NATIONAL INVENTORY REPORT

Emissions of Greenhouse Gases in Iceland from 1990 to 2017

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

2019

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Reykjavík, 15 April 2019

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 year 2017. 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 for the period 1990 – 2017.

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 to 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 April 2019.

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Annexes:

List of Abbreviations

1996 GL	1996 IPCC Guidelines for Greenhouse Gas Inventories
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
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
GPG	IPCC Good Practice Guidance in National Greenhouse Gas Inventories
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	23,900
Perfluorocarbons (PFCs)		
Tetrafluoromethane (PFC 14)	CF_4	7,900
Hexafluoroethane (PFC 116)	C_2F_6	12,200
Octafluoropropane (PFC 218)	C_3F_8	8,830
Hydrofluorocarbons		
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 from the Land Use, Land Use Change and Forestry (LULUCF) sector are calculated by the Agricultural University of Iceland (AUI), the Icelandic Forest Service (IFS), and the Soil Conservation Service of Iceland (SCSI). 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 is 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 sets 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.

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:

- For the first commitment period of the Kyoto Protocol, from 2008 to 2012, the GHG gas emissions were not to increase by more than 10% from the level of emissions in 1990.

[1] Aðgerðaáætlun í loftslagsmálum 2018-2030: https://www.stjornarradid.is/lisalib/getfile.aspx?itemid=b1bda08c-b4f6-11e8-942c-005056bc4d74

[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

- 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

The distribution of total greenhouse gas emissions over the UNFCCC sectors (excluding LULUCF) 1990 to 2017 is shown in Figure ES. 1. Emissions from the Energy sector and Industrial Processes each contribute approximately 40% of the national total. The emissions from the Agriculture and Waste sectors are considerably smaller.

A summary of the Icelandic national emissions for selected years between 1990 and 2017 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 2017. 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.

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

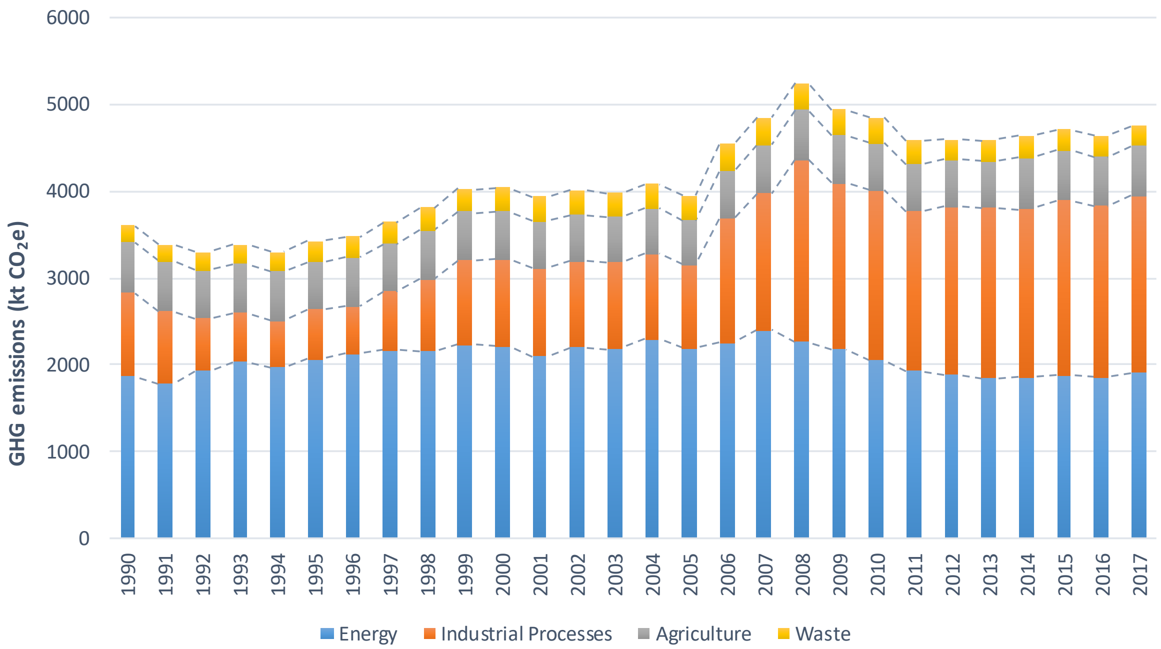

Figure ES. 1 Emissions of GHG by sector, without LULUCF, from 1990 to 2017 in kt CO2e

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

	1990	1995	2000	2005	2010	2015	2016	2017	Changes ´90-´17	Changes ´16-´17
1 Energy	1,867	2,069	2,210	2,184	2,057	1,877	1,858	1,907	2%	3%
2 Industrial Processes	958	571	1,009	965	1,951	2,023	1,974	2,039	113%	3%
3 Agriculture	593	548	552	519	546	571	571	578	-3%	1%
4 Land Use, Land Use Change and Forestry	9,407	9,361	9,387	9,427	9,472	9,363	9,345	9,321	-1%	0%
5 Waste	181	239	267	279	291	245	237	230	27%	-3%
Total emissions without LULUCF	**3,598**	**3,426**	**4,038**	**3,947**	**4,845**	**4,715**	**4,640**	**4,755**	**32%**	**2%**
Total emissions with LULUCF	**13,005**	**12,787**	**13,425**	**13,375**	**14,317**	**14,078**	**13,985**	**14,075**	**8%**	**1%**

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 2019 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 2018 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. Iceland's obligations according to the Kyoto Protocol have been and are as follows:

- For the first commitment period of the Kyoto Protocol, from 2008 to 2012, the GHG 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.
- In 2015 an agreement 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.
- The second commitment period of the Kyoto Protocol will run for eight years, from 2013 to 2020 inclusive. In 2015, an agreement was concluded between the 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.

- 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.

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.

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 87% 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.

The present report together with the associated Common Reporting Format tables (CRF) is Iceland's contribution to this round of reporting under the Convention and covers emissions and removals since 1990. The methodologies used in calculating the emissions are following the 2006 IPCC Guidelines for National Greenhouse Gas Inventories as well as various supplements to the Guidelines related to LULUCF.

As part of its submission to UNFCCC, Iceland submits Standard Electronic Format (SEF) tables for the Kyoto Protocol units issued in 2018 for the second commitment period (CP2) (see also Chapter 12.2). There were no annual external transactions made and at the end of the reported year there were no units in the party holding account.

The GHGs included in the national inventory are the following: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Emissions of the precursors nitrogen oxide (NO_x), non-methane volatile organic compounds (NMVOCs) and carbon monoxide (CO) as well as sulphur dioxide (SO_2) are also included, in compliance with the reporting guidelines.

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, with a contribution from the Agricultural University of Iceland (AUI). 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 12). 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 (*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*)
- The Icelandic Recycling Fund (Úrvinnslusjóður): IPPU
- The Icelandic Medicines Agency (IPPU)

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

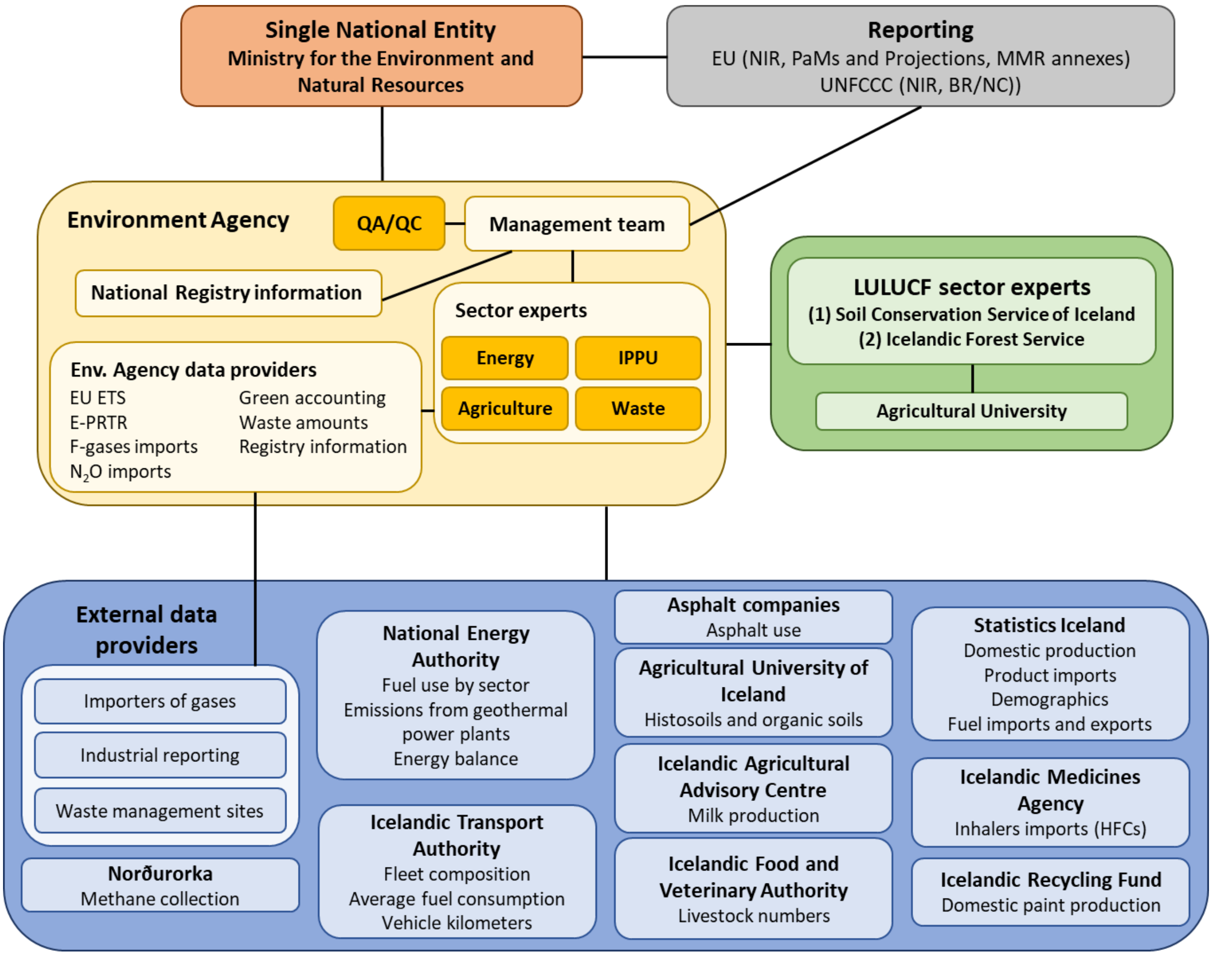

Figure 1.1 Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the UNFCCC.

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[4] 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 2019 to enhance collaboration and improve workflows.

Regulation No 520/2017 implements EU Regulation No (EU) 525/2013[5] 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 seen in Chapter 13.

1.2.4 Joint Fulfilment Agreement

According to Article 4, cf. Annex I, of the 2015 Joint Fulfilment Agreement[6] on Iceland´s participation in the joint fulfilment of the commitments of the EU, its Member States and Iceland in the second commitment period of the Kyoto Protocol, 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.

Work is underway to finalise the legal implementation of Iceland's joint fulfilment with the EU Member States and Norway for the Paris Agreement. Iceland will most likely be implementing the LULUCF Regulation (Regulation (EU) 2018/84 and 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).

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

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R0525

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

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.
- 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, IPCC Good Practice Guidance, 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.

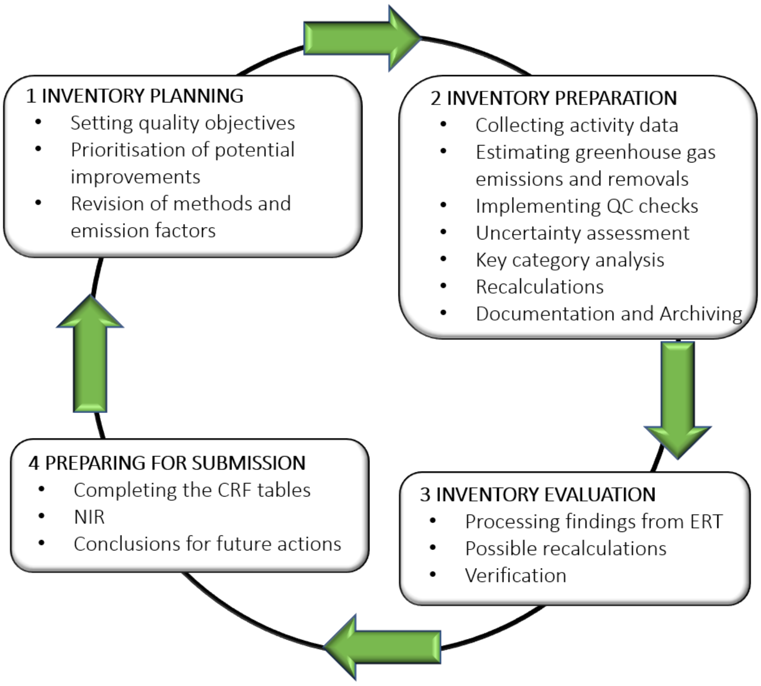

Figure 1.2 Iceland´s annual inventory cycle.

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 and are in accordance with IPCC's Good Practice Guidance. 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 online Office 365 subscription 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 fileserver 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.

1.4 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 2019 GHG inventory (including LULUCF). ✓= Key source category.

IPCC source category		**Gas**	**Level 1990**	**Level 2017**	**Trend**
Energy (CRF sector 1)					
1A2	Fuel combustion - Manufacturing Industries and Construction	CO_2	✓	✓	✓
1A3b	Road Transportation	CO_2	✓	✓	✓
1A4c	Agriculture/Forestry/Fishing	CO_2	✓	✓	✓
1B2d	Fugitive Emissions from Fuels - Other (Geothermal)	CO_2		✓	✓
IPPU (CRF sector 2)					
2C2	Ferroalloys Production	CO_2	✓	✓	✓
2C3	Aluminium Production	CO_2	✓	✓	✓
2C3	Aluminium Production	PFCs	✓		✓
2F1	Refrigeration and Air Conditioning	Aggregate F-gases		✓	✓
Agriculture (CRF sector 3)					
3A1	Enteric Fermentation - Cattle	CH_4	✓	✓	
3A2	Enteric Fermentation - Sheep	CH_4	✓	✓	
3D1	Direct N_2O Emissions from Managed Soils	N_2O	✓	✓	
Land use, Land use change and Forestry (CRF sector 4)					
4A2	Land Converted to Forest land	CO_2		✓	✓
4B1	Cropland Remaining Cropland	CO_2	✓	✓	✓
4B2	Land Converted to Cropland	CO_2	✓		✓
4C1	Grassland Remaining Grassland	CO_2	✓	✓	✓
4C2	Land Converted to Grassland	CO_2	✓		✓
4D1	Wetlands Remaining Wetlands	CO_2	✓	✓	✓
4(II) 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 2019 GHG inventory (excluding LULUCF). ✓= Key source category.

IPCC source category		Gas	Level 1990	Level 2017	Trend
Energy (CRF sector 1)					
1A2	Fuel combustion - Manufacturing Industries and Construction	CO_2	✓	✓	✓
1A3a	Domestic Aviation	CO_2	✓		
1A3b	Road Transportation	CO_2	✓	✓	✓
1A3b	Road Transportation	N_2O		✓	
1A3d	Domestic Navigation	CO_2	✓	✓	✓
1A4a	Commercial/Institutional Combustion	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	✓		✓

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 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. The next UNFCCC review is scheduled later this year, as a desk review. Furthermore, Iceland volunteered for an EU Stage 2 review (as described in Art. 32 of Regulation (EU) 749/2014).

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, for this submission. For the 2020 submission it is planned to revise and improve all assumptions and calculations for the sector 2.F.1 Refrigeration and Air Conditioning. 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.

1.5.2 Quality Control

The team uses standardised notation protocols in the calculation files to document changes, data sources and necessary improvements; Recalculations files, comparing the current and the previous submission, allow to check that no changes were made unless necessary and documented. General QC activities include cross-checking of CRF outputs, NIR tables and calculation files at various stages of the inventory compilation process.

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 QA/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.

1.5.3 Planned improvements for QA/QC activities

Work is underway to prepare a new QA/QC manual documenting all QA/QC activities, including attribution of responsibilities, check lists, timelines and other information relevant to the QA/QC procedure. Previous plan and manual are available[7], however they are outdated and need revising.

[7] QA/QC Plan: https://ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/Iceland_QAQC_plan.pdf;
QA/QC Manual: https://ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/Iceland_QAQC_manual.pdf.

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 the Tier 1 method of the IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 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 19%, whereas the uncertainty in total inventory is 40%. When looking at the uncertainty analysis without LULUCF, the trend uncertainty is 9.1%, and the uncertainty in total inventory is 8.7%.

The complete uncertainty analysis can be found in Annex 2.

1.7 General Assessment of Completeness

An assessment of the completeness of the emission inventory should, according to the IPCC's Good Practice Guidance, address the issues of spatial, temporal and sectoral coverage along with all underlying source categories and activities.

In terms of spatial coverage, the emissions reported under the UNFCCC covers all activities within Iceland's jurisdiction. In the case of temporal coverage, CRF tables are reported for the whole time series from 1990 to 2017. With regard to sectoral coverage, a few sources are not estimated usually due to a of lack of an available methodology in the 2006 IPCC Guidelines or related documents.

2 Trends in Greenhouse Gas Emissions

2.1 Emission Trends in Aggregated GHG Emissions

Total amounts of GHGs emitted in Iceland during the period 1990 to the current reporting 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).

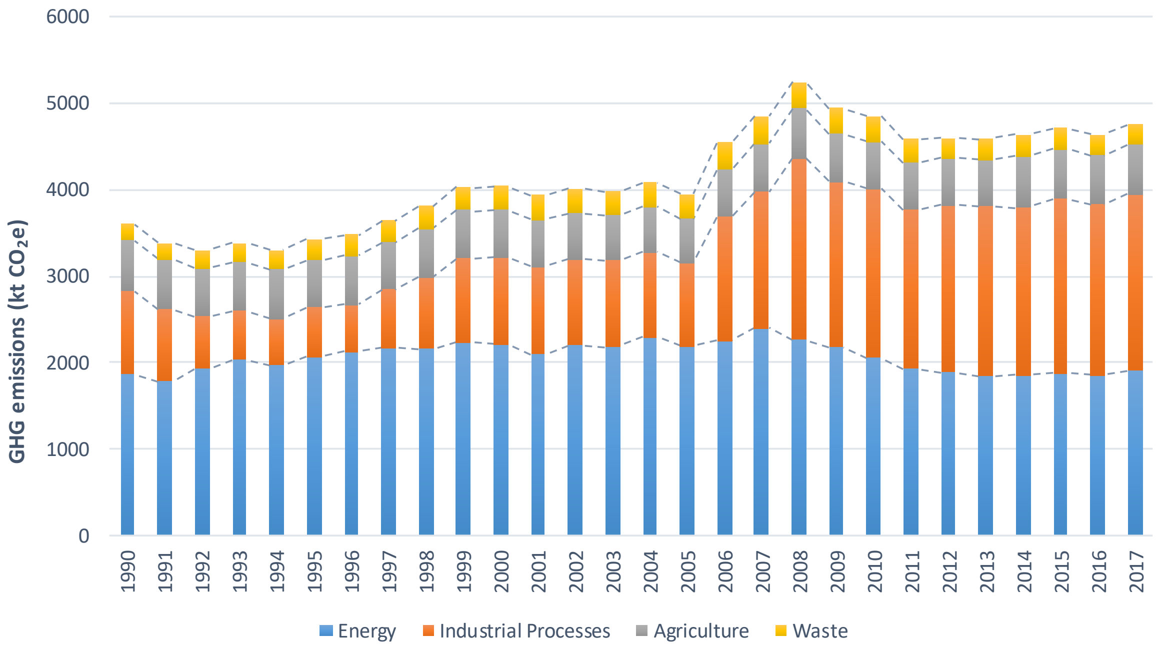

Figure 2.1 Emissions of GHG by UNFCCC sector, without LULUCF, from 1990 to 2017 (kt CO_2e).

Table 2.1 Emissions of GHG by sector in Iceland during the period 1990-2017 (kt CO_2e).

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**Changes ´90-´17**	**Changes ´16-´17**
1 Energy	1,867	2,069	2,210	2,184	2,057	1,877	1,858	1,907	2%	3%
2 Industrial Processes	958	571	1,009	965	1,951	2,023	1,974	2,039	113%	3%
3 Agriculture	593	548	552	519	546	571	571	578	-3%	1%
5 Waste	181	239	267	279	291	245	237	230	27%	-3%
Total emissions without LULUCF	**3,598**	**3,426**	**4,038**	**3,947**	**4,845**	**4,715**	**4,640**	**4,755**	**32%**	**2%**
4 Land Use, Land Use Change and Forestry (LULUCF)	9,407	9,361	9,387	9,427	9,472	9,363	9,345	9,321	-1%	0%
Total emissions with LULUCF	13,005	12,787	13,425	13,375	14,317	14,078	13,985	14,075	8%	1%

Total GHG emissions (excluding LULUCF) increased by approximately a third from 1990 – 2017. In 2017, 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 2017, with the exception of the year 2016 which saw a slight decrease. Emissions have increased between 2016 and 2017 by 2% 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 2017). This has resulted in higher emissions from most sources, but in particular from **transport** and the **construction sector**.

In 2017, **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 2017 total emissions from the aluminium sector were 18% 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 2017, 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.

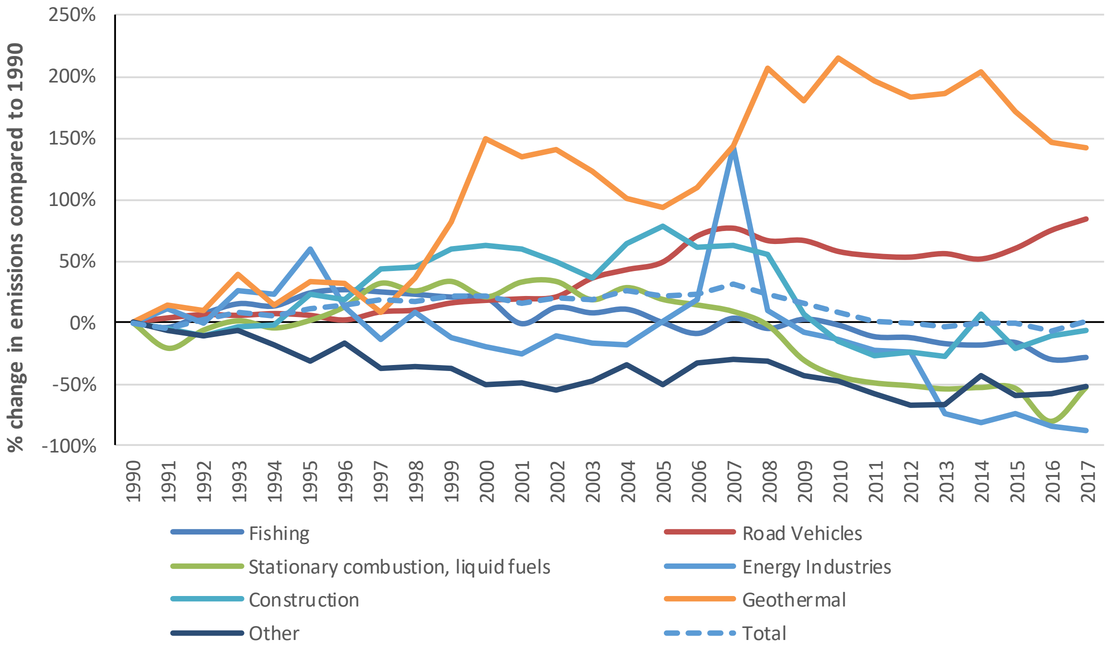

Figure 2.2 Percentage changes in GHG emissions for source categories in the Energy sector during 1990-2017, compared to 1990.

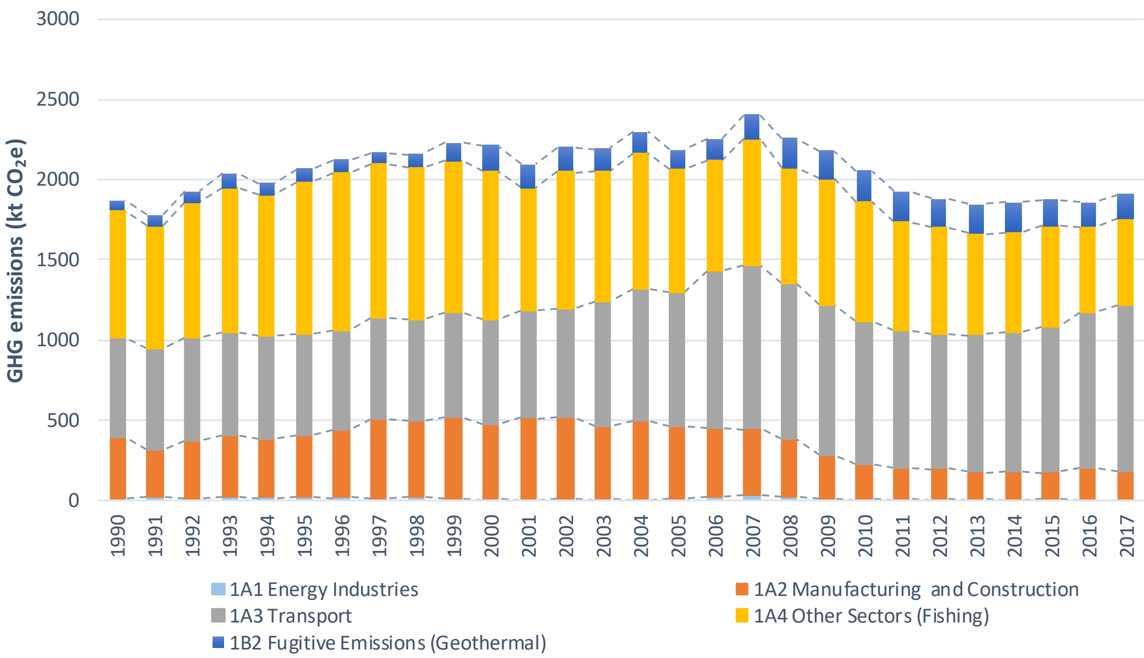

Figure 2.3 Total GHG emissions in Energy sector during 1990-2017 (kt CO_2e).

Table 2.2 Total GHG emissions from fuel combustion in the Energy sector in 1990-2017 (kt CO_2e).

Energy Sector	1990	1995	2000	2005	2010	2015	2016	2017	Change ´90-17	Change ´16-´17
1A1 Energy industries	14	22	11	14	12	3.6	2.2	1.8	-87%	-19%
1A2 Manufacturing industry and construction	377	384	456	449	214	177	198	180	-52%	-9%
1A3 Transport	620	624	663	836	890	895	975	1,030	66%	6%
1A4 Other Sectors	794	955	926	765	746	633	529	546	-31%	3%
1B2 Fugitive Emissions from Fuels (incl. Geothermal energy)	**62**	**83**	**155**	**120**	**195**	**168**	**152**	**150**	**141%**	**-2%**
Total emissions (kt)	**1,867**	**2,069**	**2,210**	**2,184**	**2,057**	**1,877**	**1,856**	**1,907**	**2%**	**3%**

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 2017. Emissions from transport have significantly increased since 1990 (by 66%), whilst emissions from energy industries, fishing and manufacturing industries and construction have decreased (-87%, -29% and -52%, 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 2017). Since 1997, annual emissions have on average been around 40% lower compared to 1990. 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 33% from 1990 to 2017. Emissions from road vehicles peaked in 2017 after a decreasing trend from the previous 2007 peak which has been followed by a rise in road emissions since 2015. The 2017 road emissions are 4.3% 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 3.1% of the total GHG emissions in Iceland in 2017. 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 2017. Electricity production using geothermal power increased 18-fold during this period from 283 to 5170 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 from 1990 to 2017 (kt CO_2e).

	1990	1995	2000	2005	2010	2015	2016	2017	Change ´90-´17	Change ´16-´17
Geothermal energy	62	83	154	119	194	167	152	149	142%	-2%

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 2017 GHG emissions from ships and aircrafts in international traffic bunkered in Iceland amounted to a total of 1,351 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 1990-2017 (kt CO_2e).

	1990	1995	2000	2005	2010	2015	2016	2017	Change ´90-´17	Change ´16-´17
1D1a International aviation	221	238	411	425	380	680	925	1,156	423%	25%
1D1b International navigation	20	3.4	55	1.8	0.3	150	187	195	899%	4%
Total GHG emissions	241	241	466	427	380	830	1,112	1351	461%	21%

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.

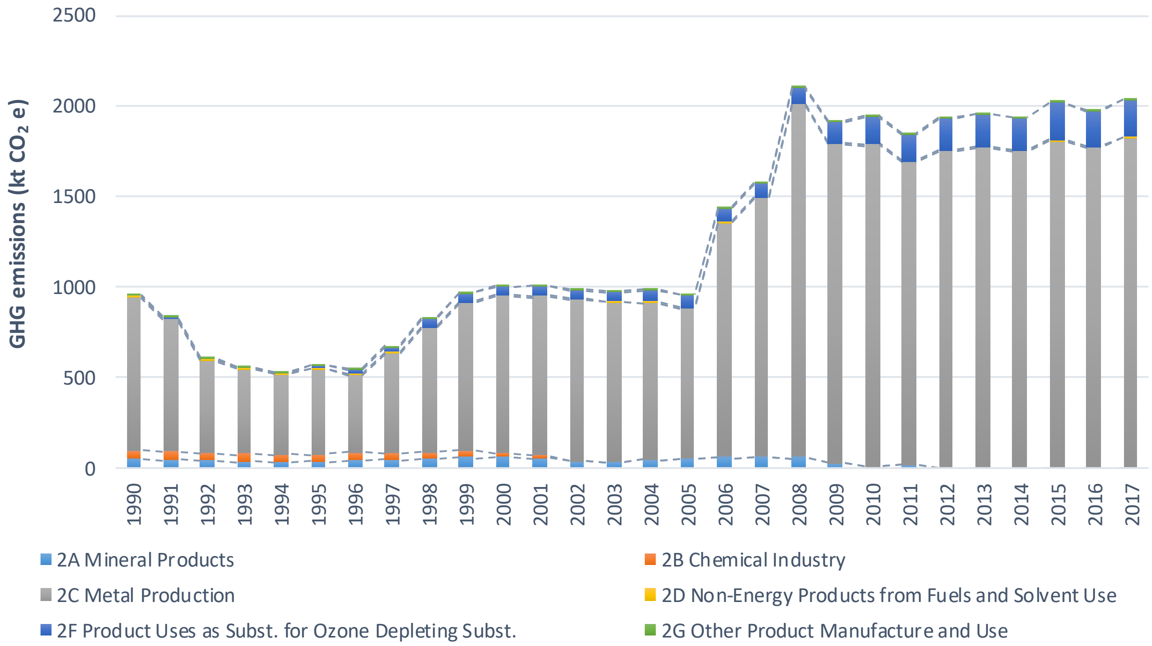

Figure 2.4 Total GHG emissions in the Industrial Process sector during 1990-2017 (kt CO_2e).

Table 2.5 GHG emissions from Industrial Processes 1990-2017 (kt CO_2e).

Industry Sector	1990	1995	2000	2005	2010	2015	2016	2017	Change ´90-´17	Change ´16-´17
2A Mineral products	52	38	65	55	10	0.7	0.8	0.9	-98%	17%
2B Chemical industry	47	41	18	NO	NO	NO	NO	NO	-	-
2C Metal production	844	469	868	828	1,781	1,807	1,772	1,824	116%	3%
2D Non-Energy Products from Fuels and Solvent Use	7.0	7.6	7.4	7.0	5.1	5.5	5.5	5.1	-26%	-6%
2F Product Uses as Substitutes for Ozone Depleting Substances	0.7	10	43	69	146	205	192	205	29596%	7%
2G Other Product Manufacture and Use	7.0	5.5	5.9	6.0	8.3	4.5	3.6	4.4	-37%	23%
Total GHG emissions	**958**	**571**	**1,009**	**965**	**1,951**	**2,023**	**1,974**	**2,039**	**113%**	**3%**

The significant category within the Industrial Processes sector is metal production, which accounts for approximately 90% of the sector's emissions across the time series:

- **Aluminium production** is the main source within the metal production category, accounting for 68% of the total Industrial Processes emissions in 2017. Aluminium is produced at three plants, Rio Tinto Alcan at Straumsvík, Century Aluminium at Grundartangi, and Alcoa Fjarðaál at Reyðarfjörður. The production technology in all aluminium plants is based on using 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 at Century Aluminium, but PFC emissions per tonne of aluminium decreased from 2007 to 2011 through improved process technology. The Alcoa Fjarðaál 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 Alcoa Fjarðaál, 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.

- 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 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 Medicated 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. Emissions have been increasing since 1990 due to the expansion of the Icelandic electricity distribution (Table 2.6). The peak 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).

	1990	1995	2000	2005	2010	2015	2016	2017	Change ´90-´17	Change ´16-´17
HFCs	0.7	10.2	43.3	69.3	146	205	192	205	29588%	7%
SF_6	1.1	1.2	1.3	2.5	4.7	1.5	1.3	2.3	110%	81%
PFC	0	0	0	0.002	0.01	0.02	0.02	0.06		

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. New addition to 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. 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 was 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.

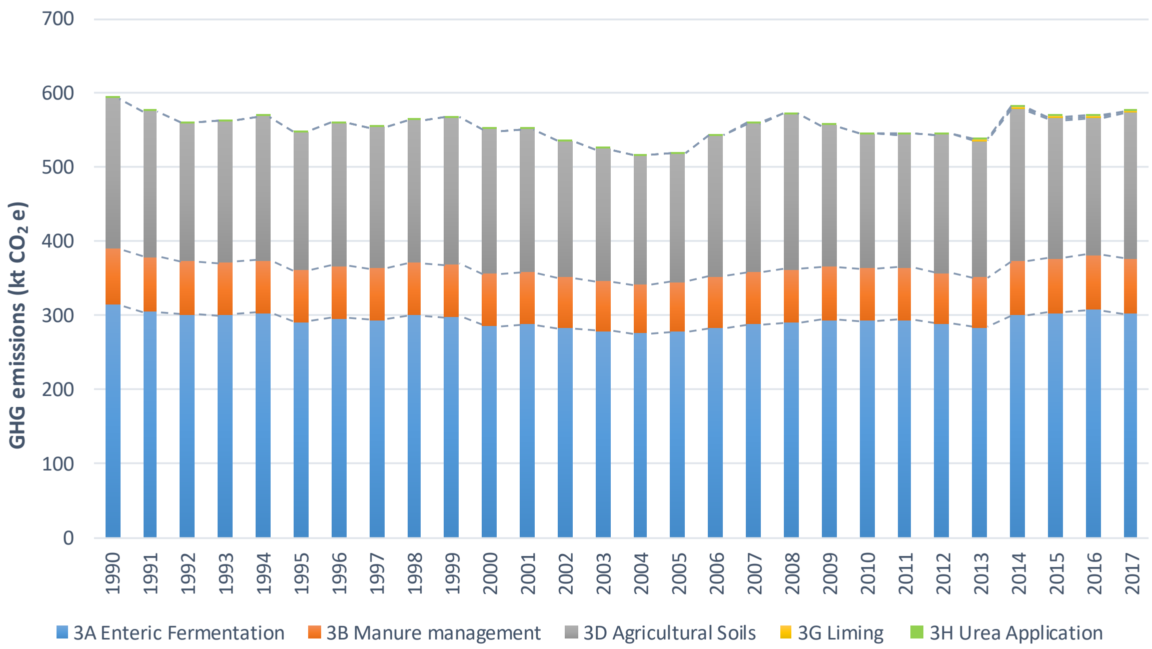

Figure 2.5 GHG emissions from agriculture sector 1990-2017 (kt CO2e).

Table 2.7 GHG emissions from agriculture sector from 1990 to 2017 (kt CO_2e).

Agriculture Sector	1990	1995	2000	2005	2010	2015	2016	2017	Change ´90-´17	Change ´16-´17
3A Enteric Fermentation	314	292	287	278	293	304	307	302	-4%	-1.5%
3B Manure management	76	69.3	69.5	67.1	70	74	75	75	-1.2%	-0.4%
3D Agricultural Soils	203	186	196	174	182	189	184	196	-3%	6%
3G Liming	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3	NA	0.0%
3H Urea Application	0.06	0.06	0.07	0.07	0.13	2.30	2.41	2.55	4529%	6%
Total GHG emissions	**593**	**548**	**552**	**519**	**546**	**571**	**571**	**578**	**-2.4%**	**1.2%**

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 1990-2017. 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 2017 was from cropland and grassland on drained organic soil. The net contribution of the main land use categories is summarized in Figure 2.6 below.

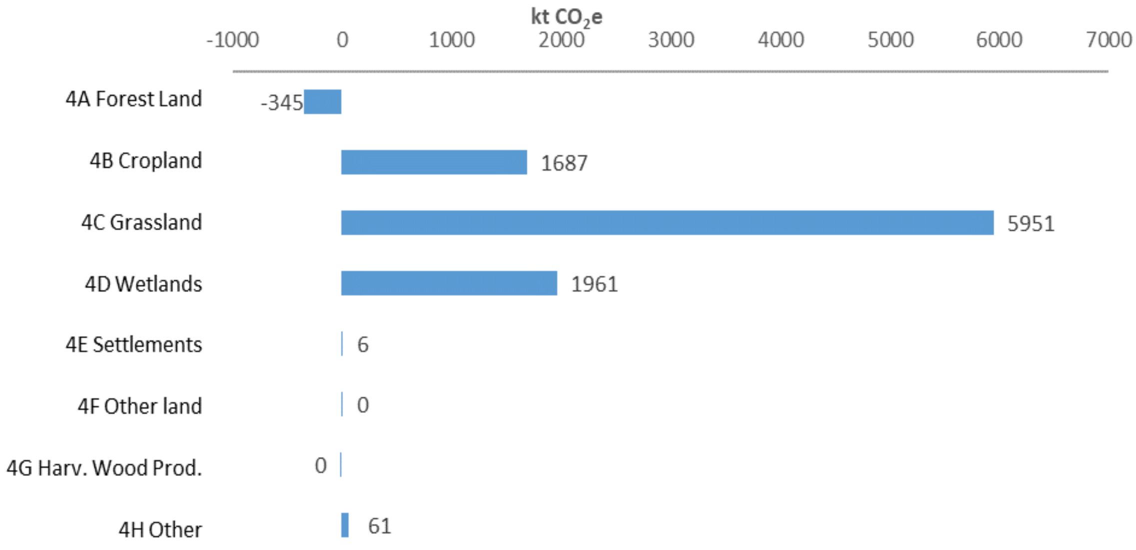

Figure 2.6 Net emissions/removals from the LULUCF land use categories (kt CO_2e)

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	2016	2017	Change ´90-´17	Change ´16-´17
4A Forest Land	-42	-66	-101	-153	-208	-314	-324	-345	721%	6%
4B Cropland	1,975	1,922	1,868	1,814	1,761	1,707	1,697	1,687	-15%	-0.6%
4C Grassland	5,372	5,407	5,530	5,677	5,882	5,940	5,944	5,951	11%	0.1%
4D Wetlands	2,027	2,032	2,019	1,999	1,973	1,964	1,963	1,961	-3%	-0.1%
4E Settlements	24	13	18	34	6	6	6	6	-75%	0.0%
4F Other Land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.003	NA,NE	0.002	-	-
4G Harvested Wood Products	NO, NA	NO, NA	0.0004	-0.0002	-0.03	-0.1	-0.04	-0.09	-	125%
4H Other	52	52	54	56	58	59	60	61	17%	1.7%
Net emissions LULUCF	**9,408**	**9,360**	**9,388**	**9,427**	**9,472**	**9,362**	**9,346**	**9,321**	**-0.9%**	**-0.3%**

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 4.7% of total GHG emissions in 2017 Approximately 90% 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 2.7 and 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 2017 amounted to 30%.
- **Wastewater handling emissions** have increased by more than half since 1990 due to increasing N_2O and methane emissions. The increase in N_2O emission estimates is proportional to an increase in population. The increase in methane emissions is mainly due to an increase in the share of wastewater treated in septic systems.
- A halving of emissions from **waste incineration** between 1990 and 2017 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 2017 composting emissions increased 11-fold due to increasing amounts of waste composted.

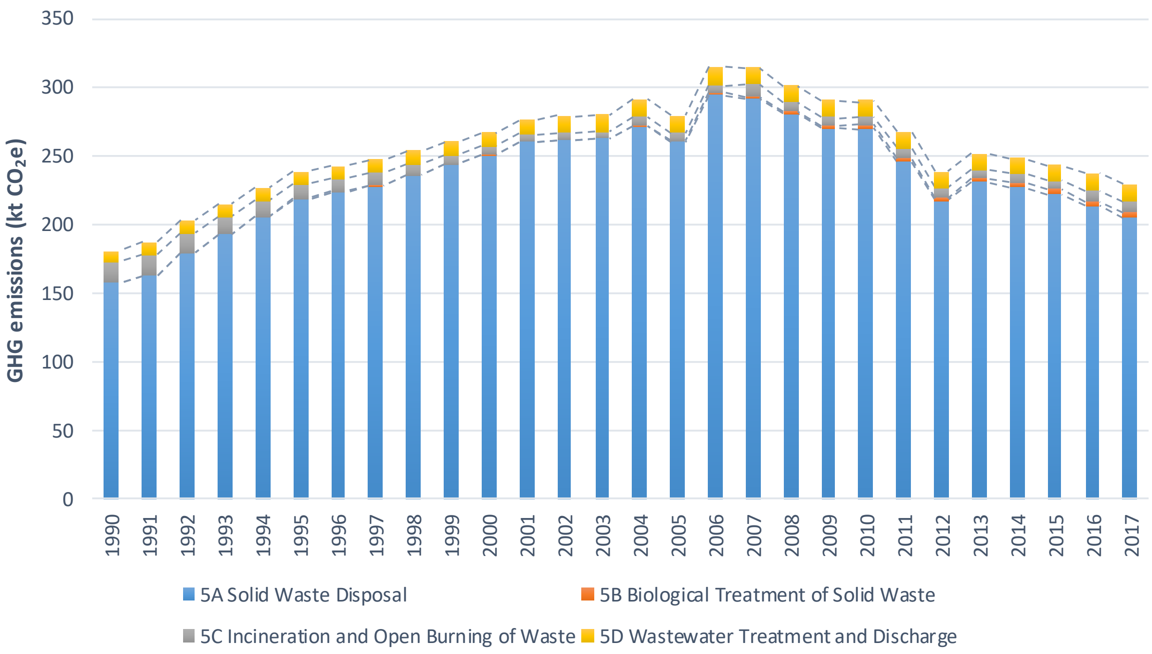

Figure 2.7 GHG emissions of the waste sector 1990-2017 (kt CO_2e).

Table 2.9 GHG emissions from the waste sector from 1990 to 2017 (kt CO_2e).

