customs import data)
- Review of the Energy chapter in this NIR by external stakeholders (planned improvement).

3.1.5 Planned Improvements

Several improvements are planned for the next submission:

- Monthly meetings with the NEA are planned in order to address discrepancies between energy statistics and data used in the inventory. Activity data for the whole time series will be checked and the attribution between IPCC subsectors will be discussed. Focus on attributing the sales statistics for 1990-2002 to IPCC categories with the same methodology as 2003-2018.
- Increased collaboration with the Icelandic Transport Authority to streamline data transfer to the EA.
- Work is underway with the EA team responsible for the surveillance of fuel imports in order to develop country-specific fuel specifications, in particular for liquid fuels. We are currently investigating the possibility to carry out measurements of carbon, oxygen and hydrogen contents as well as NCV on all imported diesel and gasoline.
- 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 is being investigated
- It is planned to send the Energy chapter for review by national stakeholders.

3.2 Fuel Combustion: Energy industries (CRF 1A)

3.2.1 Energy Industries (CRF 1A1)

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. Emissions from electricity and heat production were estimated to account for 0.12% of the total GHG emissions from the Energy sector in the most recent year.

Activity data for electricity and heat production are based on data provided by the NEA. The CO_2 emission factors reflect the average carbon content of fossil fuels. They are taken from the 2006 IPCC

Guidelines for National GHG Inventories and presented in Table 3.5. Emissions of SO_2 are calculated from the S-content of the fuels, which are also included in Table 3.5. Emission factors for other pollutants are taken from the 2006 IPCC Guidelines. The EF for 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. It has to be noted that only 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. The CO_2 emission factor for waste incineration was calculated using Tier 2 methodology and default values from the 2006 Guidelines. The IEF for energy industries is affected by the different consumption of waste and fossil fuels, as waste, gasoil and residual fuel oil have different EF. In years where more oil is used the IEF is considerably higher than in normal years.

3.2.2 Main Activity Electricity and Heat Production (CRF 1A1a)

3.2.2.1 Electricity Generation (CRF 1A1ai)

Electricity was produced from hydropower, geothermal energy, fuel combustion and wind power in 2018 (Table 3.3) with hydropower as the main source of electricity (Orkustofnun, 2019). Emissions from hydropower reservoirs are included in the LULUCF sector and emissions from geothermal power plants are reported in sector 1B2d. 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	2017	2018
Hydropower	4,159	4,678	6,352	7,014	12,592	13,781	14,059	13,813
Geothermal	283	288	1,323	1,658	4,465	5,003	5,170	6,010
Fuel combustion	5.6	8.4	4.4	7.8	1.7	4.0	2.1	1.9
Wind power	NO	NO	NO	NO	NO	11	8	4
Total	**4,447**	**4,975**	**7,679**	**8,680**	**17,059**	**18,799**	**19,239**	**19,829**

Activity Data

Activity data for 1990-2002 for electricity production is calculated from the information on electricity production, fuel use and the energy content of the fuel assuming 34% efficiency. Activity data for 2003-2018 is sales numbers for fuel sold for electricity production from the NEA. In 2018 approx. 0.01% 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 result in emissions (GHG, in kt CO_2e.) from electricity production.

	1990	1995	2000	2005	2010	2015	2017	2018
Gas/Diesel oil (kt)	1.4	2.1	1.1	0.02	1.0	1.2	0.7	0.7
Residual Fuel Oil (kt)	NO	NO	NO	NO	NO	NO	NO	NO
Biomethane (kt)	NO	NO	NO	0.3	NO	NO	NO	NO
Biodiesel (kt)	NO	NO	NO	NO	NO	NO	0.03	0.02
Emissions (kt)	**4.5**	**6.8**	**3.6**	**0.1**	**3.2**	**3.8**	**2.2**	**2.4**

Emission Factors

The CO_2 emission factors (EF) used reflect the average carbon content of fossil fuels. For diesel and biodiesel country-specific NCV values are used for 2017-2018 which are reflected in the t CO_2/t fuel emission factors. All other values are taken from the revised 2006 IPCC Guidelines for National GHG Inventories. They are presented in Table 3.5 along with the sulphur content of the fossil fuels.

Table 3.5 Emission factors for CO_2 from fuel combustion and S-content of fossil fuels for 2018.

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t fuel]	S-content [%]
Gas/Diesel oil	43.2	20.2	1	3.20	0.2
Residual Fuel Oil	40.4	21.1	1	3.13	1.8
Biomethane	50.4	14.9	1	2.75	-
Biodiesel	43.6	19.3	1	3.09	-

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.

Recalculations

Recalculations were performed for this sector for the time period 2003-2017. 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, biodiesel and biomethane for some years. This recalculation caused an 0.55 kt CO_2e increase in emissions in 2017 between the current submission and last submission, which amounts to 0.03% of total emissions from energy in 2017.

3.2.2.2 Heat Plants (CRF 1A1aiii)

Geothermal energy was the main source of heat production in 2018. 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.

Activity Data

Activity data for heat production with fuel combustion and waste incineration and the resulting emissions are given in Table 3.6. No fuel consumption for heat production was reported by the NEA for 2018. According to Annex II in the waste framework Directive 2008/98/EC incineration facilities dedicated to the processing of municipal solid waste need to have their energy efficiency equal or above 60%-65% in order to qualify as recovery operations. Since 2013 there has been only one incineration facility, Kalka, in Iceland and it does not qualify as a recovery operation. From 2013, no solid waste was used for the production of heat.

Table 3.6 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e.) from heat production.

	1990	1995	2000	2005	2010	2015	2017	2018
Residual fuel oil	2.99	3.08	0.07	0.20	NO	0.14	0.04	NO
Solid waste	NO	4.65	6.05	5.95	8.11	NO	NO	NO
Emissions (GHG)	**9.37**	**15.37**	**7.61**	**7.89**	**10.79**	**0.43**	**0.11**	**NO**

Emission Factors

Fuel combustion used for CO_2 emission factors (EF) reflects the average carbon content of fossil fuels. They are taken from the 2006 IPCC Guidelines for national greenhouse Gas inventories. They are presented in Table 3.7 along with the sulphur content of the fuels. 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.

Table 3.7 Emission factors for CO_2 from fuel combustion and S-content of fuel.

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t fuel]	S-content [%]
Residual fuel oil	40.4	21.10	1	3.13	1.8
Solid waste	10.0	33.1[1]	1	1.24[1]	0.1

[1] Mean values. Annual values vary depending on fossil carbon content of waste incinerated.

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, 100.1% for CH_4 and 100.1% for N_2O. The complete uncertainty analysis is shown in Annex 2.

Recalculations

Small recalculations for emissions between 1993-2013 from waste due to an error in waste amounts, which has been fixed. This did not change the total amount but only a percentage of each type of waste. This caused a minor increase in emissions for that time period.

3.3 Manufacturing Industries and Construction (CRF 1A2)

Emissions from the Manufacturing Industries and Construction account for 7.8% of the Energy sector’s total GHG emissions in Iceland in the most recent year. Table 3.8 shows the structure of the CRF sector 1A2, and the industries included in the various subcategories.

Table 3.8 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)

CRF code	IPCC name	Included
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 (included in 1Agvii Off-road vehicles and other machinery)
1A2gvii	Off-road vehicles and other machinery	All off-road machinery (including from agriculture/forestry subsectors)
1A2gviii	Other	All production that is not attributed to any of the other 1A2 subcategories.

3.3.1 Activity Data

Information about the total amount of fuel sold to the manufacturing industries for stationary combustion was obtained from the National Energy Authority. The sales statistics do not fully specify by which type of industry the fuel is being purchased. This division is made by 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. Fuel consumption in the fishmeal industry from 1990 to 2002 was estimated from production statistics, and the numbers for 2003 to 2018 are based on sales data provided by the NEA. 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.

Activity data for mobile combustion in this sector is provided by the NEA. Currently, activity data and information available from the National Energy Authority do not allow the distinction between fuels sold to machinery in construction, agriculture or other uses for the entire time series, 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 will be possible to distinguish between off-road vehicles in agriculture and construction from the 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, 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 and are all included under 1A2gvii. Fuel that is reported to fall under vehicle usage is in some instances actually used for machinery and vice versa as machinery sometimes tanks its fuel at a tank station and is thereby reported as road transport; conversely, it happens that fuel sold to contractors, for use on machinery, is used for road transport but is reported under construction. This is, however, very minimal and the deviations are believed to even out. Emissions are calculated by multiplying energy use with a pollutant specific emission factor.

Table 3.9 and Table 3.10 show the fuel sales statistics for the various fuel types used in Sector 1A2:

Table 3.9 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	2017	2018
Gas/Diesel oil	5.07	1.13	10.25	15.35	6.75	5.50	3.83	4.00
Residual fuel oil	55.93	56.22	46.21	24.85	17.89	10.18	4.30	5.79
LPG	0.48	0.39	0.86	0.93	1.05	0.81	0.67	1.04
Electrodes (residue)	0.80	0.29	1.50	NO	0.40	NO	NO	NO
Other bituminous coal	18.60	8.65	13.26	9.91	3.65	NO	NO	NO
Petroleum coke	NO	NO	NO	8.13	NO	NO	NO	NO
Waste oil	NO	4.99	6.04	1.82	1.36	1.59	1.14	1.25
Total GHG Emissions (kt)	**241.7**	**218.1**	**236.1**	**185.4**	**112.5**	**56.6**	**31.1**	**37.8**

Table 3.10 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from mobile combustion in the construction industry.

	1990	1995	2000	2005	2010	2015	2017	2018
Gas/Diesel oil	38.0	46.7	61.9	67.8	32.2	33.1	39.5	31.4
Other Kerosene	NO	No	NO	0.02	1.17	0.16	0.05	0.03
Biofuels	NO	NO	NO	NO	NO	NO	0.02	0.03
Emissions	**135.1**	**166.2**	**220.1**	**241.1**	**118.7**	**118.2**	**140.8**	**112.3**

3.3.2 Emission Factors

The CO_2 emission factors used reflect the average carbon content of fossil fuels. They are 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 and 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 weighed 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 CO_2 emission factors from stationary combustion and S-content of fuel reported under 1A2 (IE: Included Elsewhere) for 2018.

	NCV [TJ/kt]	Carbon Content [t C/TJ]	Fraction oxidised	CO_2 EF [t/TJ]	CH_4 EF [kg/TJ]	N_2O EF [kg/TJ]	S-content [%]
Gas/Diesel oil	43.2	20.2	1	74.1	3	0.6	0.2%
Residual fuel oil	40.4	21.1	1	77.4	3	0.6	1.8%
LPG	47.3	17.2	1	63.1	1	0.1	0.1%
Electrodes (residue)	31.4	31.4	1	115.2	10	1.5	1.5%
Other bituminous coal	25.8	25.8	1	94.6	10	1.5	1.5%
Petroleum coke	32.5	26.6	1	97.5	3	0.6	IE[1]

	NCV [TJ/kt]	Carbon Content [t C/TJ]	Fraction oxidised	CO_2 EF [t/TJ]	CH_4 EF [kg/TJ]	N_2O EF [kg/TJ]	S-content [%]
Waste oil	40.2	20.0	1	73.3	3	0.6	0.5%

[1] Sulphur emissions from use of petroleum coke occur in the cement industry.

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

	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	74.07	4.13	28.5
Biodiesel	43.6	19.3	1	19.30	4.09	28.2

3.3.3 Uncertainties

For subsectors 1A2a and 1Ab2 (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) is 7% (with an activity data uncertainty of 5%, as given by the data provider (NEA), and emission factor uncertainty of 5%), 100.1% for CH_4 emissions (with an activity data uncertainty of 5% and emission factor uncertainty of 100% (central value of default range, 2006 IPCC Guidelines)), and 100.1% for N_2O emissions (with an activity data uncertainty of 5% and emission factor uncertainty of 100% (expert judgement, Aether ltd, based on the comparison with other countries NIR (for instance UK NIR)). This can be seen in the quantitative uncertainty table in Annex 2.

3.3.4 Recalculations

Several recalculations were performed for 1A2 Manufacturing Industries and Construction which in total caused a decrease in 8.3 kt CO_2e in 2017 for this submission compared to last submission. That is a 4.6% decrease in emissions. The most significant reasons for this change are:

- Emissions from 1A2a increased by 0.45 kt CO_2e in 2017 for this submission compared to last submission. This was due to missing activity data from one company that was only in operation 2016-2017.
- Emissions from 1A2e increased by 3.4 kt CO_2e in 2017 for this submission compared to last submission. This was due to missing input data of waste oil used in the sector only for 2017.
- Emissions from 1A2gvii Off-road vehicles and machinery increased by 14.9 kt CO_2e in 2017. This was because of the review of the input data where it was discovered that data for 2015-2017 had been attributed to 1A2gviii but should have been included under 1A2gvii. This did not change the total amount of fuel used in 1A2 but did increase total emissions from the sector by 1.5 kt CO_2e in 2017 because the emission factors for mobile combustion are different from stationary combustion.

- Emissions from 1A2gviii decreased by 27.1 kt CO_2e in 2017 for this submission compared to last submission. This was due to the activity data review which is described in detail in chapter 3.1.1 Methodology. This was caused by fuels being moved from 1A2gviii to 1A5, because they were categorised as “other” in sales statistics from the NEA without any information on which type of activity the fuel was used in.

3.4 Transport (CRF 1A3)

Emissions from the transport sector were estimated to accounted for approximately 60% of the Energy sector’s total GHG emissions in Iceland in the most recent year. Road transport was estimated to account for approximately 93% of the emissions in the transport sector.

3.4.1 Domestic Aviation (CRF 1A3a)

Emissions are calculated by using Tier 1 methodology, thus multiplying energy use with a pollutant specific emission factor. This includes only flights departing from and subsequently landing in Iceland. Flights to or from destinations other than Iceland are included in International Aviation (Memo Item, 1D1a).

3.4.1.1 Activity Data

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	2017	2018
Jet kerosene	8.41	8.25	7.73	7.39	6.07	5.99	6.92	7.45
Gasoline	1.68	1.13	1.10	0.87	0.65	0.50	0.37	0.35
Total GHG Emissions	**32.00**	**29.78**	**28.02**	**26.23**	**21.32**	**20.62**	**23.15**	**24.79**

3.4.1.2 Emission Factors

The emission factors for greenhouse gases are taken from the 2006 IPCC Guidelines and are presented in Table 3.14 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 3.14 Emission factors for CO_2 and other pollutants for aviation.

	NCV [TJ/kt]	Carbon Content [t C/TJ]	Fraction oxidised	EF CO_2 [t/t fuel]	EF NOx [t/t fuel]	EF CH_4 [t/t fuel]	EF NMVOC [t/t fuel]	EF CO [t/t fuel]	EF N_2O [t/t fuel]
Jet kerosene	44.10	19.50	1	3.15	0.004	2.E-05	0.019	1.2	0.00009
Gasoline	44.30	19.10	1	3.10	0.004	2.E-05	0.019	1.2	0.00009

3.4.1.3 Uncertainties

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

3.4.1.4 Recalculations
No recalculations were performed for emissions of greenhouse gases from this sector.

3.4.1.5 Planned Improvements
Planned improvements 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).

3.4.2 Road Transportation (CRF 1A3b)
Emissions from Road Transportation are estimated using COPERT 5.3.0. which uses a tier 3 methodology to estimate N_2O and CH_4 emissions, and a tier 1 methodology to estimate CO_2 emissions. 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.

3.4.2.1 Activity Data
Total use of diesel oil, gasoline and biofuels in road transport are based on the NEA's annual sales statistics and can be found in Table 3.15.

Table 3.15 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from road transport.

	1990	1995	2000	2005	2010	2015	2017	2018
Gasoline	128	136	143	157	148	132	134	127.1
Diesel oil	37	37	47	83	106	126	164	178.9
Biogasoline/Bioethanol	NO	NO	NO	NO	NO	1.93	4.57	6.5
Biodiesel	NO	NO	NO	NO	0.14	11.9	13.2	15.3
Biomethane	NO	NO	NO	NO	0.44	1.38	1.51	1.5
Hydrogen	NO	NO	NO	0.009	2.2	NO	0.9	0.9
Emissions	**530.2**	**558.0**	**616.2**	**775.8**	**814.6**	**827.4**	**952.8**	**978.6**

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 2017-2018 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.

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

3.4.2.2 Emission Factors

NCV factors for gasoline and diesel are default values from Table 1.2 from Volume 2, Chapter 1 of the 2006 IPCC Guidelines, for all years with the exception of 2017 up to the most recent reporting year where country specific values are available. NCV´s for biofuels are taken from the Proof of Sustainability documents, which fuel suppliers are required to provide the NEA. NCV for biodiesel is significantly higher than the default value in the IPCC 2006 guidelines due to the fact that all biodiesel imported to Iceland is HVO which has a much higher NCV value than FAME biodiesel.

For this submission all EF's for road transport were revised with the use of the COPERT model. CO_2 emission factors are taken from table 3-12 in the EMEP/EEA guidebook (European Environment Agency, 2016) which are default values used by COPERT. NCV and CO_2 emission factors for the most recent reporting year are shown in Table 3.16 below. CH_4 and N_2O are calculated by COPERT based on Tier 3 methodology as prescribed in chapter 3.4 in the EMEP/EEA guidebook (European Environment Agency, 2016).

Table 3.16 NCV, CO_2 emission factors and oxidation factor for all fuel types used in road transport for the most recent inventory year.

	NCV (TJ/kt)	CO_2 EF (tCO_2/TJ)	CO_2 EF (tCO_2/kt fuel)	Oxidation factor
Gasoline	43.7*	72.5	3,169	1
Diesel	43.2*	73.4	3,169	1
Biogasoline	27	70.8	1,911	1
Biodiesel	43.6	64.0	2,790	1
Biomethane	50	49.1	2,7	1

*Measurements performed annually as a part of reporting requirements of the Fuel Quality Directive (Directive 2009/30/EC of the European Parliament and of the Council).

3.4.2.3 Uncertainties

Fuel sales uncertainties are reported by the data provider (NEA) to be within 5%. The uncertainty of CO_2 emissions from road vehicles is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%). For N_2O, both activity data and emission factors are quite uncertain. The uncertainty of N_2O emissions from road vehicles is 200% (with an activity data uncertainty of 5% and emission factor uncertainty of 200%) and for CH_4 emissions it is 200% (with an activity data uncertainty of 5% and emission factor uncertainty of 200%). The complete uncertainty analysis is shown in Annex 2.

3.4.2.4 Recalculations

For this submission a complete change in methodology was performed where COPERT 5.3.0 was implemented for calculations of emissions for the whole timeseries. This caused recalculations for all gases and all years. 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 recalculations done for this submission

	1990	1995	2000	2005	2010	2015	2016	2017
CO_2 (kt CO_2e)								
2019 submission	509	534	589	747	794	809	884	934
2020 submission	520	545	601	761	806	820	895	944
Change	**11**	**12**	**12**	**13**	**12**	**10**	**11**	**10**
CH_4 (kt CO_2e)								
2019 submission	3.8	3.4	2.1	2.0	2.4	2.5	2.7	2.7
2020 submission	5.5	5.0	3.7	2.9	2.1	1.6	1.7	1.5
Change	**1.7**	**1.6**	**1.6**	**0.9**	**-0.3**	**-0.9**	**-1.1**	**-1.2**
N_2O (kt CO_2e)								
2019 submission	14.8	19.6	30.7	38.2	36.8	35.5	37.7	38.4
2020 submission	5.2	7.7	11.1	12.2	6.0	6.0	6.5	7.3
Change	**-10**	**-12**	**-20**	**-26**	**-31**	**-30**	**-31**	**-31**
Total emissions (kt CO_2e)								
2019 submission	527	557	622	787	833	847	924	975
2020 submission	530	558	616	776	815	827	903	953
Total change	**3**	**1**	**-6**	**-12**	**-19**	**-20**	**-22**	**-22**
Total change (%)	**0.5%**	**0.2%**	**-0.9%**	**-1.5%**	**-2.3%**	**-2.4%**	**-2.4%**	**-2.3%**

Emissions of CO_2 have increased for the whole timeseries by 10-13 kt CO_2. This is due to COPERT using an emission factor from the EMEP/EEA guidebook (European Environment Agency, 2016) which is higher than the IPCC default. There are small changes in CH_4 emissions over the timeseries, this is mainly due to switching from tier 1 to tier 3 methodology.

There is a significant decrease in N_2O emissions for the whole timeseries. For previous submissions the emission factor for N_2O from passenger cars was of unknown origin and caused an overestimation of emissions from road transport. This has now been corrected with the use of COPERT which calculates N_2O based on tier 3 methodology described in chapter 3.4 in the EMEP/EEA guidebook (European Environment Agency, 2016).

3.4.2.5 Planned 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.

3.4.3 Domestic Navigation (shipping) (CRF 1A3d)

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

3.4.3.1 Activity Data

Total use of fuel for national navigation is based on NEA's annual sales statistics. National navigation fuel use includes sales to vessels of all flags departing from and sailing to Icelandic harbours. Fishing vessels are not included in this category (they are included in 1A4ciii Fishing). 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	2017	2018
Gas/Diesel oil	11.7	7.0	3.4	6.2	8.5	7.9	9.9	8.5
Residual fuel oil	7.2	4.8	0.5	0.9	2.6	0.4	NO	5.2
Biodiesel	NO	NO	NO	NO	NO	NO	0.001	NO
Emissions	**60**	**38**	**13**	**23**	**35**	**27**	**32**	**44**

3.4.3.2 Emission Factors

Default NCVs, 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. These factors are presented in Table 3.19.

Table 3.19 Emission factors for CO_2, CH_4 and N_2O for ocean-going ships. NCV value applies to all years since 2017.

	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	43.2	20.2	1	3.200	2	0.086	7	0.30
Residual fuel oil	40.4	21.1	1	3.126	2	0.081	7	0.28

3.4.3.3 Uncertainties

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

3.4.3.4 Recalculations

A small recalculation was performed for this category due to an updated NCV value for gas/diesel oil for 2017. This change increased emissions by +0.07 kt CO_2e in 2017 compared to last submission.

3.4.3.5 Planned improvements

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

3.4.4 Other transportation (CRF 1A3e)

Currently, activity data and information available from the National Energy Authority do not allow to separate fuels sold for use in off-road and ground activities occurring in airports from other off-road fuel use, thus fuel use and emissions associated with off-road and ground activities in airports are marked as included elsewhere (IE) and are included in subsector 1A2gvii “off-road vehicles and other machinery” (See also Paragraph 3.3.1).

3.4.5 International Bunker Fuels (CRF 1D1)

3.4.5.1 International Aviation (CRF 1D1a)

Activity data

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 3.20.

Table 3.20 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from international aviation

	1990	1995	2000	2005	2010	2015	2017	2018
Jet kerosene	69.4	74.6	129.2	133.2	119.5	213.7	363.7	410.0
Gasoline	0.20	0.18	0.03	0.40	0.01	0.01	NO	NO
Emissions	**221**	**238**	**411**	**425**	**380**	**680**	**1,156**	**1,304**

Emission factors

Emission factors for aviation bunkers are taken from the 2006 IPCC Guidelines, and are the same as those for domestic aviation. They are shown in Table 3.14, section 3.4.1.2.

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.

Recalculations and planned improvements

No recalculations were performed for this subcategory.

Planned improvements 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).

3.4.5.2 International Navigation (CRF 1D1b)

Activity Data

The reported fuel use numbers are based on fuel sales data from the retail suppliers. The retail supplier divides their reported fuel sales between international navigation and national navigation based on whether the vessel is sailing to an Icelandic or a foreign harbour (regardless of flag). Fuel data and associated emissions are shown in Table 3.21. 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 3.21 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from international navigation. Fuel use in 1990 was approximated using average fuel use distribution for the years 1995 to 1999.

	1990	1995	2000	2005	2010	2015	2017	2018
Gas/Diesel oil	6.0	1.1	15.0	0.1	NO	33.6	33.5	42.3
Residual fuel oil	0.05	NO	2.00	0.44	0.08	13.2	33.7	34.0
Emissions	**19.5**	**3.4**	**54.7**	**1.8**	**0.3**	**149.8**	**214.3**	**244.1**

Emission factors

Emission factors for international navigation are the same as those for domestic navigation and are shown in Table 3.19, Section 3.4.3.2.

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.

Recalculations

Recalculations were performed for this sector due to some fuel that was sold in 2016-2018 being categorised as “Other industry”. After further investigation it was concluded that this fuel was sold to international navigation and is attributed as such now.

Planned improvements

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

3.5 Other Sectors (CRF 1A4)

Sector 1A4 consists of fuel use in commercial/institutional settings (1A4a), residential settings (1A4b) as well as fuel use in agriculture, forestry, and fishing (1A4c). 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. In contrast, 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 Other sector’s total. In total, emissions from the 1A4 Other sector were estimated to account for around 29% of the Energy sector’s total in the most recent year.

3.5.1 Commercial / Institutional (1A4a) and Residential Fuel Combustion (1A4b)

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

3.5.1.1 Activity Data

Activity data is provided by the NEA, which collects data on fuel sales by sector. EA disaggregates the data provided by the NEA as further explained in paragraph 3.1.1 and in Annex 7. Activity data for fuel combustion from the Commercial/Institutional sector and the resulting emissions are given in Table 3.22.

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	2017	2018
Gas/Diesel oil	1.8	1.6	1.6	1.0	0.30	0.30	0.15	0.15
Waste oil	3.3	NO	NO	NO	NO	NO	NO	NO
LPG	0.29	0.31	0.50	0.50	0.17	0.37	0.12	0.081
Solid waste	NO	0.45	0.58	0.58	0.35	NO	NO	NO
Emissions	**17.4**	**6.6**	**7.2**	**5.4**	**1.9**	**2.1**	**0.83**	**0.72**

Activity data for fuel combustion in the Residential sector and the resulting emissions are given in Table 3.23. Kerosene is used in summerhouses, but also to some extent in the Commercial sector for heating of commercial buildings as well as in transport. The usage has been very low over the years and therefore the kerosene utilization has all been allocated to the Residential sector. The increase in usage in the years 2008 to 2011 is believed to be attributed to rapidly rising fuel prices for the Transport sector. This has motivated some diesel car owners to use kerosene on their cars as the kerosene did not have CO_2 tax, despite the fact that it is not good for the engine. It should be noted that the fuel is indeed “jet kerosene” and not “other kerosene”, since there was not enough demand for “other kerosene” to import it to Iceland (NEA, 2017, written communication). Since 2012 the CO_2 tax also covers kerosene and the use decreased rapidly again. In the beginning of 2014, the fuel use increased again due to an insufficient supply of electricity which forced heat plants to use oil for heating.

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	2017	2018
Gas/Diesel oil	8.73	6.36	6.03	3.24	1.34	0.99	2.11	0.80
LPG	0.42	0.45	0.72	0.93	1.42	0.93	1.38	1.58
Kerosene	0.51	0.15	0.15	NO	NO	NO	NO	NO
Emissions	**30.8**	**22.2**	**21.9**	**13.2**	**8.5**	**6.0**	**10.9**	**7.3**

3.5.1.2 Emission Factors

The CO_2 emission factors (EF) 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 Table 2.4 and 2.5 of the Energy chapter of the 2006 IPCC guidelines. They are presented in Table 3.24.

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

	CO_2 EF [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Gas/Diesel Oil	74.1	10	0.6
LPG	63.1	5	0.1

	CO_2 EF [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Kerosene	71.5	10	0.6
Waste oil	73.3	300	4

The emission factor for waste incineration was calculated using Tier 2 methodology and default values from the 2006 GL. 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 onwards, waste has been incinerated to produce heat at two locations (swimming pools, school building). The IEF for waste is considerably higher than for liquid fuel. Further waste oil was used in the sector from 1990 to 1993. This combined explains the rise in IEF for the whole sector.

3.5.1.3 Uncertainties

Uncertainty for the activity data (fuel sales) is estimated by the data provider (NEA) to be 5%. Emission factor uncertainties are 5% for CO2 (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, 100.1% for CH_4 and 100.1% for N_2O. The complete uncertainty analysis is shown in Annex 2.

3.5.1.4 Recalculations

Small recalculations were performed for these categories. This was due to the input data review (described in chapter 3.1.1). Kerosene had been attributed to 1A4b but as it was categorized as “transport” and “other” in sales statistics, it was reattributed to categories 1A2gvii and 1A5 respectively. This caused recalculations for 2003-2017, where emissions decreased by 0.8 kt CO_2e in 2017 between the current submission and the last submission.

3.5.1.5 Planned improvements

No improvements are currently planned for this subcategory.

3.5.2 Agriculture, Forestry and Fishing (CRF 1A4c)

For the current submission, the only activity reported under 1A4c is 1A4ciii Fishing.

3.5.2.1 Fishing (CRF 1A4ciii)

Activity Data

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). 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 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. Activity data for fuel combustion in the Fishing sector and the resulting emissions are given in Table 3.25.

Table 3.25 Fuel use (in kt) and resulting emissions (GHG, in kt CO_2e) from the fishing sector.

	1990	1995	2000	2005	2010	2015	2017	2018
Gas/Diesel oil	199.8	231.8	256.9	199.9	158.3	142.5	131.2	136.2
Residual fuel oil	32.6	57.2	22.3	32.6	69.9	52.4	35.2	35.3
Biodiesel	NO	NO	NO	NO	NO	0.094	0.037	NO
Emissions	**745.9**	**926.4**	**896.9**	**746.4**	**729.9**	**624.2**	**534.1**	**551.7**

Emission Factors

Default NCVs, 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. They are the same as those used in domestic navigation (1A3d) and international navigation (1D1b) and are presented below in Table 3.26.

Table 3.26 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	43.2	20.20	1	3.200	2	0.086	7	0.30
Residual fuel oil	40.4	21.10	1	3.126	2	0.081	7	0.28

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.

Recalculations

Recalculation was performed for this category for the year 2017 only. This is because of a country specific NCV value for gas/diesel oil was obtained for that year. This caused a 0.98 kt CO_2e increase in emissions in 2017 for this submission compared to last submission.

Planned improvements

No improvements are currently planned for this subcategory.

3.6 Other (CRF 1A5)

For this submission sector 1A5 is being reported for the first time for the timeseries 2003-2018 as a part of the review of the energy input data (see chapter 3.1.1). For previous submissions these emissions have been reported under CRF category 1A2gvii but after a review of the sales statistic no justification was found for that attribution. Therefore, all fuels categorized as *"Other"* in sales statistics without any explanation of type of use, was allocated to CRF category 1A5. For future submissions the EA will work with the NEA to try to investigate where these fuels were used so they can be attributed to the correct categories.

3.6.1 Stationary (1A5a)

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

3.6.1.1 Activity Data

Activity data is provided by the NEA, which collects data on fuel sales by sector. All fuels categorized as *"Other"* in sales statistics without any explanation of which sector it is used in, was allocated to CRF category 1A5. For the timeseries 1990-2002 these fuels are still attributed to CRF category 1A2gvii.

Table 3.27 Fuel use (in kt) and resulting emissions (GHG, in kt CO2e) from sector 1A5 Other

	1990	1995	2000	2005	2010	2015	2017	2018
Gas/Diesel oil	IE	IE	IE	8.9	2.7	1.72	NO	0.05
Residual Fuel oil	IE	IE	IE	NO	1.6	NO	NO	NO
Other kerosene	IE	IE	IE	0.15	0.05	0.03	0.01	0.03
LPG	IE	IE	IE	NO	NO	0.03	0.05	0.14
Biodiesel	IE	IE	IE	NO	NO	NO	0.04	0.04
Biomethane	IE	IE	IE	NO	NO	NO	0.06	0.05
Emissions	**IE**	**IE**	**IE**	**29.0**	**14.0**	**5.7**	**0.2**	**0.7**

3.6.1.2 Emission Factors

The CO_2 emission factors used reflect the average carbon content of fossil fuels. They are 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). NCV, carbon contents as well as emission factors are presented in Table 3.28. From 2017 NCV for gas/diesel oil is country specific based on measurements taken of imported fuel.

For biofuels NCV's are weighed 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 taken to be the same for biofuels and their fossil fuel equivalents due to a lack of more accurate biofuel-specific data.

Table 3.28 NCV's and emission factors for CO_2, CH_4 and N_2O for 1A5

	NCV [TJ/kt]	CO_2 EF [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Gas/Diesel Oil	43.2	74.1	3.0	0.6
Residual fuel oil	40.4	77.4	3.0	0.6
Other Kerosene	43.8	71.9	10.0	0.6
LPG	47.3	63.1	1.0	0.1
Biodiesel	43.6	70.8	3.0	0.6
Biomethane	50.4	54.6	1.0	0.1

3.6.1.3 Uncertainties

Uncertainty for the activity data (fuel sales) is estimated by the data provider (NEA) to be 5%. Emission factor uncertainties are 5% for CO2 (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, 100.1% for CH_4 and 100.1% for N_2O. The complete uncertainty analysis is shown in Annex 2.

3.6.1.4 Recalculations

This sector is being reported for the first time for this submission.

3.6.1.5 Planned improvements

For the next submissions a review of the energy input data for 1990-2002 will be performed. For future submissions the EA will work with the NEA to try to investigate where these fuels are used so they can be attributed to correct categories.

3.7 Cross-Cutting Issues

3.7.1 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 paragraph 3.1.1 for details). The reference approach is calculated based on the national energy statistics files submitted to Eurostat by the NEA, which include information on imports, stock changes, international navigation and international aviation.

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

3.7.2 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, except for residues of electrodes combusted in the cement industry, which are accounted for under the Energy sector (Manufacturing industry and construction).

3.8 Fugitive Emissions from Fuels (CRF 1B)

3.8.1 Distribution of Oil Products (CRF 1B2a5)

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 3.29.

Table 3.29 Fuel use (in kt) and resulting GHG emissions (in kt CO_2e) from distribution of oil products.

	1990	1995	2000	2005	2010	2015	2017	2018
Gasoline	129.4	132.2	153.4	164.2	144.5	139.6	138.2	134.0
Jet Kerosene	78.7	72.3	146.5	139.4	120.4	218.3	343.9	422.9
Gas/Diesel oil	335.8	309.3	427.9	418.2	292.3	342.1	347.6	369.5
Residual Fuel Oil	106.0	151.9	64.1	62.9	93.1	105.3	101.4	119.2
LPG	1.3	1.3	1.7	2.5	2.6	2.6	2.5	2.6
Emissions	**0.49**	**0.50**	**0.60**	**0.60**	**0.49**	**0.61**	**0.71**	**0.80**

3.8.1.1 Recalculations

No recalculations were performed for this subcategory.

3.8.2 Geothermal Energy (CRF 1B2d)

3.8.2.1 Category description

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.

3.8.2.2 Methodology

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 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[8]. 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).

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

[8] http://www.nea.is/the-national-energy-authority/energy-data/data-repository/; File OS-2019-T004-01.pdf

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.

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

	1990	1995	2000	2005	2010	2015	2017	2018
Electricity production (GWh)	283	288	1,323	1,658	4,465	5,003	5,170	6,010
CO_2 emissions (kt)	61	82	153	118	190	163	146	156
Methane emissions (kt CO_2e)	0.2	0.2	0.9	1.1	4.6	3.9	2.6	2,5
Sulphur emissions (as SO_2, kt)	13	11	26	30	58	41	33	38

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 Managment Assistance Program (The World Bank).)

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.

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, 55t CO_2 were captured, injected and mineralized in the ground. In 2014, 2015, 2016, 2017 and 2018, the amount of CO_2 captured and reinjected was 2381t, 3911t, 6644t, 10168t and 12200t respectively. A sister project, SulFix, consists of separating H_2S from the steam and also reinjecting the gas into the subsurface and mineralizing on contact with the basalt host rock.

- 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).

3.8.2.3 Recalculations
No recalculations were performed for this subcategory.

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

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

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 42% of the GHG emissions in Iceland in 2018. The dominant category within the Industrial Process sector is metal production, which accounted for 91% of the sector's emissions in 2018. 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 regulation 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, 2018 and 1990-2018 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, 2018 and trend (excluding LULUCF).

IPCC source category			Level 1990	Level 2018	Trend
IPPU (CRF sector 2)					
2A1	Cement Production	CO_2	✓		✓
2B1	Other: 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**	**NM-VOC**	**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[2] 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											

Sector		Greenhouse gases						Indirect greenhouse gases			
		CO_2	CH_4	N_2O	HFC	PFC	SF_6	NO_X	CO	NM-VOC	SO_2
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									
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											

Sector		Greenhouse gases						Indirect greenhouse gases			
		CO_2	CH_4	N_2O	HFC	PFC	SF_6	NO_X	CO	NM-VOC	SO_2
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									

[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)

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.

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

Year	Cement production [t]	Clinker production [t]	CaO content of clinker	EF_{cl}	CF_{ckd}	CO_2 emissions [kt]
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 (EFcl) 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 CFckd 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.

Category-specific recalculations

No category-specific recalculations were done for this submission.

Category-specific planned improvements

No improvements are currently planned for this category.

4.2.2 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 14 of the Icelandic law on climate change (Lög um lofstlagsmál 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 rights 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 0.90 kt CO_2e in 2018. Fluctuations in GHG emissions reflect fluctuations in annual production.

Uncertainties

The uncertainty on activity data was estimated to be 2.38%, based on the combined uncertainty for two source stream types as reported in the ETS annual emission reports. CO_2 emission factor uncertainty was estimated to be 2% (median of range given in 2006 IPCC guidelines), leading to a combined uncertainty of 3.11%. 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 3.8.2on 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 H_2 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. Productions 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 2018, 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 Soederberg 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 452.2 kt CO_2e in 2018 corresponding to an increase of 117% 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	2017	2018
Electrodes, casings and paste	3.8	3.9	5.7	6.0	4.8	5.3	5.9	5.2
Carbon blocks	-	-	-	-	-	0.1	0.1	0.2
Anthracite/coking coal	45.1	52.4	73.2	86.9	96.1	115.1	129.8	144.3
Coke oven coke	24.9	30.1	46.6	42.6	30.3	30.9	24.6	21.3
Charcoal	-	-	-	2.1	-	-	2.4	0.7
Wood	16.7	7.7	16.2	15.6	11.3	27.2	40.7	57.8
Limestone	-	-	0.5	1.6	0.5	2.2	1.7	1.9
FeSi, silicon metal production	62.8	71.4	108.7	111	102.2	117.9	121.4	122.2
Emissions (kt CO_2e)	**210.4**	**245.7**	**365.3**	**379.6**	**372.3**	**403.9**	**431.4**	**455.4**

Plant and year specific emission factors for CO_2 are based on the carbon content of the reducing agents, 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	2017	2018
Electrodes	94%	94%	94%	94%	94%	96%	95%	95%
Coal (Anthracite)	74.8%	74.8%	79.0%	75.5%	74.8%	71.8%	70.7%	70%
Coke oven coke	78.8%	78.8%	76.6%	73.8%	80.8%	70.4%	79.2%	76%
Charcoal	-	-	-	81%	-	-	85.56%	86%
Waste wood	48.7%	48.7%	48.7%	48.7%	48.7%	50.0%	50.0%	50%

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.

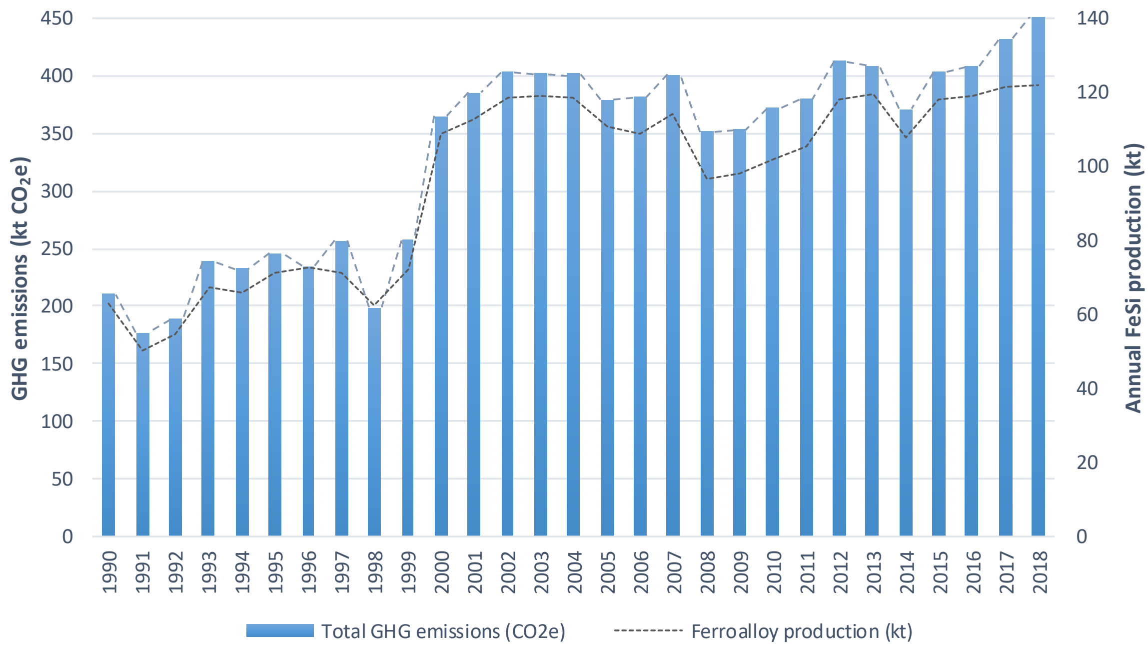

Figure 4.1 Total GHG emissions (CO_2 and CH_4) from the Ferroalloy production, and annual production (kt).

Uncertainties and time-series consistency

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from ferroalloys production is 3.4% (with an activity data uncertainty of 1.5% (as given in the ETS Annual Emission Report) and emission factor uncertainty of 3%). It is estimated that the uncertainty of the CH_4 emission factor is 100%. In combination with above mentioned activity data uncertainty this leads to a combined uncertainty of 100%. 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 2019 and 2020 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 1990-2018.

	1990	1995	2000	2005	2010	2015	2017	2018
Primary aluminium production [kt]	87.8	100.2	226.4	272.5	818.9	857.3	882.4	876.0
CO_2 emissions [kt]	139.2	154.0	353.0	417.1	1237.6	1299.6	1324.5	1313.9
PFC emissions [kt CO_2e]	494.6	69.4	149.9	30.8	171.7	103.7	68.0	76.4
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]	**633.9**	**223.3**	**502.8**	**447.9**	**1409.2**	**1403.2**	**1392.4**	**1390.3**

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 2018 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 have risen by 119% since 1990 and are largely unchanged between 2017-2018 (-0.2%).

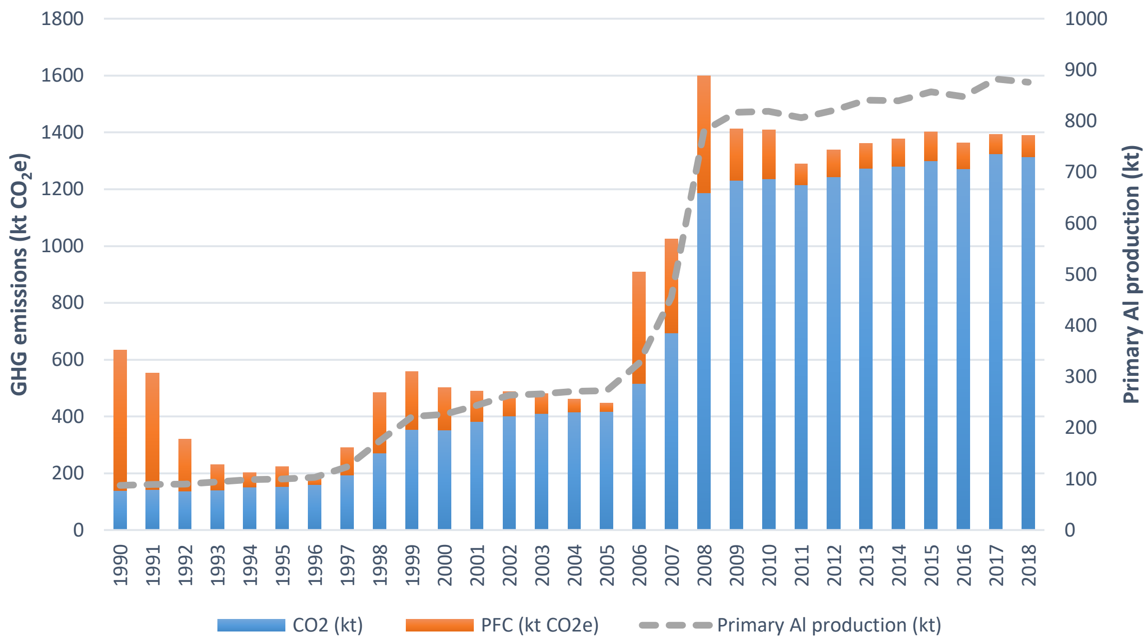

Figure 4.2 GHG emissions (CO_2 and PFC) from primary Al production, and annual production (kt).

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 and PFC emissions from aluminium production is 3.35% (with an activity data uncertainty of 1.5% % (as given in the ETS Annual Emission Report) and an emission factor uncertainty of 3%). 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 been generally 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 2.08 kt and 2.54 kt CO_2.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from lubricant use is 50.3% (with an activity data uncertainty of 5% (2006 IPCC Guidelines, vol 3, chapter 5.2.3.2) and an emission factor uncertainty of 50.1%, comprising uncertainty on the ODU and the C content (2006 IPCC Guidelines, vol 3, chapter 5.2.3.1). 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

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 were estimated to be 0.31 kt CO_2 in 1990 and 0.33 kt CO_2 in 2018.

Methodology

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

EQUATION 5.4

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

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 CC_{Wax} factor of 20.0 kg C/GJ (on a Lower Heating Value basis) and the default ODU_{Wax} 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 imports and exports of candles have been updated from previous submissions. Previously, activity data was only available from 2004 from Statistics Iceland. The values from 1990-2003 have been updated due the improved data collection. 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 estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from lubricant use is 100% (with an activity data uncertainty of 5% (2006 IPCC Guidelines, vol 3, chapter 5.3.3.2) and an emission factor uncertainty of 100%, comprising uncertainty on the ODU and the C content (2006 IPCC Guidelines, vol 3, chapter 5.3.3.1)). The complete uncertainty analysis is shown in Annex 2.

Category-specific recalculations

Due to updated activity data collection for the years 1990-2003 there are recalculations for that years as well for the rest of the time series. Changes are between -55% in 1991 and -0.7% in 2002 from 1990-2003, while the update of activity data between 2004-2017 produce changes ranging between +20% (in 2014) and -0.01% (in 2016) as can be seen in Table 4.7.

Table 4.7 Recalculations for paraffin wax use due to the update of activity data

	1990	1995	2000	2005	2010	2015	2017
2019 submission kt CO_2e	0.31000	0.31000	0.31000	0.32410	0.25770	0.34290	0.34720
2020 submission kt CO_2e	0.17318	0.21150	0.29658	0.32412	0.25775	0.34290	0.34719
Change relative to 2019	-44.1%	-31.8%	-4.3%	0.0%	0.0%	0.0%	0.0%

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, and fossil fuel-derived solvents use. The various subgroups within 2D3 are taken from the 2016 EMEP/EEA 2016 guidebook.

NMVOC 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 from NMVOC oxidation arising from 2D3 categories amounted to 2.8 kt CO_2 in 2018. An overview of the emissions from the individual subcategories is given in Table 4.10 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:

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

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

Recalculations occurred due to updated activity data obtained by Statistics Iceland and can be seen in Table 4.8. The main differences arose due to improved activity data and because for single subcategories within 2D3 Other the export data where not deducted from the import data in previous submissions, leading to changed emissions over time.

Table 4.8 Recalculations from the subcategory 2D3 Other

	1990	1995	2000	2005	2010	2015	2017
2019 submission kt NMVOC	1.18970	1.24598	1.41811	1.37729	1.13500	1.20536	1.23128
2020 submission kt NMVOC	1.15141	1.23426	1.39809	1.34339	1.12839	1.20461	1.23120
Change relative to 2019	-3.2%	-0.9%	-1.4%	-2.5%	-0.6%	-0.1%	0.0%

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. In addition, estimation of the emissions from urea based additives used in selective catalytic converters is going to be added in the next submission, while it is IE-included elsewhere in the current submission (see 4.5.3.6).

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 2018 4.1 t NMVOC, corresponding to an increase of 50% with a decrease of 20% between 2017 and 2018.

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. Activity data collection was updated by gathering data from Statistics Iceland for the whole time series. Therefore, recalculations as reported in Table 4.9 occurred. The decrease in emissions is mainly due to the fact that in previous submissions export data was not deducted from import data. In 1990 the NMVOC emissions for Coating Application were 509 t NMVOC, in 2018 380 t NMVOC, corresponding to a decrease of 25%.

Table 4.9 Recalculations for the coating applications due to updated activity data

	1990	1995	2000	2005	2010	2015	2017
2019 submission kt NMVOC	0.54967	0.56190	0.58527	0.37687	0.29890	0.32200	0.33442
2020 submission kt NMVOC	0.50863	0.54742	0.56008	0.34240	0.28871	0.31827	0.32922
Change relative to 2019	-7.5%	-2.6%	-4.3%	-9.1%	-3.4%	-1.2%	-1.6%

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 2018 54.8 t NMVOC, corresponding to a decrease of 28%. For Dry-cleaning the NMVOC were 1.5 t NMVOC in 1990 and 2.1 t NMVOC in 2018, 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 2018 5 t NMVOC, corresponding to a decrease of 68%.

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 2018 642.6 t NMVOC, corresponding to an increase of 40%.

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 2018 149.9 t NMVOC, corresponding to an increase of 93%.

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 2018 32.7 t NMVOC, corresponding to an increase of 277%.

4.5.3.6 Urea based catalytic converters

During the 2019 EU Step II review Iceland has been asked to provide emission estimates for the use of urea-based additives used in catalytic converters in diesel vehicles. Urea imports are registered at Customs Iceland and data are provided by Statistics Iceland. However, urea used as fertilizer is registered in the same category (see also Agriculture sector, Chapter 5.11.2.2 and Figure 5.7). Therefore, at the moment it results impossible to establish how much of the urea is allocated to the respective uses. Customs Iceland has been contacted to correct the error in the registration which will take place starting from 2020. In the meantime, in absence of better data, all urea is allocated to fertilizer use and the emissions from the use of urea are included there. Applying the default methodology provided in the 2006 IPCC Guidelines, based on the composition and age of the vehicle fleet registered in Iceland in 2018 and assuming that all diesel vehicles registered since 2015 have EURO 6 Standard and therefore use urea-based additives (28% of all registered diesel vehicles) it can be noted that resulting emission estimates are below the threshold of significance (between 0.12 and 0.36 kt of CO_2 depending on the assumed activity levels between 1 and 3% of diesel consumption). Nevertheless, for next submission it is expected to deduct the use of urea used for selective catalytic converters by contacting the oil distribution companies in Iceland and request data about the amount of urea sold as additive.

4.5.3.7 Emissions of Sector 2D3

Figure 4.3 and Table 4.10 show NMVOC emissions from the sector 2D3 from 1990-2018. NMVOC emissions increased by 10% between 1990 and 2018 and increased by 3% between 2017 and 2018.

Table 4.10 NMVOC emissions (in kt) from all sub-categories, and total emissions from subsector 2D3 in kt CO_2e).

	1990	1995	2000	2005	2010	2015	2017	2018
2D3a Domestic solvent use	0.461	0.482	0.510	0.540	0.573	0.599	0.627	0.643
2D3b Road paving with asphalt	0.003	0.003	0.005	0.005	0.004	0.003	0.005	0.004
2D3d Coating applications	0.509	0.547	0.560	0.342	0.289	0.318	0.329	0.381
2D3e Degreasing	0.076	0.057	0.085	0.058	0.038	0.046	0.051	0.055
2D3f Dry cleaning	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002

	1990	1995	2000	2005	2010	2015	2017	2018
2D3g Paint manufacturing	0.016	0.016	0.012	0.005	0.003	0.003	0.002	0.005
2D3h Printing	0.077	0.109	0.198	0.305	0.189	0.207	0.175	0.150
2D3i Wood preservation	0.009	0.019	0.025	0.086	0.031	0.026	0.040	0.033
Total (kt NMVOC)	**1.2**	**1.2**	**1.4**	**1.3**	**1.1**	**1.2**	**1.2**	**1.3**
Total (kt CO_2e)	**2.5**	**2.7**	**3.1**	**3.0**	**2.5**	**2.7**	**2.7**	**2.8**

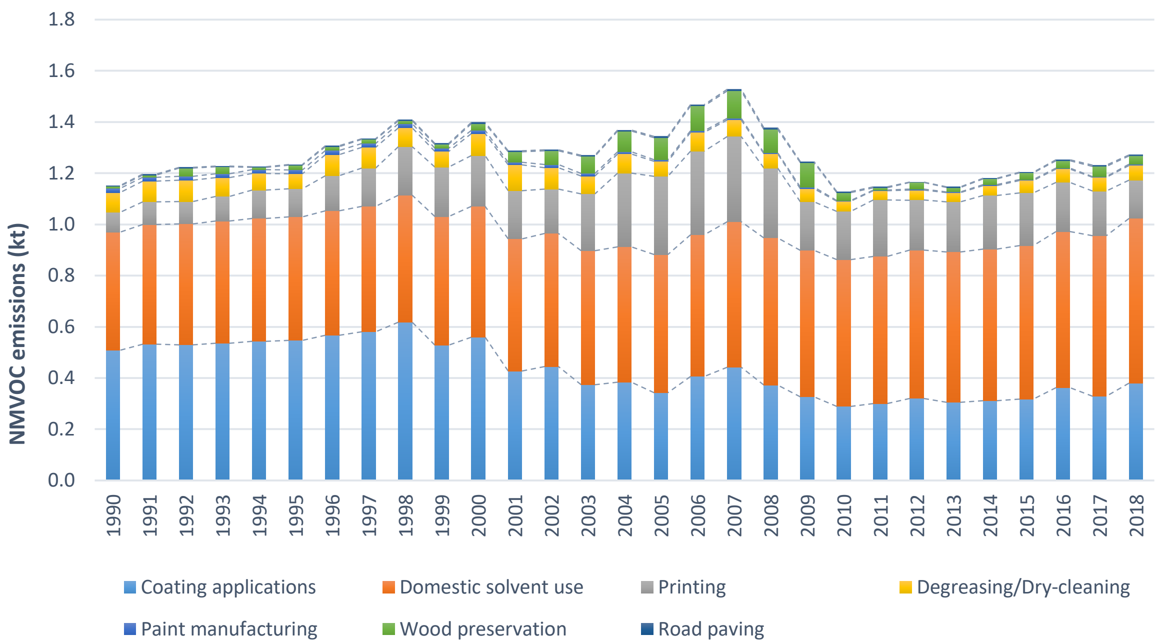

Figure 4.3 NMVOC emissions from all subgroups of Sector 2D3, other non-energy products from fuels and solvent use.

4.5.3.8 Uncertainties

The main source for EF uncertainties were uncertainties and value ranges given in the 2016/2019 EMEP/EEA Guidebook. The combined subsector uncertainties were then combined into one value due to the relative insignificance of CO_2 emissions from this sector. Combined AD uncertainty for the sector was 59%, combined EF uncertainty 170%. This resulted in 180% total uncertainty for CO_2 emission from the sector. 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 4.11 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 warning 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 166 kt CO_2e in the most recent inventory year, or approximately 8% 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.