Waste Sector	1990	1995	2000	2005	2010	2015	2016	2017	Change ´90-´17	Change ´16-´17
5A Solid Waste Disposal	158	219	251	260	270	222	213	205	30%	-4%
5B Biological Treatment of Solid Waste	NO	0.34	0.34	0.86	2.6	3.7	3.9	3.7	N/A	-5%
5C Incineration and Open Burning of Waste	15	10.3	6.0	5.5	6.5	6,2	7.4	7.8	-51%	5%
5D Wastewater Treatment and Discharge	8.0	9.5	10.0	12.7	11.9	12.3	12.5	12.7	59%	2%
Total emissions	**181**	**239**	**267**	**279**	**291**	**245**	**237**	**230**	**27%**	**-3%**

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 since 1990 (without LULUCF) (kt CO2e).

	1990	1995	2000	2005	2010	2015	2016	2017	Change ´90-´17	Change ´16-´17
CO_2	2,237	2,465	2,934	2,969	3,621	3,533	3,490	3,614	61.5%	3.6%
CH_4	543	576	602	602	632	599	594	581	7.1%	-2.1%
N_2O	322	304	307	274	269	273	271	284	-11.8%	4.6%
PFCs	495	69	150	31	172	104	92	68	-86.2%	-25.9%
HFCs	0.7	10	43	69	146	205	192	205	NA	6.7%
SF_6	1.1	1.2	1.3	2.5	4.7	1.5	1.3	2.3	110.4%	80.9%
Total emissions	**3,598**	**3,426**	**4,038**	**3,947**	**4,845**	**4,715**	**4,640**	**4,755**	**32.1%**	**2.5%**

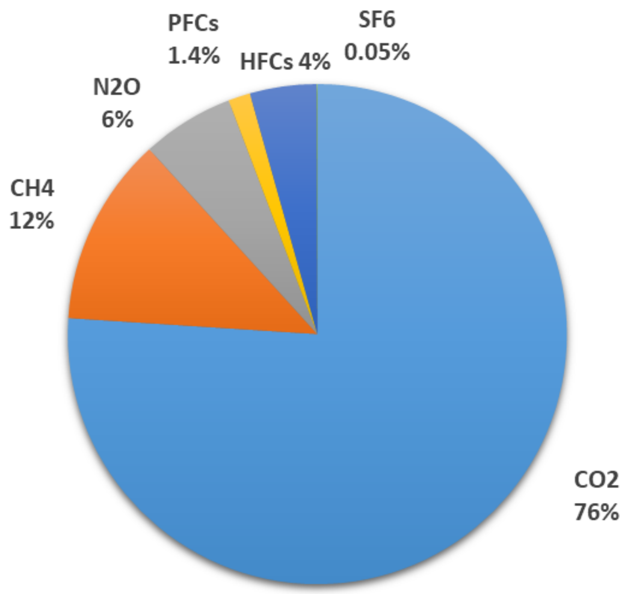

Figure 2.8 Distribution of emissions of GHGs by gas in 2017.

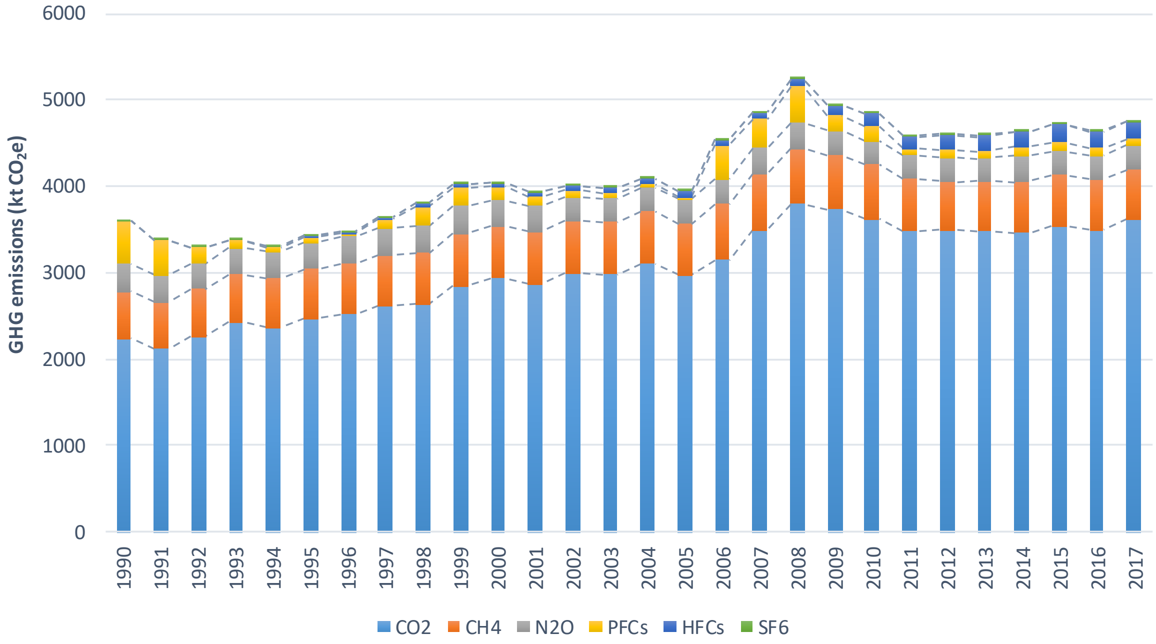

Figure 2.9 Emissions of GHGs by gas, 1990-2017.

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.
- 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 2017.
- **Road transport** CO_2 emissions have increased by 83% 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 2017 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 unmanaged manure and manure managed in solid storage.

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 68 kt CO_2e in 2017, whereas emissions of PFCs from refrigeration and air conditioning equipment were 0.058 kt CO_2e in 2017.

Total PFC emissions decreased by 86% in the period of 1990-2017. 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 Rio Tinto Alcan aluminium plant in 1997 and the establishment of the Century Aluminium 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 the Century Aluminium facility. PFC emissions per tonne of aluminium went down from 2007 to 2010 and reached 2005 levels in 2010 at the Century Aluminium plant. The Alcoa Fjarðarál 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 at both Century Aluminium plant and Alcoa Fjarðarál (except in December at Alcoa), 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 Alcoa. This led to increased PFC emissions leading to higher emissions at the plant in 2010 than in 2009.

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 2002 (0.001 to 0.007 kt CO_2e per year) and C_3F_8 was used in refrigeration and air conditioning equipment for the first time in 2009.

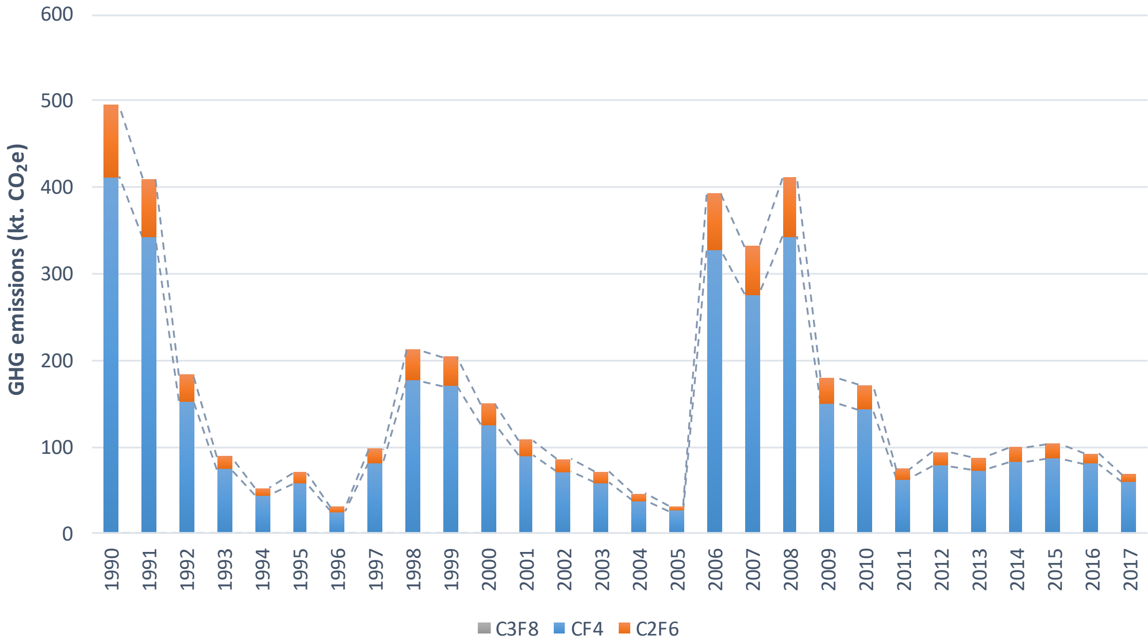

Figure 2.10 Emissions of PFCs from 1990 to 2017 (kt CO2e).

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 has increased until 2010 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.

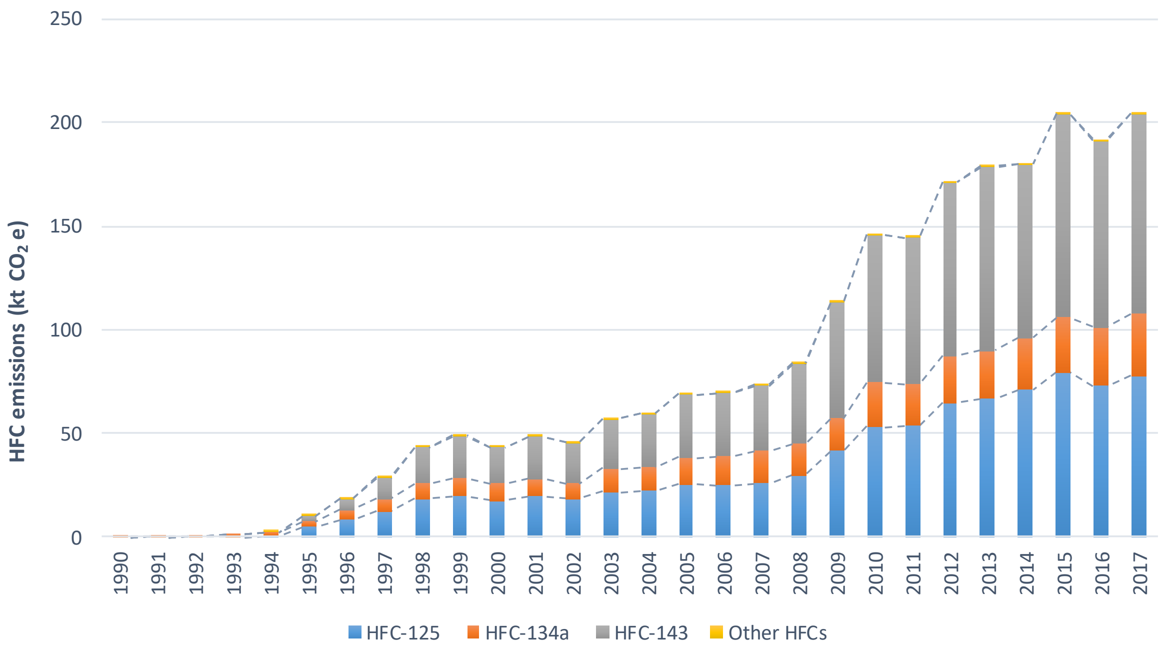

Figure 2.11Emissions of HFCs from 1990 to 2017 (kt CO2e).

2.2.6 Sulphur Hexafluoride (SF_6)

The sole source of SF_6 emissions in Iceland is leakage from electrical equipment. Emissions have increased by approximately 110% since 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.

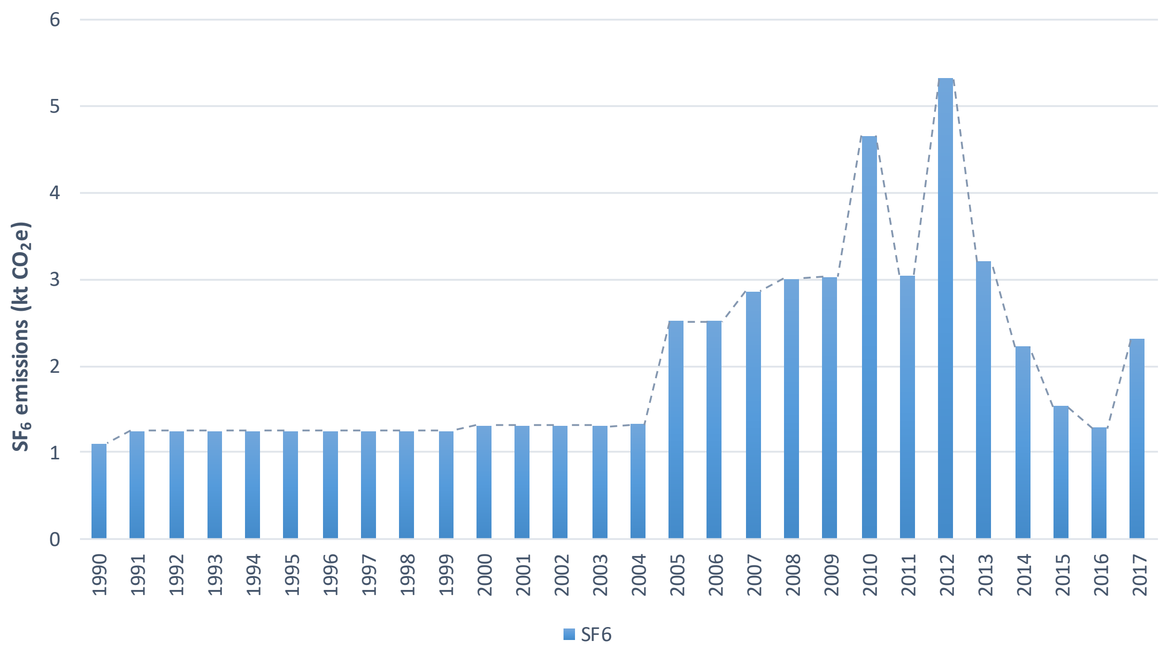

Figure 2.12 Emissions of SF6 from 1990 to 2017 (kt CO_2e).

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.

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.

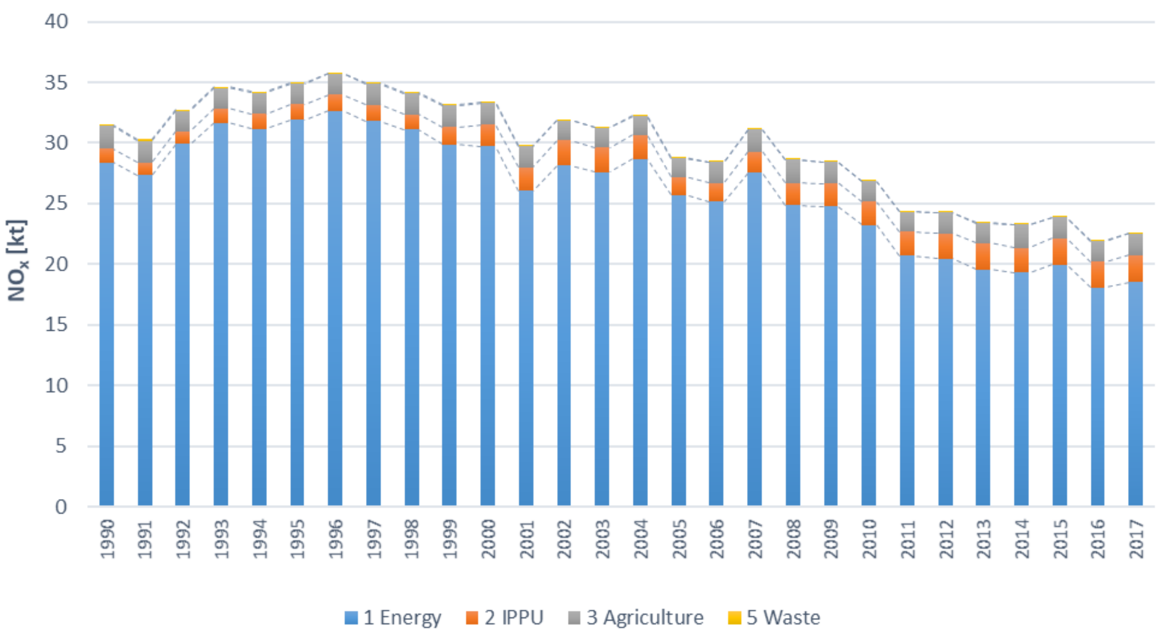

Figure 2.13 Emissions of NO_x by sector 1990-2017 in kt.

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 showed a general downward trend from 1994 to 2014 but has been slightly rising again since then.

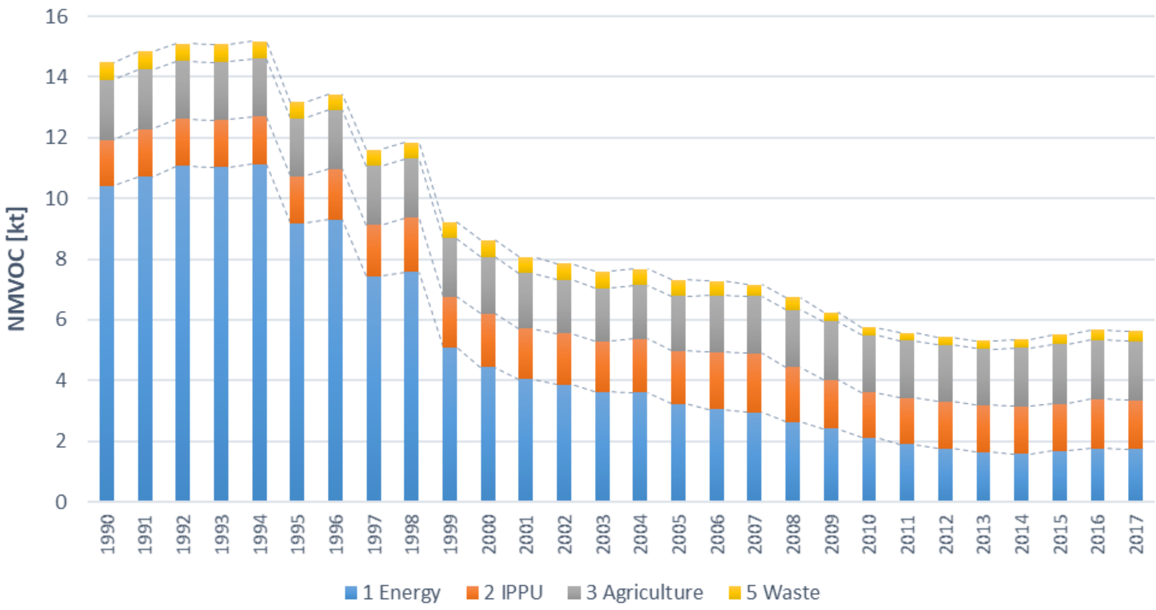

Figure 2.14 Emissions of NMVOC by sector 1990-2017 in kt.

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.

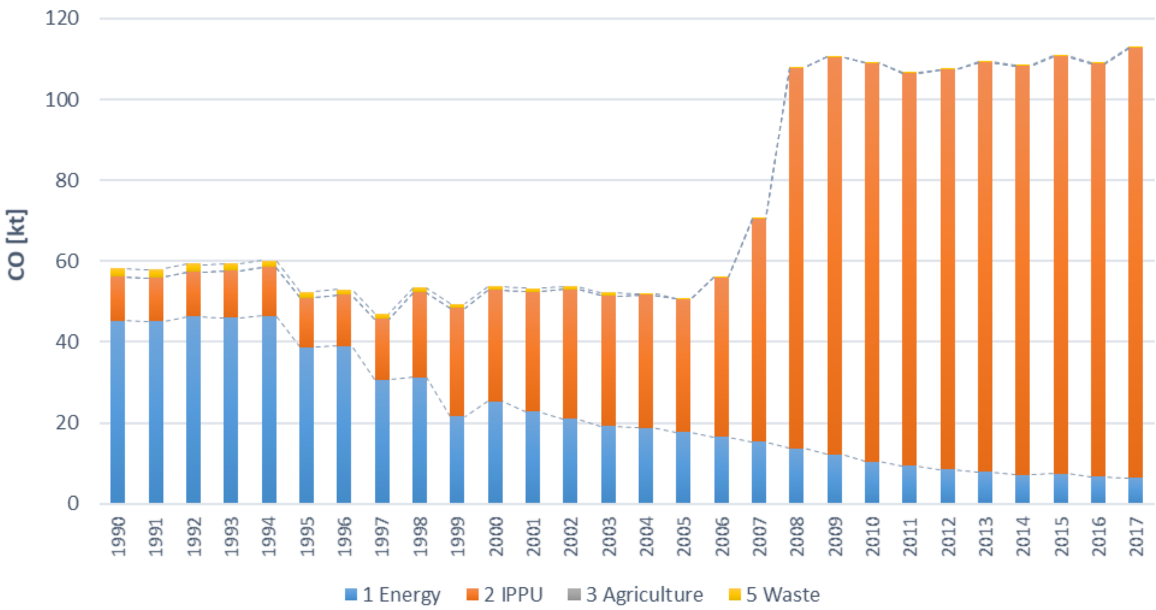

Figure 2.15 Emissions of CO by sector 1990-2017 in kt.

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. 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, but when emissions from geothermal power plants are excluded emissions have increased fourfold.

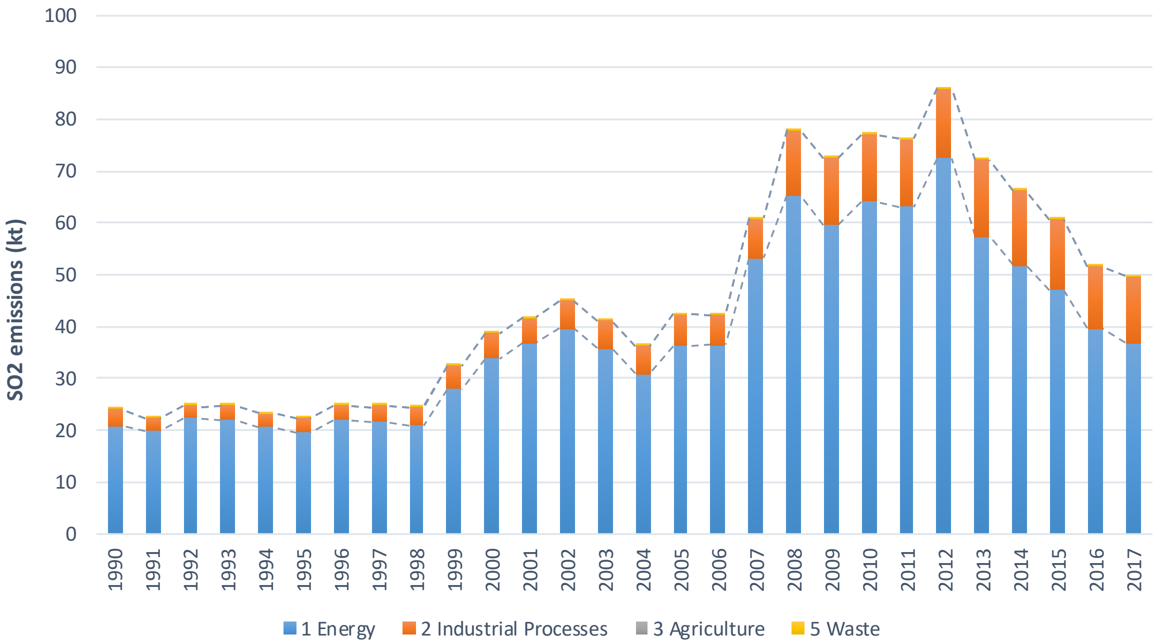

Figure 2.16 Emissions of S (sulphur) by sector 1990-2017 (kt SO_2e).

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 1,907 kt CO_2e in 2017. The 1990 emissions were estimated to be 1,867 kt CO_2e and the emissions from the energy sector in the most recent year reported are 2.1% 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 74% of the total GHG emissions in the energy sector in 2017. CO_2 emissions account for 96.7% 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. For the years 1990-2015, 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 follow:

- In years where there is less fuel sale to energy industries as 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 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 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.

For the activity data for the years 2016-2017, the NEA made an attempt to subdivide fuel sales according to IPCC sectors. EA is still using EU ETS reports for calculating the emissions from fuel combustion by installations covered by the EU ETS (Aluminium, ferroalloy and mineral wool production), and fuel combustion for electricity generation is still calculated based on electricity produced. Work is underway with the NEA to refine the categorisation of fuel use by IPCC sectors.

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.

3.1.2 Key Category Analysis (KCA)

The key sources for 1990, 2017 and 1990-2017 trend in the Energy sector are as follows (compared to total emissions without LULUCF):

Table 3.1 Key Categories for Energy 1990, 2017 and trend (excluding LULUCF).

IPCC source category			Level 1990	Level 2017	Trend
Energy (CRF sector 1)					
1A2	Fuel combustion - Manufacturing Industries and Construction	CO_2	✓	✓	✓
1A3a	Domestic Aviation	CO_2	✓		
1A3b	Road Transportation	CO_2	✓	✓	✓
1A3b	Road Transportation	N_2O		✓	
1A3d	Domestic Navigation	CO_2	✓	✓	✓
1A4a	Commercial/Institutional Combustion	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	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

The QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations, estimating uncertainties, archiving information and reporting, as further elaborated in the QA/QC manual. No source specific QA/QC procedures have yet been developed for the Energy sector.

A complete revision of the stationary and non-road transport energy sector was done for the 2019 submission in relation to file structure and the methodology used for the emission estimates. A review of the energy sector was undertaken focusing on the quality of the data and the parameters being used. This included a comparison of the available data for the reference approach (see Section 3.6.1). This work will be continued in 2019 in collaboration with the NEA to review the quality of the activity data for the entire time series. Furthermore, the revision will extend to include the road transport sector. The main recalculations and implications are outlined in the corresponding sections above for each of the CRF categories for energy.

3.1.5 Planned Improvements

Several improvements are planned for the next submission:

- Road transportation emissions will be refined with the use of the COPERT model for the whole timeseries.

- Category-specific QA/QC are being developed in collaboration with a consulting company (Aether ltd.)
- Increased collaboration with the NEA is planned in order to address discrepancies between energy statistics and data used in the inventory, and activity data for the whole time series will be checked and attribution between IPCC subsectors discussed.
- 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 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 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.

3.2 Fuel Combustion: Energy industries (CRF 1A)

3.2.1 Energy Industries (CRF 1A1)

Iceland has extensively used renewable energy sources for electricity and heat production in the past few decades, and the emissions from energy industries are therefore lower than for most other countries that utilize a higher share of fossil fuels. Emissions from electricity and heat production were estimated to account for <0.1% of the total GHG emissions from the Energy sector in the most recent year.

Activity data for the electricity and heat production are based on data provided by the NEA and attributed to various subcategories by the Environment Agency, see Annex 7. 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 Guideline. 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 2017 (Table 3.3) with hydropower as the main source of electricity (Orkustofnun, 2018). 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, Grimsey 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	2016	2017
Hydropower	4,159	4,678	6,352	7,014	12,592	13,781	13,470	14,059
Geothermal	283	288	1,323	1,658	4,465	5,003	5,067	5,170
Fuel combustion	5.6	8.4	4.4	7.8	1.7	4.0	2.7	2.1
Wind power	NO	NO	NO	NO	NO	11	9	8
Total	**4,447**	**4,975**	**7,679**	**8,680**	**17,059**	**18,799**	**18,549**	**19,239**

Activity Data

Activity data for electricity production is calculated from the information on electricity production, fuel use and the energy content of the fuel assuming 34% efficiency. In 2017 approx. 0.011% 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	2016	2017
Gas/Diesel oil (kt)	1.4	2.1	1.1	2.0	0.4	1.0	0.7	0.5
Emissions (kt)	**4.5**	**6.8**	**3.6**	**6.3**	**1.4**	**3.2**	**2.2**	**1.7**

Emission Factors

The CO_2 emission factors (EF) used reflect the average carbon content of fossil fuels. They 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 fuel.

Table 3.5 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 [%]
Gas/Diesel oil	43.00	20.20	1	3.18	0.2

The resulting greenhouse gas emissions from electricity produced from fuels in CO_2e per kWh amount to 803 g of CO_2 per kWh. Emissions from hydropower reservoirs amounted to 20.4 kt of CO_2e and emissions from geothermal power plants to 149.1 kt of CO_2e, in 2017. The resulting emissions of GHG per kWh amount to 1.45 g CO_2e/kWh for hydropower plants and to 28.8 g CO_2e/kWh for geothermal energy. The weighted average GHG emissions from electricity production in Iceland in 2017 were thus 8.8 g/kWh.

Uncertainties

The estimation of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from electricity production with fuels is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%), the uncertainty of CH_4 emissions is 100% (with an activity data uncertainty of 5%

and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 5% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex 2.

Recalculations

No recalculations were performed for this subcategory.

3.2.2.2 Heat Plants (CRF 1A1aiii)

Geothermal energy was the main source of heat production in 2017. 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 2010. 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	2016	2017
Residual fuel oil	2.99	3.08	0.07	0.20	NO	0.14	0.02	0.04
Solid waste	NO	4.65	6.05	5.95	8.11	NO	NO	NO
Emissions (GHG)	**9.37**	**15.24**	**7.48**	**7.76**	**10.58**	**0.43**	**0.06**	**0.11**

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. They are presented in Table 3.7 along with the sulphur content of the fuels. Emission factors for the waste incineration energy recovery are described in the Waste sector, chapter 7.9. 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	1.21[1]	0.1

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

Uncertainties

The estimation of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from heat production with fuels is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%), the uncertainty of CH_4 emissions is 100% (with an activity data uncertainty of 5% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 5% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex 2

Recalculations

No recalculations were performed for this subcategory.

3.3 Manufacturing Industries and Construction (CRF 1A2)

Emissions from the Manufacturing Industries and Construction account for 9.5% 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)
1A2c	Chemicals	Fertilizer production (1990-2001), Diatomite production (1990-2004)
1A2d	Pulp, Paper and Print	NO
1A2e	Food Processing	Fishmeal. Other food processing is included in "1A2gviii"
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, including food processing other than fishmeal.

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 the fuel consumption by the different industrial sources. This division is made by EA on basis of the reported fuel use by all major industrial plants falling under Act 70/2012 and the ETS Directive (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 2017 are based on data provided by the industry (application for free allowances under the EU ETS for the years 2005 to 2010, information from the Icelandic Association of Fishmeal Manufacturers for 2003, 2004, 2011 and 2012 and from EU ETS annual reporting for 2013 to 2017). The difference between the given total for the sector and the sum of the fuel use of the reporting industrial facilities are 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 to separate 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). Thus 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	2016	2017
Gas/Diesel oil	5.07	1.13	10.25	22.2	9.39	10.16	14.00	11.01
Residual fuel oil	55.93	56.22	46.21	25.01	16.55	10.18	8.65	5.43
LPG	0.48	0.39	0.86	0.93	1.05	0.50	0.91	0.72
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	0.86	NO
Total GHG Emissions (kt)	**376.7**	**384.2**	**456.1**	**448.6**	**214.0**	**177.4**	**198.5**	**180.2**

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	2016	2017
Gas/Diesel oil	38.0	46.7	61.9	67.8	32.2	30.0	34.1	35.4
Biofuels	NO	NO	NO	NO	NO	NO	0.08	0.02
Emissions	**135.1**	**166.2**	**220.1**	**241.0**	**114.6**	**106.8**	**121.3**	**125.8**

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 Guideline. CH_4 and N_2O emission factors are the default values for stationary combustion (Table 2.3, Volume 2, Chapter 2 of the 2006 IPCC guidelines), and the defaults 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). For biofuels, reported for the first time in this year´s submission, 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 equivalent due to lack of more accurate biofuel-specific data.

Table 3.11 CO_2 emission factors from fuel combustion and S-content of fuel (IE: Included Elsewhere).

	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	43.0	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)	31.35	31.4	1	115.2	10	1.5	1.6%
Other bituminous coal	25.8	25.8	1	94.6	10	1.5	0.9%
Petroleum coke	32.5	26.6	1	97.5	3	0.6	IE[1]
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 combustion in the construction sector.

	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	43.0	20.2	1	74.07	4.15	28.6
Biodiesel	43.6	19.3	1	70.80	4.15	28.6

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%), 100% for CH_4 emissions (with an activity data uncertainty of 1.5% and emission factor uncertainty of 100%)

and 150% for N_2O emissions (with an activity data uncertainty of 1.5% and emission factor uncertainty of 150%).

The uncertainty of CO_2 emissions from the other subsectors (1A2c, e, f and g) is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%), 100% for CH_4 emissions (with an activity data uncertainty of 5% and emission factor uncertainty of 100%), and 150% for N_2O emissions (with an activity data uncertainty of 5% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex 2.

3.3.4 Recalculations:

For this submission the emission factor for N_2O emissions from LPG was updated. In previous submissions it was reported as NA and now it has been replaced by a default emission factor of 0.1 kg N_2O/TJ fuel according to IPCC 2006 guidelines, volume 2, table 2.3. This updated emission factor effected subsectors 1A2b and 1A2gviii. The total difference in GHG emission because of this recalculation in sector 1A2 for the year 2016 between the 2018 and the 2019 submission amounts to 0.31 kt CO_2e.

3.4 Transport (CRF 1A3)

Emissions from the transport sector were estimated to accounted for approximately half of the Energy sector's total GHG emissions in Iceland in the most recent year. Road transport was estimated to account for approximately 95% of the emissions in the transport sector.

3.4.1 Civil 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 used for domestic flights. Activity data for fuel combustion 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	2016	2017
Jet kerosene	8.41	8.25	7.73	7.39	6.07	5.99	6.69	6.92
Gasoline	1.68	1.13	1.10	0.87	0.65	0.50	0.48	0.37
Total GHG Emissions	**32.00**	**29.78**	**28.02**	**26.23**	**21.32**	**20.62**	**22.77**	**23.15**

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

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from domestic aviation 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%). This can be seen in the quantitative uncertainty table in Annex 2.

3.4.1.4 Recalculations

No recalculations were performed for emission of greenhouse gases from this sector. Recalculations were made for emissions of NO_x, NMVOC and CO with updated emission factors from EMEP/EEA 2016 guidebook.

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 to switch 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 by multiplying the fuel use by type of fuel and vehicle, and fuel and vehicle pollutant specific emission factors. Iceland has plans of setting up COPERT in order to estimate pollution from road transportation more accurately. 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. Only CH_4 and N_2O emissions from biofuels are included in the national total.

	1990	1995	2000	2005	2010	2015	2016	2017
Gasoline	128	136	143	157	148	132	136	134
Diesel oil	37	37	47	83	106	126	146	164
Biogasoline/Bioethanol	NO	NO	NO	NO	NO	1.93	4.70	4.57
Biodiesel	NO	NO	NO	NO	0.14	11.9	11.4	13.2
Biomethane	NO	NO	NO	NO	0.44	1.38	1.42	1.51
Emissions	**527**	**557**	**622**	**787**	**833**	**847**	**924**	**975**

NEA estimates on how the fuel consumption is divided between different vehicles groups, i.e. passenger cars, light duty vehicles and heavy-duty vehicles are used for the period 1990 to 2005. From 2006 to 2016 EA estimated how the fuel consumption is divided between the different vehicles' groups, using information on the number of vehicles in each group and the driven mileage in each group from the Road Traffic Directorate, using average fuel consumption based on the 1996 IPCC Guidelines regarding average fuel consumption per group. The data for 2006 to 2016 also contains information on motorcycles. The Road Traffic Directorate does not have similar data for previous years. Therefore, the time series is not fully consistent as two different methodologies are used.

Biofuels

Last year´s inventory included for the first time emissions from biofuel used in road transport. This included biogasoline (bioethanol), biodiesel as well as biomethane from landfill gas. Biogasoline and biodiesel are mixed with their fossil equivalent and sold as a mixture at the fuel stations, therefore biogasoline and biodiesel use was distributed between the various vehicle classes using the same distribution ratios as their fossil counterparts. However, the biomethane use by vehicle type is not known, and all biomethane was attributed to passenger cars.

All of the biogasoline in Iceland is bioethanol and does therefore not include any fossil carbon (Sempos I. , 2018), for which CO_2 would need to be accounted for in this inventory. At this time the origin of biodiesel in Iceland is unknown, however work has begun to estimate the % of fatty acid methyl esters (FAME) in biodiesel in Iceland. The CO_2 emissions from the fossil part of FAME needs to be accounted for in the inventory. The fossil part ranges from 5.3% -5.5% in FAME (Sempos I. , 2018) and if it assumed that all biodiesel used in Iceland in 2017 was FAME (13.2 kt) the emissions would be equivalent to 0.04% of Iceland's total emissions in 2017 and is therefore below the threshold of significance.

3.4.2.2 Emission Factors

NCV and CO_2 emission factors are default values from Table 1.2 and 1.4 from Volume 2, Chapter 1 of the 2006 IPCC Guidelines, with the exception of NCV´s for biofuels which are taken from the Proof of Sustainability documents, which fuel suppliers are required to provide the NEA. NCV and CO_2 emission factors are shown in Table 3.16 below.

Table 3.16 NCV, CO_2 emission factors and oxidation factor for all fuel types used in road transport.

	NCV (TJ/kt)	CO_2 EF (tCO_2/TJ)	CO_2 EF (tCO_2/kt fuel)	Oxidation factor
Gasoline	44.3	69.3	3,070	1
Diesel	43	74.1	3,186	1
Biogasoline	27	70.8	1,912	1
Biodiesel	43.6	70.8	3,088	1
Biomethane	50	54.6	2,730	1

Emission factors for CH_4 and N_2O depend upon vehicle type and emission control. They are mostly Tiers 1 default emission factors taken from the 2006 IPCC Guidelines and are presented in Table 3.17. For biofuels, the same CH_4 and N_2O emission factors are assumed as their fossil fuel counterpart. For biomethane, default CH_4 and N_2O emissions from natural gas combustion were used as a proxy for biomethane.

Table 3.17 Emission factors for GHG from European vehicles, g/kg fuel.

	CH_4 (g/kg fuel)	N_2O (g/kg fuel)
1A3bi 1 Passenger car with 3-way catalyst		
Gasoline/Biogasoline	0.3	0.8
Diesel/Biodiesel	-	-
Biomethane	4.6	0.15
1A3bi 2 Passenger car without 3-way catalyst		
Gasoline/Biogasoline	1.1	0.35
Diesel/Biodiesel	0.168	0.168
1A3bii 2 Light weight truck without 3-way catalyst		
Gasoline/Biogasoline	1.5	0.14
Diesel/Biodiesel	0.168	0.168
1A3biii Heavy duty Trucks and buses		
Gasoline/Biogasoline	1.5	0.14
Diesel/Biodiesel	0.17	0.168
1A3biv Motorcycles		
Gasoline/Biogasoline	5	0.07
Diesel/Biodiesel	-	-

3.4.2.3 Uncertainties

The estimate of quantitative uncertainty has revealed that 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%). This can be seen in the quantitative uncertainty table in Annex 2.

3.4.2.4 Recalculations

For previous submissions the difference in gasoline sold and calculated gasoline usage based on VKT had been attributed to passenger cars. In the same way the difference in diesel oil sold and calculated diesel oil usage based on VKT had been attributed to heavy duty truck and buses. For this submission the differences were attributed to all vehicle types in proportion to the total amount of calculated fuel use. This recalculation was only possible to perform for the years 2006-2017 where sufficient data was available, because as stated earlier calculations for 1990-2005 were done by the NEA. This did not affect total CO_2 emissions, but it did have minor effect on CH_4 and N_2O emissions.

In addition, an error in allocation of gasoline on heavy duty trucks in 2016 was corrected. This did not affect total emissions of CO_2, only the distribution between vehicle types. However, it did have a minor effect on CH_4 and N_2O emissions.

The total difference in GHG emissions because of these recalculations in the road transport sector for the year 2016 between the 2018 and the 2019 submission amounts to -0.24 kt CO_2e of CH_4 and +1.67 kt CO_2e of N_2O. That results in a total increase in emission from 1A3b of 1.43 kt CO_2ein 2016 which is >0.2% of total emissions from the sector for that year.

3.4.2.5 Planned Improvements

For this submission vehicle fleet numbers and data on kilometres driven were received from COPERT shortly before the submissions and therefore only preliminary results are available at this time, and only for 2000-2017; given the timeline these were not included in this submission. The comparison between these primary results and the data in the current submission can be seen in Figure 3.1. It shows that the current submission and calculations preformed in COPERT correlate very well for the whole period of 2000-2017. The maximum difference is a 1.5% overestimation of the current submission for 2006.

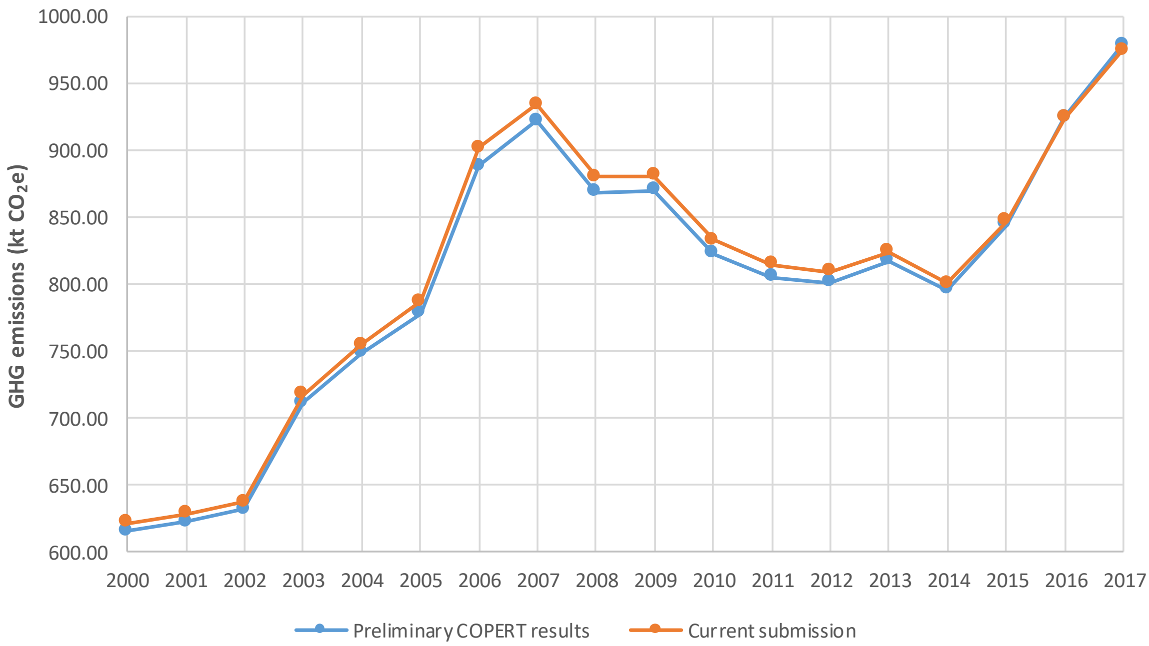

Figure 3.1 Comparison of current submission and preliminary COPERT results for emissions from road transport

For the next submissions the following improvements are planned:

- Improvement of methodologies to estimate emissions from road transportation with the use of COPERT for the whole timeseries.
- Further collaboration with the Road traffic directorate to obtain information on vehicle stock numbers and driven kilometres for 1990-1999 and 2018.
- Further collaboration with the NEA to conclude on the % of FAME in biodiesel to estimate fossil carbon and emissions from biofuels in Iceland.

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 residual fuel oil and gas/diesel oil for national navigation is based on NEA's annual sales statistics for fossil fuels. 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). According to NEA’s statistics no residual fuel oil was sold for national navigation in 2017. 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	2016	2017
Gas/Diesel oil	11.7	7.0	3.4	6.2	8.5	7.9	8.5	9.9
Residual fuel oil	7.2	4.8	0.5	0.9	2.6	0.4	0.2	NO
Emissions	**60**	**37**	**13**	**23**	**35**	**27**	**28**	**32**

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). They are presented in Table 3.19.

Table 3.19. 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	43.00	20.20	1	3.185	2	0.086	7	0.30
Residual fuel oil	40.4	21.10	1	3.126	2	0.084	7	0.28

3.4.3.3 Uncertainties

The estimate of quantitative uncertainty has revealed that 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%). This can be seen in the quantitative uncertainty table in Annex 2.

3.4.3.4 Recalculations

No recalculations were performed for this subcategory.

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 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. These data distinguish 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 with 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	2016	2017
Jet kerosene	69.4	74.6	129.2	133.2	119.5	213.7	290.8	363.7
Gasoline	0.20	0.18	0.03	0.40	0.01	0.01	NO	NO
Emissions	**221**	**238**	**411**	**425**	**380**	**680**	**925**	**1,156**

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

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from aviation 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%).

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 to switch 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 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 til 1999.

	1990	1995	2000	2005	2010	2015	2016	2017
Gas/Diesel oil	6.0	1.1	15.0	0.1	NO	33.6	34.4	30.0
Residual fuel oil	0.05	NO	2.00	0.44	0.08	13.2	24.2	31.1
Emissions	**19.5**	**3.4**	**54.7**	**1.8**	**0.3**	**149.8**	**187.0**	**194.8**

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

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from international 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%).

Recalculations

No recalculations were performed.

Planned improvements

It is planned to investigate the availability of more refined data on fleet composition/engine types in order to move to 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 accounted for around 28.6% 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 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	2016	2017
Gas/Diesel oil	1.8	1.6	1.6	1	0.3	0.3	0.15	0.15
Waste oil	3.3	NO	NO	NO	NO	NO	NO	NO
LPG	0.3	0.3	0.5	0.5	0.2	0.4	0.4	0.1
Solid waste	NO	0.5	0.6	0.6	0.3	NO	NO	NO
Emissions	**17.4**	**6.6**	**7.2**	**5.4**	**1.9**	**2.1**	**1.7**	**0.8**

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 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	2016	2017
Gas/Diesel oil	8.73	6.36	6.03	3.24	1.92	1.17	0.95	2.32
LPG	0.42	0.45	0.72	0.93	1.42	0.93	0.96	1.38
Kerosene	0.51	0.15	0.15	0.17	1.22	0.19	0.03	0.05
Emissions	**30.8**	**22.2**	**21.9**	**13.7**	**14.2**	**7.1**	**6.0**	**11.7**

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
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

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from Commercial/Institutional and Residential sector is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%), for CH_4 emissions it is 100% (with an activity data uncertainty of 5% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 5% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex 2.

3.5.1.4 Recalculations

No recalculations were performed for this subcategory.

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 residual fuel oil and gas/diesel oil for the fishing is based on the NEA's annual sales statistics for fossil fuels 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 til 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 til 1999, for diesel oil and fuel oil; this percentage was then applied to the fuel sales for the years 1990 til 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	2016	2017
Gas/Diesel oil	199.8	231.8	256.9	199.9	158.3	142.5	133.6	131.2
Residual fuel oil	32.6	57.2	22.3	32.6	69.9	52.4	29.0	35.2
Emissions	**745.9**	**926.4**	**896.9**	**746.4**	**729.9**	**624.2**	**521.5**	**533.1**

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). 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	43.00	20.20	1	3.185	2	0.086	7	0.30
Residual fuel oil	40.4	21.10	1	3.126	2	0.084	7	0.28

Uncertainties

The estimate of quantitative uncertainty has revealed that 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%). This can be seen in the quantitative uncertainty table in Annex 2.

Recalculations

No recalculations were performed for this subcategory.

Planned improvements

No improvements are currently planned for this subcategory.

3.6 Cross-Cutting Issues

3.6.1 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. In previous years, import and export data provided by Statistics Iceland were used for the reference approach. The data provided by Statistics Iceland comes from the Directorate of Customs. However, there were discrepancies between import data between Statistics Iceland and the NEA; furthermore, the dataset from Statistics Iceland does not include information on stock change. Therefore, for this submission it was decided to use Iceland's official submission to Eurostat for calculating the reference approach.

Currently there are sometimes some large disagreements between the sectoral and reference approach (see Annex 3). These disagreements will be further analysed with the NEA for next year's submission.

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

3.7 Fugitive Emissions from Fuels (CRF 1B)

3.7.1 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 are taken from Statistics Iceland. Activity data and resulting emissions are provided in Table 3.27.

Table 3.27. Fuel use (in kt) and resulting GHG emissions (in kt CO_2e) from distribution of oil products.

	1990	1995	2000	2005	2010	2015	2016	2017
Gasoline	129.4	132.2	153.4	164.2	144.5	139.6	136.2	138.2
Jet Kerosene	78.7	72.3	146.5	139.4	120.4	218.3	321.2	343.9
Gas/Diesel oil	335.8	309.3	427.9	418.2	292.3	342.1	340.9	347.6
Residual Fuel Oil	106.0	151.9	64.1	62.9	93.1	105.3	101.4	101.4
LPG	1.3	1.3	1.7	2.5	2.6	2.6	2.5	2.5
Emissions	**0.49**	**0.50**	**0.60**	**0.60**	**0.49**	**0.61**	**0.68**	**0.71**

3.7.1.1 Recalculations

For this submission emissions from LPG was added to this subcategory. This recalculation increased emissions from 1.B.2.5 by 0.002 kt CO_2e in 2016, which is 0.3% of total emissions from the subcategory. The increase in emissions was ≤0.5% for all years.

3.7.2 Geothermal Energy (CRF 1B2d)

3.7.2.1 Category description

Iceland relies heavily on geothermal energy for space heating (90%) and to a significant extent for electricity production (around 27% of the total electricity production in 2017). Small amounts of methane but considerable quantities of sulphur in the form of hydrogen sulphide (H_2S) are emitted from geothermal power plants.

3.7.2.2 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 (Orkustofnun), is the party in Iceland 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 Orkustofnun's website[8]. The values for 1969-2017 were published on 05.04.2018 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, 2018).

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

Orkustofnun 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.

[8] http://www.nea.is/the-national-energy-authority/energy-data/data-repository/

Table 3.28 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 3.28. Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2010	2015	2016	2017
Electricity production (GWh)	283	288	1,323	1,658	4,465	5,003	5,067	5,170
CO_2 emissions (kt)	61	82	153	118	190	163	149	146
Methane emissions (kt CO_2e)	0.2	0.2	0.9	1.1	4.6	3.9	2.8	2.6
Sulphur emissions (as SO_2, kt)	13	11	26	30	58	41	35	33

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 and 2017 the amount of CO_2 captured and reinjected was 2381t, 3911t, 6644t and 10168t 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).

3.7.2.3 Recalculations
No recalculations were performed for this subcategory.

3.7.2.4 Uncertainties
The estimation of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from geothermal energy is 10%, whereas the uncertainty of CH_4 estimated at 25%. This can be seen in the quantitative uncertainty table in Annex 2.

3.7.2.5 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 43% of the GHG emissions in Iceland in 2017. The dominant category within the Industrial Process sector is metal production, which accounted for 89.4% of the sector's emissions in 2017. Close to 100% of the emissions from the metal production sector are reported under the EU ETS (Directive 2003/87/EC). Figure 4.1 shows the location of major industrial plants in Iceland.

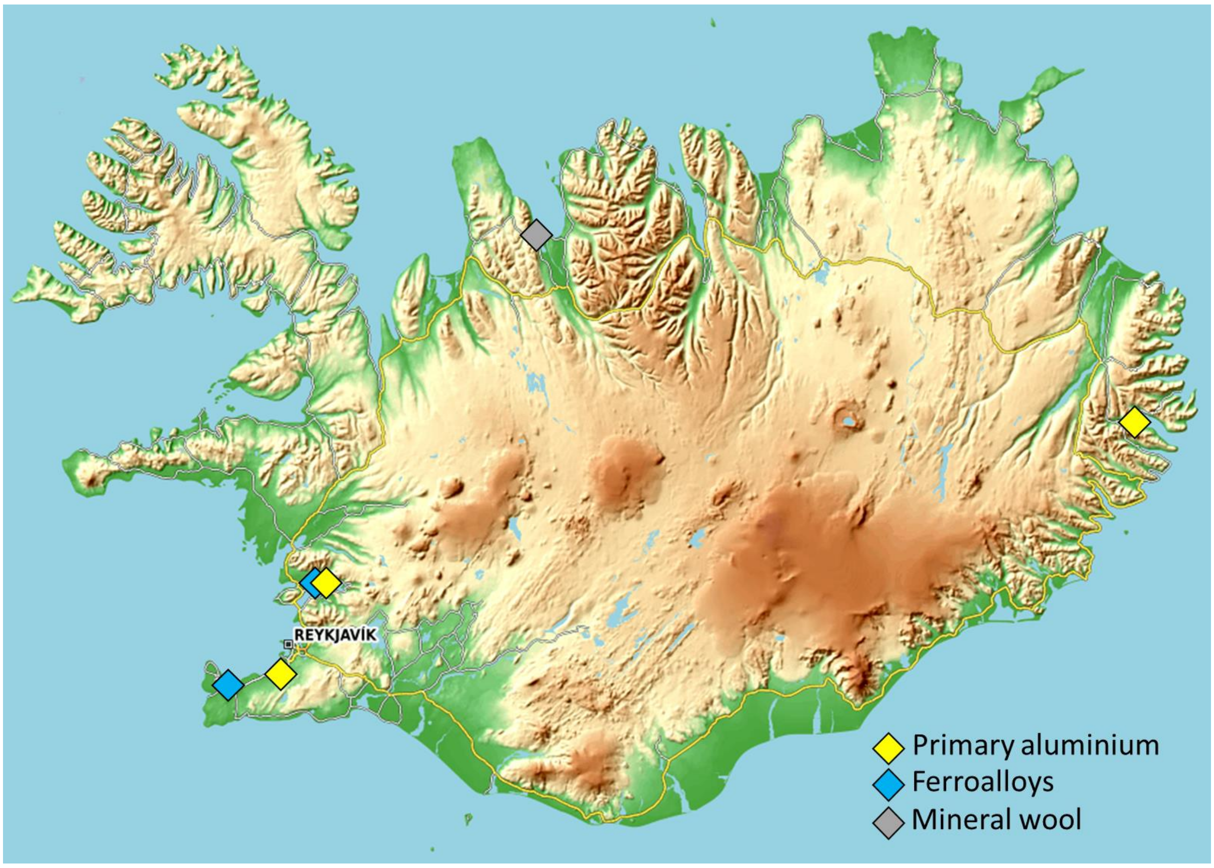

Figure 4.1 Location of major industrial sites in Iceland. This map shows only the sites that were operational in 2017, and that produce process-related emissions reported in this chapter.

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 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).

4.1.2 Key Category Analysis

The key categories for 1990, 2017 and 1990-2017 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, 2017 and trend (excluding LULUCF).

IPCC source category			Level 1990	Level 2017	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									

Sector		Greenhouse gases CO_2	CH_4	N_2O	HFC	PFC	SF_6	Indirect greenhouse gases NO_X	CO	NM-VOC	SO_2
2B5	Carbide Production	NOT OCCURRING									
2B6	Titanium Dioxide Production	NOT OCCURRING									
2B7	Soda Ash Production	NOT OCCURRING									
2B8a	Methanol production (From 2012)	IE[4]	IE[4]	NA	NA	NA	NA	NA	NA	NA	NA
2B9	Fluorochemical Production	NOT OCCURRING									
2B10	Other: Diatomite Production (until 2004)	E	NA	NA	NA	NA	NA	E	NA	NA	NA
2B10	Other: Fertilizer Production (until 2001)	NA	NA	E	NA	NA	NA	E	NA	NA	NA
2C	**Metal Industry**										
2C1	Iron and Steel Production (2014-2016)	E	NE	NA	NA	NA	NA	E	E	E	E
2C2	Ferroalloys Production	E	E	NA	NA	NA	NA	E	E	E	E
2C3	Aluminium Production	E	NA	NA	NA	E	NA	E	E	NE	E
2C4	Magnesium Production	NOT OCCURRING									
2C5	Lead Production	NOT OCCURRING									
2C6	Zinc Production	NOT OCCURRING									
2C7	Other	NOT OCCURRING									
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	E	NA	NA	NA	NA

		Greenhouse gases						Indirect greenhouse gases			
Sector		CO_2	CH_4	N_2O	HFC	PFC	SF_6	NO_X	CO	NM-VOC	SO_2
2F1b	Domestic refrigeration	NA	NA	NA	E	NA	E	NA	NA	NA	NA
2F1c	**Industrial Refrigeration**	**NA**	**NA**	**NA**	**E**	**E**	**E**	**NA**	**NA**	**NA**	**NA**
2F1d	Transport Refrigeration	NA	NA	NA	E	E	E	NA	NA	NA	NA
2F1e	Mobile Air-Conditioning	NA	NA	NA	E	NA	E	NA	NA	NA	NA
2F1f	Stationary Air-Conditioning	NA	NA	NA	E	NA	E	NA	NA	NA	NA
2F2	Foam Blowing Agents	NOT OCCURING									
2F3	Fire Protection	NOT OCCURING									
2F4	Aerosols	NA	NA	NA	E	NA	NA	NA	NA	NA	NA
2F5	Solvents	NOT OCCURING									
2F6	Other Applications	NOT OCCURING									
2G Other Product Manufacture and Use											
2G1	Use of Electric Equipment	NA	NA	NA	NA	NA	E	NA	NA	NA	NA
2G2	SF_6 and PFCs from Other Product Uses	NOT OCCURING									
2G3	N_2O from Product Use	NA	NA	E	NA	NA	NA	NA	NA	NA	NA
2G4	Other: Tobacco consumption	NA	E	E	NA	NA	NA	E	E	E	NE
2G4	Other: Fireworks use	E	E	E	NA	NA	NA	E	E	NA	E
2H Other											
2H1	Pulp and Paper Industry	NOT OCCURING									
2H2	Food and Beverage Industry	NA	NA	NA	NA	NA	NA	NA	NA	E	NA
2H3	Other	NOT OCCURING									

[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.*

4.2 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

$$CO_2 \text{ Emissions} = M_{cl} \times EF_{cl} \times CF_{ckd}$$

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

Year	Cement production [t]	Clinker production [t]	CaO content of clinker	EF_{cl}	CF_{ckd}	CO_2 emissions [kt]
1994	80,856	68,728	63%	0.495	107.5%	36.5
1995	81,514	69,287	63%	0.495	107.5%	36.8
1996	90,325	76,776	63%	0.495	107.5%	40.8
1997	100,625	85,531	63%	0.495	107.5%	45.5
1998	117,684	100,031	63%	0.495	107.5%	53.2
1999	133,647	113,600	63%	0.495	107.5%	60.4
2000	142,604	121,213	63%	0.495	107.5%	64.4
2001	127,660	108,511	63%	0.495	107.5%	57.7
2002	84,684	71,981	63%	0.495	107.5%	38.3
2003	75,314	60,403	63%	0.495	107.5%	32.1
2004	104,829	93,655	63%	0.495	107.5%	49.8
2005	126,123	99,170	63%	0.495	110%	53.9
2006	147,874	112,219	63%	0.495	110%	61.0
2007	148,348	114,668	64%	0.501	110%	63.2
2008	126,070	110,240	63.9%	0.502	110%	60.8
2009	59,290	51,864	63.9%	0.502	108%	28.1
2010	33,389	18,492	63.3%	0.497	108%	9.9
2011	38,048	35,441	64.2%	0.504	110%	19.6
2012	-	-	-	-	-	-

It has been estimated by an expert at the cement production plant that the CaO content of the clinker was 63% for all years from 1990 to 2006. From 2007 the CaO content is based on chemical analysis at the plant, as presented in Table 4.3. The CO_2 emission factor for clinker (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).

Methodology

The mineral wool production plant (Steinull hf.) 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 2017. 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%, leading to a combined uncertainty of 3.11% (See also complete uncertainty analysis 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 2.B.10.b).

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 3.7.2 on geothermal energy production.

4.3.9 Fluorochemical Production (CRF 2B9)

This activity does not occur in Iceland.

4.3.10 Other (CRF 2B10)

4.3.10.1 Diatomite Production

Category description

The company Kísiliðjan hf. 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 3%, and the CO_2 emission factor uncertainty was estimated to be 1%, leading to a combined uncertainty of 3.11% (See also complete uncertainty analysis 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 (Áburðarverksmiðjan í Gufunesi) 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 30%, and the N_2O emission factor uncertainty was estimated to be 4%, leading to a combined uncertainty of 50% (See also complete uncertainty analysis 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 (2.C.1.a)

4.4.1.1 Steel (CRF 2C1a)

Category description

A secondary steelmaking facility (GMR Endurvinnslan ehf.) was operating in Grundartangi next to the ferroalloy plant Elkem and the aluminium smelter Norðurál from 2014 to February 2017. Productions stopped at the end of 2016 and no production is reported for 2017. GMR 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%, and the CO_2 emission factor uncertainty was estimated to be 25%, leading to a combined uncertainty of 26.9% (See also complete uncertainty analysis 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 2017, two factories were producing Ferroalloys in Iceland. Elkem Iceland (Elkem Ísland ehf.) has been producing FeSi75 since 1979, whereas United Silicon (Sameinað Sílikon hf.) started production of Silicon metal in November of 2016 and stopped production in September 2017, filing for bankruptcy in January 2018. Both 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. In the case of Elkem, electric (submerged) arc furnaces with consumable Soederberg electrodes are used. The furnaces are semi-covered.

Total GHG emissions from this category amounted to 428.3 kt CO_2e in 2017, of which 27.2 kt originated from the Silicon metal factory.

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 emission factor for batch-charging in the case of United Silicon, and that of sprinkle-charging for Elkem, according to technical information provided by the operators.

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 Elkem Iceland and United Silicon

	1990	1995	2000	2005	2010	2015	2016	2017
Electrodes, casings and paste	3.8	3.9	5.7	6.0	4.8	5.3	5.4	6.0
Carbon blocks	NA	NA	NA	NA	NA	0.1	0.1	0.2
Anthracite/coking coal	45.1	52.4	73.2	86.9	96.1	115.1	123.6	129.8
Coke oven coke	24.9	30.1	46.6	42.6	30.3	30.9	24.7	24.6
Charcoal	NA	NA	NA	2.1	NA	NA	1.0	2.4
Wood	16.7	7.7	16.2	15.6	11.3	27.2	27.8	40.7
Limestone	-	-	0.5	1.6	0.5	2.2	2.4	1.7
FeSi production (Elkem)	62.8	71.4	108.7	111.0	102.2	117.9	118.4	114.1
Coarse Microsilica (Elkem)	0.9	1.0	1.4	1.6	1.1	1.4	1.3	1.3
Fine Microsilica (Elkem)	13.2	15.0	21.4	24.3	17.0	20.8	20.0	20.5
Si metal production (Un. Silicon)	NO	NO	NO	NO	NO	NO	0.9	7.3
Si slag production (Un. Silicon)	NO	NO	NO	NO	NO	NO	0.2	NO
Emissions (kt CO_2e)	**210.4**	**245.7**	**365.3**	**379.6**	**372.3**	**403.9**	**408.4**	**431.4**

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 Elkem's application for free allowances under the EU ETS for the years 2005 to 2010. Upon request by the EA, Elkem 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 and products at Elkem Iceland.

	1990	1995	2000	2005	2010	2015	2016	2017
Electrodes	94%	94%	94%	94%	94%	96%	95%	95%
Coal (Anthracite)	74.8%	74.8%	79.0%	75.5%	74.8%	71.8%	70.4%	70.7%
Coke oven coke	78.8%	78.8%	76.6%	73.8%	80.8%	70.4%	74.2%	79.2%
Charcoal	-	-	-	80.9%	-		85.6%	85.56%
Waste wood	48.7%	48.7%	48.7%	48.7%	48.7%	50.0%	50%	50.0%

Figure 4.2 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.

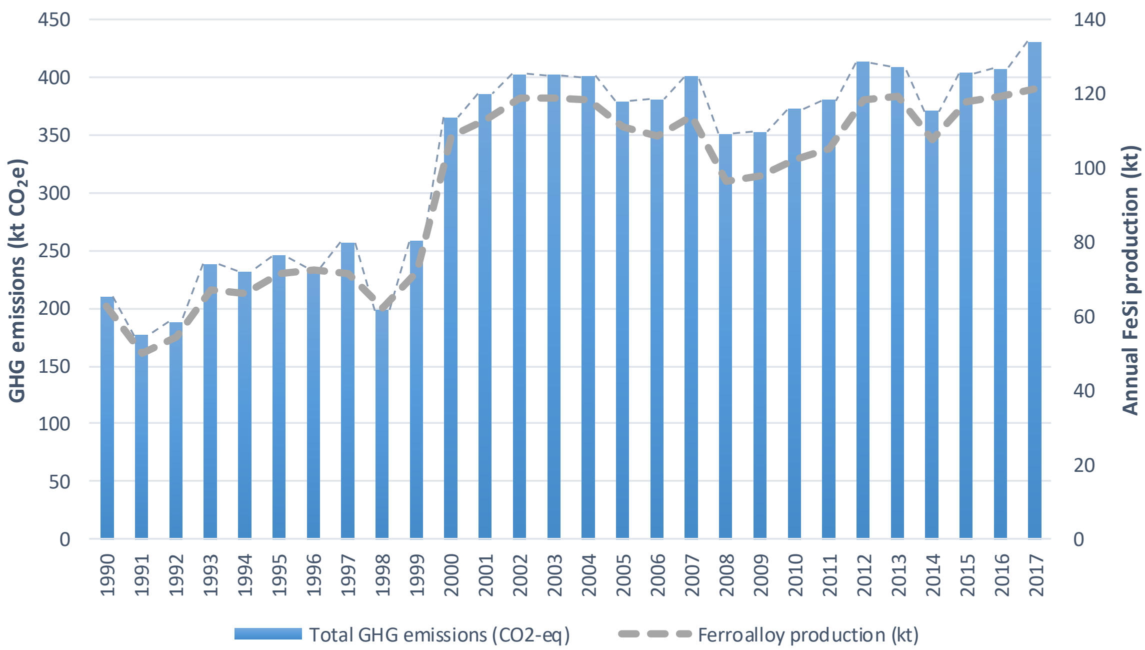

Figure 4.2 Total GHG emissions (CO2 and CH4) from the Ferroalloy production, and annual production (kt).

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% 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%. This can be seen in the quantitative uncertainty table in Annex 2.

The IEF fluctuates over the time series depending on the consumption of different reducing agents and electrodes (3.13 – 3.60 t CO_2/t FeSi), as well as expansions and changes in production capacity of the factory in the period 1996-1999.

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), for the time period 2013-2017 in the case of Elkem and for 2016 – 2017 in the case of United Silicon.

Category-specific recalculations

Due to wrongly communicated activity data, e.g. total production amounts from one Ferroalloy manufacturer, there has been a recalculation between the 2018 and 2019 submission. Therefore, CH_4 emissions for the year 2016 are revised, diminishing from 3.23 kt CO_2e to 2.99 kt CO_2e. The CO_2 emissions were not affected by the change of production amount as they are calculated based on the Tier 3 method (2006 IPCC Guidelines) using the consumption of fossil reducing agents and electrodes reported under the ETS scheme.

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, Rio Tinto Alcan in Straumsvík, Century Aluminium (Norðurál) in Grundartangi and Alcoa Fjarðarál in Reyðarfjörður. 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 4.4.

Table 4.6 Aluminium production, CO_2 and PFC emissions, IEF for CO_2 and PFC 1990-2017.

Year	Primary aluminium production [kt]	CO_2 emissions [kt]	PFC emissions [kt CO_2e]	CO_2 [t/t Al]	PFC [t CO_2e/t Al]
1990	87.8	139.2	494.6	1.58	5.63
1991	89.2	142.0	410.6	1.59	4.60
1992	90.0	136.8	183.0	1.52	2.03
1993	94.2	141.6	88.2	1.50	0.94
1994	98.6	151.0	52.5	1.53	0.53
1995	100.2	154.0	69.4	1.54	0.69
1996	103.4	160.3	29.6	1.55	0.29
1997	123.6	192.8	97.1	1.56	0.79
1998	173.9	271.1	212.3	1.56	1.22
1999	222.0	354.3	204.2	1.60	0.92
2000	226.4	353.0	149.9	1.56	0.66
2001	244.1	382.4	108.0	1.57	0.44
2002	264.1	401.2	85.5	1.52	0.32
2003	266.6	410.2	70.5	1.54	0.26
2004	271.4	415.9	45.5	1.53	0.17
2005	272.5	417.1	30.8	1.53	0.11
2006	326.3	516.4	392.8	1.58	1.20
2007	455.8	693.0	331.4	1.52	0.73
2008	781.2	1186.8	411.4	1.52	0.53
2009	817.3	1231.5	180.0	1.51	0.22
2010	818.9	1237.6	171.7	1.51	0.21
2011	806.3	1214.3	74.5	1.51	0.09
2012	821.0	1244.2	94.0	1.52	0.11
2013	841.0	1274.2	88.2	1.52	0.10
2014	839.4	1279.5	99.0	1.52	0.12
2015	857.3	1299.6	103.7	1.52	0.12
2016	847.9	1271.5	91.8	1.50	0.11
2017	882.4	1324.5	68	1.50	0.08

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 2017 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 Guideline (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

$$E_{CF4} = S_{CF4} \cdot AEM \cdot MP$$

and

$$E_{C2F6} = E_{CF4} \cdot F_{C2F6/CF4}$$

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 4.3). The main contributor to GHG emissions gas been CO_2, with various contributions from PFC. The PFC emissions rose significantly in 2006 due to an expansion of the Century Aluminium facility (Norðurál), and in 2008 which was the first full year of operations at the Alcoa Fjarðarál facility. Total GHG emissions from the primary Aluminium sector have risen by 119% since 1990 with an increase of 2.1% from 2016 to 2017.

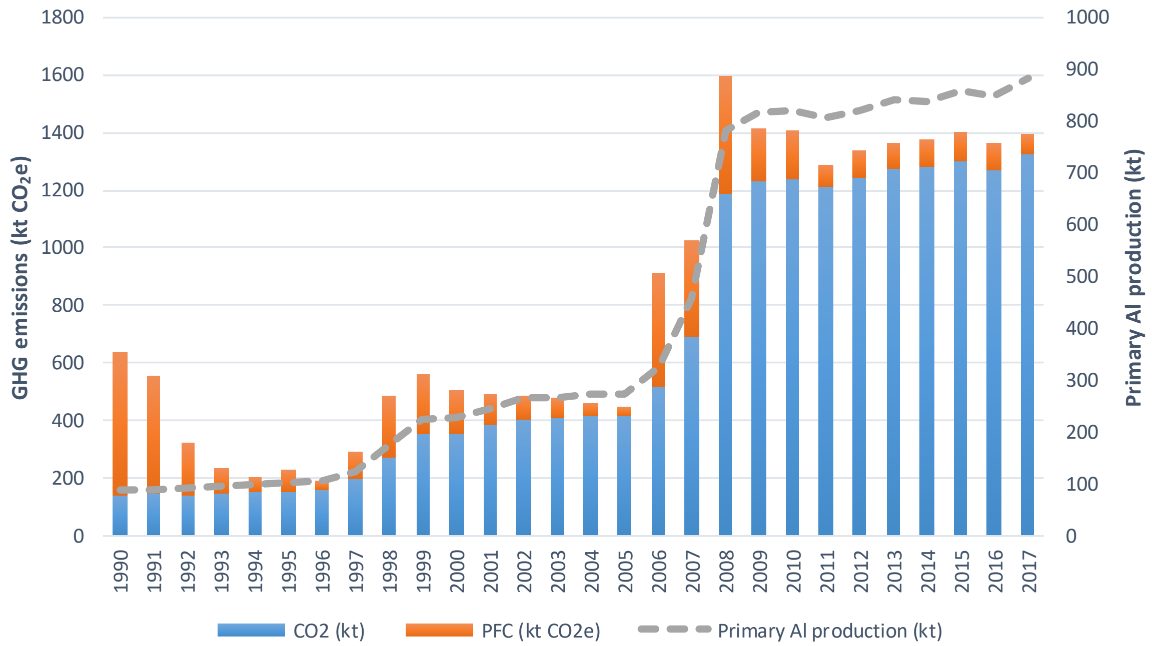

Figure 4.3 GHG emissions (CO_2 and PFC) from primary Al production, and annual production (kt).

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% and an emission factor uncertainty of 3%). This can be seen in the quantitative uncertainty table 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 at Alur in Helguvík. In 2012, another facility, Kratus, opened next to the Norðurál smelter at Grundartangi. At the end of 2014, Alur was acquired by Kratus and all secondary aluminium production moved to Grundartangi, and the operator changed the name of the company to Alur. Secondary aluminium production does not lead to GHG emissions; however, it does lead to emissions of certain atmospheric pollutants which are reported under CLRTAP.

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 went down 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 51.1% (with an activity data uncertainty of 10% and an emission factor uncertainty of 50.1%, comprising uncertainty on the ODU and the C content). This can be seen in the quantitative uncertainty table in Annex 2.

Category-specific recalculations

No category-specific recalculations were done for this submission.

Category-specific planned improvements

For future submissions, it is planned to differentiate between lubricants used in 2-stroke engines and lubricants used for their lubricating purposes, in order to allocate the emissions correctly to the energy sector and to the industry sector.

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 0.34 kt CO_2 in 2017.

Methodology

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

EQUATION 5.4

$$CO_2 \text{ Emissions} = (PW \cdot CC_{WAX} \cdot ODU_{WAX} \cdot 44/12)/1000$$

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
- /1000 = conversion from tonnes to kilotonnes.

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 exist from 2004 and is published by Statistics Iceland. For 1990-2003, the 2004 values are used. Activity data for the production of candles is missing. Imported and exported paraffin (less than 0.75% oil) is also published by Statistics Iceland from 2004. For 1990-2003 the 2004 values are used. 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 10% and an emission factor uncertainty of 100%, comprising uncertainty on the ODU and the C content). This can be seen in the quantitative uncertainty table in Annex 2.

Category-specific recalculations

No category-specific recalculations were done for this submission.

Category-specific planned improvements

For future submissions, it is planned to gather better 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. Further explanations on this are included in the paragraph below discussing recalculations.

Total CO_2 from NMVOC oxidation arising from 2D3 categories amounted to 2.72 kt CO_2 in 2017. An overview of the emissions from the individual subcategories is given in Table 4.7 and is shown in Figure 4.4.

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:

$$\text{Inputs } (CO_2) = \text{Emissions}_{NMVOC} * C * 44/12$$

where C is the fraction carbon in NMVOC by mass.

For the subcategory "Road paving with Asphalt", C was set to 0.5, the upper range given in the 2006 IPCC guidelines for asphalt production and use for road paving (Vol. 3, Chapter 5, §5.4.4). For all other subcategories of 2D3, the default value of 0.6 was given (Vol. 3, Chapter 5., §5.5.4).

Category-specific recalculations

No category-specific recalculations were done for this submission.

Category-specific planned improvements

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

4.5.3.1 Road Paving with Asphalt (CRF 2D3b)

Asphalt road surfaces are composed of compacted aggregate and asphalt binder. Gases are emitted from the asphalt plant itself, the road surfacing operations and subsequently from the road surface. Information on the amount of asphalt produced comes from Statistics Iceland for the time period 1990 to 2011, and directly from the producers since 2012. The emission factors for NMVOC (0.016 kg/t asphalt) are taken from Table 3.1, in chapter 2D3b in the EMEP/EEA emission inventory guidebook (2016). Emissions of SO_2, NO_x and CO are expected to originate mainly from combustion and are therefore not estimated here but accounted for under sector 1A2f. In 1990 the NMVOC emissions for Road Paving with Asphalt were 2.76 t NMVOC, in 2017 5.18 t NMVOC, corresponding to an increase of 88% with an increase of 52% between 2016 and 2017.

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. For the time before 1998 no data exists about the amount of solvent based paint produced domestically. Therefore, the domestically produced paint amount of 1998, which happens to be the highest of the time period for which data exists, is used for the period from 1990-1997. In 1990 the NMVOC emissions for Coating Application were 549.7 t NMVOC, in 2017 334.4 t NMVOC, corresponding to a decrease of 39%.

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 2017 50.0 t NMVOC, corresponding to a decrease of 34.4%. For Dry-cleaning the NMVOC were 1.5 t NMVOC in 1990 and 2.0 t NMVOC in 2017, corresponding to an increase of 33.3%.

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 2017 2.4 t NMVOC, corresponding to a decrease of 84.6%.

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 2017 627.0 t NMVOC, corresponding to an increase of 36%.

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 2017 174.7 t NMVOC, corresponding to an increase of 125%.

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 2017 39.8 t NMVOC, corresponding to an increase of 357%.

4.5.3.6 Emissions of Sector 2D3

Figure 4.4 and Table 4.7 show NMVOC emissions from the sector 2D3 from 1990-2016. NMVOC emissions increased by 3.6% between 1990 and 2017 and decreased by 1.5% between 2016 and 2017.

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

	1990	1995	2000	2005	2010	2015	2016	2017
2D3a Domestic solvent use	0.461	0.482	0.510	0.540	0.573	0.599	0.609	0.627
2D3b Road paving with asphalt	0.0028	0.0028	0.0052	0.0054	0.0038	0.0031	0.0024	0.0052
2D3d Coating applications	0.550	0.562	0.585	0.377	0.299	0.322	0.364	0.334
2D3e Degreasing	0.076	0.057	0.085	0.058	0.038	0.046	0.050	0.051
2D3f Dry cleaning	0.0015	0.0016	0.0017	0.0018	0.0019	0.0019	0.0020	0.0020
2D3g Paint manufacturing	0.016	0.016	0.012	0.0054	0.0032	0.0033	0.0038	0.0024
2D3h Printing	0.077	0.109	0.198	0.309	0.189	0.207	0.192	0.175
2D3i Wood preservation	0.0087	0.019	0.025	0.087	0.031	0.026	0.029	0.04
Total (kt NMVOC)	**1.192**	**1.249**	**1.423**	**1.383**	**1.139**	**1.208**	**1.253**	**1.236**
Total (kt CO_2e)	**2.62**	**2.75**	**3.13**	**3.04**	**2.50**	**2.66**	**2.76**	**2.72**

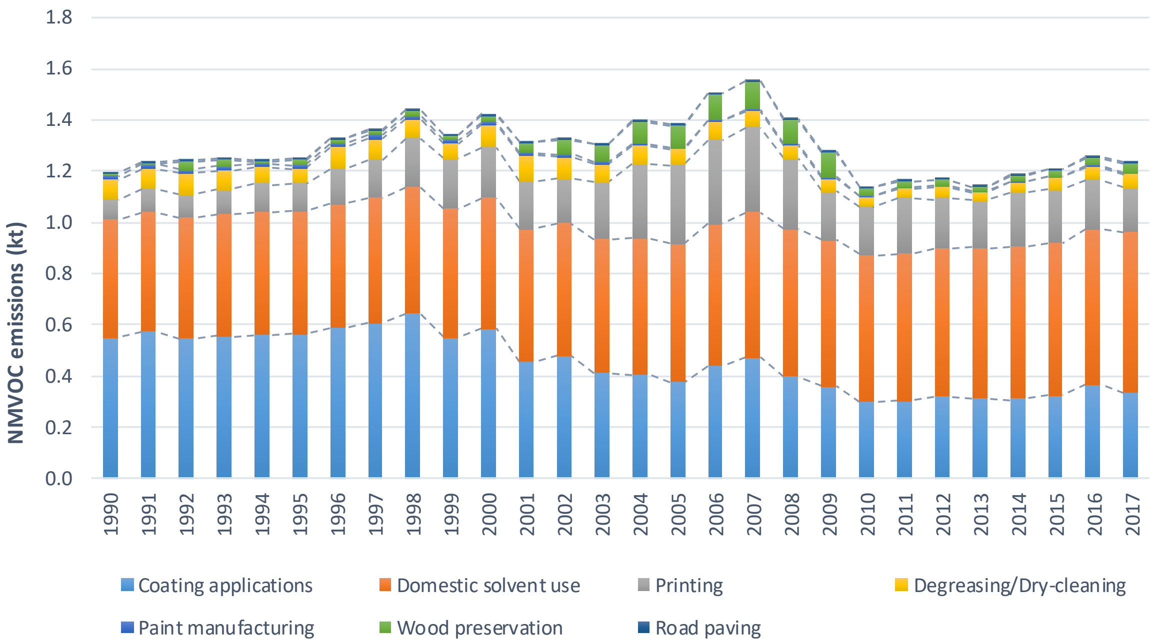

Figure 4.4 NMVOC emissions from all subgroups of Sector 2D3, other non-energy products from fuels and solvent use.

4.5.3.7 Uncertainties

The main source for EF uncertainties were uncertainties and value ranges given in the 2016 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 for this inventory can be found 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 as substitutes for Ozone Depleting Substances. In Iceland Hydrofluorocarbons (HFCs) are 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 4.8. Use of HFCs and PFCs in other sub-source categories of sector 2F is not occurring.

Table 4.8 Source category structure of product uses as substitutes for ozone depleting substances.

GHG source category	GHG sub-source category		Further specification	HFCs	PFCs
2F1 Refrigeration and Air Conditioning	Refrigeration	2F1a Commercial Refrigeration	Combination of stand-alone and medium & large commercial refrigeration	✓	✓
		2F1b Domestic Refrigeration		✓	
		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)			✓	

HFCs were first imported to Iceland in 1993. The use of fluorinated gases was regulated in 1998 with the implementation of 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 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.

HFCs are used either as single compounds, or in blends. Since 2001, two blends containing PFCs (R412A and R508B) have been used in Iceland. 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, reefers and MDIs. 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. HFC-134a is also used in metered dose inhalers (MDI) and are reported under CRF sector 2F4a.

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 by calculations into their components.

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 will soon be obsolete as the refrigerant is no longer available and its use for repairs and servicing is prohibited.

Refrigeration systems on-board ships are fundamentally different from systems on land regarding their susceptibility to leakage. Therefore, they are allocated to transport refrigeration, as are refrigerated containers (reefers). Industrial refrigeration, on the other hand, comprises refrigeration systems used in food industries such as fish farming, meat processing, and vegetable production.

4.7.2 Refrigeration and Air Conditioning (CRF 2F1)

Emissions from Refrigeration and Air Conditioning amounted to 204 kt CO_2e in the most recent inventory year, or approximately 10% of the emissions originating from the IPPU sector. It is a significant sector in Iceland, as it is by far the largest source in the IPPU sector when considering the sources outside of the EU ETS.

4.7.2.1 Methodology

Emissions for the refrigeration and air conditioning sector are estimated using the 2006 IPCC Guideline Tier 2a - Emission-factor approach. For some sectors, however, the approach had to be modified since no information on the number of units and their average charge could be obtained. Instead, the bulk import of HFCs was allocated to sub-source categories based on expert judgement. This is explained in more detail when discussing activity data.

4.7.2.2 Activity data

All HFCs and PFCs used in Iceland are imported, the majority of which in bulk. The amounts imported are recorded by Customs Iceland whence it is reported to the EA. Since 1995 importers also have to apply at the EA for permits to import HFCs. R-134A and R-404A are also imported in equipment such as reefers, vehicle ACs and domestic refrigerators.

The bulk import of refrigerants is subdivided thusly into the following applications:

- All R-407C and R-410A amounts are allocated to Residential and Commercial AC, including heat pumps.
- Since reefers are refilled, the amount of R-134A and R-404A leaking from reefers is replaced by corresponding amounts of imported R-134A and R-404A.
- 65% of the import of each remaining refrigerant - all refrigerants with the exceptions of R-407C, R-410A and fractions of R-134A and R-404A - are allocated to fishing vessels (transport refrigeration)
- 20% of all remaining refrigerants are allocated to industrial refrigeration
- 15% of all remaining refrigerants are allocated to commercial refrigeration

This division is based on two sources of information: A) sales data supplied by the main importers of refrigerants as well as B) a poll of the majority of companies designing, installing and servicing a broad range of refrigeration systems. Nevertheless, the EA is aware that this method simplifies the sector. Figure 4.5 shows the quantity of HFCs and PFCs introduced to Iceland in bulk between 1993 and 2017.

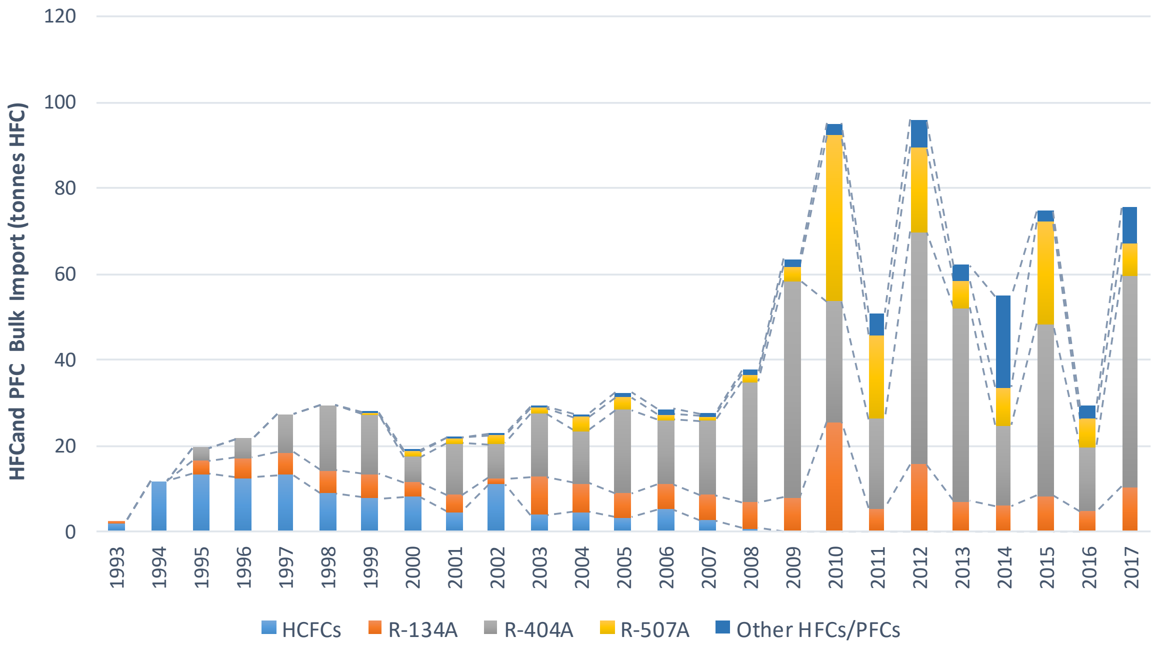

Figure 4.5 Quantity of HFCs imported in bulk to Iceland between 1993 and 2017

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 5 kg refrigerant. Due to the limited number of stakeholders involved in the sector, further information is confidential.