4.7.2.1 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 current submission the Icelandic estimation model has been 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:
- $E_{charge,t}$= emissions during system manufacture/assembly, in year t, kg
- M_t= amount of HFC charged into new equipment per year t, kg
- k= emission factor of assembly losses of HFC charged into new equipment, percent

EQUATION 7.13
Sources of Emissions during equipment lifetime

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

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:
- $E_{end\text{-}of\text{-}life,t}$= emissions at system disposal, in year t, kg
- $M_{t\text{-}d}$= 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.

4.7.2.2 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).
- 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:

a) All R-407C and R-410A goes to 2F1f Stationary AC as suggested by the 2006 IPCC Guidelines

b) 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)

c) HFC-134a from MAC (2F1e) is calculated (applying the calculation procedure from the 2006/2019 IPCC Guidelines, Chapter 7, Vol. 3)

d) The calculated amounts of HFC-134a and R404A from Reefers and MACs are subtracted from the total imported amount of that species/blends

e) 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 1990-2018 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).

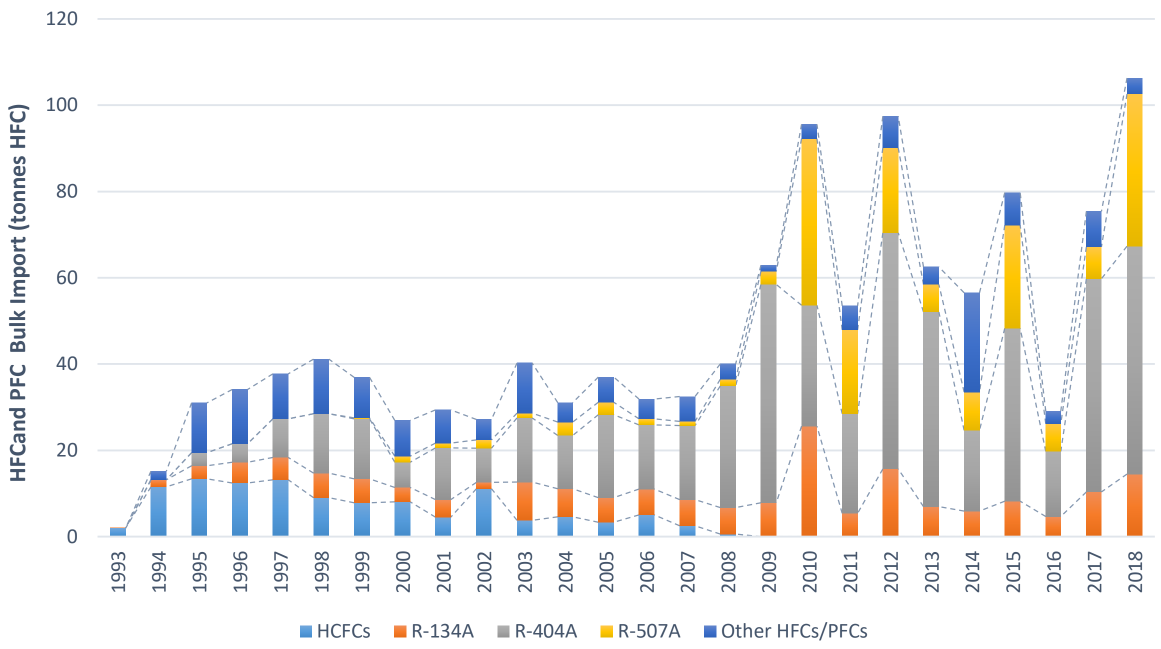

Figure 4.4 Quantity of F-gases imported in bulk to Iceland between 1993 and 2018

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 N2 and N3 (trucks): default value of 1.2 kg for trucks
- EU class M3 (coaches): country specific value of 10 kg (expert judgement)

The information on vehicles' first registration years was used to estimate the number of vehicles equipped with (R-134A containing) MACs. Based on a study by the EU (Schwarz, et al., 2012) it is assumed that 80% of all vehicles manufactured 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. 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".

4.7.2.3 Emission factors

All emission factors applied in the different subcategories are shown in Table 4.12. 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 4.12 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%

[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 & 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 rather recovered. The poll revealed that the majority of refrigerants are recovered. Therefore, it is assumed that the share not lost during recovery (1-z) is reused thus remaining in the same sub-source´s stock.

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.

4.7.2.4 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 166 kt CO_2e in 2018. Emissions disaggregated to constituents are shown in Table 4.13.

Table 4.13 HFC and PFC emissions for all individual compounds, recalculated into kt CO_2e using AR4 GWPs.

	1990	1995	2000	2005	2010	2015	2017	2018
HFC-23	NO	NO	NO	0.035	0.009	0.007	0.023	0.052
HFC-32	NO	NO	0.0051	0.0157	0.0612	0.1056	0.2116	0.3056
HFC-125	NO	0.800	18.848	19.787	37.749	66.821	70.107	58.385
HFC-134a	NO	1.7315	5.6219	10.0859	15.5944	23.2706	29.6128	34.0963
HFC-143a	NO	0.170	18.663	24.696	50.805	88.252	89.658	73.169
HFC152a	NO	0.0084	0.0667	0.0213	0.0225	0.0040	NO	0.0011
HFC-227ea	NO	NO	NO	0.108	0.023	0.326	0.344	0.284
Total HFC (kt CO_2e)	**NO**	**2.71**	**43.21**	**54.75**	**104.26**	**178.79**	**189.96**	**166.29**
C_2F_6 (PFC-116)	NO	NO	NO	0.0032	0.0009	0.0084	0.0272	0.0522
C_2F_8 (PFC-218)	NO	NO	NO	NO	0.0006	0.0002	0.0002	NO
Total PFC (kt CO_2e)	**NO**	**NO**	**NO**	**0.0032**	**0.0015**	**0.0086**	**0.0274**	**0.0522**
Total HFC+PFC (kt CO_2e)	**NO**	**2.71**	**43.21**	**54.75**	**104.27**	**178.80**	**189.98**	**166.35**

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 don't use F-gases for refrigeration but rather natural refrigerants. Commercial refrigeration, industrial refrigeration and mobile air conditioning contribute approximately equal parts in 2018 to the overall emissions.

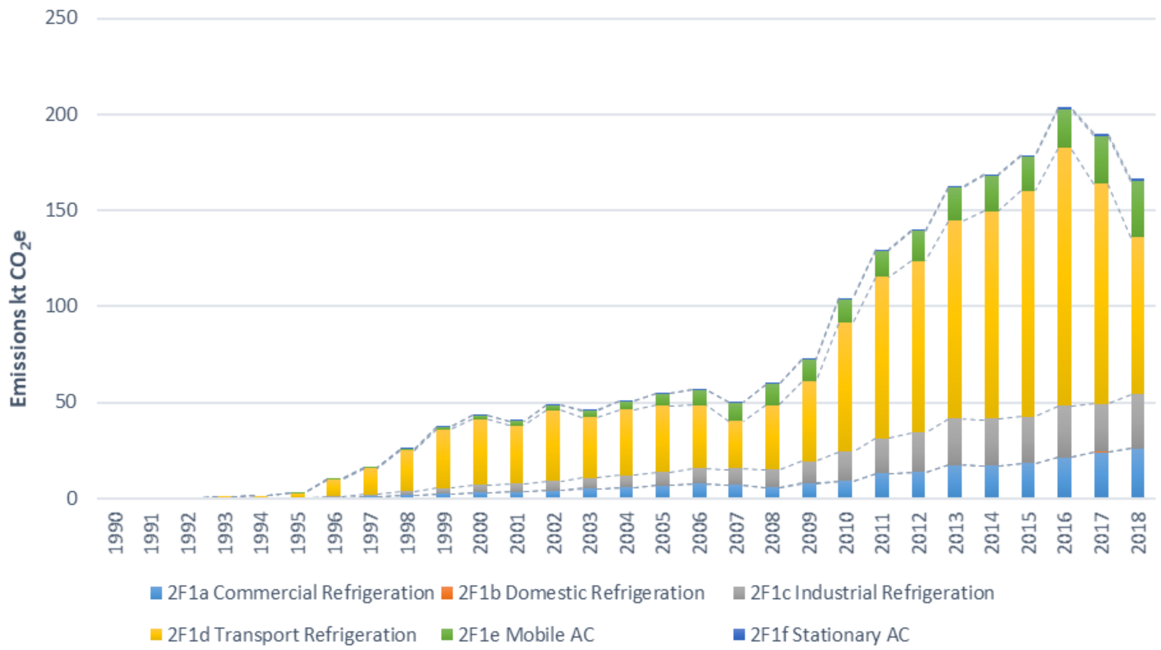

Figure 4.5 Total F-gas emissions from Refrigeration and Air Conditioning, split by subcategories and in kt CO2e.

4.7.2.5 Uncertainties

Emission factor uncertainty of the refrigeration and air conditioning sector were calculated by relating the lifetime emission factor ranges given in the 2006 IPCC Guidelines to the respective values used. Initial and end-of-life emission factors were not considered since they play a very minor role when compared to lifetime emissions and activity data uncertainty. The only exception to this rule is domestic refrigeration where end-of-life emissions outweigh lifetime emissions. Their relative share of total refrigeration emissions, however, is only 0.03%.

AD uncertainty was estimated by expert judgement and is deemed to be a factor of one or two for most sub-source categories. Uncertainty factors are summarized in Table 4.14. This can also be found in Annex 2.

Table 4.14 Lifetime EFs used along with EF ranges given in the 2006 IPCC Guidelines; calculated EF uncertainties and estimated AD uncertainties as well as combined uncertainties.

Value ranges (Lifetime EF)	EF, lower bound	EF, upper bound	Lifetime EF used	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
Commercial ref.	5.5	20	10	200	100	224
Domestic ref.	0.1	0.5	0.3	500	67	504
Industrial ref.	7	25	10	100	150	180
Transport ref.				100	100	141
Fishing vessels	*15*	*50*	*50-20%*			
Reefers	*5*	*20*	*15-10%*			
Residential AC	1	5	3	200	100	224
MAC	10	20	10	100	100	141

4.7.2.6 Recalculations and improvements

The in-depth review of the calculations of this sector in collaboration with consultants from Aether ltd. carried out for the current submission included a revision of all methodologies, new and improved calculation spreadsheets, and inclusion of the results from the survey conducted by the Environment Agency on the allocation of refrigerants by the main importers to ensure accuracy and completeness of the inventory. This led to recalculations ranging between +18% in 1993 and -71% in 1995. The changes are not attributable to different input data, or allocation of the different blends of F-gases imported in bulk, but rather due to methodological issues. In the previous submissions, the amount of initial (or assembly/manufacturing) emissions was overestimated, by multiplying all imported amounts in the year with the EF for initial emissions (different for each subcategory). Also, the calculations of the bank were carried out differently, leading to a different amount of F-gases present in stock, and therefore to different lifetime emissions. Recovery efficiency factors were modified (diminished) to fit the ranges given by the 2006 IPCC Guidelines in absence of category specific research regarding recovery and disposal. Figure 4.6 shows the comparison between the previous and current total emissions as kt CO_2e graphically. Looking at the different subsectors (Table 4.16) not all subcategories lead to a decrease of emissions. Mobile AC registers an increase ranging from 8% in 2003 to 145% in 2013.

Table 4.15 Comparison of the total emissions in kt CO2e from the sector 2F1 Refrigeration and air conditioning for the submission years 2019 and 2020.

	1990	1995	2000	2005	2010	2015	2017
2019 submission kt CO_2e	NO	10	43	68	145	204	204
2020 submission kt CO_2e	NO	3	43	55	104	179	190
Change relative to 2019	NO	-71.5%	1.6%	-20.0%	-28.1%	-12.3%	-6.9%

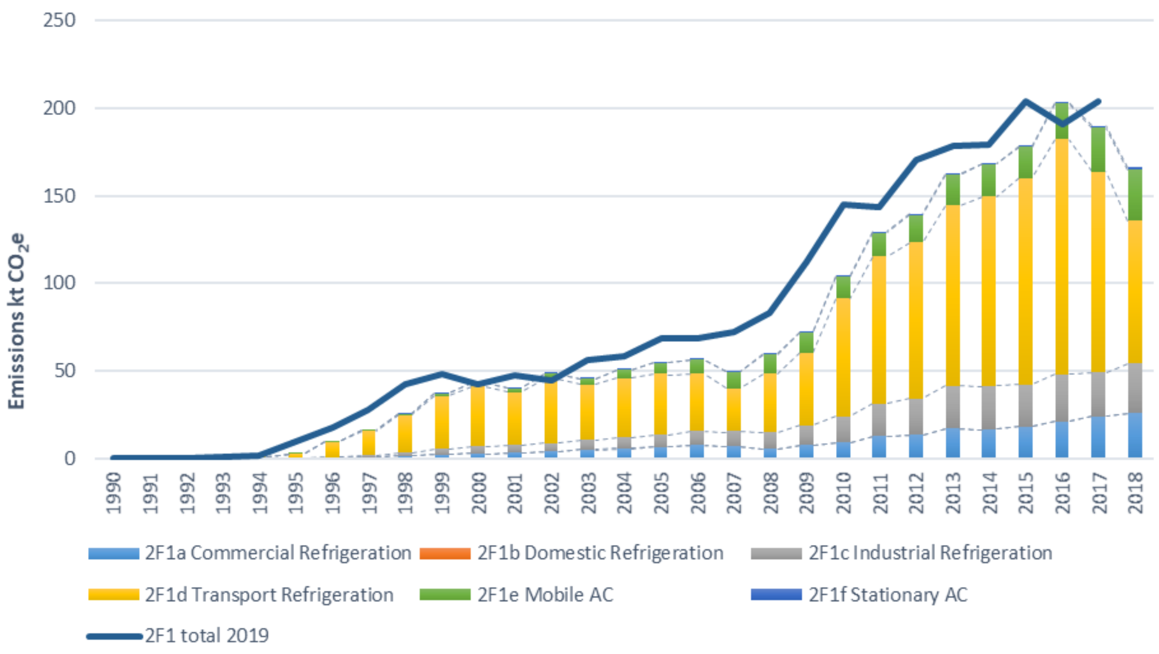

Figure 4.6 Current inventory (bars) compared to previous 2019 submission (line)

Table 4.16 Comparison between 2019 and 2020 submission for the subcategories 2F1a Commercial Refrigeration, 2F1d Transport refrigeration and 2F1e Mobile Air Conditioning, in kt CO_2e.

2F1a Commercial	1990	1995	2000	2005	2010	2015	2017
2019 submission kt CO_2e	NO	0.41	3.55	7.31	15.38	23.77	25.97
2020 submission kt CO_2e	NO	0.14	3.03	6.60	9.09	18.15	24.07
Change relative to 2019	NO	-67%	-15%	-10%	-41%	-24%	-7%
2F1d Transport							
2019 submission kt CO_2e	NO	8.50	32.59	47.58	102.41	139.52	132.28
2020 submission kt CO_2e	NO	2.41	34.29	34.73	67.10	117.79	114.71
Change relative to 2019	NO	-72%	5%	-27%	-34%	-16%	-13%
2F1e Mobile AC							
2019 submission kt CO_2e	NO	0.04	1.59	4.37	6.11	8.23	12.21
2020 submission kt CO_2e	NO	0.05	1.97	6.20	12.28	17.75	24.95
Change relative to 2019	NO	10%	24%	42%	101%	116%	104%

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. Only R-134A is used in MDI´s imported to Iceland. No other emissions are attributed to CRF sector 2F4.

4.7.5.1 Methodology

Emissions from MDIs are assumed to all occur in the same year as they are imported.

4.7.5.2 Activity data
The Icelandic Medicines Agency records import of MDIs containing R-134A since 2002. The amount of R-134A in MDIs imported has been oscillating between 500 and 650 kg since that time. 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.

4.7.5.3 Emissions
Emissions from MDIs in 2018 were approx. 0.9 kt CO_2e.

4.7.5.4 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.

4.7.5.5 Recalculations
No category-specific recalculations were done for the 2020 submission.

4.7.5.6 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.

4.8.1.2 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[9]. Based on this information the amount “Remaining in products at decommissioning” and the resulting emissions “from disposal” and the “recovery” is reported as “NO”.

4.8.1.3 Emissions

SF_6 emissions amounted to 142 kg (3.3 kt CO_2e) in 2018. Emissions increased by 197% since 1990. However, this increase is less than proportional compared to the net increase in SF_6 nameplate capacity since 1990.

Figure 4.7 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.

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

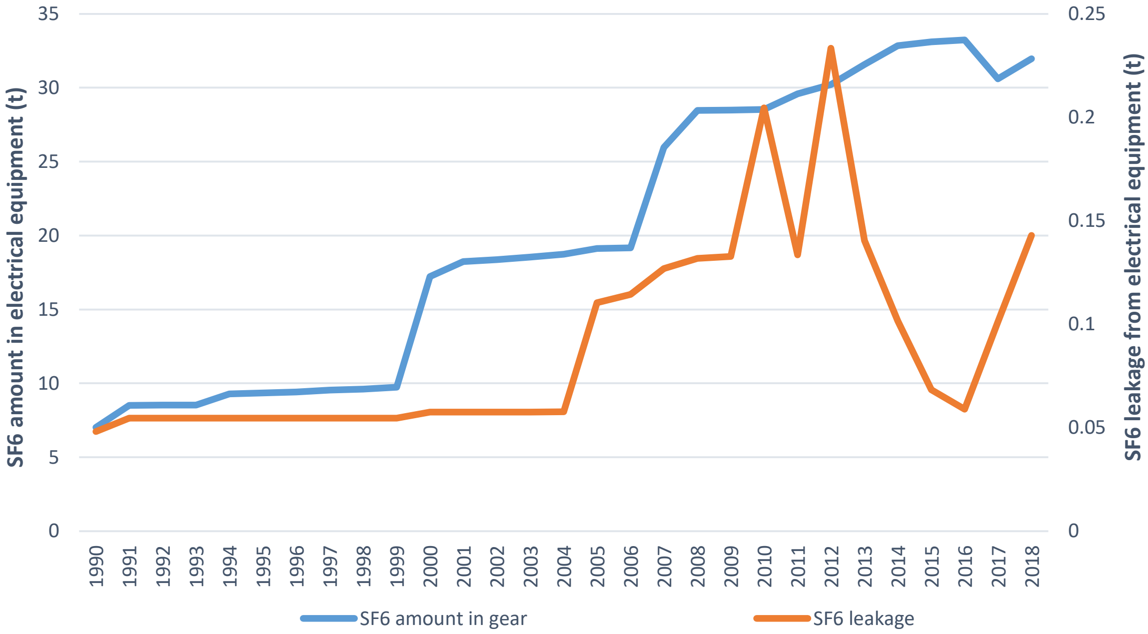

Figure 4.7 Total SF_6 amounts contained in and SF_6 leakage from electrical equipment (tonnes).

4.8.1.4 Uncertainty

The uncertainty on SF_6 emissions is estimated to be 30% (Table 8.5, Chapter 8 vol 3 IPPU IPCC guidelines). The complete uncertainty analysis is shown in Annex 2.

4.8.1.5 Recalculations and planned improvements

During 2019 all stakeholders such as power companies, power distribution companies, main industries with own switchgear have been contacted to update and revise the reported amounts of SF_6 used and refilled from 1990-2018. This update in activity data, e.g. amount in stock and leaked amount, lead to recalculations as shown in Table 4.17. Over the whole time series, emissions change between +1.2% in 2007 and +5.4% in 2016, with most of the years remaining unchanged, while stocks are up to 44% higher (as in 1999) compared to previously reported. There are no improvements planned in this category.

Table 4.17 Recalculations for the use of SF6 in electrical switchgear, stocks and leakages.

SF_6 (t)	1990	1995	2000	2005	2010	2015	2017
2019 amount in gear (stocks)	5.090	6.620	14.050	15.440	24.480	28.910	30.210
2019 emissions (leakage)	0.048	0.055	0.058	0.110	0.205	0.067	0.101
2020 amount in gear (stocks)	7.017	9.358	17.222	19.115	28.523	33.106	30.597
2020 emissions (leakage)	0.048	0.055	0.058	0.110	0.205	0.068	0.101
Change relative to 2019 stocks	38%	41%	23%	24%	17%	15%	1%
Change relative to 2019 leakage	0%	0%	0%	0%	0%	2%	0%

4.8.2 N_2O from Product Use (CRF 2G3)

4.8.2.1 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.

4.8.2.2 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 2015-2018 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- 2018, and the ratio used (95% vs 5%) was confirmed by expert judgment.

The Directorate of customs does not register the number of aerosol cans of cream or whipped cream cartridges imported to Iceland. In order to estimate the amount of N_2O that could be emitted from whipped cream containers, Iceland follows the Finnish example of applying an average of the EFs used in Central Europe, that is, 3.3 g N_2O/inhabitant/year.

EQUATION 8.24

$$E_{N2O}(t) = \Sigma i \{ [0.5 \bullet Ai(t) + 0.5 \bullet Ai(t-1)] \bullet EFi \}$$

Where:

- $E_{N2O}(t)$ = emissions of N_2O in year t, tonnes
- A_i (t) = total quantity of N_2O supplied in year t for application type i, tonnes
- A_i (t-1) = total quantity of N_2O supplied in year t-1 for application type i, tonnes
- EF_i = emission factor for application type i, fraction

4.8.2.3 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 2018 (2 kt CO_2e). Because the Icelandic market is relatively small there can be large fluctuations in imports year-to-year, and sometimes whether a shipment is recorded at the end of a calendar year or at the begin of the next one can have a large impact on the yearly totals. The significant interannual change in the IEF between 2016 and 2017 arises from the amount of N_2O imported in those years, especially the imported amount in 2016 which is half of the year 2015 and a third less than in 2017. Combining half of the emissions of the current year with the previous year leads to the deviation of the IEF from 1.

4.8.2.4 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 1.47 t N_2O (437 t CO_2e) in 2018.

4.8.2.5 Uncertainties

The uncertainty on activity data was calculated by combining 1.5% uncertainty on completeness, 3% on accuracy and 5% on possible misallocation in import categories, leading to a total 6% activity data uncertainty. An EF uncertainty of 5% is estimated in compliance with the value used in Denmark´s NIR (Danish Centre for Environment and Energy, 2018). Combined uncertainty for N_2O emissions from other product use is therefore estimated to be 7.8%. The complete uncertainty analysis is shown in Annex 2.

4.8.2.6 Recalculations and Planned improvements

The addition of the calculation of the emissions arising from aerosol cans and cartridges for whipped cream lead to recalculations which can be seen in Table 4.18.

Table 4.18 Recalculations for 2G3, use of N_2O in medical and other applications

	1990	1995	2000	2005	2010	2015	2017
2019 submission kt N_2O	0.019	0.014	0.015	0.011	0.011	0.009	0.006
2020 submission kt N_2O	0.020	0.015	0.016	0.012	0.012	0.010	0.007
Change relative to 2019	4%	6%	7%	13%	9%	12%	20%

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. NOx, 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 4.8, Tobacco consumption in Iceland has been steadily decreasing since 1990, with the 2018 imports (237 t) approximately 58% of the 1990 imports (561 t). Accordingly, the GHG emissions have also decreased by 60%, with 0.045 kt CO_2e CH_4 and 0.011 kt CO_2e N_2O in 1990 and 0.019 kt CO_2e CH_4 and 0.0045 kt CO_2e N_2O in 2018. NOx decreased from 1.01 t in 1990 to 0.43 t in 2018, NMVOC decreased from 2.7 t in 1990 to 1.1 t in 2018, and CO decreased from 30.9 t in 1990 to 13 t in 2018.

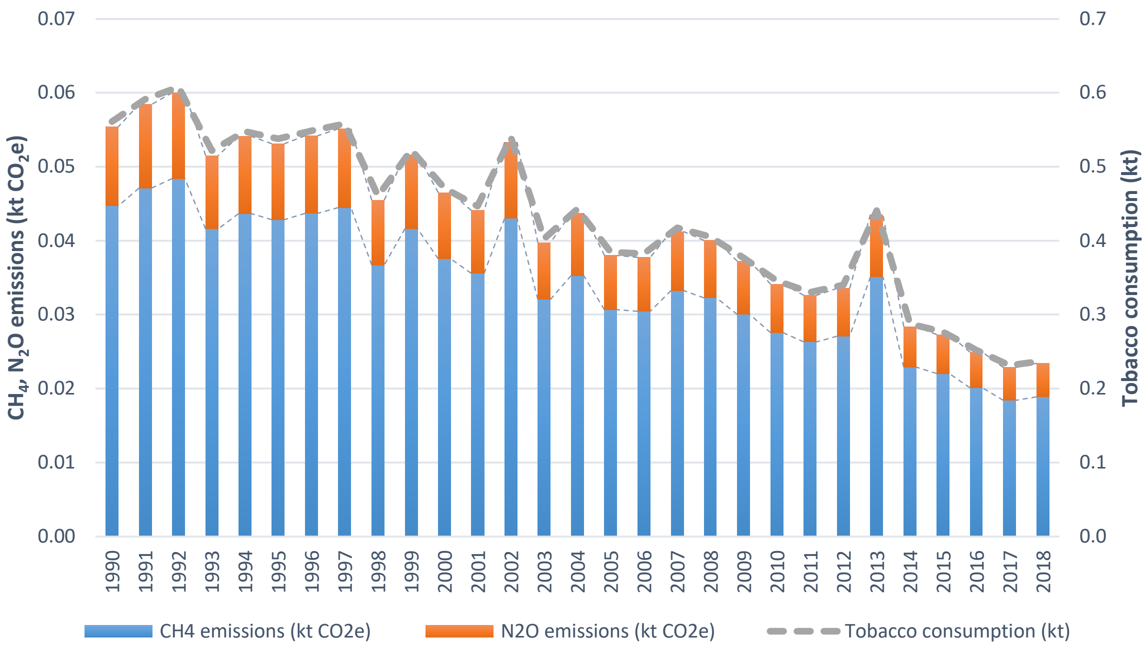

Figure 4.8 Tobacco import and GHG emissions (kt CO_2e) from tobacco use.

Recalculations and planned improvements

No category-specific recalculations were done for the 2020 submission, and no improvements are currently planned for this category.

4.8.3.2 Fireworks

All fireworks used in Iceland are imported. Here we are reporting emission data for CO_2, CH_4, N_2O, NO_x, CO and SO_2 emissions.

Methodology

Activity data for fireworks use was collected from Statistics Iceland and is based on yearly imports. CO_2, CH_4 and N_2O emissions were calculated using emission factors from the Netherland National Water Board (2008). Emissions of SO_2, CO and NO_x were calculated using default Tier 2 emission factors from the 2016 EMEP/EEA Guidebook.

Emissions

Total fireworks use has been gradually increasing since the early 1990’s, with associated increase in emissions (Figure 4.9). The large spike in fireworks import in 2007 was due to a strong economic upturn, which was then followed by a financial collapse in 2008 which is reflected in the fireworks activity data and associated emissions. Total GHG emissions is estimated to have been less than 0.1 kt CO_2 in 1990 and amounted to 0.49kt CO_2e in 2018. The main contributor to GHG emissions from fireworks is N_2O, with about 90% of total emissions (when calculated in CO_2e).

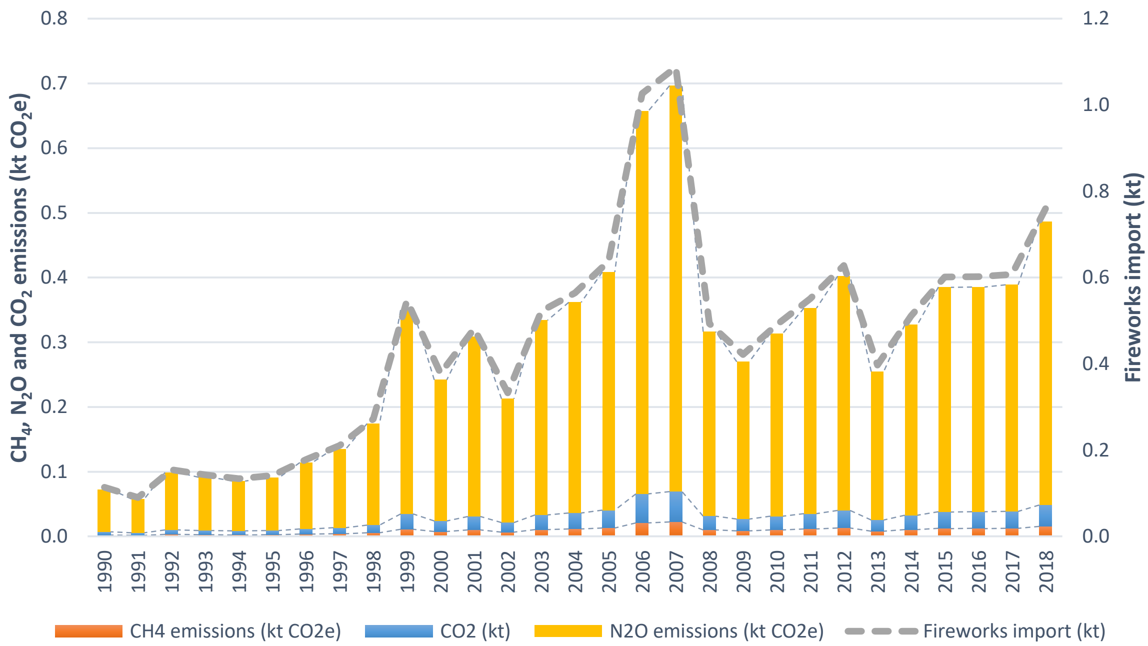

Figure 4.9 Fireworks import and GHG emissions (kt CO_2e) from firework use.

Recalculations and planned improvements

Activity data was collected from Statistics Iceland for the whole time series, leading to updated values from 1990-1994 (previously no data available). In addition, previous submissions reported import data as activity data, without subtracting export data. This has been corrected in the current submission leading to recalculations, especially for the years 1990-2007 (Table 4.19). No category-specific improvements are planned for this category.

Table 4.19 Recalculations for fireworks between the 2019 and 2020 submission due to an update of activity data as communicated by Statistics Iceland.

	1990	1995	2000	2005	2010	2015	2017
2019 submission kt CO_2	0.006	0.006	0.009	0.012	0.021	0.026	0.026
2020 submission kt CO_2	0.005	0.006	0.016	0.028	0.021	0.026	0.026
Change relative to 2019	-19%	0%	76%	130%	0%	0%	0%

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 2018 NMVOC emissions were estimated at 0.4 kt, which represents a 23% increase from the 1990 levels. Figure 4.10 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.

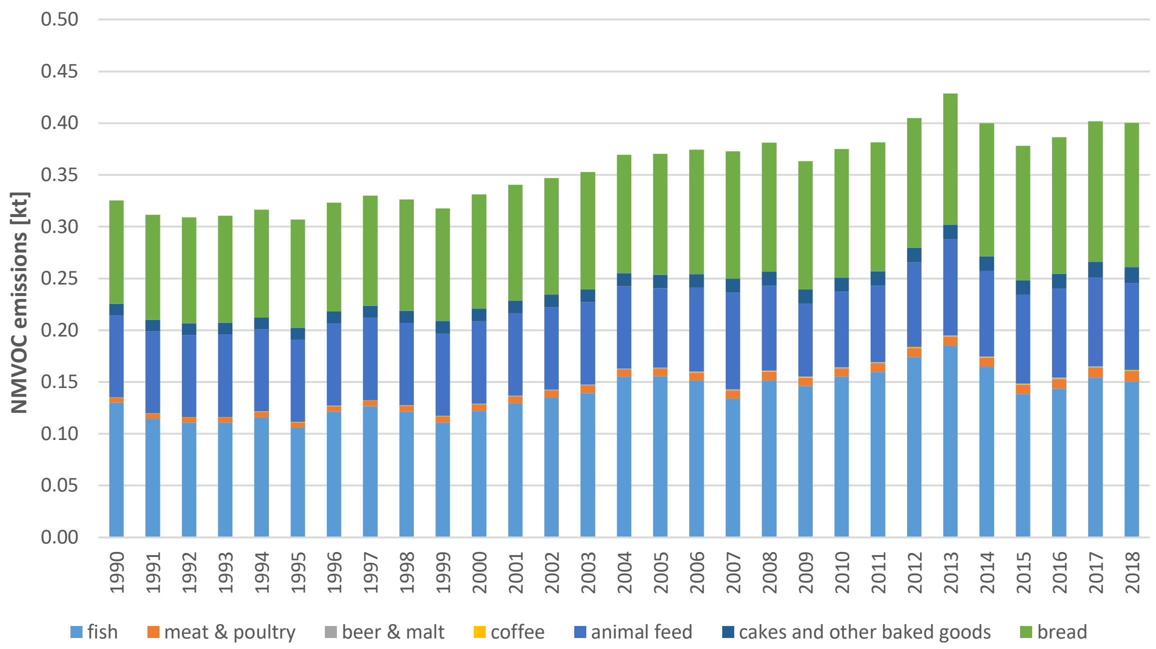

Figure 4.10 NMVOC emissions (in kt NMVOC) for various food and beverage processing.

4.9.4 Recalculations and Planned Improvements

Activity data was collected from Statistics Iceland for the whole time series, leading to updated input data explaining the occurrence of recalculations.

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 635 kt CO_2e in the year 2018 and were 6.4% below the 1990 level (Table 5.1). Emissions of CH_4 and N_2O accounted for over 99% of the total emissions from agriculture - CO_2 accounted for the rest. The decrease of GHG emissions since 1990 is mainly due to a decrease in sheep livestock population, reducing methane emissions from enteric fermentation. 84% of CH_4 emissions were caused by enteric fermentation, the rest by manure management. 93% of N_2O emissions were caused by agricultural soils, the rest by manure management, i.e. storage of manure.

For the 2020 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 2019 EU Step II review and the 2019 UNFCCC desk review.

Table 5.1 Emission of GHG in the agricultural sector in Iceland 1990-2018 in kt CO_2e

	1990	1995	2000	2005	2010	2015	2017	2018
CH_4	385	359	353	342	359	376	377	358
N_2O	293	270	278	259	270	279	286	270
CO_2	0.06	0.06	0.07	4	2	4	4	6
Total	678	629	632	605	631	659	666	635
Emission reduction (year-base year)/base year		-7.3%	-6.9%	-10.8%	-6.9%	-2.8%	-1.7%	-6.4%

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 2016 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, 2018 and 1990-2018 trend in the Agriculture sector are as follows (compared to total emissions without LULUCF):

Table 5.2 Key source analysis for Agriculture, 1990, 2018 and trend (excluding LULUCF)

IPCC source category			Level 1990	Level 2018	Trend
Agriculture (CRF sector 3)					
3A1	Enteric Fermentation – Cattle	CH_4	✓	✓	
3A2	Enteric Fermentation - Sheep	CH_4	✓	✓	✓
3A4	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 Icelandic Agricultural Advisory Center (Ráðgjafamiðstöð landbúnaðarins) to cross-check parameters used for livestock characterisation.
- 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

For next submission, animal characterization data is going to be reviewed, e.g. pregnancy rates, age at slaughter, weight at birth, weight gain and final body weight, type of housing, time in stall, feeding situation for the past years and, if possible, for the whole timeline. In addition, all comments received during the 2019 EU Stage II and the 2019 UNFCCC desk review which could not be implemented for this submission are going to be addressed.

In 2019 both IPCC Guidelines and the EMEP/EEA Guidebook used as a basis for the estimation of the emissions have been updated. It is planned to adapt and check the Icelandic inventory against the 2019 IPCC Refinements and to the 2019 EMEP/EEA air pollution inventory Guidebook to be fully consistent with emission factors and methodologies.

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
Icelandic Food and Veterinary Authority (IFVA)	Mast.is	- annual livestock census (bustofn.is) - slaughtering data - inorganic fertilizer import data
Icelandic Agricultural Advisory Centre (Ráðgjafarmiðstöð landbúnaðarins – RML)	Rml.is	- milk yield - fat content milk - feed digestibility data dairy cows 2018 - birth weight, weight gain, weight at slaughtering lambs - pregnancy rates dairy cattle and ewes 2018 - weight mature dairy cattle 2018 - expert judgements
Soil Conservation Service (SCS)	Land.is	- areas of drained organic soils
Statistics Iceland	Hagstofa.is	- crop production - import data of carbon containing fertilisers and urea - livestock numbers for comparison
Municipalities		- use of sewage sludge for land reclamation purposes
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 Icelandic Food and Veterinary Authority (IFVA) conducts an annual livestock census. Farmers count their livestock once a year in November and send the numbers to IFVA 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)[10]. Lambs are not reported in Statistics Iceland or in the IFVA 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 IFVA; 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

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

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 IFVA, 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	2017	2018
Mature dairy cattle	**Statistics Iceland**	32,246	30,428	27,066	24,538	25,711	27,386	26,742	26,386
	NIR	31,604	30,428	27,066	24,488	25,379	27,441	26,742	26,477
Other Mature Cattle	**Statistics Iceland**	…	…	949	1,355	1,672	2,049	2,266	2,640
	NIR	645	737	953	1,355	1,608	2,049	2,266	2,640
Ewes	**Statistics Iceland**	445,513	458,341	465,777	454,950	374,266	374,863	364,899	344,452
	NIR	445,185	372,222	373,240	360,119	372,672	373,278	365,671	344,795
Lambs	**Statistics Iceland**	…	…	…	…	….	…	…	…
	NIR	312,801	261,163	263,750	256,227	271,156	272,279	259,674	225,572
Swine	**Statistics Iceland**	3,116	3,726	3,862	3,982	3,615	3,550	3,567	3,323
	NIR	29,768	30,746	32,242	39,350	38,032	42,542	43,221	40,278
Laying hens	**Statistics Iceland**	214,936	164,402	193,097	166,119	173,419	238,000	220,460	253,763
Poultry	**NIR**	669,280	353,214	531,853	765,860	630,258	706,067	826,550	866,435

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). IFVA is in the process to set up a better system by linking Worldfengur, the studbook of origin for the Icelandic horse[11] 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 review and update the livestock numbers for horses for the years 2014-2018 by modelling them as the sum of two thirds of animals registered at IFVA and one third registered in the studbook after consulting with Jón Baldur Lorange, manager or the agricultural affairs at IFVA 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 2014-2018 and calculated livestock numbers to be used in this submission.

Source	2014	2015	2016	2017	2018
IFVA (bustofn.is)	67,997	67,417	67,239	64,816	53,453
Studbook (worldfengur.com)	97,693	97,941	97,955	96,840	96,689
Calculated for NIR	79,733	79,429	79,315	77,328	69,702

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 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).

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

Subcategory	Equations from Chapter 10, vol. 4 of the IPCC 2006 guidelines. Net energy for maintenance, activity, growth, lactation, wool, and pregnancy					
	Maintenance NEm	Activity NEa	Growth NEg	Lactation NEl	Wool NEwool	Pregnancy NEp
Mature dairy cattle	10.3	10.4	NA	10.8	NA	10.13
Other mature cattle	10.3	10.4	NA	10.8	NA	10.13
Heifers[1]	10.3	10.4	10.6	NA	NA	4.8
Steers for producing meat	10.3	10.4	10.6	NA	NA	NA
Calves	10.3	10.4	10.6	NA	NA	NA
Mature ewes	10.3	10.4	NA	10.1	10.12	10.13
Other mature sheep	10.3	10.4	NA	NA	10.12	NA
Animals for replacement[1]	10.3	10.4	10.7	NA	10.12	10.13
Lambs	10.3	10.4	10.7	NA	10.12	NA

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

Table 5.9 shows national parameters that were used to calculate gross energy intake for cattle in 2018. 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 2018. (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	17.2	5.5	NA	NA	NA
Fat content of milk (%)	4.26	4.2	NA	NA	NA

[1]Steers are not allowed outside. The young cows inside the category are grazing on pasture for 120 days. [2] Average for cows and steers, not weighted.

Table 5.10 shows national parameters that were used to calculate gross energy intake for sheep in 2018.

Table 5.10 Animal performance data used in calculation of gross energy intake for sheep for 2018. 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

	Mature ewes	Other mature sheep	Animal for replacement	Lambs
Body weight at 1 year or old or at slaughter (kg)	NA	NA	55	16.56
Birth weight (kg)	4	4	4	3.94
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)	64.31	64.31	64.3	77.2

[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.

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. 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 2020 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 2018.

	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

	DMD (%)	DE (%)	Ash in feed (%)
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 265 MJ/day in 2018. 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 2018. In addition, for 2018 the feed digestibility parameters for mature dairy cattle where updated as well as the mature body weight (RML, written communication, 2020).

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.

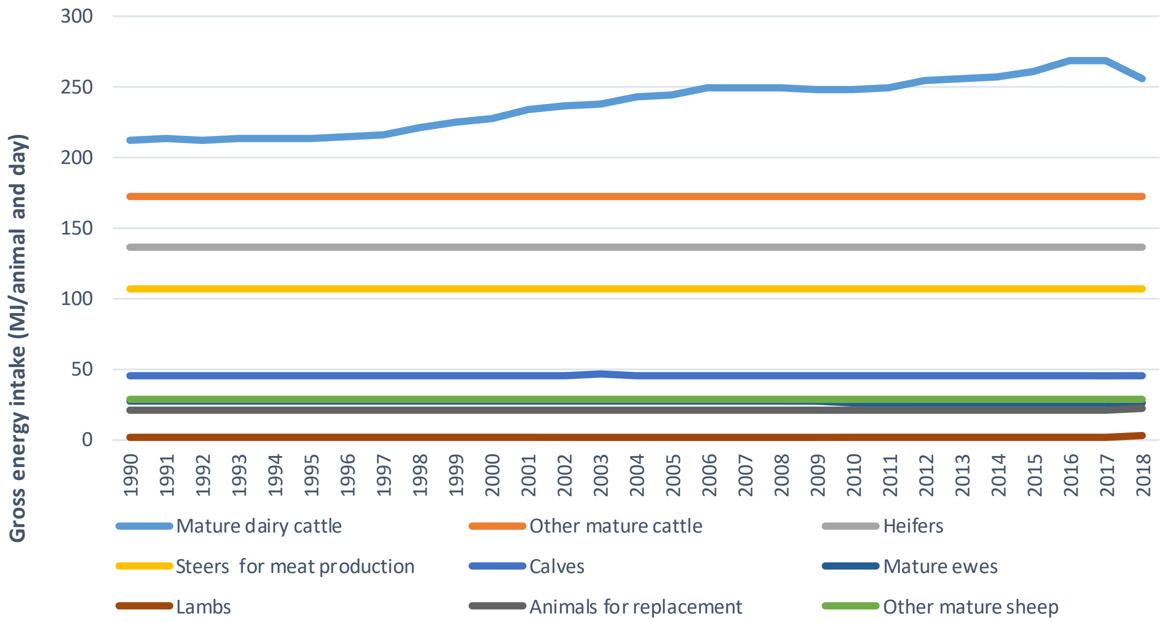

Figure 5.1 Gross energy intake (MJ/day) for cattle and sheep subcategories from 1990-2018.

5.2.4 Recalculations

Animal population numbers

In response to a request from the additional findings (A.31) of the 2019 UNFCCC Preliminary Review Report to ensure time series consistency, the animal populations of other mature dairy cattle were updated adding interpolated values for the years 1990-1991 as well as for turkeys and geese. The values for other mature cattle were included in the total number of dairy cattle for the first two years of the time series and by assuming the same ratio of other mature cattle vs. mature dairy cattle from 1992 (2%) the population numbers for 1990 and 1991 were estimated; the population numbers for mature dairy cattle also changed accordingly (subtraction of the other mature cattle value). For turkeys and geese, the average of the population 1992-1996 was used to fill the gaps of 1990 and 1991.

Animal characterization update

In response to the 2019 UNFCCC preliminary report, outstanding issue A.3, data for animal characterization were collected, mainly for cattle and sheep, as these categories are key categories in the agriculture emissions. The Icelandic Agricultural Advisory Centre (RML, written communication, 2020) collected data for mature dairy cattle for the year 2018 including average live body weight and feeding characteristics leading to an update of the digestible energy (%).

In the animal category sheep several parameters were updated thanks to the collaboration with the Icelandic Agricultural Advisory Centre (RML, written communication, 2020):

- pregnancy rate for sheep and animals for replacement 2018
- age of animal slaughtered 2010-2018, birth weight 2002-2018 (Sveinbjörnsson, Eyþórsdóttir, & Örnóflsson, 2018), carcass weight 2002-2018, daily weight gain 2002-2018, body weight at weaning 2002-2018, body weight at 1 year old or at slaughter, average body weight for lambs.

Lambs are alive for only around 4.5 months a year (born in April-May and slaughtered in September-October), therefore the AAP are estimated using the Equation 10.1 from Vol. 4 of the 2006 IPCC Guidelines. As this population already corresponds to the annual population it was decided to change the equation for the estimation of the net energy for growth (Eq. 10.7 from Vol. 4 of the 2006 IPCC Guidelines) from dividing it by 365 to dividing it by 139 (average amount of days alive) to obtain the actual daily energy requirements whilst alive. This leads to recalculations for the whole time series.

Compared to the 2019 submission, there have been recalculations for the gross energy (GE) for the whole time series for the categories mature dairy cattle and other mature cattle (cows used for meat production) due to an update of the coefficient (Cfi) for calculating the net energy for maintenance (NEm). For mature dairy cows and other mature cattle, the values from table 10.4 of the 2006 IPCC Guidelines for lactating cows and non-lactating cows were used and multiplied with the respective lactating periods to obtain the final Cfi. In addition, milk yield numbers (kg milk per day) were updated for the years 2006 and 2014 and the fat content of milk was updated for the years 2008-2010, 2012-2014, 2016 and 2017. The weight of mature dairy cattle was also updated for the year 2018, reaching 471.3 kg. After consultation with the Agricultural University (Sveinbjörnsson, e-mail communication, 2020), it was decided to interpolate linearly the weight from 1990 (430 kg) to 2018 (471.3 kg) changing the weight for the whole time series. These parameters influence the net energy for maintenance (NEm) and net energy for lactation (NEl) and therefore the gross energy (GE). The changes of around 5-6% for mature dairy cattle have already been implemented in the 2019 v2 resubmission in light of the 2019 UNFCCC desk review and can be seen in Table 5.12. With the updated weight the GE change from 1-3% compared to the 2019 v2 submission. The value (non-time dependant) for other mature cattle changed from 170 MJ/day (2019 v1 submission) to 173 MJ/day.

For the livestock category growing cattle (heifers, steers for producing meat and calves) the formula for calculating the net energy for growth NEg was updated to match equation 10.6 of the 2006 IPCC Guidelines. Changes are however very little.

Table 5.12 Recalculation for the whole time series of the gross energy (MJ/day) for mature dairy cattle compared to 2019 v1 and 2019 v2 submission[12]

Mature dairy cattle	1990	1995	2000	2005	2010	2015	2017
2019 v1 submission	200	200	213	228	230	242	249
2019 v2 submission	212	212	225	240	242	254	261
2020 submission	212	214	228	244	248	261	269
Change relative to 2019 v1	6%	7%	7%	7%	8%	8%	8%
Change relative to 2019 v2	0%	1%	1%	2%	2%	3%	3%

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 with the aim of updating productivity data, such as the digestible energy content of feed and gross energy intake, on a regular basis.

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	2018
Swine	Table 10.10 2006 IPCC	1.5
Horses	Table 10.10 2006 IPCC	18
Goats	Table 10.10 2006 IPCC	5
Minks, foxes, rabbits	Norwegian NIR	0.1
Poultry	Norwegian NIR	0.02

Tier 2

Livestock population characterisation was used to calculate gross energy intake of cattle and sheep as shown in paragraph 5.2.3. These values together with the default values of the methane conversion rate from the IPCC 2006 Guidelines and reported in Table 5.14 were used to calculate emission factors for methane emissions from enteric fermentation by applying Equation 10.21. Table

[12] 2019 v1 submission refers to the submission in April 2019, whereas 2019 v2 submission refers to the resubmission in November 2019 following a Saturday Paper received during that year's UNFCCC desk review. More details about the resubmission can be found in Chapter 10.2.

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
- Y_m = methane conversion rate which is the fraction of gross energy in feed converted to methane
- 55.65 = energy content of methane, MJ/kg CH_4

Table 5.14 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)
Y_m	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	2018
Mature dairy cattle	109.2
Other mature cattle	73.8
Heifers	58.4
Steers used for producing meat	45.5
Calves	19.2
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 16% between 1990 and 2018. Methane emissions, however, have increased by 1% from 2.86 kt to 2.89 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 24% between 1990 and 2018 (from 5.05 to 3.8 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 which has been reviewed for the current submission as explained in paragraph 5.2.1, decreased slightly in 2018 and the methane emissions decreased consequently by 5.6% from 1990 (from 1.3 kt to 1.25 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 12 kt in 2018, or by 7.7% (Table 5.16).

Table 5.16 Methane emissions from enteric fermentation from agricultural animals for years 1990, 1995, 2000, 2005, 2010 and 2017-2018 in t methane.

Livestock category	1990	1995	2000	2005	2010	2015	2017	2018
Mature dairy cattle	2,860	2,770	2,629	2,552	2,681	3,055	3,062	2,890
Other mature cattle	48	54	70	100	119	151	167	195
Heifers	267	746	371	393	386	418	389	351
Steers for producing meat	817	700	903	694	858	899	1,018	1,066
Calves	388	268	346	351	387	429	438	441
Mature ewes	5,043	4,217	4,228	4,092	4,045	4,054	4,002	3,844
Other mature sheep	158	148	144	134	144	141	141	139
Animals for replacement	845	695	756	786	872	834	774	720
Lambs	1,231	1,028	1,038	1,000	1,132	1,154	1,126	1,054
Swine	45	46	48	59	57	64	65	60
Horses	1,330	1,444	1,361	1,379	1,419	1,430	1,392	1,255
Goats	2	3	3	3	5	7	9	11
Fur animals	5	4	4	4	4	5	3	2
Poultry	14	7	11	16	13	14	17	18
Total methane emissions	**13,053**	**12,129**	**11,913**	**11,561**	**12,122**	**12,654**	**12,604**	**12,046**
Emission reduction (year-base year)/base year		-7.1%	-8.7%	-11.4%	-7.1%	-3.1%	-3.4%	-7.7%

Table 5.17 Livestock category Growing Cattle: weighed averages of parameters necessary to calculate the methane emissions as reported in CRF.

Growing Cattle	1990	1995	2000	2005	2010	2015	2017	2018
Population heifers	4,579	12,781	6,361	6,728	6,620	7,157	6,671	6,011
Population steers for meat production	17,957	15,379	19,848	15,250	18,873	19,757	22,388	23,445

Growing Cattle	1990	1995	2000	2005	2010	2015	2017	2018
Population calves	20,118	13,874	17,916	18,149	20,029	22,372	22,828	23,000
Weighed average Body weight (BW) kg	237.4	274.2	252.2	243.8	245.4	242.6	244.7	244.4
Weighed average digestible energy (DE) %	69.9	69.2	69.5	69.8	69.7	69.8	69.7	69.6
Weighed average gross energy (GE) MJ/day	81.0	95.6	86.1	84.0	84.1	83.1	83.4	83.1
Sum CH_4 emissions (kt)	**1.47**	**1.71**	**1.62**	**1.44**	**1.63**	**1.75**	**1.84**	**1.85**
IEF	34.52	40.76	36.71	35.83	35.84	35.41	35.56	35.42

5.3.3 Recalculations

The recalculations of the gross energy (GE), explained in paragraph 5.2.4 for mature dairy cattle and other mature cattle lead to recalculations in the methane emission factor and therefore in the methane emissions for the whole time series. The recalculations for mature dairy cattle have already been implemented during the 2019 resubmission as requested by the 2019 UNFCCC desk review. For the current submission the update of animal characterization parameters for cattle and sheep, such as the weight for mature dairy cattle, also lead to recalculations. In the category other mature cattle, the interpolation of livestock data for the years 1990 and 1991 (previously reported as "NO" and further explained in section 5.2.4) lead to recalculations for the base year besides the changes due to the update of the GE calculation. The changes show a 6% increase for 1990 and 4.7% increase in 2017 (Table 5.18). The increase in gross energy (GE) for other mature cattle leads to an increase of 1.7% for the whole timeseries (Table 5.18).

The update for the horse population numbers (paragraph 5.2.1) for the years 2014-2017 leads to recalculations increasing the emissions by 4.7% in 2017 compared to the 2019 v1 submission as can be seen in Table 5.19.

In the case of the animal category lambs, the decision to change the equation 10.7 for the net energy for growth (as explained in section 5.2.4) leads to recalculations for the whole timeline from +38% in 1990 to +53% in 2017 as can be seen in Table 5.20. In addition to this, animal parameters for lambs, especially birth weight and weight at slaughter were updated with the help of the Icelandic Agricultural Advisory Centre (RML, written communication, 2020) for 2003-2018 contributing to the recalculations.

Table 5.18 Comparison between the 2019 v1, 2019 v2 submission and the 2020 submission for mature dairy cattle and other mature cattle for the whole time series.

Mature dairy cattle	1990	1995	2000	2005	2010	2015	2017
2019 v1 submission (kt CH_4)	2.752	2.595	2.456	2.380	2.484	2.829	2.842
2019 v2 submission (kt CH_4)	2.918	2.752	2.596	2.507	2.619	2.971	2.974
2020 submission (kt CH_4)	2.860	2.770	2.629	2.552	2.681	3.055	3.062
Change relative to 2019 v1	3.9%	6.8%	7.1%	7.2%	7.9%	8.0%	7.8%
Change relative to 2019 v2	-2.0%	0.7%	1.3%	1.8%	2.4%	2.8%	3.0%
Other mature cattle	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2017**
2019 v1 submission (kt CH_4)	NO	0.053	0.069	0.098	0.117	0.149	0.164
2019 v2 submission (kt CH_4)	NO	0.053	0.069	0.098	0.117	0.149	0.164
2020 submission (kt CH_4)	0.048	0.054	0.070	0.100	0.119	0.151	0.167
Change relative to 2019 v1	NO	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%
Change relative to 2019 v2	NO	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%

Table 5.19 Comparison between the 2019 v1 submission (same as 2019 v2 submission) and the 2020 submission for horses. Updated population numbers lead to recalculations in the methane emissions in the years 2014-2017

Horses	2014	2015	2016	2017
2019 v1 = 2019 v2 submission (kt CH_4)	1.330	1.358	1.361	1.329
2020 submission (kt CH_4)	1.435	1.430	1.428	1.392
Change relative to first	7.9%	5.3%	4.9%	4.7%

Table 5.20 Comparison between the 2019 v1 submission (same as 2019 v2 submission) and the 2020 submission for lambs.

Lambs	1990	1995	2000	2005	2010	2015	2017
2019 v1 = 2019 v2 submission (kt CH_4)	0.887	0.741	0.748	0.727	0.757	0.755	0.736
2020 submission (kt CH_4)	1.231	1.028	1.038	1.000	1.132	1.154	1.126
Change relative to first	38.8%	38.8%	38.8%	37.6%	49.5%	52.8%	53.0%

5.3.4 Uncertainties

Uncertainty for emissions from CH4 emission estimates for enteric fermentation was calculated using IPPC default values from 2006 GL. For cattle and sheep, the estimated quantitative uncertainty of CH4 emissions for enteric fermentation is 40%. Cattle and sheep population data were deemed reliable and were therefore attributed with an uncertainty of 5% (expert judgement). Emission factor uncertainty was set at 40% according to 2006 IPCC GL.