To derive activity data pertaining to mobile air-conditioning (MAC), information on registered 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.

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. 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, page 7.52).

4.7.2.3 Emission factors

Total emissions from refrigeration and air conditioning equipment are calculated using equation 7.4 from the 2006 IPCC Guideline (p. 7.17).

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.

Assembly or manufacture emissions are calculated by multiplying the amount of HFC and PFC charged into new equipment with an emission factor k that represents the percentage of initial charge that is released during assembly of the e.g. refrigeration system (equation 7.12 in the 2006 IPCC Guideline).

Operation emissions are calculated by multiplying the amount of HFC and PFC in stock with an annual leak rate x (equation 7.13 in the 2006 IPCC Guideline).

The calculation of disposal emissions requires information on the average lifetime n of equipment, see equation 7.14 The average lifetime is not only necessary to allocate disposal emissions to an appropriate year but also to estimate the charge remaining in equipment (y) by continually discounting the original charge with n years. If refrigerants are recovered during disposal, the disposal emissions have to be reduced with a recovery efficiency factor z. This factor will be zero if no refrigerant recycling takes place.

All emission factors used are shown in

Table 4.9 (Sources for the majority of values are taken for the 2006 IPCC Guideline, Tables 7.9 pages 7.52).

The equation for disposal emissions is the following:

EQUATION 7.14

Disposal Emissions = (HFC and PFC Charged in year t – n) • (y / 100) • (1 – z / 100) – (Amount of Intentional Destruction)

Where:

- n is the lifetime of equipment
- y is the charge remaining in equipment
- z is a recovery efficiency factor

Table 4.9 Values used for charge, lifetime and emission factors for stationary and transport refrigeration equipment and mobile air conditioning.

Application	HFC charge (kg/unit)	Lifetime n (years)	Initial EF k (% of initial charge)	Lifetime EF x (%/year)	End-of-life EF z (% recovery efficiency)
Domestic refrigeration	0.25	12	NO	0.3%	70%
Commercial refrigeration	NE	8	2%	10%	80%
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	75%
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%

The lifetime for domestic refrigerators is at the lower end of the range given by the 2006 IPCC Guideline. The lifetime EF and the efficiency of recovery at end of life are 2006 IPCC Guideline 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; however, they 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 Guideline default values. 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 Guideline (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 to 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 are default values given by the 2006 IPCC Guideline 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 exists 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.

Reefers are periodically refilled. Their initial charge is deemed constant and the amount emitted (and refilled) is subtracted from the amounts of R-134A and R-404A imported in bulk during the same year. Based on expert judgment the lifetime EF for reefers is estimated to be 15%. This method implies end-of-life emissions in lifetime emissions: by assuming refill the charge of each reefer is renewed every 6-7 years.

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 dissected 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 204 kt CO_2e in 2017. Emissions disaggregated to constituents are shown in Table 4.10.

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

	1990	1995	2000	2005	2010	2015	2016	2017
HFC-23	NO	NO	NO	0.02	0.02	0.02	0.02	0.06
HFC-32	NO	NO	0.01	0.03	0.05	0.19	0.19	0.27
HFC-125	NO	5.08	17.49	25.40	53.43	79.60	73.19	77.66
HFC-134a	NO	1.92	7.49	12.36	20.65	25.66	27.29	29.34
HFC-143a	NO	2.46	17.46	30.52	70.73	98.07	89.95	96.32
HFC-152a	NO	0.04	0.07	0.05	0.02	0.01	0.01	0.01
HFC-227ea	NO	0.00	0.00	0.08	0.03	0.35	0.35	0.29
total HFC emissions	**NO**	**9.50**	**42.52**	**68.45**	**144.93**	**203.91**	**191.00**	**203.94**
C_2F_6 (PFC-116)	NO	NO	NO	NO	0.0005	0.0003	0.0001	0.0001
C_3F_8 (PFC-218)	NO	NO	NO	0.0023	0.0066	0.0172	0.0193	0.0579
total PFC emissions	**NO**	**NO**	**NO**	**0.002**	**0.007**	**0.017**	**0.019**	0.058
Total HFC+PFC emissions	**NO**	**9.50**	**42.52**	**68.45**	**144.94**	**203.92**	**191.02**	**204.00**

Lifetime emissions are 87.3% of total emissions, -10% are end-of-life emissions and 2.4% are initial emissions (Figure 4.6). The low fraction of initial emissions is mainly caused by comparably low initial EFs and to a lesser extent by the fact that equipment of some sub-sources is assembled outside Iceland. The low fraction of end-of-life emissions is caused by the fact that the majority of refrigerants are recovered at-end-of-life. Another factor is that the amount of imported HFCs and PFCs has been steadily increasing since their introduction. The amount of equipment being retired now, i.e. equipment imported or installed during the late 90s and early 2000s is therefore comparatively low. This also means that end-of-life emissions will increase in years to come.

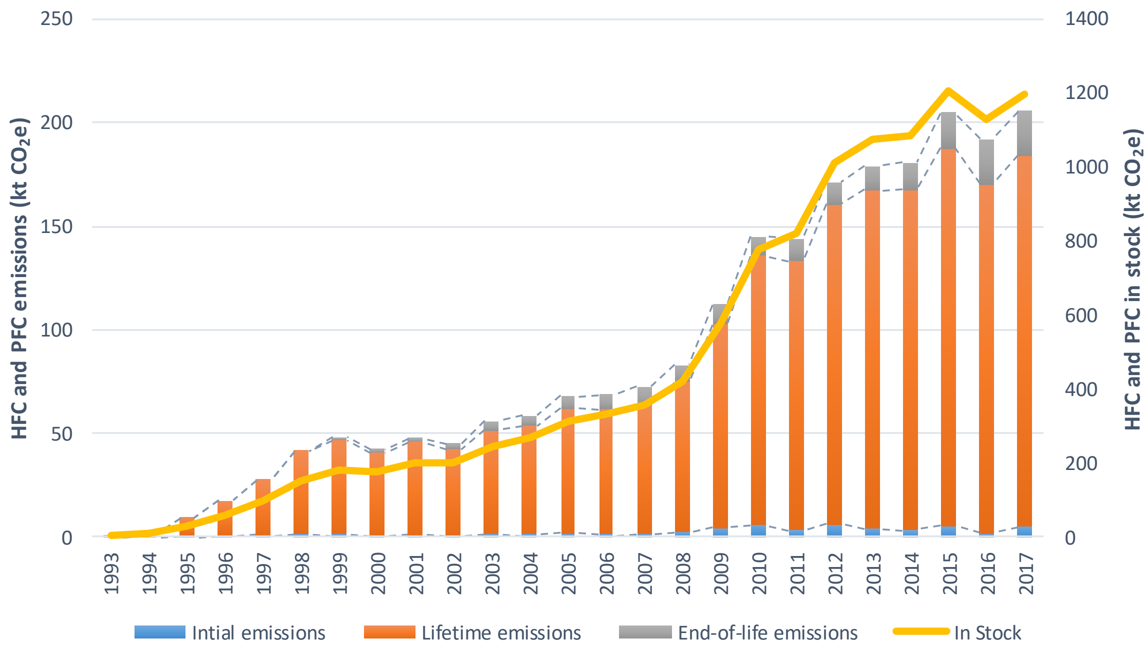

Figure 4.6 HFC/PFC stock (right y-axis) and emissions (left y-axis) from refrigeration and air conditioning equipment.

Figure 4.7 shows how the emissions from refrigeration and air conditioning equipment are split across the six subcategories. 62% of the 2017 emissions from Sector 2F1 stem from refrigeration systems on fishing vessels. Total transport refrigeration emissions, i.e. including reefers, account for 65% of all HFC and PFC emissions. Other important sectors are industrial refrigeration (16 %), commercial refrigeration (13%), and MAC (6%). Stationary AC emission shares are 0.6% of total refrigeration and AC emissions due to low EFs and no sub-source HFC import until 1999. Emissions from domestic refrigeration constitute less than 0.1% of total refrigeration emissions due to the insignificance of imported refrigerants containing fluorinated gases for domestic utilisation.

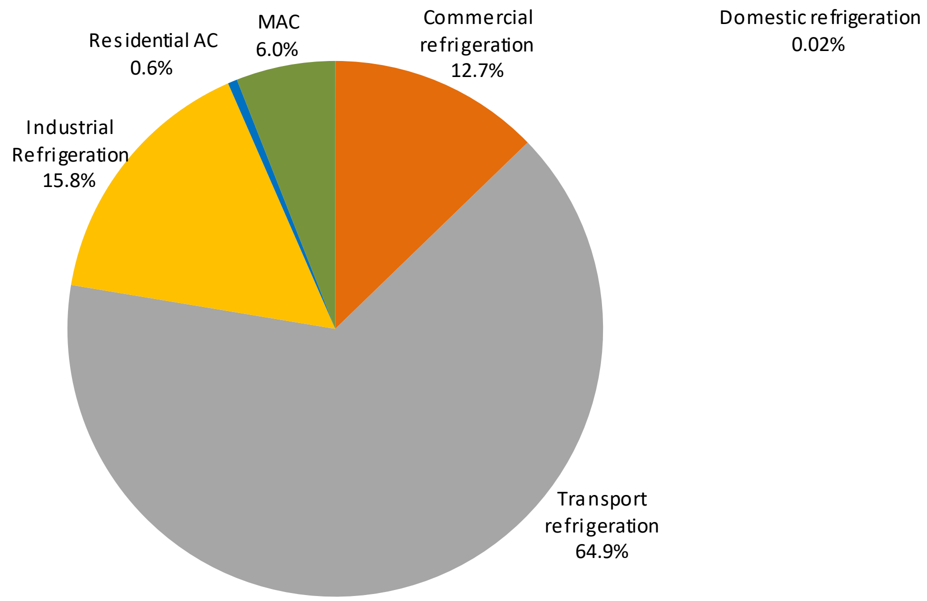

Figure 4.7 2017 emission distribution of refrigeration and AC sub-source categories.

The relations between imports, stock development and emission trends are shown below for fishing vessels and MAC. The stock of HFCs/PFCs in refrigeration systems on fishing vessels (Figure 4.8) shows a distinct increase between 2008 and 2010 an again in 2012. This is caused by a stark import increase of especially R-404A and R-507A, two refrigerants with high GWPs. The import decreases in 2011 which slows the growth of the sub-source´s HFC stock but the record imports of bulk HFC in 2012 accelerates stock growth again. Lifetime emissions increased slightly between 2014 and 2015 due to greater amounts in stock. End-of-life emissions start in 1999 when the first equipment containing HFC imported in 1993 is retired (after emitting lifetime emissions for 7 years). The imports, stock development and emission trends for commercial and industrial refrigeration follows the same trends on different scales and with different onset years for end-of-life emissions.

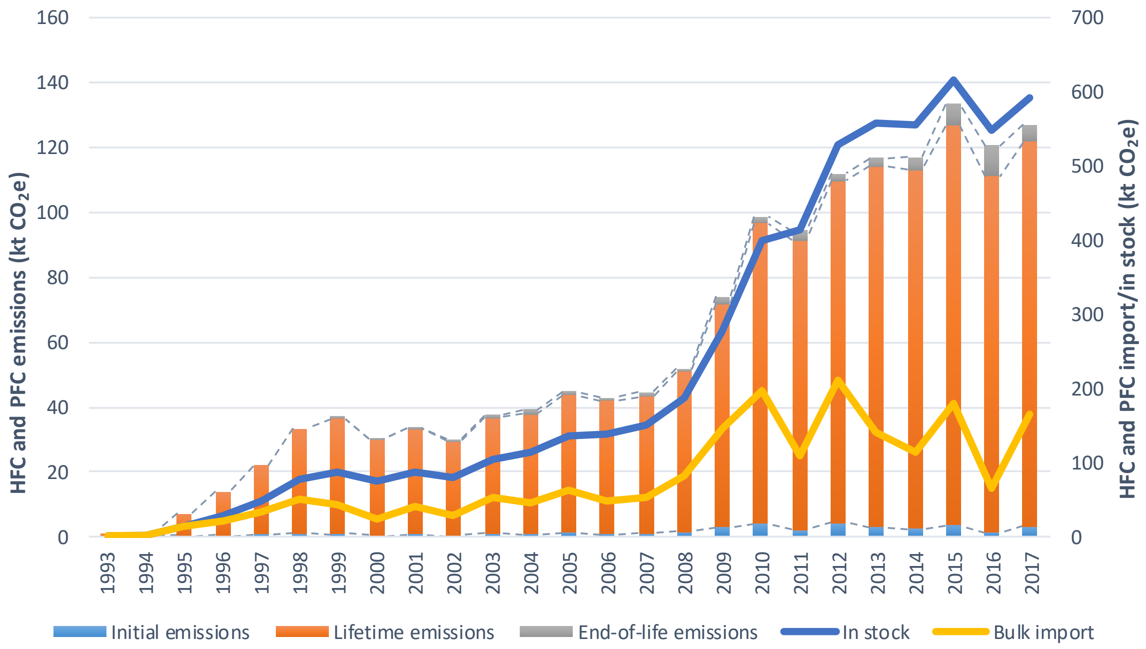

Figure 4.8 Import, stock development and emissions from refrigeration systems on fishing vessels between 1993 and 2017.

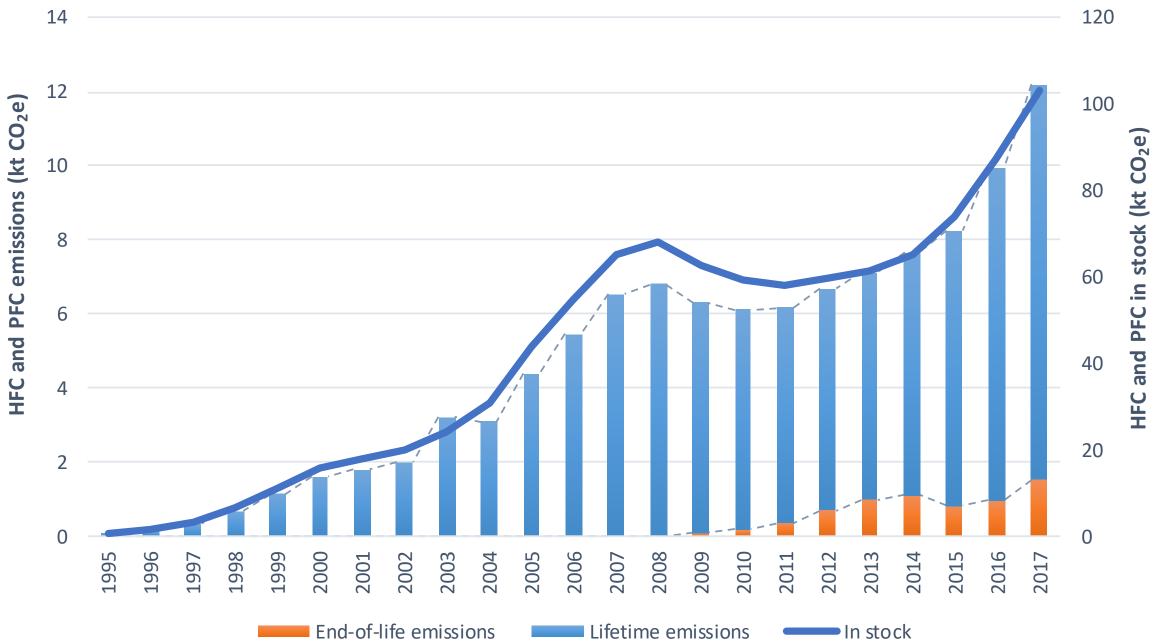

Figure 4.9 Emissions from mobile air conditioning (MACs).

The graph for MACs (Figure 4.9) does not show import quantities as information exists on the vehicle stock. HFC amount in stock rises between 1995 and 2007 not only because of the assumed linear increase in the share of vehicles with ACs but also because of a 75% increase in fleet size. Since 2007 the fleet size has been more or less stagnant at around 240,000 vehicles. The stable fleet size from 2007 to 2011, in interaction with a stagnant vehicle AC share of 80% since 2010, led to a decrease in stock until 2011 which was caused by the precedence of lifetime emissions over additions to the stock in form of new vehicles. The vehicle fleet size increased again in 2013 leading to a stock increase during the same year.

4.7.2.5 Recovery

Recovery was 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.

4.7.2.6 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 4.11. This can also be found in Annex 2.

Table 4.11 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*	*35*			
Reefers	*5*	*20*	*10*			
Residential AC	1	5	3	200	100	224
MAC	10	20	10	100	100	141

4.7.2.7 Recalculations and improvements

Planned improvements for future submissions include an in-depth review of the calculations of this sector in collaboration with consultants from Aether ltd. This will include a revision of all methodologies, improved calculation spreadsheets, and inclusion of the results from a survey conducted by the Environment Agency on the allocation of refrigerants by the main importers to ensure accuracy and completeness of the inventory. In 2017 new refrigerants (R32 and R452A) were imported in small quantities. The estimation of their contribution to the emission is around 0.05 kt CO_2e to the sector 2F1, well below the threshold of significance. However, these gases will be included in next year's submission.

4.7.3 Foam Blowing Agents (CRF 2F2)

This activity does not occur in Iceland.

4.7.4 Fire Protection (CRF 2F3)

This activity does not occur in Iceland.

4.7.5 Aerosols (CRF 2F4)

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 2017 were approx. 1 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%.

4.7.5.5 Recalculations

No category-specific recalculations were done for the 2019 submission.

4.7.5.6 Planned improvements

This subsector will be revisited during the overall revision of Iceland's F-gases inventory planned for the year 2019. However, this is not expected to impact the emissions reported under this subsector.

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 (SF6 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.

4.8.1.3 Emissions

SF_6 emissions amounted to 101 kg (2.3 kt CO_2e) in 2016. Emissions increased by 110% since 1990. However, this increase is less than proportional compared to the net increase in SF_6 nameplate capacity since 1990.

Figure 4.10 shows the evolution of SF_6 in switchgear and the associated emissions due to leakage. The spike in 2010 is caused by two unrelated incidents during which switchgear was destroyed and SF_6 emitted. The spike in 2012 is caused by an increase of emissions from Landsnet LLC.

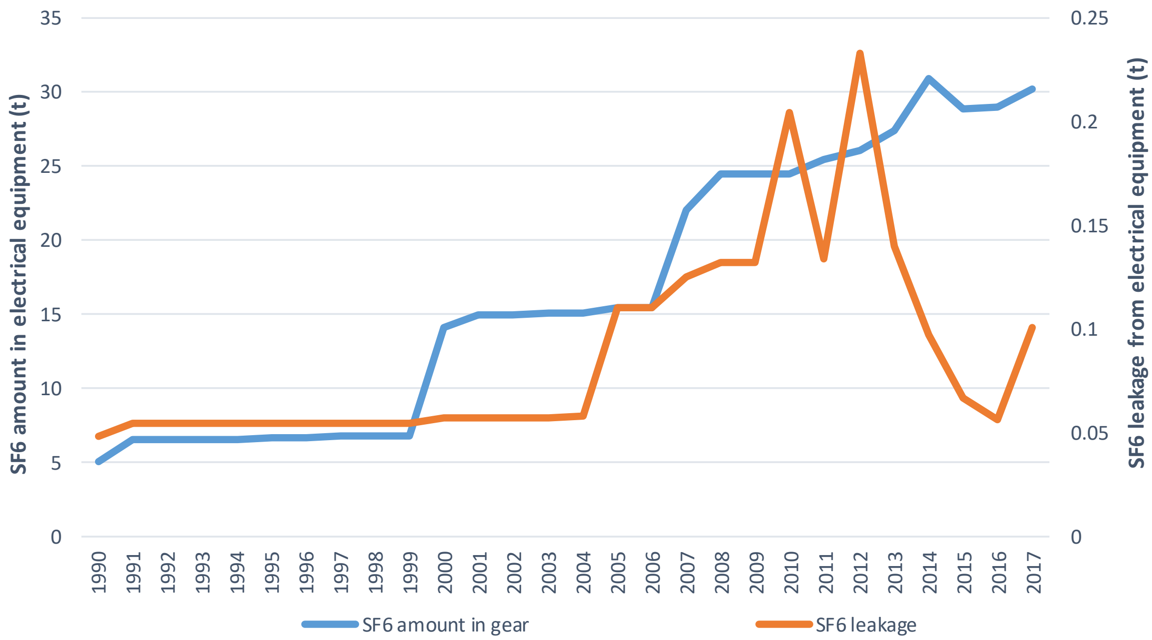

Figure 4.10 Total SF6 amounts contained in and SF6 leakage from electrical equipment (tonnes).

4.8.1.4 Uncertainty

The uncertainty on SF_6 emissions is estimated to be 30%, see also Annex 2.

4.8.1.5 Recalculations and planned improvements

An update of activity data lead to a minor recalculation of the SF6 emissions of the 2018 submission.

Planned improvements for future submissions include improving data acquisition pertaining to the amount of SF_6 remaining at decommissioning of electrical equipment, as well as to estimate emissions of SF_6 from equipment disposal. Furthermore, this subsector will be revisited during the overall revision of Iceland's F-gases inventory planned for the year 2019. However, this is not expected to impact the emissions reported under this subsector.

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).

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 2015,2016 and 2017 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, 2016 and 2017, and the ratio used (95% vs 5%) was confirmed by expert judgment.

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 2017 (1.64 kt CO_2e).

4.8.2.4 Emissions from Other product use (2G3b)

Emissions from other use of N_2O decreased from 1.6 t N_2O in 1990 to 0.3 t in 2016 (0.09 kt CO_2e).

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 (Nielsen et al., 2017). Combined uncertainty for N_2O emissions from other product use is therefore estimated to be 8%.

4.8.2.6 Planned improvements

For future submissions, it is planned to assess whether available data allows to determine recovery of N_2O in medical applications.

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 (Nielsen et al., 2017) 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 4.11, Tobacco consumption in Iceland has been steadily decreasing since 1990, with the 2017 imports (231 t) approximately 59% 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 0.018 kt CO_2e CH_4 and 0.004 kt CO_2e N_2O in 2017. NOx decreased from 1.01 t in 1990 to 0.42 t in 2017, NMVOC decreased from 2.7 t in 1990 to 1.1 t in 2017, and CO decreased from 30.9 t in 1990 to 12.7 t in 2017.

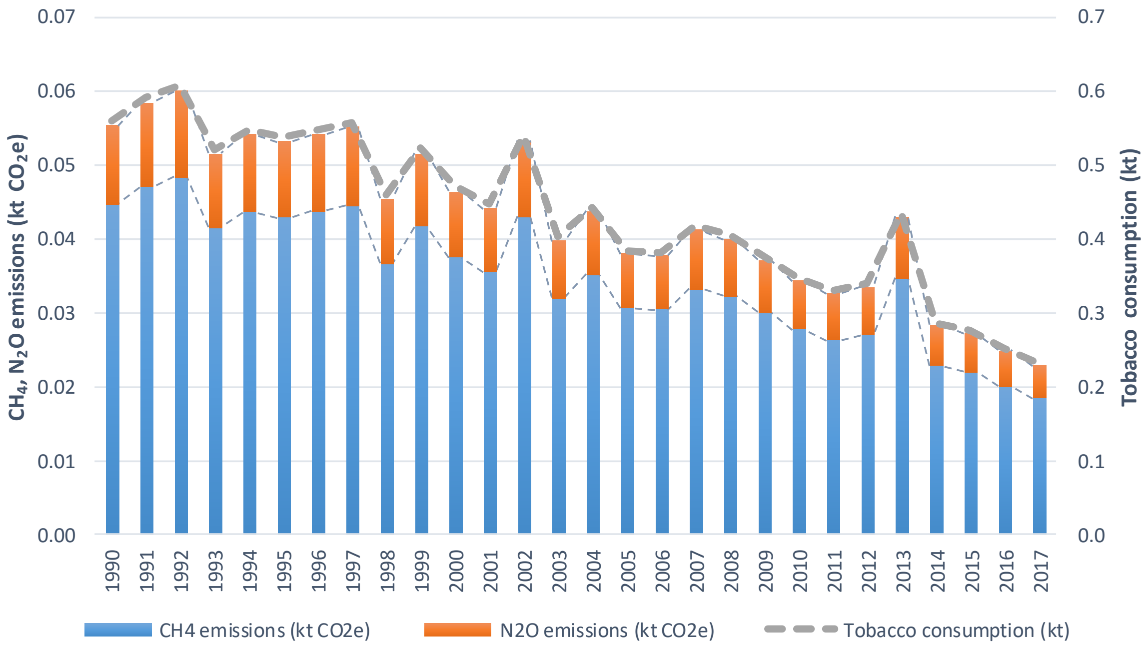

Figure 4.11 Tobacco import and GHG emissions (kt CO2e) from tobacco use.

Recalculations and planned improvements

No category-specific recalculations were done for the 2019 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. No activity data is available prior to 1995, therefore activity data for 1990 to 1994 was taken to be the same as for 1995. 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 4.12). 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 0.39 kt CO_2e in 2017. The main contributor to GHG emissions from fireworks is N_2O, with about 90% of total emissions (when calculated in CO_2e).

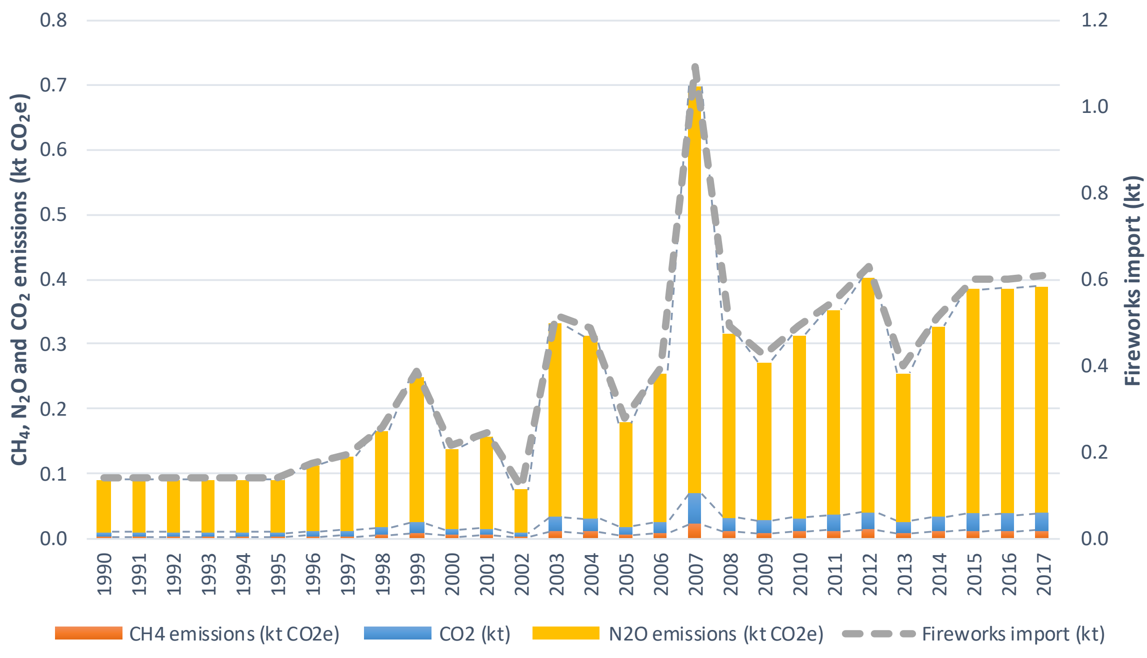

Figure 4.12 Fireworks import and GHG emissions (kt CO2e) from firework use.

Recalculations and planned improvements

No category-specific recalculations were done for the 2019 submission, and no improvements are currently planned for this category.

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 2017 NMVOC emissions were estimated at 0.37 kt, which represents a 13.8% increase from the 1990 levels. Figure 4.13 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.

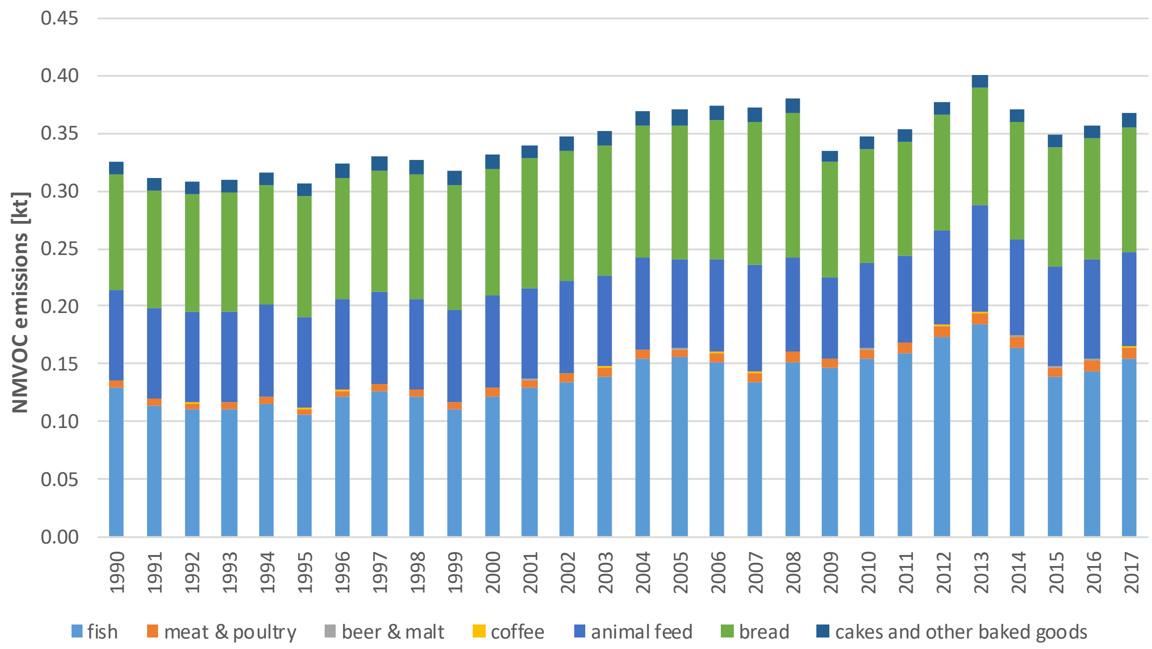

Figure 4.13 NMVOC emissions (in kt NMVOC) for various food and beverage processing.

4.9.4 Recalculations and Planned Improvements

No category-specific recalculations were done for the 2019 submission. Planned improvements include obtaining activity data for spirits and carbonated beverage production to estimate emissions from the production of these goods.

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 a 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 578.19 kt CO_2e in the year 2017 and were 2.5% below the 1990 level. 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. 85% of CH_4 emissions were caused by enteric fermentation, the rest by manure management. 91% of N_2O emissions were caused by agricultural soils, the rest by manure management, i.e. storage of manure.

5.1.1 Methodology

The calculation of CH_4 emissions from agriculture is based on the methodologies presented in Volume 4 (AFOLU) of the 2006 IPCC Guidelines (IPCC, 2006). For estimating N_2O emissions, a comprehensive nitrogen flow approach, as presented in the 2016 EMEP Emissions Inventory Guidebook, was used. This approach is fully consistent with the methodologies presented in the 2006 IPCC Guidelines, but allows a more detailed assessment of N_2O emissions (and other N species).

For this 2019 submission last year´s work on reviewing and updating calculations for the sector on agriculture in order to improve documentation, increase transparency throughout the calculation files and improve accuracy of the reported data was continued. Further improvements are to be made for the next submission (detailed later in this chapter).

Emission factors for methane emissions from enteric fermentation and manure management have been updated to 2006 IPCC Guidelines and resulted in a small increase in emissions.

The methodology that was applied to the categories direct- and indirect N_2O emissions from agricultural soils for the first time last year, in order for the categories to be consistent with CLRTAP emissions, was adjusted slightly from the previous submission. Instead of using fracgasm from IPCC 2006 to estimate N volatilised as NH_3 and NO_2, this is now summing the NH_3 and NO_2 emissions estimated with EMEP/EEA methodology for Manure to soils and Grazing animals.

5.1.2 Key Category Analysis

The key sources for 1990, 2017 and 1990-2017 trend in the Agriculture sector are as follows (compared to total emissions without LULUCF):

Table 5.1 Key source analysis for Agriculture, 1990, 2017 and trend (excluding LULUCF).

IPCC source category			Level 1990	Level 2017	Trend
Agriculture (CRF sector 3)					
3A1	Enteric Fermentation – Cattle	CH_4	✓	✓	
3A2	Enteric Fermentation - Sheep	CH_4	✓	✓	✓
3A4	Enteric Fermentation – Horses	CH_4	✓	✓	
3B1	Manure Management - Cattle	CH_4	✓		
3D1	Direct N_2O Emissions from Managed Soils	N_2O	✓	✓	✓
3D2	Indirect N_2O Emissions from Managed Soils	N_2O	✓	✓	

5.1.3 Completeness

Table 5.2 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 Agricultural sector.

Table 5.2 Agriculture – completeness (E: estimated, NE: not estimated, NA: not applicable, NO: not occurring).

Sources	CO_2	CH_4	N_2O
3A1 Enteric Fermentation	NA	E	NA
3A2 Manure Management	NA	E	E
3C7 Rice Cultivation	NO		
3C4,5 Agricultural Soils			
Direct Emissions	NA	NA	E
Animal Production	NA	NA	E
Indirect Emissions	NA	NA	E
Other	NO		
3B Prescribed burning of Savannas	NO		
3F Field burning of Agricultural Residues	NO		
3G Other	E		

5.1.4 Planned Improvements

The party aims to include information on the non-occurrence of field burning of agricultural crop residues in future submissions.

5.2 Activity Data

5.2.1 Animal Population Data

The Icelandic Food and Veterinary Authority (IFVA) conducts an annual livestock census. For the census, farmers count their livestock once a year in November and send the numbers to the IFVA.

Consultants from local municipalities visit each farm during March of the following year and correct the numbers from the farmers in case of discrepancies.

This methodology provides greenhouse gas inventories which need information on livestock throughout the year with one problem: 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).
- 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.

Numbers for young animals with a live span of less than one year were weighed with the respective animal ages 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

As a result, the numbers of several animal species are higher in the NIR than they are in the national census. 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, 2019).

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. However there seems to be an underreporting for horses and poultry. The IFVA is in the process of taking up new systems for delivering and logging the livestock census which aim at making the census more accurate. The data from the livestock census for poultry and horses is therefore corrected as described below. For horses there are discrepancies from different data sources. According to expert opinion the total number is approximately 72 thousand animals, which is considerably higher than in than reported in the national census and has remained similar for the past few years (Lorange, written communication, 2018).

For this submission, livestock population numbers were updated for the whole time series (1990-2017). This was done due to changed reporting at the IFVA, which no longer publishes final livestock numbers for each year. Therefore, the currently used data was pulled directly from their livestock database (www.bustofn.is) where all the livestock census reports from farmers are stored. The current data should, therefore, be the most accurate data available.

5.2.2 Livestock Population Characterization

For the previous (2018) submission, enhanced livestock population characterisation was applied to cattle and sheep and subsequently used in estimating methane emissions from enteric fermentation and manure management.

In accordance with the census there are five subcategories used for cattle in the livestock population characterisation: mature dairy cows, cows used for producing meat, heifers, steers used for producing meat, and young cattle. The subcategories "heifers", "steers used for producing meat" and "young cattle" were aggregated in the category "growing cattle". This is an adjustment from previous years and causes a slight shift in emissions from the aforementioned categories. The total emissions from cattle has, however, not changed. The subcategory steers used for producing meat was the most heterogeneous in the census since it contains all steers between one year of age and age at slaughter (around 27 months) as well as heifers between one year of age and insemination (around 18 months). The population data did not permit dividing this subcategory further. The share of females inside the category was estimated by assuming that there were as many cows as steers inside the subcategory, only for a shorter time (6 vs. 15 months). This results in a share of cows of 29%. The subcategory young cattle contained both male and female calves until one year of age. Fractions of male and female calves fluctuated slightly between years.

For sheep, the subcategory lambs was added to the census data. The following four categories were used for the livestock population characterization of sheep: mature ewes, other mature sheep, animals for replacement and lambs.

Table 5.3 shows the equations used in calculating net energy needed for maintenance, activity, growth, lactation, wool production and pregnancy for cattle and sheep subcategories. Equation 4.9 was used to calculate the ratio of net energy available in the animals´ diets for maintenance to the digestible energy consumed. Equation 4.10 from the GPG was used to calculate the ratio of net energy available in the animals´ diets for growth to the digestible energy consumed. Net energy needed and ratios of net energy available in diets to digestible energy consumed were subsequently used in equation 4.11 to calculate gross energy intake for cattle and sheep subcategories.

Table 5.3. Overview of equations used to calculate gross energy intake in enhanced livestock population characterisation for cattle and sheep (NA: not applicable).

Subcategory	Equations from IPCC 2006 guidelines. Net energy for maintenance, activity, growth, lactation, wool, and pregnancy					
	Maintenance	Activity	Growth	Lactation	Wool	Pregnancy
Mature dairy cows	10.3	10.4	NA	10.8	NA	10.13
Cows used for producing meat	10.3	10.4	NA	10.8	NA	10.13
Heifers[1]	10.3	10.4	10.6	NA	NA	4.8
Steers used principally for producing meat	10.3	10.4	10.6	NA	NA	NA
Young cattle	10.3	10.4	10.6	NA	NA	NA
Mature ewes	10.3	10.4	NA	10.1	10.12	10.13

Subcategory	Equations from IPCC 2006 guidelines. Net energy for maintenance, activity, growth, lactation, wool, and pregnancy					
	Maintenance	Activity	Growth	Lactation	Wool	Pregnancy
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 5.4 shows national parameters that were used to calculate gross energy intake for cattle in 2017. Not all parameters have been constant over the last two decades. The ones that have changed during that time period are *months on stall*, *months on pasture* and *kg milk per day*.

Table 5.4. Animal performance data used in calculation of gross energy intake for cattle in 2017. (NA: Not applicable, NO: Not occurring).

	Mature dairy cows	Cows for producing meat	Heifers	Steers for producing meat	Young cattle
Weight (kg)	430	500	370	328[2]	126
Months in stall	8.71	1	8	11	12
Months on pasture	3.29	11	4	1[1]	0
Mature body weight (kg)	430	500	430	515	515
Daily weight gain (kg)	NO	NO	0.5	0.5	0.5
Kg milk per day	16.8	5.5	NA	NA	NA
Fat content of milk (%)	4.2	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 5.5 shows national parameters that were used to calculate gross energy intake for sheep in 2017.

Table 5.5. Animal performance data used in calculation of gross energy intake for sheep from 1990-2017 (no time dependent data). NA: Not applicable, NO: Not occurring

	Mature ewes	Other mature sheep	Animal for replacement	Lambs
Weight (kg)	65	95	36	21
Months in stall	7	7	7	0
Months on flat pasture	2	2	2	1
Months on hilly pasture	3	3	3	3
Body weight at weaning (kg)	NA	NA	22	22
Body weight at 1 year or old or at slaughter (kg)	NA	NA	55	38
Birth weight (kg)	4	4	4	4
Single birth fraction[1]	0.2	NA	0.6	NA
Double birth fraction	0.7	NA	0.1	NA

	Mature ewes	Other mature sheep	Animal for replacement	Lambs
Triple birth fraction	0.1	NA	NO	NA
Annual wool production (kg)	3	3	2	2
Digestible energy (in % of gross energy)	64	64	64	77

[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

Submission characteristics of cattle and sheep build on feed composition, daily feed amounts, their dry matter digestibility and feed ash content. This information was collected by the Agricultural University of Iceland (AUI) (Sveinbjörnsson, written communication) and 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 5.6 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 2018 submission.

Table 5.6. Dry matter digestibility, digestible energy and ash content of cattle and sheep feed.

	DMD (%)	DE (%)	Ash in feed (%)
Mature dairy cows	74	68	7
Cows used for producing meat	74	68	7
Heifers	74	68	7
Steers used principally for producing meat	73	66	7
Young cattle	80	73	8
Mature ewes	70	64	7
Other mature sheep	70	64	7
Animals for replacement	70	64	7
Lambs	84	77	7

Figure 5.1 shows the gross energy intake (GE) in MJ per day for all cattle and sheep subcategories. As of the 2014 submission only mature dairy cattle have time dependent values for GE (see: chapter 5.2.3). The GE of mature dairy cattle has increased from 200 MJ/day in 1990 to 249 MJ/day in 2017. 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 6.2 t in 2017.

Feed digestibility is constant in Iceland for all cattle types and sheep types, except for young cattle. Feed digestibility of young cattle 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. The digestibility of heifers, steers and calves are constant along the time series. The feed digestibility is estimated based on parameters which are assumed to be constant over the time series.

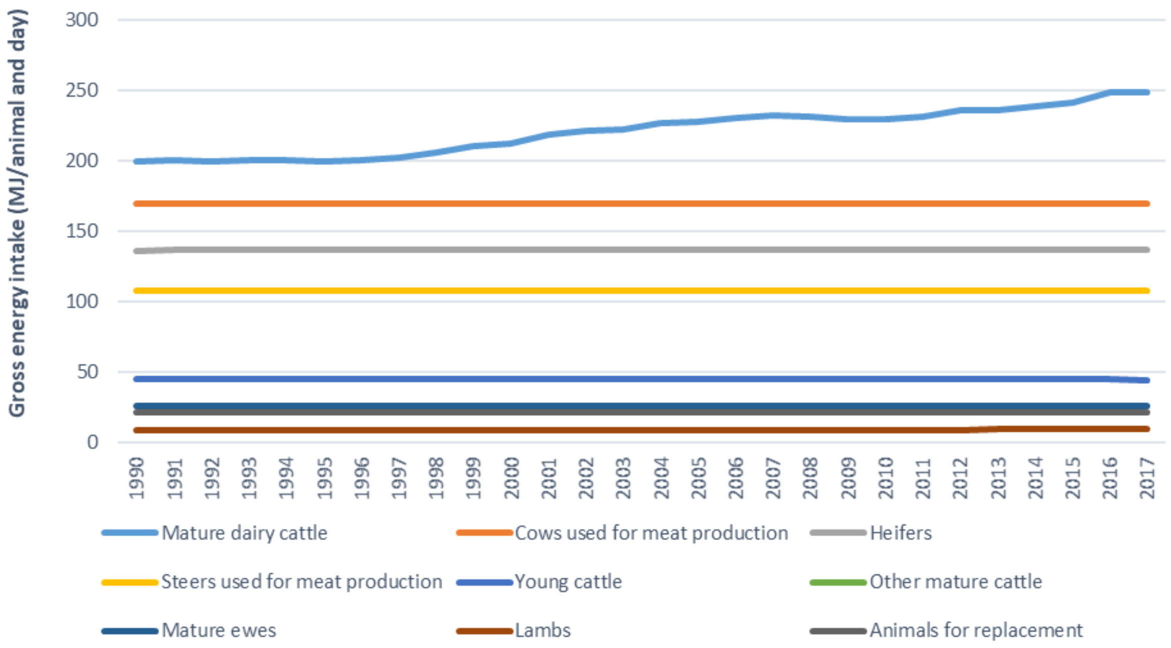

Figure 5.1 Gross energy intake (MJ/day) for cattle and sheep subcategories from 1990-2017.

5.2.4 Planned Improvements

Iceland is working on an improvement plan to include more detailed explanations of activity data and emission factors. The improvement plan also includes setting up a system to update 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 in Domestic Livestock (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 (IPCC, 2006).

5.3.1 Emission Factors

Livestock population characterisation was used to calculate gross energy intake of cattle and sheep. The values for gross energy intake were used to calculate emission factors for methane emissions from enteric fermentation. To this end equation 10.21 from the GPG was applied:

EQUATION 10.21

Emission factor development

$$EF = (GE * Ym * 365 \text{ days/yr}) / (55.65 \text{ MJ/kg } CH_4)$$

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

Table 5.7 Country specific emission factors for cattle and sheep, calculated based on Equation 10.21 (IPCC, 2006).

Livestock category	2017
Mature dairy cattle	106,3
Cows used for producing meat	72,5
Heifers	58,4
Steers used for producing meat	46,2
Young cattle	19,2
Mature ewes	11,3
Other mature sheep	11,9
Animals for replacement	9,4
Lambs	2,8

Gross energy intake is calculated in the livestock population characterisation. The methane conversion rate depends on several interacting feed and animal factors; good feed usually means lower conversion rates. Default values from the GPG were applied (Table 5.8).

Table 5.8. Methane conversion rates for cattle and sheep (IPCC, 2006).

Category/Subcategory	Cattle	Mature sheep	Lambs (<1 year old)
Y_m	0.065	0.065	0.045

Methane emission factors for pseudo-ruminant and mono-gastric animal species were taken from the 2006 Guidelines. Values from the Norwegian NIR (Statistics Norway, 2011) were used for poultry and fur animals as the agricultural practises and climate are similar and most Icelandic farmers take their further education in Norway.

5.3.2 Emissions

Methane emissions from enteric fermentation in domestic livestock are calculated by multiplying emission factors 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 5.9 are solely based on fluctuations in population size. The population size of mature dairy cattle has decreased by 17% between 1990 and 2017. Methane emissions, however, have increased by 3.3% from 2.75 kt to 2.84 kt during the same period due to the increase in the emission factor associated with the increase in milk production. The livestock category emitting most methane from enteric fermentation is mature ewes. Due to a proportionate decrease in population size, emissions from mature ewes decreased by 17.8% between 1990 and 2017 (from 5.05 to 4.14 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 has not varied much since 1990, and consequently the emissions have remained around 1.4 kt.

The decrease in methane emissions from sheep caused total methane emissions from enteric fermentation in agricultural livestock to drop from 12.6 kt in 1990 to 12.1 kt in 2017, or by 3.8% (Table 5.9).

Table 5.9. Methane emissions from enteric fermentation from agricultural animals for years 1990, 1995, 2000, 2005, 2010 and 2016-2017 in t methane.

Livestock category	1990	1995	2000	2005	2010	2016	2017
Mature dairy cattle	2,752	2,595	2,456	2,380	2,484	2,793	2,842
Cows used for producing meat	0	53	69	98	117	158	164
Heifers	267	746	371	393	386	382	389
Steers used for producing meat	830	711	918	705	873	1,059	1,035
Young cattle	387	267	344	349	385	423	437
Mature ewes	5,043	4,217	4,228	4,080	4,222	4,288	4,143
Other mature sheep	158	148	144	134	144	143	141
Animals for replacement	845	695	756	786	872	812	774
Lambs	887	741	748	727	757	763	736
Swine	45	46	48	59	57	64	65
Horses	1,330	1,444	1,361	1,379	1,419	1,358	1,329
Goats	2	3	3	3	5	9	9
Fur animals	5	4	4	4	4	4	3
Poultry	13	7	11	16	13	15	17
Total methane emissions	**12,565**	**11,676**	**11,463**	**11,112**	**11,737**	**12,269**	**12,085**
Emission reduction (year-base year)/base year		**-7.1%**	**-8.8%**	**-11.6%**	**-6.6%**	**-2.4%**	**-3.8%**

5.3.3 Recalculations

For the 2019 submission there were no recalculations undertaken.

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).

This can be seen in the quantitative uncertainty table in Annex 2.

5.3.5 Improvements

No improvements are currently planned for this category.

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

Emission factors for manure management were calculated for cattle and sheep using data compiled in the livestock population characterization. For all other livestock categories IPCC default values (based on information in the 2006 Guidelines) were used. In order to calculate emission factors from manure management, daily volatile secretion (VS) rates have to be calculated first. VS are calculated using gross energy intake per day in the livestock population characterisation and national values for digestible energy and ash content of feed (cf. chapter 6.2.3). Equation 4.16 from the GPG was used.

EQUATION 4.16

Volatile solid excretion rates

$$VS = GE * (1\ kg\text{-}dm/18.45\ MJ) * (1 - DE/100) * (1 - ASH/100)$$

Where:

- VS = volatile solid excretion per day on a dry-matter weight basis, kg-dm/day
- GE = Estimated daily average feed intake in MJ/day
- DE = Digestible energy of the feed in percent
- ASH = Ash content of the manure in percent

Volatile solid excretion per day is then used in equation 4.17 from the GPG to calculate emission factors for manure management, as shown below:

EQUATION 4.17

Emission factor from manure management

$$EFi = VSi * 365\ days/year * Boi * 0.67\ kg/m3 * \Sigma(j)\ MCFj * MS\ ij$$

Where:

- EF_i = annual emission factor for defined livestock population i, in kg
- VS_i = daily VS excreted for an animal within defined population i, in kg
- B_{oi} = maximum CH_4 producing capacity for manure produced by an animal within defined
- population i, m^3/kg of VS
- MCF_j = CH_4 conversion factors for each manure management system j
- MS_{ij} = fraction of animal species/category i’s manure handled using manure system j

Maximum methane producing capacity values are taken from the 2006 Guidelines. They are 0.17 m^3/kg VS for non-dairy cattle, 0.19 m^3/kg VS for sheep, and 0.24 m^3/kg VS for dairy cattle. Methane conversion factors (MCF) for the three manure management systems used in cattle and sheep farming, i.e. pasture/range/paddock, solid storage and liquid/slurry are taken from the 2006 Guidelines.

Table 5.10. Methane conversion factors (fractions) included in 2006 Guidelines for different manure management systems.

		Cattle	Cattle	Cattle	Sheep
	Conditions	Pasture/range	Solid storage	Liquid/ slurry	All manure management systems
2006 GL	Average annual temperature <10°C	1%	2%	10%[1] 17%[2]	Same as for cattle

[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 impact not only CH_4 emissions from manure management but also N_2O emissions from manure management and in 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. 65% of the manure managed is managed as solid storage, the remaining 35% as liquid/slurry (Table 5.11).

Table 5.11. Manure management system fractions for all livestock categories.

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

Emission factors both calculated with volatile solid excretion rates, methane conversion factors, and manure management fractions as well as IPCC default values for other livestock categories than cattle and sheep were used to calculate methane emissions from manure management and are shown in Table 5.12.

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

Table 5.12. Emission factors values, range and origin used to calculate methane emissions from manure management.

Livestock category	Emission factor 2017	Emission factor range 1990-2017	Source
	(kg CH_4/head year)	(kg CH_4/head year)	
Mature dairy cattle	29.59	24.4 – 29.6	LPS
Cows used for producing meat	2.65		LPS
Heifers	10.70		LPS
Steers used for producing meat	11.84		LPS
Young cattle	4.23	4.23 - 4.27	LPS
Mature ewes	0.99		LPS
Other mature sheep	1.04		LPS
Animals for replacement	0.82		LPS
Lambs	0.05		LPS
Swine	6.00		2006 GL
Horses	1.09		2006 GL
Goats	0.12		2006 GL
Minks	0.68		2006 GL
Foxes	0.68		2006 GL
Rabbits	0.08		2006 GL
Poultry	0.62		2006 GL

[1]Livestock population characterisation.

5.4.3 Emissions

As can be seen in Table 5.12 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 high emission factor for mature dairy cattle and steers has already been addressed. Mature ewes have an emission factor that is roughly twenty times lower than the ones for dairy cattle and steers but has a much bigger population size. Other important livestock categories for methane emissions from manure management are young cattle, animals for replacement, swine, horses, and poultry.

Total methane emissions from manure management increased from 2.115 kt in 1990 to 2.191 kt in 2017 or by 3,6%.

Table 5.13. Methane emissions from manure management in tonnes.

Livestock category	1990	1995	2000	2005	2010	2016	2017
Mature dairy cattle	793	742	696	670	692	778	791
Cows used for producing meat	0	2	3	4	4	6	6
Heifers	49	137	68	72	71	70	71
Steers used for producing meat	213	182	235	181	223	271	265
Young cattle	85	59	76	77	85	93	97
Mature ewes	439	367	368	355	367	373	360
Other mature sheep	14	13	13	12	13	12	12
Animals for replacement	74	60	66	68	76	71	67
Lambs	16	13	14	13	14	14	13
Swine	179	184	193	236	228	255	259
Horses	81	87	82	84	86	82	80
Goats	0	0	0	0	0	0	0
Fur animals (minks and foxes)	32	26	28	25	27	26	23
Rabbits	0	0	0	0	0	0	0
Poultry	141	105	127	107	99	133	144
Total methane from manure management	**2,115**	**1,979**	**1,967**	**1,902**	**1,985**	**2,184**	**2,191**
Emission reduction (year-base year)/base year		**-6,4%**	**-7,0%**	**-10,1%**	**-6,1%**	**3,3%**	**3,6%**

5.4.4 Recalculations

For the 2019 submission there were no recalculations undertaken.

5.4.5 Uncertainties

Uncertainty of emissions from CH4 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%).

This can be seen in the quantitative uncertainty table in Annex 2.

5.4.6 Improvements

The Party is currently working on setting up an improvement plan for future submissions. It will include setting up a system to update the Nex rate on a regular basis. The available information on the circumstances under which the country-specific N excretion data has been estimated will be included in the next submission.

5.5 N_2O Emissions from Manure Management (CRF 3B2)

The nitrous oxide estimated in this section is the N_2O produced during the storage and treatment of manure before it is applied to land. The emission of N_2O from manure during storage and treatment depends on the nitrogen that forage or are fed in paddocks, animals kept in pens around homes) the manure is not stored or treated but is deposited directly on land. The N_2O emissions generated by manure in the and carbon content of manure, and on the duration of the storage and type of treatment (IPCC, 2000). In the case of animals whose manure is unmanaged (i.e. animals grazing on pasture or grassland, animals system pasture, range, and paddock occur directly and indirectly from the soil, and are therefore reported in chapters 5.6 and 5.7.

Significant improvements have been made to the methodology for estimating N_2O emissions from all sources within 3.B Manure management and 3.D Managed soils. 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 at the disaggregated livestock category level (e.g. 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 Overview of the N-flow Methodology

The N-flow methodology is presented in detail in the 2016 version of the EMEP/EEA Emissions Inventory Guidebook and is therefore not duplicated here. But the following provides an overview of the different “steps” that comprise the methodology.

- **Step 1: Define the livestock subcategories** that are homogeneous with respect to feeding, excretion and age/weight range. Steps 2 to 14 inclusive should then be applied to each of these subcategories and the emissions summed.
- **Step 2: Calculate the total annual excretion of N by the animals**. This is done by combining livestock numbers with corresponding N excretion rates.
- **Step 3: Calculate the amount of the annual N excreted that is deposited within buildings** in which livestock are housed, on uncovered yards and during grazing. This is based on the total annual N excretion and the proportions of excreta deposited at these locations.
- **Step 4: Calculate the proportion of the N excreted as TAN** (which is used to calculate the amount of TAN deposited during grazing, on yards or in buildings).
- **Step 5: Calculate the amounts of TAN and total N deposited in buildings handled as liquid slurry.** This is done by combining the total N and TAN with the fraction of manure in slurry management systems.
- **Step 6: Calculate the losses of N compounds from the livestock building** (and yards if applicable), by multiplying the amount of N and/or TAN by corresponding EFs for both slurry and FYM.

- **Step 7:** For solid manure only, **Account for added N and the immobilisation of TAN in added bedding material.** The amounts of total-N and TAN in solid manure that are removed from buildings and yards, and either passed to storage or spread directly to the fields, are then calculated, remembering to subtract the NH3-N emissions from the livestock buildings.
- **Step 8: Calculate the amounts of total-N and TAN stored before application to land.** Not all manures are stored before spreading; some will be applied to fields directly from buildings. Some manures (mainly slurries) will be used as feedstocks for AD in biogas facilities.
- **Step 9:** For slurries only, **Calculate the amount of N and TAN from which emissions will occur** from slurry stores. For slurries, a fraction of the organic N is mineralised (fmin) to TAN before the gaseous emissions are calculated.
- **Step 10: Calculate the emissions of NH3, N2O, NO and N2** (using the corresponding EFs).
- **Step 11: Calculate the total-N and TAN that is applied to the field** (remembering to subtract the emissions of NH3, N2O, NO and N2 from storage).
- **Step 12: Calculate emissions during and immediately after field application** is calculated using appropriate EFs.
- **Step 13: Calculate the net amount of N returned to soil from manure after losses of NH3-N.**
- **Step 14: Calculate the emissions from grazing** (using information from Steps 2,3 and corresponding EFs).
- **Step 15:** All the emissions from the manure management system that are to be reported under Chapter 3B are summed and converted to the mass of the relevant compound.

The use of this approach has meant that indirect N_2O emissions from manure management were calculated and included in the inventory for the first time.

The integrated nature of this approach makes it difficult to give a discrete list of reasons for recalculations. For example, indirect emissions from manure management are impacted by several changes to the “upstream” parts of the N-flow calculations.

5.5.2 Activity Data

The activity data for the N-flow approach is considered to be N and TAN that is quantified throughout the manure management process, and not 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.

Many of the different input variables, such as livestock numbers, days housed, the use of different manure management systems have already been considered in Sections 5.2 and 5.4 above. But additional information is provided below, and in particular N excretion rates are presented. Numbers for head of livestock species/category exist (with distinction between adult and young animals for all livestock categories with the exceptions of rabbits and fur animals). The manure management system fractions for cattle and sheep have been discussed in chapter 5.4.2. 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 were summarized above in Table 5.11.

Average annual nitrogen excretion rates were calculated using 2006 GL default values (Table 5.14). The defaults relate to 1000 kg animal mass. This means that they account for two cows weighing 500 kg each or roughly 15 ewes weighing 65 kg each. The calculated default for dairy cattle was not used since national, time dependent values existed: Ketilsdóttir and Sveinsson (2010) measured the Annual N excretion rates for dairy cows. The resulting value of 94.8 kg N was applied to dairy cows from 2000-2017. Since the value is based on new measurements for dairy cows with an annual milk production in excess of 5000 kg, it was adjusted for the 1990s (average milk production of 4200 kg) by interpolating linearly between it and a national literature value of 72 kg (Óskarsson & Eggertsson, 1991).

Table 5.14 Nitrogen excretion rates (Nex).

Livestock category	Nex default (kg N/1000 kg animal mass/day)	Animal weight (kg)	Annual N excretion rates (kg N/animal year)
Mature dairy cattle	0.48	430	75.336[1]
Cows used for producing meat	0.33	500	60.2
Heifers	0.33	370	44.5
Steers used for producing meat	0.33	328	39.5
Young cattle	0.33	126	15.2
Mature ewes	0.85	65	20.2
Other mature sheep	0.85	95	29.5
Animals for replacement	0.85	36	11.1
Lambs	0.85	21	6.5
Sows	0.42	150	23.0
Piglets	0.51	41	7.6
Horses	0.26	375	35.6
Young horses	0.26	175	16.6
Foals	0.26	60	5.7
Goats	1.28	44	20.3
Minks	NE	NE	4.6
Foxes	NE	NE	12.1
Rabbits	NE	NE	8.1
Hens	0.96	4	1.4
Broilers	1.10	4	1.6
Pullets	0.55	3	0.6
Chickens	0.55	1	0.2
Ducks/geese	0.83	4	1.2
Turkeys	0.74	5	1.4

[1] National, time dependent values ranging from 72 to 94.8 kg N were used instead.

5.5.3 Emission Factors

The EFs and methodologies for estimating the losses of N as NH_3 from housed animals, and NH_3 and NO losses during manure storage, are presented in Iceland's Informative Inventory Report, 2018.

N_2O EFs from the storage of manure are based on the 2006 IPCC Guidelines, table 10.21 that 0.001 kg N_2O-N is emitted per kg nitrogen excreted when cattle and sheep manure is managed as liquid slurry but incorporates a degree of local expert judgement to account for local conditions and farming practices in Iceland. Emissions from pigs are assumed to be zero, as indicated in both the 2006 IPCC Guidelines and the 2016 EMEP/EEA Emissions Inventory Guidebook.

The EFs used for manure managed in solid storage are based on the default values of N_2O-N emitted per kg of nitrogen excreted presented in table 3.8 in the 2016 EMEP/EEA Guidebook (2016) but incorporate local expert judgement to account for local conditions in Iceland.

5.5.4 Emissions

N_2O emissions from the manure management systems liquid/slurry and solid storage amounted to 37 tonnes N_2O in 2017 and 43 tonnes in 1990 (-15%).

Emissions from liquid systems make up only a small part of total emissions from managed systems or only 10% of total N_2O emissions from manure management systems in 2017. 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 2017, followed by solid storage of poultry manure (2%), horse manure (6%), and fur animal manure (1%).

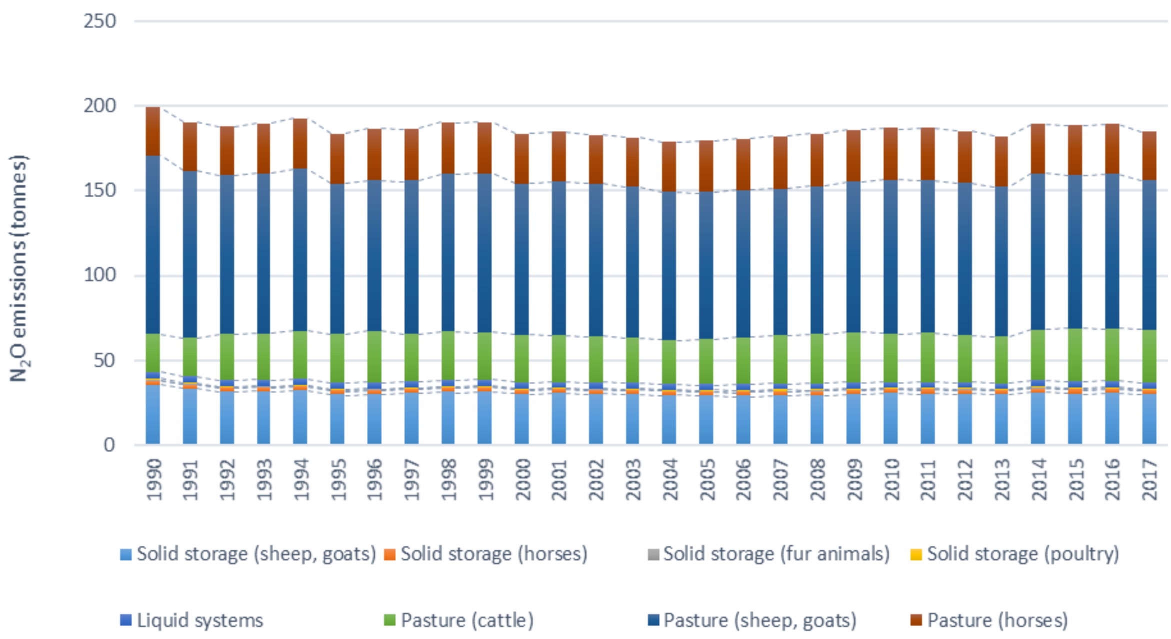

Figure 5.2 N_2O emissions from manure management in kt N_2O.

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. 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 2017 N_2O emissions from manure spread on pasture by livestock amounted to 148 tonnes. Emissions from sheep manure were 88 tonnes, emissions from horse manure were 29 tonnes, and emissions from cattle manure amounted to 31 tonnes N_2O.

Indirect emission from manure management were calculated for the first time in this version of NIR. The calculation results in a total of 31 tonnes N_2O for 2017, decreasing from 34 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&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 is considered in 3.D Managed soils.

5.5.6 Recalculations

Based on comments from the EMRT after the 15th of January submission of data, it was discovered that our N_2O emissions were based on the wrong EF for manure managed in solid storage. The EF were taken from table A1.7 from the EMEP/EEA Guidebook (2016) but have now been updated to the EFs in table A3.8 from the EMEP/EEA Guidebook (2016). This was updated for all livestock categories and the recalculations resulted in lower N_2O emissions from manure management.

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 112% (AD uncertainty at 51.2% and EF uncertainty at 100.0%). For sheep, the estimated quantitative uncertainty of CH4 emissions for manure management is 115% (AD uncertainty at 56.1% 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))

This can be seen in the quantitative uncertainty table in Annex 2.

5.5.8 Planned Improvements

The Party is currently working on setting up an improvement plan for future submissions. It will include improving information on sewage sludge and other organic fertilizers applied to soils, as well as N2O emissions from mineral soils. Furthermore, information on indirect emissions from manure management, including N2O emissions from nitrogen volatilized as ammonia and NOx and from nitrogen lost through leaching and run-off, will be improved.

5.6 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. Agricultural activities like the return of crop residue, use of synthetic fertilizer and manure application add nitrogen to soils, increasing the amount of nitrogen (N) 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 NH3 and NOx 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 5.7.

Improvements to Activity Data

Substantial improvements to the N_2O emission estimates from all agriculture sector sources were undertaken. 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.

Improvements to Emission Factors

In accordance with the IPCC 2006 Guidelines, the EF used for grazing Sheep (and selected other animal classes) is 0.01 N_2O-N/kg N. Previously a figure of 0.02 N_2O-N/kg N was used for all animal classes. This has a particularly large impact on emissions of N_2O as sheep are a major source in the agriculture sector.

Other EF updates include the EFs used to estimate emissions from soils were updated in line with the information provided in the 2006 IPCC Guidelines (Volume 4, Chapter 11, Table 11.1). Consequently, the EF for the application of synthetic and organic fertilisers and crop residues was reduced from 0.0125 to 0.01 kg N_2O-N/kg N, and EFs for pasture range and paddock of 0.02 and 0.01 kg N_2O-N/kg N were used for cattle/poultry/pigs and sheep/other animals respectively.

Revisions were also made to the EF for 3Db2 Indirect emissions, Leaching & run-off. In accordance with the IPCC 2006 Guidelines (Table 11.3), the EF used in this submission is 0.0075 kg N_2O-N/kg N leached. This is a substantial reduction on the value previously used of 0.025 kg N_2O-N/kg N.

5.6.1 Activity Data and Emission Factors

Direct N_2O emissions from agricultural soils are calculated with equation 11.2 from the 2006 GL. Of the possible sources of input into soils the following are applicable for Iceland:

- Synthetic fertilizer nitrogen
- Animal manure nitrogen used as fertilizer
- Urine and dung N deposited during pasture, range and paddock by grazing animals
- Nitrogen in crop residues returned to soils
- Cultivation of organic soils

EQUATION 11.2

DIRECT N_2O EMISSIONS FROM AGRICULTURAL SOILS (TIER 1a)

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

Where:

- N_2O_{Direct} -N = Emission of N_2O in units of Nitrogen
- F_{SN} = Annual amount of synthetic fertiliser nitrogen applied to soils
- F_{ON} = Annual amount of organic N amendments applied to soils
- F_{CR} = Amount of nitrogen in crop residues returned to soils annually
- F_{PRP} = Amount of N deposited by animals at pasture, range, paddock
- F_{OS} = Area of organic soils cultivated annually
- 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)

5.6.2 Synthetic Fertilizer Nitrogen (F_{SN})

Activity data comes from the Icelandic Food and Veterinary Authority (IFVA) and consists of the amount of nitrogen in synthetic fertilizer applied to soils with the exception of the amount of fertilizer applied in forestry (Figure 5.3).

The IPCC 2006 default EF of 0.01 kg N_2O-N/kg N input is used.

5.6.3 Organic Nitrogen Amendments (F_{ON})

Animal manure nitrogen available from storage for application as a fertiliser is available from the N flow approach detailed in earlier sections of this chapter. The IPCC 2006 default EF of 0.01 kg N_2O-N/kg N input is used.

All application of sewage sludge is municipality controlled and under strict regulation, it´s application has been very limited and only allowed in non-agricultural soil if not treated. Assuring proper channels for accurate data is ongoing work and emission estimates will be included in next year´s submission.

5.6.4 N Deposited During Pasture range and Paddock (F_{PRP})

N deposited from animals at pasture, range and paddock is also determined by the N-flow approach described earlier in this chapter. This is combined with the two default EFs provided in the 2006 IPCC Guidelines: 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.

Synthetic and organic N applied to soils is shown in Figure 5.3.

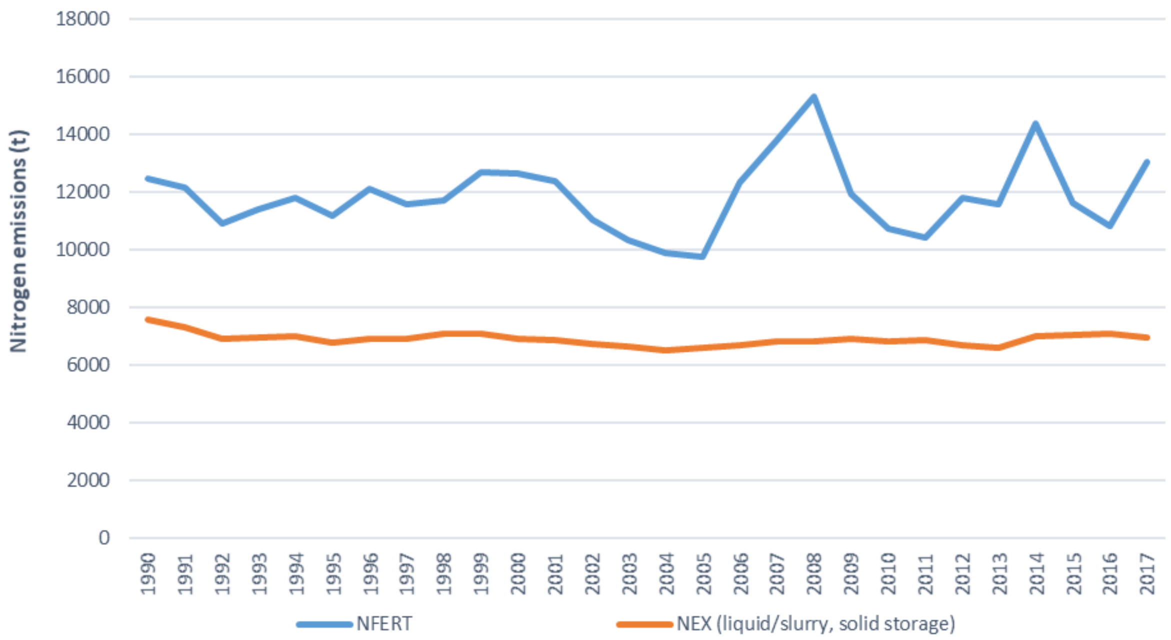

Figure 5.3 Amounts of nitrogen from synthetic fertilizer and animal manure application

5.6.5 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.

Residue/crop ratio, dry matter fraction and nitrogen fraction are IPCC default values. 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 are shown below in Figure 5.4.

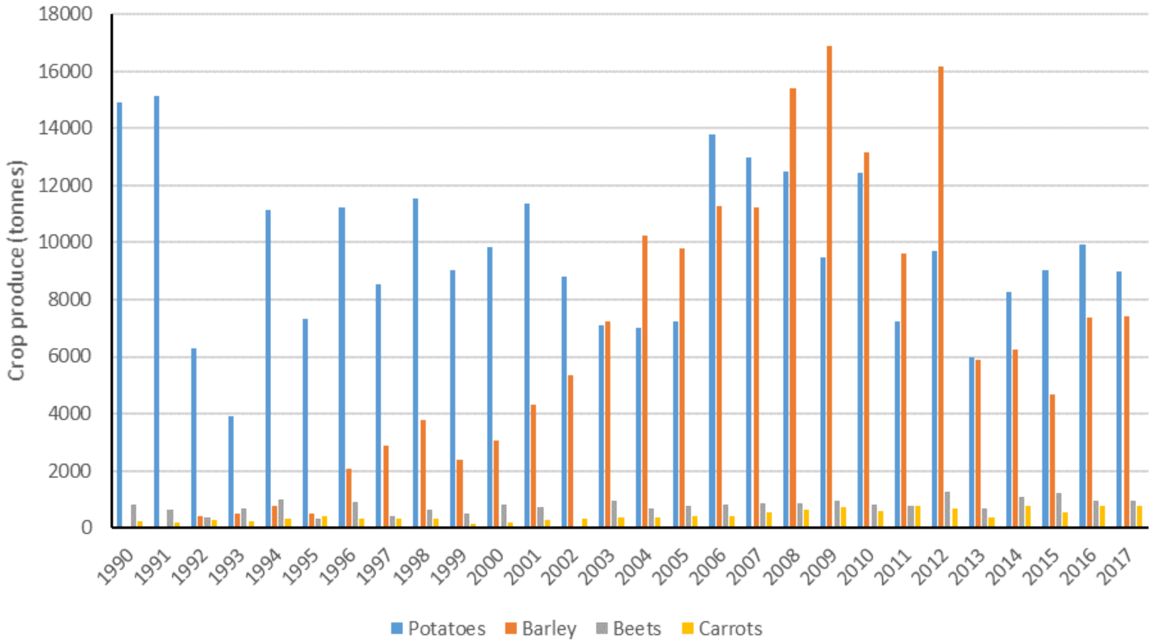

Figure 5.4 Crop produce in kt for 1990-2017.

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 29 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.

5.6.6 Cultivation of Organic Soils

In response to a remark of the review of the Icelandic 2010 submission, the N_2O emissions from cultivated organic soils were included under the Agriculture sector. Data about the area of cultivation of organic soils, including histosols, histic andosols, and hydric andosols, is supplied by the Agricultural University of Iceland. The area estimated for cultivated organic soils in 1990 was 65.1 kha. This area has decreased steadily since then and was estimated to be less 56.0 kha in 2017.

A country specific emission factor of 0.96 kg N_2O-N per ha was used as organic soil emission factor. It is based on measurements in a recent project where N_2O emissions were measured on drained organic soils. In this project, at total of 231 samples were taken from drained organic soils in every season over three years. The results have shown that the EF is higher for cultivated drained soils (0.96 kg N_2O-N per ha) than other drained soils (0.01 and 0.44 kg N_2O-N per ha) and much lower than the EF for tilled drained soils (8.36 kg N_2O-N per ha). This research was conducted in Iceland over the period from 2006 to 2008 and is considered to be reliable, results are available in a project report to the Icelandic Research Council (Guðmundsson J. , 2009).

The product of nitrogen amounts, and respective emission factors was subsequently transformed into N_2O emissions by multiplying units of nitrogen with 44/28 (molar mass of N_2O divided by molar mass of N_2). Direct emission from agricultural soils amounted to 399 tonnes N_2O in 2017, which meant a slight decrease in comparison to 1990 emissions (Figure 5.5).

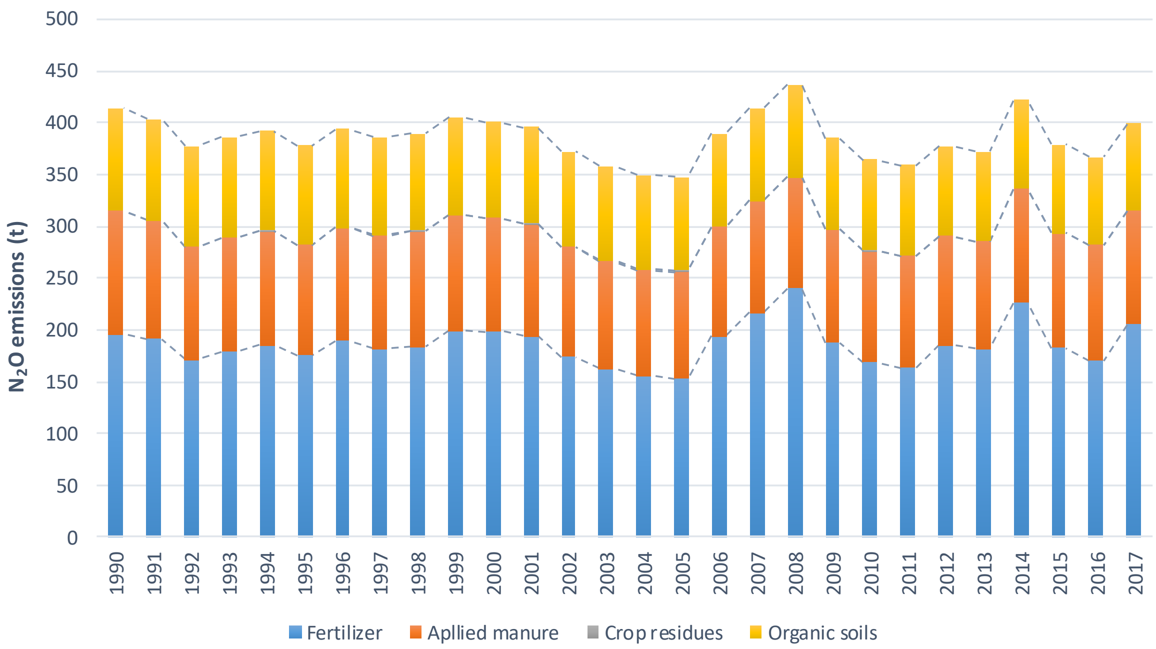

Figure 5.5 Direct N2O emissions from soils (kt).

5.6.7 Recalculations

For the 2019 submission there were no recalculations undertaken. However, data on the area of organic soil was updated for the years 2015-2017. Data on Nfert used in forestry was also updated for 2016 and 2017. These updates resulted in minor (<1%) changes in emissions from agricultural soils.

5.6.8 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).

5.6.9 Planned improvements

The completeness of the submission will continue to be worked on and Iceland aims to improve the reporting of sewage sludge applied to soils, other organic fertilisers applied to soils, mineralisation of organic matter as well as review its fertiliser import data for future submissions.

A comparison of the country-specific N2O EF for the cultivation of histosols with peer-reviewed studies will be conducted for future submissions.

Preliminary results have indicated an approximate amount of 200 tonnes of stabilized sewage sludge used in all Iceland in the year 2015. This was a substantial increase since 2012-2014 where the total in Iceland was estimated to have been around 25 tonnes. Sewage sludge cannot be used on agricultural land in Iceland without proper treatment. Its use in agriculture is therefore expected to be minimal. There have been complications regarding the gathering of the required data and the issue will carried on and addressed in the next submission.

For the 2020 submission Iceland aims to estimate N_2O emissions from mineral soils. The emissions are, however, not expected to be significant.

5.7 Indirect N_2O Emissions from Managed Soils (CRF 3D2)

5.7.1 Activity Data and Emission Factors

Indirect N_2O emissions originate from three sources:

- Volatilization of applied synthetic fertilizer and animal manure and subsequent atmospheric deposition;
- Leaching and runoff of applied fertiliser and animal manure; and
- Discharge of human sewage nitrogen into rivers or estuaries.

The last source is covered in chapter 6. The first two sources are covered here.

5.7.2 N_2O from Atmospheric Deposition

Atmospheric deposition of nitrogen compounds such as nitrogen oxides (NOx) and ammonium (NH_4) fertilises soils and surface waters, which results in enhanced biogenic N_2O emissions.

The methodology presented in the 2006 IPCC Guidelines has been used with default input parameters to estimate emissions.

Total N inputs to the soils from synthetic fertiliser and organic amendments are combined with volatilisation factors to give the amount of N being released to the air in the form of NH_3 and NOx. A portion of this deposits on the surface and is re-emitted as N_2O (the default EF of 0.01 kg N_2O-N per kg of NH_3-N & NO-N deposited is used). This is summarized in equation 11.9 of Chapter 11 of the 2006 IPCC Guidelines.

EQUATION 11.9

N_2O FROM ATMOSPHERIC DEPOSITION OF N (TIER 1a)

$$N_2O_{AD}\text{-}N = [(N_{SN} \bullet Frac_{GASF}) + ((F_{ON} + F_{PRP}) \bullet Frac_{GASM})] \bullet 0.01$$

Where:

- N_2O_{AD} -N = Emission of N_2O in units of Nitrogen
- F_{SN} = Annual amount of synthetic fertiliser nitrogen applied to soils
- F_{ON} = Annual amount of animal manure nitrogen intentionally applied to soils
- F_{PRP} = Amount of nitrogen deposited during pasture, range and paddock
- $Frac_{GASF}$ = Fraction of synthetic N applied that volatilises as NH_3 and NOx
- $Frac_{GASM}$ = Fraction of organic N applied that volatilises as NH_3 and NOx

5.7.3 N_2O from Leaching and Runoff

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 leaches or runs off, the methodology in the 2006 IPCC Guidelines is used (equation 11.10) with default input parameters and EFs.

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: 0.0075 kg N_2O-N/kg N leached & runoff.

5.7.4 Emissions

The development of indirect N_2O emissions from 1990-2017 - after conversion from nitrogen to nitrous oxide - is shown in Figure 5.6. N_2O emissions amounted to 111 tonnes N_2O in 2016, which is slightly higher than the 1990 value of 110 tonnes. The general slight downward trend in emissions was reversed from 2006 to 2008, when high amounts of synthetic fertilizer application caused an increase of indirect N_2O emissions from agricultural soils above the 1990 level.

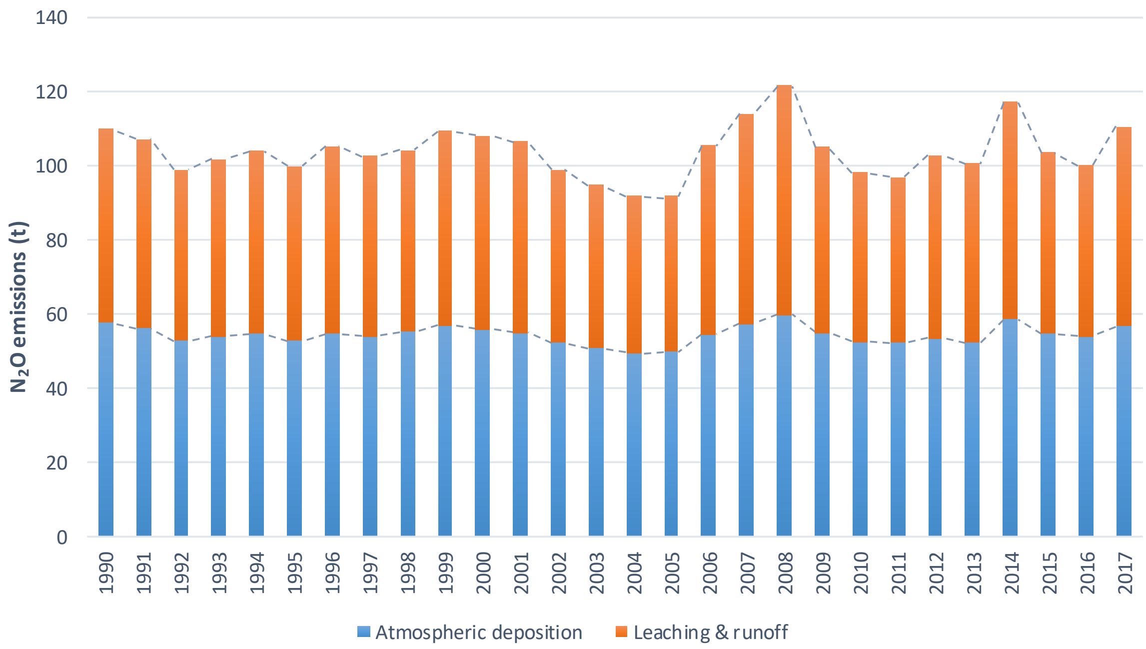

Figure 5.6 Indirect N2O emissions from agricultural soils.

5.7.5 Recalculations

For the 2019 submission there were no recalculations undertaken.

5.7.6 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)).

5.7.7 Planned Improvements

No improvements are currently planned for this category.

5.8 CO_2 Emissions from Liming, Urea Application, Other Carbon Containing Fertilizers and Other (CRF 3G, 3H, 3I, 3J)

5.8.1 Activity Data and Emission Factors

Data on liming is based on sold $CaCO_3$ and imported synthetic fertilizers containing chalk or dolomite. Carbon dioxide emissions from agricultural lime application are estimated. Information on lime application was obtained from distributors. Numbers reported included lime application in the form of shell-sand, which contains 90 % $CaCO_3$, dolomite and limestone. Limestone or other calcifying agents included in many of the imported fertilizers are also included. Although the ratio of calcifying materials is low in these fertilizers the amount of fertilizers applied make this source relatively large. Numbers on lime application are only available at the national level and all of it is assumed to be applied on cropland. The bulk of the liming in Iceland can be assumed to be on organic soil as pH of mineral soils is generally so high that liming is unnecessary.

Default emission factors for limestone (0.12) and dolomite (0.13) were used, as well as for carbon emissions from urea applications (0.20) (2006 IPCC GL).

5.8.2 Emissions

The CO_2 emissions due to liming of cropland are calculated by conversion of carbonated carbon to CO_2. CO_2 emissions from liming amounted to 1.29 kt in 2017, CO_2 and emissions from Dolomite were 1.02 kt (CRF 3G). CO_2 emissions from Urea were 0.83 kt (CRF 3H) and Other carbon containing fertilisers (Shell sand) 1.72 kt (CRF 3I). Other (CRF 3J) was not occurring for the timeseries.

5.8.3 Recalculations

Until 2012 liming was under LULUCF. From 2013 all liming was moved from LULUCF to agriculture, but calculations since 2013 have been incorrect and based only on import of a part of the liming fertilizers that are imported to Iceland. For the 2019 submission, data from 2012 has been used to estimate the amount used for liming, for the years 2013-2017 - including all liming fertilizers (also where CaCO3 is not the only ingredient in the fertilizer), including also dolomite and shell sand.