For other livestock, activity data uncertainty is slightly higher at 20% and emission factor uncertainty is set at 40%, with an estimate of total quantitative uncertainty at 45% (2006 IPCC GL).

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 10.15 from the 2006 IPCC Guidelines. Table 5.21 summarizes the emission factors used for the whole timeline. For the livestock category poultry, the emissions are calculated in a disaggregated level (laying hens, broilers, pullets, chicken, ducks/geese, turkeys) to reflect the different emission factors and then summed.

Table 5.21 Tier 1 default emission factors for methane emissions from manure management.

Livestock category	Source	2018
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 in5.2.2, the volatile solid excretion rate (VS) is calculated following Equation 10.24 of the 2006 IPCC Guidelines.

EQUATION 10.24

Volatile solid excretion rates

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

Where:

- VS = volatile solid excretion per day on a dry-matter weight basis, kg VS/day
- GE = gross energy intake, MJ/day
- DE% = Digestibility of the feed, %
- UE*GE = urinary energy expressed as fraction of GE; value of 0.04 GE used
- ASH = Ash content of the manure in percent
- 18.45 = Conversion factor for dietary GE per kg of dry matter (MJ/day)

Volatile solid excretion per day is then used in equation 10.23 of the 2006 IPCC Guidelines to calculate the CH_4 emission factor from manure management:

EQUATION 10.23

CH_4 Emission factor from manure management

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

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, m^3 CH_4/kg of VS excreted
- 0.67 = conversion factor of m^3 CH_4 to kg CH_4
- $MCF_{S,k}$ = CH_4 conversion factors for each manure management system S by climate region k, %
- $MS_{S,k}$ = fraction of livestock category manure handled using manure management system S by climate region k

Methane conversion factors (MCF) and maximum methane producing capacity values (B_o) for both livestock categories, cattle and sheep, are taken from the 2006 IPCC Guidelines and shown in Table 5.22.

Table 5.22 MCF and B_o 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 manure manag. 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 - B_o	Tables 10A-4, 10A-9 2006 IPCC	0.24		0.19	

(1): with natural crust cover. (2): without natural crust cover; MCF used for liquid/slurry

5.4.2 Manure Management System Fractions

The fractions of total manure managed in the different manure management systems (MMS) impact not only CH_4 emissions from manure management but also N_2O emissions from manure management and as a consequence 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 5.23).

Table 5.23 Manure management system fractions for all livestock categories.

	Liquid/slurry	Solid storage	Pasture/range/ paddock
Mature dairy cattle	73%		27%
Other mature cattle	8%		92%
Heifers	67%		33%
Steers for producing meat	91%		9%
Calves	100%		
Mature ewes	19%	36%	45%
Other mature sheep	19%	36%	45%
Animals for replacement	19%	36%	45%
Lambs			100%

	Liquid/slurry	Solid storage	Pasture/range/ paddock
Goats		55%	45%
Horses		14%	86%
Young horses		14%	86%
Foals			100%
Sows	100%		
Piglets	100%		
Poultry, fur animals		100%	

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

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

Livestock category	Emission factor 2018	Emission factor range 1990-2018	Source
	(kg CH_4/head year)	(kg CH_4/head year)	
Mature dairy cattle	30.69	29.14-35.47	LPS
Other mature cattle	3.01		LPS
Heifers	12.04		LPS
Steers for producing meat	13.03		LPS
Calves	4.87	4.87-4.96	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 5.24 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 2.28 kt in 2018 or by 3.7%.

Table 5.25 Methane emissions from manure management in tonnes.

Livestock category	1990	1995	2000	2005	2010	2015	2017	2018
Mature dairy cattle	928	893	838	808	840	958	960	813
Other mature cattle	2	2	3	4	5	6	7	8

Livestock category	1990	1995	2000	2005	2010	2015	2017	2018
Heifers	55	154	77	81	80	86	80	72
Steers for producing meat	234	200	259	199	246	257	292	306
Calves	99	68	88	89	98	109	111	112
Mature ewes	488	408	409	396	391	392	387	372
Other mature sheep	15	14	14	13	14	14	14	13
Animals for replacement	82	67	73	76	84	81	75	70
Lambs	26	22	22	21	24	24	24	22
Swine	179	184	193	236	228	255	259	242
Horses	81	87	82	84	86	87	84	76
Goats	0	0	0	0	0	0	0	0
Fur animals (minks and foxes)	32	26	28	25	27	32	23	13
Rabbits	0	0	0	0	0	0	0	0
Poultry	142	105	127	107	99	86	144	156
Total methane from manure management (t)	**2362**	**2231**	**2213**	**2139**	**2223**	**2389**	**2461**	**2275**
Emission reduction (year-base year)/base year		-5.5%	-6.3%	-9.5%	-5.9%	1.1%	4.2%	-3.7%

5.4.4 Recalculations

For cattle (and subcategories therein), and for the whole time series, the update of the gross energy (GE) as described in paragraph 5.2.4 influences the calculation of the volatile solid excretion rates (VS). In addition, for cattle and sheep, the formula for calculating VS has been updated from that previously used (which was taken from the Good Practice Guidance (2014)), following the request of the reviewers during the 2019 EU step 2 review. The urinary energy (UE) was missing from the equation. Changes in the livestock characterization parameters (cattle and sheep) as explained in the previous chapters affect the methane emissions from manure management as well.

The changes for horses are due to the update of the population data for the years 2014-2017 as explained in section 5.2.2.

Considering all changes, the CH_4 emissions from Manure Management result in an increase of 11.7% in 1990 and 12.3% in 2017 as shown in Table 5.26.

Table 5.26 Comparison of CH_4 emissions in kt from Manure Management between 2019 v1 submission (= 2019 v2 submission) and 2020 submission

Total	1990	1995	2000	2005	2010	2015	2017
2019 v1 = 2019 v2 subm. (kt CH_4)	2.115	1.979	1.967	1.902	2.063	1.985	2.191
2020 submission (kt CH_4)	2.362	2.231	2.213	2.139	2.223	2.389	2.461
Change relative to first	11.7%	12.8%	12.5%	12.4%	7.8%	20.3%	12.3%

5.4.5 Uncertainties

Uncertainty of emissions from CH_4 emission estimates for manure management was calculated using IPPC default values from 2006 GL. For cattle the estimate of quantitative uncertainty of CH4 emissions for manure management is 23% (AD uncertainty at 11.2% and EF uncertainty at 20.0%). The estimated quantitative uncertainty of CH4 emissions for sheep for manure management is 32%

(AD uncertainty at 25.5% and EF uncertainty at 20.0%). For activity data uncertainty MM system uncertainty and livestock number uncertainty were aggregated. The MMS uncertainty is highest for sheep due to the variability in sheep manure management (25%) and less for other livestock categories (10%)

For other livestock, the estimate of quantitative uncertainty of CH4 emissions was made according to 2006 IPCC GL and is estimated to be 36% for manure management (AD uncertainty at 20.0% and EF uncertainty at 30.0%).

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 2016 version of the EMEP/EEA 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.

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 considers 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 2016 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 2016 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 2016 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 2016 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.

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 5.23.

The Nitrogen excretion rate is calculated applying Tier 1 methodology from the 2006 IPCC Guidelines for all livestock categories except mature dairy cattle. Table 5.27 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 weighed average in relation to the population data (growing cattle, horses, poultry).

The calculation method for the Nex rate has been changed for the current submission. While until the 2019 v1 submission a national value from Ketilsdóttir and Sveinsson (2010) was used, Iceland was urged to change the method during the 2019 UNFCCC desk review and the 2019 EU step 2 review in order to account for improved milk yield over the years. Therefore, Tier 2 methodology from the 2006 IPCC Guidelines (Volume 4, chapter 10) is used by applying Equation 10.31, Equation 10.32 and Equation 10.33 for dairy cows.

EQUATION 10.31

Annual N excretion rates (Tier 2)

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

Where:

- Nex= annual N excretions rates, kg N/animal/yr
- N_{intake}= the daily N intake per head of animal category, kg N/animal/day
- $N_{retention\_frac}$= fraction of N intake that is retained by animal category, dimensionless

EQUATION 10.32

N intake rates for cattle

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

Where:

- N_{intake}= the daily N consumed per head of animal category, kg N/animal/day
- GE= gross energy intake, MJ/animal/day
- 18.45= conversion factor for dietary GE per kg of dry matter, MJ/kg
- CP%= percent crude protein in diet, input
- 6.25= conversion factor from kg of dietary protein to kg of dietary N, kg feed protein/ kg N

EQUATION 10.33

N retained rates for cattle

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

Where:

- $N_{retention}$= daily N retained per head of animal category, kg N/animal/day
- Milk= milk production, kg/animal/day
- Milk PR%= percent of protein in milk, calculated as [1.9+0.4*%Fat], %Fat assumed to be 4%
- 6.38= conversion from milk protein to milk N, kg Protein/ kg N

- WG= weight gain, kg/day
- 268= constant, g Protein/kg/animal
- 7.03= constant, g Protein/MJ/animal
- NEg= net energy for growth, MJ/day
- 6.25= conversion factor from kg of dietary protein to kg of dietary N, kg feed protein/ kg N

Table 5.27 Nitrogen excretion rates defaults, animal weight and Nex for the time series 1990-2018

Livestock category	Nex default (kg N/1000 kg animal mass/day)	animal weight (kg)	1990	1995	2000	2005	2010	2015	2017	2018
Mature dairy cattle (1)	0.48	(2)	87	88	93	98	99	103	105	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	33	30	29	30	29	29	29
Mature ewes	0.85	65	20	20	20	20	20	20	20	20
Other mature sheep	0.85	95	29	29	29	29	29	29	29	29
Animals for replacement	0.85	36	11	11	11	11	11	11	11	11
Lambs	0.85	21	7	7	7	7	7	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	375	36	36	36	36	36	36	36	36
Foals	0.26	60	6	6	6	6	6	6	6	6
Horses (weighed average)	weighed average from horses, young horses and foals		28	27	29	29	28	29	29	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	0	0		0	0	0	0
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	weighed 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 2016 EMEP/EEA air pollution inventory guidebook and an extract is given in Table Table 5.28.

Table 5.28 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 solid	0.2 0.19	0.2 0.27	0.001 0.02	0.0001 0.01
Non-dairy cattle	0.6	1	0	322	slurry solid	0.2 0.19	0.2 0.27	0.001 0.02	0.0001 0.01
Sheep	0.5	0.35	0.65	128	slurry solid	0.22	0.28	0.001 0.02	0.0001 0.01
Swine -piglets	0.7	1	0	365	slurry solid	0.28 0.27	0.14 0.45	0.01	0.0001 0.01
Swine -Sows	0.7	1	0	365	slurry solid	0.22 0.25	0.14 0.45	0.01	0.0001 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	solid slurry	0.41 0.41	0.14 0.14	0.002	0.0001 0.01
Broilers	0.7	0	1	365	solid	0.28	0.17	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 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 35 tonnes N_2O in 2018 and 43 tonnes in 1990 (-20%).

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 2018. 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 (81% in 2018), followed by solid storage of horse manure (6%), poultry manure (2%), and fur animal manure (0.4%).

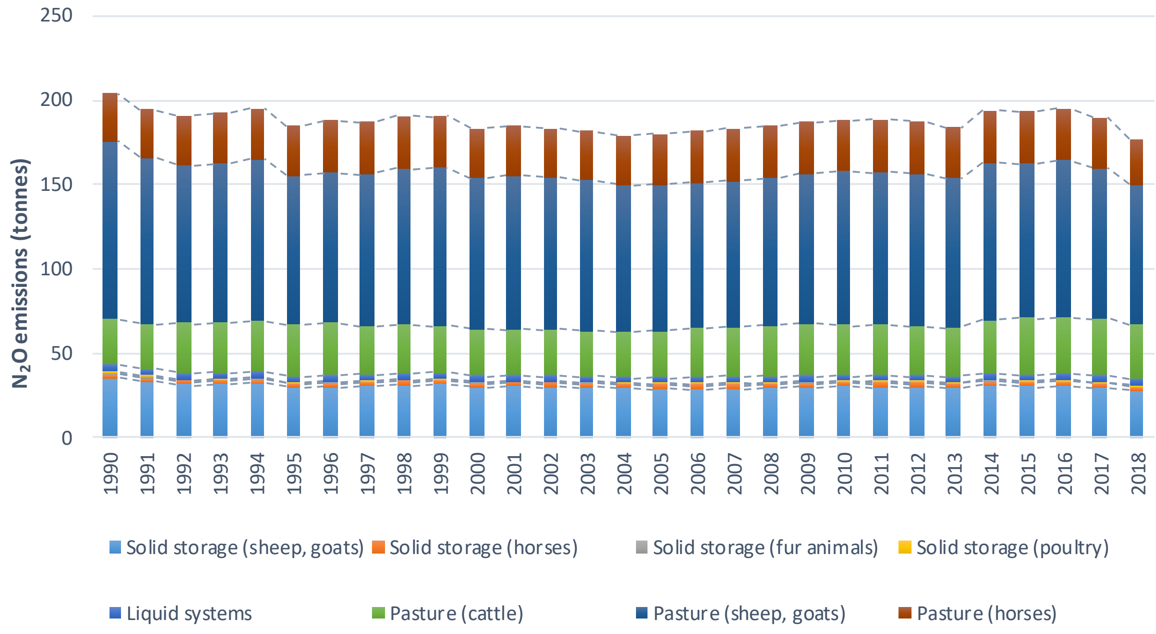

Figure 5.2 N_2O emissions from manure management in t N_2O

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 2018 N_2O emissions from manure spread on pasture by livestock amounted to 142 tonnes. Emissions from sheep manure were 83 tonnes, emissions from horse manure were 27 tonnes, and emissions from cattle manure amounted to 34 tonnes N_2O.

Indirect emission from manure management due to the losses of volatilization of N resulted in a total of 31 tonnes N_2O for 2018, decreasing by 14% from 36 tonnes in 1990.

5.5.5 Indirect Emissions from Leaching and Run-off from Storage

Whilst detailed information is available regarding the N going into different manure stores, and the losses to air during storage, Iceland does not have country specific data on the fraction of N from manure storage that goes to leaching and run-off. This country specific information is needed to allow emissions from leaching and run-off from storage to be calculated.

Having reviewed the approaches used in several other countries (Denmark, Sweden, Norway, Finland) it is clear that there is a wide variety of approaches and assumptions that are used for estimating this source (and in particular the fraction of stored N going to leaching and run-off). Consequently, it was not considered appropriate to arbitrarily take a value from the 1-20% range that is quoted in the 2006 IPCC Guidelines. Notably no default fraction is given to support a Tier 2 calculation.

The approach that has been used assumes that there is no N loss to leaching and run-off from stored manure. This approach is expected to give rise to a small over-estimate of N_2O emissions from the agriculture sector. This is because instead of assigning N to leaching and run-off, the N is retained in the stored N which is then applied to land – giving rise to emissions of N_2O. The EF for leaching and run-off (0.0075 kg N_2O-N / kg N leaching and run-off) is smaller than that from storage and/or application (0.01 kg N_2O-N / kg N applied).

Leaching and run-off that may arise from N inputs to agricultural soils are considered in 3.D Managed soils.

5.5.6 Recalculations

Recalculations in this subsector are summarized in Table 5.29 and Table 5.30. The biggest changes arise from the change in the estimation of the Nex rate for mature dairy cattle as explained in section 5.5.2. The differences between the two 2019 submissions are also due to the improved method of calculation of the Nex rate, but for the 2019 v2 submission it was estimated using only Eq. 10.31 and 10.32, while for the 2020 submission Eq. 10.33 was also applied to better account for the varying milk yield with time. Consequently, the indirect emissions from volatilisation of NH_3-N and NO-N change also due to the different activity data.

Table 5.29 Direct N_2O emissions from Manure Management from the 2019 v1 and v2 submissions compared to the current submission

	1990	1995	2000	2005	2010	2015	2017
2019 v1 submission kt N_2O	0.07744	0.06650	0.06830	0.06557	0.06747	0.06874	0.06811
2019 v2 submission kt N_2O	0.07775	0.06658	0.06826	0.06562	0.06754	0.06888	0.06828
2020 submission kt N_2O	0.07893	0.06696	0.06810	0.06585	0.06838	0.06965	0.06917
Change relative to 2019 v1	1.9%	0.7%	-0.3%	0.4%	1.4%	1.3%	1.6%
Change relative to 2019 v2	1.5%	0.6%	-0.2%	0.3%	1.2%	1.1%	1.3%

Table 5.30 Indirect N_2O emissions from Manure Management compared to the 2019 submission

	1990	1995	2000	2005	2010	2015	2017
2019 v1 = v2 submission kt N_2O	0.03440	0.02999	0.03118	0.02963	0.03025	0.03137	0.03146
2020 submission kt N2O	0.03560	0.03036	0.03102	0.02983	0.03053	0.03202	0.03223
Change relative to 2019	3.5%	1.2%	-0.5%	0.7%	0.9%	2.1%	2.5%

5.5.7 Uncertainties

The uncertainty of emissions from N_2O emission estimates for manure management was calculated using value IPPC default values from 2006 GL. For cattle the estimated quantitative uncertainty of N_2O emissions for manure management is 110% (AD uncertainty at 44% and EF uncertainty at 100.0%). For sheep, the estimated quantitative uncertainty of CH4 emissions for manure management is 113% (AD uncertainty at 52% and EF uncertainty at 100.0%).

For other livestock the estimated quantitative uncertainty of CH4 emissions was made according to 2006 IPCC GL and is estimated to be from 114% for manure management.

For indirect N_2O emissions from manure management combined uncertainty is estimated at 510% (AD 100% and 500% EF (2006 IPCC Guidelines table 11.3))

The complete uncertainty analysis is shown in Annex 2.

5.5.8 Planned Improvements

It is planned to apply the 2019 EMEP/EEA air pollutants inventory guidebook to the N-flow methodology and to increase overall transparency of reporting of N-species also in accordance with the reporting under CLTRAP.

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 and sewage sludge)
- 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 2016 EMEP/EEA Guidelines, 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[13]. Table 5.31 reports the nitrogen content in inorganic fertilizers and the associated N_2O emissions from 1990-2018. 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 5.3). 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, 1990-2018

	1990	1995	2000	2005	2010	2015	2017	2018
N content in inorganic N fertilizer, kt N	12.47	11.20	12.68	9.78	10.77	11.64	13.07	11.74
N_2O emissions, kt N_2O	**0.20**	**0.18**	**0.20**	**0.15**	**0.17**	**0.18**	**0.21**	**0.18**

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 available 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	2017	2018
N input - slurry, kt N	4.24	3.98	3.91	3.73	3.94	4.21	4.24	4.03
N input - solid, kt N	3.68	2.93	3.06	2.97	3.00	3.04	2.98	2.81
N_2O emissions, kt N_2O	**0.124**	**0.109**	**0.109**	**0.113**	**0.109**	**0.114**	**0.113**	**0.107**

[13] 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. At the moment in Iceland, only three municipalities are using sewage sludge as an organic fertilizer for land reclamation purposes in collaboration with the Soil Conservation Service of Iceland[14]. 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). From this report the N-content of sewage sludge measured in Iceland (0.8%) has been retrieved. As can be seen from Table 5.33 the emissions from the application of sewage sludge are low, reaching 0.24 t N_2O in 2018.

Table 5.33 Nitrogen content of sewage sludge for the years 2013-2015 and 2016-2018 and associated N_2O emissions

	1990	1995	2013	2014	2015	2016	2017	2018
N in sewage sludge, kg N	NO	NO	1440	1920	960	NO	3680	15480
N_2O emissions, kt N_2O	**NO**	**NO**	**0.000023**	**0.00003**	**0.000015**	**NO**	**0.00006**	**0.00024**

Other Organic Fertilizers Applied to Soils

At the moment there are no other organic fertilizers applied to soils in Iceland. Efforts are constantly made to stay up to date with this category.

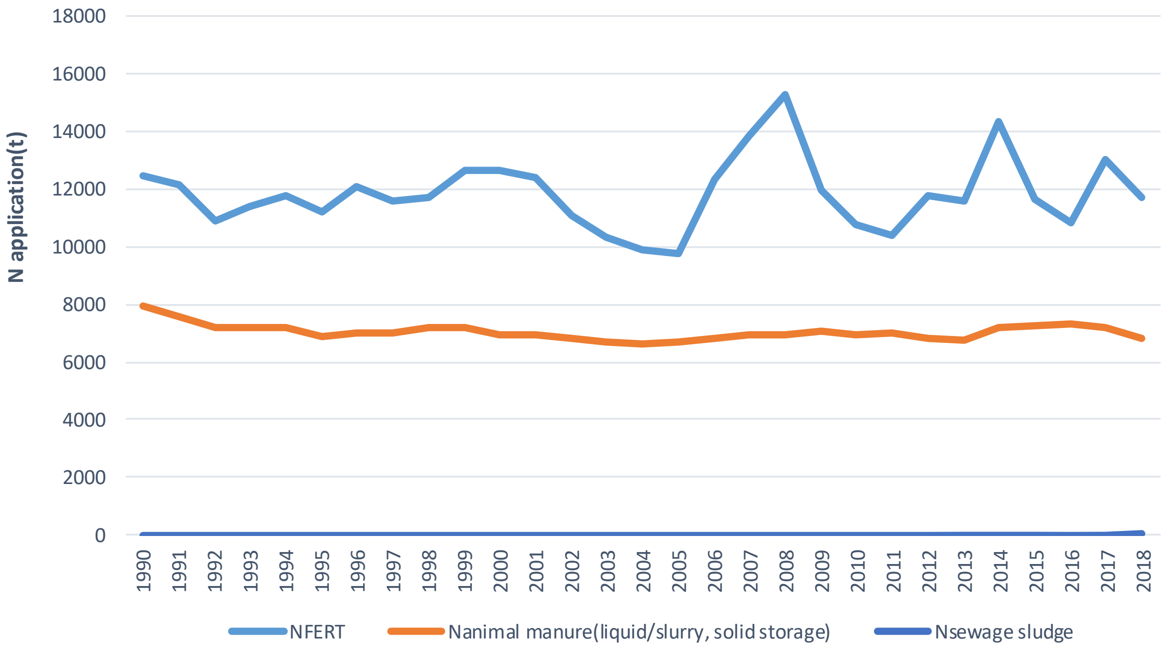

Figure 5.3 Amounts of nitrogen from synthetic and organic fertilizer (animal manure and sewage sludge) applied to soils, t.

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

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

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 5.34).

Table 5.34 Nitrogen deposited by grazing animals (pasture, range and paddock) and associated N_2O emissions, 1990-2018.

	1990	1995	2000	2005	2010	2015	2017	2018
N excretion, grazing, kt N	9.37	8.49	8.43	8.31	8.67	8.84	8.64	8.03
N_2O emissions, kt N_2O	**0.161**	**0.148**	**0.146**	**0.144**	**0.151**	**0.156**	**0.153**	**0.142**

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 defaults 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 5.4.

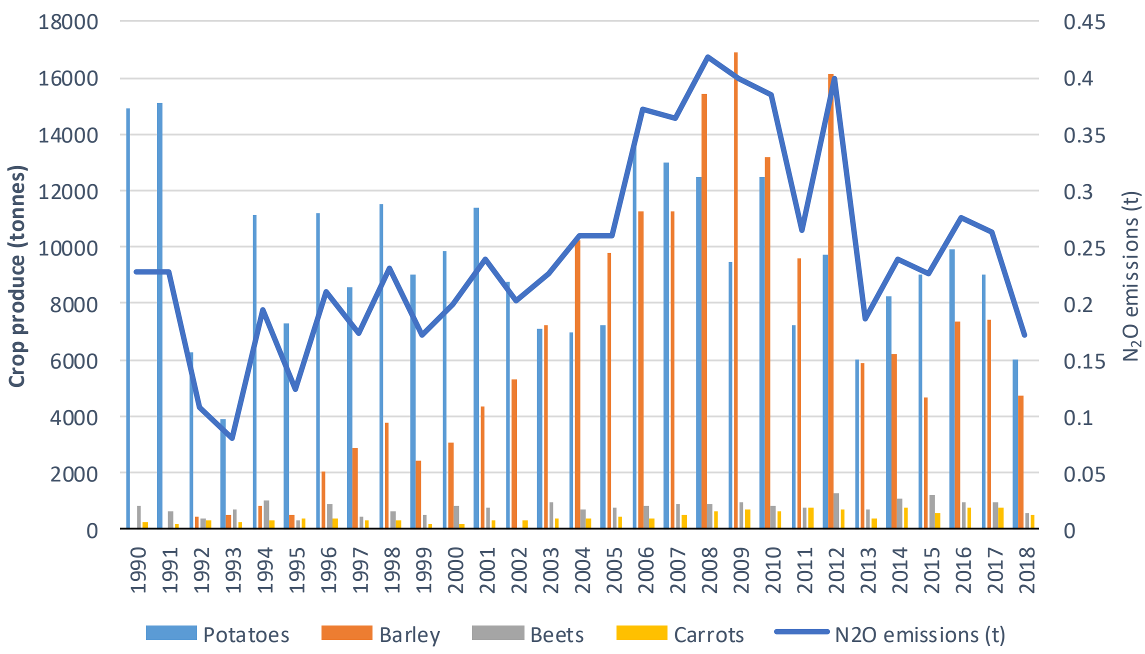

Figure 5.4 Crop produce and associated N_2O emissions in t for 1990-2018.

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 emissions originating from drained organic soils used for grazing were reported under LULUCF, Table 4II H until this submission and were moved in response to recurring comments by the UNFCCC expert review team in the last few reviews, as well as by the review team during the 2019 EU step 2. Therefore, the area increases from 64 kha to 316 kha in 1990, and from 40 kha to 346 kha in 2017 compared to the previous 2019 submission. The areas and associated N_2O emissions are reported in Table 5.35.

Table 5.35 Area of organic soils in kha and associated N_2O emissions, 1990-2018.

	1990	1995	2000	2005	2010	2015	2017	2018
Organic soils-histosols	64	60	55	51	47	42	40	39
Drained organic soils-grasslands	252	258	269	281	295	303	306	307
Total area	316	318	324	332	341	345	346	347
N_2O emissions, kt N_2O	**0.271**	**0.269**	**0.269**	**0.271**	**0.274**	**0.273**	**0.272**	**0.272**

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 5.36. 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 (0.96 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 5.36 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	EF_1	0.01	Table 11.1 IPCC 2006
Animal manure applied to soils	EF_1	0.01	Table 11.1 IPCC 2006
Sewage sludge applied to soils	EF_1	0.01	Table 11.1 IPCC 2006
Urine and Dung deposited by grazing animals	EF_{PRP}	0.02 cattle, poultry, pigs	Table 11.1 IPCC 2006
	EF_{PRP}	0.01 sheep and other	
Crop residues	EF_1	0.01	Table 11.1 IPCC 2006
Cultivation of organic soils	EF_{OS}	0.96/0.44 kg N_2O-N/ha/yr	CS (Annex 9)

5.7.4 Emissions

The direct emissions from agricultural soils diminished by 6 % from 753 t of N_2O in 1990 to 706 t in 2018. Main fluctuations are due to the import and use of synthetic N-fertilizers as can be seen in Figure 5.5.

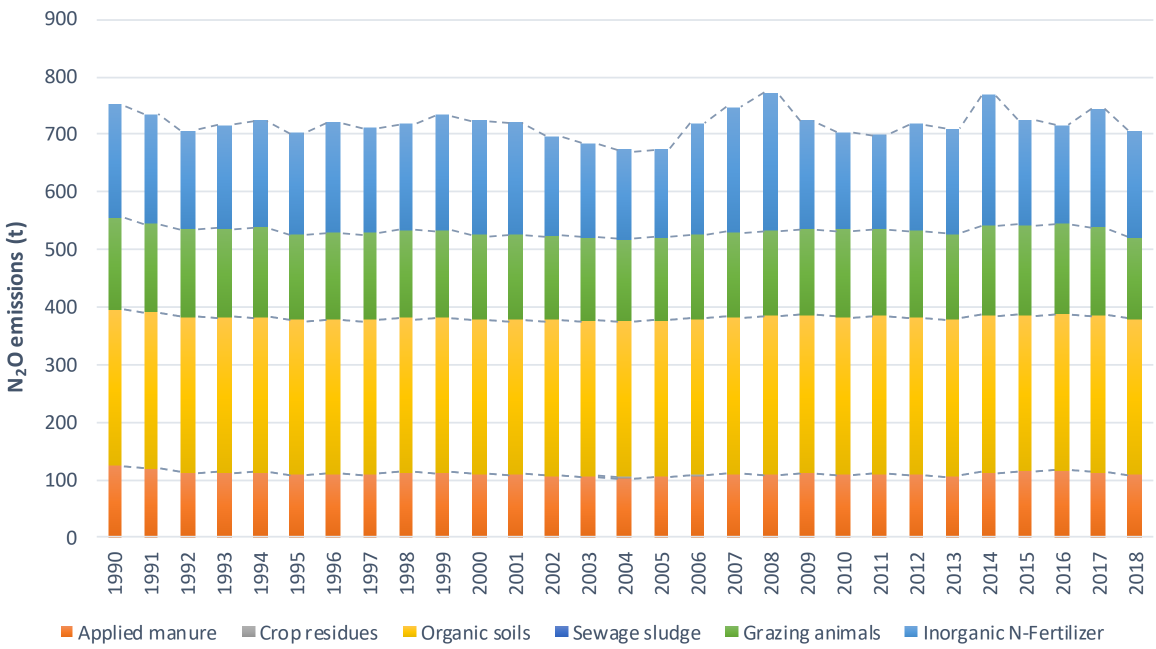

Figure 5.5 Direct N_2O emissions from agricultural soils (t).

5.7.5 Recalculations

Several recalculations have been performed in this category following the 2019 EU step 2 and 2019 UNFCCC desk reviews. In total, the emissions of N_2O in this category increase by 69% in 1990 and by 82.5% in 2017 compared to the resubmitted 2019 v2 inventory (Table 5.37).

Table 5.37 Recalculations of the direct emissions from managed agricultural soils (CRF 3D1)

	1990	1995	2000	2005	2010	2015	2017
2019 v1 submission kt N_2O	0.56967	0.52538	0.54790	0.49128	0.51397	0.52981	0.54730
2019 v2 submission kt N_2O	0.57923	0.52806	0.54649	0.49164	0.51419	0.53158	0.54992
2020 submission kt N_2O	0.98035	0.82500	0.92266	0.94159	1.08687	0.94962	1.00363
Change relative to 2019 v1	72.09%	57.03%	68.40%	91.66%	111.47%	79.24%	83.38%
Change relative to 2019 v2	69.25%	56.23%	68.83%	91.52%	111.37%	78.64%	82.50%

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. This leads to recalculations for the whole timeline, as the activity data change. Due to the small amount of fertilizer used in forestry compared to the total amount the recalculations show small changes from +0.02% in 1990 and 0.05% in 2017 as can be seen in Table 5.38.

Table 5.38 Recalculations for Synthetic N fertilizers

	1990	1995	2000	2005	2010	2015	2017
2019 v2 submission kt N_2O	0.19597	0.17589	0.19902	0.15332	0.16898	0.18275	0.20522
2020 submission kt N_2O	0.19602	0.17595	0.19927	0.15361	0.16928	0.18293	0.20532
Change relative to first	0.02%	0.03%	0.13%	0.19%	0.18%	0.10%	0.05%

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. Some of the changes were implemented as a result of the 2019 UNFCCC desk review at the end of which the inventory had to be resubmitted (2019 v2). Total recalculations are shown for both 2019 inventories (Table 5.39). Emissions from the use of sewage sludge as organic fertilizer has been estimated for the first time in the current inventory submission.

Table 5.39 Recalculations for Animal Manure applied to soils

	1990	1995	2000	2005	2010	2015	2017
2019 v1 submission kt N_2O	0.11916	0.10645	0.10906	0.10387	0.10719	0.11071	0.10975
2019 v2 submission kt N_2O	0.12488	0.10864	0.10954	0.10551	0.10924	0.11372	0.11318
2020 submission kt N_2O	0.12445	0.10867	0.10949	0.11322	0.10910	0.11391	0.11341
Change relative to 2019 v1	4.44%	2.09%	0.40%	9.00%	1.78%	2.89%	3.33%
Change relative to 2019 v2	-0.35%	0.03%	-0.04%	7.30%	-0.13%	0.17%	0.20%

Recalculations in the category urine and dung deposited by grazing animals derive from the changes in the N-flow calculations (chapter 5.5), some of which had already been implemented during the 2019 UNFCCC desk review. Table 5.40 shows the comparison between the current 2020 submission and the two 2019 v1 and v2 submissions.

Table 5.40 Recalculations for Urine and Dung deposited by grazing animals

	1990	1995	2000	2005	2010	2015	2017
2019 v1 submission kt N_2O	0.15608	0.14732	0.14668	0.14355	0.14980	0.15118	0.14818
2019 v2 submission kt N_2O	0.15991	0.14781	0.14479	0.14227	0.14797	0.14993	0.14738

	1990	1995	2000	2005	2010	2015	2017
2020 submission kt N_2O	0.16060	0.14845	0.14618	0.14424	0.15102	0.15563	0.15269
Change relative to 2019 v1	2.89%	0.77%	-0.34%	0.48%	0.81%	2.95%	3.04%
Change relative to 2019 v2	0.43%	0.43%	0.97%	1.38%	2.06%	3.80%	3.60%

The biggest recalculation in this category is due to the moving of drained histosols used for grazing from the LULUCF chapter, table 4IIH, as recommended by the review teams during the 2019 EU step 2 review, 2019 UNFCCC desk review and previous reviews. In addition, there have been slight changes in the area of drained organic soils as communicated by the Soil Conservation Service leading to changes. For 1990, there is an increase of 176% in the emissions, and for 2017 emissions are 224% higher (Table 5.41); the areas are reported in Table 5.35.

Table 5.41 Recalculations of the emissions from cultivated organic soils.

	1990	1995	2000	2005	2010	2015	2017
2019 v2 submission kt N_2O	0.09824	0.09559	0.09294	0.09028	0.08762	0.08494	0.08387
2020 submission kt N_2O	0.27126	0.26881	0.26941	0.27086	0.27410	0.27268	0.27212
Change relative to first	176%	181%	190%	200%	213%	221%	224%

5.7.6 Uncertainties

Uncertainties were estimated for each of the subcategories. For synthetic fertilizer nitrogen the estimated combined uncertainty is 301% (AD uncertainty 20% and EF uncertainty 300%). The amount of N in fertilizer applied was deemed to be known with an uncertainty of 20% mainly stemming from possible differences between annual import and final application (expert judgement). See also planned improvements below.

For animal manure applied to soils the estimated combined uncertainty is 305% (AD uncertainty 56% (max uncertainty in 3B N_2O) and EF uncertainty 300% (IPCC 2006 table 11.1)).

For urine and dung deposited by grazing animals the estimated combined uncertainty is 355% (AD uncertainty 59% and EF uncertainty 350% (IPCC 2006 table 11.1)).

For crop residues the estimated combined uncertainty is 361% (AD uncertainty 200% (EMEP/EEA) and EF uncertainty 300% (IPCC 2006 table 11.1)).

For the cultivation of organic soils, the estimated combined uncertainty is 32%. The area of cultivated organic soils was attributed with an uncertainty of 20% in accordance with area uncertainty estimates for cropland in LULUCF and the EF uncertainty is estimated at 25% (expert judgement).

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 to do so. This issue will be solved for the next submission.

Efforts will be made to assure the completeness of the inventory by researching 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 NH3 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 2018, volatilized nitrogen from agricultural inputs diminished by 10% or from 2924 t in 1990 to 2628 t in 2018.

5.8.2.2 Leaching and Runoff

The amount of N input (deriving from the application of inorganic and organic N-fertilizers, manure and dung deposited by grazing animals and from crop residues) lost to soils through leaching and runoff is calculated by summing all the agricultural inputs and applying the default 30% ($Frac_{LEACH-H}$). This amount has diminished by 10.5% from 8933 t in 1990 to 7993 t in 2018.

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	EF_4	0.01 kg N_2O–N / (kg NH_3–N + NO_X–N volatilised)	Table 11.3 IPCC 2006
Leaching and runoff	EF_5	0.0075 kg N_2O–N / (kg N leaching/runoff)	Table 11.3 IPCC 2006
$Frac_{LEACH-H}$		0.3 kg N (kg N additions or deposition by grazing animals)	Table 11.3 IPCC 2006

5.8.4 Emissions

The development of indirect N_2O emissions from 1990-2018 - after conversion from nitrogen to nitrous oxide - is shown in Figure 5.6. N_2O emissions amounted to 135 tonnes N_2O in 2018, which is 10% lower than the 1990 emissions of 151 t. 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.

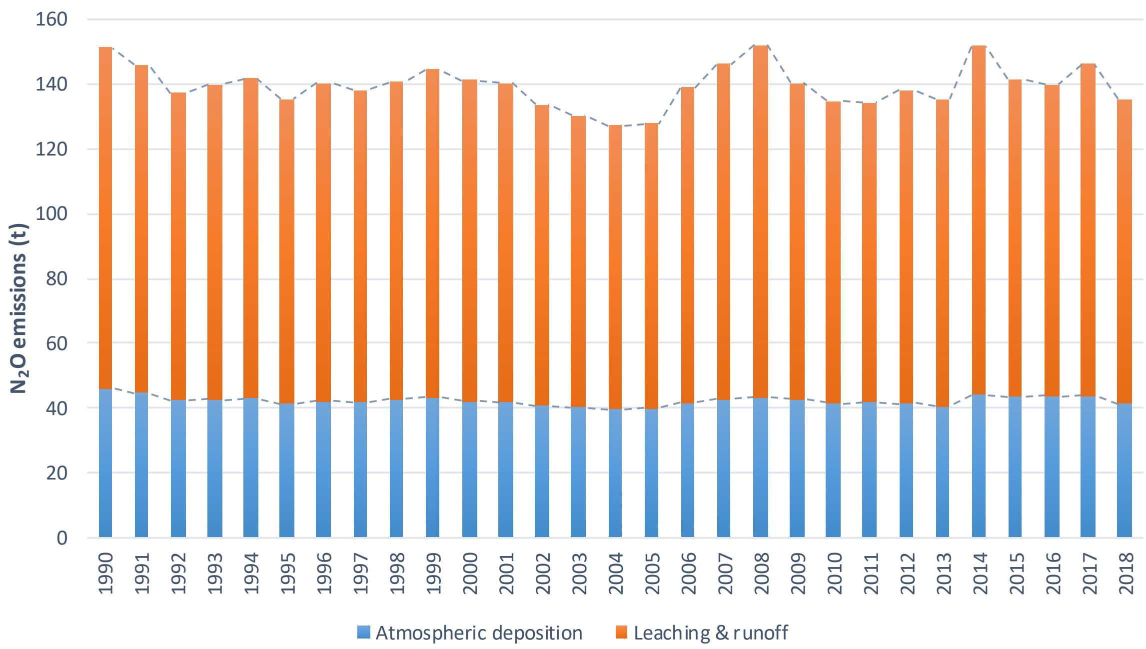

Figure 5.6 Indirect N_2O emissions from agricultural soils.

5.8.5 Recalculations

Indirect emissions are calculated starting from the amount of N applied to soils under various forms. Therefore, all changes in the sector direct emissions from agricultural soils (3D1) and the connected changes within the sector Manure Management (3B) also lead to recalculations also in the indirect emissions from agricultural soils (3D2). During the 2019 UNFCCC desk review the changes performed in the 3B subsector lead to a resubmission of the inventory (2019 v2). Table 5.43 and Table 5.44 show the recalculations performed in the current 2020 submission compared to both 2019 v1 and 2019 v2 submissions. The drop in emissions deriving from atmospheric deposition is due to the use of NO_x and NH_3 calculated through the EMEP/EEA methodology instead of using FracGas. The proportion of synthetic N volatilised as NH_3 and NO is only about 0.022, compared to the 0.1 assumed with IPCC FracGas. 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 FracGas = 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 omission of some N inputs in the past which has now been rectified.

Table 5.43 Recalculations for indirect N_2O emissions, atmospheric deposition

Atmospheric deposition	1990	1995	2000	2005	2010	2015	2017
2019 v1 submission kt N_2O	0.05777	0.05291	0.05594	0.04996	0.05258	0.05481	0.05689
2019 v2 submission kt N_2O	0.07873	0.07151	0.07268	0.06624	0.06963	0.07410	0.07622
2020 submission kt N_2O	0.04595	0.04142	0.04181	0.04005	0.04158	0.04349	0.04391
Change relative to 2019 v1	-20%	-22%	-25%	-20%	-21%	-21%	-23%
Change relative to 2019 v2	-42%	-42%	-42%	-40%	-40%	-41%	-42%

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

Nitrogen leaching and run-off	1990	1995	2000	2005	2010	2015	2017
2019 v1 submission kt N_2O	0.05223	0.04710	0.05247	0.04191	0.04568	0.04893	0.05396
2019 v2 submission kt N_2O	0.05693	0.05128	0.05624	0.04557	0.04951	0.05325	0.05829
2020 submission kt N_2O	0.10529	0.09407	0.09933	0.08768	0.09336	0.09809	0.10233
Change relative to 2019 v1	102%	100%	89%	109%	104%	100%	90%
Change relative to 2019 v2	85%	83%	77%	92%	89%	84%	76%

5.8.6 Uncertainties

For atmospheric deposition estimated combined uncertainty is 503% (AD uncertainty 56% and EF uncertainty 500% (expert judgement)).

For nitrogen leaching and run-off, the estimated combined uncertainty is 601% (AD uncertainty 333% (IPCC 2006. table 11.3) and EF uncertainty 500% (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 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[15]. 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. At the moment 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.

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

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 ($CaMg(CO_3)_2$), t/yr
- EF = emission factor, t of C/ t of limestone or dolomite

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. 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). No activity data are available for 1990-2003 for limestone and 1990-2002 for dolomite. 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 show a sharp increase from 2014 (Figure 5.7) which cannot be explained by agricultural practices. Therefore, we assume that urea used in selective catalytic reduction for diesel cars must have been registered with the same customs number as urea used as fertilizers. It is planned to carry out further investigations to ensure that the activity data is allocated to the right sectors and subsectors.

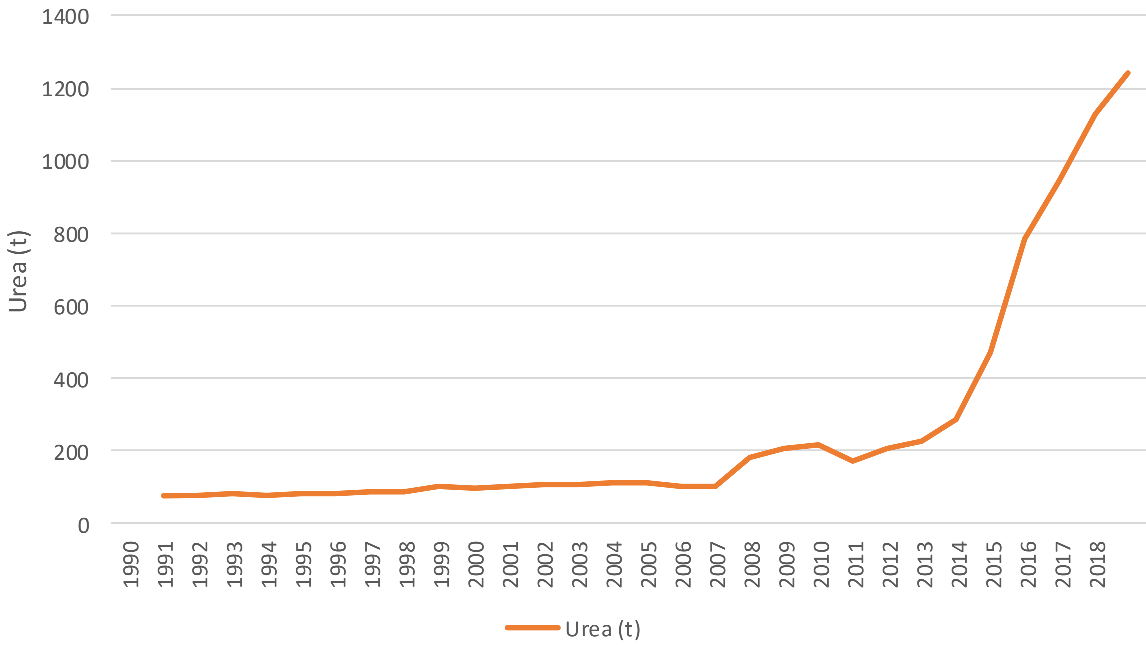

Figure 5.7 Import data of urea fertilizers 1990-2018

5.11.2.3 Other Carbon-containing Fertilizers

In this subsector the use of shellsand as a liming agent is estimated. Shellsand contains 90% of $CaCO_3$ and is naturally available from Icelandic seashores and there is no system in place at the moment registering the amount of shellsand used by single farmers. 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 shellsand 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 3.3 kt in 2018, CO_2 and emissions from Dolomite are 0.5 kt (CRF 3G). CO_2 emissions from Urea are 0.91 kt (CRF 3H) and Other carbon containing fertilisers (shellsand) 1.62 kt (CRF 3I). Other (CRF 3J) is not occurring for the timeseries. Figure 5.8 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.

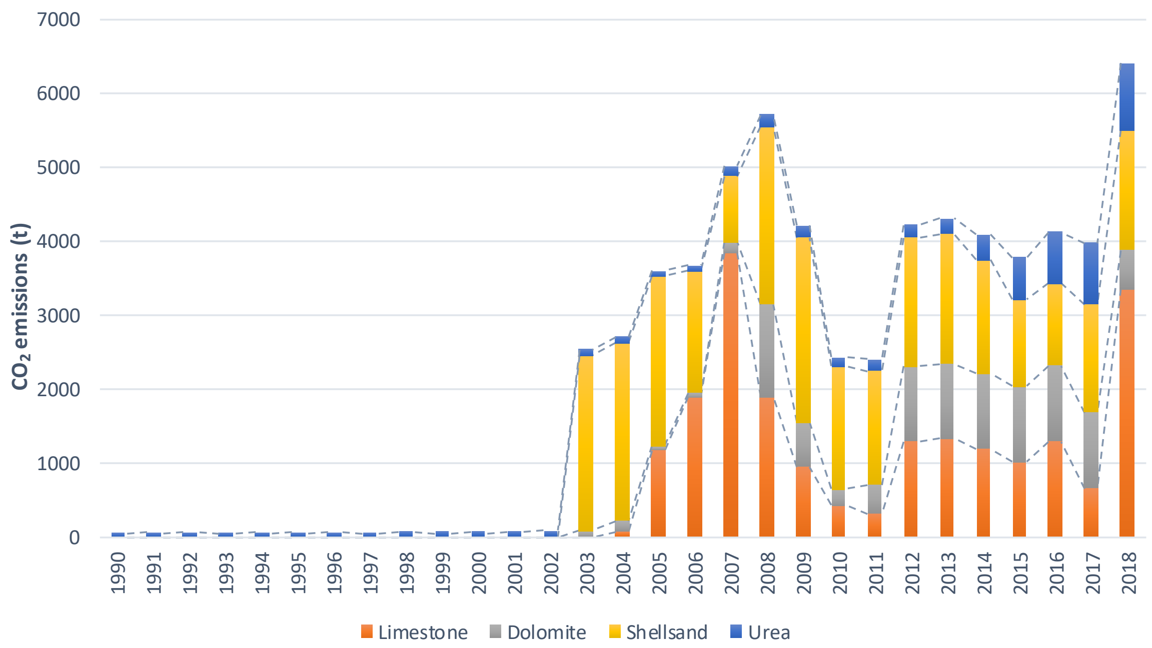

Figure 5.8 CO_2 emissions from liming (limestone and dolomite), urea application and other carbon containing fertilizers (shellsand).

5.11.5 Recalculations

In the current submission, recalculations were carried out for liming (3G) and other carbon containing fertilizer (3I). In the past, these data were reported under LULUCF and then moved to the Agriculture chapter, but the emissions estimates from 2002/03 – 2012 did not enter the inventory correctly. In addition, activity data has been updated for 3G and 3I for 2013-2017 due to improved data collection. In 3H-urea application there have not been any recalculations.

5.11.6 Uncertainties

For liming and urea, which are estimated using the Tier 1 approach, the estimated uncertainty is 20% (AD uncertainty 20% (expert judgment)). 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 especially regarding urea fertilizers.

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

6.1 Overview of Sector

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 were changed considerably in the 2019 submission as parts of the Grassland category were moved to either "Other land" or Wetland, but changes in this submission are smaller.

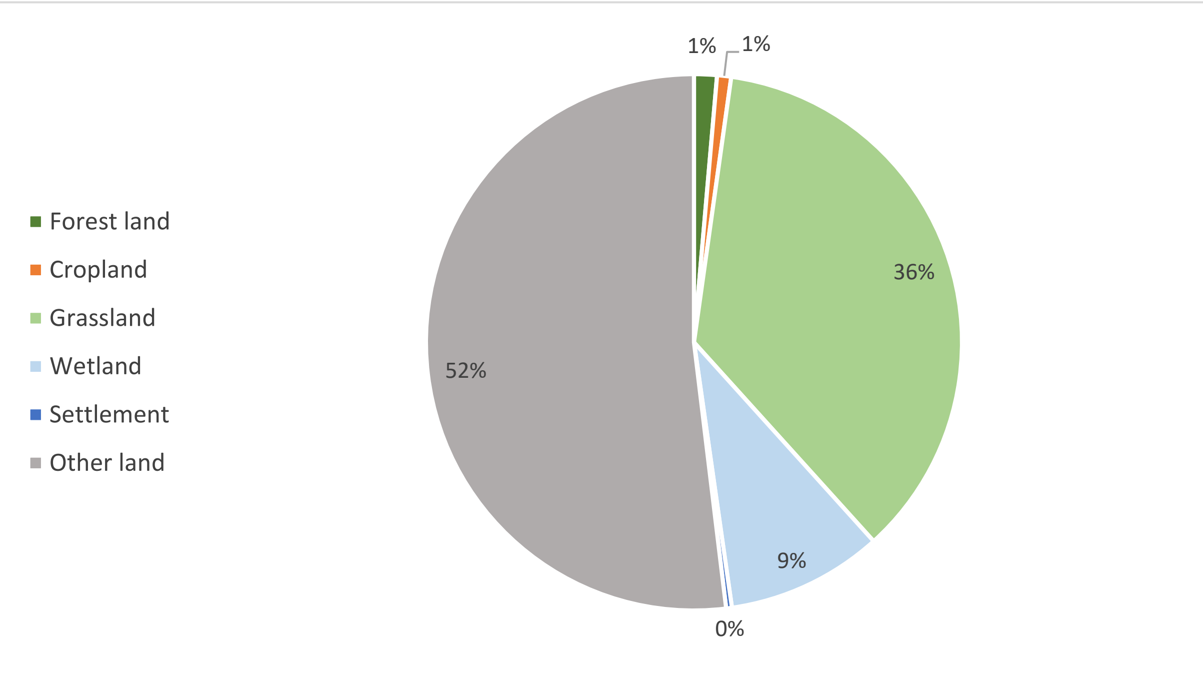

Figure 6.1 Relative size of land use categories in Iceland according to IGLUD land use map 2018 and other land use estimates available for the reporting.

This shift in land classification was because of new data is available as described in last year's submission. Figure 6.1 shows the relative division of the area of Iceland to the six main land use categories reported.

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.

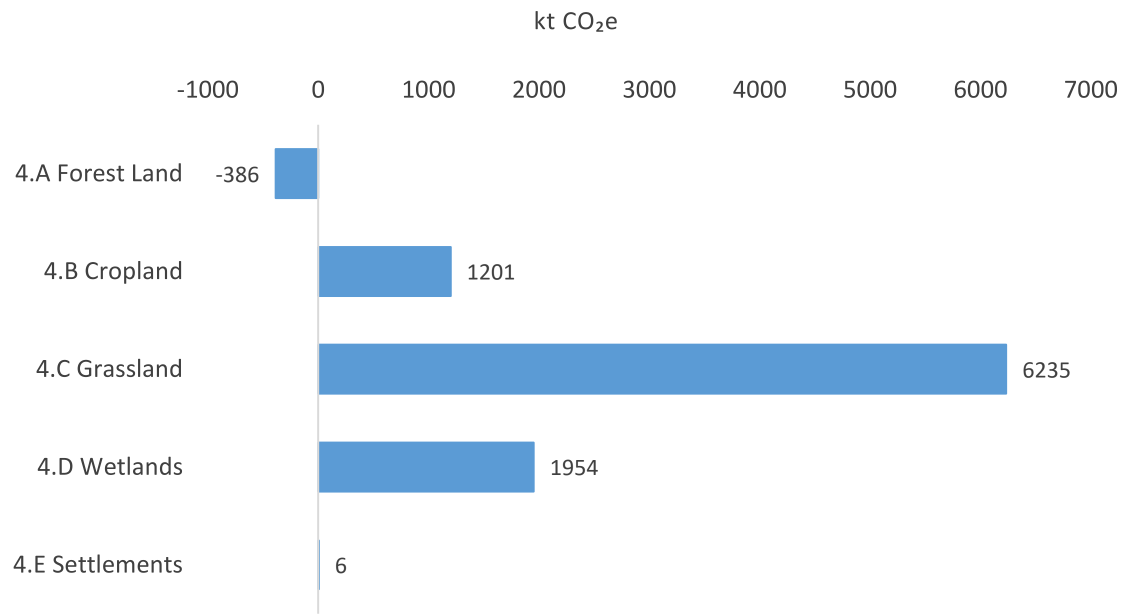

Figure 6.2. The net emissions/removals of land use categories (kt CO_2e) in 2018. Emissions from Other land (4F) are not included in this graph. The N_2O emission from Cropland management of organic soils is reported under the Agricultural sector and not included here.

The sum of all emissions reported is 11,566.2 kt CO_2e and is dominated 71.7% by 8290.7 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 26.9% or 3,115.1 kt CO_2e, is methane emission from managed wetlands. The remaining reported emissions are assigned to biomass burning, application of N-fertilizers, hydropower reservoirs (CO_2), losses of soil organic carbon (SOC) from mineral soils, loss of biomass due to conversion of land to Settlements. The removal by sinks reported is by sequestration of carbon to wetlands 54.4% or 1,365.4 kt CO_2, to biomass and SOC in revegetation 25.0% or 628.4 kt CO_2, and to biomass and SOC in forest 15.5% or 388.6 kt CO_2. Other contributing components total of 5.2% 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 decreased from 9,320.8 kt CO_2e to 9,053.7 kt CO_2e. New area estimate of many 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 have the same structure as in the 2019 submission.

6.1.1 General 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 and maps on revegetation from the Soil Conservation Service of Iceland (SCSI), time series of Afforestation, Reforestation, Cropland and Grassland categories, including revegetation, drainage and cropland abandonment, and of reservoirs. Data on biomass burning is based on area mapping of the Icelandic Institute of Natural History and biomass estimation for relevant land categories 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 images from 2011-2013, but also made use of other images 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, which will be addressed in near future submissions.