5.8.4 Uncertainties

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

5.8.5 Planned Improvements

As is described in chapter 5.8.3 Recalculations, the same import number for liming fertilizers have been used since 2012. For the next submission, it is planned to go over import data, check which import categories should be included and see if there are any other mixed fertilisers that should be added to the data on liming, urea and other carbon containing 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 land within these categories according to guidelines given in Volume 4: Agriculture, Forestry and Other Land Use of the 2006 Guidelines (IPCC, 2006), hereafter named AFOLU Guidelines, and the 2013 Supplement to the 2006 Guidelines: Wetlands (IPCC, 2014), hereafter named 2013 Wetland Supplement. The Agricultural University of Iceland (AUI), the Icelandic Forest Research (IFR) and the Soil Conservation Service of Iceland (SCSI) 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. Compared to previous submissions there are considerable changes in land use classification where some land previously classified as Grassland is now classified as “Other land” or Wetland.

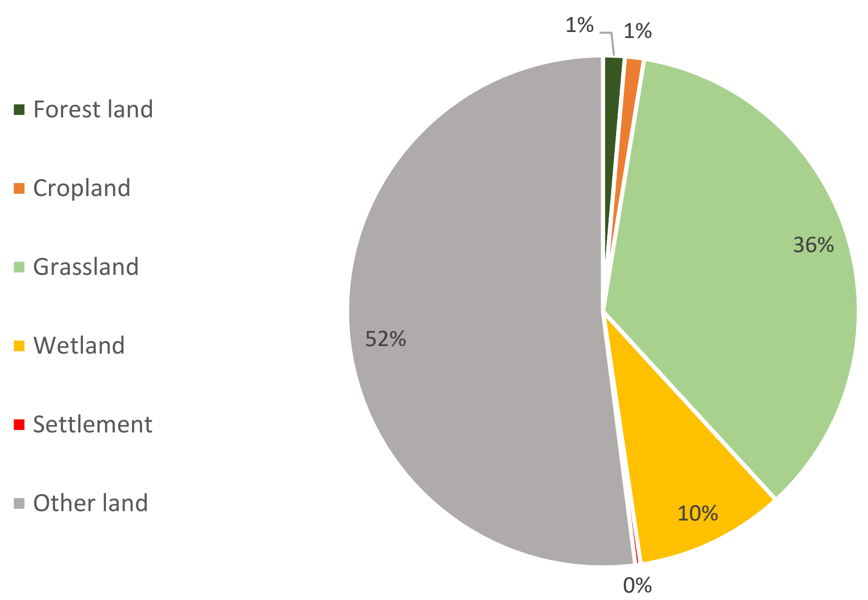

Figure 6.1 Relative size of land use categories in Iceland according to IGLUD land use map 2017 and other land use estimates available for the reporting.

This shift in land classification is because of new data is now available in the first habitat type map for Iceland and is applied as base map for the 2017 land use map. This new data has both more categories and smaller mapping units. The new data and the consequent changes are discussed further below. 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.

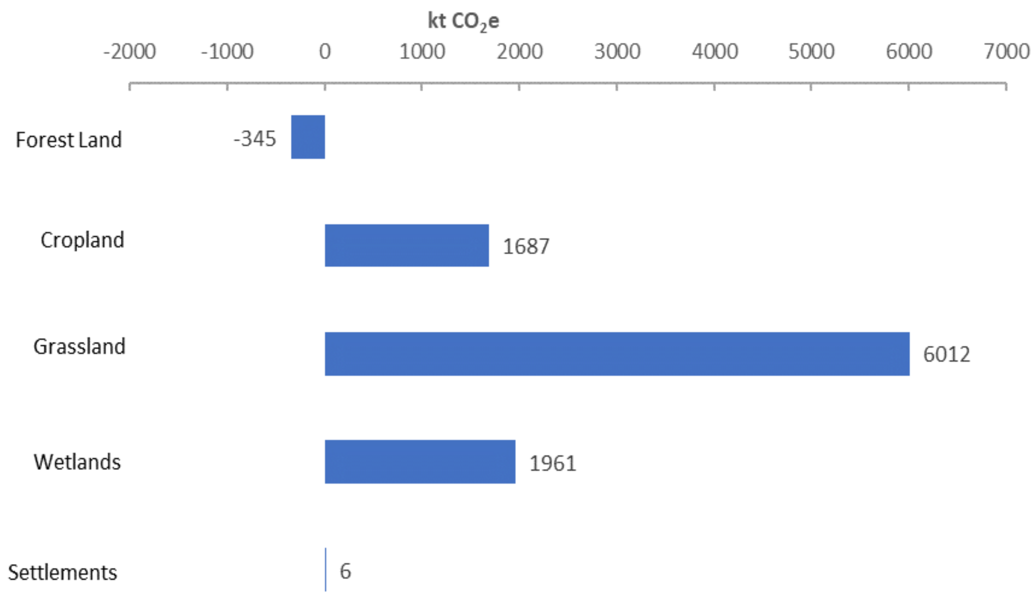

Figure 6.2. The net emissions/removals of land use categories (kt CO_2e) in 2017. N_2O emissions from drained Grassland are reported as LULUCF "Other (4H)" but included as Grassland emissions in this figure. Emissions from Other land (4F) are not included in this graph since they are negligible (0.002 kt CO_2e in 2017). The N_2O emission from Cropland management of organic soils is reported under Agricultural sector and not included here.

The sum of all emissions reported is 11,762 kt CO_2e and is dominated 71.5% by 8,411 kt CO_2e emissions related to drainage of organic soils, mostly included under Grassland, Cropland and small areas of Forest land. Another important emission component 26.58% or 3,127 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 56.6 % or 1,371 kt CO_2e, to biomass and SOC in revegetation 25.0 % or 607 kt CO_2e, and to biomass and SOC in forest 14.5 % or 352 kt CO_2e. Other contributing components total of 3.8 % 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 10,224 kt CO_2e to 9,321 kt CO_2e. New area estimate of many land use categories is included in this submission explains most of the changes. The emission for the year 2016 applying this new area estimate is 9,345 kt CO_2e, reflecting the effect of this revision.

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 last 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 Icelandic Forest Research (IFR), maps of natural birch forest and shrubland from 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 base IGLUD land use map that has been applied for evaluating the area of the land use categories has been revised considerably. The most important revision is the inclusion of the first Habitat map of Iceland (HMI), prepared by the Icelandic Institute of Natural History (IINH) (Ottósson, Sveinsdóttir, & Harðardóttir, 2016). The map is a modified EUNIS pan-European habitat classification and has 105 habitat types of which 64 are terrestrial, 17 freshwaters and 24 costal habitat types. All the 64 terrestrial types are included in the new IGLUD map, two topographical map layers for rivers and lakes represent all the freshwater habitat types. The costal (tidal zone) habitat types are not included. The HMI is replacing the Icelandic Farmland Database (IFD) as base layer in the IGLUD land use map.

The habitat type 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. Data used includes various other available data and direct mapping on aerial photographs.

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 IFD the classification method was supervised classification adjusted to ground truth sampling points to reach reasonable certainty. In 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 is in Table 6.3.

This new available data changes the previous land use classification considerably for some land use categories. Most apparent is the change in three of the main land use categories, Grassland, Wetland and Other land. Area estimate for the Grassland category decreases by 1,680 kha and for the categories, Wetland and Other land, it increases by 325 kha and 1,361 kha respectively. These transfers explain the bulk of the changes. The results of preliminary analyses of these changes show shifts in the categorization of the land. The main explanations of these shifts are considered to be, more categories in the HMI (64 instead of 12 in IFD), and smaller mapping unit (5x5 m instead of 15x15m). The more detailed categorization and smaller mapping unit offer more refined separation of the land use categories.

The net shift is from the category “Other grassland” to “Other land” and “Wetland other” as stated above but there is shift in both directions as summarized in Table 6.1 and Table 6.2. The new estimate for the area of Grassland on drained soil is explained by revision of that specific map layer (see below).

Table 6.1 Comparison of Area estimate of the new HMI based IGLUD map and the previous IFD based IGLUD map

	Area New IGLUD (HMI) map [ha]		Area IGLUD (IFD) map last submission [ha]		Changes [ha]	
	Sub-category	Total main category	Sub-category	Total main category	Sub-category	Total main category
Cultivated forest	51,492		50,174		1,318	
Natural birch forest	96,965		95,886		1,080	
Forest total		**148,457**		**146,060**		**2,397**
Cropland	178,869		172,566		6,303	
Cropland total		**178,869**		**172,566**		**6,303**
Grassland on drained soils	268,000		339,188		-71,188	
Natural birch shrubland	54,163		54,092		72	
Revegetated before 1990	4,374		3,363		1,011	
Revegetated since 1990	122,393		117,211		5,182	
Other grassland	3,121,743		4,801,899		-1,680,156	
Grassland total		**3,570,673**		**5,315,752**		**-1,745,079**
Reservoirs	58,325		58,340		-15	
Lakes and rivers	227,720		217,448		10,272	
Wetland other	686,182		360,809		325,373	
Wetland total		**972,227**		**636,597**	**0**	**335,630**
Settlement	**34,661**	**34,661**	**27,468**	**27,468**	**7,194**	**7,194**
Other land except glaciers	4,244,810		2,883,246		1,361,564	
Glaciers	1,086,568		1,086,578		-10	
Other land total		**5,331,378**		**3,969,823**		**1,361,555**
Total area		**10,236,265**		**10,268,265**		**-32,000**

Table 6.2 Table shows the percentage of area included in an HMI category matching to area in IFD category (upper part) and below the vice versa.

Category \matching to	**% included in**			
HMI\IFD	**Grassland**	**Wetland other**	**Other land**	**Sum**
Grassland	80	11	6	98
Wetland other	68	27	4	99
Other land	31	0	68	100
IFD\HMI	**Grassland**	**Wetland other**	**Other land**	**Sum**
Grassland	55	11	33	99
Wetland other	58	37	3	98
Other land	8	1	90	99

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, 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 HMI map. These map layers do not completely match to each other.

Maps of Forest land: 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. That map layer has since been improved, and few areas previously mapped there as afforested removed. The map layer applied in the IGLUD map is representing all afforested land up to and including 2017. The HMI category Mixed forest plantations ("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.

Map of birch shrubland: In HMI the map layer Birkiskógur (Birch woodland) includes the two categories of birch woodland in IGLUD but categorized to different land use categories. The birch woodland reaching average height of 2 m or more, categorized as Forest land and birch woodland with 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.

Map of Cropland: The HMI map layer is prepared from the IGLUD map for Cropland, by the extension of available map of recently cultivated fields form the Icelandic Agricultural Advisory Centre (IAAC). The AUI Cropland map layer is therefore replaced by the HMI map layer which is better representing the extent of Cropland. Both layers include abandoned cropland.

Map of Settlement: In last year's submissions the land use category Settlement has been represented by the IS 50V dataset from the National Land Survey of Iceland (NLSI).

Map of drained Grassland soils: The process for preparing the map of drained organic grassland soils is comparable to the process in previous IGLUD maps, i.e. starting with a 200 m buffer zone tailored according to other land cover maps layers. Until for this year's submission, these land cover map layers originated from IFD, in this submission HMI map layers replace the IFD map layers. Another important change in the data applied to prepare the IGLUD land use map is new digital elevation model (DEM), replacing the previous DEM from NLSI. The new Arctic digital elevation model (ADEM) is by far more accurate and with higher resolution (2m pixel size and isoclines) (Jóhannesson and Þorsteinsson 2017) than the previous (15 m pixels and 20 m or 100m isoclines).

The emissions related to that land use category have dominated the LULUCF sector in submissions since 2015 and been recognized as key category. The area estimate of this land use category is improved considerably by this new data sources.

The summary of GIS processing of this particular map layer is in Figure 6.3.

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.

Listed in Table 6.3 are the map layers apply 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.

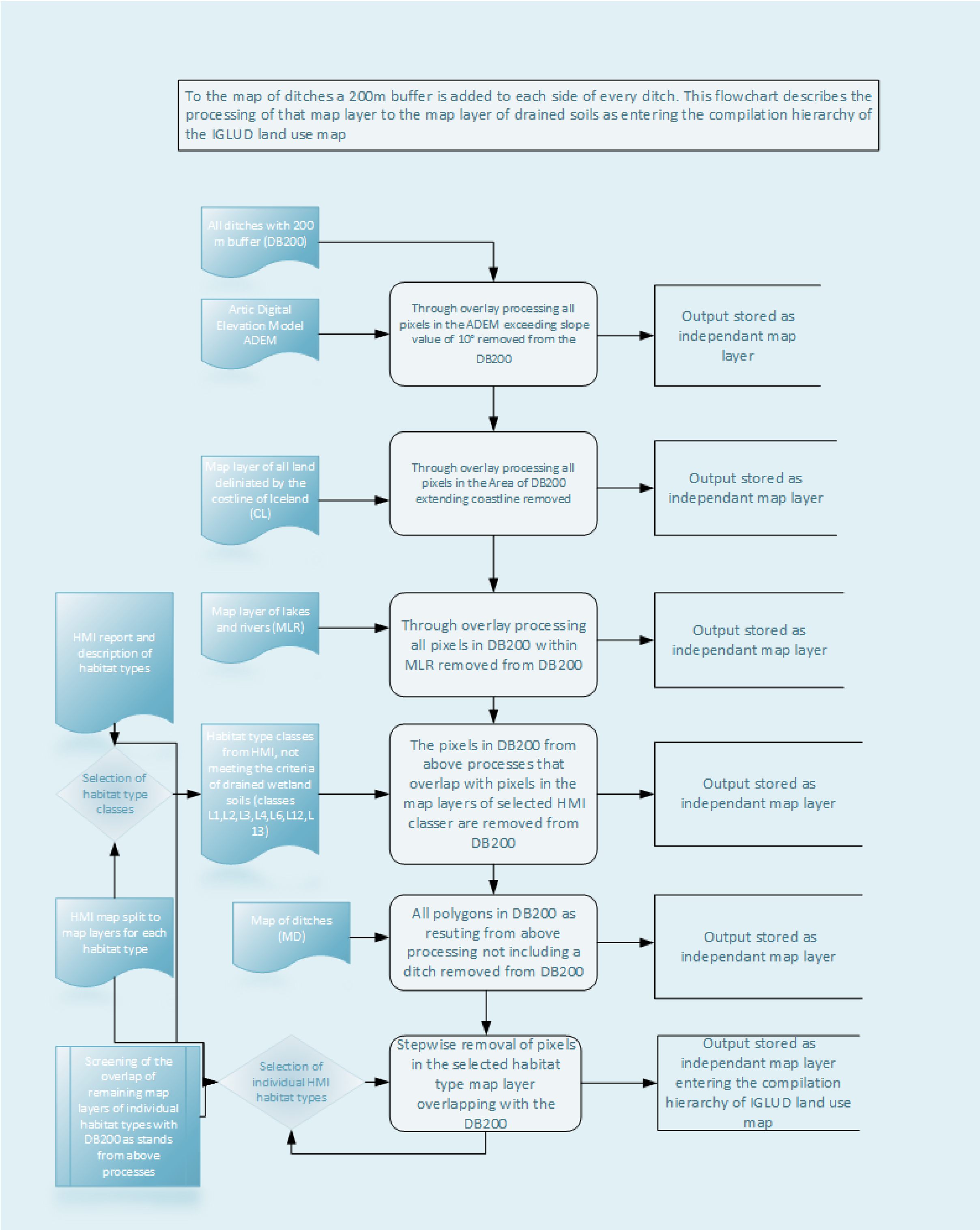

Figure 6.3 Flowchart of processing the map layer “Grassland on drained soils” describing the sequence of the processes.

Table 6.3 List of map layers included in the land use map, showing for each layer the land use category and order of hierarchy in compilation process (because of the length of this table it takes more than one page.)

Land use category	Subcategories	Habitat type class	Habitat type/or other map layer	Compilation hierarchy
Forest land	Cultivated forest 1990-2017	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	Cropland on organic soil	Not HMI category	Not HMI category/	12
	Cropland on mineral soil	Other land types	L14.2 Cultivated agricultural, horticultural and domestic habitats	13
Grassland	Revegetated land SCSI before 1990	Not HMI category	Not HMI category/	6
	Revegetated land SCSI 1990 -2017	Not HMI category	Not HMI category/	7
	Farmers revegetation before 1990	Not HMI category	Not HMI category/	8
	Farmers revegetation 1990-2017	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/	16
	Other Grassland	Fell fields, moraines and sands	L1.6 Icelandic inland dunes	17
		Exposed aeolian soils	L2.1 Icelandic exposed andic soils	18
		River plains	L4.2 Icelandic braided river plains	19
		Moss lands	L5.3 Moss and lichen fjell fields	20
		Lava fields	L6.4 Icelandic lava field shrub heaths	21
		Coastal lands	L7.1 Icelandic sand beach perennial communities	22
			L7.4 Northern fixed grey dunes	23
			L7.7 Atlantic sea-cliff communities	24
		Grasslands	L9.1 Icelandic Carex bigelowii grasslands	25
			L9.2 Insular Nardus-Galium grasslands	26
			L9.3 Wavy hair-grass grasslands	27
			L9.4 Boreal tufted hairgrass meadows	28
			L9.5 Icelandic Festuca grasslands	29
			L9.6 Boreo-subalpine Agrostis grasslands	30
			L9.7 Northern boreal Festuca grasslands	31
		Heathlands	L10.1 Icelandic Racomitrium grass heaths	32
			L10.2 Arctic Dryas heaths	33
			L10.3 Icelandic Carex bigelowii heaths	34
			L10.4 Icelandic Empetrum Thymus grasslands	35
			L10.5 Icelandic lichen Racomitrium heaths	36
			L10.6 North Atlantic boreo-alpine heaths	37
			L10.7 Oroboreal moss-dwarf willow snowbed communities	38
			L10.8 North Atlantic Vaccinium-Empetrum-Racomitrium heaths	39
			L10.9 Icelandic Salix lanata/S. phylicifolia scrub	40
			L10.10 Oroboreal willow scrub	41
		Woodlands	L11.1-3 subclasses of Birch wood	42
		Other land types	L14.3 Mixed forestry plantations	43
		Other land types	L14.4 Land reclamation forb fields	44

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	14
	Rivers	Running waters	V2	15
	Coastal wetlands	Coastal lands	L7.5 Atlantic lower shore communities	45
			L7.6 Icelandic Carex lyngbyei salt meadows	46
	Mires and fens	Wetlands	L8.1 Philonotis-Saxifraga stellaris springs	47
			L8.2 Icelandic stiff sedge fens	48
			L8.3 Cottonsedge marsh-fens	49
			L8.4 Juncus arcticus meadows	50
			L8.5 Boreal black sedge-brown moss fens (high altitude)	51
			L8.6 Boreal black sedge-brown moss fens (low altitude)	52
			L8.7 Aapa mires	53
			L8.8 Palsa mires	54
			L8.9 Icelandic black sedge-brown moss fens	55
			L8.10 Icelandic Carex rariflora alpine fens	56
			L8.11 Common cotton-grass fens	57
			L8.12 Icelandic black sedge-brown moss fens	58
			L8.13 Basicline bottle sedge quaking mires	59
			L8.14 Icelandic Carex lyngbyei fens	60
	Geothermal wetland	Geothermal lands	L12.1 Geothermal wetlands	61
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	62
			L1.2 Sparsely- or un-vegetated habitats on mineral substrates not resulting from recent ice activity	63
			L1.3 Oroboreal Carex bigelowii-Racomitrium moss-heaths	64
			L1.4 Glacial moraines with very sparse or no vegetation	65
			L1.5 Volcanic ash and lapilli fields	66
		Screes and cliffs	L3.1 Icelandic talus slopes	67
			L3.2 Icelandic Salix herbacea screes	68
			L3.3 Icelandic Alchemilla screes	69
		River plains	L4.1 Unvegetated or sparsely vegetated shores	70
		Moss lands	L5.1 Boreal moss snowbed communities	71
			L5.2 Icelandic Racomitrium ericoides heaths	72
		Lava fields	L6.1 Barren Icelandic lava fields	73
			L6.2 Icelandic lava field lichen heaths	74
			L6.3 Icelandic lava field moss heaths	75
		Coastal lands	L7.2 Upper shingle beaches with open vegetation	76
			L7.3 Atlantic embryonic dunes	77
		Geothermal lands	L12.2 Geothermal heathlands	78
			L12.3 Geothermal alpine habitats	79
			L12.4 Geothermal bare grounds	80

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

Table 6.4 Key Categories for LULUCF: 1990, 2017, and 1990-2017 trend.

IPCC source category			Level 1990	Level 2017	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 6.5 below presents the sources and sinks not estimated in this submission. For these categories, it is discussed if it is likely to be a source or a sink.

Table 6.5 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

Source/sink	Land use category	Component	GHG NE
Carbon stock changes	**Land converted to Settlement**		
	All other grassland converted to Settlement	Living biomass-gain	CO_2
		Mineral soil	CO_2
	Natural birch shrubland converted to Settlement	Gains	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.

Broad Land Use Categories

Settlements: All areas included within map layers "Towns and villages" and "Airports" as defined in the IS 50 v2013 geographical database. Settlement include roads classified with 15 m wide road zone, including primary and secondary roads. Roads within forest land are excluded were 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 more than 2 m high, crown cover of minimum 10% and at least 0.5 ha in continuous area and a minimum width of 20 m and also land which currently falls below these thresholds but is expected to reach them in situ at mature state.

Cropland: All cultivated land not included under Settlements or Forest land and at least 0.5 ha in continuous area and minimum width 20 m. This category includes harvested hayfields with perennial grasses.

Wetland: All land that is covered or saturated by water for all or 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 meeting the definition of the activity and does not fall into 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 Figure 6.4, Figure 6.5, Figure 6.6 and Figure 6.7 below; they are also available at the AUI website http://www.lbhi.is/vefsja.

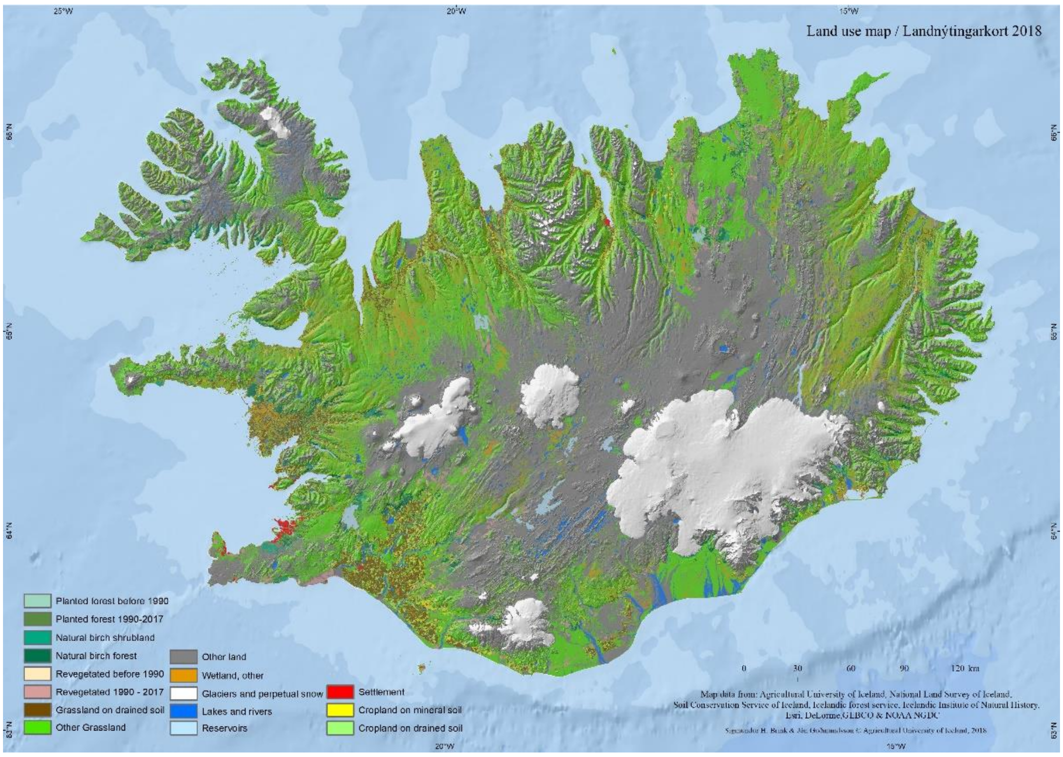

Figure 6.4 The land use map of IGLUD prepared for the year 2017.

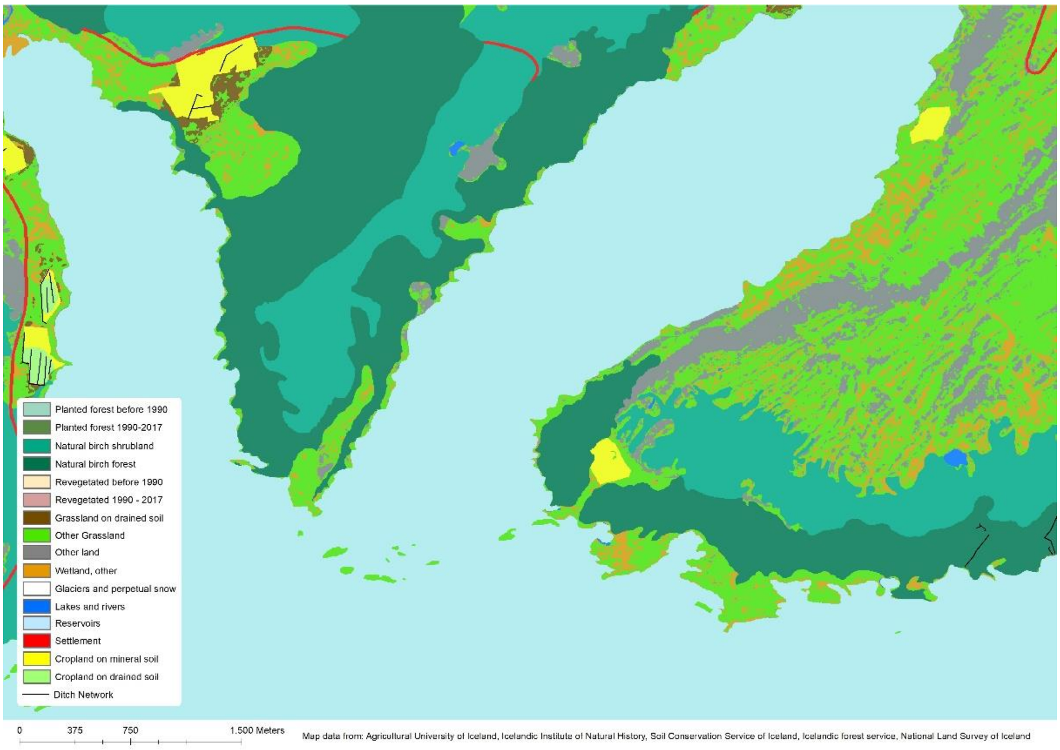

Figure 6.5 Enlargement of land use map emphasizing the different Forest land subcategories.

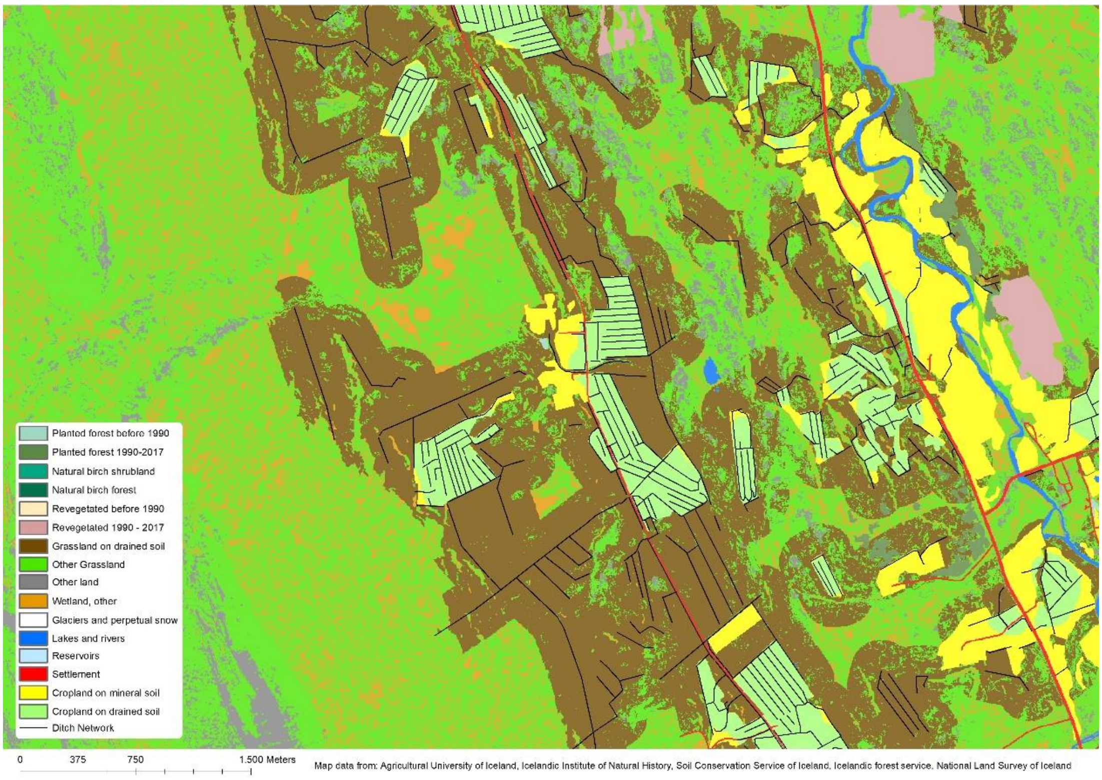

Figure 6.6 Enlargement of land use map emphasizing the Revegetation area mapped.

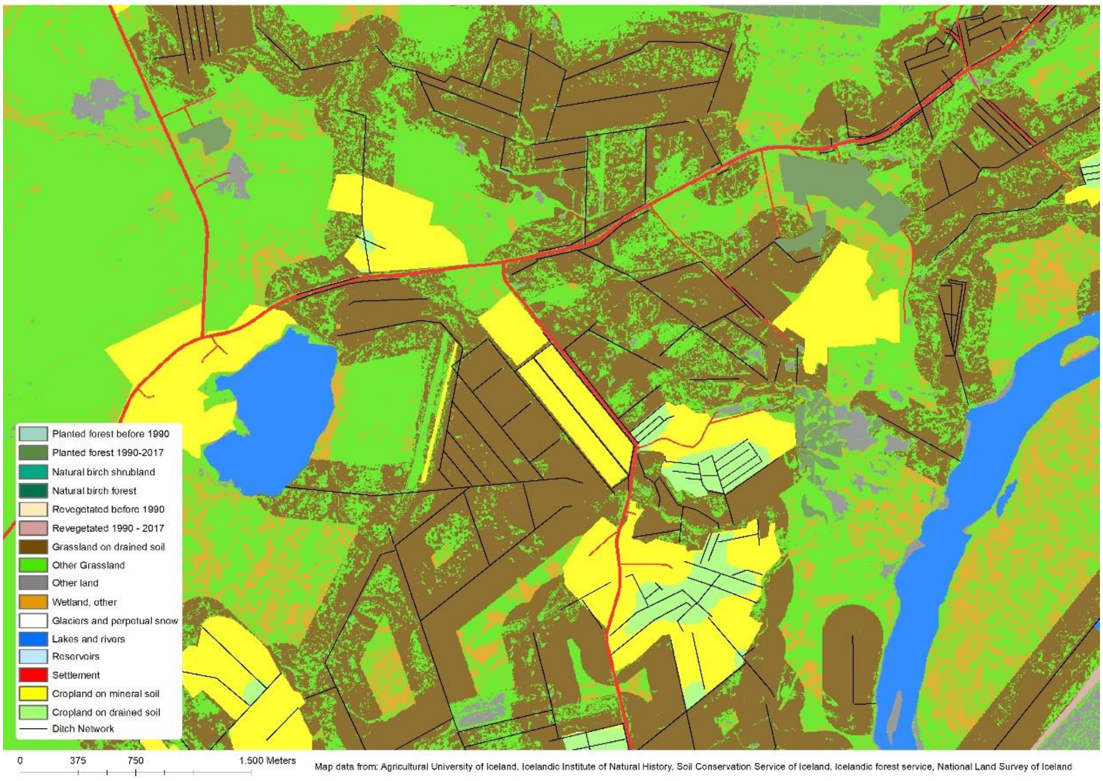

Figure 6.7 Enlargement of land use map emphasizing the subcategory Grassland on drained soils.

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. Time series for revegetated land show also some improvements in mapping accuracy. Both categories revegetation and ARD are activities included as KP activities for Iceland and accordingly require more accuracy in mapping than land use categories only reported under the UNFCCC reporting obligations. These UNFCCC land use categories have been lagging behind. No official recording of new drainages, new areas converted to cropland or cropland abandoned, exists for Iceland.

From the year 2017 agricultural support was modified with Regulation 1240/2016 on general support for agriculture (In Icelandic: Reglugerð No 1240/2016 um almennan stuðning við landbúnað) and more emphasises put 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, when around 40% of the ditch network is completed, are applied to estimate annual changes in drained areas of Cropland and Grassland from 2008 to 2017. Changes from 1990 up to 2007 are estimated as in previous submissions from the estimation of new ditches, based on records from one region (Kristján Bjarndal, personal communication).

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 and is maintained by AUI. 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 6.6.

Table 6.6 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								8,819						
FL NB														
CL				17,321				38,108						
GL. drained									669					
GL. Nb. shrub														
RV before. "90														
RV since. "90														
O.GL		798			1,528	160,982						175		
WL.O				4,500										
WL. L&R														
WL. Reserv.														
Settlements														
OL							6,583							
Other														
Other estimate	42,673	97,763	123,440	289,152	55,691	165,356	128,976					34,836		
Map area	51,492	96,965	178,869	268,000	54,163	4,374	122,393	3,121,743	686,182	227,720	58,325	34,661	4,244,810	1,086,568
Difference	8,819	-798	55,429	-21,152	-1,528	- 160,982	-6,583					-175		
Corrected area	42,673	97,763	123,440	289,152	55,691	165,356	128,976	3,005,185	682,351	227,720	58325	34,836	4,238,227	1,086,568
Total area [ha]														**10,236,265**
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 (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 interwall. 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. Currently the third inventory round of CF and the second one of the NBW is 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 in Iceland (Alþingi, 1955), 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 is to find in 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 afforested 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 2005-2017. In 2010 the second inventory round of cultivated forest started with re-measurement of plots measured in 2005 and of new plots since 2005 on new afforestation areas. In each inventory year the internal annual growth rate of all living trees is estimated by the differences between current biomass and the biomass five years ago. Trees that died or were cut and removed in the 5 years period are not included so the C-stock gain estimated is not entirely a gross gain.

The biomass stock change estimates of the C-stock of CF are for each year built on five years sample plot measurements (Table 6.7). The most accurate estimates are for 2007-2015 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 2017 and 2016 the estimates are forwarded two and one year respectively, compared to the midvalue for 2015. 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 6.7 Measurement years used to estimate different annual estimates of biomass stock change.

Mid value estimates	Forwarded estimates	Backwarded estimates	Built on measurement years
	2017		2013-2017
	2016		2013-2017
2015			2013-2017
2014			2012-2016
2013			2011-2015
2012			2010-2014
2011			2009-2013
2010			2008-2012

Mid value estimates	Forwarded estimates	Backwarded estimates	Built on measurement years
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)). 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 clearcut, 49 ha were commercial thinned and 162 ha precommercial 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 this time not recalculated. Estimates for the natural birch forest are built on the same methodology as in last year´s submission and are unchanged.

6.5.1.5 Category-specific planned improvements

Data from NFI are used for the 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.

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 (2017) as well as in 1990-2017 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 – 2016.

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 (2002 & 2000) 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}.

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.

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, (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 2017) as well as in 1990-2017 trend.

Cropland in Iceland consists mainly of cultivated hayfields, many of which are on drained organic soil. Cultivation of barley is on a small but increasing part of the cropland area. Cultivation of potatoes and vegetables also takes place.

The new HMI map introduced as base map for IGLUD land use map contains extended map layer for Cropland, compared to previous versions of IGLUD land use map. The extension involves adding area of recently cultivated fields obtained from Icelandic Agricultural Advisory Centre (IAAC), to the previous IGLUD Cropland map layer. The IGLUD Cropland map layer was digitized from satellite images supported by aerial photographs in 2008 by AUI and NLSI in cooperation. That map layer was then 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 178.87 kha compared to 172.57 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 123.43 kha, whereof 55.60 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 are estimated for the first time in this submission, according to T2. 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}.

Changes in SOC of organic soils are calculated according to T1 applying equation 2.3 in the 2013 Wetlands supplement (IPCC 2014). Organic soils of “Cropland remaining Cropland” 52.87 kha. These organic soils are estimated to lose 417.66 kt C. The consequent emission is estimated as 1531.43 kt CO_2.

6.6.1.3 Uncertainties and time-series consistency

The estimate of total area of land cultivated to 2017 according to time series applied is 174.0 kha and the mapped area is 178.9 kha. Abandoned cropland is included in both estimates.

Both mapping and recording of Cropland in use has been fragmentary until now in Iceland. 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 in the 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 in IGLUD as such (AUI unpublished data). A survey of cropland was initiated the summer 2010 to control the IGLUD mapping of cropland. 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. Of this mapped cropland 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 estimated through preparation of time series of land use conversion as described above. The ratio of hayfields on organic soil was estimated in a survey on vegetation in hayfields 1990-1993 (Þorvaldsson, 1994) as 44%. The time series of Cropland organic soil were 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 50x50m 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 (IPCC 2014) 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 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 considerably 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.

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 1990-2017 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 6.4 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, is 1.27 kg C m^{-2}, and for Wetland below 200m 1.80 kg C m^{-2}.

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 Deforestation event of converting Forest land into Cropland is from 2015 on drained organic soil. For biomass of trees removed, Tier 3 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 (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 (2006).

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)

The revision of area reported for different land use categories explains the decreased area designed to the Grassland category. The previous estimate of the total area in the year 2016 was 5,390 kha compared to 3,637 kha in this submission for the year 2016. The area reported in 2017 is 3,645 kha.

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 2017) as well as in 1990-2017 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 27.10 kha whereof 7.53 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 under "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 $ha^{-1}yr^{-1}$) (2014).

The subcategory is "Grassland converted to Natural birch shrubland". It is extracted from the new mapping survey of the NBW. 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 – 2017.

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 6.3) 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 2,972 kha and 2,974 kha for the year 2016 compared to 4,645 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 4.14 kha. This area is not at present recognized as separate mapping unit but assumed to be included in the mapping unit Revegetation before 1990, despite currently limited area of that mapping unit (see Table 6.6).

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 H. , 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 to have increased by 1.01 kt C and 0.65 kt C respectively removing 3.69 kt CO_2 and 2.39 kt CO_2 from the atmosphere. The C-stock changes in living biomass of Natural birch shrubland is presented in the NFI applying T3 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 0.37 kt C for “Natural birch shrubland-recently expanded into Other Grassland” equivalent to 1.36 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 0.90 kt C in the year 2017 and thereby removing a total of 3.28 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=5.7 t C ha^{-1} yr^{-1}. The area, C-stock changes and comparable CO_2 emission is summarized in Table 6.8.

Table 6.8. 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	256.99	-1,462.19	5,631.40
Cropland abandoned for more than 20 years	7.53	-42.89	157.28
Natural birch shrubland (N.b.s)- old	0.26	-0.09	0.35
N.b.s.- recently expanded into Other Grassland	0.23	-0,09	0.32
Wetland drained for more than 20 years	248.97	-1,419.12	5,203.45
Land converted to Grassland	33.33	-189.97	696.53
Cropland converted to Grassland	9.80	-55.84	204.73
Wetland converted to Grassland	23.53	-134.13	491.80
Total	**290.32**	**-1,652.16**	**6,057.93**

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 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 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 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 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 1990-2017 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 23.46 kha with 9.80 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 23.53 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. For the year 2016 the area is 23.79 kha in this submission compared to 33.64 kha in last submission reflecting this revision of area.

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 forth 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 293.23 kha, with 161.22 kha as revegetation before 1990, 128.98 kha as revegetation since 1990, and 3.04 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 2.93 kha in 2012. Mean annual area increase of 0.11 kha is interpolated over the 1989-2012 period and extrapolated for the years 2013 – 2016.

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 12.41 kt C in 2017, consequently removing 45.51 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; 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 16.54 kt C and thereby removing 60.65 kt CO_2 from the atmosphere. This increase is divided to three subcategories; Revegetation before 1990 9.19 kt C (33.69 kt CO_2), Revegetation since 1990-protected from grazing 6.71 kt C (24.60 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 0.73 kt C removing 2.70 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 0.43 kt C in the year 2017 and accordingly removing 1.57 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 6.5.2). The loss from mineral soils of Cropland converted to Grassland is reported as 1.42 kt C and consequently emitting 5.21 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 148.87 kt C, removing 545.85 kt CO_2 from the atmosphere. This increase is divided on three subcategories, "Revegetation before 1990" 82.70 kt C (303.25 kt CO_2), "Revegetation since 1990 – protected from grazing" 60.39 kt C (221.42 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 1.56 kt C and to have removed 5.72 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 6.8.

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 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. 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 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.

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 2017) as well as in 1990-2017 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 942.67 kha. The area of the category as emerging from the new HMI based IGLUD land use map, is considerably larger than in previous submissions. The area reported for the year 2016 is 942.27 kha in this submission compared to 624.56 kha reported for 2016 in last submission showing the effect of the revision. 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 682 kha compared to 711 kha in the year 1990. Most of the changes in the total area of the wetland category is in this subcategory. The estimate for the area of the category 2016 is in this submission 682 kha compared to 348 kha reported in last submission. 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 2017 and in trend 1990-2017.

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 the three subcategories: "Mires converted to reservoir", Medium SOC to reservoirs", and "Low SOC to reservoirs". In the CRF tables this emission is reported as aggregate numbers under carbon stock changes of organic and mineral soils.

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 1,374.80kt CO_2 and 2.29 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 T1, 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 6.9).

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 6.9 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 emission. 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 15.35 kha and other settlements 19.48 kha in the inventory year. The total area reported in this submission is 34.84 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 T1, 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 6.4 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 2017 as 0.01 kha, and “All other Grassland subcategories converted to Settlement”, 0.18 kha.

According to the 2006 AFOLU IPCC Guidelines Tier 1 method for dead organic matter of Forest Land converted to settlements (Chapter 8.3.2), all carbon contained in litter is assumed to be lost during conversion and subsequent accumulation not accounted for. Carbon stock in litter has been measured outside of forest areas as control data in measuring the change in the C-stock with afforestation. Its value varies depending on the condition of the vegetation cover. On treeless medium to fertile sites a mean litter C stock of 1.04 t ha^{-1} was measured (n=40, SE=0.15; data from research described in Snorrason et al., 2002). Given the annual increase of 0.141 t C ha^{-1} as used in this year submission, the estimated C stock in litter of afforested areas of 10 years of age on medium to fertile land is 2.45 t C ha^{-1}. Treeless, poorly vegetated land has a much sparser litter layer. Data from the research cited above showed a C-stock of 0.10 t ha^{-1} (n=5, SE: 0.03). A litter C-stock of a 10 years old afforestation site would be 1.51 t C ha^{-1}. Using the similar ratio between poor and fully vegetated land as in this year submission, i.e. 17% and 83%, accordingly, will give 2.29 t C ha^{-1} as weighted C-stock of 10 years old afforestation site. As with carbon in litter, soil organic carbon (SOC) has been measured in research projects. SOC in the same research plots that were mentioned above for poorly vegetated areas was 14.9 t C ha^{-1}, for fully vegetated areas with thick developed andosol layers it was 72.9 t C ha^{-1} (n=40; down to 30 cm soil depth). Annual increase in poor soil according to this year submission is 0.513 t C ha^{-1} yr^{-1} for poorly vegetated sites and 0.365 t C ha^{-1} yr^{-1} for fully vegetated sites. Accordingly, ten years old forests will then have a C-stock of 20 and 76.6 t ha^{-1} on poor and fully vegetated sites, respectively. Weighted C-stock of treeless land is then 66.9 t ha^{-1}. According to the 2006 IPCC guidelines Tier 1 method for mineral soil stock change of land converted to Settlements that is paved over is attributed a soil stock change factor of 0.8. Using a 20 years conversion period this means an estimated carbon stock loss of 1% during the year of conversion, i.e. the annual emission from SOC will be 0.67 t C ha^{-1}. These factors were used to estimate emission from litter and soil in this first type of deforestation.

The second type of deforestation leading to conversion of Forest land to Settlement is one event in 2006 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 -1.56 kt C or 5.71 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 vegetation cover < 20% or covered with mosses.

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 T1, 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 second 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[9] the annual unofficial report of the Iceland Forest Association does contain data about sawnwood production from 1996 to 2016 (See Table 6.10); Gunnarsson E., 2010; 2011; 2012; 2013; 2014; 2015; 2016; Gunnarsson & Brynleifsdóttir (2017).

Table 6.10 Annual wood production (in m^3 on bark) and sawnwood production (in m^3) in 1996 to 2016.

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

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

These data were used to estimate C-stock changes in HWP. Sawnwood is only a small fragment of commercial wood removal. 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 2017 has not yet been published. In the meantime, the sawnwood amount of 2017 is assumed to be the same as in 2016.

6.11.1.2 Category-specific recalculations

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.

6.12 Other (CRF 4H)

6.12.1.1 Category description

The N_2O emissions form drained Grassland soils are reported here. These emissions are discussed in chapter 6.14.

6.12.1.2 Methodology

This emission is discussed in chapter 6.14.

6.12.1.3 Uncertainties and time-series consistency

This emission is discussed in chapter 6.14.

6.12.1.4 Category-specific QA/QC and verification

This emission is discussed in chapter 6.14.

6.12.1.5 Category-specific recalculations

This emission is discussed in chapter 6.14.

6.12.1.6 Category-specific planned improvements

This emission is discussed in chapter 6.14.

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 5.6)

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) 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 2017 and CH_4 in trend 1990- 2017.

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 T1 applying equation 2.4 in the 2013 wetland Supplement (IPCC 2014). For the three categories of organic Cropland soils, the emission calculated is 23.26 kt CO_2 for organic soils of "Cropland remaining Cropland", 0.01 kt CO_2 for soils of "Forestland 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 T1 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 T1 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 T1 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 3.24 kt CH_4 or 80.96 kt CO_2e total for all three categories with organic soils. No estimate on the fraction of area covered by ditches is available and the indicated value from table 2.4 in the 2013 wetland supplement is applied.

Rewetted soils under Cropland: No rewetting of soils in land included as Cropland and no other source or sink of GHG related to drainage or rewetting of Cropland soils is recognized and the relevant categories of 4(II) reported with notation key NO.

Grassland: Two sources of emission are reported here i.e. off-site CO_2 emissions via waterborne losses from drained inland soils, and CH_4 emissions and removal from drained inland soils. The third source described here is N_2O emission from drained soils of the Grassland category. 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 T1 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 T1 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 127.74 kt CO_2. The disaggregation of these numbers to the subcategories involved is shown in Table 6.11.

Table 6.11 Drained soils, estimated of- 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	256.98	113.07
Cropland abandoned for more than 20 years	7.52	3.31
Natural birch shrubland (N.b.s)- old	0.26	0.11
N.b.s.- recently expanded into Other Grassland	0.23	0.10
Wetland drained for more than 20 years	248.97	109.55
Land converted to Grassland	33.33	14.66
Cropland converted to Grassland	9.80	4.31
Wetland converted to Grassland	23.53	10.35
Total	**290.31**	**127.74**

CH_4 emission and removals from drained inland soils: The CH_4 emission from drained land is calculated according to T1 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 17.30 kt CH_4 or 432.42 kt CO_2e. Of this emission 16.91 kt CH_4 is reported from the ditches while only 0.39 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 6.12.

Table 6.12 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	256.98	0.34	14.97	15.31	382.78
Cropland abandoned for more than 20 years	7.52	0.01	0.44	0.45	11.21
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	0.23	0.00	0.01	0.01	0.35
Wetland drained for more than 20 years	248.97	0.33	14.50	14.83	370.84
Land converted to Grassland	33.33	0.04	1.94	1.99	49.64
Cropland converted to Grassland	9.80	0.01	0.57	0.58	14.59
Wetland converted to Grassland	23.53	0.03	1.37	1.40	35.05
Total	**290.31**	**0.39**	**16.91**	**17.30**	**432.42**

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: The emission of N_2O form drained Grassland soil is in CRF reported as three subcategories, Grassland remaining Grassland, Cropland converted to Grassland, and Wetland converted to Grassland under "4.H Other -N_2O from Grassland drained soils-4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils -Total Organic Soils - Drained Organic Soils". This emission is included as Grassland emission in this report, although reported under 4H in the CRF tables.

The emissions are calculated according to T2 applying equation 2.7 in the 2013 wetland supplement (IPCC 2014). The N_2O emission from drained Grassland 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). The total emission of N_2O reported under 4H is 0.20 kt N_2O or 61.04 kt CO_2e. The disaggregation of this emission to subcategories is shown in Table 6.13.

Table 6.13 Drained soils, estimated N_2O emission from drained soils of Grassland categories/subcategories.

Category/subcategory	Drained "organic" soils [kha]	Emission from draining and other management of organic soils.	
		[kt N_2O]	[kt CO_2e]
Grassland remaining Grassland	256.98	0.18	54.18
Cropland abandoned for more than 20 years	7.52	0.01	1.55
Natural birch shrubland (N.b.s)- old	0.26	0.00	0.05
N.b.s.- recently expanded into Other Grassland	0.23	0.00	0.05
Wetland drained for more than 20 years	248.97	0.18	52.52
Land converted to Grassland	33.33	0.02	9.01
Cropland converted to Grassland	9.80	0.01	2.02
Wetland converted to Grassland	23.53	0.02	4.85
Total	**290.31**	**0.21**	**61.04**

<u>Wetland:</u> 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 (IPCC 2014). 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 (IPCC 2014). The reported emission is 0.29 kt CO_2, 199.97 kt CO_2, 0.03 kt CO_2, and 0.18 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 6.9. Estimated CH_4 emission from reservoirs is 0.41 kt CH_4 (10.15 kt CO_2e).

In this year's submission CH_4 emission from wet soils of three categories i.e. "Intact mires", "Refilled lakes and ponds", and "Rewetted organic soils", is reported. The emission of CH_4 for these categories is estimated according to T1 applying equation 3.8 in 2013 wetland supplement (IPCC 2014). The CH_4 emission and removal from "Intact mires", "Refilled lakes and ponds", and "Rewetted wetland soils" is calculated according to T1 applying EF= 137 kg CH_4-C ha^{-1} yr^{-1} from table 3.3 in 2013 wetland supplement (IPCC 2014). The reported emission is 124.53, 0.02, and 0.12 kt CH_4 for "Intact mires", "Refilled lakes and ponds", and "Rewetted organic soils" respectively. This is equivalent to 3,113.17, 0.53, and 2.90 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 T1 approach of 2013 wetland supplement (IPCC 2014)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 T2 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 second time in this year submission for drained organic forest soils or drained organic grassland soils convert 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 T1, 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 1.5 and 0.04 t N_2O or 0.44 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 T1, 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 5.7).

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, 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 during 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 for amount of waste landfilled, as well as amount 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 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 2017. The result was projected back in time using expert judgement.

7.1.3 Key Category Analysis

The key sources for 1990, 2017 and 1990-2017 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 2017	Trend
Waste (CRF 5)				
5A1 Managed Waste Disposal	CH_4	✓	✓	✓
5A2 Unmanaged Waste Disposal	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)	NO	E	NA	NE	NE	E
Unmanaged Waste Disposal Sites (CRF 5A2)	NO	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	IE[2]	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.

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 Guideline 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.

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 send 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 separated categories makes the use of the umbrella category industrial waste obsolete (more on this in Chapter 7.2.2).

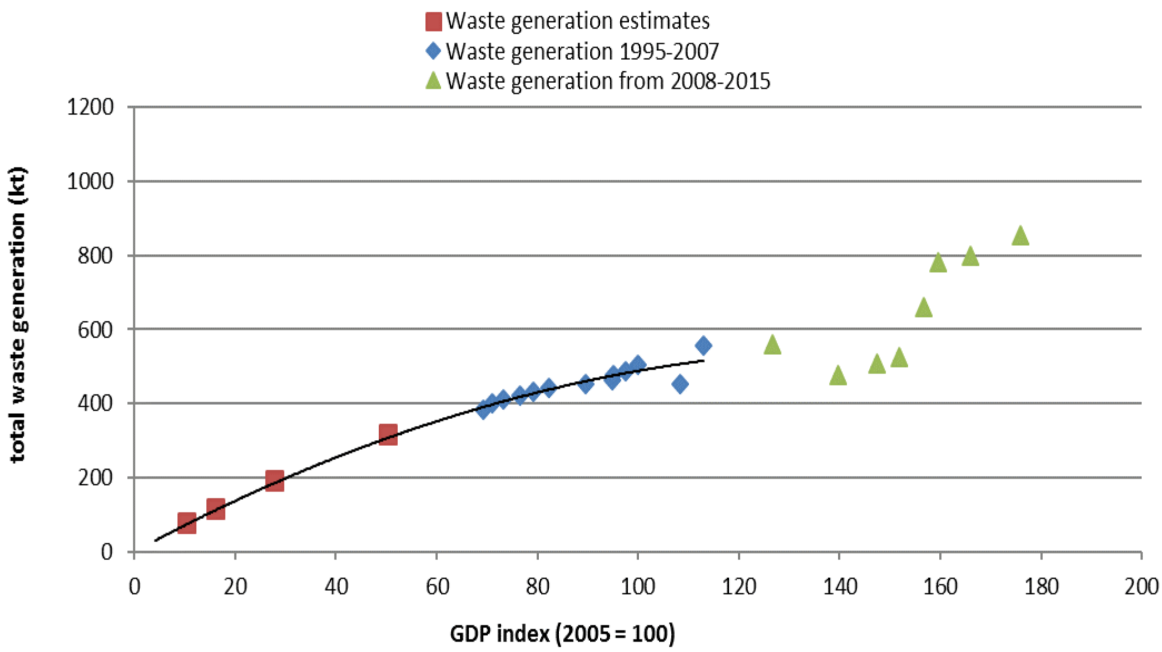

Figure 7.1 Correlation between waste generation and GDP index in Iceland used for waste generation estimates before 1995.

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 1950-2017 are shown in Figure 7.2.

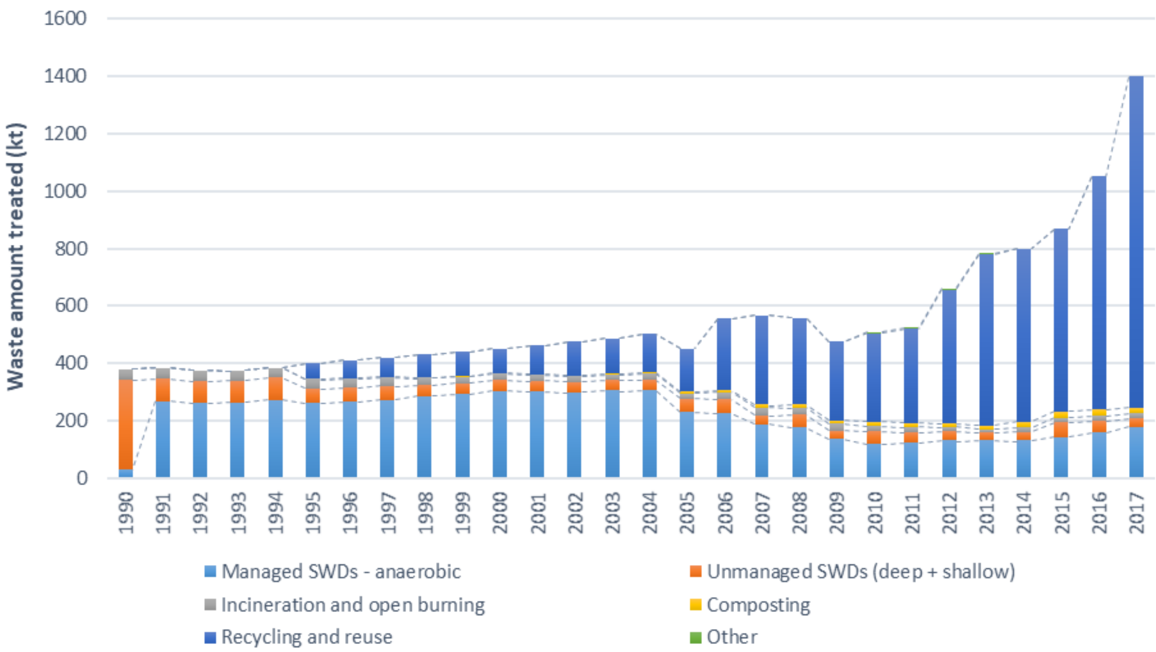

Figure 7.2 Waste amount and allocation to incineration/open burning, solid waste disposal, recycling and composting.

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.

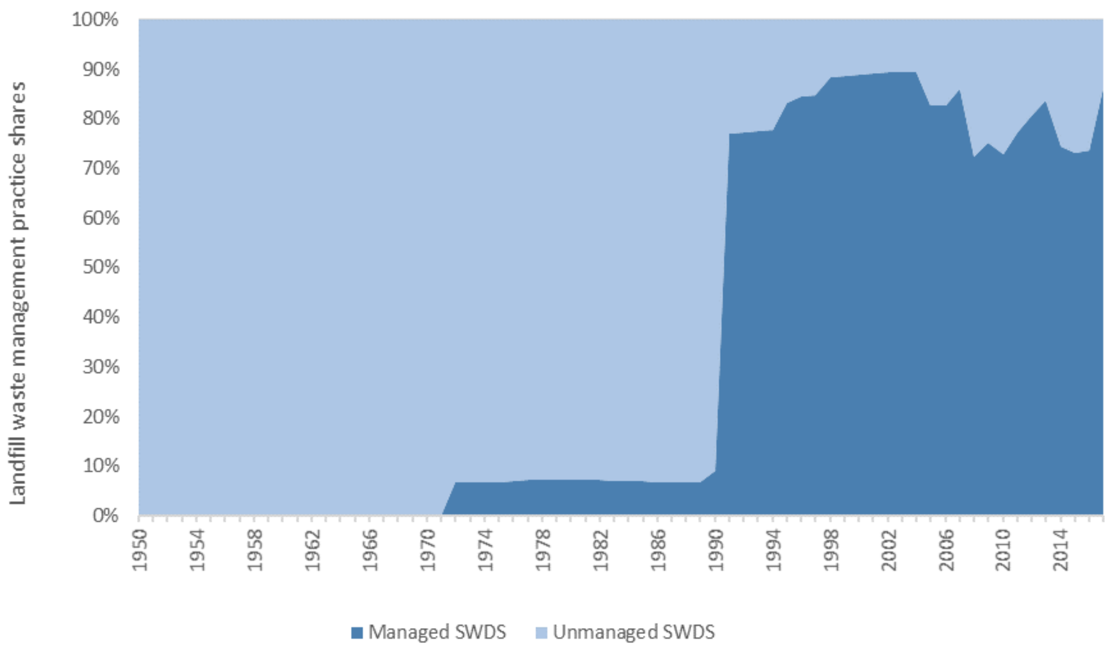

Figure 7.3 Waste management practice shares of total waste disposed of in managed and unmanaged SWDS.

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	Industrial	Total
1950	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1953	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1954	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1955	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1956	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1957	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1960	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1961	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1962	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1965	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1966	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1969	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1972	5.2	0.4	1.7	0.4	0.3	0.0	0.2	3.0	0.7	**11.9**
1973	5.7	0.5	2.0	0.4	0.3	0.0	0.2	3.4	0.8	**13.3**
1974	5.7	0.5	2.0	0.5	0.3	0.0	0.2	3.5	0.8	**13.5**
1975	5.5	0.4	2.0	0.4	0.3	0.0	0.2	3.5	0.8	**13.1**
1976	5.9	0.5	2.2	0.5	0.4	0.0	0.3	3.8	0.8	**14.4**
1977	6.6	0.5	2.5	0.5	0.4	0.0	0.3	4.4	0.9	**16.2**
1978	6.9	0.6	2.7	0.6	0.4	0.0	0.3	4.7	1.0	**17.2**
1979	6.9	0.6	2.8	0.6	0.4	0.0	0.3	4.8	1.0	**17.6**
1980	7.2	0.6	3.0	0.6	0.5	0.0	0.3	5.1	1.1	**18.4**

Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industrial	Total
1981	7.1	0.6	3.1	0.6	0.5	0.1	0.3	5.4	1.1	**18.9**
1982	6.9	0.6	3.2	0.6	0.5	0.2	0.3	5.7	1.1	**19.2**
1983	6.3	0.6	3.2	0.6	0.5	0.2	0.3	5.7	1.1	**18.4**
1984	6.2	0.6	3.3	0.6	0.5	0.3	0.3	6.0	1.1	**19.0**
1985	6.1	0.7	3.4	0.7	0.5	0.4	0.3	6.4	1.1	**19.6**
1986	6.3	0.7	3.8	0.7	0.5	0.5	0.4	7.1	1.2	**21.2**
1987	6.5	0.8	4.2	0.8	0.6	0.7	0.4	7.9	1.3	**23.1**
1988	6.0	0.8	4.2	0.8	0.6	0.8	0.4	8.1	1.3	**22.9**
1989	5.6	0.8	4.2	0.8	0.6	0.8	0.4	8.2	1.3	**22.7**
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**
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										

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

Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Inert	Industrial	Total
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**
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**
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 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	23	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. The bulk of methane recovered since 2007 is sold as fuel for vehicles, e.g. cars and urban buses. Figure 7.4 gives an overview of the annual methane amounts segregated by utilization.

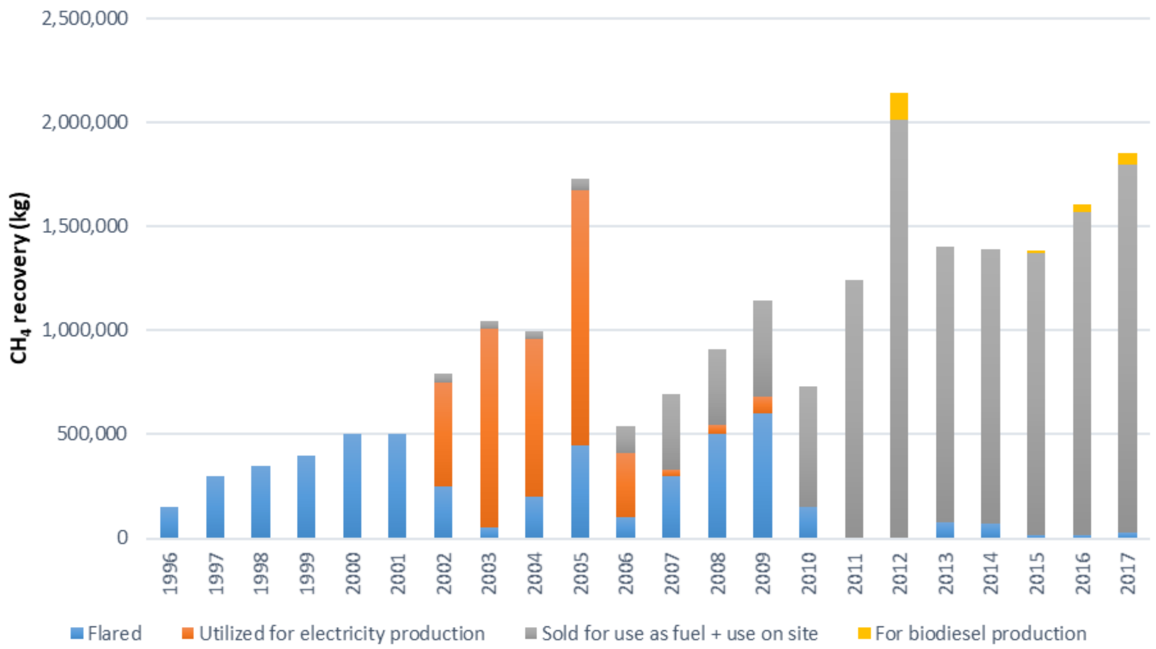

Figure 7.4 Methane recovery at Álfsnes and Glerárdalur SWDS's (kg CH_4).

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 8.2 kt in 2017. This equals an increase of 30% between 1990 and 2017.

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 close 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 11% of all SWDS emissions, whereas the fraction of emissions from unmanaged SWDS accounted for 89%. This trend has been reversed since then and in 2017 87% of SWDS emissions originated from managed SWDS. The main event underlying this development is the close 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.

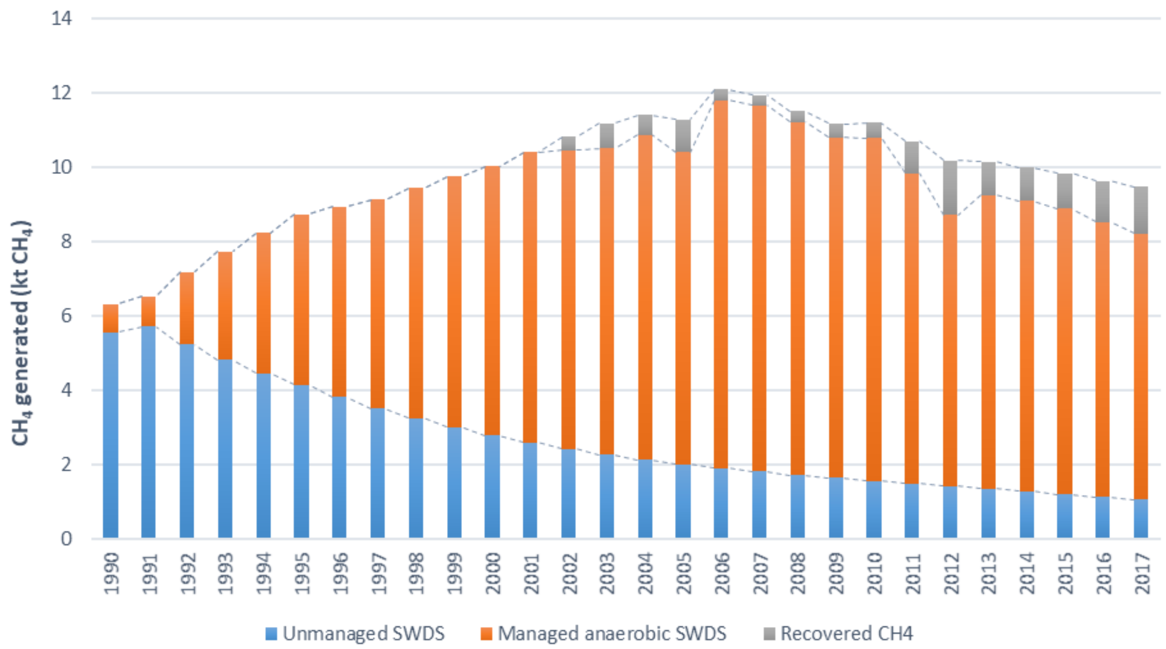

Figure 7.5 Methane generation estimates and recovery from Solid Waste Disposal Sites 1990-2017.

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 estimate of quantitative uncertainty has revealed that 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%). This can be seen in the quantitative uncertainty table in Annex 2.

7.2.6 Recalculations

For the 2019 submission, minor changes were made from last years' submission, resulting in recalculations for all years from 2014. The following changes were made:

- *Data used in the IPCC FOD model for 2014-2015 was synchronized with data for 2016-2017.*

  From 2014 the Environment Agency of Iceland has collected synchronized data on waste amounts according to the WStatR categorization. For the previous submission that data was used to attribute all waste in Iceland to the corresponding IPCC categories (paper, wood etc.) for the year 2016. For this submission the categorization of waste for 2014-2015 was attributed to the IPCC categories using the same methodology as 2016-2017. This resulted in a slight increase in emissions from SWDS. The increase of emissions in 2015 was 1.87 kt CO_2e, or 0.7% of total emissions from waste, and 1.21 kt. CO_2e in 2016, or 0.5% of total emissions from waste.

- *Data for methane recovery from the SWDS Glerárdalur added*

  In previous submissions recovery of landfill gas from the SWDS Glerárdalur had not been included. Recovery began at the site in 2014 and for this submissions data has been added to the IPCC Model for the years 2014-2017. The amount of methane recovered from Glerárdalur was 0.01 kt CH_4 in 2014, 0.04 kt CH_4 in 2015 and 0.05 kt CH_4 in 2016. These amounts of methane correspond to an increase of methane collected for energy recovery by 1.1% in 2014, 4.0% in 2015 and 4.7% in 2016.

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. A collection of detailed information on landfill gas utilization (e.g. energy content of recovered gas, place of utilization) is 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.

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 1990. 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 around 21.8 kt in 2016. There exists data on the composition of waste composted since 2007. In 2017 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 1995-2017.

Year	Waste amount composted (kt)
1995	2
1996	2
1997	2
1998	2
1999	2
2000	2
2001	2
2002	2
2003	3

Year	Waste amount composted (kt)
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

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 0.087 kt CH_4 or 2.17 kt CO_2e in 2017. N_2O emissions amounted to 0.005 kt N_2O or 1.55 kt CO_2e in 2017. The waste composted and emission trend since 1990 is shown in Figure 7.6.

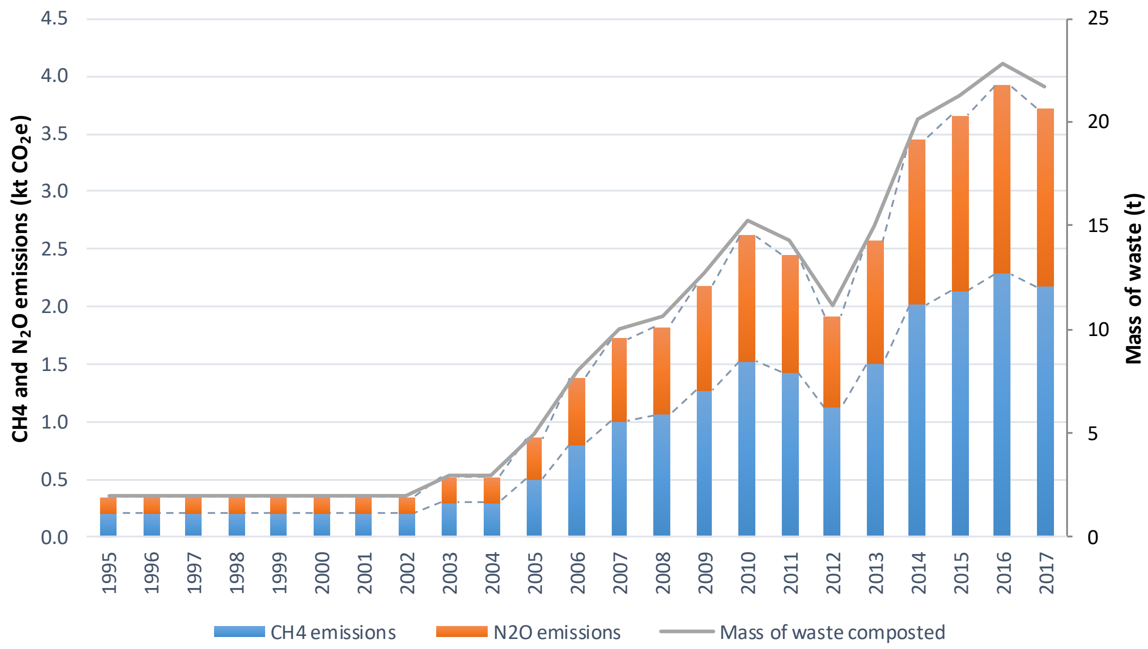

Figure 7.6 Mass of waste composted and estimated CH4 and N2O emissions (kt CO2e).

7.3.5 Uncertainties

Uncertainty for emissions from composting was calculated using value ranges from the 2006 GL (table 4.). The estimate of quantitative uncertainty has revealed that 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%). This can be seen in the quantitative uncertainty table in Annex 2.

7.3.6 Recalculations

No recalculations were done for the 2019 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 2017. 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 7.6 kt CO_2e in 2017.

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.

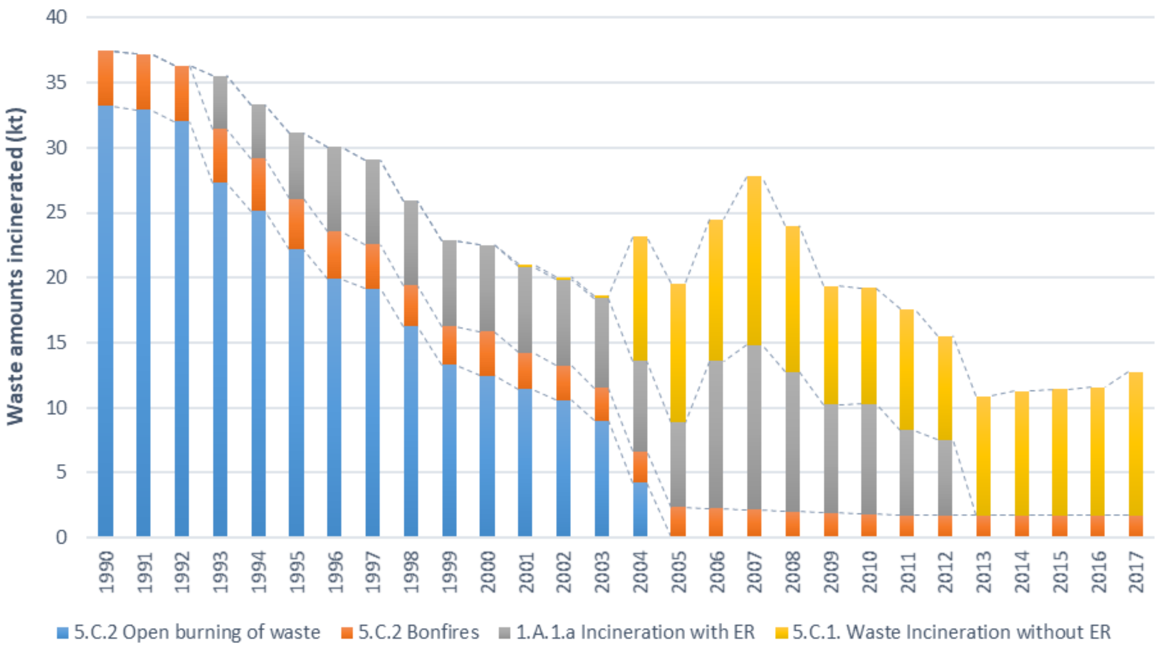

Figure 7.7 Amounts of waste incinerated with and without energy recovery, burned openly and amount of wood burned in bonfires 1990-2017

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 2017.

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 to one of the 13 categories shown in Figure 7.8, along with their weight fractions from 2005 to 2017. 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.

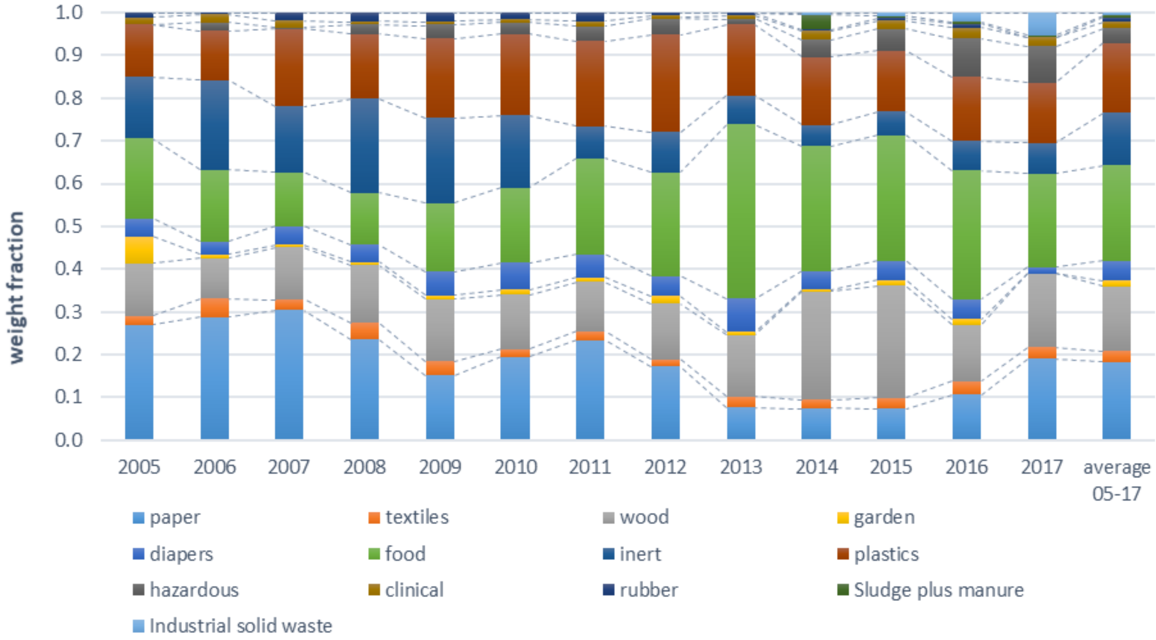

Figure 7.8 Waste categories for incineration along with weight fractions for 2005-2017 and the average weight fraction of whole period.

This data exists only for waste incineration and for the years from 2005 to 2017. 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 2017 in Table 7.10.

Table 7.10 Calculation of fossil carbon amount incinerated in 2017. The column "fossil carbon (wet weight basis), fraction" is the product of the three columns preceding it.

	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	2,586	0.19	0.9	0.46	0.01	2.2
Textiles	358	0.03	0.8	0.5	0.2	0.8
Wood	2,324	0.17	0.85	0.5	0	0.0
Garden	0	0.00	0.4	0.49	0	0.0
Diapers	213	0.02	0.4	0.7	0.1	0.1
Food	2,956	0.22	0.4	0.38	0	0.0
Inert	968	0.07	0.9	0.03	1	2.0
Plastics	1,918	0.14	1	0.75	1	214.4
Hazardous	1,152	0.09	0.5	NA	0.28	8.9
Clinical	293	0.02	0.65	NA	0.25	1.1
Rubber	1	0.00	0.84	0.67	0.2	0.0
Sludge plus manure	48	0.00	0.4	0.45	0	0.0
Industrial solid waste	725	0.05	0.4	0.38	0	0.0
Sum	**13,542**	**1**				**229.4**

The input for individual years from 2005 to 2011 differs from Table 7.11 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. The EMEP guidebook defaults are applied to both open burning and incineration of waste. Defaults 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	1,800	700	20	1,700
Incineration (ISW, hazardous) EF	237	100	870	70	7,400	47
Incineration (clinical) EF	237	100	1,800	1,500	700	1,100
Open burning EF	6,500	150	3,180	55,830	1,230	110

7.4.4 Emissions

GHG emissions from incineration and open burning of waste are shown in Figure 7.9. Total GHG emissions estimates have decreased from 15.1 kt CO_2e in 1990 to 7.80 kt CO_2e in 2017. 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 2017 and N_2O emissions have decreased from 1.7 kt CO_2e in 1990 to 0.36 kt CO_2e in 2017.

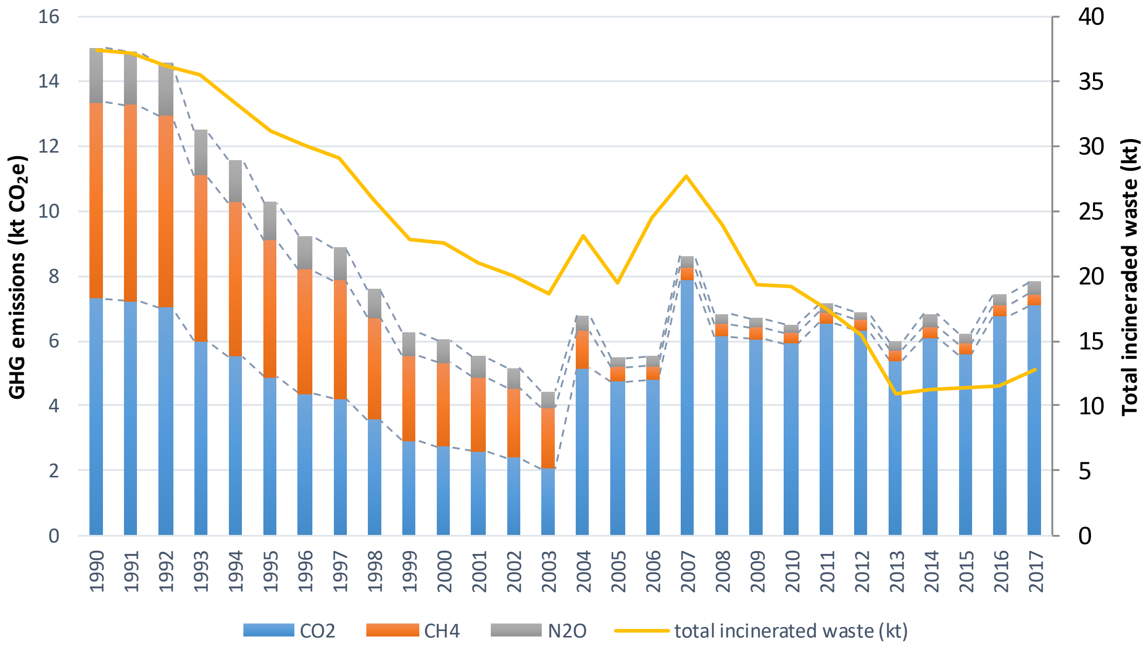

Figure 7.9 Emission estimates from incineration and open burning of waste 1990-2017.

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). This can be seen in the quantitative uncertainty table in Annex 2

7.4.6 Recalculations

From the year 2014 the Environment Agency of Iceland has collected detailed data from all waste operators in Iceland on waste amounts based on the WStatR categorization. For the last submission that data was used to divide all waste in Iceland to the corresponding categories (paper, wood, rubber etc.) for the years 2015 and 2016. For this submission the categorization of waste for 2014 was attributed to the categories using the same methodology as 2015-2017 which resulted in a decrease in emissions of 0.015 kt CO_2e, or 0.2% of total emissions from incineration of waste in Iceland in 2014.

Recalculations were performed for emissions from incineration of waste for 2015 based on more accurate data on mixed waste composition. Emissions from 5C1 decreased by 3.04 kt CO_2e in 2015 which equals -52% change in emissions for that year. The biggest contributing factor for that was that plastic in mixed waste had been overestimated in previous submissions, but with more accurate data from Sorpa, the larget waste operator in Iceland, the amount of plastic decreased resulting in a decrease in emissions from the sector.

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 has increased slightly and has been fluctuating around 10% since 2002. Septic systems in Iceland are used in remote places. These include both summer houses and building sites in the highlands such as the Kárahnjúkar hydropower plant. Since 2002 the share of direct discharge of wastewater into rivers and the sea has reduced 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 12.7 kt CO_2e in 2017. Compared to 1990 emissions of 8 kt CO_2e this means an increase of 59%.

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 and the Good Practice Guidance. Wastewater treatment is not a key source in Iceland and country-specific emissions factors are not available for key pathways. 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, 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 zero since all methane emissions originates from domestic sewage. 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 2017 annual TOW increased proportionally to population from 7.0 kt to 9.3 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 (zero since all methane emissions originates from domestic sewage)

Table 7.12 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 the wastewater

Year	Population (n)	Protein consumption (kg/person/yr)	Total organic matter (kt BOD/yr)
1990	253,785	37.2	6.95
1991	255,866	37.2	7.00
1992	259,727	37.2	7.11
1993	262,386	37.2	7.18
1994	265,064	37.2	7.26
1995	266,978	37.2	7.31
1996	267,958	37.2	7.34
1997	269,874	37.2	7.39
1998	272,381	37.2	7.46
1999	275,712	37.2	7.55
2000	279,049	37.2	7.64
2001	283,361	37.2	7.76
2002	286,575	32.9	7.84
2003	288,471	32.9	7.90
2004	290,570	32.9	7.95
2005	293,577	32.9	8.04
2006	299,891	32.9	8.21
2007	307,672	32.9	8.42
2008	315,459	32.9	8.64
2009	319,368	32.9	8.74
2010	317,630	32.9	8.70
2011	318,452	32.9	8.72
2012	319,575	32.9	8.75
2013	321,857	32.9	8.81
2014	325,671	32.9	8.92
2015	329,100	32.9	9.01
2016	332,529	32.9	9.10
2017	338,349	32.9	9.26

Industrial wastewater

Industrial wastewater in Iceland is untreated and either discharged directly into rivers or the sea or by means of closed sewers. For industrial wastewater, the same MCFs as for domestic wastewater were used, i.e. zero (see rationale in chapter Emission Factors. Therefore, methane emissions from industrial wastewater are reported in NFR category 5D1.

7.5.2.2 Activity data - nitrous oxide emissions from wastewater

The activity data needed to estimate N_2O emissions is the total amount of nitrogen in the wastewater effluent ($N_{EFFLUENT}$). $N_{EFFLUENT}$ was calculated using equation 6.8 from the 2006 GL:

EQUATION 6.8

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

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

Fraction of nitrogen in protein, factor for non-consumed protein added to wastewater, and factor for industrial and commercial co-discharged protein are 2006 GL defaults and are shown in Table 7.13.

Table 7.13 Default factors used in the calculations.

Parameter	Default value	Range	Remark
F_{NPR}	0.16		
$F_{NON\text{-}CON}$	1.4	1-1.5	The default value of 1.4 for countries with garbage disposal was selected.
$F_{IND\text{-}COM}$	1.25	1-1.5	Default value used

Other parameters influencing the nitrogen amount of wastewater is 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 was multiplied with a literature value of 2% (N content of domestic septage; (McFarland, 2000).

7.5.3 Emission Factors

The CH_4 emission factor for 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). Four wastewater discharge pathways exist in Iceland. They are shown in Table 7.14 along with respective shares of total wastewater discharge and MCFs.

Table 7.14 Wastewater discharge pathways fractions and population of Iceland from 1990 to 2017.