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. On ground, classification from 1081 transects performed as part of HMI, plus 189 other transects from other projects. Total available transects were therefor 1,270.

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 map of Developed Land. Updated versions of these map layers enter the compilation process for the land use map. Of these map layers' comparable maps of Forest Land, Cropland and Birch Shrubland are included in the HMI map. These map layers do not completely match to each other. This will be addressed in future submission as an effort to improve the overall quality and accuracy.

<u>Maps of Forest Land:</u> The HMI map layer is map of forest from the IFR from the year 2012 and is identical to forest map included in 2014 submission but with improvements: the map layer currently applied in the IGLUD map represents all Afforested Land up to and including 2018. The HMI category "Mixed Forest plantations (Icelandic: skógrækt) is an older version of afforested land than the version included in IGLUD. Accordingly, the latest map of Afforested Land 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.

<u>Map of birch shrubland:</u> 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 birch woodland reaching average height of 2 m or more at maturity, categorized as Forest land and birch woodland reaching height less than 2 m, categorized as Grassland. Accordingly, the category Birch woodland is ordered lower in the IGLUD compilation hierarchy, than both the IGLUD birch map layers.

<u>Map of Cropland:</u> The HMI map layer is prepared from the IGLUD map for Cropland, with corrections from the Icelandic Agricultural Advisory Centre (IAAC) added, as in last year's submission. The layer contains abandoned cropland.

Map of Settlements: is based on data from the National Land Survey of Iceland's (NLSI) IS 50V dataset as in last year's submission.

The summary of GIS processing of this particular map layer can be found in **Error! Reference source not found.** in last year's submission.

The introduction of HMI map layers as base map for IGLUD land use map improves the land use map 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 are included in the compilation process.

The HMI layer "Cultivated agricultural, horticultural and domestic habitats" representing Cropland was prepared from AUI layer of cultivated land and addition of map layer representing new cultivations and renewals of older hayfields, subsided from the government. This addition is on screen digitised as the AUI map layer, but with slightly different criteria i.e. polygons only drawn to the edge of the ditches and thus excluding area of ditch width. In most cases this with is less than 20 m and therefore contrasting the above definition of Cropland.

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 1990-2018	Not HMI category	Not HMI category/	3
	Cultivated forest before 1990	Not HMI category	Not HMI category/	4
Forest land	Natural Birch forest	Not HMI category	Not HMI category/	5
Cropland	Harvested croplands - organic soil 2018	Not HMI category	Not HMI category/	12
	Harvested croplands - organic soil 2017	Not HMI category	Not HMI category/	13
	Harvested croplands - mineral soil 2018	Other land types	Not HMI category/	14
	Harvested croplands - mineral soil 2017	Other land types	L14.2 Cultivated agricultural, horticultural and domestic habitats	15
	Cropland on organic soil	Other land types	Not HMI category/	16
	Cropland on mineral soil	Other land types	Not HMI category/	17
Grassland	Revegetated land SCSI before 1990	Not HMI category	Not HMI category/	6
	Revegetated land SCSI 1990 -2018	Not HMI category	Not HMI category/	7
	Farmers revegetation before 1990	Not HMI category	Not HMI category/	8

Land use category	Subcategories	Habitat type class	Habitat type/or other map layer	Compilation hierarchy
	Farmers revegetation 1990-2018	Not HMI category	Not HMI category/	9
	Natural Birch shrubland	Not HMI category	Not HMI category/	11
	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
			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

Land use category	Subcategories	Habitat type class	Habitat type/or other map layer	Compilation hierarchy
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
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

Land use category	Subcategories	Habitat type class	Habitat type/or other map layer	Compilation hierarchy
		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

6.1.2 Key Category Analysis (KCA)

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, 2018, and 1990-2018 trend.

IPCC source category			Level 1990	Level 2018	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) Cropland	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	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 include 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.

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 area of the country.

The land use map resulting from the preparation of map layers and the compilation process is shown in **Error! Reference source not found.**, Figure 6.4, Figure 6.5 and Figure 6.6 below; they are also available at the AUI website http://www.lbhi.is/vefsja.

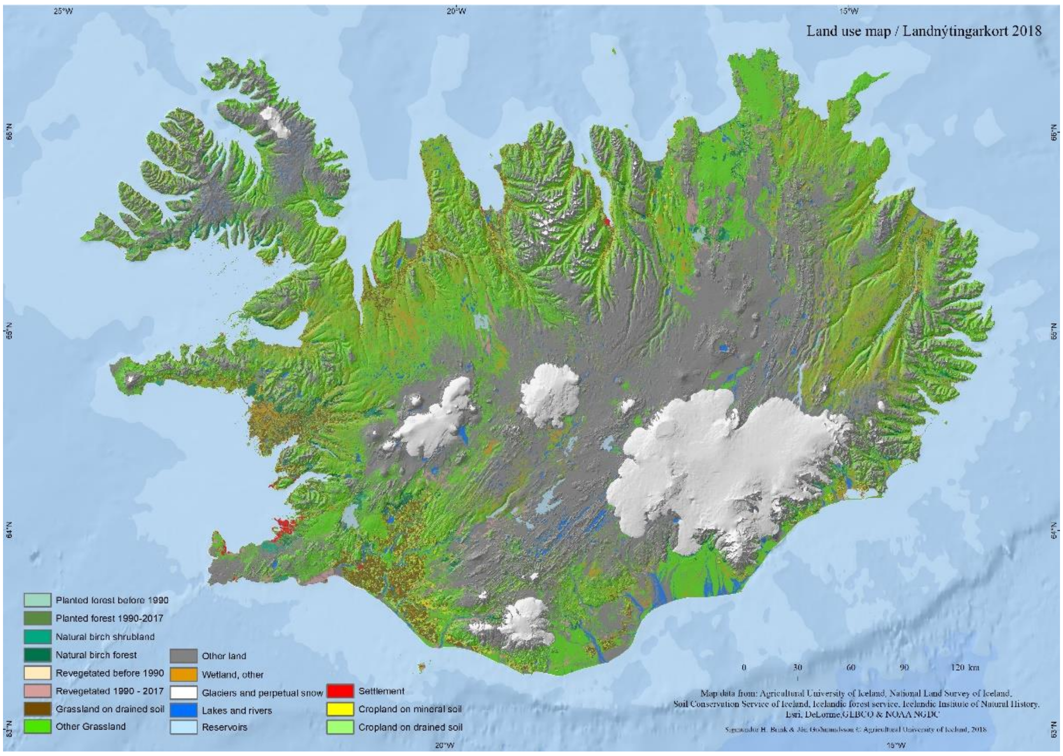

Figure 6.3 The land use map of IGLUD prepared for the year 2018.

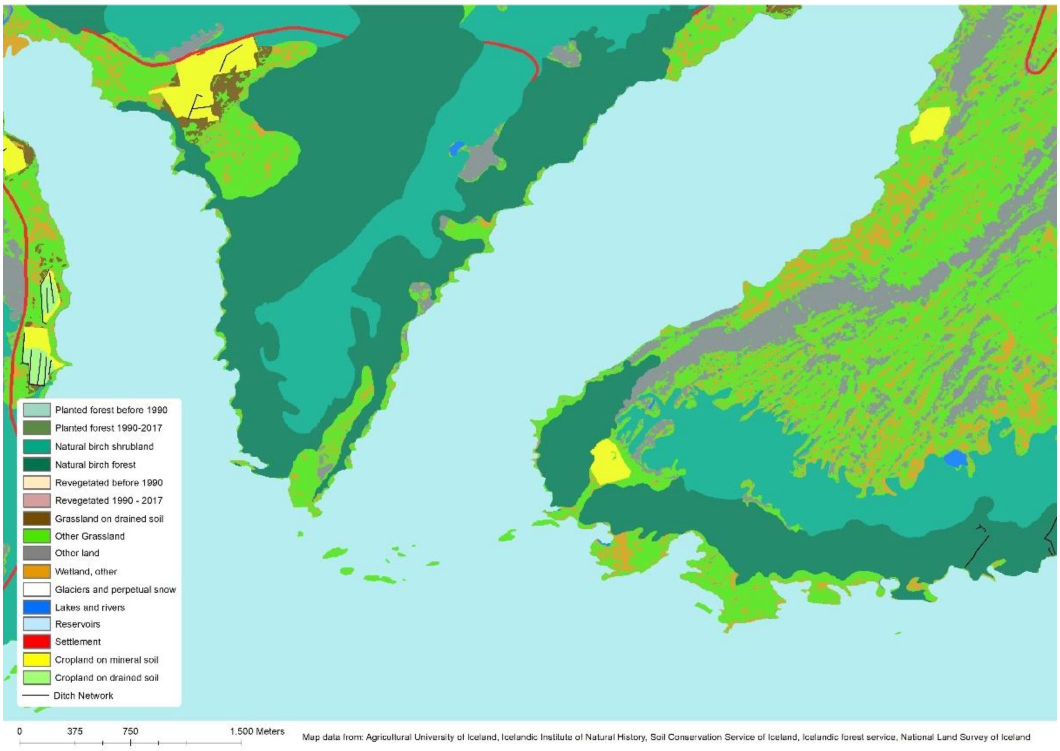

Figure 6.4 Enlargement of land use map from the 2019 submission, emphasizing the different Forest land subcategories.

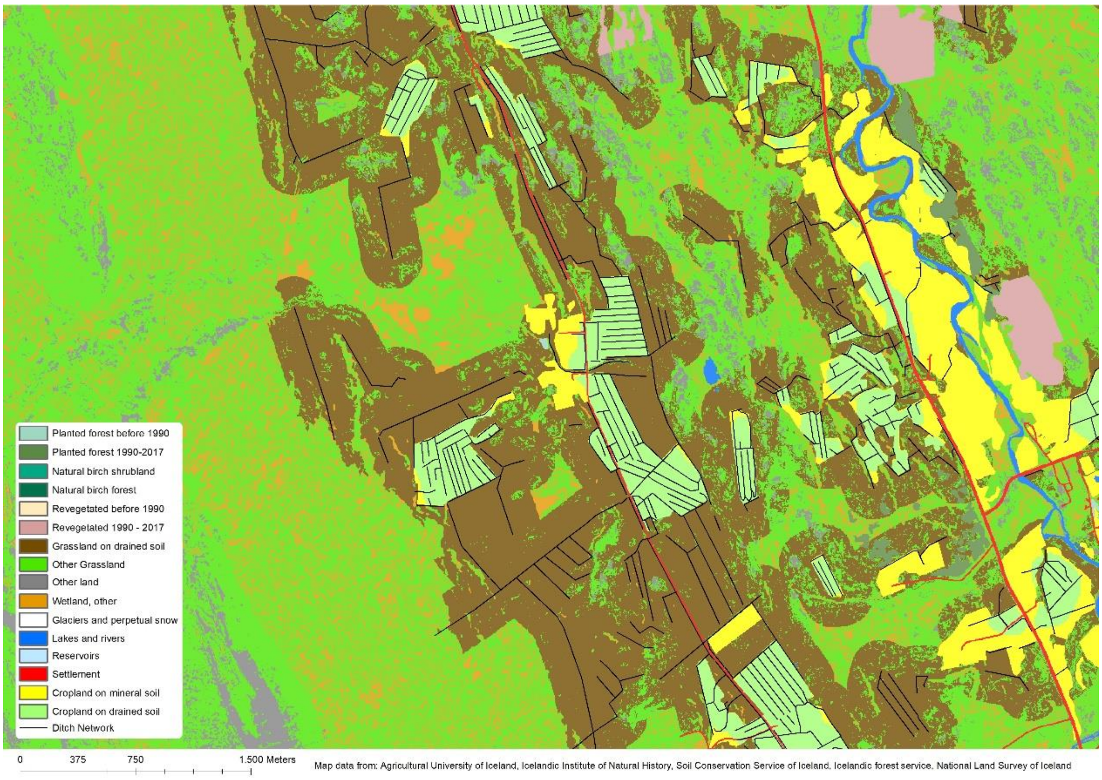

Figure 6.5 Enlargement of land use map from the 2019 submission, emphasizing the Revegetation area mapped.

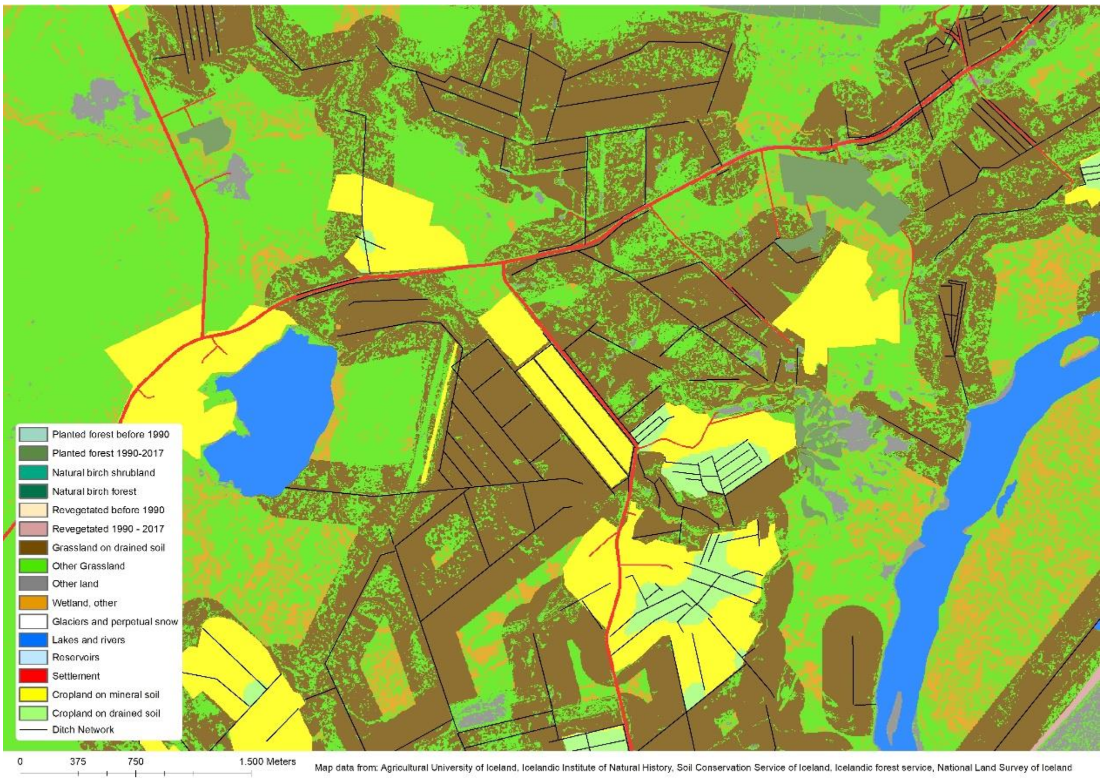

Figure 6.6 Enlargement of land use map from the 2019 submission, emphasizing the subcategory Grassland on drained soils.

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[16] , putting more emphasis on land-based support. Due to these modifications in support farmers applying for support have to 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. This work will, however, not be finished until next submission.

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

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 Afforestation or is spatially known (Approach 3) as for some land converted to reservoirs.

The land use database used in this reporting is IGLUD (Icelandic Geographical Land Use Database). That database was constructed by AUI, but is now maintained by SCSI. The compilation of available geographical 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.

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 [ha]	FL C	FL NB	CL	GL. drained	GL. Nb. shrub	RV before. "90	RV s. "90	O.GL	WL.O	WL. L&R	WL. Reserv.	Settlements	OL	Glaciers
FL C														
FL NB														
CL														
GL. drained														
GL. Nb. shrub														
RV before. "90														
RV since. "90														
O.GL		1,191			1,743	161,063						888		
WL.O				5,806										
WL. L&R														
WL. Reserv.														
Settlements														
OL							14,994							
Other														
Other estimate	42,738	98,122	86,862	306,315	55,895	165,356	140,114					35,394		
Map area	51,788	96,931	86,862	300,509	54,152	4,294	125,120	3,180,996	685,616	227,673	58,325	34,506	4,242,963	1,086,568
Difference	9,049	-1,191		-5,806	-1,743	-161,063	-14,994					-888		
Corrected area	42,738	98,122	86,862	306,315	55,895	165,356	140,114	3,025,162	679,810	227,673	58,325	35,394	4,227,969	1,086,568
Total area [ha]														**10,236,303**

FL C: Cultivated forest. FL NB: Natural birch forest. CL: Cropland GL. Drained: Grassland on drained soils GL Nb. shrub: Natural birch shrubland	RV b. "90: Revegetation initiated before 1990 RV s. "90: Revegetation initiated since 1990 O.GL: other Grassland WL. O: other wetlands WL. L&R: Lakes and rivers	WL. Reserv.: reservoirs Settlements: settlements OL: other land Glaciers: Glaciers and perpetual snow

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 to 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). 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 woodlands were used for grazing and still are, 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 intervall. The sample population for NBF is the mapped area of NBW. The sample population of cultivated forest 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 cultivated forests. To ensure that forest areas are not outside the population area, the populations for both strata are increased with buffering of mapped border. Current buffering is 16 m. The third inventory round of CF and the second one of the NBW was ongoing in the period 2015-2019. 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 to 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 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 2016. 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:

1. Afforestation older than 50 years
2. Plantations in natural birch forest
3. 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. No area changes are reported with exception of deforestation in the NBF.

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 2007-2017 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 forwarded value and the midvalue of the year 2008 which is 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.

Table 6.5 Measurement years used to estimate different annual estimates of biomass stock change.

Mid value estimates	Forwarded estimates	Backwarded estimates	Built on measurement years
	2018		2015-2019
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)). 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 are estimated by default emission factor of 0.37 t CO_2-C $ha^{-1}yr^{-1}$ for 'Forest Land, drained, including shrubland and drained land that may not be classified as forest' (see Table 2.1 in the 2013 IPCC Wetlands supplement (IPCC, 2014)).

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 the 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 2016 and 2017 due to new data from NFI measurements in 2018 and 2019. Estimates for the natural birch forest are built on the same methodology as in last year´s submission and are unchanged.

Category-specific planned improvements

Data from NFI are used for the 12th time to estimate main sources of carbon stock changes in the cultivated forest where changes in carbon stock are most rapid.

Sampling of soil, litter, and other vegetation than trees, is included as part of NFI and higher tier estimates of changes in the carbon stock in soil, dead organic matter and other vegetation than trees are expected in future reporting when data from re-measurement of the permanent sample plot will be available and analysed for C-content.

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

One can therefore expect gradually improved estimates of carbon stock and carbon stock changes regarding forest and forestry in Iceland. As mentioned before improvements in forest inventories will also improve uncertainty estimates both on area and stock changes.

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 (2018) as well as in 1990-2018 trend.

Four categories are defined as Land Converted to Forest Land:

4.A.2.2: Grassland Converted to Forest land

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

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

3. Afforestation 1 - 50 years old – Cultivated forest
4. 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 where 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 – 2018.

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 researches 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 is to find in 6.12, 6.13, 6.14 and 6.15. 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.

Direct CO_2-emission from drained organic soil are estimated by default emission factor of 0.37 t CO_2-C $ha^{-1}yr^{-1}$ for 'Forest Land, drained, including shrubland and drained land that may not be classified as forest' (see Table 2.1, (IPCC, 2014)) .

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 2018) as well as in 1990-2018 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 last year’s submission, contains extended map layer for Cropland, compared to previous versions. The extension involves adding area of recently cultivated fields obtained from Icelandic Agricultural Advisory Centre (IAAC). 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 187.30 kha compared to 178.87 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 86.86 kha, whereof 39.43 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. 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.

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. Organic soils of "Cropland remaining Cropland" 36.70 kha. These organic soils are estimated to lose 289.93 kt C. The consequent emission is estimated as 1,063.08 kt CO_2.

6.6.1.3 Uncertainties and time-series consistency

Both mapping and recording of Cropland in use has been fragmentary until now. Improvements related to changes in agricultural support are on the horizon and expected to be available for next submission.

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%.

The emission/removal estimated for land converted to Cropland is based on factors estimated with standard error of 20-30%. The uncertainty of the calculated emission removal is in the same range.

The emissions reported from drained organic Cropland soils are based on default EF from table 2.1 in 2013 wetland supplement 95% confidence intervals ± 1.5 t CO_2-C $ha^{-1}yr^{-1}$, or approximately 20%.

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

There are no category specific recalculations for this category.

6.6.1.6 Category-specific planned improvements

As indicated above improvements in the recording of Cropland in use are still pending in relation to changes in payments of governmental support to agriculture, and are expected to be presented in the 2021 submission. Additionally, the Register Iceland (Þjóðskrá Íslands) is presently preparing map of cultivated land. 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 will improve 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 pending geographically explicit mapping of Cropland will enable tracking of land conversion to and from the Cropland category and enable spatially explicit tracking of cropland in use and abandoned cropland.

The geographical separation of organic and mineral soils of the category is pending.

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) as well as in 1990-2018 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. The mapping units of Cropland show larger area than area reported in CRF tables based on time series for Cropland. The excess area is considered as abandoned cropland and is reported under Grassland.

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 in this year's submission 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 is used and data from a measurement plot of the SSP-NFI of CF situated in this area, is used to estimate C-stock removed and instantly oxidized. Same Tier 2 approach as used in Deforestation when Forest Land is converted to Settlement is used for C-stock losses of litter. C-stock emission from drained organic soil are 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” because other land does not contain organic soil. Mineral soils were reported as “IE” because 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 “Forest land converted to Cropland” is estimated through deforestation recording of IFR. The area of land converted is thus assumed to highly uncertain on yearly basis.

The bulk of the emission is from drained organic soil and the EF applied is IPCC default. The overall uncertainty of the category will thus be dominated by uncertainty of that EF and area estimate.

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. 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.

6.7 Grassland (CRF 4C)

Grassland is a very diverse category with regard to 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.

The Grassland category is divided into twelve subcategories in this year´s submission as before. 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 is 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.

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 2018) as well as in 1990-2018 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 40.71 kha whereof 13.18 kha is organic soil.

Natural Birch Shrubland:

Natural birch shrubland is the part of the natural birch woodland not meeting the thresholds to be accounted for as forest but covered with birch (*Betula pubescens*) to a minimum of 10% in vertical cover and at least 0.5 ha in continuous area. The natural birch shrubland is included in the NFI and the area and stock changes estimated by the IFR. The estimates of total area and changes in carbon pools are based on the same methods and data sources as used to estimate the natural birch forest.

Two subcategories of natural birch shrubland are reported as “Grassland remaining Grassland”. One is “Natural birch shrubland –old” including shrubland surveyed in the 1987-1991 inventory. As for natural birch forest, the C-stock of natural birch shrubland 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 – 2018.

Other Grassland:

The mapping unit “Other Grassland” includes 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 category is 2,970 kha and compared to 2972 kha in last submission. The change in the area included in this category is as explained earlier the result of new data from HMI.

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 4.79 kha. This area is not at present recognized as separate mapping unit but assumed to be included in the mapping unit Revegetation before 1990, despite currently limited area of that mapping unit (see Table 6.4).

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 this 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 248.97 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”.

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 living biomass of these categories is estimated 1.01 kt C and 0.60 kt C respectively removing 3.69 kt CO_2 and 2.19 kt CO_2 from the atmosphere. 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 in dead organic matter is estimated to have increased by 0.39 kt C for "Natural birch shrubland-recently expanded into Other Grassland" equivalent to 1.44 kt CO_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.

Changes in the carbon stock of the mineral soil of subcategory "Natural birch shrubland recently expanded to Other Grassland" is estimated as having increased by 0.93 kt C in the year 2019 and thereby removing a total of 3.40 kt CO_2 form the atmosphere. These C- stock changes are estimated applying same EF (0.365 t C ha^{-1} yr^{-1}) as for mineral soils of afforested Grassland (Bjarnadóttir, 2009).

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.

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 all categories the emission is estimated according to Tier 1, and default EF=0.37 t C ha^{-1} yr^{-1}. The area, C-stock changes and comparable CO_2 emission is summarized in Table 6.6.

Table 6.6. Area of drained soils, 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	263.81	-1,501.05	5,493.13
Cropland abandoned for more than 20 years	13.18	-75.14	275.52
Natural birch shrubland (N.b.s)- old	0.26	-0.09	-3.34
N.b.s.- recently expanded into Other Grassland	0.24	-0.09	-6.69
Wetland drained for more than 20 years	250.13	-1,425.72	5,227.64
Land converted to Grassland	43.32	-246.91	182.81
Cropland converted to Grassland	20.44	-116.53	343.20
Wetland converted to Grassland	22.87	-130.38	478.06
Total	**307.12**	**-1,747.95**	**5,675.93**

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. The uncertainty introduced by applying Tier 1, is as such not estimated. According to a recent report changes in carbon stocks of mineral soils of the category “Grassland remaining Grassland” can be considerable and involving large area (Guðmundsson J. , 2016).

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

The area of Wetland drained for more than 20 years and of Other Grassland is revised as described above. 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 7,067 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 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). 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 1990-2018 trend.

Land converted to Grassland is reported for three main categories i.e.; “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 48.93 kha with 20.44 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 22.87 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 303.83 kha, with 160.56 kha as revegetation before 1990, 140.11kha as revegetation since 1990, and 3.14 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 – 2018.

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 more or less 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). The living biomass of this category is estimated to have increased by 25.89 kt C in 2018, consequently removing 94.94 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 17.81 kt C and thereby removing 65.32 kt CO_2 from the atmosphere. This increase is divided to three subcategories; Revegetation before 1990 9.15 kt C (33.56 kt CO_2), Revegetation since 1990-protected from grazing 7.34 kt C (26.93 kt CO_2), and Revegetation since 1990-limited grazing allowed 0.64 kt C (2.35 kt CO_2). The carbon stock in living biomass of the forth subcategory “Other land converted to Natural birch shrubland” is estimated in the NFI to have increased by 0.67 kt C removing 2.47 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 by 0.44 kt C in the year 2018 and accordingly removing 1.63 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). 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.

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). The loss from mineral soils of Cropland converted to Grassland is reported as 2.97 kt C and consequently emitting 10.87 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 155.86 kt C, removing 571.50 kt CO_2 from the atmosphere. This increase is divided on three subcategories, “Revegetation before 1990” 82.37 kt C (302.03 kt CO_2), “Revegetation since 1990 – protected from grazing" 66.10 kt C (242.37 kt CO_2), "Revegetation since 1990- limited grazing allowed" 5.78 kt C (21.18 kt CO_2). The changes in carbon stock in mineral soils of the forth 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 sub category is estimated as 1.61 kt C and to have removed 5.92 kt 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 uncertainty of the calculated emission removal is accordingly in the same range. 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%. The uncertainty in C-stock changes in revegetation is estimated as ± 30% for the 1990 – 2010 activities. The C-stock changes in living biomass of "Other land converted to Natural birch shrubland" is estimated by IFR in NFI and subjected to same uncertainty as other estimates of C-stock changes in living biomass in that inventory.

The emissions reported from drained Grassland soils are based on default EF from table 2.1 in 2013 wetland supplement (IPCC, 2014) 95% confidence intervals ± 2.8 t CO_2-C ha^{-1} yr^{-1}, or approximately 50%.

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 expected to be finished in 2020 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. These improvements 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 was expected in last submission that this year's submission would include an update of all reclamation areas, both prior to and after 1990, as well as the corresponding emission/removal factors, based on the ongoing NIRA update. This work has been delayed and is now expected to be finished 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 2018) as well as in 1990-2018 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 939.07 kha. Wetlands include lakes and rivers as unmanaged land and reservoirs and intact and rewetted mires and fens as managed land. The Mires and fens are included in the rangeland grazed by livestock and are grazed to some extent and accordingly included as managed land.

The subdivision of Wetland remaining Wetland is described below. Contrary to other land use categories, except "Other land" this category contains land defined as unmanaged, i.e. Lakes and rivers which are according to AFOLU Guidelines included as unmanaged land. It can be argued that some lakes and rivers should be included as managed land as they are impacted in the sense that their emission of GHG is affected. Examples of potential impacts on lakes and rivers are urban, agricultural and industrial inputs of nutrients and organic matters. Channelling of rivers and other alteration of their paths could also potentially affect their GHG profile. Although there is no attempt made to separate potentially managed lakes and rivers from unmanaged, except the lakes used as reservoirs. For the category wetland remaining Wetland, four subcategories are reported i.e. "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. and 6.3.

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 679.15 kha compared to 711.42 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 2018 and in trend 1990-2018.

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 is 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 1369.62 kt CO_2 and 1.33 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.

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 next two years to lead to revision of area of drained wetlands, also likely to affect the estimate of intact mires.

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).

Reservoirs 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 mire. 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 mire (Óskarsson & Guðmundsson, 2008). The default EF 137 kg CH4-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 mire 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 reservoirs 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. The uncertainty of the emission factors applied is estimated as 50%, and of area as 20%.

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, 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 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 15.60 kha and other settlements 19.80 kha in the inventory year. The total area reported in this submission

is 35.39 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 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 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.

Forest land converted to Settlement: As already described in Chapter 6.5 does IFR estimates the area, of this category, as deforestation activities. Permanent deforestation resulting from building activities as road and house building as removal of trees 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 2018 as 0.01 kha, and “All other Grassland subcategories converted to Settlement”, 0.19 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 were trees in an afforested area were cut down for a 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 Grassland converted to Settlement 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 is 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
See text for Settlement remaining Settlement.

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%.

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)

6.11.1.1 Category description
Emissions/removals related to harvested wood products (HWP) are estimated for the third 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[17] the annual unofficial report of the Iceland Forest Association does contain data about sawnwood production from 1996 to 2016

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

(See Table 6.6); Gunnarsson E., 2010; 2011; 2012; 2013; 2014; 2015; 2016; Gunnarsson & Brynleifsdóttir (2017).

Table 6.8 Annual wood production (in m³ on bark) and sawnwood production (in m³) in 1996 to 2017.

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

These data were used to estimate C-stock changes in HWP. Sawnwood is only a small fragment of commercial wood removal. In 2016 only 266 m^3 (6.4%) of 4,182 m^3 of total commercial wood removal were used to produce sawnwood (Gunnarsson & Brynleifsdóttir, 2017). Other HWP than sawnwood are not produced from domestic wood. The report for the year 2018 has not yet been published. In the meantime, the sawnwood amount of 2018 is assumed to be increasing following the same trend as the total wood production and by the same ratio as the ratio between total wood production and sawnwood production in 2017 (Gunnarsson & Brynleifsdóttir, 2019) .

6.12 Other (CRF 4H)

6.12.1.1 Category description

In response to the 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”. For 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))

6.13.1.1 Category description

The N_2O emissions from fertilizers used in Revegetation are reported under agricultural soil (Chapter 5.7). Direct N_2O emissions from N inputs to managed soils is reported for Forest land categories:

Land Converted to Forest Land (CRF 4.A.2)/ Grassland Converted to Forest land/ Afforestation 1 - 50 years old – Cultivated forest, were inorganic fertilizer is partially used when planting seedlings in afforestation. Aggregated activity figures (Gunnarsson & Brynleifsdóttir, 2017; 2019) for amount of nitrogen (N) in inorganic fertilizer are used as an input for calculation of N_2O emission by default method described in Chapter 11 in AFOLU (IPCC 2006). Inorganic fertilizer is too used in *Land Converted to Forest Land (CRF 4.A.2)/ Other land Converted to Forest land/ Afforestation 1 - 50 years old – Cultivated forest* but there IE is reported as the use of inorganic fertilizer cannot be divided between these two categories. Fertilization of NBF expansion does not occur. Use of organic fertilizer is not practiced.

6.14 Emissions and Removals from Drainage and Rewetting and Other Management of Organic and Mineral Soils (CRF 4(II))

6.14.1.1 Category description

Emissions of both CO_2 and CH_4 of this category are key categories in level 1990 and 2018 and CH_4 in trend 1990- 2018.

Forest land: As mentioned above are all drained organic soil reported and resulting in direct and indirect CO_2 emission and CH_4 and N_2O emission. Indirect CO_2 emission and CH_4 and N_2O emission for same areas is reported here.

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 $EF_{CH4\_land} = 0$ and $EF_{CH4\_ditch} = 1{,}165$ kg CH_4 ha^{-1} yr^{-1} from table 2.3 and 2.4 in 2013 wetland supplement respectively. The emission reported is 2.30kt CH_4 or 57.40kt 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. That emission is although reported under CRF table 4H.

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 135.13 kt 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 CO_2 emission [kt CO_2]
Grassland remaining Grassland	263.81	116.08
Cropland abandoned for more than 20 years	13.18	5.80
Natural birch shrubland (N.b.s)- old	0.26	0.11
N.b.s.- recently expanded into Other Grassland	0.24	0.11
Wetland drained for more than 20 years	250.13	110.06
Land converted to Grassland	43.32	19.06
Cropland converted to Grassland	20.44	9.00
Wetland converted to Grassland	22.87	10.06
Total	**307.12**	**135.13**

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 EF_{CH4_land} = 1.4 and EF_{CH4_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 18.30 kt CH_4 or 457.46 kt CO_2e. Of this emission 17.89 kt CH_4 is reported from the ditches while only 0.41 kt 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 CH4 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	263.81	0.35	15.37	15.72	392.94
Cropland abandoned for more than 20 years	13.18	0.02	0.77	0.79	19.64
Natural birch shrubland (N.b.s)- old	0.26	0.00	0.01	0.02	0.38
N.b.s.- recently expanded into Other Grassland	0.24	0.00	0.01	0.01	0.36
Wetland drained for more than 20 years	250.13	0.33	14.57	14.90	372.56
Land converted to Grassland	43.32	0.06	2.52	2.58	64.52
Cropland converted to Grassland	20.44	0.03	1.19	1.22	30.45
Wetland converted to Grassland	22.87	0.03	1.33	1.36	34.07
Total	**307.12**	**0.41**	**17.89**	**18.30**	**457.46**

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 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 0.29 kt CO_2, 199.22 kt CO_2, 0.03 kt CO_2, and 0.19 kt 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 emission is 124.06, 0.02, and 0.12 kt CH_4 for “Intact mires”, “Refilled lakes and ponds”, and “Rewetted organic soils” respectively. This is equivalent to 3,101.46, 0.53, and 3.00 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.

<u>Settlement:</u> 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.

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

6.14.1.2 Methodology

Area estimation for organic soils in Forest land is built for the CF on assessment in field on the measurement plots. For the NBF the mapping ratio between mineral soil and drained organic soil is used.

Off-site CO_2 and CH_4 emission are calculated according to Tier 1 approach applying equation 2.4. and 2.6 in the 2013 Wetland Supplement. A factor for the Boreal Zone of 0.12 tons CO_2-C $ha^{-1}yr^{-1}$ is chosen (Table 2.2.). For CH_4 emission from drained land (Table 2.3.), a factor for ‘Forest Land, drained, Nutrient rich, Boreal’ is used. The factor is 2.0 kg CH_4 $ha^{-1}yr^{-1}$. For emission from the ditches (Table 2.4.) a factor for the Boreal/Temperate Zone of Drained Forest Land of 217 kg CH_4 $ha^{-1}yr^{-1}$ is chosen and corresponding ditch fraction of 0.025. Together, they yield emission of 7.375 kg CH_4 $ha^{-1}yr^{-1}$.

N_2O emission is calculated according to Tier 2 applying equation 2.7 in the 2013 Wetland Supplement (IPCC, 2014). The N_2O emission from drained organic soils is estimated applying CS emission factor EF= 0.44 kg N_2O-N ha^{-1} yr^{-1} from in country measurements (Guðmundsson J. , 2009). This factor is used for the third time in this year submission for drained organic forest soils or drained organic grassland soils converted to forest soils.

6.14.1.3 Uncertainties and time-series consistency

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

6.14.1.4 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.

6.14.1.5 Category-specific recalculations

No category specific recalculations are performed for this category.

6.14.1.6 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))

6.15.1.1 Category description

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

6.15.1.2 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 3.11 and 0.04 t N_2O or 0.93 and 0.01 kt CO_2e for these categories respectively

6.15.1.3 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.

6.15.1.4 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.

6.15.1.5 Category-specific recalculations

No category specific recalculations are performed.

6.15.1.6 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))

6.16.1.1 Category description

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, C-stock losses from mineral soil are not occurring so indirect N_2O emissions from management of soils are reported as not occurring.

6.16.1.2 Methodology

See Agricultural section.

6.16.1.3 Uncertainties and time-series consistency

See Agricultural section.

6.16.1.4 Category-specific QA/QC and verification

See Agricultural section.

6.16.1.5 Category-specific recalculations

See Agricultural section.

6.16.1.6 Category-specific planned improvements

See Agricultural section.

6.17 Biomass Burning (CRF 4(V))

6.17.1.1 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).

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

Equation 1. Equation 2.27 from AFOLU guidelines (IPCC 2006): L_{fire}=tons of GHG emitted, A= area burned [ha], MB=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 C_f 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. G_{ef}= 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 considered as 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.

6.17.1.2 Planned improvements regarding 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, the 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.

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%.

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, 2018 and the 1990-2018 trend in the Waste sector are as follows (compared to total emissions excluding LULUCF):

Table 7.1 Key source categories for Waste (excluding LULUCF).

IPCC source category		Level 1990	Level 2018	Trend
Waste (CRF 5)				
5A1 Managed Waste Disposal	CH_4	✓	✓	✓
5A2 Unmanaged Waste Disposal	CH_4	✓		✓
5D2 Industrial Wastewater Treatment	CH_4	✓		✓

7.1.4 Completeness

Table 7.2 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 7.2 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
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 7.2). Therefore, the polynomial regression was chosen. More recent data were not used because the economic crisis that began in 2008 had an immediate impact on GDP whereas the impact on MSW generation was delayed, therefore, reducing the correlation between the two. Information on GDP dates back to 1945 and is reported relative to the 2005 GDP. It was therefore used to estimate waste generation since 1950. The formula the regression analysis provided is:

$$\textbf{Waste amount generated (t)} = -22.045 * \text{GDP index}^2 + 7367 * \text{GDP index}$$

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).

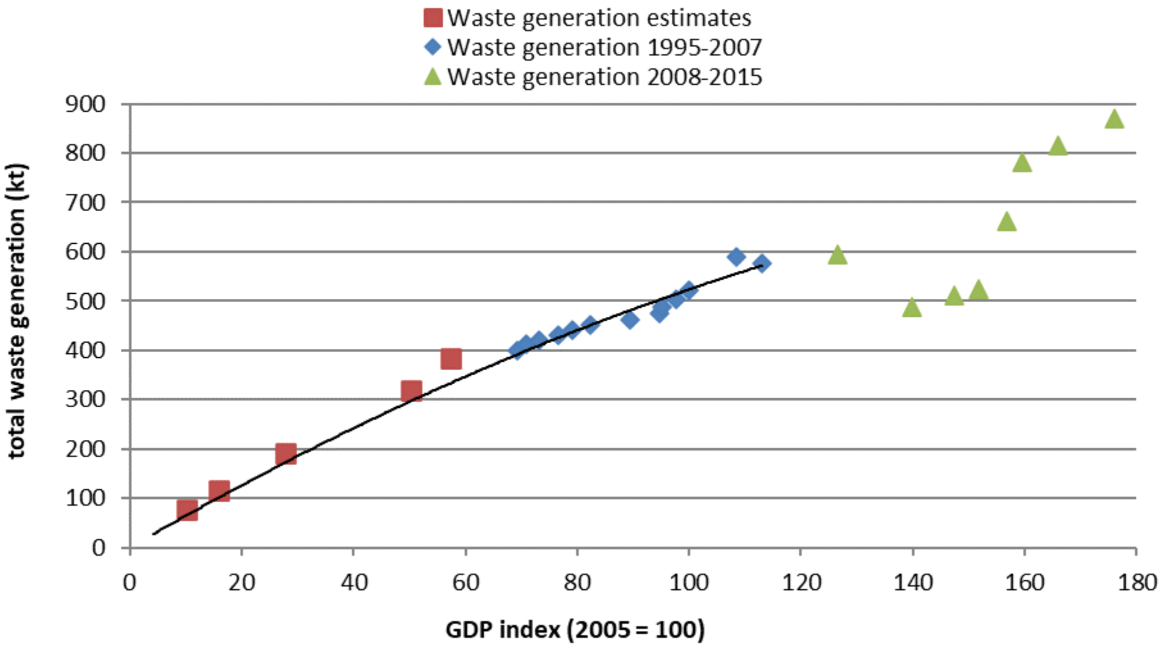

Figure 7.1 Correlation between waste generation and GDP index in Iceland used for waste generation estimates before 1995.

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 1950-2018 are shown in Figure 7.2.

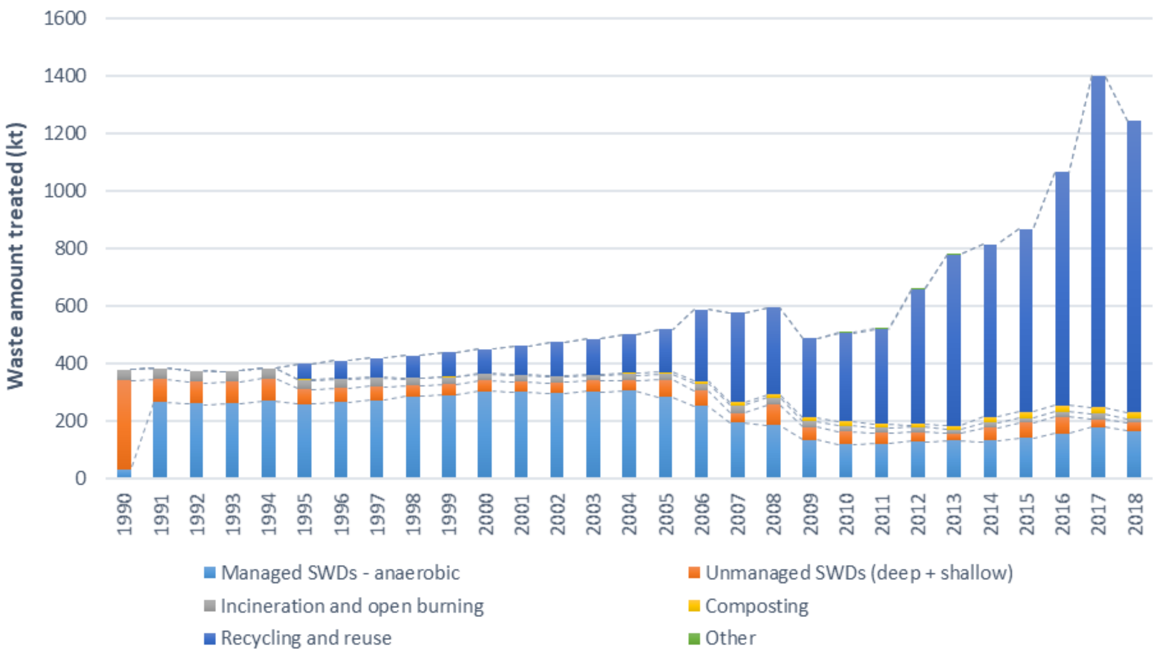

Figure 7.2 Waste amount and allocation to incineration/open burning, solid waste disposal, recycling and composting.

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 7.3 shows the development of landfill waste management practice shares since 1950.

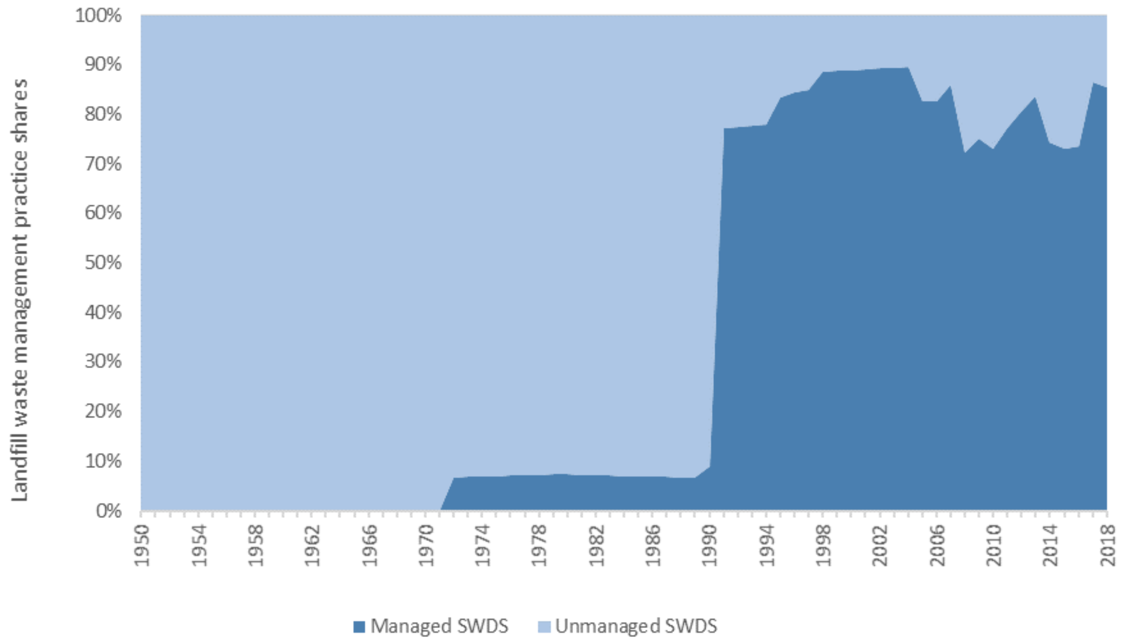

Figure 7.3 Waste management practice shares of total waste disposed of in managed and unmanaged SWDS.

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 7.3 for Managed Solid Waste Disposal Sites and in Table 7.4 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 7.3 Waste composition amounts for Managed Waste Disposal Sites (CRF 5A1a), in kt.

Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industria l	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**

Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industria l	Total
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**
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**

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 7.4 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**
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**

Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industrial	Total
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**

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 7.5.

Table 7.5 Manipulations of waste category fractions for the time-period 1950-1990.

Waste category	Adjustment	Rationale
Nappies/ disposable diapers	linear reduction by 100% between 1990 and 1980	Disposable diapers were introduced to Iceland around 1980 and were not widely used until the 1990s
Paper/cardboard	linear reduction by 50% between 1990 and 1950	The fraction of paper in waste was assumed to be much smaller decades ago. Also, paper was rather burned than landfilled (expert judgement)
Inert waste	linear reduction by 25% between 1990 and 1980 and linear reduction by 25% between 1980 and 1950	Plastic and glass comprise around 50% of inert waste. Glass was reused during the beginning of the period. Plastic was much rarer during the beginning of the period. The amount of plastic in circulation increased in the 1980s (data from Norway), therefore the steeper decrease during that decade.
Food waste	Increase of fraction by the amount that other categories were reduced by.	Expert judgement and trend in data from study by Sorpa ltd.

Waste data adjustments

The Environment Agency receives data from all 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

$$CH_4 \text{ emissions} = \left(\Sigma_x CH_4 \text{ generated}_{x,T} - R_t \right) * \left(1 - OX_t \right)$$

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)

The IPCC default of zero was used for OX_T. 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 7.6.

Table 7.6 Emission factors and parameters used to calculate methane generated.

Emission factors/parameters	Values
Degradable organic carbon in the year of deposition (DOC)	Table 7.7
Fraction of DOC that can decompose (DOC_f)	0.5
Methane correction factor for aerobic decomposition (MCF)	Table 7.8
Fraction of methane in generated landfill gas (F)	0.5
Molecular weight ratio CH_4/C	16/12 (=1.33)
Methane generation rate (k)	Table 7.7
Half-life time of waste in years (y)	Table 7.7
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 7.7.

Table 7.7 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	0.15	0.05	NA
k	0.185	0.06	0.06	0.03	0.1	0.1	0.09	0.185	NA
y	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, DOC_f, and the methane correction factor results in the mass of decomposable DOC deposited annually ($DDOC_m$).

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 7.8. Based on two landfill gas studies (Kamsma & Meyles, 2003) no methane production was reported for several of the SWDS contained in the category unmanaged, shallow. Therefore, 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 7.8 IPCC default MCFs and MCFs used in the emission estimates.

SWDS type	Managed, anaerobic	Unmanaged, deep	Unmanaged, shallow
MCF (IPCC default)	1	0.8	0.4
MCF used	1	0.8	0.2

The FOD method is then used in order to establish both the mass of decomposable DOC accumulated and decomposed at the end of each year. To this end the k values of waste categories are used. A delay time of six months takes into account that decomposition is aerobic at first and production of methane does not start immediately after the waste deposition. Equations 3.4 and 3.5 from the 2006 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)/t1/2 (y-1)
- t1/2 = 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 3.4.2). Figure 7.4 gives an overview of the annual methane amounts segregated by utilization.

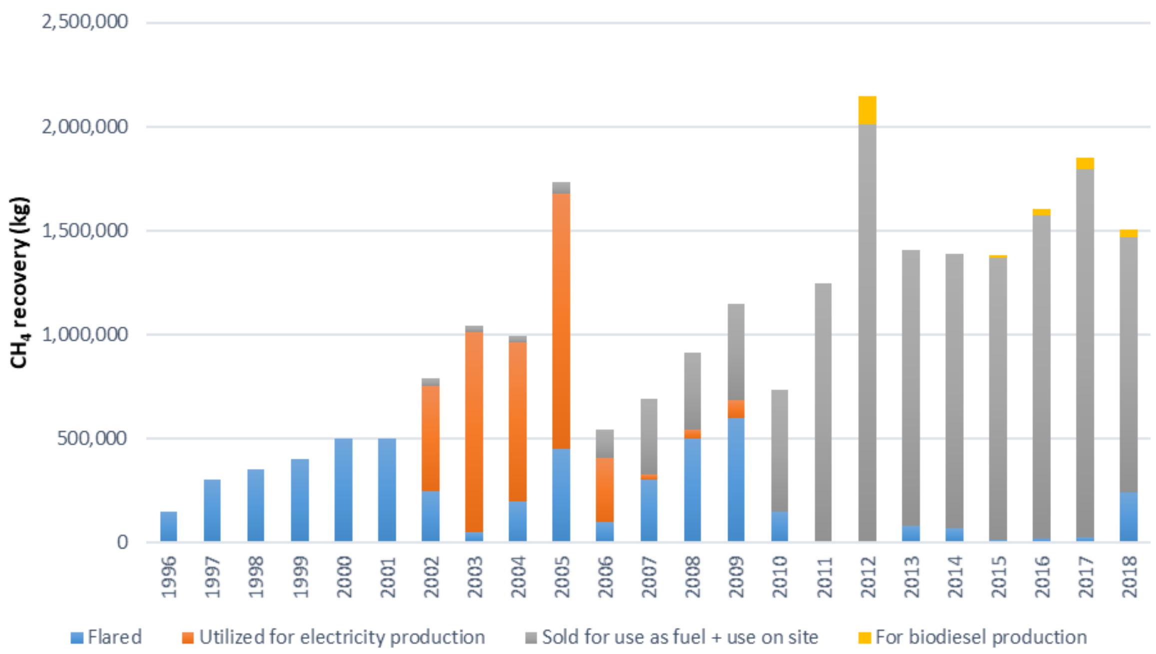

Figure 7.4 Methane recovery (CRF 5A1a) at Álfsnes and Glerárdalur SWDS's (kg CH_4).

7.2.4.2 Methane emissions

In 1990 methane emissions from SWDS amounted to 6.3 kt CH_4 and increased to 11.8 kt in 2006. Since 2006 they decreased again and were estimated at 8.6 kt in 2018. This equals an increase of 37% between 1990 and 2018.

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 7.5. In 1990 the fraction of CH_4 emissions from managed SWDS amounted to only 12% of all SWDS emissions, whereas the fraction of emissions from unmanaged SWDS accounted for 88%. This trend has been reversed since then and in 2018 88% 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.

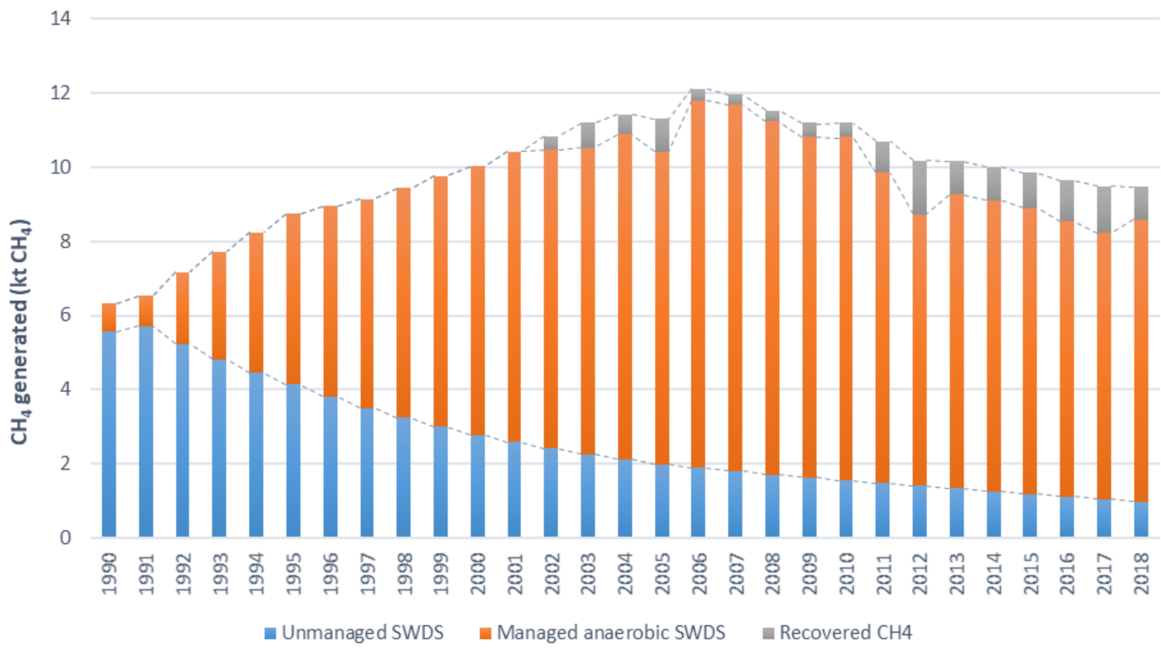

Figure 7.5 Methane generation estimates and recovery from Solid Waste Disposal sites since 1990.

7.2.5 Uncertainties

Uncertainty for emissions from solid waste disposal was calculated using value IPPC default values from 2006 GL (Table 3.5) The uncertainty of CH_4 emissions from solid waste disposal is 66% (with an activity data uncertainty of 52% and emission factor uncertainty of 40%). The complete uncertainty analysis is shown in Annex 2.

7.2.6 Recalculations

No recalculations were done for the 2020 submission solid waste disposal.

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 7.9 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 2018. There exists data on the composition of waste composted since 2007. In 2018 the main waste types composted were garden and park waste, slaughterhouse waste, food waste, and wood. The Tier 1 method, however, makes no use of waste composition data.

Table 7.9 Waste amounts composted since 1995.

Year	Waste amount composted (kt)
1995	2
1996	2
1997	2
1998	2
1999	2
2000	2
2001	2
2002	2
2003	3
2004	3
2005	5
2006	8
2007	10
2008	10.6
2009	12.7
2010	15.2
2011	14.3
2012	11.2
2013	15.0
2014	20.1
2015	21.3
2016	22.8
2017	21.7
2018	24.0

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 0.096 kt CH_4 or 2.40 kt CO_2e in 2018. N_2O emissions amounted to 0.006 kt N_2O or 1.72 kt CO_2e in 2018. The waste composted and emission trend since 1990 is shown in Figure 7.6.

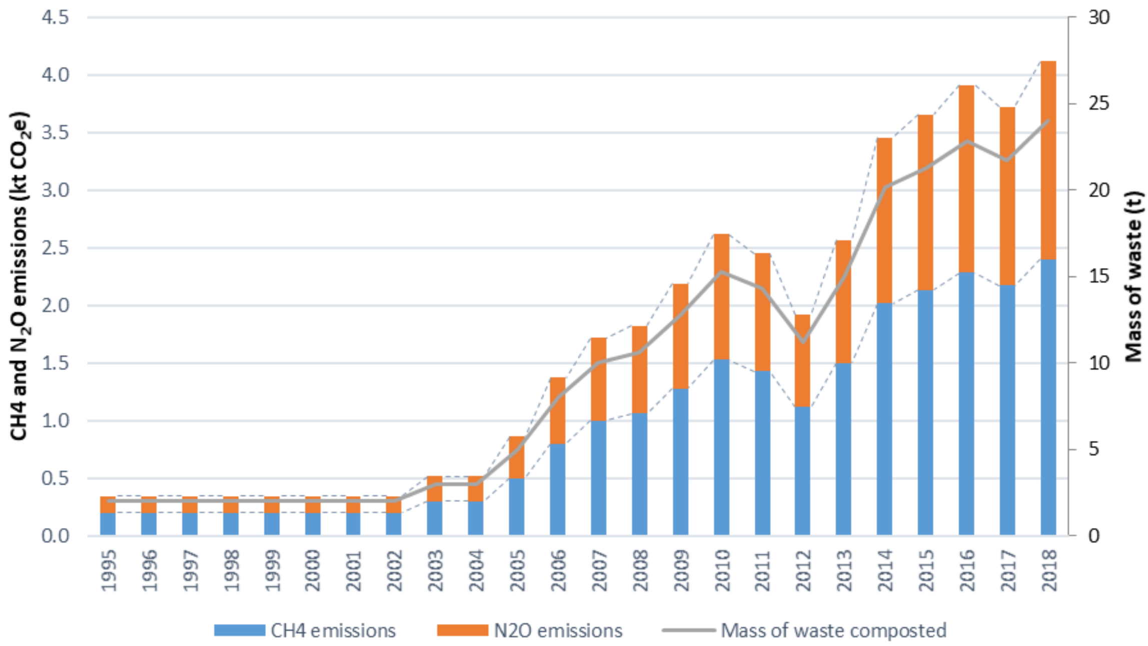

Figure 7.6 Mass of waste composted and estimated CH_4 and N_2O emissions (kt CO_2e).

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.

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 2018. Incineration of waste in incineration plants without energy recovery started in 2001 and incinerated waste amounts have been oscillating between 9 and 13 kt since 2004.

Total GHG emissions from waste incineration and open burning of waste decreased from 15.1 kt CO_2e in 1990 to 6.9 kt CO_2e in 2018.

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 7.7.

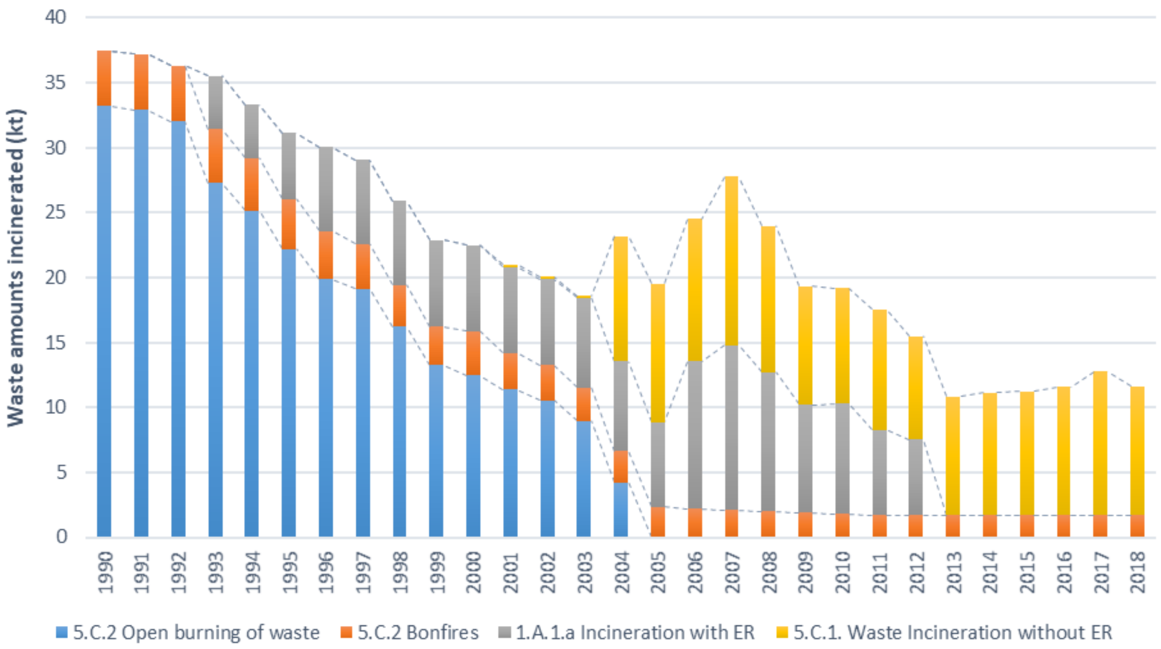

Figure 7.7 Amounts of waste incinerated with and without energy recovery, burned openly and amount of wood burned in bonfires 1990-2018.

Figure 7.7 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

$$CO_2 \text{ emissions} = MSW * \Sigma_j (WF_j * dm_j * CF_j * FCF_j * OF_j) * 44/12$$

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
- WFj = fraction of waste type/material of component j in the MSW (as wet weight incinerated or open-burned)
- dmj = dry matter content in the component j of the MSW incinerated or open-burned, (fraction)
- CFj = fraction of carbon in the dry matter (i.e., carbon content) of component j
- FCFj = fraction of fossil carbon in the total carbon of component j
- OFj = oxidation factor, (fraction)
- 44/12 = conversion factor from C to CO_2
- with: Σj WFj = 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 2018 in Table 7.10.

Table 7.10 Calculation of fossil carbon amount incinerated in 2018 (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	2,420	0.20	0.9	0.46	0.01	2.0
Textiles	234	0.02	0.8	0.5	0.2	0.4
Wood	2,472	0.20	0.85	0.5	0	0.0

	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)
Garden	0	0.00	0.4	0.49	0	0.0
Diapers	200	0.02	0.4	0.7	0.1	0.1
Food	1,631	0.13	0.4	0.38	0	0.0
Inert	1,000	0.08	0.9	0.03	1	2.2
Plastics	1,834	0.15	1	0.75	1	204.0
Hazardous	1,255	0.10	0.5	NA	0.28	17.5
Clinical	325	0.03	0.65	NA	0.25	1.4
Rubber	133	0.01	0.84	0.67	0.2	0.2
Sludge plus manure	0	0	0.4	0.49	0	0.0
Industrial solid waste	863	0.07	0.4	0.38	0	0.0
Sum	**12,367**	**1.00**				**227.6**

The input for individual years from 2005 to 2011 differs from Table 7.10 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 7.11.

Table 7.11 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	NA	NA	NA	NA

GHG	CH_4	N_2O		NO_x	CO	NMVOC	SO_x
			abatement technology				
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 7.8. Total GHG emissions estimates have decreased from 15.1 kt CO_2e in 1990 to 6.9 kt CO_2e in 2018. 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 0.36 kt CO_2e in 2018 and N_2O emissions have decreased from 1.7 kt CO_2e in 1990 to 0.36 kt CO_2e in 2018.

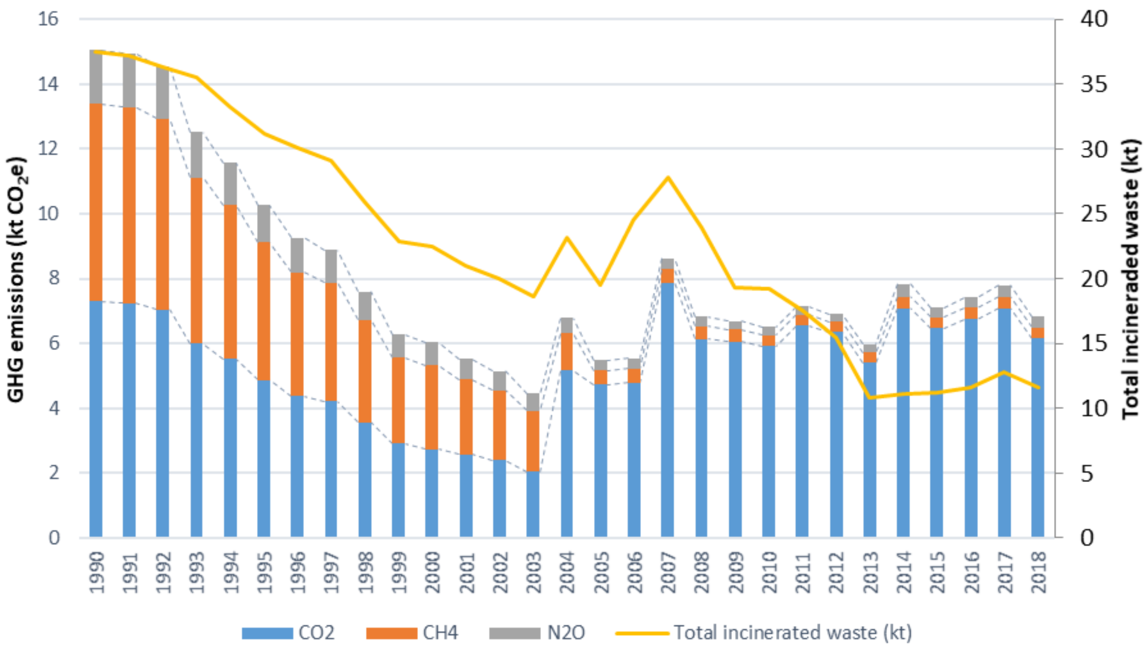

Figure 7.8 Emission estimates from incineration and open burning of waste since 1990.

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 from the 2006 GL of ± 40% was used to estimate the EF uncertainty for CO_2 emissions from incineration and open burning of waste. This value is proposed for countries relying on default data on the composition in their calculations. AD uncertainty of CO_2 emissions from incineration and open burning of waste was also estimated by using IPCC default values and was estimated to 52% for the AD. The total uncertainty for CO_2 emissions from incineration and open burning of waste was estimated to ± 66%.

Default values were also used to estimate the uncertainties associated with N_2O and CH_4 emissions. The total uncertainty for N_2O and CH_4 emissions was estimated to be ±113% (100% for EF and 52% for the AD). The complete uncertainty analysis is shown in Annex 2.

7.4.6 Recalculations

Recalculations were performed for the amount of municipal solid waste incinerated in 2014 and 2015. There was an error in previous calculations where bonfires were included when the shares of waste categories (e.g. paper, textiles, etc.) of the total municipal solid waste going to incineration were calculated. This has now been fixed.

Emission factors for NO_x, CO, NMVOC and SO_x were updated for all waste incineration categories for the 2020 Informative Inventory Report (IIR) and have, therefore, also been updated correspondingly in the NIR.

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 Káranhjúkar 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 51 kt CO_2e in 2018. Compared to 1990 emissions of 55 kt CO_2e this is a decrease of 6%.

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 BOD_5 value for Canada, Europe, Russia and Oceania were used, 60 g per person per day (table 6.4). Between 1990 and 2018 annual TOW increased proportionally to population from 5.6 kt to 7.6 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)
    - = 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 7.2 provides information on activity data used to estimate emissions from wastewater treatment and discharge in Iceland.

Table 7.12 Information on population, protein consumption and total organic matter in domestic wastewater since 1990.

Year	Population (n)	Protein consumption (kg/person/yr)	Total organic matter (kt BOD/yr)
1990	253,785	37.2	5.56
1991	255,866	37.2	5.60

Year	Population (n)	Protein consumption (kg/person/yr)	Total organic matter (kt BOD/yr)
1992	259,727	37.2	5.69
1993	262,386	37.2	5.75
1994	265,064	37.2	5.80
1995	266,978	37.2	5.85
1996	267,958	37.2	5.87
1997	269,874	37.2	5.91
1998	272,381	37.2	5.97
1999	275,712	37.2	6.04
2000	279,049	37.2	6.11
2001	283,361	37.2	6.21
2002	286,575	32.9	6.28
2003	288,471	32.9	6.32
2004	290,570	32.9	6.36
2005	293,577	32.9	6.43
2006	299,891	32.9	6.57
2007	307,672	32.9	6.74
2008	315,459	32.9	6.91
2009	319,368	32.9	6.99
2010	317,630	32.9	6.96
2011	318,452	32.9	6.97
2012	319,575	32.9	7.00
2013	321,857	32.9	7.05
2014	325,671	32.9	7.13
2015	329,100	32.9	7.21
2016	332,529	32.9	7.28
2017	338,349	32.9	7.41
2018	348,450	32.9	7.63

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 (TOW_i) are calculated using equation 6.6 of the 2006 IPCC Guidelines. In the equation, the annual amount of TOW_i is a product of the total industrial product for industrial sector *i*, wastewater generated and kg chemical oxygen demand (COD_i).

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 COD_i value for fish processing, 2.5 kg/m^3 (table 6.9), was used. For fish processing W_i is 13 $m^3/t_{product}$.

Table 7.13 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 7.13 Information on fish processing and organic matter in industrial wastewater since 1990.

Year	Processed fish (kt)	COD generated (kt COD/yr)
1990	1,371.06	44.56
1991	1,371.06	44.56
1992	1,333.41	43.34
1993	1,474.56	47.92
1994	1,299.89	42.25
1995	1,376.39	44.73
1996	1,814.76	58.98
1997	1,965.55	63.88
1998	1,436.97	46.70
1999	1,487.56	48.35
2000	1,704.74	55.40
2001	1,700.91	55.28
2002	1,832.73	59.56
2003	1,619.46	52.63
2004	1,367.08	44.43
2005	1,253.83	40.75
2006	978.92	31.81
2007	1,051.60	34.18
2008	907.56	29.50
2009	1,051.60	25.55
2010	729.44	23.71
2011	829.37	26.95

Year	Processed fish (kt)	COD generated (kt COD/yr)
2012	1,131.76	36.78
2013	1,047.09	34.03
2014	823.90	26.78
2015	1,104.93	35.91
2016	836.86	27.20
2017	994.15	32.31
2018	1,077.88	35.03

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

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

Where:

- $N_{EFFLUENT}$ = total annual amount of nitrogen in the wastewater effluent, kg N/yr
- P = human population
- Protein = annual per capita protein consumption, kg/person/yr
- F_{NPR} = fraction of nitrogen in protein, default = 0.16, kg N/kg protein
- $F_{NON-CON}$ = factor for non-consumed protein added to the wastewater
- $F_{IND-COM}$ = factor for industrial and commercial co-discharged protein into the sewer system
- N_{SLUDGE} = nitrogen removed with sludge, kg N/yr

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 7.14.

Table 7.14 Default parameters used to calculate the amount of nitrogen in the wastewater effluent

Parameter	Default value	Range	Remark
F_{NPR}	0.16	0.15-0.17	Default value used
$F_{NON-CON}$	1.1	1-1.5	The default value of 1.1 for countries with no garbage disposal was selected.
$F_{IND-COM}$	1.25	1-1.5	Default value used

Other parameters influencing the nitrogen amount 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 (B_o) 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 7.15 along with respective shares of total wastewater discharge and MCFs.

Table 7.15 Wastewater discharge pathways fractions ow MSW and population of Iceland since 1990..

		Collected – untreated systems		Collected – treated systems			Uncollected		Population
discharge pathway	Not known	Not known into sea, river, lake	No treatment	Primary treatment	Secondary treatment	Tertiary treatment	Septic tank urban	Septic tank rural	
1990	0.00	0.00	0.75	0.03	0.02	0.00	0.00	0.20	253,785
1995	0.00	0.00	0.72	0.05	0.03	0.00	0.00	0.20	266,978
2000	0.00	0.00	0.49	0.05	0.26	0.00	0.00	0.20	279,049
2005	0.00	0.00	0.31	0.09	0.39	0.01	0.00	0.20	293,577
2010	0.01	0.00	0.22	0.06	0.57	0.01	0.01	0.12	317,630
2013	0.01	0.00	0.22	0.06	0.57	0.01	0.01	0.12	321,857
2014	0.01	0.02	0.23	0.00	0.50	0.01	0.01	0.22	325,671
2015	0.01	0.02	0.23	0.00	0.50	0.01	0.01	0.22	329,100
2016	0.01	0.02	0.23	0.00	0.50	0.01	0.01	0.22	332,529
2017	0.01	0.02	0.23	0.00	0.50	0.01	0.01	0.22	338,349
2018	0.01	0.02	0.23	0.00	0.50	0.01	0.01	0.22	348,450
MCF	**0.5**	**0.1**	**0.1**	**0.1**	**0**	**0**	**0.5**	**0.5**	

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

EQUATION 6.1

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

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

Industrial wastewater

The CH_4 emission factor for industrial wastewater is a function of the maximum CH_4 producing capacity (B_o) 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 (B_o) 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 7.16 along with respective shares of total wastewater discharge and MCFs.

Table 7.16 Wastewater discharge pathways fractions for industrial wastewater since 1990.

		Collected - untreated systems		Collected - treated systems			Uncollected
discharge pathway	Not known	Not known into sea, river, lake	No treatment	Primary treatment	Secondary treatment	Tertiary treatment	Septic tank urban
1990	0.00	0.00	0.94	0.04	0.02	0.00	0.00
1995	0.00	0.00	0.90	0.06	0.04	0.00	0.00
2000	0.00	0.00	0.61	0.06	0.33	0.00	0.00
2005	0.00	0.00	0.39	0.11	0.49	0.01	0.00
2010	0.01	0.00	0.25	0.07	0.65	0.01	0.01
2013	0.01	0.00	0.25	0.07	0.65	0.01	0.01
2014	0.00	0.06	0.22	0.00	0.70	0.01	0.01
2015	0.00	0.06	0.22	0.00	0.70	0.01	0.01
2016	0.00	0.06	0.22	0.00	0.70	0.01	0.01
2017	0.00	0.06	0.22	0.00	0.70	0.01	0.01

		Collected - untreated systems		Collected - treated systems			Uncollected
discharge pathway	Not known	Not known into sea, river, lake	No treatment	Primary treatment	Secondary treatment	Tertiary treatment	Septic tank urban
2018	0.00	0.06	0.22	0.00	0.70	0.01	0.01
MCF	**0.5**	**0.1**	**0.1**	**0.1**	**0**	**0**	**0.5**

Total CH_4 emissions from industrial wastewater were calculated with equation 6.4 from the 2006 IPCC Guidelines.

EQUATION 6.4

$$CH_4 \text{ emissions} = \Sigma_i \left(\left(TOW_i - S_i \right) * EF_i - R_i \right)$$

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 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 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.

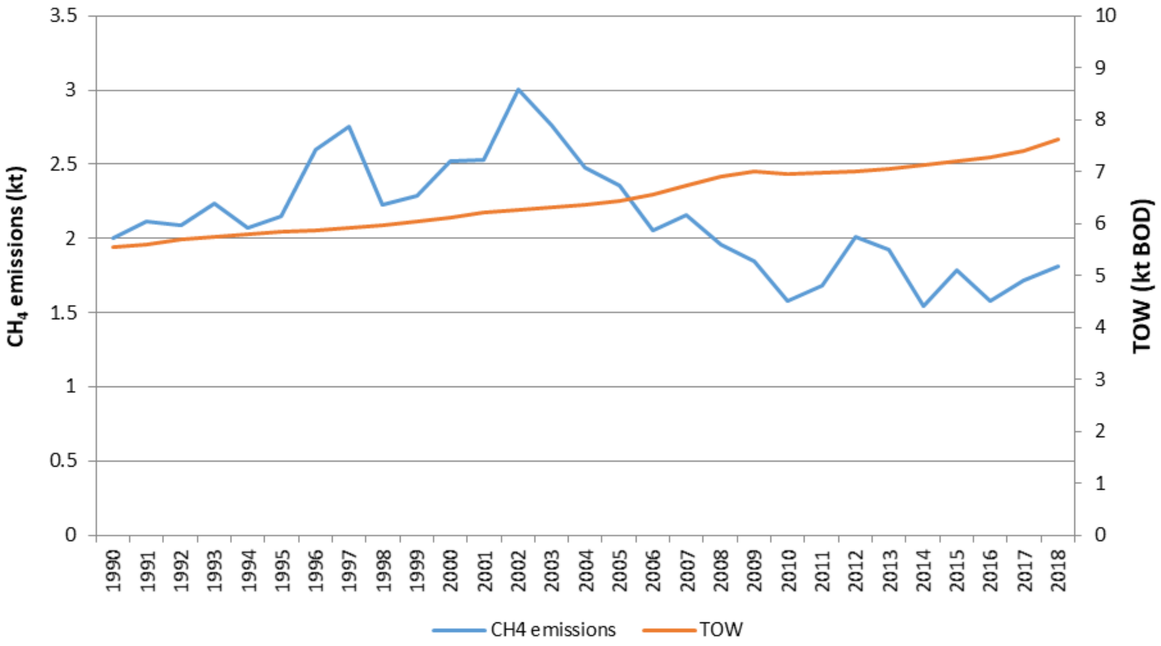

Figure 7.9 Methane emissions and total organics in domestic wastewater in Iceland since 1990.

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.

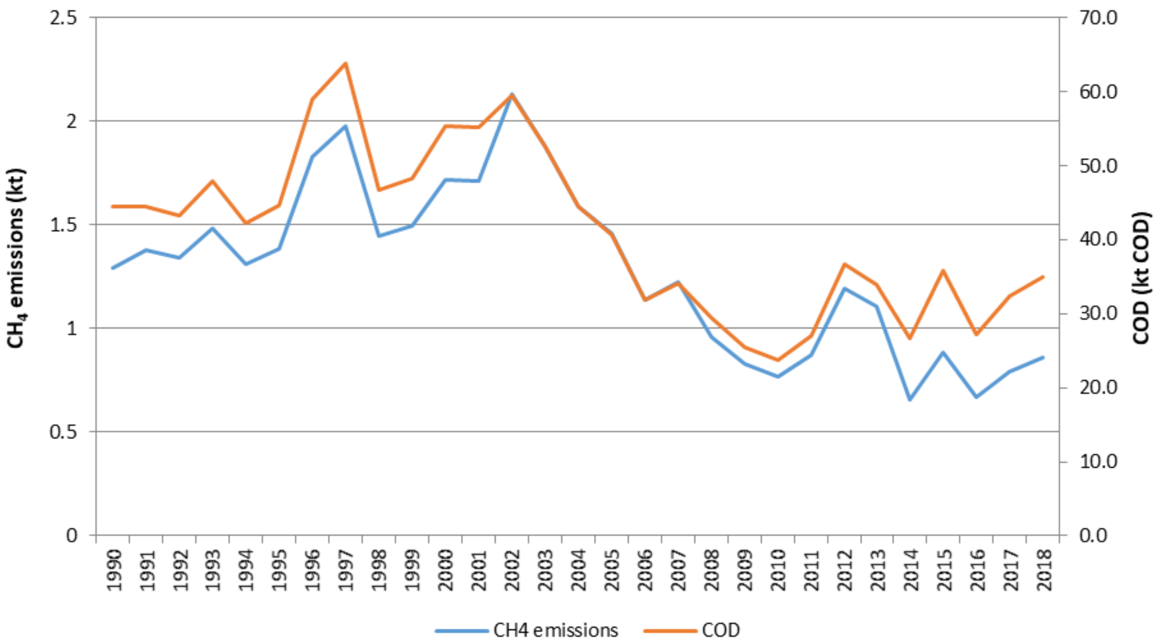

Figure 7.10 Methane emissions and total organics in industrial wastewater in Iceland since 1990.

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 shown 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 7.17 Amount of sludge removed and N in effluent

Year	Sludge removed (kt DC)	N in effluent (kt N/year)
1990	6.01	1.96
1995	5.52	2.07
2000	6.01	2.16
2005	4.89	2.03
2010	3.89	2.22
2012	3.45	2.24
2013	3.45	2.26
2014	3.04	2.30
2015	3.18	2.32
2016	2.79	2.35
2017	2.85	2.39
2018	3.46	2.45

The resulting emissions are shown in Figure 7.11. Emissions rose from 0.015 kt in 1990 to 0.019 in 2018. This is tantamount to an increase of 25%. The main driver behind this development was a 37% 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).

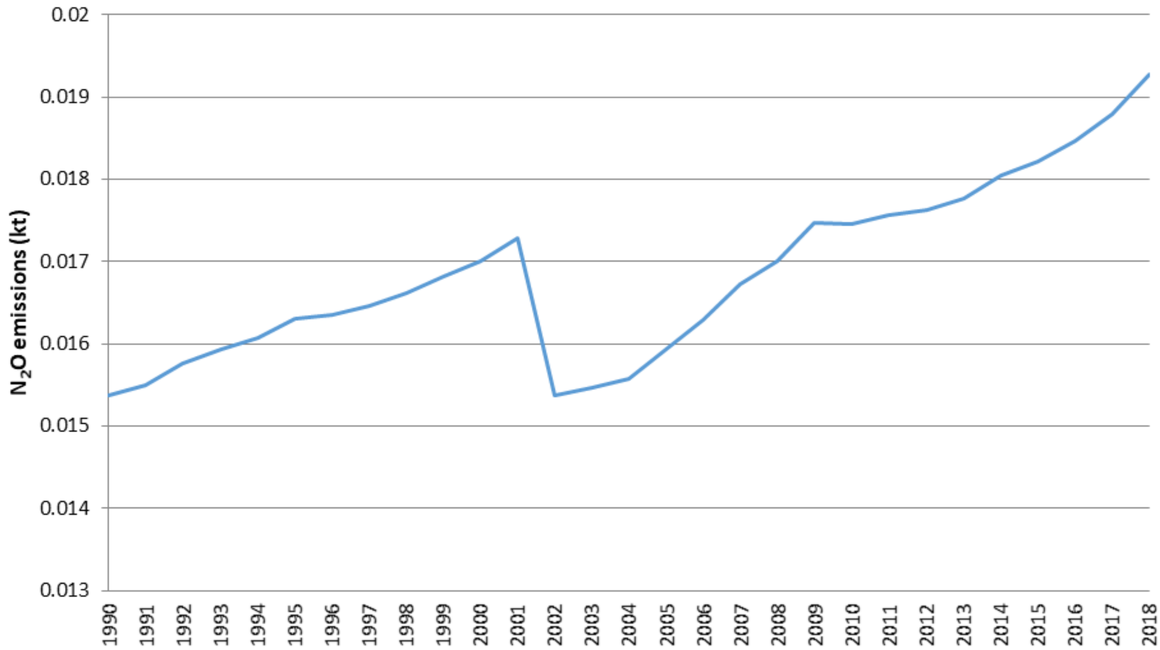

Figure 7.11 Emission estimates for N_2O from wastewater effluent since 1990.

7.5.5 Uncertainties

AD uncertainty for N_2O emissions from wastewater were calculated to 39% and is not closer analysed here since it is dwarfed by an EF uncertainty of 1000% as given in table 6.11 of the 2006 GL (page 6.27), resulting in a combined uncertainty of 1001%. The combined uncertainty for CH4 emissions from wastewater were estimated to be 70% based on default IPCC 2006 values (39% uncertainty for AD and 58% for EF). The complete uncertainty analysis is shown in Annex 2.

7.5.6 Recalculations

Several significant recalculations were performed for the 5D wastewater treatment sector for this submission, based on comments received in the 2019 step 2 ESD review. These recalculations increased the CH_4 emissions from the sector from 5.56 CO_2e to 42.3 CO_2e in 2017 and decreased the N_2O emissions from 7.2 CO_2e to 5.6 CO_2e in 2017. Therefore, the total increase of emissions in the sector was 35.8 CO_2e and 46.6 CO_2e for 2017 and 1990 respectively.

Two changes were made in CH_4 emissions;

- During the 2019 ESD review, Iceland received comments on the calculations of CH_4 emissions from industrial wastewater treatment. Prior to this submission, CH_4 emissions from industrial wastewater were reported as IE and included in CH_4 emissions from domestic wastewater by using a co-discharge factor of 1.25. For this submission Iceland is reporting CH_4 emissions from industrial wastewater separately for the first time. The reported emissions from industrial wastewater are 21.6 kt CO_2e in 2017. The co-discharge factor for domestic wastewater was changed to 1, which decreased the emissions from that sector by 1.1 kt CO_2e in 2017. The total change in emissions in 2017 due to industrial wastewater being calculated separately is +20.5 kt CO_2e.

- Wastewater pathways were identified and characterized from Table 2 from a report published by the EA on the status of wastewater treatment (Environment Agency of Iceland, 2017) which was provided by Iceland during the 2019 ESD review. In previous submissions Iceland assumed that due to the cold climate no methanogenesis occurred, except in septic tanks, so all other MCFs were assumed to be 0. That assumption was not deemed justified and therefore for this submission default MCF values from the 2006 IPCC guidelines are used for all pathways. This increased the emissions from domestic wastewater by 19.3 kt CO_2e in 2017.

This resulted in updated calculations in this chapter and increased Iceland´s CH_4 emissions from wastewater from 5.56 kt CO_2e to 42.97 kt CO_2e for the year 2017. The recalculations affected the whole time series (1990-2017) and resulted in similar increases in CH_4 emissions from wastewater treatment for all reported years.

In addition to the significant recalculations for CH_4 emissions from wastewater, a small recalculation was performed for N_2O emissions. In the 2019 ESD review a comment was received on the factor of non-consumed protein added to the wastewater ($F_{NON-CON}$ in equation 6.8). For previous submissions Iceland was using 1.4 which is the default for countries where garbage disposal units are common. As that is not the case in Iceland, this factor was changed to 1.1. which is the default for countries where garbage disposal units are not common. This decreased the N_2O emissions from 7.2 CO_2e to 5.6 CO_2e in 2017.

The total change between this submission and last submission for sector 5D over the whole timeseries can be seen in Figure 7.12.

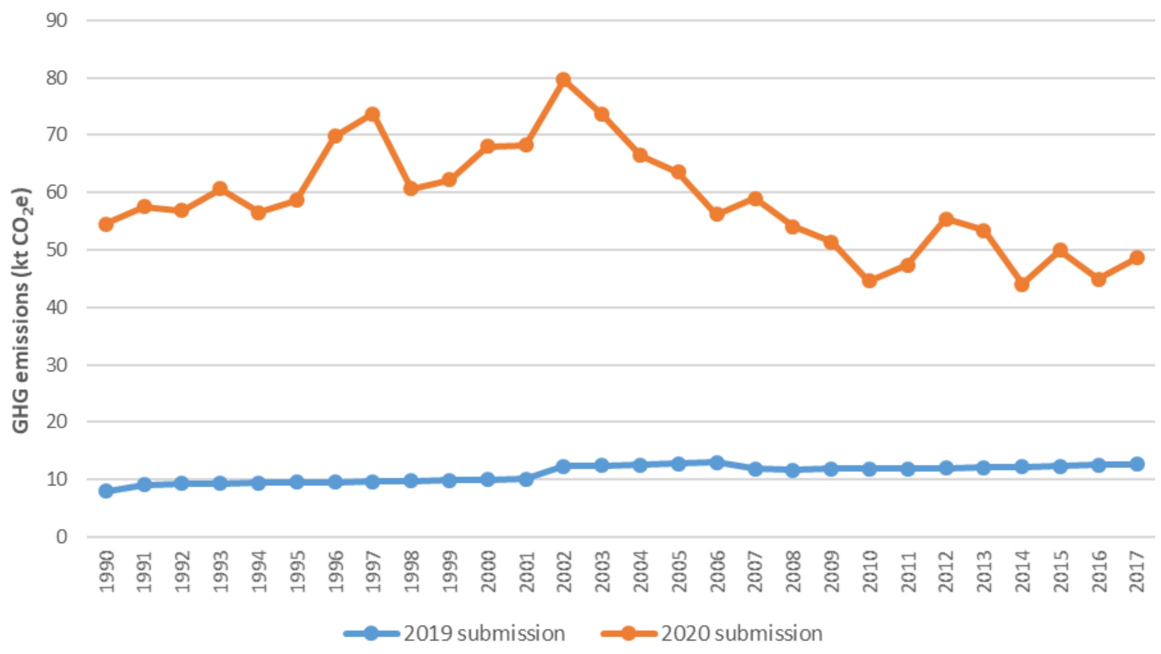

Figure 7.12 The difference in emissions from wastewater treatment and discharge between the 2020 submission and 2019 submission due to recalculations in sector 5D.

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 being performed in 2020 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.

9.3 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 has been used for the 2019 submission. This QAQC file compares emissions from all GHG for year x-3 (2016) 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 2020 greenhouse gas emission inventory has been 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 revised estimates, technical corrections and potential problems as identified in 2019's reviews, one of which lead to resubmission to UNFCCC of the 2019 inventory. The effect of these recalculations is documented in chapters 10.2.1 and 10.2.2 below.

Table 10.1 and Table 10.2 below show the difference between the total emissions in the 2020 submission and the 2019 resubmission, without and with emissions from the LULUCF sector. Explanations for the differences are given in Chapter 10.6 Sector-specific recalculations.

Table 10.1 Total emissions according to the 2020 submission compared to the 2019 resubmission, kt CO_2e (without LULUCF).

Inventory year	2019 resubmission	2020 submission	Change (kt)	Change (%)
1990	3,613	3,733	120	3.3%
1995	3,438	3,551	113	3.3%
2000	4,047	4,171	124	3.1%
2005	3,957	4,059	102	2.6%
2010	4,855	4,929	74	1.5%
2015	4,726	4,780	74	1.6%
2016	4,651	4,755	104	2.2%
2017	4,766	4,836	70	1.5%

Table 10.2 Total emissions according to the 2020 submission compared to the 2019 resubmission, kt CO_2e (with LULUCF).

Inventory year	2018 submission	2019 submission	Change (kt)	Change (%)
1990	13,020	13,076	56	0.4%
1995	12,799	12,811	12	0.1%
2000	13,434	13,409	-25	-0.2%
2005	13,384	13,302	-82	-0.6%

Inventory year	2018 submission	2019 submission	Change (kt)	Change (%)
2010	14,326	14,191	-136	-0.9%
2015	14,090	13,941	-149	-1.1%
2016	13,997	13,865	-132	-0.9%
2017	14,087	13,889	-198	-1.4%

10.2 2019 Reviews

10.2.1 EU Step 2 review

Iceland volunteered to a EU Step 2 review which took place in April 2019. This is a comprehensive review following the EU's first step review, and is conducted according Art. 32 of Regulation (EU) 749/2014, with checks as listed in Art. 19 of Regulation (EU) 525/2013. This review only covers emissions falling under the scope of the Effort Sharing Decision (ESD) No 406/2009/EC, that is, excluding EU ETS emissions as well as LULUCF emissions and removals. After the review, Iceland received a review report containing 15 recommendations, of which 4 entailed revised estimates as sent in by Iceland (3 in Agriculture and 1 in waste), as well as one technical correction (as defined in Art. 3 of Regulation 525/2013) accepted by Iceland by the end of the review week. Since Iceland is not a EU member state and took part in the review on a voluntary basis, the review report was not published by the EU, and Iceland did not have to resubmit its 2019 inventory to the EU nor to UNFCCC. For information, the comments listed in the review report can be found in Annex 5 of this report, with Iceland's explanations on the current status of the issues. The table below shows the impact of the revised estimates and the technical correction on the total 2017 emissions (without LULUCF).

Table 10.3 Effect of recalculations as performed during the EU Step 2 review

Data/Source category	Reference/Comment ID	2017 Emission estimates (kt CO_2e)
Total GHG emissions	As submitted to EU 14/03/2019	4754.65
Total GHG emissions after step 2 review	Including accepted revised estimates and technical correction	4867.21
Total difference		112.56
Revised estimates		
3.A Enteric fermentation, CH_4	IS-3A-2019-0006	3.46
3.B Manure management, CH_4	IS-3B-2019-0008	6.26
3.D.1 Direct N_2O emissions from managed soils, N_2O	IS-3D1-2019-0003	61.04
5.D Wastewater treatment and discharge	IS-5D-2019-0003	37.41
Technical correction		
3.A Enteric fermentation, N_2O	IS-3B-2019-0005	4.382

10.2.2 UNFCCC desk review

Iceland's inventory submitted to UNFCCC in April 2019 was subjected to a UNFCCC desk review during the week from 16 to 21 September 2019. During the review week the expert review team (ERT) identified two potential problems that lead to the issuance of a Saturday Paper. One of the issues pertained to Iceland's use of a country-specific emission factor for N_2O emission from cultivation of organic soils (i.e. histosols). Iceland provided explanations on the rationale for using this country-specific factor, and these explanations were accepted by the ERT, and no recalculations were performed for this particular sector. The document provided to, and accepted by, the ERT is copied in its integrality in Annex 9 of this report. The other issue, relating to the nitrogen excretion rate of mature dairy cattle, lead to recalculations in Agriculture's categories 3.A Enteric fermentation CH_4, 3.B.1 Manure management N_2O and 3.D direct and indirect N_2O emissions from agricultural soils. Iceland therefore resubmitted the 2019 inventory data (CRF tables) to the UNFCCC on 1st of November 2019. Iceland´s 2019 National Inventory Report (NIR) was not updated in accordance to the recalculations, but all changes made for the resubmission are documented in this report.

The table below shows the difference in Iceland's two 2019 submissions. It is worth noting that in this recalculation chapter, as well as in all recalculations documented in the sectoral chapters of this report, we compare the 2020 submission with the 2019 November resubmission.

Table 10.4 Effect of recalculations for the resubmission to UNFCCC

Data/Source category	2019 v.1 (kt CO_2e)	2019 v.2 (kt CO_2e)	Difference (kt CO_2e)
Energy	1907.49	1907.49	0.00
IPPU	2039.34	2039.34	0.00
Agriculture	578.19	589.38	11.19
Waste	229.62	229.62	0.00
Total (w/o LULUCF)	**4754.64**	**4765.83**	**11.19**

10.3 Sector-specific Recalculations

10.3.1 Energy (CRF sector 1)

Significant recalculations were performed for the energy sector for this submission, leading to a difference in GHG emissions between the 2019 and the 2020 submission amounting to -30 kt CO_2e for the year 2017 and +2.8 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 account for the recalculations in the energy sector:

1. COPERT was used for calculations of emissions from 1A3b Road Transport for the whole timeseries. This caused significant changes in the emissions, it increased CO_2 emission slightly and decreased N_2O for the most recent years. More details of these recalculations can be seen in Chapter 3.4.2.4.
2. A comprehensive review of input data for the whole energy sector was preformed (see chapter 3.1.1 Methodology). This cause recalculations for the years 2002-2017.

10.3.2 Industrial Processes and Products Use (CRF sector 2)

For the current inventory recalculations in the IPPU sector lead to changes of -0.035% (or -0.34 kt CO2e) in 1990 and -0.7% (or -13.7 kt CO2) in 2017. These changes are related to the following recalculations performed in different subsectors of IPPU:

1. 2D2 Paraffine wax use: update of the activity data or the whole time series obtained from Statistics Iceland
2. 2D3 Other non-energy products from fuels and solvent use: update of activity data for the whole time series obtained from Statistics Iceland
3. 2F1 Refrigeration and air conditioning: review of the emission estimation model and adaptation to the 2019 IPCC Refinements of the guidelines causing the biggest changes
4. 2G1b Use of SF_6 in electrical equipment: update of the activity data for the whole time series as a result of an enquiry sent to all stakeholders
5. 2G3 N2O from product use: addition of the emissions deriving from the use of aerosol cans of cream and cartridges
6. 2G4: updated of the activity data for the import of fireworks obtained from Statistics Iceland

Further details are documented under the specific "recalculations" sections in each individual subcategory of Chapter 4 (Industrial Processes and Product Use).

10.3.3 Agriculture (CRF sector 3)

The agriculture sector has been extensively reviewed in light of the 2019 EU Step II and 2019 UNFCCC desk review in order to accommodate corrections and comments. Further details can be found under each subsector and are summarized here below:

1. Update of livestock numbers of horses for the year 2014-2017
2. Recalculation of gross energy (GE) for mature dairy cattle and other mature cattle due to an update of the coefficient (Cfi) for calculating the net energy for maintenance (NEm)
3. Update of milk yield numbers for 2006 and 2014, fat content of milk 2008-2010, 2012-2014, 2016-2017
4. Recalculation of Methane emission factor due to the changes in GE
5. Update of the equation used to calculate volatile solid excretion rates (VS)
6. Change to Tier 2 methodology to calculate the Nitrogen excretion rate for mature dairy cattle
7. Update of the amount of inorganic fertilizers applied to soils for the whole time series by reporting the amount used in forestry also under Agriculture
8. Addition of the amount of sewage sludge used for land reclamation purposes to organic fertilizers applied to soils
9. In the subsector cultivation of organic soils, updated areas as reported by the LULUCF chapter lead to small recalculations, while the biggest part arises from the moving drained organic soils from 4IIH to 3D, leading to an increase of 176% of emissions in this subsector for the year 1990 and +224% for 2017
10. Addition of liming and other carbon containing fertilizer data for the time series 2002/2003-2012 to the Agriculture sector and update of the input data due to improved data collection for the years 2013-2017.
11. Update of animal population numbers for mature dairy cattle, other mature cattle, turkeys and geese to ensure time series consistency (1990-1991)
12. Update of animal characterization parameters, such as weight for mature dairy cattle (1990-2018), feed digestibility for mature dairy cattle (2018), pregnancy rate for sheep and animals for replacement 2018, for lambs: age of animal slaughtered 2010-2018, birth weight 2002-2018, carcass weight 2002-2018, daily weight gain 2002-2018.
13. Change of formula of the net energy for growth for lambs (Eq 10.7) to account for AAP calculation (division with number of days alive instead of days in a year) (see paragraph 5.2.4)

10.3.4 LULUCF (CRF sector 4)

Recalculations have been done to the LULUCF sector between the 2019 and 2020 submission, mostly due to revised area estimation. The effect of the recalculations on the emissions from the sector are shown in Table 10.5. Further explanations for the subsectors are also explained below.

Table 10.5 Total emissions from LULUCF according to the 2020 submission compared to the 2019 resubmission, kt CO_2e.

Inventory year	2019 submission	2020 submission	Difference (kt CO_2e)	Difference (%)
1990	9,407	9,344	-63	-0.7%
1995	9,361	9,260	-101	-1.1%
2000	9,387	9,238	-149	-1.6%
2005	9,427	9,242	-185	-2.0%
2010	9,472	9,262	-210	-2.2%
2015	9,363	9,141	-222	-2.4%
2016	9,345	9,110	-235	-2.5%
2017	9,321	9,053	-268	-2.9%

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)

N2O 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 N2O 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 2020 submission, the main recalculations in the waste chapter were done in the chapter on Wastewater Treatment and Discharge (5D). There were also minor recalculations in the chapter Waste Incineration and Open Burning of Waste (5C).

Solid Waste Disposal (5A)

No specific recalculations were made for this category.

Biological Treatment of Solid Waste: Composting (5B)

No specific recalculations were made for this category.

Waste Incineration and Open Burning (5C)

There were minor recalculations in this chapter for the amount of municipal solid waste incinerated in 2014 and 2015, see chapter 7.4.6.

Wastewater Treatment and Discharge (5D)

During the 2019 ESD review, Iceland received comments on the calculations of emissions from wastewater treatment. Recalculations for this sector resulted in a total increase of emissions of 35.8 CO_2e and 46.6 CO_2e for 2017 and 1990 respectively. These recalculations affected the whole time series

The following two changes were made to the calculations of CH_4 emissions;

- Iceland is reporting CH_4 emissions from industrial wastewater separately for the first time. Prior to this submission, CH_4 emissions from industrial wastewater were reported as IE and included in CH_4 emissions from domestic wastewater.
- Previous country specific assumptions by Iceland on MCFs were not deemed justified and, therefore, for this submission default MCF values from the 2006 IPCC guidelines are used for all pathways.

Furthermore, a small recalculation was performed for N_2O emissions from wastewater treatment and discharge. The factor of non-consumed protein added to the wastewater was updated from 1.4 (default for countries where garbage disposal units are common) to 1.1 (default for countries where garbage disposal units are not common).

For more detailed explanations, see chapter 7.5.6.

10.3.6 KP-LULUCF (CRF Sector 7)

As explained in Chapter 6.4 and above in Chapter 11 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 6.14).

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.

10.5 Overview of Implemented and Planned Improvements, Including in Response to the Review Process

Iceland´s 2020 submission was reviewed during EU's Step 1 and Step 2 review process, according to Art. 29 and 32 of Commission Implementing Regulation (EU) No 749/2014, as was as during a UNFCCC desk review which took place 16 to 21 September 2019. This desk review was the first UNFCCC review since the 2017 in-country review, and many of the improvements were in response to the 2017 review. 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 2020 submission were the revision of the calculation files used for calculating emissions from F gases in the sector 2F1 Refrigeration and air conditioning; another improvement that had a major impact on emission estimates was change in livestock characterisation in Agriculture, as well as the move of N_2O emissions previously reported under LULUCF 4H Other to 3.D.a.6 cultivation of organic soils.

In Chapter 10.6 a table for each sector shows the status of implementation of each general recommendation listed in the 2017 Assessment Report (Report on the individual review of the annual submission of Iceland submitted in 2017 - FCCC/ARR/2017/ISL).

Status of implementation in response to EU´s review process can be found in Annex 5.

10.6 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 2017 Assessment Report.

Table 10.6 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	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
	resulting from such implementation (if any).			
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 (planned improvements).	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

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
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.	
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 guigelines as the only guidelines for QA/QC procedure and for assessing completenes.. 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	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.	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	the recalculations on the AD and emission trend at the category and sectoral level.			
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.	

10.6.1 Energy (CRF Sector 1)

For this submission the EA implemented the COPERT model for calculating emissions from road transport and preformed a comprehensive review of the input data for the energy sector. 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.

Furthermore, work is underway with the EA team responsible for surveillance of fuel imports in order to develop country-specific fuel specifications, in particular liquid fuels.

Table 10.7 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	In progress, in collaboration with the National Energy Agency.	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	In progress, resolved for 2003-onwards	Energy Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
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 and NEA regarding the uncertainty analysis.	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
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	FCCC/ARR/2019/ISL /E.8	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
	fuels for the entire time series in CRF table 1.A(c)			
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 CO2 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 content of fuels) that would allow it to use the tier 2 approach for key categories in line with the 2006 IPCC Guidelines.	FCCC/ARR/2019/ISL /E.10	Partly resolved, country specific NCV value for diesel and gasoline is available but still working on country specific carbon content	Energy Chapter
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 CO2 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	Partially resolved. The values for steam coal have now been replaced by IPCC default values for petroleum coke: Regarding the parameters for waste electrodes, work is in progress to determine either the source of the information, or which IPCC default value would be most representative for this fuel. This will be finalised for next submission.	Energy Chapter
1.A.2.	The ERT recommends that Iceland assess the use of the CH4 and N2O 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 CH4 and N2O 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	FCCC/ARR/2019/ISL /E.14	We have implemented the use of COPERT which uses a consistent methodology for the whole timeseries.	Energy Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	years of the time series (1990–2005)		/ Done	
1.A.3.b	The ERT recommends that Iceland update the NIR with the CH4 and N2O 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 CH4 and N2O 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 CH4 collected from waste yards in road transportation and consider estimating and reporting the emissions associated with the use of CH4 in road transportation, avoiding potential double counting with the waste sector.	FCCC/ARR/2019/ISL /E.16	For the 2018 submission Iceland included emissions from CH4 collected from landfill sites and sold as fuel for vehicles. / Done	Energy Chapter
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	Currently all off-road transportation is reported under 1A2gvii. NIR and CRF updated accordingly. / Done	Energy Chapter
1.A.4.	The ERT recommends that Iceland collect AD on the consumption of charcoal, estimate its emissions, report the corresponding CO2 emissions as a memo item and include the non-CO2 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. /In Progress	Energy Chapter
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	FCCC/ARR/2019/ISL /E.20	Additional information about this was added to section 3.8.2.1	Energy Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	it explicit that all geothermal power plants are covered and that other uses of geothermal power are not considered.			
1.B.2.d.	The ERT recommends that Iceland identify the main drivers for the trend in CO2 and CH4 emissions (e.g. power plants, geothermal fields) and investigate why geothermal electricity is being produced with decreasing levels of CO2 emissions per GWh since 1993, and report 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 electrodes	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 CO2 emissions 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.	FCCC/ARR/2019/ISL /E.22	Electrodes are now reported as NO in the reference approach	CRF
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	FCCC/ARR/2019/ISL /E.23	Not relevant anymore because now we use COPERT	Energy Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	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.			
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 improvements to the improvements 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 CO2 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	In progress. 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	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.	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	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.			
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 CH4 and N2O 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 information on the EFs used for biofuels to justify any significant inter-annual changes in the biomass IEFs.	FCCC/ARR/2019/ISL /E.33	Partly resolved. We have yet to add explanation about inter annual changes in IEFs.	
1.A.3.b.i biomass	The ERT recommends that the Party update the N2O 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	FCCC/ARR/2019/ISL /E.35	Addressing. Whilst it seems unlikely this disaggregation will be available for past years of the time series, for future submissions it will be possible to separate fuel use in agriculture/construction/other from 2019 and onwards, following changes made by	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	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.		the NEA to facilitate the attribution of fuel sales to the various IPCC categories.	
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.	

10.6.2 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, to add the emissions from the use of urea based catalytic converters, to keep improving the input data quality for the sector non-energy products from fuels and solvent use, including paraffin wax and candles.

Table 10.8 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

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
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 have been be thoroughly revised in 2019 in collaboration with consultants from Aether Ltd. Included in the revision is 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
2.G.1	The ERT recommends that Iceland obtain clear information about the recovery of SF6 emissions from electrical equipment and revise its emission estimates as necessary	FCCC/ARR/2019/ISL /I.5	Iceland got its first SF6 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 NF3 emissions in the country.	FCCC/ARR/2019/ISL /I.7	Information has been added in section 4.1.1.	IPPU Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
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 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.	IPPU Chapter
2.G.3	The ERT recommends that the Party include estimates for N2O emissions from whipped cream containers.	FCCC/ARR/2019/ISL /I.12	This information has been added in chapter 4.8.2	IPPU Chapter

10.6.3 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.

In addition, category specific QA/QC will be carried out, including amongst other the comparison of synthetic fertilizers reported by Iceland with international data providers.

Regarding the N-flow methodology, it is planned to apply the 2019 EMEP/EEA air pollutants inventory guidebook to the national model to increase transparency of reporting of N-species also in accordance with the reporting under CLTRAP.

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

Table 10.9 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 N2O 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
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

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
3.A.4	The ERT recommends that Iceland correct the CH4 and N2O 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 CH4 EF reported in the NIR to the CH4 EF used to estimate CH4 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 CH4 EF reported in the NIR to the CH4 EF used to estimate CH4 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 CH4 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 CH4 emissions from enteric fermentation from horses and poultry.	FCCC/ARR/2019/ISL / A.10	This has been updated. / Done	Agriculture Chapter
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. Improvements are planned - in progress.	Agriculture Chapter
3.B	The ERT recommends that Iceland correct its N2O 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 N2O estimation from 3 B Manure Management, so no correction is required.	Agriculture Chapter
3.B	The ERT recommends that Iceland correct its N2O emission estimates from manure management systems by using the default N2O EFs from the 2006 IPCC Guidelines or provide additional information that supports the use of other N2O EFs that may be more representative of manure management systems in Iceland.	FCCC/ARR/2019/ISL / A.14	In progress.	Agriculture Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
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 N2O emissions from manure management.	FCCC/ARR/2017/ISL / A.16	Resolved /Done	Agriculture Chapter
3.B.5	The ERT recommends that Iceland estimate indirect N2O emissions from manure management (3.B.5), including N2O emissions from nitrogen volatilized as ammonia and NOX 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 UNFCCC Annex I inventory reporting guidelines	FCCC/ARR/2019/ISL / A.17	Resolved	Agriculture Chapter
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 N2O emissions from mineral soils, or, if the Party considers these emissions as insignificant, provide in the NIR sufficient information showing that the likely level of emissions meets the criteria in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines	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 N2O 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

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
3.D.a.6	The ERT recommends that Iceland correct the misallocation of N2O emissions by moving the N2O emissions under the subcategory other (4.II.H) in CRF table 4(II) to the subcategory cultivation of organic soils (3.D.a.6) in CRF table 3.D.	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 table with the overall mass balance of N, including information on N volatilized as NOx, nitric oxide and N2O.	FCCC/ARR/2019/ISL / A.23	This is still in progress.	Agriculture Chapter
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 - CH4	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 - N2O	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 - N2O	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 - CH4 - CH4	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 - CH4	The ERT recommends that Iceland justify the appropriateness of the current	FCCC/ARR/2019/ISL / A.30	No livestock parameters for "Other mature cattle" were	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	parameters and/or update the input parameters and consequently the CH4 EF for future submissions, as planned.		updated for this submission, work is nevertheless underway to update these parameters for future submissions.	
3.A.1 Cattle - CH4	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 - CH4	The ERT recommends that the Party justify the low CH4 IEF reported for growing cattle and explain any significant changes in the animals covered by this subcategory that would affect the CH4 IEF trend.	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 - CH4	The ERT recommends that the Party revise the explanation of CH4 estimates for mature dairy cattle in the NIR by indicating the use of the Cfi value from the 2006 IPCC Guidelines and ensure that the approach is used consistently across the time series.	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 - N2O	The ERT recommends that Iceland update the NIR with the revised information on the estimation method and the input parameters used in the N2O 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 - CH4	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 CH4/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
3.B.5 indirect N2O	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	FCCC/ARR/2019/ISL / A.36	We will consider this for future submissions.	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	methodology and assumptions used in the calculations.			
3.D.a.1 - N2O	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 - N2O	The ERT recommends that the Party include in the NIR the explanation for the low country-specific N2O 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 - CO2	The ERT recommends that the Party implement the planned checks of the AD for the category and update them as planned and report CO2 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 - CO2	The ERT recommends that the Party report CO2 emissions from other carbon-containing fertilizers consistently across the time series under category 3.I. If the change is not made in the next submission, 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

10.6.4 LULUCF and KP-LULUCF (CRF Sectors 4 and7)

10.6.4.1 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.

10.6.4.2 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.

10.6.4.3 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.

<u>Land converted to Grassland:</u>

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.

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.

10.6.4.4 Settlements (4E)

There are no category specific planned improvements for this category.

10.6.4.5 Other land (4F)

No emissions are reported under this category.

Harvested Wood Products (4G)

There are no category specific planned improvements for this category.

10.6.4.6 Other (4H)

There are no category specific planned improvements for this category.

10.6.4.7 Direct N2O Emissions from N Inputs to managed Soils (4(I))

There are no category specific planned improvements for this category.

10.6.4.8 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.

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

There are no category specific planned improvements for this category.

10.6.4.10 Indirect N2O Emissions from Managed Soils (CRF 4(IV))

There are no category specific planned improvements for this category

10.6.4.11 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 10.10 Status of implementation in the LULUCF sector in response to UNFCCC´s review process [not updated for 2019 submission].

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	No improvement has been made regarding this issue for the 2020 submission. Iceland will take this issue 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	The solution of this issue is in progress. We estimate that it will be resolved for the 2021 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	NE for litter under forest land remaining forest land have been changed to NA	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
4 Land representation	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	No improvement has been made regarding this issue for the 2020 submission. Iceland will take this issue into consideration in future submissions.	LULUCF Chapter
4 Land representation	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	Iceland has improved consistency in CRF table 4.1 between final and initial areas for 2020 submission. However, the improvement made in CRF table 4.1 has produced slight inconsistency between final areas in CRF table 4.1 and corresponding CRF tables on carbon stocks. Iceland will improve this issue in future submissions.	
4 Land representation	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	Resolved	
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 2020 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	FCCC/ARR/2019/ISL/L.8	No improvement has been made regarding this issue for the 2020 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
	explanation in the NIR and in CRF table 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	Iceland replaced the previous used notation key “NE” with notation key "NA" for CSC in mineral soils under forest land remaining forest land. 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 9: "Justification of use of country-specific N2O 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 161 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	There was a forgetfulness error in the text of the NIR 2019. The error has been corrected for the 2020 submission.	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	With regard to Other Land converted to Cropland the Party has improved information on the use of notation key “NO” and “IE” in NIR 2020, as it did during the review (see chapter 6.6.2.2 Methodology).	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 2020 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	The Party is working to improve this issue.	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	With regard to "Revegetation older than 60 years" the Party changed notation key for mineral and organic soil in "NA" for the entire time series 1990-2018.	LULUCF Chapter
4.C.2	The ERT recommends that Iceland revise its CO2 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	With regard to land converted to other wetlands - refilled lakes and ponds the Party has revised notation key in CRF table 4.D.2.3.3.	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	FCCC/ARR/2019/ISL/L.19	Text in chapter 6.8.1.2 (Carbon stock changes in soils) is updated in NIR 2020.	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	wetlands consists of two subcategories (grassland converted to flooded land and other land converted to flooded land) and that CSC in mineral and organic soils are reported separately in the CRF tables.			
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	Recommendation is appreciated. No improvements are made for 2020 submission. However, recommendation is noted and will be included under planned improvements of the category.	LULUCF Chapter
4(II)	The ERT recommends that Iceland correct its N2O emission estimates by using the default N2O EFs from the Wetlands Supplement or provide additional information that supports the use of other N2O 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	This has been implemented	
4 (III)	The ERT recommends that Iceland estimate direct N2O 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	Resolved. Iceland estimated for the first time direct N2O emissions from N mineralization associated with the loss of soil carbon resulting from land converted to settlements from forest land in the 2018 submission since 2004 and reported “NO” for AD and emissions for 1990–2003.	LULUCF Chapter
4(IV)	The ERT recommends that Iceland estimate and report indirect N2O emissions from managed soils, excluding those from	FCCC/ARR/2019/ISL/L.23	With regard to atmospheric deposition and N leaching and run-off in, information regarded notation key "IE" is provided in the	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	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.		documentation box of the CRF table 4(IV).	
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	Information regarding notation keys used for biomass burning in several categories was added to the documentation boxes to the relative categories. Moreover, additional description related to this issue was added in chapter 6.17.1.1 in NIR 2020.	
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	The Party appreciates the recommendation and will take it into consideration for future submissions	
4.C.1 - CO2	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	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 - CO2 and CH4	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 2020 submission. The Party will consider the ERT encouragement for future submissions	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
4(I)	The ERT recommends that Iceland check the EF used for inorganic fertilizers, revise it, if appropriate and report any recalculations made for N2O emissions from inorganic fertilizers on forest land.	FCCC/ARR/2019/ISL/L.28	These errors have been corrected in this year's submission (2020)	
4(II) - CO2, CH4 and N2O	The ERT recommends that Iceland check and revise, if appropriate, the EFs for CO2 and CH4 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	These errors have been corrected in this 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	Link in section "6.6.2.1 Category description" regarded to "area estimates by Icelandic Forest Research" has been updated 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 notation key “IE” where areas have been accounted for elsewhere.	FCCC/ARR/2019/ISL/L.31	With regard notation key "IE" used in CRF table 4.1 for several land transitions, Iceland has not provided additional discussions in sections 6.1 - 6.3 in NIR 2020. Nevertheless, information regarded the use of NK "IE" was added in documentation box of the CRF table 4.1	
4. Land representation – CO2, CH4 and N2O	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	Iceland has improved consistency of national land area across the inventory time series and also between final and initial areas of all land transitions in CRF table 4.1 for 2020 submission. However, the improvement made in CRF table 4.1 has produced slight inconsistency between final areas in CRF table 4.1 and corresponding CRF tables on carbon stocks. Iceland is planning to improve this issue in 2021 submission.	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
4.A – CO2	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	The Party has changed "NE" notation to "NA" notation for litter in FrF.	
4.B.1 – CO2	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	The Party has provided additional information regarding this issue in section 6.6.1.2 Methodology in NIR 2020.	
4.B.2 – CO2	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	The Party has provided additional information to the relative documentation boxes under CRF table 4.B	
4.C – CO2	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	The Party has provided additional information to the relative documentation boxes under CRF table 4.C	
4.C.1 – CO2	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	FCCC/ARR/2019/ISL/L.37	The Party has updated notation keys in "Revegetation older than 60 years" for organic and mineral soils. No additional explanations regarding this issue are provided in NIR 2020	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	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).			
4.D.1 – CO2	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	The Party welcomes the recommendation which will be taken into consideration in future submissions	
4.D.2.2 – CO2 and CH4	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. Nevertheless, as already the Party has indicated during the review, there are major difficulties in gathering data related to this issue. This is not a priority issue. However, Iceland is working to improve this issue for future submissions.	
4(III)– N2O	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	The party has added addition discussions regarding this issue in section 6.6.1.2 in NIR 2020	
4(V) – CO2, CH4 and N2O	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	The Party has improved information regarding this issue in both documentation boxes in CRF tables and in section 6.17.1.1 in NIR 2020	
4(KP)	The ERT recommends that Iceland improve the transparency of its reporting by providing information on how harvesting or forest	FCCC/ARR/2019/ISL/KL.1	This information has been included.	KP-LULUCF Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	disturbance that is followed by the re-establishment of a forest is distinguished from deforestation			
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 2020 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 2020 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 2020 submission. Iceland will take this issue into consideration in future submissions.	KP-LULUCF Chapter
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 2020 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).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.	KP-LULUCF Chapter
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 2020 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 2020 submission. Iceland will take this issue into consideration in future submissions.	
4(KP) Afforestation Reforestation	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	NA has been changed to NO in the HWP pool under AR in CRF table 4(KP-I)C.	
4(KP) Forest managment	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 2020 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
4(KP) revegetation	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 2020 submission. However, survey strategy has currently been revised to address this issue.	
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	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 - CO2	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 - CO2	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	The Party has included this information to NIR2020. See Chapter 6.5 page 155.	
KP - AR – CO2	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	FCCC/ARR/2019/ISL/KL.16	The reference has been corrected in NIR 2020	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	needed (e.g. in this case, extrapolated years should be updated from 2013–2016 to 2013–last reported year).			
KP - AR – CO2	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 N2O	The ERT recommends that the Party report the AD, CSC and related N2O 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" for AD and CSC related to N2O 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.	FCCC/ARR/2019/ISL/KL.18	The Party welcomes the recommendation which will be taken into consideration in future submissions	
KP - FM – CO2	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	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
KP - FM – CO2	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 – CO2	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 welcomes the recommendation which will be taken into consideration in future submissions	
KP - FM – CO2	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	This will be fixed for the 15. April submission.	
KP - HWP – CO2	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	The party has added harvest data to the 4(KP-I) table.	

10.6.5 Waste (CRF Sector 5)

A complete revision of the waste sector was done for the 2018 submission in relation to file structure and the methodology used for the emission estimates. This work has continued for the 2019 submission with more focus on the quality of the data and will continue for the next submission. Following the 2019 Eu Step 2 review, the chapter on Wastewater Treatment and Discharge (5D) was improved for the 2020 submission.

Table 10.11 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: N2O emissions from managed waste disposal sites (5.A.1); N2O emissions from unmanaged waste disposal sites (5.A.2); CO2 emissions from biological treatment of solid waste	FCCC/ARR/2019/ISL/W.1	Notation keys for the relevant categories have been changed; CO2 emissions have been changed to "NO" in accordance with comment W.5 and N2O emissions have been change to "NA". This can be seen in table 7.2. / Done	Waste chapter - 7.1.4 Completeness, table 7.2

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	(5.B); CO2 emissions from domestic wastewater (5.D.1); and CO2 emissions from industrial wastewater (5.D.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 was 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 CO2 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 N2O emissions from composting using the default N2O EF for composting given in the 9th corrigenda for the 2006 IPCC Guidelines.	FCCC/ARR/ 2019/ISL/ W.5	Resolved. Explained in section 7.3.3. of the NIR.	Waste Chapter - Section 7.3.3
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 N2O 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	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

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	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			
5.D.2	The ERT recommends that Iceland correct the use of notation keys in the NIR to report CH4 emissions from industrial wastewater and encourages Iceland to investigate the possibility to report CH4 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 - CO2, CH4 and N2O	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 - CH4	The ERT recommends that the Party document and provide in the NIR all the parameters used in the estimation of CH4 emissions from solid waste disposal and include in its future submissions the population data and waste generation rates used as input data in the IPCC waste model.	FCCC/ARR/ 2019/ISL/ W.12	In progress. Activity data will be included in an annex in the next submission.	
5.A - CH4	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 - CH4	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	FCCC/ARR/ 2019/ISL/ W.14	Resolved. This has been updated in table 7.7. in the NIR.	Table 7.7

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	the information used in its estimation files.			
5.D - CH4	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 - N2O	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

11.1.3.1 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.

11.1.3.2 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.

11.1.3.3 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.

11.1.3.4 Forest management

Forest under Forest Management in KP is defined as all Forest Land that was Forest Land before 1990. The initiation time is set to plantation year of plantations and the estimated age for afforestation through natural expansion. All forest that existed or were formed before 1990 are defined as Forest under Forest Management.

11.1.3.5 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; NBF as estimated in the end of 1989. They are all defined as Forest remaining forest and not in a transitional state; 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). 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 6.4 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 second re-measurement of the CF and the first re-measurement of the NBF started in 2015.

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 1990-2018. 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 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 6.4. 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)) 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 6.4, 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 6.4.

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 third 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[18], 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)). These data were used to estimate C-stock changes in HWP (see above further descriptions in Chapter 6.1).

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 6.4 and above in Chapter 11 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 6.14).

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 2012 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.

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

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 on 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 CO2 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 is 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 was not updated in this year's submission. Further technical correction will be done before the end of the commitment period.

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 third 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)).

Table 11.3 Annual wood production (in m³ on bark) and sawnwood production (in m³) in 1996 to 2017).

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

These data were used to estimate C-stock changes in HWP. Sawnwood is only a small fragment of commercial wood removal. In 2016 only 266 m^3 (6.4%) of 4,182 m^3 of total commercial wood removal were used to produce sawnwood (Gunnarsson & Brynleifsdóttir, 2017). Other HWP than sawnwood are not produced from domestic wood. The report for the year 2018 has not yet been published. In the meantime, the sawnwood amount of 2018 is assumed to be increasing at same trend as the total wood production and by same ratio as the ratio between total wood production and sawnwood production in 2017.

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 1990/2017 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 2018**	**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 2019: 55 EU ETS accounts, thereof 9 Operator holding accounts, 35 Aircraft operator holding accounts, 9 Verifier accounts, 1 National holding account and 1 Party holding account. Iceland's AAUs were 0 tonnes of CO_2e, on December 31, 2019.

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 2019. Iceland´s Standard Electronic Format (SEF) reports for 2019, for the second commitment period, are reported with the CRF data and NIR, and will be made available at the UNFCCC website[19]. Chapter 14 includes information on changes in the national registry.

12.1.1 First Commitment Period - CP1

Decision 14/CP.7 "Impact of single projects on emissions in the commitment period" set a threshold for significant proportional impact of single projects at 5% of total CO_2 emissions of a party in 1990. Projects exceeding this threshold were to be reported separately and CO_2 emissions from them were not included in national totals to the extent that they would have cause the party to exceed its assigned amount. The Government of Iceland notified the Conference of the Parties with a letter, dated October 17th, 2002, of its intention to avail itself of the provisions of Decision 14/CP.7. In small economies such as Iceland, a single project can dominate the changes in emissions from year to year, as can be seen in Iceland's GHG emission profile where for instance clear increases in national totals occurred around 1998 and 2006-2007, where two new aluminium smelters started their operations. When the impact of such projects becomes several times larger than the combined effects of available GHG abatement measures, it becomes very difficult for the party involved to adopt quantified emissions limitations. It does not take a large source to strongly influence the total emissions from Iceland. A single aluminium plant can add more than 15% to the country's total GHG emissions. A plant of the same size would have negligible effect on emissions in most industrialized countries.

The total amount that could be reported separately under Decision 14/CP.7 was set at 8 million tonnes of CO_2. The scope of this was explicitly limited to small economies, defined as economies emitting less than 0.05% of total Annex I CO_2 emissions in 1990. In addition to the criteria above, which relate to the fundamental problem of scale, additional criteria were included that relate to the nature of the project and the emission savings resulting from it. Only projects using renewable

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

energy were eligible, and only where this use of renewable energy resulted in a reduction in GHG emissions per unit of production. The use of best environmental practice (BEP) and best available technology (BAT) was also required. It should be underlined that the decision only applied to CO_2 emissions from industrial processes. Other emissions, such as energy emissions or process emissions of other gases, such as PFCs, were not affected.

The industrial process CO_2 emissions falling under Decision 14/CP.7 could not be transferred by Iceland or acquired by another Party under Articles 6 and 17 of the Kyoto Protocol. If CO_2 emissions were to be reported separately according to the Decision, it would have implied that Iceland would not have be able to transfer assigned amount units to other Parties through international emissions trading.

Iceland fulfilled its commitments under the first commitment period of the Kyoto Protocol by retiring the number of units equal to its accountable emissions.

Iceland´s initial assigned amount for CP1 were 18,523,847 AAUs. Added to that are a total of 1,542,761 RMUs from Art. 3.3 and Art. 3.4 activities and 33,125 AAUs, CERs and ERUs from Joint Implementation Projects, resulting in an available assigned amount of 20,098,931 AAUs.

Emissions from Annex A sources during CP1 were 23,356,066 tonnes CO_2e. This means that Annex A emissions were 3,257,140 tonnes CO_2 in excess of Iceland´s available assigned amount.

Two projects fulfilled the provisions of Decision 14/CP.7 in 2008, 2009, 2010, 2011, and 2012 total CO_2 emissions fulfilling the provisions of Decision 14/CP.7 for the first commitment period under the Kyoto Protocol therefore were 5,913 kt Emissions from Annex A sources during CP1 were 23,356,066 tonnes CO_2e. Emissions with the exception of Decision 14/CP.7 were 17,443,107 tonnes CO_2e.

That means that 3,257,140 tonnes were reported separately under decision 14/CP.7 in December 2015 and not included in national totals. However, Emissions falling under Decision 14/CP.7 were not excluded from national totals in the current report (2018), as Iceland undertook the accounting with respect to the Decision at the end of the commitment period, and the accompanying CRF tables contain Iceland´s Annex A emissions in their entirety.

Table 12.1 and Figure 12.1 show all Kyoto units accounting relevant to the CP1, as well as the emissions for the period.

Table 12.1. Summary of Kyoto accounting for CP1.

		2008	2009	2010	2011	2012	CP1
Initial assigned amount	AAUs	3,704,769	3,704,769	3,704,769	3,704,769	3,704,769	18,523,847
Activity Deforestation Cancelation (Art.3.3)	AAUs					-802	-802
JI Projects	AAUs CERs ERUs					33,125	33,125
Art. 73a international credits	CERs ERUs					102,346	102,346
Art. 73a credits returned	AAUs					-102,346	-102,346
KP-LULUCF Art. 3.3	RMUs	103,428	115,625	135,586	153,426	172,966	681,031
KP-LULUCF Art. 3.4	RMUs	152,293	159,608	171,719	184,453	193,658	861,730
Total RMUs from KP-LULUCF	**RMUs**	**255,721**	**275,233**	**307,305**	**337,879**	**366,624**	**1,542,761**
Available assigned amount	AAUs	3,960,490	3,980,002	4,012,074	4,042,648	4,103,716	20,098,931

		2008	2009	2010	2011	2012	CP1
Emissions from Annex A sources	t 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

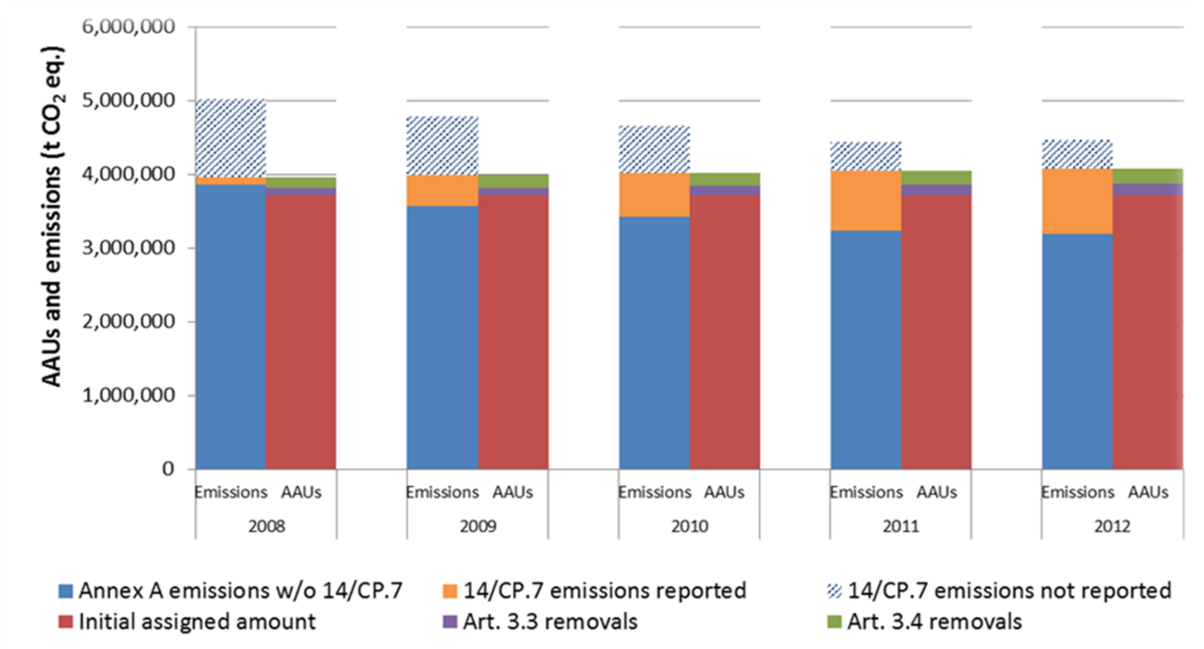

Figure 12.1 Summary of Kyoto accounting for CP1

12.1.2 Second Commitment Period - CP2

The second Commitment Period started 1. January 2013 and will end 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[20]). Iceland does not intend to account for Decision 14/CP.7 on the “Impact of single project on emissions in the commitment period”. No Kyoto Protocol units were requested to be carried over to the second commitment period in accordance with paragraph 49(c) of the annex to decision 13/CMP.1. Calculation of the Commitment Period Reserve (CPR) can be found in chapter 12.5 of this report.

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).

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

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 2019, 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 2019, 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 2019 SEF tables for second commitment period were submitted in March 2020. The Kyoto Protocol party holding account did not hold any units relevant for the second commitment period at the end of reported year 2018.

12.3 Discrepancies and Notifications

No discrepancies or notifications have occurred in relation to Iceland's accounting of Kyoto units in 2019.

Table 12.2 Discrepancies and notifications in 2019.

Annual Submission Item	Reporting Information
15/CMP.1 Annex 1.E paragraph 12: List of discrepant transactions	No discrepant transaction occurred in 2019
15/CMP.1 Annex 1.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2019
15/CMP.1 Annex 1.E paragraph 15: List of non-replacements	No non-replacements occurred in 2019
15/CMP.1 Annex 1.E paragraph 16: List of invalid units	No invalid units exist as of 31 December 2019
15/CMP.1 Annex 1.E paragraph 17: Actions and changes to address discrepancies	No discrepant transactions occurred in 2019

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 (http://www.ust.is/atvinnulif/vidskiptakerfi-esb/skraningarkerfi/) and in English (aimed at foreign account holders in the EU ETS - http://www.ust.is/the-environment-agency-of-iceland/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: http://www.ust.is/the-environment-agency-of-iceland/eu-ets/registry/#Tab3

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:

90% of Iceland's assigned amount
= 0.9 × 15,327,217 tonnes CO_2 equivalent
= 13,794,495 tonnes CO_2 equivalent.

or,

100% of 8 × (the national total in the most recently reviewed inventory)
= 8 × 4,765,830 tonnes CO_2 equivalent
= 38,126,638 tonnes CO_2 equivalent

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 2019.

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 CO2e, as per the Appendix of Annex of Decision 2/CMP.7) and a technical correction (amounting to 76,950 t CO2e) 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 five 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 six years of CP2.

	2013	2014	2015	2016	2017	2018
Article 3.3						
A.1 Afforestation/Reforestation	-182,939	-203,303	-223,663	-242,418	-291,586	-291,635
A.2 Deforestation	155	111	647	269	462	462
Article 3.4						
B.1 Forest Management	-3,725	-7,045	-10,795	-13,592	-14,888	-17,797
B.4 Revegetation	-237,426	-243,968	-251,302	-258,108	-272,998	-289,309
Total RMUs	-423,936	-454,206	-485,113	-513,849	-579,010	-598,280

13 Information on Changes in National System

No changes have been made in the National System since the 2019 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[21] 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)	
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**

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

Article nr.	Comments	Chapter
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 the all 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
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.	

Article nr.	Comments	Chapter
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 til 10	The institutional arrangements have been changed for this inventory cycle, with the main responsibility of data acquisition and emission calculations pertaining to the LULUCF sector now with

Article nr.	Status of implementation
	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. A meeting is planned later in September 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 2019. Note that the 2019 SIAR confirms that previous recommendations have been implemented and included in the annual report.

Table 14.1 Changes in the National Registry in 2019.

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 have been no new EUCR releases after version 8.2.2 (the production version at the time of the last Chapter 14 submission). No change was therefore required to the database and application backup plan or to the disaster recovery plan. The database model is provided in Annex A. 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**	No changes have been introduced since version 8.2.2 of the national registry (Annex B). It is to be noted that each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and are carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) **Change to discrepancies procedures**	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) **Change regarding security**	No changes regarding security occurred during the reported period.
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[22], 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).

[22] www.carbfix.com

	More information can be found in Iceland's Seventh National Communication and Third Biennial Report submitted to the UNFCCC, in particular Tables 7-2 and 7-3.
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

<u>European</u>

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*

<u>National</u> (all in Icelandic)

3/1955 Lög um skógrækt – “Forestry Act”

70/2012 Lög um loftslagsmál – “Climate Act”

62/2015 Lög um breytingu á lögum um loftslagsmál, nr. 70/2012, með síðari breytingum (EES-reglur, geymsla koldíoxíðs, vistvæn ökutæki, Kyoto-bókunin). – “Act amending the Climate Act, no. 70/2012, with subsequent amendments (EEA regulations, storage of carbon dioxide, eco-friendly vehicles, Kyoto Protocol”

48/2007 Lög um breytingu á lögum nr. 87/2003, um Orkustofnun. – “Act amending Act no. 87/2003, on the National Energy Authority”

230/1998 Reglugerð um tiltekin efni sem stuðla að auknum gróðurhúsaáhrifum. – “Regulation on certain substances that contribute to increased greenhouse effect”

851/2002 Reglugerð um grænt bókhald. – “Regulation about Green Accounting”

244/2009 Reglugerð um skil atvinnurekstrar á upplýsingum um losun gróðurhúsalofttegunda. – “Regulation on the provision of information on greenhouse gas emissions to business operators”

834/2010 Reglugerð um flúoraðar gróðurhúsalofttegundir – “Regulation on fluorinated greenhouse gases”

520/2017 Reglugerð um gagnasöfnun og upplýsingagjöf stofnana vegna bókhalds Íslands yfir losun gróðurhúsalofttegunda og bindingu kolefnis úr andrúmslofti. – “Regulation of data collection and reporting of agencies for Icelands accounting of greenhouse gas emissions and carbon sequestration from the atmosphere”

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Annexes to the national inventory report

Annex 1: Key categories

According to the IPCC definition, key categories are those that add up to 95% of the total inventory in level and/or in trend. In the Icelandic Emission Inventory key categories are identified by means of Approach 1 method.

Table 1.2 lists identified key categories. Tables A1, A2 and A3 show the 1990 level, 2018 level and 1990-2018 trend assessment without LULUCF, and Table A4, A5 and A6 show the 1990 level, 2018 level and 1990-2018 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 category code	IPCC category	Gas	1990 Emissions (kt CO_2e)	Level assessment (%)	Cumulative total of level (%)
1A4c	Agriculture/Fishing	CO_2	738	19.8%	19.8%
1A3b	Road Transport	CO_2	520	13.9%	33.7%
2C3	Metal Production - aluminium Production	PFCs	495	13.3%	46.9%
1A2	Manufacturing Industries & Construction	CO_2	362	9.7%	56.6%
3D1	Direct N2O emissions from managed soils	N_2O	224	6.0%	62.6%
2C2	Metal Production - Ferroalloys	CO_2	209	5.6%	68.2%
3A2	Enteric Fermentation - Sheep	CH_4	182	4.9%	73.1%
2C3	Metal Production - aluminium Production	CO_2	139	3.7%	76.8%
5A2	Unmanaged waste disposal sites	CH_4	139	3.7%	80.6%
3A1	Enteric Fermentation - Cattle	CH_4	109	2.9%	83.5%
1B2d	Other emission from Energy Production - Geothermal	CO_2	61	1.6%	85.1%
1A3d	Water - borne Navigation	CO_2	60	1.6%	86.7%
2A1	Cement Production	CO_2	52	1.4%	88.1%
3D2	Indirect N2O emissions from managed soils	N_2O	46	1.2%	89.4%
2B10	Other: Fertilizer production	N_2O	45	1.2%	90.6%
3B11	Manure Management - Cattle	CH_4	33	0.9%	91.5%
3A4 horses	Enteric Fermentation - Horses	CH_4	33	0.9%	92.3%
5D2	Industrial Wastewater Treatment and Discharge	CH_4	32	0.9%	93.2%
1A3a	Domestic Aviation	CO_2	32	0.9%	94.1%
1A4b	Residential	CO_2	31	0.8%	94.9%
5A1	Managed waste disposal sites	CH_4	19	0.5%	95.4%

Table A1. 2 Key category analysis approach 1 level for 2018 in kt CO_2e, excluding LULUCF.

IPCC category code	IPCC category	Gas	2018 Emissions (kt CO_2e)	Level assessment (%)	Cumulative total of level (%)
2C3	Metal Production - aluminium Production	CO_2	1314	27.1%	27.1%
1A3b	Road Transport	CO_2	969	20.0%	47.0%
1A4c	Agriculture/Fishing	CO_2	546	11.2%	58.3%
2C2	Metal Production - Ferroalloys	CO_2	452	9.3%	67.6%
3D1	Direct N2O emissions from managed soils	N_2O	211	4.3%	71.9%
5A1	Managed waste disposal sites	CH_4	190	3.9%	75.8%
2F1	Refrigeration and air conditioning	HFCs	166	3.4%	79.2%
1B2d	Other emission from Energy Production - Geothermal	CO_2	156	3.2%	82.5%
3A2	Enteric Fermentation - Sheep	CH_4	144	3.0%	85.4%
1A2	Manufacturing Industries & Construction	CO_2	138	2.8%	88.3%
3A1	Enteric Fermentation - Cattle	CH_4	124	2.5%	90.8%
2C3	Metal Production - aluminium Production	PFCs	76	1.6%	92.4%
1A3d	Water - borne Navigation	CO_2	43	0.9%	93.3%
3D2	Indirect N2O emissions from managed soils	N_2O	40	0.8%	94.1%
3B11	Manure Management - Cattle	CH_4	33	0.7%	94.8%
3A4 horses	Enteric Fermentation - Horses	CH_4	31	0.6%	95.4%

Table A1. 3 Key category analysis approach 1 1990-2018 trend assessment in kt CO_2e, excluding LULUCF.

IPCC Category code	IPCC Category	Gas	Base Year (1990) Estimate $E_{x,0}$ (kt CO_2e)	Current Year (2018) Estimate $E_{x,t}$ (kt CO_2e)	Trend Assessment $T_{x,t}$	Contribution to Trend (%)	Cumulative Total of trend (%)
2C3	Metal Production - aluminium Production	CO_2	139	1314	0.303	29.1%	29.1%
2C3	Metal Production - aluminium Production	PFCs	495	76	0.152	14.6%	43.7%
1A4c	Agriculture/Fishing	CO_2	738	546	0.111	10.6%	54.3%
1A2	Manufacturing Industries & Construction	CO_2	362	138	0.089	8.5%	62.8%
1A3b	Road Transport	CO_2	520	969	0.079	7.5%	70.4%
2C2	Metal Production - Ferroalloys	CO_2	209	452	0.048	4.6%	75.0%
5A1	Managed waste disposal sites	CH_4	19	190	0.044	4.2%	79.2%
5A2	Unmanaged waste disposal sites	CH_4	139	25	0.042	4.0%	83.3%
3A2	Enteric Fermentation - Sheep	CH_4	182	144	0.025	2.4%	85.6%
3D1	Direct N2O emissions from managed soils	N_2O	224	211	0.022	2.1%	87.7%
1B2d	Other emission from Energy Production - Geothermal	CO_2	61	156	0.021	2.0%	89.7%
2A1	Cement Production	CO_2	52	0	0.018	1.7%	91.4%
2B10	Other: Fertilizer production	N_2O	46	0	0.016	1.6%	93.0%
1A3d	Water - borne Navigation	CO_2	60	43	0.009	0.9%	93.9%
1A4b	Residential	CO_2	31	7	0.009	0.8%	94.7%
5D2	Industrial Wastewater Treatment and Discharge	CH_4	32	22	0.005	0.5%	95.2%

Table A1. 4 Key Category analysis approach 1 Level Assessment for 1990 in kt CO_2e, including LULUCF.

IPCC category code	IPCC category	Gas	1990 Emissions /Removals (kt CO_2e)	Level assessment (%)	Cumulative total of level (%)
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	3251	20.3%	20.3%
4C1	Grassland remaining Grassland	CO_2	3130	19.5%	39.8%
4C2	Land Converted to Grassland	CO_2	1773	11.1%	50.9%
4D1	Wetlands remaining Wetlands	CO_2	1433	8.9%	59.8%
4B1	Cropland remaining Cropland	CO_2	1189	7.4%	67.2%
1A4c	Agriculture/Fishing	CO_2	738	4.6%	71.8%
4B2	Land Converted to Cropland	CO_2	635	4.0%	75.8%
1A3b	Road Transport	CO_2	520	3.2%	79.0%
2C3	Metal Production - aluminium Production	PFCs	495	3.1%	82.1%
4(II) - Grassland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	376	2.3%	84.5%
1A2	Manufacturing Industries & Construction	CO_2	362	2.3%	86.7%
3D1	Direct N2O emissions from managed soils	N_2O	224	1.4%	88.1%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	209	1.3%	89.4%
2C2	Metal Production - Ferroalloys	CO_2	209	1.3%	90.7%
3A2	Enteric Fermentation - Sheep	CH_4	182	1.1%	91.9%
2C3	Metal Production - aluminium Production	CO_2	139	0.9%	92.7%
5A2	Unmanaged waste disposal sites	CH_4	139	0.9%	93.6%
4(II) - Grassland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	111	0.7%	94.3%
3A1	Enteric Fermentation - Cattle	CH_4	109	0.7%	95.0%
4(II) - Cropland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	93	0.6%	95.6%

Table A1. 5 Key category analysis approach 1 level for 2018 in kt CO_2e, including LULUCF

IPCC category code	IPCC category	Gas	2018 Emissions/ Removals (kt CO_2e)	Level assessment (%)	Cumulative total of level (%)
4C1	Grassland remaining Grassland	CO_2	5493	31.6%	31.6%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	3115	17.9%	49.5%
4D1	Wetlands remaining Wetlands	CO_2	1367	7.9%	57.3%
2C3	Metal Production - aluminium Production	CO_2	1314	7.6%	64.9%
4B1	Cropland remaining Cropland	CO_2	1035	5.9%	70.8%
1A3b	Road Transport	CO_2	969	5.6%	76.4%
1A4c	Agriculture/Fishing	CO_2	546	3.1%	79.5%
4(II) - Grassland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	457	2.6%	82.2%
2C2	Metal Production - Ferroalloys	CO_2	452	2.6%	84.8%
4A2	Land converted to Forest Land	CO_2	343	2.0%	86.7%
3D1	Direct N2O emissions from managed soils	N_2O	211	1.2%	87.9%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	200	1.1%	89.1%
5A1	Managed waste disposal sites	CH_4	190	1.1%	90.2%
4C2	Land Converted to Grassland	CO_2	183	1.1%	91.2%
2F1	Refrigeration and air conditioning	HFCs	166	1.0%	92.2%
1B2d	Other emission from Energy Production - Geothermal	CO_2	156	0.9%	93.1%
3A2	Enteric Fermentation - Sheep	CH_4	144	0.8%	93.9%
1A2	Manufacturing Industries & Construction	CO_2	138	0.8%	94.7%
4(II) - Grassland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	135	0.8%	95.5%

Table A1. 6 Key category analysis approach 1 1990-2018 trend assessment in kt CO_2e, including LULUCF.

IPCC Category code	IPCC Category	Gas	Base Year (1990) Estimate $E_{x,0}$ (kt CO_2e)	Current Year (2018) Estimate $E_{x,t}$ (kt CO_2e)	Trend Assessment $T_{x,t}$	Contribution to Trend (%)	Cumulative Total of trend (%)
4C1	Grassland remaining Grassland	CO2	3130	5493	0.131	22.5%	22.5%
4C2	Land Converted to Grassland	CO2	1773	183	0.109	18.7%	41.1%
2C3	Metal Production - aluminium Production	CO2	139	1314	0.073	12.5%	53.6%
4B2	Land Converted to Cropland	CO2	635	91	0.037	6.4%	60.0%
2C3	Metal Production - aluminium Production	PFCs	495	76	0.029	4.9%	65.0%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH4	3251	3115	0.026	4.4%	69.4%
1A3b	Road Transport	CO2	520	969	0.025	4.3%	73.8%
4A2	Land converted to Forest Land	CO2	27	343	0.020	3.4%	77.1%
4B1	Cropland remaining Cropland	CO2	1189	1035	0.016	2.7%	79.9%
1A4c	Agriculture/Fishing	CO2	738	546	0.016	2.7%	82.6%
1A2	Manufacturing Industries & Construction	CO2	362	138	0.016	2.7%	85.3%
2C2	Metal Production - Ferroalloys	CO2	209	452	0.014	2.4%	87.8%
4D1	Wetlands remaining Wetlands	CO2	1433	1367	0.012	2.0%	89.8%
5A1	Managed waste disposal sites	CH4	19	190	0.011	1.8%	91.6%
5A2	Unmanaged waste disposal sites	CH4	139	25	0.008	1.4%	92.9%
1B2d	Other emission from Energy Production - Geothermal	CO2	61	156	0.006	1.0%	93.9%
2A1	Cement Production	CO2	52	0	0.003	0.6%	94.5%
3A2	Enteric Fermentation - Sheep	CH4	182	144	0.003	0.6%	95.1%

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 is done including or excluding LULUCF. When including LULUCF, the overall trend uncertainty estimate for this submission is 19%, whereas the uncertainty in total inventory is 40%. When looking at the uncertainty analysis without LULUCF, the trend uncertainty is 8.7%, and the uncertainty in total inventory is 9.1%.

Table A2. 1 and Table A2. 2 on the next pages show the complete uncertainty assessment, with and without LULUCF, respectively.

Table A2. 1 Uncertainty Analysis including LULUCF

	Gas	1990 emissions (kt CO_2e)	2018 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1A1ai Public electricity and heat production (electricity generation)	CO_2	4.45	2.37	5.0%	5.0%	7.1%	1.6E-10	9.4E-04	1.3E-03	2.7E-08
1A1aiii Public electricity and heat production (heat plants)	CO_2	9.34	0.00	5.0%	5.0%	7.1%	0.0E+00	4.0E-03	0.0E+00	1.6E-07
1A2a Iron and Steel	CO_2	0.36	1.50	1.5%	5.0%	5.2%	3.5E-11	2.2E-04	2.5E-04	1.2E-09
1A2b Non-Ferrous Metals	CO_2	13.50	8.11	1.5%	5.0%	5.2%	1.0E-09	1.2E-03	1.4E-03	3.5E-08
1A2c Chemicals	CO_2	7.43	0.00	5.0%	5.0%	7.1%	0.0E+00	1.6E-03	0.0E+00	2.5E-08
1A2e Food Processing, Beverages and Tobacco	CO_2	128.24	26.05	5.0%	5.0%	7.1%	1.9E-08	2.2E-02	1.5E-02	7.1E-06
1A2f Non-metallic minerals	CO_2	50.32	0.38	5.0%	5.0%	7.1%	4.2E-12	1.1E-02	2.2E-04	1.2E-06
1A2g Other manufacturing industries and Constructions	CO_2	161.82	102.31	5.0%	5.0%	7.1%	3.0E-07	1.4E-02	5.8E-02	3.6E-05
1A3a Domestic Aviation	CO_2	31.73	24.58	5.0%	5.0%	7.1%	1.7E-08	1.9E-03	1.4E-02	2.0E-06
1A3b Road Transport	CO_2	519.50	969.42	5.0%	5.0%	7.1%	2.7E-05	8.4E-02	5.5E-01	3.1E-03
1A3d Domestic Water - borne Navigation	CO_2	59.83	43.33	5.0%	5.0%	7.1%	5.4E-08	4.1E-03	2.5E-02	6.2E-06
1A4a Commercial/Institutional	CO_2	16.24	0.72	5.0%	5.0%	7.1%	1.5E-11	3.4E-03	4.1E-04	1.2E-07
1A4b Residential	CO_2	30.64	7.28	5.0%	5.0%	7.1%	1.5E-09	5.2E-03	4.1E-03	4.5E-07
1A4c Agriculture/Fishing	CO_2	738.31	546.10	5.0%	5.0%	7.1%	8.5E-06	4.9E-02	3.1E-01	9.8E-04
1A5a Other - stationary	CO_2	0.00	1.28	5.0%	5.0%	7.1%	4.7E-11	2.8E-04	7.3E-04	6.0E-09
1B2a5 Oil - Distribution of oil products	CO_2	0.00	0.00	5.0%	5.0%	7.1%	7.1E-16	4.3E-07	2.8E-06	8.1E-14
1B2d Other emission from Energy Production	CO_2	61.36	156.46	10.0%	10.0%	14.1%	2.8E-06	3.9E-02	1.8E-01	3.3E-04
2A1 Cement Production	CO_2	51.56	0.00	2.0%	30.0%	30.1%	0.0E+00	7.1E-02	0.0E+00	5.1E-05
2A4d Other: Mineral Wool Production	CO_2	0.70	0.91	2.4%	2.0%	3.1%	4.5E-12	1.4E-05	2.4E-04	6.0E-10
2B10 Other: Silica production	CO_2	0.36	0.00	5.0%	1.0%	5.1%	0.0E+00	1.7E-05	0.0E+00	2.8E-12
2C1 Metal Production - Iron and steel	CO_2	0.00	0.00	10.0%	25.0%	26.9%	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Gas	1990 emissions (kt CO_2e)	2018 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
2C2 Metal Production - Ferroalloys	CO_2	208.80	452.24	1.5%	3.0%	3.4%	1.3E-06	3.0E-02	7.7E-02	6.8E-05
2C3 Metal Production - Aluminium Production	CO_2	139.21	1313.87	1.5%	3.0%	3.4%	1.1E-05	1.5E-01	2.2E-01	7.3E-04
2D1 Lubricants	CO_2	4.06	2.48	5.0%	50.1%	50.3%	8.9E-09	3.5E-03	1.4E-03	1.4E-07
2D2 Paraffin wax use	CO_2	0.17	0.33	5.0%	100.1%	100.2%	6.1E-10	6.8E-04	1.9E-04	4.9E-09
2D3 Solvents	CO_2	2.53	2.80	2.0%	20.0%	20.1%	1.8E-09	2.2E-04	6.3E-04	4.5E-09
2G4b Other: Fireworks	CO_2	0.00	0.03	11.3%	50.0%	51.3%	1.6E-12	6.1E-05	4.2E-05	5.5E-11
3G Liming	CO_2	0.00	3.89	20.0%	0.0%	20.0%	3.5E-09	0.0E+00	8.8E-03	7.8E-07
3H Urea application	CO_2	0.06	2.53	20.0%	0.0%	20.0%	1.5E-09	0.0E+00	5.7E-03	3.3E-07
5C Incineration and Open Burning of waste	CO_2	7.30	6.15	52.0%	40.0%	65.6%	9.3E-08	2.1E-03	3.6E-02	1.3E-05
1A1ai Public electricity and heat production (electricity generation)	CH_4	0.005	0.002	5.0%	100.0%	100.1%	3.5E-14	9.1E-06	1.4E-06	8.5E-13
1A1aiii Public electricity and heat production (heat plants)	CH_4	0.009	0	5.0%	100.0%	100.1%	0.0E+00	4.0E-05	0.0E+00	1.6E-11
1A2a Iron and Steel	CH_4	0.0004	0.001	1.5%	100.0%	100.0%	6.4E-15	3.1E-06	1.8E-07	9.5E-14
1A2b Non-Ferrous Metals	CH_4	0.012	0.007	1.5%	100.0%	100.0%	3.2E-13	2.2E-05	1.3E-06	4.8E-12
1A2c Chemicals	CH_4	0.007	0	5.0%	100.0%	100.1%	0.0E+00	3.2E-05	0.0E+00	1.0E-11
1A2e Food Processing, Beverages and Tobacco	CH_4	0.124	0.026	5.0%	100.0%	100.1%	3.8E-12	4.4E-04	1.5E-05	1.9E-09
1A2f Non-metallic minerals	CH_4	0.128	0.0004	5.0%	100.0%	100.1%	8.5E-16	5.7E-04	2.2E-07	3.2E-09
1A2g Other manufacturing industries and Constructions	CH_4	0.210	0.141	5.0%	100.0%	100.1%	1.1E-10	3.1E-04	8.0E-05	1.0E-09
1A3a Domestic Aviation	CH_4	0.006	0.004	5.0%	100.0%	100.1%	1.1E-13	5.7E-06	2.4E-06	3.8E-13
1A3b Road Transport	CH_4	5.52	1.47	5.0%	200.0%	200.1%	5.0E-08	3.6E-02	8.4E-04	1.3E-05
1A3d Domestic Water - borne Navigation	CH_4	0.14	0.10	5.0%	100.0%	100.1%	5.8E-11	1.7E-04	5.7E-05	3.3E-10
1A4a Commercial/Institutional	CH_4	1.01	0.002	5.0%	100.0%	100.1%	2.5E-14	4.4E-03	1.2E-06	2.0E-07
1A4b Residential	CH_4	0.10	0.02	5.0%	100.0%	100.1%	1.9E-12	3.7E-04	1.0E-05	1.4E-09

	Gas	1990 emissions (kt CO_2e)	2018 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	CH_4	1.73	1.28	5.0%	100.0%	100.1%	9.4E-09	2.0E-03	7.3E-04	4.7E-08
1A5a Other - stationary	CH_4	0	0.0015	5.0%	100.0%	100.1%	1.2E-14	6.4E-06	8.2E-07	4.2E-13
1B2a5 Oil - Distribution of oil products	CH_4	0.49	0.79	5.0%	100.0%	100.1%	3.6E-09	1.3E-03	4.5E-04	2.0E-08
1B2d Other emission from Energy Production	CH_4	0.20	2.53	10.0%	25.0%	26.9%	2.6E-09	2.6E-03	2.9E-03	1.5E-07
2C2 Metal Production - Ferroalloys	CH_4	1.57	3.16	1.5%	100.0%	100.0%	5.7E-08	7.0E-03	5.4E-04	4.9E-07
2G4a Other: Tobacco combustion	CH_4	0.045	0.019	11.3%	50.0%	51.3%	5.4E-13	5.7E-05	2.4E-05	3.9E-11
2G4b Other: Fireworks	CH_4	0.002	0.016	11.3%	50.0%	51.3%	3.7E-13	2.9E-05	2.0E-05	1.3E-11
3A1 Enteric Fermentation - Cattle	CH_4	109.49	123.58	5.0%	40.0%	40.3%	1.4E-05	2.4E-02	7.0E-02	5.5E-05
3A2 Enteric Fermentation - Sheep	CH_4	181.95	143.92	5.0%	40.0%	40.3%	1.9E-05	6.9E-02	8.2E-02	1.1E-04
3A3 Enteric Fermentation - Swine	CH_4	1.12	1.51	20.0%	40.0%	44.7%	2.6E-09	6.9E-04	3.4E-03	1.2E-07
3A4 goats Enteric Fermentation - Goats	CH_4	0.06	0.27	20.0%	40.0%	44.7%	8.5E-11	3.8E-04	6.2E-04	5.2E-09
3A4 horses Enteric Fermentation - Horses	CH_4	33.24	31.37	20.0%	40.0%	44.7%	1.1E-06	3.7E-03	7.1E-02	5.1E-05
3A4 other Enteric Fermentation - other - Fur animals	CH_4	0.12	0.05	20.0%	40.0%	44.7%	2.7E-12	1.4E-04	1.1E-04	3.1E-10
3A4 poultry Enteric Fermentation - Poultry	CH_4	0.34	0.44	20.0%	40.0%	44.7%	2.2E-10	1.7E-04	9.9E-04	1.0E-08
3B11 Manure Management - Cattle	CH_4	32.93	32.76	11.2%	20.0%	22.9%	3.2E-07	3.2E-04	4.2E-02	1.7E-05
3B12 Manure Management - Sheep	CH_4	15.28	11.93	25.5%	20.0%	32.4%	8.5E-08	3.1E-03	3.5E-02	1.2E-05
3B13 Manure Management - Swine	CH_4	4.47	6.04	20.0%	30.0%	36.1%	2.7E-08	2.1E-03	1.4E-02	1.9E-06
3B14 goats Manure Management - Goats	CH_4	0.001	0.007	20.0%	30.0%	36.1%	3.2E-14	6.8E-06	1.5E-05	2.7E-12
3B14 horses Manure Management - Horses	CH_4	2.01	1.90	20.0%	30.0%	36.1%	2.7E-09	1.7E-04	4.3E-03	1.9E-07
3B14 other Manure Management - other - Fur animals	CH_4	0.82	0.33	20.0%	30.0%	36.1%	8.1E-11	6.6E-04	7.5E-04	1.0E-08

	Gas	1990 emissions (kt CO_2e)	2018 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
3B14 poultry Manure Management - Poultry	CH_4	3.54	3.90	20.0%	30.0%	36.1%	1.1E-08	4.6E-04	8.9E-03	7.9E-07
5A1 Managed waste disposal sites	CH_4	18.89	189.63	52.0%	40.3%	65.8%	8.9E-05	3.1E-01	1.1E+00	1.3E-02
5A2 Unmanaged waste disposal sites	CH_4	138.95	24.71	52.0%	40.3%	65.8%	1.5E-06	2.1E-01	1.5E-01	6.4E-04
5B Biological treatment of solid waste	CH_4	0	2.40	52.0%	100.0%	112.7%	4.2E-08	1.1E-02	1.4E-02	3.2E-06
5C Incineration and Open Burning of waste	CH_4	6.09	0.35	52.0%	100.0%	112.7%	8.9E-10	2.6E-02	2.1E-03	6.8E-06
5D Wastewater Treatment and Discharge	CH_4	50.00	45.34	38.7%	58.3%	70.0%	5.8E-06	1.3E-02	2.0E-01	4.0E-04
1A1ai Public electricity and heat production (electricity generation)	N_2O	0.011	0.006	5.0%	100.0%	100.1%	2.0E-13	2.2E-05	3.3E-06	5.1E-12
1A1aiii Public electricity and heat production (heat plants)	N_2O	0.022	0	5.0%	100.0%	100.1%	0.0E+00	9.8E-05	0.0E+00	9.6E-11
1A2a Iron and Steel	N_2O	0.001	0.002	1.5%	100.0%	100.0%	2.7E-14	6.0E-06	3.7E-07	3.6E-13
1A2b Non-Ferrous Metals	N_2O	0.029	0.017	1.5%	100.0%	100.0%	1.7E-12	5.2E-05	3.0E-06	2.8E-11
1A2c Chemicals	N_2O	0.017	0	5.0%	100.0%	100.1%	0.0E+00	7.8E-05	0.0E+00	6.1E-11
1A2e Food Processing, Beverages and Tobacco	N_2O	0.296	0.062	5.0%	100.0%	100.1%	2.2E-11	1.1E-03	3.5E-05	1.1E-08
1A2f Non-metallic minerals	N_2O	0.23	0.0009	5.0%	100.0%	100.1%	4.9E-15	1.0E-03	5.2E-07	1.1E-08
1A2g Other manufacturing industries and Constructions	N_2O	14.01	11.53	5.0%	100.0%	100.1%	7.6E-07	1.1E-02	6.5E-03	1.7E-06
1A3a Domestic Aviation	N_2O	0.27	0.21	5.0%	200.0%	200.1%	9.6E-10	5.6E-04	1.2E-04	3.2E-09
1A3b Road Transport	N_2O	5.20	7.70	5.0%	200.0%	200.1%	1.4E-06	2.2E-02	4.4E-03	5.2E-06
1A3d Domestic Water - borne Navigation	N_2O	0.47	0.34	5.0%	200.0%	200.1%	2.7E-09	1.2E-03	1.9E-04	1.5E-08
1A4a Commercial/Institutional	N_2O	0.171	0.001	5.0%	100.0%	100.1%	9.3E-15	7.7E-04	7.2E-07	6.0E-09
1A4b Residential	N_2O	0.072	0.008	5.0%	100.0%	100.1%	4.1E-13	2.9E-04	4.8E-06	8.3E-10
1A4c Agriculture/Fishing	N_2O	5.91	4.36	5.0%	200.0%	200.1%	4.3E-07	1.4E-02	2.5E-03	2.1E-06
1A5a Other - stationary	N_2O	0	0.003	5.0%	100.0%	100.1%	4.0E-14	1.2E-05	1.5E-06	1.5E-12

	Gas	1990 emissions (kt CO_2e)	2018 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 (%)
2B10 Other: Ferilizer production	N_2O	46.49	0	5.0%	40.0%	40.3%	0.0E+00	8.5E-02	0.0E+00	7.2E-05
2G3a Other Product Manufacture and Use - Medical Applications	N_2O	5.30	2.04	6.0%	5.0%	7.8%	1.5E-10	7.5E-04	1.4E-03	2.5E-08
2G3b Other Product Manufacture and Use - Other N_2O use	N_2O	0.72	0.44	6.0%	5.0%	7.8%	6.7E-12	6.5E-05	3.0E-04	9.3E-10
2G4a Other: Tobacco combustion	N_2O	0.011	0.005	11.3%	50.0%	51.3%	3.1E-14	1.4E-05	5.8E-06	2.3E-12
2G4b Other: Fireworks	N_2O	0.07	0.44	11.3%	50.0%	51.3%	2.9E-10	8.5E-04	5.6E-04	1.0E-08
3B11 Manure Management - Cattle	N_2O	0.77	0.79	44.4%	100.0%	109.4%	4.3E-09	7.9E-05	4.0E-03	1.6E-07
3B12 Manure Management - Sheep	N_2O	10.99	8.62	51.7%	100.0%	112.6%	5.4E-07	1.1E-02	5.1E-02	2.7E-05
3B14 goats Manure Management - Goats	N_2O	0.016	0.070	48.4%	100.0%	111.1%	3.5E-11	2.5E-04	3.9E-04	2.1E-09
3B14 horses Manure Management - Horses	N_2O	0.65	0.63	53.2%	100.0%	113.3%	2.9E-09	1.3E-04	3.8E-03	1.5E-07
3B14 other Manure Management - other - Fur animals	N_2O	0.111	0.037	47.6%	100.0%	110.7%	9.5E-12	3.4E-04	2.0E-04	1.6E-09
3B14 poultry Manure Management - Poultry	N_2O	0.36	0.23	43.8%	100.0%	109.2%	3.7E-10	6.0E-04	1.2E-03	1.7E-08
3B25 Indirect N_2O emissions (from manure management)	N_2O	10.61	9.17	100.0%	500.0%	509.9%	1.2E-05	3.4E-02	1.0E-01	1.2E-04
3D11 Inorganic N Fertilizers Inorganic N fertilizers	N_2O	58.41	54.99	20.0%	300.0%	300.7%	1.6E-04	5.2E-02	1.2E-01	1.8E-04
3D12 a. Animal Manure Applied to Soils Animal manure applied to soils	N_2O	37.09	32.03	56.1%	300.0%	305.2%	5.5E-05	7.2E-02	2.0E-01	4.7E-04
3D13 Urine and dung Deposited by Grazing Animals Urine and dung deposited by grazing animals	N_2O	47.86	42.43	59.4%	350.0%	355.0%	1.3E-04	9.2E-02	2.9E-01	9.0E-04
3D14 Crop Residues Crop residues	N_2O	0.068	0.051	200.0%	300.0%	360.6%	1.9E-10	2.4E-04	1.2E-03	1.4E-08

	Gas	1990 emissions (kt CO_2e)	2018 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 (%)
3D16 Cultivation of Organic Soils Cultivation of organic soils (i.e. histosols)	N_2O	80.83	81.01	20.0%	25.0%	32.0%	3.8E-06	4.5E-04	1.8E-01	3.4E-04
3D21 Atmospheric Deposition Atmospheric deposition	N_2O	13.69	12.31	56.2%	500.0%	503.1%	2.2E-05	3.4E-02	7.8E-02	7.3E-05
3D22 Nitrogen Leaching and Run-off Nitrogen leaching and run-off	N_2O	31.38	28.07	333.3%	500.0%	600.9%	1.6E-04	8.1E-02	1.1E+00	1.1E-02
5B Biological treatment of solid waste	N_2O	0	1.72	52.0%	150.0%	158.7%	4.2E-08	1.2E-02	1.0E-02	2.4E-06
5C Incineration and Open Burning of waste	N_2O	1.67	0.33	52.0%	100.0%	112.7%	7.7E-10	6.3E-03	1.9E-03	4.3E-07
5D Wastewater Treatment and Discharge	N_2O	4.58	5.74	38.7%	0.0%	38.7%	2.8E-08	0.0E+00	2.5E-02	6.4E-06
2C3 Metal Production - aluminium Production	PFCs	494.64	76.39	0.015	0.03	3.35%	3.7E-08	5.8E-02	1.3E-02	3.6E-05
2F1a Commercial refrigeration	HFCs	0	26.01	200.0%	100.0%	223.6%	1.9E-05	1.2E-01	5.9E-01	3.6E-03
2F1a Commercial refrigeration	PFCs	0	0.007	200.0%	0.0%	200.0%	1.0E-12	0.0E+00	1.5E-04	2.3E-10
2F1b Domestic refrigeration	HFCs	0	0.043	500.0%	67.0%	504.5%	2.7E-10	1.4E-04	2.4E-03	6.0E-08
2F1c Industrial refrigeration	HFCs	0	28.14	100.0%	150.0%	180.3%	1.5E-05	2.0E-01	3.2E-01	1.4E-03
2F1c Industrial refrigeration	PFCs	0	0.007	100.0%	0.0%	100.0%	2.6E-13	0.0E+00	7.7E-05	5.9E-11
2F1d Transport refrigeration	HFCs	0	81.65	100.0%	100.0%	141.4%	7.6E-05	3.9E-01	9.3E-01	1.0E-02
2F1d Transport refrigeration	PFCs	0	0.039	100.0%	0.0%	100.0%	8.5E-12	0.0E+00	4.4E-04	1.9E-09
2F1e Mobile air-conditioning	HFCs	0	29.13	100.0%	100.0%	141.4%	9.7E-06	1.4E-01	3.3E-01	1.3E-03
2F1f Stationary air-conditioning	HFCs	0	1.31	200.0%	100.0%	223.6%	4.9E-08	6.2E-03	3.0E-02	9.3E-06
2F4 Product Uses as Substitutes for ODS -Aerosols	HFCs	0.35	0.93	5.0%	5.0%	7.1%	2.5E-11	1.4E-04	5.3E-04	3.0E-09
2G1 Other Product Manufacture and Use - Electrical equipment	SF_6	1.10	3.26	30.0%	30.0%	42.4%	1.1E-08	3.0E-03	1.1E-02	1.3E-06
4A1 Forest land remaining forest land	CO_2	-15.61	-34.16	14.0%	10.0%	17.2%	2.0E-07	8.6E-03	5.4E-02	3.0E-05
4A2 Land converted to forest land	CO_2	-27.22	-353.78	5.0%	10.0%	11.2%	8.9E-06	1.5E-01	2.0E-01	6.4E-04

	Gas	1990 emissions (kt CO_2e)	2018 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 (%)
4A Forest land	N_2O	0.13	0.90	5.0%	400.0%	400.0%	7.4E-08	1.4E-02	5.1E-04	2.1E-06
4B1 Cropland remaining Cropland	CO_2	1189.05	1034.96	20.0%	90.0%	92.2%	5.2E-03	8.3E-01	2.3E+00	6.2E-02
4B2 Land converted to Cropland	CO_2	634.84	90.95	20.0%	90.0%	92.2%	4.0E-05	2.6E+00	2.1E-01	6.6E-02
4C1 Wetland drained for more than 20 years	CO_2	3080.97	5227.64	20.0%	90.0%	92.2%	1.3E-01	8.9E+00	1.2E+01	2.2E+00
4C1 All other remaining Grassland	CO_2	49.25	265.48	20.0%	20.0%	28.3%	3.2E-05	2.7E-01	6.0E-01	4.3E-03
4C21/2/3/4 All other conversion to Grassland	CO_2	2122.62	821.25	20.0%	90.0%	92.2%	3.3E-03	6.5E+00	1.9E+00	4.6E-01
4C25 Other land converted to Grassland, revegetation	CO_2	-349.98	-638.44	30.0%	25.0%	39.1%	3.6E-04	4.9E-01	2.2E+00	5.0E-02
4D Wetlands	CO_2	-1224.01	-1161.25	20.0%	50.0%	53.9%	2.2E-03	4.1E-01	2.6E+00	7.1E-02
4D Wetlands	CH_4	3250.71	3115.12	20.0%	50.0%	53.9%	1.6E-02	8.3E-01	7.1E+00	5.1E-01
4E Settlements	CO_2	24.47	6.26	5.0%	10.0%	11.2%	2.8E-09	1.6E-02	3.6E-03	2.6E-06
Total emissions		**12,468.10**	**13,232.41**							
Total Uncertainties						**% Uncertainty in total inventory (including LULUCF):**	**40%**		**Trend uncertainty:**	**18.6%**

Table A2. 2 Uncertainty Analysis excluding LULUCF

IPCC Category	Gas	1990 emissions (kt CO_2e)	2018 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1A1ai Public electricity and heat production (electricity generation)	CO_2	4.45	2.37	5.0%	5.0%	7.1%	1.19E-09	4.6E-03	4.5E-03	4.1E-07
1A1aiii Public electricity and heat production (heat plants)	CO_2	9.34	0	5.0%	5.0%	7.1%	0.00E+00	1.6E-02	0.0E+00	2.7E-06
1A2a Iron and Steel	CO_2	0.36	1.50	1.5%	5.0%	5.2%	2.59E-10	6.9E-04	8.5E-04	1.2E-08
1A2b Non-Ferrous Metals	CO_2	13.50	8.11	1.5%	5.0%	5.2%	7.60E-09	6.4E-03	4.6E-03	6.2E-07
1A2c Chemicals	CO_2	7.43	0	5.0%	5.0%	7.1%	0.00E+00	6.5E-03	0.0E+00	4.2E-07
1A2e Food Processing, Beverages and Tobacco	CO_2	128.24	26.05	5.0%	5.0%	7.1%	1.44E-07	9.5E-02	4.9E-02	1.1E-04
1A2f Non-metallic minerals	CO_2	50.32	0.38	5.0%	5.0%	7.1%	3.08E-11	4.5E-02	7.2E-04	2.1E-05
1A2g Other manufacturing industries and Constructions	CO_2	161.82	102.31	5.0%	5.0%	7.1%	2.22E-06	7.8E-02	1.9E-01	4.4E-04
1A3a Domestic Aviation	CO_2	31.73	24.58	5.0%	5.0%	7.1%	1.28E-07	1.3E-02	4.7E-02	2.3E-05
1A3b Road Transport	CO_2	519.50	969.42	5.0%	5.0%	7.1%	1.99E-04	1.9E-01	1.8E+00	3.4E-02
1A3d Domestic Water - borne Navigation	CO_2	59.83	43.33	5.0%	5.0%	7.1%	3.98E-07	2.7E-02	8.2E-02	7.5E-05
1A4a Commercial/Institutional	CO_2	16.24	0.72	5.0%	5.0%	7.1%	1.10E-10	1.6E-02	1.4E-03	2.6E-06
1A4b Residential	CO_2	30.64	7.28	5.0%	5.0%	7.1%	1.12E-08	2.6E-02	1.4E-02	8.5E-06
1A4c Agriculture/Fishing	CO_2	738.31	546.10	5.0%	5.0%	7.1%	6.32E-05	3.4E-01	1.0E+00	1.2E-02
1A5a Other - Stationary	CO_2	0	0.68	5.0%	5.0%	7.1%	3.47E-10	1.1E-03	2.4E-03	7.1E-08
1B2a5 Oil - Distribution of oil products	CO_2	0.003	0.005	5.0%	5.0%	7.1%	5.25E-15	9.0E-07	9.4E-06	9.0E-13
1B2d Other emission from Energy Production	CO_2	61.36	156.46	10.0%	10.0%	14.1%	2.07E-05	1.2E-01	5.9E-01	3.7E-03
2A1 Cement Production	CO_2	51.56	0	2.0%	30.0%	30.1%	0.00E+00	3.8E-01	0.0E+00	1.5E-03
2A4d Other: Mineral Wool Production	CO_2	0.70	0.91	2.4%	2.0%	3.1%	3.35E-11	2.5E-05	8.1E-04	6.6E-09
2B10 Other: Silica production	CO_2	0.36	0	5.0%	1.0%	5.1%	0.00E+00	9.1E-05	0.0E+00	8.2E-11
2C1 Metal Production - Iron and steel	CO_2	0	0	10.0%	25.0%	26.9%	0.00E+00	0.0E+00	0.0E+00	0.0E+00

IPCC Category	Gas	1990 emissions (kt CO_2e)	2018 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
2C2 Metal Production - Ferroalloys	CO_2	208.80	452.24	1.5%	3.0%	3.4%	9.75E-06	8.6E-02	2.6E-01	7.3E-04
2C3 Metal Production - aluminium Production	CO_2	139.21	1313.87	1.5%	3.0%	3.4%	8.23E-05	6.3E-01	7.5E-01	9.5E-03
2D1 Lubricants	CO_2	4.06	2.48	5.0%	50.1%	50.3%	6.60E-08	2.1E-02	4.7E-03	4.7E-06
2D2 Paraffin wax use	CO_2	0.17	0.33	5.0%	100.1%	100.2%	4.56E-09	2.4E-03	6.2E-04	6.3E-08
2D3 Solvents	CO_2	2.53	2.80	2.0%	20.0%	20.1%	1.34E-08	5.2E-04	2.1E-03	4.8E-08
2G4b Other: Fireworks	CO_2	0.005	0.033	11.3%	50.0%	51.3%	1.20E-11	2.6E-04	1.4E-04	8.7E-10
3G Liming	CO_2	0	3.89	20.0%	0.0%	20.0%	2.56E-08	0.0E+00	2.9E-02	8.7E-06
3H Urea application	CO_2	0.06	2.53	20.0%	0.0%	20.0%	1.08E-08	0.0E+00	1.9E-02	3.7E-06
5C Incineration and Open Burning of waste	CO_2	7.30	6.15	52.0%	40.0%	65.6%	6.89E-07	1.8E-02	1.2E-01	1.5E-04
1A1ai Public electricity and heat production (electricity generation)	CH_4	0.005	0.002	5.0%	100.0%	100.1%	2.56E-13	5.3E-05	4.7E-06	2.8E-11
1A1aiii Public electricity and heat production (heat plants)	CH_4	0.009	0	5.0%	100.0%	100.1%	0.00E+00	2.0E-04	0.0E+00	4.0E-10
1A2a Iron and Steel	CH_4	0.0004	0.0011	1.5%	100.0%	100.0%	4.76E-14	1.2E-05	6.0E-07	1.5E-12
1A2b Non-Ferrous Metals	CH_4	0.012	0.007	1.5%	100.0%	100.0%	2.37E-12	1.3E-04	4.3E-06	1.7E-10
1A2c Chemicals	CH_4	0.0072	0	5.0%	100.0%	100.1%	0.00E+00	1.6E-04	0.0E+00	2.6E-10
1A2e Food Processing, Beverages and Tobacco	CH_4	0.12	0.03	5.0%	100.0%	100.1%	2.85E-11	2.3E-03	4.9E-05	5.1E-08
1A2f Non-metallic minerals	CH_4	0.1282	0.0004	5.0%	100.0%	100.1%	6.34E-15	2.8E-03	7.3E-07	8.0E-08
1A2g Other manufacturing industries and Constructions	CH_4	0.21	0.14	5.0%	100.0%	100.1%	8.46E-10	1.9E-03	2.7E-04	3.9E-08
1A3a Domestic Aviation	CH_4	0.006	0.004	5.0%	100.0%	100.1%	7.86E-13	4.1E-05	8.1E-06	1.8E-11
1A3b Road Transport	CH_4	5.52	1.47	5.0%	200.0%	200.1%	3.69E-07	1.9E-01	2.8E-03	3.5E-04
1A3d Domestic Water - borne Navigation	CH_4	0.14	0.10	5.0%	100.0%	100.1%	4.31E-10	1.2E-03	1.9E-04	1.4E-08
1A4a Commercial/Institutional	CH_4	1.006	0.002	5.0%	100.0%	100.1%	1.87E-13	2.2E-02	4.0E-06	5.0E-06
1A4b Residential	CH_4	0.102	0.018	5.0%	100.0%	100.1%	1.38E-11	1.9E-03	3.4E-05	3.7E-08

IPCC Category	Gas	1990 emissions (kt CO_2e)	2018 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	CH_4	1.73	1.28	5.0%	100.0%	100.1%	6.95E-08	1.4E-02	2.4E-03	2.0E-06
1A5a Other - Stationary	CH_4	0	0.0008	5.0%	100.0%	100.1%	8.94E-14	2.8E-05	2.7E-06	7.8E-12
1B2a5 Oil - Distribution of oil products	CH_4	0.49	0.79	5.0%	100.0%	100.1%	2.65E-08	4.3E-03	1.5E-03	2.1E-07
1B2d Other emission from Energy Production	CH_4	0.20	2.53	10.0%	25.0%	26.9%	1.96E-08	1.1E-02	9.6E-03	2.1E-06
2C2 Metal Production - Ferroalloys	CH_4	1.57	3.16	1.5%	100.0%	100.0%	4.23E-07	2.6E-02	1.8E-03	6.6E-06
2G4a Other: Tobacco combustion	CH_4	0.045	0.019	11.3%	50.0%	51.3%	3.98E-12	3.2E-04	8.1E-05	1.1E-09
2G4b Other: Fireworks	CH_4	0.002	0.016	11.3%	50.0%	51.3%	2.73E-12	1.2E-04	6.7E-05	2.0E-10
3A1 Enteric Fermentation - Cattle	CH_4	109.49	123.58	5.0%	40.0%	40.3%	1.05E-04	2.5E-02	2.3E-01	5.5E-04
3A2 Enteric Fermentation - Sheep	CH_4	181.95	143.92	5.0%	40.0%	40.3%	1.43E-04	5.3E-01	2.7E-01	3.5E-03
3A3 Enteric Fermentation - Swine	CH_4	1.12	1.51	20.0%	40.0%	44.7%	1.93E-08	1.6E-03	1.1E-02	1.3E-06
3A4 goats Enteric Fermentation - Goats	CH_4	0.06	0.27	20.0%	40.0%	44.7%	6.28E-10	1.6E-03	2.1E-03	6.9E-08
3A4 horses Enteric Fermentation - Horses	CH_4	33.24	31.37	20.0%	40.0%	44.7%	8.34E-06	6.2E-02	2.4E-01	6.0E-04
3A4 other Enteric Fermentation - other - Fur animals	CH_4	0.12	0.05	20.0%	40.0%	44.7%	2.01E-11	7.9E-04	3.7E-04	7.7E-09
3A4 poultry Enteric Fermentation - Poultry	CH_4	0.34	0.44	20.0%	40.0%	44.7%	1.63E-09	3.3E-04	3.3E-03	1.1E-07
3B11 Manure Management - Cattle	CH_4	32.93	32.76	11.2%	20.0%	22.9%	2.39E-06	2.4E-02	1.4E-01	2.0E-04
3B12 Manure Management - Sheep	CH_4	15.28	11.93	25.5%	20.0%	32.4%	6.34E-07	2.5E-02	1.2E-01	1.4E-04
3B13 Manure Management - Swine	CH_4	4.47	6.04	20.0%	30.0%	36.1%	2.01E-07	4.9E-03	4.6E-02	2.1E-05
3B14 goats Manure Management - Goats	CH_4	0.001	0.007	20.0%	30.0%	36.1%	2.35E-13	3.0E-05	4.9E-05	3.3E-11
3B14 horses Manure Management - Horses	CH_4	2.01	1.90	20.0%	30.0%	36.1%	1.99E-08	2.9E-03	1.4E-02	2.2E-06
3B14 other Manure Management - other - Fur animals	CH_4	0.82	0.33	20.0%	30.0%	36.1%	5.99E-10	3.9E-03	2.5E-03	2.2E-07

IPCC Category	Gas	1990 emissions (kt CO_2e)	2018 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
3B14 poultry Manure Management - Poultry	CH_4	3.54	3.90	20.0%	30.0%	36.1%	8.39E-08	1.7E-03	3.0E-02	8.8E-06
5A1 Managed waste disposal sites	CH_4	18.89	189.63	52.0%	40.3%	65.8%	6.59E-04	1.4E+00	3.7E+00	1.6E-01
5A2 Unmanaged waste disposal sites	CH_4	138.95	24.71	52.0%	40.3%	65.8%	1.12E-05	1.1E+00	4.9E-01	1.5E-02
5B Biological treatment of solid waste	CH_4	0	2.40	52.0%	100.0%	112.7%	3.10E-07	5.1E-02	4.7E-02	4.9E-05
5C Incineration and Open Burning of waste	CH_4	6.09	0.35	52.0%	100.0%	112.7%	6.58E-09	1.5E-01	6.9E-03	2.1E-04
5D Wastewater Treatment and Discharge	CH_4	50.00	45.34	38.7%	58.3%	70.0%	4.27E-05	1.7E-01	6.7E-01	4.7E-03
1A1ai Public electricity and heat production (electricity generation)	N_2O	0.011	0.006	5.0%	100.0%	100.1%	1.46E-12	1.5E-04	1.1E-05	2.2E-10
1A1aiii Public electricity and heat production (heat plants)	N_2O	0.022	0	5.0%	100.0%	100.1%	0.00E+00	5.5E-04	0.0E+00	3.0E-09
1A2a Iron and Steel	N_2O	0.001	0.002	1.5%	100.0%	100.0%	2.01E-13	2.5E-05	1.2E-06	6.4E-12
1A2b Non-Ferrous Metals	N_2O	0.029	0.017	1.5%	100.0%	100.0%	1.30E-11	3.6E-04	9.9E-06	1.3E-09
1A2c Chemicals	N_2O	0.017	0	5.0%	100.0%	100.1%	0.00E+00	4.4E-04	0.0E+00	1.9E-09
1A2e Food Processing, Beverages and Tobacco	N_2O	0.30	0.06	5.0%	100.0%	100.1%	1.62E-10	6.2E-03	1.2E-04	3.9E-07
1A2f Non-metallic minerals	N_2O	0.23	0.0009	5.0%	100.0%	100.1%	3.60E-14	5.9E-03	1.7E-06	3.4E-07
1A2g Other manufacturing Industries and Constructions	N_2O	14.01	11.53	5.0%	100.0%	100.1%	5.65E-06	1.1E-01	2.2E-02	1.2E-04
1A3a Domestic Aviation	N_2O	0.27	0.21	5.0%	200.0%	200.1%	7.14E-09	4.7E-03	3.9E-04	2.2E-07
1A3b Road Transport	N_2O	5.20	7.70	5.0%	200.0%	200.1%	1.01E-05	6.9E-02	1.5E-02	5.0E-05
1A3d Domestic Water - borne Navigation	N_2O	0.47	0.34	5.0%	200.0%	200.1%	2.00E-08	9.3E-03	6.5E-04	8.7E-07
1A4a Commercial/ Institutional	N_2O	0.17	0.001	5.0%	100.0%	100.1%	6.88E-14	4.3E-03	2.4E-06	1.9E-07
1A4b Residential	N_2O	0.072	0.008	5.0%	100.0%	100.1%	3.02E-12	1.7E-03	1.6E-05	2.7E-08
1A4c Agriculture/ Fishing	N_2O	5.91	4.36	5.0%	200.0%	200.1%	3.22E-06	1.1E-01	8.3E-03	1.3E-04
1A5a Other - Stationary	N_2O	0	0.0012	5.0%	100.0%	100.1%	2.96E-13	5.8E-05	5.0E-06	3.3E-11

IPCC Category	Gas	1990 emissions (kt CO_2e)	2018 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 (%)
2B10 Other: Fertilizer production	N_2O	46.49	0.00	5.0%	40.0%	40.3%	0.00E+00	4.8E-01	0.0E+00	2.3E-03
2G3a Other Product Manufacture and Use - Medical Applications	N_2O	5.30	2.04	6.0%	5.0%	7.8%	1.08E-09	4.7E-03	4.7E-03	4.4E-07
2G3b Other Product Manufacture and Use - Other N_2O use	N_2O	0.72	0.44	6.0%	5.0%	7.8%	4.95E-11	4.6E-04	1.0E-03	1.2E-08
2G4a Other: Tobacco combustion	N_2O	0.011	0.005	11.3%	50.0%	51.3%	2.28E-13	9.0E-05	1.9E-05	8.6E-11
2G4b Other: Fireworks	N_2O	0.07	0.44	11.3%	50.0%	51.3%	2.14E-09	4.0E-03	1.9E-03	1.9E-07
3B11 Manure Management - Cattle	N_2O	0.77	0.79	44.4%	100.0%	109.4%	3.20E-08	2.7E-03	1.3E-02	1.9E-06
3B12 Manure Management - Sheep	N_2O	10.99	8.62	51.7%	100.0%	112.6%	4.00E-06	9.8E-02	1.7E-01	3.8E-04
3B14 goats Manure Management - Goats	N_2O	0.02	0.07	48.4%	100.0%	111.1%	2.59E-10	1.1E-03	1.3E-03	3.0E-08
3B14 horses Manure Management - Horses	N_2O	0.65	0.63	53.2%	100.0%	113.3%	2.17E-08	3.3E-03	1.3E-02	1.7E-06
3B14 other Manure Management - other - Fur animals	N_2O	0.11	0.04	47.6%	100.0%	110.7%	7.07E-11	2.1E-03	6.6E-04	4.9E-08
3B14 poultry Manure Management - Poultry	N_2O	0.36	0.23	43.8%	100.0%	109.2%	2.76E-09	4.4E-03	3.9E-03	3.4E-07
3B25 Indirect N_2O emissions (from manure management)	N_2O	10.61	9.17	100.0%	500.0%	509.9%	9.27E-05	3.8E-01	3.5E-01	2.7E-03
3D11 Inorganic N Fertilizers Inorganic N fertilizers	N_2O	58.41	54.99	20.0%	300.0%	300.7%	1.16E-03	9.7E-01	4.2E-01	1.1E-02
3D12 a. Animal Manure Applied to Soils Animal manure applied to soils	N_2O	37.09	32.03	56.1%	300.0%	305.2%	4.05E-04	8.3E-01	6.8E-01	1.1E-02
3D13 Urine and dung Deposited by Grazing Animals Urine and dung deposited by grazing animals	N_2O	47.86	42.43	59.4%	350.0%	355.0%	9.62E-04	1.2E+00	9.5E-01	2.3E-02
3D14 Crop Residues	N_2O	0.07	0.05	200.0%	300.0%	360.6%	1.44E-09	2.1E-03	3.9E-03	1.9E-07

IPCC Category	Gas	1990 emissions (kt CO_2e)	2018 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 (%)
3D16 Cultivation of Organic Soils Cultivation of organic soils (i.e. histosols)	N_2O	80.83	81.01	20.0%	25.0%	32.0%	2.85E-05	9.2E-02	6.1E-01	3.9E-03
3D21 Atmospheric Deposition Atmospheric deposition	N_2O	13.69	12.31	56.2%	500.0%	503.1%	1.62E-04	4.9E-01	2.6E-01	3.1E-03
3D22 Nitrogen Leaching and Run-off Nitrogen leaching and run-off	N_2O	31.38	28.07	333.3%	500.0%	600.9%	1.21E-03	1.1E+00	3.5E+00	1.4E-01
5B Biological treatment of solid waste	N_2O	0	1.72	52.0%	150.0%	158.7%	3.15E-07	6.1E-02	3.4E-02	4.8E-05
5C Incineration and Open Burning of waste	N_2O	1.67	0.33	52.0%	100.0%	112.7%	5.73E-09	4.0E-02	6.4E-03	1.6E-05
5D Wastewater Treatment and Discharge	N_2O	4.58	5.74	38.7%	0.0%	38.7%	2.10E-07	0.0E+00	8.4E-02	7.1E-05
2C3 Metal Production - aluminium Production	PFCs	494.64	76.39	1.5%	3.0%	3.4%	2.78E-07	3.7E-01	4.3E-02	1.4E-03
2F1a Commercial refrigeration	HFCs	0	26.01	200.0%	100.0%	223.6%	1.43E-04	7.0E-01	2.0E+00	4.4E-02
2F1a Commercial refrigeration	PFCs	0	0.007	200.0%	0.0%	200.0%	7.65E-12	0.0E+00	5.1E-04	2.6E-09
2F1b Domestic refrigeration	HFCs	0	0.043	500.0%	67.0%	504.5%	2.00E-09	7.7E-04	8.2E-03	6.7E-07
2F1c Industrial refrigeration	HFCs	0	28.14	100.0%	150.0%	180.3%	1.09E-04	1.1E+00	1.1E+00	2.4E-02
2F1c Industrial refrigeration	PFCs	0	0.007	100.0%	0.0%	100.0%	1.96E-12	0.0E+00	2.6E-04	6.6E-10
2F1d Transport refrigeration	HFCs	0	81.65	100.0%	100.0%	141.4%	5.65E-04	2.2E+00	3.1E+00	1.4E-01
2F1d Transport refrigeration	PFCs	0	0.039	100.0%	0.0%	100.0%	6.34E-11	0.0E+00	1.5E-03	2.1E-08
2F1e Mobile air-conditioning	HFCs	0	29.13	100.0%	100.0%	141.4%	7.19E-05	7.8E-01	1.1E+00	1.8E-02
2F1f Stationary air-conditioning	HFCs	0	1.31	200.0%	100.0%	223.6%	3.66E-07	3.5E-02	1.0E-01	1.1E-04
2F4 Product Uses as Substitutes for ODS -Aerosols	HFCs	0.35	0.93	5.0%	5.0%	7.1%	1.85E-10	6.5E-04	1.8E-03	3.5E-08
2G1 Other Product Manufacture and Use - Electrical equipment	SF_6	1.10	3.26	30.0%	30.0%	42.4%	8.11E-08	1.5E-02	3.7E-02	1.6E-05
Total Emissions		**3,732.87**	**4,857.48**							
Total Uncertainties						**% Uncertainty in total inventory (excluding LULUCF):**	**7.9%**		**Trend uncertainty %:**	**8.2%**

Annex 3: National Energy Balance for the year 2018

The Icelandic energy balance is compiled by the Environment Agency using data from the National Energy Authority and Statistics Iceland. This is the second time that a National Energy Balance is reported in the National Inventory Report. 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 3308 TJ, which is 18% of the total energy consumption in Iceland in 2018. The biggest discrepancies in fuel use are in diesel oil and residual fuel oil. These discrepancies will be further analysed with the agencies that provide the data.

Table A3. 1 National Energy Balance for 2018

2018 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)	Peat	Solid Biomass	Landfill gas
Indigenous Production	-	-	-	-	-	-	-	-	-	-	-	-	-	-	78
Imports	5,839	19,592	15,956	4,815	123	1,778	171	415	0.1	3,499	600	0.1	13	902	-
Exports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Bunkers	-	17,973	1,817	1,375	-	-	-	-	-	-	-	-	-	-	-
Stock Change	253	1,149	1,245	112	-	-	-	-	-	-	-	-	-	-	-
Primary Energy Supply	5,586	470	12,894	3,327	123	1,778	171	415	0.1	3,449	600	0.1	13	902	78
Non-Energy Use of Fuels						1,778	171	415		3,449	600	0.1	13	902	
Available Final Energy Consumption	**5,586**	**470**	**12,894**	**3,327**	**123**	**0**	**0**	**0**	**0.1**	**0**	**0**	**0**	**0**	**0**	**78**
1A1ai - Electricity generation	-	-	32	-	-	-	-	-	-	-	-	-	-	-	-
1A1aiii - Heat Plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1A2a - Iron and Steel	-	-	10	-	12	-	-	-	-	-	-	-	-	-	-
1A2b - Non-ferrous Metals	-	-	11	85	11	-	-	-	-	-	-	-	-	-	-
1A2e - Food processing, beverages and tobacco	-	-	147	149	-	-	-	-	-	-	-	-	-	-	-
1A2f - Non-metallic minerals (mineral wool)	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
1A2gvii - Off-road vehicles and mobile machinery	-	-	1,358	-	-	-	-	-	-	-	-	-	-	-	-
1A2gviii - Other industry	-	-	-	-	26	-	-	-	-	-	-	-	-	-	-
1A3a - Domestic Aviation	15	329	-	-	-	-	-	-	-	-	-	-	-	-	-
1A3b - Road Transport	5,555	-	7,729	-	-	-	-	-	-	-	-	-	-	-	75
1A3d - Domestic Navigation	-	-	365	210	-	-	-	-	-	-	-	-	-	-	-
1A4ai - Commercial/Institutional - Stationary combustion	-	-	6	-	4	-	-	-	-	-	-	-	-	-	-
1A4bi - Residential - Stationary combustion	-	-	35	-	75	-	-	-	-	-	-	-	-	-	-
1A4ciii - Fishing	-	-	5,882	1,427	-	-	-	-	-	-	-	-	-	-	-
1A5a - Other, stationary	-	1	2	-	7										
Final Energy Consumption	**5,570**	**330**	**15,583**	**1,872**	**135**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**75**
Statistical Differences	-16	-140	2,689	-1,456	12	0	0	0	-0.1	0	0	0	0	0	-3

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	4832.28	1854.7	38.4%	
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	3650.0	1854.7	50.8%	

For footnotes, see under Table A4. 4 below.

Table A4. 2 Total GHG inventory CO_2 emissions vs. emissions verified under the EU ETS, by CRF sector.

CO_2 emissions					
Category [1]	**Gas**	**GHG inventory emissions [kt CO_2] [3]**	**Verified emissions under Directive 2003/87/EC [kt CO_2] [3]**	**Ratio in % (Verified emissions/ inventory emissions) [3]**	**Comment [2]**
1.A Fuel combustion activities, total	CO_2	1732.8	NA	NA	
1.A Fuel combustion activities, stationary combustion [4]	CO_2	141.4	12.2	8.6%	
1.A.1 Energy industries	CO_2	2.4	NA		
1.A.1.a Public electricity and heat production	CO_2	2.4	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	453.7	1.5	0.3%	includes Ferroalloy/Silicon production
1.A.2. Manufacturing industries and construction	CO_2	138.35	12.2	8.8%	
1.A.2.a Iron and steel	CO_2	1.50	1.49	99.8%	
1.A.2.b Non-ferrous metals	CO_2	8.11	8.20	101.1%	small differencess 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	26.05	2.4	9.4%	
1.A.2.f Non-metallic minerals	CO_2	0.38	NA		
1.A.2.g Other	CO_2	102.31	0.03608	0.0%	
1.A.3. Transport	CO_2	1037.33	NA		
1.A.3.e Other transportation (pipeline transport)	CO_2	NO	NO		
1.A.4 Other sectors	CO_2	554.1	NA		
1.A.4.a Commercial / Institutional	CO_2	0.72	NA		
1.A.4.c Agriculture/ Forestry / Fisheries	CO_2	546.1	NA		
1.B Fugitive emissions from Fuels	CO_2	156.46	NA		
1.C CO2 Transport and storage	CO_2	NO	NO		
1.C.1 Transport of CO_2	CO_2	NO	NO		
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	0.91	NA		
2.A.1 Cement Production	CO_2	NO	NO		

CO₂ 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]**
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	0.91	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	1766.12	1766.1	100.0%	
2.C.1. Iron and steel production	CO_2	NO	NO		
2.C.2 Ferroalloys production	CO_2	452.24	452.24	100.0%	
2.C.3 Aluminium production	CO_2	1313.87	1313.9	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).

N₂O 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	76.39	76.39	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, Iceland volunteered to be subjected to a EU Step 2 review in 2019. A review report was sent to Iceland, however, since Iceland is not a EU Member State and volunteered for this review, the review report was not published by the EU. However, 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
1.A.3.b Road transportation, 2017, CO2	For category 1.A.3.b Road transportation and gas CO2 for the year 2017, the TERT noted that the fossil part of biofuels might not be included in the GHG inventory. In response to a question raised during the review, Iceland explained that according to the National Energy Authority of Iceland (NEA), 100% of biogasoline used in Iceland is bioethanol which has 0% fossil carbon. At this time the origin of biodiesel in Iceland is unknown, however, work has begun to estimate the share of FAME in biodiesel in Iceland. Assuming that all 100% of biodiesel used in Iceland in 2017 was FAME, the fossil origin CO2 (kt) is below the threshold of significance. This information was included in the NIR for the 15 March submission. The TERT agreed with the explanation provided by Iceland. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Iceland investigate the issue, provide estimates and explain the methodology in the next inventory submission.	IS-1A3b-2019-0001	Resolved. Iceland has investigated this issue with the team for chemicals and the Environment Agency, which is responsible for monitoring reporting under the Fuel Quality Directive. They have confirmed that no FAME biodiesel has been imported to Iceland, only HVO and HVO does not have a fossil component.	3.4.2 Road Transport (CRF 1A3b)
1.A.4 Other sectors (fuel combustion activities), 2017, CH4, CO2, N2O	For category 1.A.4.b Other sectors (Fuel combustion activities) and gases CH4 and N2O for the year 2017 the TERT noted that the in-country UNFCCC review in 2017 recommended to investigate the amount of charcoal used in the country and to estimate relevant emissions. In response to a question raised during the review, Iceland explained that there is charcoal used for grilling in Iceland, however, the inventory team has not been able to obtain activity data on it. The TERT agreed with the explanation provided by Iceland. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Iceland make efforts to obtain the relevant data and include relevant emissions in its next submission, possibly by investigating data reported by FAOSTAT http://www.fao.org/faostat/en/#data/FO.	IS-1A4-2019-0001	Work has begun with Statistics Iceland to obtain activity data on charcoal imported to Iceland for grilling. However, that work has not been completed and therefore it is not included in this submission.	Energy chapter
2.D Non-energy products from fuels and solvent use, 2017, CO2	For category 2.D.3 Non-energy products from fuels and solvent use and CO2 for year 2017, the TERT noted that Iceland does not report CO2 emissions from urea-based catalytic converters (non-combustive emissions)	IS-2D-2019-0001	This has been included in the NIR, section 4.5.3.6. A preliminary estimate of emission is given	Chapter 4.5

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	although it is a mandatory category and methods to estimate these emissions are provided in 2006 IPCC Guidelines. In response to a question raised during the review, Iceland provided preliminary estimates, which were performed following default methodology provided in the 2006 IPCC Guidelines, based on the composition and age of the vehicle fleet registered in Iceland in 2017 and assuming that all diesel vehicles registered since 2015 have EURO 6 Standard and therefore use urea-based additives (28% of all registered diesel vehicles). Iceland noted that resulting emission estimates are below the threshold of significance and stated that it will be included in the next submission. The TERT agreed with the explanation provided by Iceland and noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Iceland include CO2 emissions from urea-based catalytic converters in its next submission.		there as well, although no calculations are performed in CRF due to the lack of activity data. This will be corrected and implemented in future submissions. The emissions from urea based additives in Iceland are estimated to be below the threshold of significance.	
3 Agriculture, 1990-2017, N2O	For categories 3.B Manure management and 3.D Soil cultivation, N2O for all years, the TERT noted that there was inconsistencies between Table3.B(b) and Table3.D. Firstly, the amount of nitrogen excreted in pasture is expected to be the same in both tables. This was not the case in the reporting of Iceland. In response to a question raised during the review, Iceland explained that there was a mistake in the reporting of nitrogen excreted under pasture for mature dairy cattle. Secondly, the total amount of nitrogen applied to soil should be consistent with the amount of manure excreted (except pasture) after deduction of nitrogen losses and possibly nitrogen inputs (straw). In response to a question raised during the review, Iceland sent an example of the nitrogen balance for 2017. The TERT considered that the presented figures are plausible even if the value for nitrogen applied to soil was not exactly the same as the one reported in table 3D. The TERT notes that these issues do not relate to an over- or underestimation and recommends that Iceland correct the incorrect values in its next submission and include a clear explanation on the contribution of N2 and nitrogen from bedding (straw) in the nitrogen balance.	IS-3-2019-0002	This issue should be solved in the current submission. Routine QC have been implemented to avoid these discrepancies in the future.	
3.A Enteric fermentation, 1990-2017, CH4	For category 3.A Enteric fermentation, CH4 and all years, the TERT noted that Iceland still uses the value 0.335 for the parameter CFi to calculate the energy for maintenance which comes from the IPCC GPGs and not from the 2006 IPCC Guidelines. In response to a question raised during the review, Iceland recognized it was a mistake and provided revised estimates for 2017 and stated that these will be included in the next submission. The TERT agreed with	IS-3A-2019-0006	This has been implemented. Information can be found in section 5.2.4 of the current NIR.	Chapter 5.2

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	the revised estimates provided by Iceland. The TERT recommends that Iceland include the revised estimates in its next submission.			
3.B Manure management, 2000-2017, N2O	For category 3.B.1 Manure management - mature dairy cattle, N2O and after the year 2000, the TERT noted that the nitrogen excretion rate is constant and equal to 94.79 kg/head/year. The TERT considers that this is in contradiction with the increases of milk yield and gross energy intake. This issue was raised by the 2017 UNFCCC review (recommendation A.21). During the review Iceland agreed with the proposal of the TERT and indicated that additional investigations will be led for the whole time series but did not provide revised estimates. The TERT decided to calculate a technical correction for the year 2017 which was accepted by Iceland. The estimates demonstrate that the issue is above the threshold of significance. The TERT recommends that Iceland include a revised estimate in its next submission.	IS-3B-2019-0005	This has been implemented. Information can be found in section 5.5.2, table 5.27 and 5.5.6 of the current NIR.	Chapter 5.5
3.B Manure management, 1990-2017, N2O	For category 3.B Manure management, N2O and all years, the TERT noted that there are discrepancies between nitrogen excretion rates and total excreted nitrogen. In Table3.B(b), total nitrogen excretion was different from animal populations multiplied by nitrogen excretion rates for different livestock (mature dairy cattle, growing cattle, mature ewes…). In response to a question raised during the review, Iceland explained that nitrogen excretion rates were not weighted average, which would be changed in next submission. The main discrepancy was for mature dairy cattle, which was not known to have different subcategories, but this case was resolved with another answer from Iceland confirming that there was a mistake in the reporting of nitrogen excretion from mature dairy cattle under pasture (IS-3-2019-0002). The TERT notes that this issue does not relate to an over- or underestimation but this issue was already raised by a previous ESD review (IS-3B-2018-0001) for other animals and in the 2017 UNFCCC review (recommendation A.10). The TERT recommends that Iceland report weighted average and consistent figures in table 3.B(b). The weighted average can easily be obtained by dividing total nitrogen excretion by animal population.	IS-3B-2019-0006	Table 5.27 in the NIR reports the Nex for animal categories as well as the weighted averages for those categories which are calculated on a disaggregated level. We will implement a QC procedure to make sure these discrepancies are not happening again - work in progress.	
3.B Manure management, 1990-2017, N2O	For category 3.B Manure management, N2O and for all years the TERT noted that some implied emission factors were not sufficiently justified. In Iceland, manure management is split into two main systems: liquid/slurry and solid/dry lot. According to the IPCC 2006 Guidelines, the N2O emission factor for liquid/slurry can fluctuate between 0 (without	IS-3B-2019-0007	The NIR has been improved in section 5.5.3 regarding the emission factors used; MMS fractions are explained in section 5.4.2 but a thourough discussion	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	natural crust) and 0.005 (with natural crust) kg N2O-N/kgN. In 2017, Iceland reports an IEF of 0.00046 kg N2O-N/kgN in Table3.B(b). This may be explained by a mix of liquid manure with and without crust, but there is no related explanation in the NIR. Moreover, according to the IPCC 2006 Guidelines the N2O emission factor for solid/dry lot can fluctuate between 0.005 (solid) and 0.02 (dry lot) kgN2O-N/kgN. In 2017, Iceland reports an IEF of 0.0052 kgN2O-N/kgN in Table3.B(b). This may be explained by a mix of solid and dry lot, but there is no related explanation in the NIR. In response to a question raised during the review, Iceland explained that they were currently unable to identify the sources used and justify the emission factors. The TERT could not conclude whether the issue relates to an over- or underestimation, but considers that it does not represent an issue above the threshold of significance. The TERT recommends that Iceland check the sources of the emission factors and modify accordingly the methodology presented in the NIR.		of IEF in this section is still lacking and will be added in future submissions.- work in progress.	
3.B Manure management, 1990-2017, CH4	For category 3B Manure management and gas CH4 and all years, the TERT noted that Iceland uses a GPG equation to calculate the parameter VS (volatile solid). The equation to calculate VS is different in the GPGs and in the IPCC 2006 Guidelines (equation 4.16 in the GPGs and 10.24 in the 2006 IPCC Guidelines). The difference concerns the inclusion of urine in VS. In response to a question raised during the review, Iceland recognized it was a mistake and provided revised estimates for 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-3B-2019-0008	This has been implemented. Information can be found in section 5.4.1 and 5.4.4 of the current NIR.	
3.D.1 Direct N2O emissions from managed soils, 2017, N2O	For category 3.D.a.2.b Direct N2O emissions from managed soils - sewage sludge application, N2O and all years, the TERT noted that emissions are not estimated for the entire time series. This issue has already been raised by previous ESD and UNFCCC reviews. In response to a question raised during the review, Iceland explained that no improvements were undertaken for the submission this year due to unforeseen circumstances in the inventory team and that the issue will be addressed for next year submission. The TERT considers that the emissions are expected to be low and below the threshold of significance for technical correction. The TERT recommends that Iceland investigate the ways to collect required data for completing the reporting.	IS-3D1-2019-0001	This has been added in section 5.7.2.2 in the current NIR.	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
3.D.1 Direct N2O emissions from managed soils, 1990-2017, N2O	For category 3.D.a.6 Direct N2O emissions from managed soils -cultivation of histosols, N2O for all years, the TERT noted that Iceland does not include N2O emissions from organic grazing land under 3.D.a.6 and reports these emissions under the LULUCF sector (Category 4(II)H). This reporting allocation is in contradiction with CRF table footnote of Table4(II) "(1) Nitrous oxide (N2O) emissions from drained cropland and grassland soils are covered in the agriculture tables of the CRF under cultivation of organic soils". In response to a question raised during the review, Iceland explained that they agreed with the TERT to shift these emissions from LULUCF towards agriculture. Iceland provided revised estimates for the year 2017 and stated that these 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-3D1-2019-0003	This has been implemented. Information can be found in section 5.7.2.6 and 5.7.5 of the current NIR.	Chapter 5.7
3.G Liming, 2017, CO2	For category 3.G Liming and CO2 for all years, the TERT noted two different issues. First, both categories 3.G.1 and 3.G.2 have identical emissions for the last four years 2012-2017. Second, activity for previous years was reported with IE supposing that liming was included in LULUCF for the period before 2012, although they should be reported in agriculture for the entire times series. Moreover it is not clear that these emissions are actually reported under LULUCF, such emissions were not found by the TERT in the years before 2012 (CRF tables are not designed anymore to report any liming in LULUCF). In response to a question raised during the review, Iceland explained that no improvements were undertaken for the submission this year due to unforeseen circumstances in the inventory team and that the issue will be addressed for next year submission. The TERT considers that the issue is below the threshold of significance for technical correction considering the magnitude of emissions reported under 3.G. The TERT recommends that Iceland revise both the time series consistency and the trend of activities based on updated data for most recent years.	IS-3G-2019-0001	This has been implemented and rectified as can be seen in section 5.11.2 in the current NIR.	Chapter 5.11
5.D Wastewater treatment and discharge, 1990-2017, CH4, N2O	For category 5.D Wastewater treatment and gases CH4 and N2O for the years 1990-2017, the TERT noted that there are inconsistencies in applying correction factors for additional industrial BOD/N discharged into public sewers. In response to a question raised during the review, Iceland confirmed that the comment to the equation 6.3 in the NIR on using zero for I-factor was incorrect and confirmed that the default I=1.25 is used in emission estimation. The TERT recommends that Iceland continue to use the default correction factors (1.25) for	IS-5D-2019-0001	This has been updated and has been included in the 2020 inventory. See chapter 7.5.	Chapter 7.5 Wastewater Treatment and Discharge (CRF 5D)

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	additional industrial BOD/N discharged into public sewers, until they are able to develop and fully justify the use of a country-specific factor.			
5.D Wastewater treatment and discharge, 1990-2017, CH_4	For the category 5D, CH_4 and years 1990-2017 the TERT noted that there is a lack of transparency regarding the overall picture of wastewater management in Iceland, the use of MCF and I-factor parameters and a completeness issue due to missing information on industrial wastewater. In response to a question raised during the review and following webinar, Iceland provided a revised estimate for the year 2017 and stated that it will gather better country-specific information to recalculate the time series. The TERT agreed with the revised estimate provided by Iceland. The TERT recommends that Iceland include the revised estimate in its next submission. The TERT also recommends that Iceland update its wastewater pathways allocation and improve transparency of the use of parameters (MCF and I-factor) for emissions estimation. The TERT recommends that Iceland improve completeness of emissions from wastewater by quantifying industrial wastewater separately from domestic wastewater.	IS-5D-2019-0003	This has been updated and has been included in the 2020 inventory. See chapter 7.5.	Chapter 7.5 Wastewater Treatment and Discharge (CRF 5D)
5.D Wastewater treatment and discharge, 1990-2017, N_2O	For category 5.D Wastewater treatment and gas N_2O for years 1990 – 2017, the TERT noted that Iceland is using the factor for non-consumed protein (Fnon-con = 1.4) applicable to countries with widespread use of garbage disposal units. The TERT asked Iceland to consider the use of Fnon-con =1.1 (for countries not using waste disposal units) and concluded that the use of Fnon-con=1.4 is an overestimation of emissions below the threshold of significance. In response to a question raised during the review, Iceland agreed to use Fnon-con =1.1 as it is more suitable for wastewater practice in Iceland and stated that it will be included in the next submission. The TERT recommends that Iceland use the Fnon-con = 1.1 for recalculation of N_2O emissions from domestic wastewater and estimation of these emissions in the future and include these changes in its next submission.	IS-5D-2019-0006	This has been updated and has been included in the 2020 inventory. See chapter 7.5.	Chapter 7.5 Wastewater Treatment and Discharge (CRF 5D)

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: Explanation of EA's adjustment of data on fuel sales 1990-2002

Table A7. 1 Fuel sales (gas oil and residual fuel oil) by sectors 1A1a, 1A2 (stationary and mobile) and 1A4 (stationary) – as provided by the National Energy Authority

No.	Category	1990 Tonnes	1995 Tonnes	2000 Tonnes	2001	2002
Gas/Diesel Oil						
10X40	house heating and swimming pools	10,623	8,535	7,625	6,349	5,756
10X5X	industry	5,072	1,129	8,920	9,443	10,233
10X60	energy industries	1,300	1,091	1,065	897	1,112
10X90	other	0	458	1,386	1,32	756
Residual Fuel Oil						
10840	house heating and swimming pools	2,989	3,079	122	162	203
1085X	industry	55,934	56,172	46,146	55,782	64,026
10860	energy industries	0	0	0	0	23
10890	other	39	52	67	4,978	6,465

ADJUSTMENTS

For gas oil:

First fuel consumption needed for the known electricity production with fuels is calculated (**1A1a** – electricity production), assuming 34% efficiency, the values calculated are compared with the fuel sales for the category 10X60 Energy industries.

- In years where there is less fuel sale to energy industries as would be needed for the electricity production, the fuel needed is taken from the category 10X90 Other and when that is not sufficient from the category 10X40 House heating and swimming pools.
- In years where there is surplus the extra fuel is added to the category 10X40 House heating and swimming pools.

NEA has estimated the fuel use by swimming pools (**1A4a**). These values are subtracted from the adjusted 10X40 category. The rest of the category is then **1A4c** – Residential.

For years when there is still fuel in the category 10X90 Other, this is added to the 10X5X Industry. This is the fuel use in **1A2** – Industry.

	1990	1995	2000	2001	2002
Swimming pools	1,800	1,600	1,600	1,400	1,400

For Residual Fuel Oil:

The sectors 10840 and 10860 are added together. This is the fuel use by **1A1a** - public heat plants, In year 1997 four tonnes are subtracted from this category as the category 10890 has minus four tonnes, leaving category 10890 with 0 in 1997. The categories 1085X Industry and 10890 Other are added together, this is the fuel use in **1A2** – industry.

Annex 8: Values used in Calculation of Digestible Energy of Cattle and Sheep Feed

Table A8. 1 Values used in Calculation of Digestible Energy of Feed: Mature Dairy Cattle

1. Dairy cattle, stallfed, lactation period[23,24]		1990-2017	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		1990-2017	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

[23] Jóhannes Sveinbjörnsson og Grétar H. Harðarson, 2008. Þungi og átgeta íslenskra mjólkurkúa. Fræðaþing landbúnaðarins: 336-344

[24] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

3. Dairy cattle, pasture, lactation period		1990-2017	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
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		1990-2017	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)	1990-2017	2018
Digestible organic matter per kg of dry matter	681.5771	715.37184
Metabolisable energy per gram dry matter	15	15
Metabolisable energy per kg dry matter	10223.657	10730.578
Ratio of metabolisable 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 A8. 2 Values used in Calculation of Digestible Energy of Feed: Cows Used for Producing Meat

1. Cows used for prod. meat, stallfed[25]	amount/day (kg dm)	dry matter digestibility (%)	ash (%)
hay	10.0	70.0	7.0
sum	10.0		
average		70.0	7.0

[25] Jóhannes Sveinbjörnsson og Bragi L. Ólafsson, 1999. Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi. Ráðunautafundur 1999: 204-217.

2. Cows used for prod. meat, pasture[3]	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 A8. 3 Values used in Calculation of Digestible Energy of Feed: Heifers

1. Heifers, stallfed[3,26]	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

Table A8. 4 Values used in Calculation of Digestible Energy of Feed: Steers

1. Steers[27,28]	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

[26] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

[27] Jóhannes Sveinbjörnsson og Bragi L. Ólafsson, 1999. Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi. Ráðunautafundur 1999: 204-217.

[28] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

Duration of periods	days for periods	dry matter digestibility (%)	ash (%)
1. Steers	365.0		
annual average	6.0	72.5	7.2

Table A8. 5 Values used in Calculation of Digestible Energy of Feed: Calves

1. Calves, first 90 days[29]	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[5]	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

Table A8. 6 Values used in Calculation of Digestible Energy of Feed: Sheep

1. Sheep, stallfed[30]	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[31]	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[32]	amount/day (kg dm)	dry matter digestibility (%)	ash (%)
gras/vegetation	1.8	70.0	7.0
Sum	1.8		
Average		70.0	7.0

[29] 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

[30] Jóhannes Sveinbjörnsson, 2013: Fóðrun og fóðurþarfir sauðfjár. Kafli 4 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.

[31] Jóhannes Sveinbjörnsson, 2013: Fóðuröflun og beit á ræktað land. Kafli 5 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.

[32] Ólafur Guðmundsson, 1987: Átgeta búfjár og nýting beitar. Ráðunautafundur 1987: 181-192

Duration of periods	days for periods	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 A8. 7 Values used in Calculation of Digestible Energy of Feed: Lambs

1. Lambs, pre-weaning[33,34]	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
2. Lambs, after-weaning[35,12]	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 A8. 8 Conversion of DMD into DE

	dry matter digestibility	organic matter digestib ility	metabo-lisable energy	metabo-lizality	Net energy for lactation	Net energy of 1 kg barley	Digestible energy
	DMD	OMD	BO	q	NO_m	FE_m	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	NO_m/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 principally 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

[33] Ólafur Guðmundsson, 1987: Átgeta búfjár og nýting beitar. Ráðunautafundur 1987: 181-192

[34] 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)

[35] Jóhannes Sveinbjörnsson, 2013: Fóðuröflun og beit á ræktað land. Kafli 5 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.

	dry matter digestibility	organic matter digestib ility	metabo-lisable energy	metabo-lizality	Net energy for lactation	Net energy of 1 kg barley	Digestible energy
	DMD	OMD	BO	q	NO_m	FE_m	DE
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

Annex 9: Justification of use of country-specific N2O emission factor for cultivation of organic soils (histosols)

As mentioned in Chapter 10.2.2 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 N20 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 integrality.

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 ($(Al_2O_3)(SiO_2)_{1.3}$•$2.5(H_2O)$), Imogolite ($Al_2SiO_3(OH)_4$), Ferrihydrite ($Fe^{3+}{}_2O_3$•$0.5(H_2O)$) and Halloysite ($Al_2Si_2O_5(OH)_4$)[36]. 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

[36] all empirical formulas from http://webmineral.com

reaction, grain size and other overall properties (Arnalds, 2015). The aeolian input in Iceland is not only given by the episodical volcanic eruptions providing material in the form of ash but also due to the desertic conditions and highly eroded areas acting as source areas for dust which then is transported by the wind.

These two factors, together with the carbon content are the basis for the Icelandic soil classification system (Figure 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).

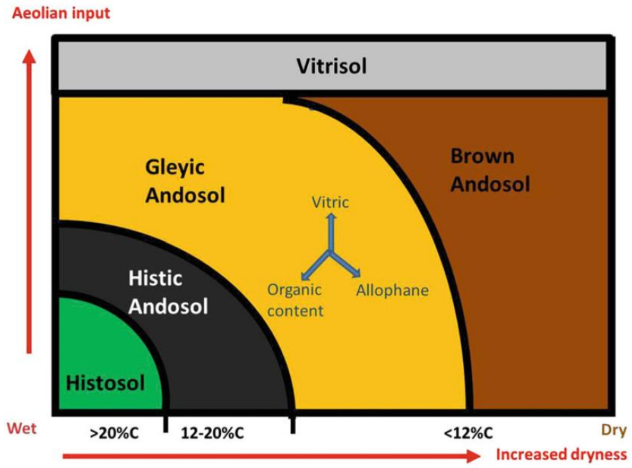

Figure A9. 1 Classification of Icelandic Andosols together with Vitrisols (soils of the desert) and Histosols (wetland soils), determined by the aeolian input and the drainage conditions. The amount of soil carbon is also given, separating Histosols (20%) from Andosols, (Arnalds, 2015).

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 A9. 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)

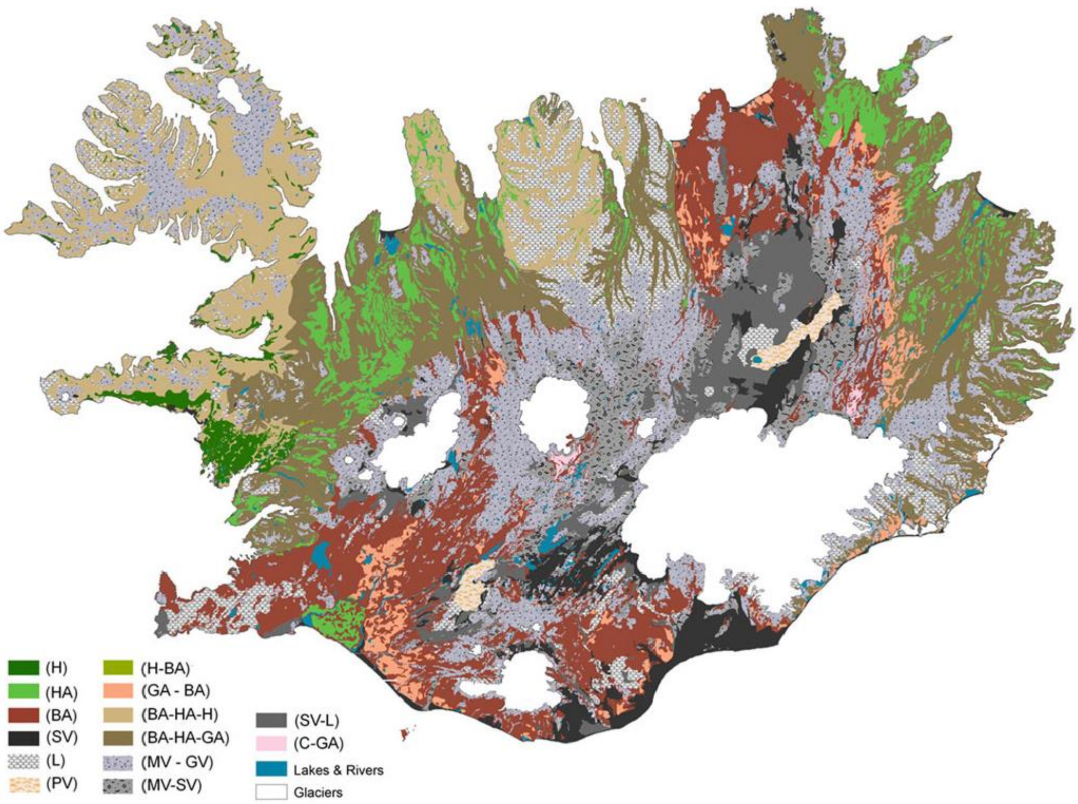

Figure A9. 2 General soil map of Iceland (Arnalds, 2015), based on Arnalds & Oskarsson, (2009). H: Histosol, HA: Histic Andosol, GA: Gleyic Andosol, BA: Brown Andosol, MV: Cambic Vitrisol, GV: Gravelly Vitrisol, SV: Sandy Vitrisol, PV: Pumice Vitrisol, L: Leptosol, C: Cryosol

Cultivation of Organic Soils in Iceland

According to the IPCC 2006 Guidelines, Volume 4 (AFOLU), Chapter 11[37], soils are organic if they satisfy the requirements 1 and 2 or 1 and 3 defined by FAO. The minimum soil organic carbon is 12% by weight among other conditions. As can be seen from Figure A9. 1, the icelandic soil types containing 12% of soil carbon or more are **Histic Andosols** and **Histosols**. The former is part of the Andosols and presents andic properties. Histosols, on the other hand, can be distinguished from

[37] IPCC 2006 Guidelines, Volume 4, Agriculture, Forestry and Other Land Use.

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 20^{th} 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).

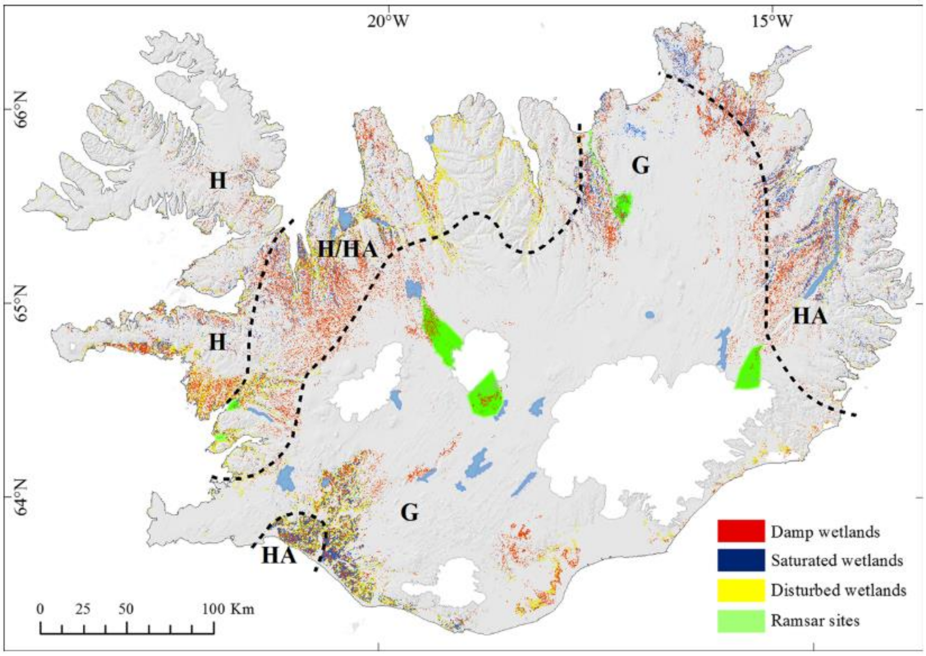

Figure A9. 3 Inland wetlands in Iceland. H: Histosols, HA: Histic Andosols, G: Gleyic Andosols. In green the Ramsar sites are shown. Large water bodies are light blue, in white are the main glaciers (Arnalds et al., 2016).

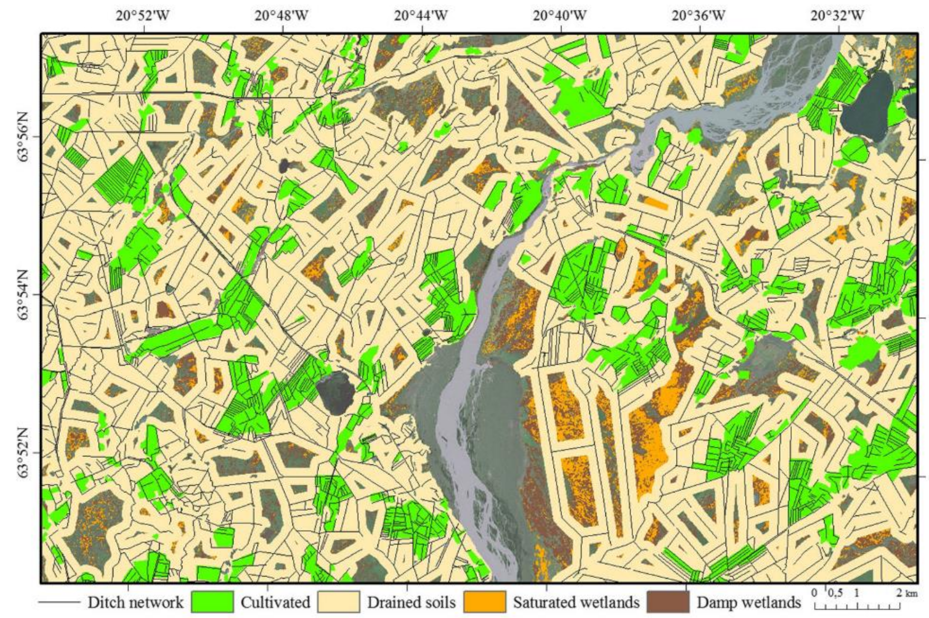

Figure A9. 4 South Iceland, close to the river Þjórsá. The black lines show the system of ditches created to drain the wetlands. Of the drained soils, only the green patches are cultivated as hay fields (Arnalds et al., 2016).

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[38] different emission factors for managed soils. In particular, the $EF_{2CG, Temp}$ 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.

[38] IPCC 2006 Guidelines, Volume 4, Agriculture, Forestry and Other Land Use.

Table A9. 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 N_2O ha^{-1} day^{-1}	kg N_2O_N ha^{-1} yr^{-1}
Undrained	0.45	10.34	209	0.72	23.18	0.11	0.02
Drained 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 A9. 3 All N_2O measurements in the different land-use categories over 12 months and weighted average: transcribed and translated from Guðmundsson (2009).

Month	1	2	3	4	5	6	7	8	9	10	11	12	Monthly average kg ha^{-1} yr^{-1}	CO_2e kg ha^{-1} yr^{-1}
							Undrained							
n	10	5	11	25	25	30	30	44	15	4	10	0		
kg N_2O_N ha^{-1} yr^{-1}	0	0	0	-0.02	0.12	0	0	-0.08	0.41	0	0		0.04	19.08
kg CH_4 ha^{-1} yr^{-1}	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		
kg N_2O_N ha^{-1} yr^{-1}	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
kg CH_4 ha^{-1} yr^{-1}	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		
kg N_2O_N ha^{-1} yr^{-1}	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
kg CH_4 ha^{-1} yr^{-1}	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 (C_I – cultivated hayfield, D_I - drained) ranging between 0.03 and 0.04 g N $m^{-2}yr^{-1}$ (Liimatainen et al., 2018) [39]. 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 ^{13}C enriched and ^{15}N 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 A9. 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

[39] 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).

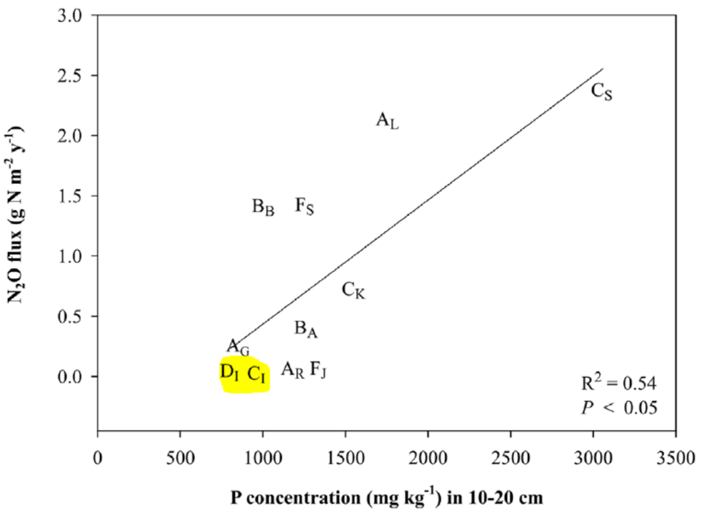

Fig. 4. Correlation between N_2O emissions (g N m^{-2} y^{-1}) *in situ* and the content of total P (mg kg^{-1}) in soil at the depth of 10–20 cm.

Figure A9. 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 10: CRF (Common Reporting Format) Summary 2 Tables for 1990-2018

1990

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2020 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]	7871.41	4330.28	378.64	0.35	494.64	1.10	NO,NA	NO,NA	13076.41
1. Energy	1833.06	9.68	26.71						1869.45
A. Fuel combustion (sectoral approach)	1771.70	9.00	26.71						1807.41
1. Energy industries	13.79	0.01	0.03						13.83
2. Manufacturing industries and construction	361.66	0.48	14.59						376.73
3. Transport	611.06	5.66	5.94						622.67
4. Other sectors	785.19	2.84	6.15						794.18
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	0.35	494.64	1.10	NO,NA	NO,NA	957.68
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				0.35	NO	NO	NO	NO	0.35
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	0.06	385.37	292.85						678.27
A. Enteric fermentation		326.32							326.32
B. Manure management		59.05	23.52						82.57
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	269.33						269.33
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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]	5623.60	3719.69	0.24						9343.54
A. Forest land	-42.76	0.10	0.13						-42.54
B. Cropland	1852.14	93.47	NO,NE,NA						1945.61
C. Grassland	5013.77	375.41	0.12						5389.30
D. Wetlands	-1224.01	3250.71	NO,NA,NE						2026.70
E. Settlements	24.47	NE	NO,NE,IE						24.47
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	7.30	213.92	6.26						227.47
A. Solid waste disposal	NO,NA	157.84							157.84
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	238.74	0.08	1.98						240.81
Aviation	219.44	0.04	1.83						221.31
Navigation	19.30	0.05	0.16						19.50
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NA								NO,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									3732.87
Total CO_2 equivalent emissions with land use, land-use change and forestry									13076.41
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 emissions

(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 2020 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)]	7738.61	4330.34	368.20	0.70	410.61	1.24	NO,NA	NO,NA	12849.70
1. Energy	1748.12	9.76	26.01						1783.90
A. Fuel combustion (sectoral approach)	1678.17	9.17	26.01						1713.35
1. Energy industries	15.39	0.02	0.04						15.44
2. Manufacturing industries and construction	285.41	0.40	13.78						299.59
3. Transport	622.70	5.80	6.28						634.78
4. Other sectors	754.67	2.95	5.92						763.54
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	50.58	0.70	410.61	1.24	NO,NA	NO,NA	837.43
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				0.70	NO	NO	NO	NO	0.70
G. Other product manufacture and use	0.00	0.05	5.59		NO	1.24			6.88
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	374.72	284.98						659.76
A. Enteric fermentation		316.86							316.86
B. Manure management		57.86	22.29						80.15
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	262.69						262.69
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)]	5610.20	3722.39	0.34						9332.94
A. Forest land	-44.38	0.14	0.18						-44.05
B. Cropland	1827.36	92.19	NO,NE,NA						1919.55
C. Grassland	5027.51	377.06	0.16						5404.73
D. Wetlands	-1217.10	3253.00	NO,NA,NE						2035.89
E. Settlements	16.82	NE	NO,NE,IE						16.82
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	7.24	222.16	6.28						235.68
A. Solid waste disposal	NO,NA	163.25							163.25
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	229.11	0.06	1.91						231.08
Aviation	221.77	0.04	1.85						223.66
Navigation	7.34	0.02	0.06						7.42
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NA								NO,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									3516.77
Total CO_2 equivalent emissions with land use, land-use change and forestry									12849.70
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 emissions

(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 2020 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)]	7867.07	4340.37	350.81	0.70	183.04	1.24	NO,NA	NO,NA	12743.23
1. Energy	1890.92	9.73	26.29						1926.94
A. Fuel combustion (sectoral approach)	1823.30	9.08	26.29						1858.67
1. Energy industries	13.83	0.01	0.03						13.87
2. Manufacturing industries and construction	341.74	0.43	12.99						355.16
3. Transport	633.20	5.82	6.73						645.75
4. Other sectors	834.54	2.82	6.53						843.89
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	45.27	0.70	183.04	1.24	NO,NA	NO,NA	607.91
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	5.04		NO	1.24			6.34
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	370.06	272.48						642.59
A. Enteric fermentation		313.02							313.02
B. Manure management		57.03	20.88						77.91
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	251.60						251.60
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)]	5592.80	3721.77	0.45						9315.03
A. Forest land	-48.89	0.20	0.25						-48.44
B. Cropland	1801.97	90.91	NO,NE,NA						1892.88
C. Grassland	5039.61	378.71	0.20						5418.53
D. Wetlands	-1216.71	3251.95	NO,NA,NE						2035.24
E. Settlements	16.82	NE	NO,NE,IE						16.82
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	7.04	237.40	6.32						250.76
A. Solid waste disposal	NO,NA	179.30							179.30
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	215.09	0.06	1.79						216.94
Aviation	203.42	0.04	1.70						205.15
Navigation	11.67	0.03	0.09						11.79
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NA								NO,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									3428.21
Total CO_2 equivalent emissions with land use, land-use change and forestry									12743.23
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions

(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 2020 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)]	8018.27	4356.39	358.13	1.58	88.24	1.24	NO,NA	NO,NA	12823.86
1. Energy	2000.92	9.93	28.40						2039.25
A. Fuel combustion (sectoral approach)	1915.54	9.28	28.40						1953.22
1. Energy industries	17.30	0.03	0.10						17.43
2. Manufacturing industries and construction	368.86	0.47	14.03						383.36
3. Transport	633.70	5.59	7.20						646.48
4. Other sectors	895.68	3.18	7.08						905.95
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	565.22
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	4.92		NO	1.24			6.21
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	369.42	275.83						645.31
A. Enteric fermentation		312.72							312.72
B. Manure management		56.70	21.00						77.70
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	254.84						254.84
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)]	5586.11	3721.13	0.50						9307.74
A. Forest land	-54.00	0.21	0.26						-53.53
B. Cropland	1776.59	89.63	NO,NE,NA						1866.22
C. Grassland	5053.38	380.37	0.25						5434.00
D. Wetlands	-1216.31	3250.92	NO,NA,NE						2034.61
E. Settlements	26.45	NE	NO,NE,IE						26.45
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	6.00	254.18	6.15						266.33
A. Solid waste disposal	NO,NA	193.13							193.13
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	214.41	0.08	1.78						216.27
Aviation	195.45	0.03	1.63						197.11
Navigation	18.96	0.04	0.15						19.15
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NA								NO,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									3516.12
Total CO_2 equivalent emissions with land use, land-use change and forestry									12823.86
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions

(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 2020 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)]	7927.42	4364.43	361.56	2.03	52.53	1.24	NO,NA	NO,NA	12709.22
1. Energy	1941.43	8.64	28.90						1978.97
A. Fuel combustion (sectoral approach)	1871.31	7.97	28.90						1908.19
1. Energy industries	16.97	0.03	0.09						17.10
2. Manufacturing industries and construction	346.98	0.44	14.22						361.65
3. Transport	636.46	5.43	7.78						649.67
4. Other sectors	870.90	2.07	6.80						879.76
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	47.13	2.03	52.53	1.24	NO,NA	NO,NA	530.91
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	4.51		NO	1.24			5.81
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	371.79	278.88						650.72
A. Enteric fermentation		315.20							315.20
B. Manure management		56.59	21.05						77.64
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	257.82						257.82
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)]	5554.13	3720.00	0.56						9274.69
A. Forest land	-56.90	0.22	0.27						-56.40
B. Cropland	1751.22	88.35	NO,NE,NA						1839.57
C. Grassland	5067.29	382.26	0.29						5449.83
D. Wetlands	-1215.65	3249.17	NO,NA,NE						2033.53
E. Settlements	8.16	NE	NO,NE,IE						8.16
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	5.53	262.31	6.10						273.93
A. Solid waste disposal	NO,NA	205.83							205.83
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	231.55	0.08	1.92						233.55
Aviation	213.41	0.04	1.78						215.23
Navigation	18.14	0.04	0.15						18.32
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NA								NO,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									3434.54
Total CO_2 equivalent emissions with land use, land-use change and forestry									12709.22
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 emissions

(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 2020 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)]	8017.50	4364.54	354.81	3.43	69.36	1.24	NO,NA	NO,NA	12810.90
1. Energy	2028.09	8.51	33.47						2070.06
A. Fuel combustion (sectoral approach)	1945.85	7.82	33.47						1987.13
1. Energy industries	21.95	0.04	0.12						22.12
2. Manufacturing industries and construction	366.16	0.46	17.68						384.30
3. Transport	612.18	5.08	8.25						625.50
4. Other sectors	945.56	2.24	7.41						955.21
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	564.56
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	269.53						628.61
A. Enteric fermentation		303.23							303.23
B. Manure management		55.79	19.95						75.74
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	249.57						249.57
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)]	5540.80	3718.41	0.65						9259.86
A. Forest land	-66.49	0.26	0.32						-65.91
B. Cropland	1725.83	87.07	NO,NE,NA						1812.89
C. Grassland	5082.43	384.37	0.33						5467.14
D. Wetlands	-1214.72	3246.71	NO,NA,NE						2031.99
E. Settlements	13.74	NE	NO,NE,IE						13.74
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	4.87	276.77	6.17						287.81
A. Solid waste disposal	NO,NA	218.53							218.53
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,NA								NO,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									3551.04
Total CO_2 equivalent emissions with land use, land-use change and forestry									12810.90
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 emissions

(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 2020 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)]	8061.52	4385.87	369.65	10.65	29.64	1.24	NO,NA	NO,NA	12858.57
1. Energy	2084.57	8.42	34.10						2127.10
A. Fuel combustion (sectoral approach)	2003.30	7.65	34.10						2045.05
1. Energy industries	15.48	0.04	0.13						15.65
2. Manufacturing industries and construction	408.79	0.49	17.26						426.54
3. Transport	602.92	4.79	9.10						616.81
4. Other sectors	976.11	2.33	7.61						986.05
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	52.26	10.65	29.64	1.24	NO,NA	NO,NA	538.70
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	4.88		NO	1.24			6.17
H. Other	NA	NA	NA						NA
3. Agriculture	0.07	364.24	276.51						640.82
A. Enteric fermentation		307.87							307.87
B. Manure management		56.37	20.18						76.56
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	256.33						256.33
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)]	5529.47	3718.84	0.70						9249.01
A. Forest land	-70.70	0.28	0.33						-70.09
B. Cropland	1700.39	85.78	NO,NE,NA						1786.17
C. Grassland	5096.70	386.38	0.37						5483.45
D. Wetlands	-1212.36	3246.40	NO,NA,NE						2034.04
E. Settlements	15.44	NE	NO,NE,IE						15.44
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	4.37	292.51	6.07						302.95
A. Solid waste disposal	NO,NA	223.57							223.57
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,NA								NO,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									3609.56
Total CO_2 equivalent emissions with land use, land-use change and forestry									12858.57
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 emissions

(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 2020 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)]	8149.04	4388.25	362.90	16.89	97.08	1.24	NO,NA	NO,NA	13015.40
1. Energy	2120.99	8.19	38.33						2167.51
A. Fuel combustion (sectoral approach)	2054.14	7.39	38.33						2099.86
1. Energy industries	11.99	0.04	0.12						12.15
2. Manufacturing industries and construction	475.93	0.58	20.78						497.28
3. Transport	614.36	4.51	9.95						628.82
4. Other sectors	951.86	2.26	7.49						961.61
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	0.06	360.77	273.30						634.13
A. Enteric fermentation		305.43							305.43
B. Manure management		55.35	20.29						75.64
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	253.01						253.01
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)]	5521.52	3716.29	0.77						9238.58
A. Forest land	-77.49	0.30	0.36						-76.83
B. Cropland	1674.99	84.50	NO,NE,NA						1759.49
C. Grassland	5118.47	389.02	0.42						5507.91
D. Wetlands	-1210.85	3242.47	NO,NA,NE						2031.62
E. Settlements	16.39	NE	NO,NE,IE						16.39
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	4.21	301.17	6.06						311.44
A. Solid waste disposal	NO,NA	228.45							228.45
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,NA								NO,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									3776.82
Total CO_2 equivalent emissions with land use, land-use change and forestry									13015.40
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions

(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 2020 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)	8166.13	4385.30	362.37	26.32	212.33	1.24	NO,NA	NO,NA	13153.69
1. Energy	2114.12	8.11	39.44						2161.67
A. Fuel combustion (sectoral approach)	2030.40	7.10	39.44						2076.94
1. Energy industries	14.97	0.04	0.13						15.14
2. Manufacturing industries and construction	452.81	0.57	20.96						474.35
3. Transport	617.59	4.23	10.96						632.78
4. Other sectors	945.03	2.25	7.39						954.67
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	39.52	26.32	212.33	1.24	NO,NA	NO,NA	811.12
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				26.32	NO	NO	NO	NO	26.32
G. Other product manufacture and use	0.01	0.04	5.08		NO	1.24			6.37
H. Other	NA	NA	NA						NA
3. Agriculture	0.08	368.13	276.58						644.79
A. Enteric fermentation		311.29							311.29
B. Manure management		56.84	20.80						77.64
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	255.78						255.78
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)	5518.28	3712.54	0.87						9231.68
A. Forest land	-85.93	0.34	0.41						-85.18
B. Cropland	1649.57	83.22	NO,NE,NA						1732.79
C. Grassland	5146.45	392.26	0.46						5539.17
D. Wetlands	-1208.48	3236.72	NO,NA,NE						2028.23
E. Settlements	16.67	NE	NO,NE,IE						16.67
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	-0.01								-0.01
H. Other	IE	IE	IE						IE
5. Waste	3.57	294.92	5.96						304.45
A. Solid waste disposal	NO,NA	235.85							235.85
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,NA								NO,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									3922.02
Total CO_2 equivalent emissions with land use, land-use change and forestry									13153.69
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 emissions

(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 2020 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)	8377.51	4388.79	370.91	37.98	204.17	1.24	NO,NA	NO,NA	13380.61
1. Energy	2172.00	8.28	41.71						2221.98
A. Fuel combustion (sectoral approach)	2060.72	6.91	41.71						2109.34
1. Energy industries	12.05	0.04	0.12						12.21
2. Manufacturing industries and construction	479.86	0.61	22.93						503.40
3. Transport	639.36	4.04	11.36						654.76
4. Other sectors	929.45	2.22	7.29						938.97
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	964.24
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	0.07	366.52	282.38						648.97
A. Enteric fermentation		310.02							310.02
B. Manure management		56.50	20.89						77.39
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	261.49						261.49
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)	5523.56	3708.16	0.93						9232.65
A. Forest land	-92.24	0.36	0.43						-91.45
B. Cropland	1624.20	81.93	NO,NE,NA						1706.13
C. Grassland	5178.64	395.73	0.50						5574.87
D. Wetlands	-1206.00	3230.13	NO,NA,NE						2024.13
E. Settlements	18.96	NE	NO,NE,IE						18.96
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.92	303.98	5.88						312.78
A. Solid waste disposal	NO,NA	243.91							243.91
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,NA								NO,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									4147.96
Total CO_2 equivalent emissions with land use, land-use change and forestry									13380.61
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 emissions

(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 2020 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)	8481.24	4382.50	350.27	43.96	149.89	1.31	NO,NA	NO,NA	13409.18
1. Energy	2154.87	8.06	42.04						2204.98
A. Fuel combustion (sectoral approach)	2001.72	6.55	42.04						2050.32
1. Energy industries	11.03	0.04	0.12						11.19
2. Manufacturing industries and construction	432.30	0.57	23.31						456.18
3. Transport	641.79	3.77	11.39						656.95
4. Other sectors	916.59	2.18	7.22						925.99
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	788.78	2.76	22.86	43.96	149.89	1.31	NO,NA	NO,NA	1009.57
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	4.95		NO	1.31			6.32
H. Other	NA	NA	NA						NA
3. Agriculture	0.07	353.16	278.34						631.57
A. Enteric fermentation		297.84							297.84
B. Manure management		55.32	20.29						75.62
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	258.05						258.05
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)	5534.77	3702.25	1.11						9238.13
A. Forest land	-102.32	0.42	0.56						-101.34
B. Cropland	1598.80	80.65	NO,NE,NA						1679.45
C. Grassland	5222.32	399.95	0.54						5622.82
D. Wetlands	-1202.64	3221.23	NO,NA,NE						2018.59
E. Settlements	18.61	NE	NO,NE,IE						18.61
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.74	316.27	5.92						324.93
A. Solid waste disposal	NO,NA	250.55							250.55
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,NA								NO,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									4171.05
Total CO_2 equivalent emissions with land use, land-use change and forestry									13409.18
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 emissions

(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 2020 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)]	8416.08	4390.27	345.24	41.10	108.04	1.31	NO,NA	NO,NA	13302.05
1. Energy	2041.58	7.56	41.00						2090.14
A. Fuel combustion (sectoral approach)	1897.81	6.03	41.00						1944.84
1. Energy industries	10.34	0.04	0.12						10.50
2. Manufacturing industries and construction	477.45	0.62	22.95						501.02
3. Transport	652.65	3.57	11.97						668.19
4. Other sectors	757.36	1.80	5.96						765.12
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	20.23	41.10	108.04	1.31	NO,NA	NO,NA	1004.55
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	4.71		NO	1.31			6.08
H. Other	NA	NA	NA						NA
3. Agriculture	0.08	355.45	276.91						632.44
A. Enteric fermentation		299.54							299.54
B. Manure management		55.91	20.16						76.07
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	256.75						256.75
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)]	5540.84	3698.52	1.17						9240.53
A. Forest land	-108.05	0.45	0.58						-107.02
B. Cropland	1573.46	79.36	NO,NE,NA						1652.82
C. Grassland	5257.33	403.27	0.59						5661.19
D. Wetlands	-1200.30	3215.45	NO,NA,NE						2015.14
E. Settlements	18.40	NE	NO,NE,IE						18.40
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.58	325.87	5.93						334.39
A. Solid waste disposal	NO,NA	260.21							260.21
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,NA								NO,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									4061.52
Total CO_2 equivalent emissions with land use, land-use change and forestry									13302.05
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 emissions

(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 2020 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)]	8561.77	4391.55	319.52	49.32	85.51	1.31	NA,NO	NA,NO	13408.98
1. Energy	2149.74	7.54	40.74						2198.02
A. Fuel combustion (sectoral approach)	2002.33	6.00	40.74						2049.07
1. Energy industries	12.32	0.04	0.12						12.48
2. Manufacturing industries and construction	480.71	0.60	21.55						502.86
3. Transport	656.43	3.33	12.32						672.09
4. Other sectors	852.87	2.03	6.75						861.65
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
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	4.38	49.32	85.51	1.31	NA,NO	NA,NO	991.84
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	4.38		NO	1.31			5.75
H. Other	NA	NA	NA						NA
3. Agriculture	0.08	348.67	267.81						616.56
A. Enteric fermentation		294.12							294.12
B. Manure management		54.55	19.98						74.53
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	247.83						247.83
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
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)]	5561.25	3693.34	1.27						9255.86
A. Forest land	-117.27	0.48	0.64						-116.15
B. Cropland	1548.12	78.07	NO,NE,NA						1626.19
C. Grassland	5304.64	407.41	0.63						5712.68
D. Wetlands	-1197.26	3207.38	NO,NA,NE						2010.12
E. Settlements	23.01	NE	NO,NE,IE						23.01
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.40	338.97	5.32						346.69
A. Solid waste disposal	NO,NA	261.53							261.53
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						312.17
Navigation	85.46	0.20	0.69						86.35
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NA								NO,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									4153.12
Total CO_2 equivalent emissions with land use, land-use change and forestry									13408.98
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 emissions

(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 2020 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)]	8546.31	4378.56	312.75	46.55	70.48	1.31	NA,NO	NA,NO	13355.95
1. Energy	2140.79	7.29	39.33						2187.41
A. Fuel combustion (sectoral approach)	2004.45	5.79	39.33						2049.57
1. Energy industries	9.63	0.04	0.11						9.79
2. Manufacturing industries and construction	422.62	0.53	19.71						442.86
3. Transport	751.06	3.29	13.00						767.34
4. Other sectors	813.83	1.93	6.49						822.24
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	4.33	46.55	70.48	1.31	NA,NO	NA,NO	974.86
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	4.33		NO	1.31			5.71
H. Other	NA	NA	NA						NA
3. Agriculture	2.54	344.12	262.40						609.05
A. Enteric fermentation		290.56							290.56
B. Manure management		53.56	19.79						73.35
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	242.61						242.61
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.08								0.08
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)]	5551.75	3690.15	1.35						9243.25
A. Forest land	-127.99	0.52	0.68						-126.79
B. Cropland	1522.77	76.79	NO,NE,NA						1599.56
C. Grassland	5332.80	410.43	0.67						5743.91
D. Wetlands	-1195.38	3202.41	NO,NA,NE						2007.03
E. Settlements	19.55	NE	NO,NE,IE						19.55
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.05	333.99	5.34						341.38
A. Solid waste disposal	NO,NA	262.77							262.77
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									4112.70
Total CO_2 equivalent emissions with land use, land-use change and forestry									13355.95
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions

(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 2020 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)]	8669.92	4371.58	312.65	51.46	45.48	1.31	NA,NO	NA,NO	13452.41
1. Energy	2236.09	7.47	43.64						2287.20
A. Fuel combustion (sectoral approach)	2113.19	5.84	43.64						2162.67
1. Energy industries	7.89	0.04	0.11						8.04
2. Manufacturing industries and construction	418.52	0.57	23.47						442.56
3. Transport	803.44	3.21	13.28						819.93
4. Other sectors	837.81	1.99	6.66						846.45
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	4.15	51.46	45.48	1.31	NA,NO	NA,NO	978.32
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	51.46
G. Other product manufacture and use	0.02	0.05	4.15		NO	1.31			5.53
H. Other	NA	NA	NA						NA
3. Agriculture	2.71	339.48	258.12						600.31
A. Enteric fermentation		286.73							286.73
B. Manure management		52.76	19.51						72.26
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	238.61						238.61
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.22								0.22
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)]	5553.04	3686.61	1.42						9241.07
A. Forest land	-134.13	0.53	0.71						-132.89
B. Cropland	1497.37	75.50	NO,NE,NA						1572.87
C. Grassland	5357.94	413.53	0.71						5772.18
D. Wetlands	-1193.36	3197.05	NO,NA,NE						2003.69
E. Settlements	25.22	NE	0.00						25.22
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	5.17	335.00	5.33						345.51
A. Solid waste disposal	NO,NA	271.70							271.70
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									4211.34
Total CO_2 equivalent emissions with land use, land-use change and forestry									13452.41
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 emissions

(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 2020 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)]	8545.23	4354.23	313.59	55.56	30.76	2.52	NO	NO	13301.88
1. Energy	2121.78	7.11	44.11						2172.99
A. Fuel combustion (sectoral approach)	2003.62	5.37	44.11						2053.09
1. Energy industries	7.81	0.04	0.11						7.96
2. Manufacturing industries and construction	400.61	0.52	25.32						426.44
3. Transport	809.11	2.99	12.62						824.73
4. Other sectors	757.18	1.79	5.98						764.96
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	4.00	55.56	30.76	2.52	NO	NO	951.52
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	4.00		NO	2.52			6.59
H. Other	NA	NA	NA						NA
3. Agriculture	3.60	342.50	258.59						604.69
A. Enteric fermentation		289.03							289.03
B. Manure management		53.47	19.62						73.09
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	238.96						238.96
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	1.24								1.24
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)]	5559.26	3681.67	1.49						9242.41
A. Forest land	-153.53	0.56	0.73						-152.25
B. Cropland	1472.04	74.21	NO,NE,NA						1546.25
C. Grassland	5396.43	417.38	0.76						5814.56
D. Wetlands	-1190.52	3189.52	NO,NA,NE						1999.00
E. Settlements	34.84	NE	0.00						34.84
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	4.73	320.14	5.41						330.27
A. Solid waste disposal	NO,NA	260.38							260.38
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	421.22	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	0.81								0.81
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									4059.46
Total CO_2 equivalent emissions with land use, land-use change and forestry									13301.88
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 emissions

(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 2020 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)]	8781.65	4387.50	329.39	57.39	392.79	2.61	NO	NO	13951.33
1. Energy	2191.06	7.73	36.81						2235.60
A. Fuel combustion (sectoral approach)	2063.63	5.32	36.81						2105.76
1. Energy industries	17.16	0.07	0.20						17.43
2. Manufacturing industries and construction	381.35	0.50	22.98						404.83
3. Transport	952.58	3.10	8.13						963.81
4. Other sectors	685.74	1.61	5.43						692.79
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	4.06	57.39	392.79	2.61	NO	NO	1424.50
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	4.06		NO	2.61			6.76
H. Other	NA	NA	NA						NA
3. Agriculture	3.67	350.76	275.72						630.15
A. Enteric fermentation		294.56							294.56
B. Manure management		56.20	19.82						76.02
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	255.89						255.89
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	1.96								1.96
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)]	5617.25	3678.72	7.07						9303.04
A. Forest land	-159.78	0.58	0.76						-158.44
B. Cropland	1446.73	72.94	0.02						1519.69
C. Grassland	5473.59	427.91	5.15						5906.65
D. Wetlands	-1185.51	3177.29	1.13						1992.90
E. Settlements	42.22	NE	0.01						42.23
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	347.51	5.74						358.04
A. Solid waste disposal	NO,NA	294.97							294.97
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	0.20								0.20
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									4648.29
Total CO_2 equivalent emissions with land use, land-use change and forestry									13951.33
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions

(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 2020 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)]	9156.43	4379.46	336.25	50.85	331.39	2.89	NO	NO	14257.28
1. Energy	2336.54	8.52	37.63						2382.69
A. Fuel combustion (sectoral approach)	2189.17	5.43	37.63						2232.22
1. Energy industries	34.52	0.09	0.26						34.87
2. Manufacturing industries and construction	381.67	0.56	23.21						405.43
3. Transport	988.06	2.95	7.99						999.01
4. Other sectors	778.08	1.82	6.15						786.05
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	4.52	50.85	331.39	2.89	NO	NO	1555.23
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	4.52		NO	2.89			7.52
H. Other	NA	NA	NA						NA
3. Agriculture	5.02	356.47	286.42						647.90
A. Enteric fermentation		298.84							298.84
B. Manure management		57.63	20.13						77.76
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	266.28						266.28
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.99								3.99
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)]	5644.34	3664.23	1.66						9310.22
A. Forest land	-167.48	0.59	0.80						-166.09
B. Cropland	1421.44	71.63	NO,NA						1493.07
C. Grassland	5530.28	428.75	0.85						5959.89
D. Wetlands	-1179.93	3163.25	NO,NA,NE						1983.33
E. Settlements	40.02	NE	0.01						40.02
F. Other land	NO,NA,NE	NO,NA	NO,NA						NO,NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	7.86	347.33	6.04						361.23
A. Solid waste disposal	NO,NA	291.90							291.90
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	0.60								0.60
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									4947.06
Total CO_2 equivalent emissions with land use, land-use change and forestry									14257.28
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 emissions

(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 2020 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]	9488.35	4357.51	343.46	60.43	411.39	3.01	NO	NO	14664.15
1. Energy	2208.79	8.01	35.63						2252.43
A. Fuel combustion (sectoral approach)	2022.85	4.89	35.63						2063.37
1. Energy industries	17.70	0.07	0.20						17.96
2. Manufacturing industries and construction	352.73	0.51	22.42						375.66
3. Transport	933.49	2.64	7.37						943.50
4. Other sectors	711.81	1.67	5.64						719.11
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	1604.30	2.45	4.15	60.43	411.39	3.01	NO	NO	2085.73
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	6.38	NE,NA	NE,NA						6.38
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	4.15		NO	3.01			7.22
H. Other	NA	NA	NA						NA
3. Agriculture	5.72	359.78	295.77						661.27
A. Enteric fermentation		301.85							301.85
B. Manure management		57.93	20.04						77.97
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	275.73						275.73
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.15								3.15
H. Urea application	0.15								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]	5663.41	3656.04	1.78						9321.24
A. Forest land	-171.69	0.62	0.79						-170.29
B. Cropland	1396.16	70.34	NO,NA						1466.51
C. Grassland	5593.87	434.16	0.96						6028.99
D. Wetlands	-1175.27	3150.92	0.02						1975.68
E. Settlements	20.35	NE	0.01						20.36
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	331.22	6.13						343.48
A. Solid waste disposal	NO,NA	280.69							280.69
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	1.64								1.64
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									5342.91
Total CO_2 equivalent emissions with land use, land-use change and forestry									14664.15
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 emissions

(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 2020 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)]	9373.54	4347.04	318.50	73.11	180.05	3.02	NO	NO	14295.28
1. Energy	2114.22	7.48	28.81						2150.50
A. Fuel combustion (sectoral approach)	1944.10	4.63	28.81						1977.54
1. Energy industries	12.94	0.05	0.15						13.14
2. Manufacturing industries and construction	250.72	0.34	15.60						266.67
3. Transport	906.66	2.44	6.97						916.07
4. Other sectors	768.94	1.80	6.07						776.81
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	1615.69	2.49	3.62	73.11	180.05	3.02	NO	NO	1877.99
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	4.88	NE,NA	NE,NA						4.88
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	3.62		NO	3.02			6.70
H. Other	NA	NA	NA						NA
3. Agriculture	4.22	364.49	277.93						646.63
A. Enteric fermentation		306.14							306.14
B. Manure management		58.35	20.43						78.78
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	257.50						257.50
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	1.55								1.55
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)]	5633.36	3654.55	1.77						9289.68
A. Forest land	-185.28	0.64	0.83						-183.81
B. Cropland	1370.91	69.05	NO,NA						1439.97
C. Grassland	5614.68	436.36	0.93						6051.97
D. Wetlands	-1174.18	3148.48	NO,NA,NE						1974.30
E. Settlements	7.24	NE	0.01						7.25
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	318.04	6.38						330.47
A. Solid waste disposal	NO,NA	270.22							270.22
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	1.27								1.27
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									5005.60
Total CO_2 equivalent emissions with land use, land-use change and forestry									14295.28
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 emissions

(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 2020 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)]	9267.23	4334.72	307.29	105.11	171.66	4.66	NO	NO	14190.67
1. Energy	2028.99	9.33	24.94						2063.27
A. Fuel combustion (sectoral approach)	1839.35	4.27	24.94						1868.56
1. Energy industries	13.82	0.05	0.15						14.02
2. Manufacturing industries and construction	218.41	0.30	12.56						231.27
3. Transport	862.57	2.19	6.44						871.20
4. Other sectors	730.64	1.71	5.76						738.11
5. Other	13.91	0.01	0.03						13.95
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	1622.78	2.59	3.86	105.11	171.66	4.66	NO	NO	1910.66
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	5.11	NE,NA	NE,NA						5.11
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	3.86		NO	4.66			8.58
H. Other	NA	NA	NA						NA
3. Agriculture	2.43	358.65	270.17						631.25
A. Enteric fermentation		303.06							303.06
B. Manure management		55.59	20.21						75.79
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	249.96						249.96
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.65								0.65
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)]	5607.11	3652.86	1.78						9261.75
A. Forest land	-208.38	0.66	0.84						-206.88
B. Cropland	1345.66	67.76	NO,NA						1413.43
C. Grassland	5636.78	438.68	0.93						6076.40
D. Wetlands	-1173.15	3145.75	0.00						1972.60
E. Settlements	6.22	NE	0.01						6.23
F. Other land	NO,NA,NE	NO,NA	NO,NA						NO,NA,NE
G. Harvested wood products	-0.03								-0.03
H. Other	IE	IE	IE						IE
5. Waste	5.91	311.29	6.54						323.74
A. Solid waste disposal	NO,NA	269.98							269.98
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	1.60								1.60
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									4928.92
Total CO_2 equivalent emissions with land use, land-use change and forestry									14190.67
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 emissions

(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 2020 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)	9088.15	4311.39	303.92	130.46	74.52	3.05	NO	NO	13911.48
1. Energy	1884.41	7.88	22.75						1915.04
A. Fuel combustion (sectoral approach)	1704.90	3.86	22.75						1731.51
1. Energy industries	11.30	0.04	0.12						11.46
2. Manufacturing industries and construction	195.87	0.26	11.47						207.60
3. Transport	827.47	2.00	5.92						835.40
4. Other sectors	663.37	1.55	5.22						670.14
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	1617.27	2.67	4.04	130.46	74.52	3.05	NO	NO	1832.00
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	5.34	NE,NA,NO	NE,NA,NO						5.34
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	4.04		NO	3.05			7.15
H. Other	NA	NA	NA						NA
3. Agriculture	2.40	359.59	268.80						630.79
A. Enteric fermentation		302.59							302.59
B. Manure management		57.00	20.38						77.38
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	248.42						248.42
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.71								0.71
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)	5577.51	3651.20	1.81						9230.53
A. Forest land	-235.52	0.67	0.87						-233.97
B. Cropland	1320.40	66.47	NO,NA						1386.87
C. Grassland	5658.55	441.00	0.93						6100.47
D. Wetlands	-1172.11	3143.06	NO,NA,NE						1970.94
E. Settlements	6.23	NE	0.01						6.24
F. Other land	NO,NA,NE	NO,NA	NO,NA						NO,NA,NE
G. Harvested wood products	-0.03								-0.03
H. Other	IE	IE	IE						IE
5. Waste	6.55	290.06	6.51						303.13
A. Solid waste disposal	NO,NA	246.18							246.18
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	3.00								3.00
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									4680.96
Total CO_2 equivalent emissions with land use, land-use change and forestry									13911.48
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions

(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 2020 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)]	9070.99	4282.83	308.93	140.74	94.00	5.32	NO	NO	13902.81
1. Energy	1832.20	6.92	21.86						1860.99
A. Fuel combustion (sectoral approach)	1660.15	3.65	21.86						1685.66
1. Energy industries	11.38	0.04	0.11						11.53
2. Manufacturing industries and construction	173.27	0.21	10.87						184.35
3. Transport	818.14	1.86	5.70						825.70
4. Other sectors	656.45	1.54	5.18						663.17
5. Other	0.91	0.00	0.00						0.92
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	1660.11	3.00	3.96	140.74	94.00	5.32	NO	NO	1907.13
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	1751.29
D. Non-energy products from fuels and solvent use	5.24	NE,NA,NO	NE,NA,NO						5.24
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	3.96		NO	5.32			9.34
H. Other	NA	NA	NA						NA
3. Agriculture	4.23	354.01	275.05						633.29
A. Enteric fermentation		299.58							299.58
B. Manure management		54.43	20.12						74.55
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	254.93						254.93
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.31								2.31
H. Urea application	0.17								0.17
I. Other carbon-containing fertilizers	1.75								1.75
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5568.11	3649.39	1.78						9219.28
A. Forest land	-246.09	0.69	0.83						-244.58
B. Cropland	1295.13	65.18	NO,NA						1360.31
C. Grassland	5683.92	443.33	0.94						6128.19
D. Wetlands	-1171.03	3140.20	NO,NA,NE						1969.17
E. Settlements	6.24	NE	0.01						6.26
F. Other land	NA,NE	0.00	0.00						0.00
G. Harvested wood products	-0.06								-0.06
H. Other	IE	IE	IE						IE
5. Waste	6.35	269.50	6.28						282.13
A. Solid waste disposal	NO,NA	217.88							217.88
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	4.47								4.47
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									4683.54
Total CO_2 equivalent emissions with land use, land-use change and forestry									13902.81
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 emissions

(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 2020 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)]	9042.99	4286.22	304.25	163.38	88.17	3.20	NO	NO	13888.21
1. Energy	1796.98	7.43	20.97						1825.38
A. Fuel combustion (sectoral approach)	1623.84	3.44	20.97						1648.25
1. Energy industries	4.53	0.01	0.02						4.57
2. Manufacturing industries and construction	163.47	0.20	10.34						174.00
3. Transport	833.48	1.79	5.74						841.01
4. Other sectors	619.82	1.45	4.87						626.14
5. Other	2.53	0.00	0.01						2.54
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	1686.09	3.03	3.43	163.38	88.17	3.20	NO	NO	1947.30
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	5.17	NE,NA,NO	NE,NA,NO						5.17
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	3.43		NO	3.20			6.69
H. Other	NA	NA	NA						NA
3. Agriculture	4.31	346.86	271.43						622.61
A. Enteric fermentation		293.63							293.63
B. Manure management		53.23	19.72						72.96
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	251.71						251.71
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.35								2.35
H. Urea application	0.21								0.21
I. Other carbon-containing fertilizers	1.75								1.75
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5550.21	3647.65	1.81						9199.67
A. Forest land	-264.71	0.69	0.84						-263.18
B. Cropland	1269.84	63.89	NO,NA						1333.73
C. Grassland	5708.94	445.67	0.96						6155.56
D. Wetlands	-1169.98	3137.40	NO,NA,NE						1967.42
E. Settlements	6.19	NE	0.01						6.20
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	5.39	281.25	6.61						293.25
A. Solid waste disposal	NO,NA	231.33							231.33
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	10.52								10.52
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									4688.54
Total CO_2 equivalent emissions with land use, land-use change and forestry									13888.21
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 emissions

(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 2020 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)]	8992.62	4296.21	332.83	169.61	99.03	2.32	NO	NO	13892.62
1. Energy	1803.94	7.87	25.54						1837.35
A. Fuel combustion (sectoral approach)	1620.98	3.32	25.54						1649.85
1. Energy industries	5.13	0.01	0.01						5.15
2. Manufacturing industries and construction	161.35	0.21	14.95						176.50
3. Transport	835.96	1.66	5.77						843.39
4. Other sectors	615.89	1.44	4.80						622.14
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	1654.56	2.73	3.13	169.61	99.03	2.32	NO	NO	1931.38
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	5.23	NE,NA,NO	NE,NA,NO						5.23
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				169.61	0.00	NO	NO	NO	169.61
G. Other product manufacture and use	0.02	0.03	3.13		NO	2.32			5.50
H. Other	NA	NA	NA						NA
3. Agriculture	4.09	371.43	295.14						670.65
A. Enteric fermentation		312.97							312.97
B. Manure management		58.46	20.93						79.39
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	274.20						274.20
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.22								2.22
H. Urea application	0.35								0.35
I. Other carbon-containing fertilizers	1.53								1.53
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5522.94	3645.79	1.79						9170.52
A. Forest land	-288.36	0.69	0.81						-286.86
B. Cropland	1244.55	62.60	NO,NA						1307.15
C. Grassland	5729.21	447.76	0.97						6177.93
D. Wetlands	-1168.64	3134.74	0.01						1966.11
E. Settlements	6.25	NE	0.01						6.26
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	268.40	7.23						282.72
A. Solid waste disposal	NO,NA	227.34							227.34
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	10.48								10.48
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									4722.10
Total CO_2 equivalent emissions with land use, land-use change and forestry									13892.62
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 emissions

(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 2020 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)	9040.16	4300.51	315.21	179.67	103.70	1.56	NO	NO	13940.80
1. Energy	1827.91	7.92	23.61						1859.44
A. Fuel combustion (sectoral approach)	1664.78	3.37	23.61						1691.75
1. Energy industries	4.20	0.00	0.01						4.22
2. Manufacturing industries and construction	162.32	0.20	12.31						174.83
3. Transport	866.79	1.69	6.35						874.83
4. Other sectors	625.82	1.46	4.93						632.21
5. Other	5.65	0.01	0.01						5.67
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	1707.09	2.98	3.23	179.67	103.70	1.56	NO	NO	1998.22
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	5.53	NE,NA,NO	NE,NA,NO						5.53
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				179.67	0.01	NO	NO	NO	179.68
G. Other product manufacture and use	0.03	0.03	3.23		NO	1.56			4.85
H. Other	NA	NA	NA						NA
3. Agriculture	3.79	376.07	279.11						658.97
A. Enteric fermentation		316.35							316.35
B. Manure management		59.71	20.75						80.47
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	258.36						258.36
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.03								2.03
H. Urea application	0.58								0.58
I. Other carbon-containing fertilizers	1.18								1.18
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5494.91	3644.08	2.01						9140.99
A. Forest land	-312.47	0.70	0.84						-310.92
B. Cropland	1218.58	61.30	NO,NA						1279.88
C. Grassland	5750.22	450.15	1.10						6201.47
D. Wetlands	-1167.56	3131.92	0.04						1964.41
E. Settlements	6.26	NE	0.01						6.28
F. Other land	NE,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	269.46	7.25						283.17
A. Solid waste disposal	NO,NA	222.43							222.43
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	40.77								40.77
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									4799.81
Total CO_2 equivalent emissions with land use, land-use change and forestry									13940.80
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 emissions

(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 2020 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)]	8963.99	4290.14	313.21	204.48	91.86	1.34	NO	NO	13865.02
1. Energy	1803.08	6.75	25.30						1835.12
A. Fuel combustion (sectoral approach)	1654.12	3.22	25.30						1682.63
1. Energy industries	2.37	0.00	0.01						2.38
2. Manufacturing industries and construction	182.82	0.23	14.28						197.33
3. Transport	944.85	1.75	6.87						953.48
4. Other sectors	523.60	1.23	4.13						528.96
5. Other	0.47	0.00	0.00						0.48
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	1683.58	3.03	2.70	204.48	91.86	1.34	NO	NO	1986.98
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	5.47	NO,NE,NA	NO,NE,NA						5.47
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				204.48	0.02	NO	NO	NO	204.50
G. Other product manufacture and use	0.03	0.03	2.70		NO	1.34			4.10
H. Other	NA	NA	NA						NA
3. Agriculture	4.13	382.74	276.02						662.89
A. Enteric fermentation		321.33							321.33
B. Manure management		61.41	21.12						82.53
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	254.90						254.90
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.32								2.32
H. Urea application	0.69								0.69
I. Other carbon-containing fertilizers	1.12								1.12
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5466.45	3642.24	1.73						9110.42
A. Forest land	-334.06	0.70	0.80						-332.56
B. Cropland	1193.80	60.01	NO,NA						1253.81
C. Grassland	5767.07	452.26	0.93						6220.26
D. Wetlands	-1166.59	3129.27	NO,NE,NA						1962.67
E. Settlements	6.26	NE	0.01						6.27
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	255.38	7.46						269.60
A. Solid waste disposal	NO,NA	213.33							213.33
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
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	45.06								45.06
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									4754.60
Total CO_2 equivalent emissions with land use, land-use change and forestry									13865.02
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions

(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 2020 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)]	9025.17	4277.77	324.49	190.91	68.01	2.31	NO	NO	13888.66
1. Energy	1844.96	6.37	26.55						1877.88
A. Fuel combustion (sectoral approach)	1698.48	3.04	26.55						1728.08
1. Energy industries	2.33	0.00	0.01						2.34
2. Manufacturing industries and construction	157.14	0.21	14.55						171.89
3. Transport	998.55	1.56	7.76						1007.87
4. Other sectors	540.30	1.27	4.24						545.80
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	1758.84	3.16	2.44	190.91	68.01	2.31	NO	NO	2025.66
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	5.14	NO,NE,NA	NO,NE,NA						5.14
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				190.91	0.03	NO	NO	NO	190.94
G. Other product manufacture and use	0.03	0.03	2.44		NO	2.31			4.80
H. Other	NA	NA	NA						NA
3. Agriculture	3.99	376.63	285.86						666.48
A. Enteric fermentation		315.11							315.11
B. Manure management		61.53	20.61						82.14
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	265.25						265.25
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	1.68								1.68
H. Urea application	0.83								0.83
I. Other carbon-containing fertilizers	1.48								1.48
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5410.30	3640.72	2.13						9053.15
A. Forest land	-384.82	0.71	1.15						-382.96
B. Cropland	1168.60	58.71	NO,NA						1227.31
C. Grassland	5785.99	454.57	0.96						6241.52
D. Wetlands	-1165.63	3126.73	0.01						1961.11
E. Settlements	6.26	NE	0.01						6.27
F. Other land	NE,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	250.89	7.51						265.48
A. Solid waste disposal	NO,NA	205.39							205.39
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	50.10								50.10
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									4835.51
Total CO_2 equivalent emissions with land use, land-use change and forestry									13888.66
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions

(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 2020 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)]	9086.08	4226.39	307.31	167.23	76.44	3.26	NO	NO	13866.71
1. Energy	1889.30	6.37	24.24						1919.91
A. Fuel combustion (sectoral approach)	1732.84	3.06	24.24						1760.14
1. Energy industries	2.37	0.00	0.01						2.38
2. Manufacturing industries and construction	138.35	0.18	11.61						150.14
3. Transport	1037.33	1.58	8.25						1047.16
4. Other sectors	554.10	1.30	4.37						559.76
5. Other	0.68	0.00	0.00						0.69
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	1772.66	3.19	2.92	167.23	76.44	3.26	NO	NO	2025.70
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	5.60	NO,NE,NA	NO,NE,NA						5.60
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				167.23	0.05	NO	NO	NO	167.28
G. Other product manufacture and use	0.03	0.03	2.92		NO	3.26			6.25
H. Other	NA	NA	NA						NA
3. Agriculture	6.42	358.02	270.53						634.97
A. Enteric fermentation		301.14							301.14
B. Manure management		56.88	19.56						76.44
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	250.97						250.97
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.89								3.89
H. Urea application	0.91								0.91
I. Other carbon-containing fertilizers	1.62								1.62
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5411.55	3596.37	1.84						9009.76
A. Forest land	-387.47	0.71	0.90						-385.86
B. Cropland	1143.26	57.42	NO,NA						1200.68
C. Grassland	5810.91	423.12	0.93						6234.96
D. Wetlands	-1161.25	3115.12	NO,NE,NA						1953.87
E. Settlements	6.26	NE	0.01						6.27
F. Other land	NE,NA	NA	NA						NE,NA
G. Harvested wood products	-0.15								-0.15
H. Other	IE	IE	IE						IE
5. Waste	6.15	262.44	7.79						276.37
A. Solid waste disposal	NO,NA	214.35							214.35
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	1534.29	0.79	12.68						1547.75
Aviation	1292.68	0.23	10.78						1303.68
Navigation	241.60	0.56	1.91						244.07
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	49.65								49.65
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									4856.95
Total CO_2 equivalent emissions with land use, land-use change and forestry									13866.71
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.