	Untreated systems		Treated systems		Population
Discharge pathway	**Flowing sewer (closed)**	**Sea, river and lake discharge**	**Centralized, aerobic treatment plant**	**Septic system**	
1990	0.02	0.94	0	0.04	253,785
1995	0.04	0.9	0	0.06	266,978
2000	0.33	0.61	0	0.06	279,049
2005	0.54	0.326	0.024	0.11	293,577
2010	0.57	0.33	0.02	0.08	317,630
2012	0.57	0.33	0.02	0.08	319,575
2013	0.57	0.33	0.02	0.08	321,857
2014	0.57	0.33	0.02	0.08	325,671
2015	0.57	0.33	0.02	0.08	329,100
2016	0.57	0.33	0.02	0.08	338,349
2017	0.57	0.33	0.02	0.08	338,349
MCF	0	0	0	0.5	

MCFs are in line with the 2006 GL except for the category sea, river and lake discharge. The 2006 GL propose a MCF of 0.1 and give a range of 0 – 0.2. Based on expert judgement a MCF of zero was used. The rationale behind this assessment is the cold climate in Iceland on one hand and fast running streams and rivers on the other hand. In Iceland the annual mean temperature for inhabited areas is 4 °C and the maximum temperature rises only occasionally above 15°C, which is a threshold temperature for activity of methanogens. The geology of Iceland results in a hydrological setup with fast running streams and rivers. In combination with a low population density and therefore low organic loadings, this means that streams and rivers do not turn anaerobic. Thus, the only discharge pathway with a MCF (and emission factor) above zero is septic systems.

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

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)

Since septic tanks are the only wastewater treatment in Iceland attributed with an emission factor above zero, their fraction of total wastewater discharge determines the amount of methane emissions and this can be seen in Figure 7.10. The slight increase of TOW caused a slight increase of methane emissions during years when the share of septic tanks stayed unchanged. CH_4 emissions were highest in 2006, when they reached 0.27 kt. The sudden increase of emissions between 2001 and 2002 is due to an increase of septic system fraction from 6 to 11%. This increase was by the far most attribute to the setup of big septic tank system for the workforce of the Kárahnjúkar hydropower plant. The decrease of septic systems in Iceland after 2008 was caused by the completion of this same power plant.

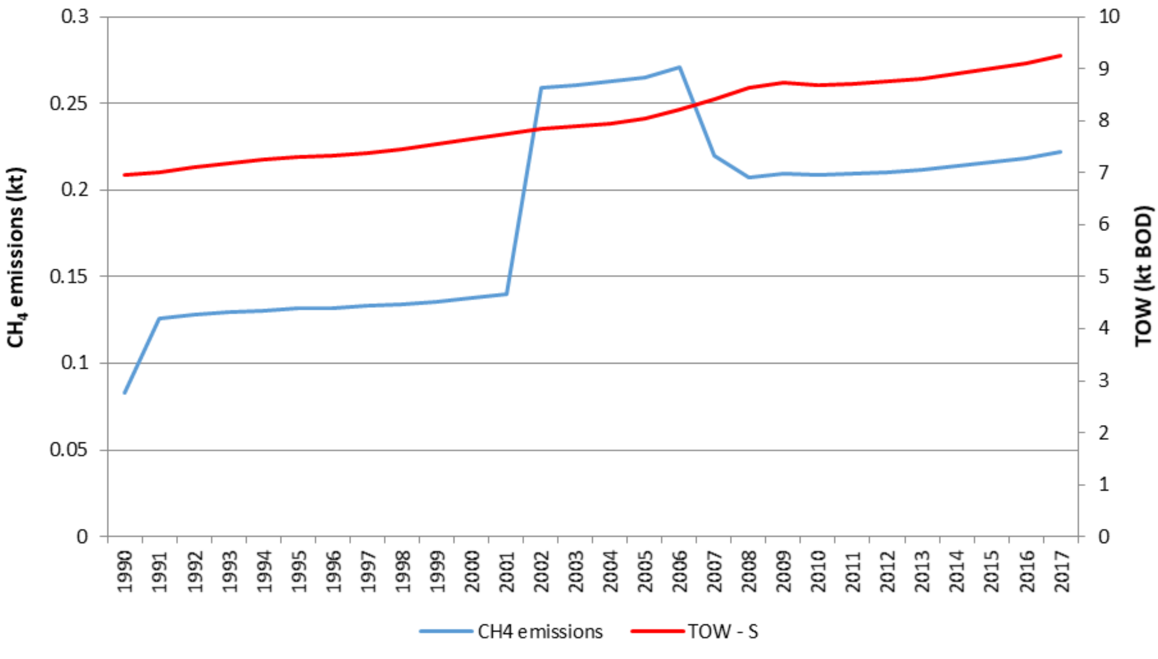

Figure 7.10 Methane emissions and total organics in wastewater in Iceland 1990-2017.

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 7.15 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 NRF category *5.A.1.a Managed waste disposal sites.*

Table 7.15 Amount of sludge removed and N in effluent

Year	Sludge removed (kt DC)	N in effluent (kt N/year)
1990	6.01	2.53
1995	5.52	2.67
2000	6.01	2.79
2005	4.89	2.60
2010	3.89	2.84
2012	3.45	2.87
2013	3.45	2.89
2014	2.52	2.95
2015	3.12	2.96
2016	2.71	3.00
2017	2.80	3.06

The resulting emissions are shown in Figure 7.11. Emissions rose from 0.020 kt in 1990 to 0.024 in 2017. This is tantamount to an increase of 21%. The main driver behind this development was a 33% increase of population during the same time.

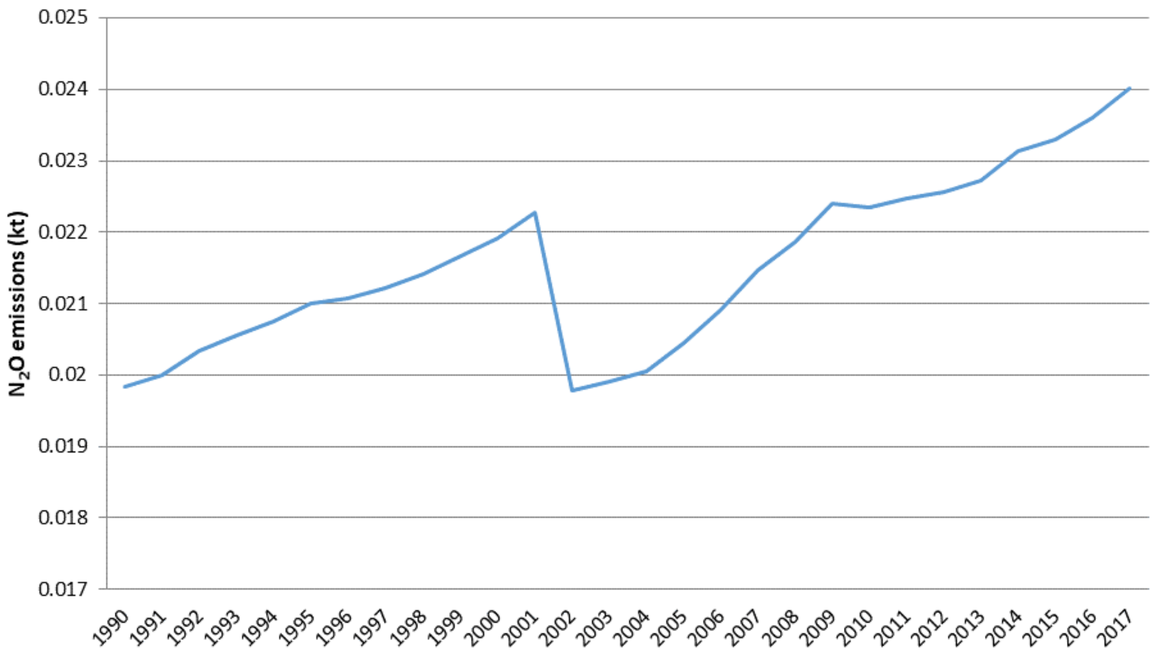

Figure 7.11 Emission estimates for N_2O from wastewater effluent 1990-2017.

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). This can be seen in the quantitative uncertainty table in Annex 2.

7.5.6 Recalculations

With more detailed waste amount data back to 2014 as discussed in 5A and 5C, better data on sludge removed became available for the years 2014-2016. This resulted in a slight increase in N_2O emissions. The increase of N_2O emissions were 0.081 CO_2e in 2014, 0.100 CO_2e in 2015 and 0.128 CO_2e in 2016.

In addition, a minor error in population numbers for 2016 was corrected which resulted in a small decrease in N_2O and CH_4 emissions for that year. CH_4 emissions decreased by 0.096 0.081 CO_2e and N_2O emissions by 0.125 CO_2e.

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.

7.6 Source Specific QA/QC Procedures

The QC activities include general methods such as accuracy checks on data acquisition and calculations as well as the use of approved standardised procedures for emission calculations, estimating uncertainties, archiving information and reporting. Further information can be found in Chapter 1.5 on Quality Assurance and & Quality Control.

7.7 Source Specific Recalculations

For the 2018 submission, several recalculations were made from the 2017 submission. A complete revision of the waste sector was done for the 2017 submission in relation to file structure and the methodology used for the emission estimates. This work has continued for the 2018 submission with more focus on the quality of the data and parameters being used. The main recalculations and implications are outlined in the corresponding sections above for each of the CRF categories for waste.

7.8 Source Specific Planned Improvements

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.

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. This process of identifying recalculation changes and the documentation of changes is in line with Chapter 7 of the IPCC Good Practice guidelines[10] regarding the reporting of recalculations. However, the IPCC guidelines recommend that recalculations are performed for every year. Currently, only the base and latest year are considered. Extending the scope of the current QAQC check to all years is a planned improvement.

The Icelandic 2019 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.

Tables 10.1 and 10.2 below show the difference between the total emissions in the 2019 submission and 2018 submission, without and with emissions from the LULUCF sector. Explanations for the differences are given in Chapter 10.2 Sector-specific recalculations.

Table 10.1 Total emissions in 2019 submission compared to 2018 submission, kt CO_2e (without LULUCF).

Inventory year	2018 submission	2019 submission	Change (kt)	Change (%)
1990	3,634	3,598	-35.9	-0.99%
1995	3,454	3,426	-27.9	-0.81%
2000	4,067	4,038	-29.3	-0.72%
2005	3,976	3,947	-28.6	-0.72%
2010	4,879	4,845	-34.2	-0.70%
2015	4,749	4,715	-33.5	-0.71%
2016	4,669	4,640	-29.4	-0.63%

Table 10.2 Total emissions in 2019 submission compared to 2018 submission, kt CO_2e (with LULUCF).

Inventory year	2018 submission	2019 submission	Change (kt)	Change (%)
1990	13,727	13,005	-722	-5.26%
1995	13,495	12,787	-708	-5.24%

[10] http://www.ipcc-nggip.iges.or.jp/public/gp/english/7_Methodological.pdf

2000	14,156	13,425	-732	-5.17%
2005	14,122	13,375	-747	-5.29%
2010	15,162	14,317	-846	-5.58%
2015	14,996	14,078	-918	-6.12%
2016	14,891	13,985	-906	-6.09%

10.2 Sector-specific Recalculations

10.2.1 Energy (CRF sector 1)

Only minor recalculations were done in the Energy sector for this submission, leading to a difference in GHG emissions between the 2018 and the 2019 submission amounting to 1.4 kt CO_2e for the year 2016 and no changes 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 reasons account for the recalculations in the energy sector:

1. For this submission the emission factor for N_2O emissions from LPG in 1A2 was updated. In previous submissions it was reported as NA and now it has been replaced by a default emission factor of 0.1 kg N_2O/TJ fuel according to IPCC 2006 guidelines.
2. In road transport, the difference between fuel sold and fuel calculated based on VKT was attributed to all vehicle types in proportion to the total amount of calculated fuel use. For previous submissions the difference in gasoline sold and calculated gasoline usage based on VKT had been attributed to passenger cars and the difference in diesel had been attributed to heavy duty truck and buses. This recalculation did not affect total CO_2 emissions, but it did have minor effect on CH_4 and N_2O emissions.

10.2.2 Industrial Processes and Products Use (CRF sector 2)

For the IPPU sector, there are no substantial differences in GHG emissions between the 2018 and the 2019 submissions. A summary of the changes made are presented here, and further details are documented under the specific "recalculations" sections in each individual subcategory of Chapter 4 (Industrial Processes and Product Use).

The changes include minor recalculations due to an update in activity data. In the subsector 2C2 Ferroalloy production these lead to a change of -0.24 kt CO_2e for the CH_4 emissions and for the subcategory 2G an update of activity data leads to a change of -0.001 kt CO_2e for the SF_6 emissions.

10.2.3 Agriculture (CRF sector 3)

Based on comments from the EMRT after the 15 January submission of data, it was discovered that the N_2O emissions were based on the wrong EF for manure managed in solid storage. The EF were taken from table A1.7 from the EMEP/EEA Guidebook (2016) but have now been updated to the EFs in table A3.8 from the EMEP/EEA Guidebook (2016). This was updated for all livestock categories and the recalculations resulted in lower N_2O emissions from manure management.

Livestock population numbers were updated for the whole time series (1990-2017). This was done due to changed reporting at the IFVA, which no longer publishes final livestock numbers for each year. Therefore, the currently used data was pulled directly from their livestock database (www.bustofn.is) where all the livestock census reports from farmers are stored. This resulted in a very minor (between 0% and 1%) change in emissions from enteric fermentation and manure management.

Data on the area of organic soil was updated for the years 2015-2017. Data on Nfert used in forestry was also updated for 2016 and 2017. These updates resulted in minor (<1%) changes in emissions from agricultural soils.

10.2.4 LULUCF (CRF sector 4)

Recalculations have been done to the LULUCF sector between the 2018 and 2019 submission, mostly due to revised area estimation. The effect of the recalculations on the emissions from the sector are shown in table 10.3. Further explanations for the subsectors are also explained below.

Table 10.3 Total emissions from LULUCF in 2019 submission compared to 2018 submission, kt CO_2e.

Inventory year	2018 submission	2019 submission	Increase (kt)	Increase (%)
1990	10,093	9,407	-686	-6.80%
1995	10,041	9,361	-680	-6.77%
2000	10,089	9,387	-702	-6.96%
2005	10,146	9,427	-719	-7.08%
2010	10,283	9,472	-811	-7.89%
2015	10,248	9,363	-884	-8.63%
2016	10,222	9,345	-877	-8.58%

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)

No specific recalculations have been made for this category.

Grassland (4C)

The area of Wetland drained for more than 20 years and of Other Grassland was revised. The time series for area of “Wetland converted to Grassland” was revised according to revised estimate of the total area of map layer “Grassland on drained soils”. Emissions of all pools depending on that area were recalculated accordingly. The area for Revegetation since 1990 protected from grazing back to 2012 were revised and emissions accordingly recalculated.

Wetland (4D)

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.

Settlements (4E)

As the total area is revised the time series for “All other Grassland converted to Settlement” is modified accordingly and emission recalculated.

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 (4H)

No emissions are reported under this category.

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

No recalculations were done in this category.

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.

10.2.5 Waste (CRF sector 5)

For the 2019 submission, several recalculations were made in the waste sector from the 2018 submission. 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. 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 7 (Waste).

Solid Waste Disposal (5A)

- *Data used in the IPCC FOD model for 2014-2015 was synchronized with data for 2016-2017.*

  From 2014 the Environment Agency of Iceland has collected synchronized data on waste amounts according to the WStatR categorization. For the previous submission that data was used to attribute all waste in Iceland to the corresponding IPCC categories (paper, wood etc.) for the year 2016. For this submission the categorization of waste for 2014-2015 was attributed to the IPCC categories using the same methodology as 2016-2017. This resulted in a slight increase in emissions from SWDS.

- *Data for methane recovery from the SWDS Glerárdalur added*

In previous submissions recovery of landfill gas from the SWDS Glerárdalur had not been included. Recovery began at the site in 2014 and for this submissions data has been added to the IPCC Model for the years 2014-2017. This resulted in a small increase of methane collected for energy recovery.

Waste Incineration and Open Burning (5C)

For this submission the WStatR categorization of waste for 2014 was attributed to the categories using the same methodology as 2015-2017 which resulted in a decrease in emissions of 0.015 kt CO_2e, or 0.2% of total emissions from incineration of waste in Iceland in 2014.

Recalculations were performed for emissions from incineration of waste for 2015 based on more accurate data on mixed waste composition. Emissions from 5C1 decreased by 3.04 kt CO_2e in 2015 which equals -52% change in emissions for that year.

Wastewater Treatment and Discharge (5D)

With more detailed waste amount data back to 2014 as discussed in 5A and 5C, better data on sludge removed became available for the years 2014-2016 which resulted in a small increase in N_2O emissions. In addition, a minor error in population numbers for 2016 was corrected which resulted in a small decrease in N_2O and CH_4 emissions for that year.

10.2.6 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 6.13).

10.3 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.

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

Iceland´s 2019 submission was reviewed during EU’s Step 1 review process, according to Art. 29 of Commission Implementing Regulation (EU) No 749/2014. The 2017 submission was subjected to a UNFCCC in-country review, and many of the improvements are in response to that review. No UNFCCC review took place in 2018, and a desk review will take place later in 2019.

The main improvement implemented in the inventory compilation for the 2019 submission is the revision of the calculation files used for calculating emissions from the Energy Sector; another improvement that had a major impact on emission estimates was the revision of area estimates for the LULUCF sector.

The main planned improvements include better collaboration with the National Energy Authority with regards to activity data and the energy balance; a revision of the F-gas inventory; as well as setting up and implementing more thorough QA/QC activities.

In Chapter 10.5 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.

10.5 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 10.4 Status of implementation of general recommendations in response to UNFCCC´s review process.

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section 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/2017/ISL /G.2	Iceland´s National Energy Authority (NEA) is responsible for providing the national energy balance to the IEA. The energy balance has been used to generate the reference approach, and the complete energy balance for the year 2017 was added to the NIR for the 15 March submission / Done	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/2017/ISL /G.3	This information was provided to the UNFCCC review team during the in-country review week (August 2017). The NR disaster recovery plan will be modified accordingly during the next update. There has been a slight delay on the modification process due to changes of IT companies supporting the EA but is still in process. / 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/2017/ISL /G.4	Done	Chapter 13
General	The ERT recommends that Iceland report comprehensive information in the NIR on the status of implementation of regulation 520/2017, including	FCCC/ARR/2017/ISL /G.5	A summary of Regulation 520/2017 was added to Chapter 13 on Changes in national system; work is in progress with the Agencies	Chapter 13

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	how Iceland ensures that the institutional, legal and procedural arrangements between different government agencies, including the roles and responsibilities, are fully understood by all the involved institutions (e.g. Agricultural University of Iceland, IFR and the Ministry of Environment and Natural Resources) and the changes in the national system resulting from such implementation (if any).		mentioned in the Regulation to improve the collaboration for the inventory. / In progress	
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/2017/ISL /G.6	In progress	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/2017/ISL /G.7	Information on QA/QC tools have been included in the NIR; the revision of the QA/QC manual and plan are still ongoing. / In progress	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/2017/ISL /G.8	This has been implemented. / Done	Paragraph 1.6; Annex 2.

10.5.1 Energy (CRF Sector 1)

For this submission the EA worked in collaboration with a consulting company (Aether ltd.) to completely review and restructure the Energy sector, including updating/redesigning calculation spreadsheets. For future submissions Aether will collaborate with the EA on harmonising energy data processing between various organisations (such as EA, the national Energy Authority and Statistics Iceland) and updating the NIR text. For the next submission the COPERT model will be used to estimate GHG emissions from Road Transport, and Iceland 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 10.5 Status of implementation in the Energy sector in response to UNFCCC´s review process.

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
1.	Work with the Icelandic Directorate of Customs to correct the errors related to reporting of AD in the 2014 annual submission; for example, where coke was recorded as coal, and where coking coal was recorded as coke	FCCC/ARR/2017/ISL /E.1	In progress	Energy Chapter
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/2017/ISL /E.2	In progress	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/2017/ISL /E.3	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/2017/ISL /E.4	This has been implemented. / Done	Energy Chapter
1.	Consider the possibility of redefining the coordination agreement between NEA and the Environment Agency of Iceland (EA) in order to change the data collection process by preparing a data collection template that is consistent with the IPCC categories	FCCC/ARR/2017/ISL /E.5	A new Icelandic regulation (520/2017 - in Icelandic) entered into force in 2017, formally introducing Regulation 525/2013 into Icelandic legislation and redefining the nature of the partnership between the NEA and the EA. Collaborative work is in	Energy Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
			progress in order to streamline data collection to be in line with IPCC categories. /in progress	
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/2017/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/2017/ISL /E.7	This has been implemented. / Done	Energy Chapter
1.AB	The ERT recommends that Iceland report estimates for the apparent energy consumption (excluding non-energy use, reductants and feedstocks) of liquid and solid fuels for the entire time series in CRF table 1.A(c)	FCCC/ARR/2017/ISL /E.8	This has been implemented. / Done	Energy Chapter
1.D.1.a	Improve the methodology for distinguishing between international and domestic aviation	FCCC/ARR/2017/ISL /E.9	Data collected by NEA does distinguish between international and domestic flights which is in line with 2006 IPCC GL. / Done	Energy Chapter
1.D.1.b	Improve the methodology for distinguishing between international and domestic navigation	FCCC/ARR/2017/ISL /E.10	Data collected by NEA does distinguish between international and domestic ports of each journey which is in line with 2006 IPGG GL. /Done	Energy Chapter
1.A	Use either default oxidation factors in accordance with the 2006 IPCC Guidelines or country-specific oxidation factors if there is sufficient information to support their use for estimating CO_2 emissions from fuel combustion, and ensure that the oxidation factors reported in the NIR are consistent with those used in estimating CO_2 emissions	FCCC/ARR/2017/ISL /E.11	This was done during the UNFCCC in-country review and updated CRF tables were submitted to UNFCCC at the end of the review week in 2017 / Done	Energy Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
1.A.2 - solid fuels	Investigate how the EF was derived and include this information in the NIR	FCCC/ARR/2017/ISL /E.12	This has been implemented / Done	Energy Chapter
1.A.2	Correct the differentiation of fuel consumption between stationary and mobile combustion in the construction sector	FCCC/ARR/2017/ISL /E.13	This has been implemented / Done	
1.A.3.b	Make an effort to apply higher-tier methods to estimate GHG emissions from road transportation, which is a key category	FCCC/ARR/2017/ISL /E.14	We are in the process of implementing the use of COPERT which will facilitate the use of higher tier for CH4 and N2O. Furthermore, the Team for Chemicals at the EA, who is responsible for monitoring reporting under the Fuel Quality Directive, is investigating the possibility of obtaining information on C, O and H content and NCVs from imported gasoline and diesel to derive country-specific CO2 EFs. / in progress	Energy Chapter
1.A.3.b	Use a consistent methodology for the division of vehicle groups and conduct recalculations for the earlier years of the time series (1990–2005)	FCCC/ARR/2017/ISL /E.15	With the implementation of COPERT the methodology will be consistent for the whole timeseries and recalculations will be conducted for the earlier years. This is planned for the next submission. / In progress	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/2017/ISL /E.16	Currently all off-road transportation is reported under 1A2gvii. NIR and CRF updated accordingly. / Done	Energy Chapter
1.	The ERT recommends that Iceland reassess the uncertainty values for AD and EFs used to carried out the uncertainty evaluation and archive the relevant supporting information in accordance with decision 19/CMP.1, and implement the provision from its regulation 520/2017 on the joint work of EA and NEA regarding the uncertainty analysis.	FCCC/ARR/2017/ISL /E.17	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
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/2017/ISL /E.18	We have now corrected errors as far as the currently available data permitted. Category-specific procedures are being worked on. / In progress	Energy Chapter
1.	The ERT encourages Iceland to develop a prioritized improvements plan for the energy sector, taking into consideration the follow-up of previous recommendations and the results of the key category analysis and the uncertainty analysis.	FCCC/ARR/2017/ISL /E.19	In progress	Energy Chapter
1.AB	The ERT recommends that Iceland report the correct amount of carbon excluded from anthracite use in CRF table 1.A(d) for the calculation of CO2 emissions from fuel combustion activities under the reference approach.	FCCC/ARR/2017/ISL /E.20	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/2017/ISL /E.21	This is a planned improvement, in collaboration with the team responsible for collecting information related to the Fuel Quality Directive (Directive 2009/30/EC of the European Parliament and of the Council). The team is investigating the possibility of obtaining information on C, O and H content and NCVs from imported gasoline and diesel to derive country-specific CO2 EFs / Planned improvement	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 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/2017/ISL /E.22	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/2017/ISL /E.23	The values have been replaced by the IPCC default values / Done	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/2017/ISL /E.24	The EFs have been replaced by the IPCC default EFs / Done	Energy Chapter
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/2017/ISL /E.25	Iceland has updated the Efs used for calculating CH4 and N2O emissions from road transport in accordance with the IPCC 2006 GL, and updated the NIR accordingly (table 3.17) / 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/2017/ISL /E.26	For the 2018 submission Iceland included emissions from CH4 collected from landfill sites and sold as fuel for vehicles. Data on how the CH4 is split between vehicle groups is not available so all CH4 was attributed to passanger cars. / 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	FCCC/ARR/2017/ISL /E.27	Iceland is aware that charcoal is being used for grilling in the country, however data on this activity has not been	Energy Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	emissions as a memo item and include the non-CO2 emissions in the corresponding CRF table and national totals.		obtained. If the relevant data becomes available Iceland will update its NIR accordingly. /In Progress	
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/2017/ISL /E.28	This has been implemented / Done	Energy Chapter
1.B.2.d.	The ERT recommends that Iceland include in the NIR additional information regarding the use of geothermal fluids and associated emissions, making it explicit that all geothermal power plants are covered and that other uses of geothermal power are not considered.	FCCC/ARR/2017/ISL /E.29	This has been implemented / Done	Energy Chapter
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/2017/ISL /E.31	In progress	Energy Chapter

10.5.2 Industrial Processes and Products Use (CRF Sector 2)

For future submissions, it is planned to differentiate between lubricants used in 2-stroke engines and lubricants used for their lubricating purposes, in order to allocate the emissions correctly to the energy sector and to the industry sector.

Planned improvements for future submissions include a complete revision of methodology, refined activity data and emission factors for Sector 2F1, including estimation and reporting of potential emissions. Planned improvements for future submissions also include improving data acquisition pertaining to the amount of SF_6 remaining at decommissioning of electrical equipment, as well as to estimate emissions of SF_6 from equipment disposal. It is also planned to assess whether available data allows to determine recovery of N_2O in medical applications.

Planned improvements include obtaining activity data for spirits and carbonated beverage production to estimate emissions from the production of these goods.

Table 10.6 Status of implementation in the IPPU sector in response to UNFCCC´s review process.

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section 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/2017/ISL /I.1	NK added for 2A3, 2B1, 2B3, 2B7, 2E, 2F2, 2F3, 2F5 and 2F6. / Done	IPPU Chapter
2.A/2.C.	The ERT recommends that Iceland improve the transparency of its reporting by reporting emissions from lime production at the Elkem Iceland ferrosilicon plant separately under lime production (category 2.A.2) in the CRF tables and by updating the relevant sections of the NIR	FCCC/ARR/2017/ISL /I.2	Limestone is used in the manufacturing process for Ferrosilicon as a fluxing agent, as opposed to lime production as such. Therefore, the Party reports emissions linked to limestone in 2C2 ferrosilicon. (Source: IPCC GL 2006, Vol. 3, Chap.2, p. 2.33 Other process uses of carbonates, "Where carbonates are used as fluxes or slagging agents (e.g., in iron and steel, chemicals, or for environmental pollution control etc.) emissions should be reported in the respective source categories where the carbonate is consumed".) NIR updated /Done	IPPU Chapter
2.A.4	The ERT recommends that Iceland use the notation key “IE” for reporting information on the use of soda ash under the subcategory 2.A.4.b and indicate, in CRF table 9, that emissions are reported under the subcategory other (chemical industry) (2.B.10)	FCCC/ARR/2017/ISL /I.3	This has been implemented / Done	IPPU Chapter
2.C.2	The ERT recommends that Iceland improve the transparency of its reporting of emissions from ferroalloys production by resolving the inconsistencies between the NIR and the CRF tables	FCCC/ARR/2017/ISL /I.4	This has been implemented / Done	IPPU Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
2.D	The ERT recommends that Iceland estimate and report the missing emissions from solvent use and resolve the inconsistencies between the NIR and the CRF tables for the category non-energy products from fuels and solvent use (2.D)	FCCC/ARR/2017/ISL /I.5	This has been implemented / Done	IPPU Chapter
2.F.1	The ERT recommends that Iceland improve the accuracy and transparency of its reporting by correcting the emission estimates for the subcategories refrigeration and air conditioning (2.F.1), and by resolving the inconsistencies between the NIR and the CRF tables	FCCC/ARR/2017/ISL /I.6	The 2F1 category will be thoroughly revised in 2019 in collaboration with consultants from Aether Ltd./ Planned Improvement.	IPPU Chapter
2.F.1	The ERT recommends that Iceland report the HFC and PFC emissions recovered for the subcategory refrigeration and air conditioning (2.F.1) separately from the emissions themselves	FCCC/ARR/2017/ISL /I.7	The 2F1 category will be thoroughly revised in 2019 in collaboration with consultants from Aether Ltd./ Planned Improvement.	IPPU Chapter
2.F.4	The ERT recommends that Iceland estimate HFC emissions from the subcategory metered dose inhalers (under aerosols (2.F.4)) using a methodology consistent with the 2006 IPCC Guidelines, and report the estimates	FCCC/ARR/2017/ISL /I.8	2F4 - MDI emissions were calculated using 2006 guidelines (equation 7.6, vol. 3, Chapter 7), as mentioned in Iceland´s 2017 NIR p. 91, paragraph 4.6.3.1. / Done	IPPU Chapter
2.G.1	The ERT recommends that Iceland estimate and report emissions from the category electrical equipment (2.G.1) using a methodology in accordance with the 2006 IPCC Guidelines	FCCC/ARR/2017/ISL /I.9	SF6 emissions are calculated using the only available data, which is on leakage refills (typically, we have information on amount of SF6 in kg leaked in year X which the companies derive from weighing of gas cylinders, as well as total amount of SF6 in equipment). / Done	IPPU Chapter
2	The ERT encourages Iceland to remove any reference to the IPCC good practice guidance from the NIR as no emissions under the IPPU sector are estimated using this guidance.	FCCC/ARR/2017/ISL /I.10	This has been implemented / Done	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/2017/ISL /I.11	All imported goods are registered by the Directorate of Customs and subsequently by Statistics Iceland. Therefore, no industrial use of carbonates is reported. If carbonates are imported, e.g. for manufacturing artistic ceramics, the quantity is very small and negligible. /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/2017/ISL /I.13	The F-gases will 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./ Planned Improvement.	IPPU Chapter
2.F.1	The ERT recommends that Iceland revise its estimates of HFC-23 emissions from manufacturing of commercial refrigeration.	FCCC/ARR/2017/ISL /I.14	This has been implemented / 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/2017/ISL /I.15	The 2G category will be thoroughly revised in 2019 in collaboration with consultants from Aether Ltd./ Planned Improvement.	IPPU Chapter

10.5.3 Agriculture (CRF Sector 3)

Iceland is working on an improvement plan to set up a system to update livestock productivity data, such as the digestible energy content of feed, gross energy intake and the Nitrogen excretion rate, on a regular basis.

Further planned improvements are to include more detailed explanations of activity data and emission factors in the enteric fermentation category and more information on the country-specific N excretion data. Information on indirect emissions from manure management, including N_2O emissions from nitrogen volatilized as ammonia and NOx and from nitrogen lost through leaching and run-off, will be also be improved. In the future, the party also aims to include information on the non-occurrence of field burning of agricultural crop residues as well as a comparison of the country-specific N2O EF for the cultivation of histosols with peer-reviewed studies.

Preliminary results have indicated an approximate amount of 200 tonnes of stabilized sewage sludge used in all Iceland in the year 2016. This was a substantial increase since 2012-2014 where the total in Iceland was estimated to have been around 25 tonnes. Sewage sludge cannot be used on agricultural land in Iceland without proper treatment. Its use in agriculture is therefore expected to be minimal. There have been complications regarding the gathering of the required data on sewage sludge and other organic fertilizers applied to soils and the issue will carried on and addressed in the 2020 submission. For the 2020 submission Iceland furthermore aims to estimate N_2O emissions from mineral soils. The emissions are, however, not expected to be significant.

Work will also continue on improving liming fertiliser data for coming submissions, for example information on import data. Improvements have already been made on completeness and consistency in the liming, urea and other carbon-containing fertilisers categories, which will be continued next year.

Table 10.7 Status of implementation in the Agriculture sector in response to UNFCCC´s review process.

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section 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/2017/ISL / A.1	No additional information on AD and Efs has been provided in the NIR since the previous submission. The Party is working on restructuring the NIR to include more details explanations on AD, EF and emission trends. / In progress	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/2017/ISL / A.2	The available information on the circumstances under which the country-specific N excretion data have been estimated will be included in the next submission. / Planned improvement	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	FCCC/ARR/2017/ISL / A.3	This issue is on the improvement plan for the next submission. The consistency issue will be checked and documentation will be improved. / Planned improvement	Agriculture Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	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			
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/2017/ISL / A.4	This issue is on the improvement plan for the next submission. / Planned improvement	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/2017/ISL / A.5	This issue is on the improvement plan for the next submission. / Planned improvement	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/2017/ISL / A.6	This issue is on the improvement plan for the future submissions. / Planned improvement	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/2017/ISL / A.7	More information on the non-occurrence of field burning of agricultural crop residues activity will be included in the future. / Planned improvement	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/2017/ISL / A.8	No additional information on AD and Efs has been provided in the NIR since the previous submission.The Party is working on restructuring the NIR to include more details explanations on AD, EF and emission trends. / In progress	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/2017/ISL / A.9	The Party is currently working on setting up an improvement plan for future submissions. It will include setting up a system to update productivity data on a regular basis. / Planned improvement	Agriculture Chapter
3.	The ERT recommends that Iceland report weighted average AD for feed intake, typical animal mass, VS excretion rates	FCCC/ARR/2017/ISL / A.10	No additional information on AD and Efs has been provided in the NIR since the previous	Agriculture Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	and Nex rates in the CRF tables and in the NIR, as used in the calculations.		submission.The Party is working on restructuring the NIR to include more details explanations on AD, EF and emission trends. / In progress	
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/2017/ISL / A.11	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/2017/ISL / A.12	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/2017/ISL / A.13	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/2017/ISL / A.14	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/2017/ISL / A.15	This has been updated. / Done	Agriculture Chapter
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/2017/ISL / A.16	This has been updated. / Done	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.17	This has been updated. / Done	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/2017/ISL / A.18	This information has been added to the NIR. / Done	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/2017/ISL / A.19	This has been updated. / Done	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	FCCC/ARR/2017/ISL / A.20	This has been updated. / Done	Agriculture Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	provide additional information that supports the use of other N2O EFs that may be more representative of manure management systems in Iceland.			
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/2017/ISL / A.21	The Party is currently working on setting up an improvement plan for future submissions. It will include setting up a system to update the Nex rate on a regular basis. / Planned improvement	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/2017/ISL / A.22	This has been updated. / Done	Agriculture Chapter
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/2017/ISL / A.23	Since this recommendation implies moving emissions from LULUCF (i.e., not counting towards Iceland's comittments under the Kyoto protocol) to Agriculture (i.e. Counting towards icelandic commitments under the Kyoto protocol), the issue is currently being adressed by the Ministry of the Environment and natural Resources. / Not resolved	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/2017/ISL / A.24	This has been done in collaboration with external sectoral experts. / Done	Agriculture Chapter

10.5.4 LULUCF (CRF Sector 4) and KP-LULUCF (CRF Sector 7)

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.

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.

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 et al. 2009, Arnalds and 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, 2016) potential emission and removal of greenhouse gasses from the category were identified and its range estimated. This report shows clearly the need to obtain better information on this land use category and its soils.

One component pinpointed in this report is the effects of soil thickening on C-sequestration. The aeolian deposition of sand and dust on soil of grassland, as well as other land use categories, causes soil thickening. On vegetated land this soil addition will accumulate, carbon in the end. The deposition rate of aeolian materials of different regions in Iceland has been estimated by (Arnalds 2010). The rate and variability of C-sequestration following this deposition is still not estimated. This potential carbon sink needs to be quantified and its variability mapped. The potential of the soil samples, collected in the IGLUD survey, to estimate this component will be explored.

Land converted to Grassland:

The planned improvements described above for drained areas of "Grassland remaining Grassland" also applies for drained area of this "Land converted to Grassland". New map of the drainage network presently in progress and expected to be finished in 2019 is expected to provide better estimate of recent changes in the ditches network, and thereby improved accuracy of the estimate of land converted to grassland on drained soils.

Maps of cropland in use are currently improving along with reformation of agricultural support payments. This improvement will enable better tracking of abandoned Cropland i.e. Cropland converted to Grassland or eventually to other categories.

Improvements in both the sequestration rate estimates and area recording for revegetation, aim at establishing a transparent, verifiable inventory of carbon stock changes accountable according to the Kyoto Protocol. It is expected that in the 2020 submission, all reclamation areas, both prior to and after 1990, will be revised, as well as the corresponding emission/removal factors, based on the ongoing NIRA update.

When implemented, these improvements will provide more accurate area and removal factor estimates for revegetation, subdivided according to management regime, regions and age.

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.

Settlements (4E)

There are no category specific planned improvements for this category.

Other land (4F)

No emissions are reported under this category.

Harvested Wood Products (4G)

There are no category specific planned improvements for this category.

Other (4H)

There are no category specific planned improvements for this category.

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

There are no category specific planned improvements for this category.

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.

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

There are no category specific planned improvements for this category.

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

There are no category specific planned improvements for this category

Biomass burning (4(V))

Recording of the area where controlled biomass burning is licensed is still not practiced. General awareness on the risk of controlled burning getting out of hand is presently rising and concerns are frequently expressed by municipal fire departments regarding this matter. Prohibition or stricter licenses on controlled burning can be expected in near future. This development might involve better recordkeeping on biomass burning.

Table 10.8 Status of implementation in the LULUCF 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/2017/ISL/L.1	Thank you for the recommendation, this will be considered for future submissions./This has not been estimated but will be done for next year´s submission.	LULUCF Chapter
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	FCCC/ARR/2017/ISL/L.2		LULUCF Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	used to derive the land representation			
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/2017/ISL/L.3	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	LULUCF Chapter
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/2017/ISL/L.4	Recommendation is appreciated. Although soil, litter and vegetation samples has been sampled from NFI plots no financial and man power resources for chemical analysis and further scientific processing does exist.	LULUCF Chapter
4.B.1	The ERT recommends that Iceland estimate and report carbon-stock changes in mineral soils under cropland remaining cropland	FCCC/ARR/2017/ISL/L.5		LULUCF Chapter
4.B.2	Report N_2O emissions from disturbances associated with land-use conversion to cropland	FCCC/ARR/2017/ISL/L.6		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/2017/ISL/L.7	Recommendation is appreciated. There is no systematic recordation of previous land use on land converted to cropland. All estimates are most likely to be pure guesswork. This will however be noted and included as planned improvements.	LULUCF Chapter
4.B.2	The ERT recommends that Iceland ensure the equivalence of climatic, historical and edaphic conditions when analysing pairs of samples (i.e. in cropland and grassland), to determine the dynamic of the soil carbon stocks associated with conversion among the two land uses	FCCC/ARR/2017/ISL/L.8	Recommendation is appreciated. The underlaying data will be explored to better ensure equivalence of the pairs of samples.	LULUCF Chapter
4.C	Prepare estimates for the emissions from degraded areas of grassland	FCCC/ARR/2017/ISL/L.9	Recommendation is appreciated. The preparation of this estimate has been initiated. Methodology needs further	LULUCF Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
			development and appropriate funding to be secured.	
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/2017/ISL/L.10	Recommendation is appreciated. Although soil, litter and vegetation samples has been sampled from NFI plots no financial and man power resources for chemical analysis and further scientific processing does exist.	LULUCF Chapter
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/2017/ISL/L.11	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	LULUCF Chapter
4.E.2	The ERT recommends that Iceland estimate and report carbon-stock changes in mineral soils under land converted to settlements	FCCC/ARR/2017/ISL/L.12	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	LULUCF Chapter
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/2017/ISL/L.13	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	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/2017/ISL/L.14		

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
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/2017/ISL/L.15		
4 Land representation	The ERT recommends that Iceland improve the land representation data used to report LULUCF emissions and removals under the Convention by reconciling all data on areas contained in databases and land-use maps, as well as data collected from observations, including an estimation of uncertainties related to AD once land matrices are improved and updated. The ERT further recommends that Iceland 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/2017/ISL/L.16		
4.A	The ERT recommends that Iceland improve the estimates of CSC under forest land, particularly by including estimates for the deadwood and litter carbon pools, or provide an explanation in the NIR and in CRF table 9 of why these pools could not be estimated.	FCCC/ARR/2017/ISL/L.17	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	
4.A.2	The ERT recommends that Iceland include transparent information in the NIR on the carbon stock in the Icelandic land-use categories. The ERT also recommends that Iceland implement the calculation methods in line with equations 2.15 and 2.16 of	FCCC/ARR/2017/ISL/L.18		

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	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.			
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/2017/ISL/L.19		
4.D.2.3	The ERT recommends that Iceland correct the statement in section 6.7.3.2 of the NIR referring to the reporting of aggregate CSC for mineral and organic soils so as to clarify that the value reported in CRF table 4.D as loss from mineral soils from land converted to wetlands consists of two subcategories (grassland converted to flooded land and other land converted to flooded land) and that CSC in mineral and organic soils are reported separately in the CRF tables.	FCCC/ARR/2017/ISL/L.20		
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/2017/ISL/L.21		

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
4(IV)	The ERT recommends that Iceland estimate and report indirect N2O emissions from managed soils, excluding those from agricultural lands that are reported in CRF table 3.D, and, in those cases where the notation key "IE" is used, indicate in the NIR and in the documentation box of the corresponding CRF table where in the inventory the emissions have been included and report information on the use of this notation in CRF table 9.	FCCC/ARR/2017/ISL/L.22		
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/2017/ISL/L.23		
4(KP)	The ERT recommends that Iceland improve the transparency of its reporting by providing information on how harvesting or forest disturbance that is followed by the re-establishment of a forest is distinguished from deforestation	FCCC/ARR/2017/ISL/KL.1	As described at page 240-241 in the NIR-2017 all permanent deforestation has to be reported to the forest authority and are in that way distinct from clear cutting fields.	KP-LULUCF Chapter
4(KP)	The ERT recommends that Iceland include in the NIR country-specific information on the associated forest management and afforestation and reforestation and background levels of emissions associated with annual disturbances, and information on margin and how to avoid the expectation of net credits or net debits during the commitment period, including through the use of a margin.	FCCC/ARR/2017/ISL/KL.2	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	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/2017/ISL/KL.3	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	KP-LULUCF Chapter

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
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/2017/ISL/KL.4	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	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/2017/ISL/KL.5		KP-LULUCF Chapter
4(KP).B.1	The ERT recommends that Iceland provide the technical correction to the FMRL in the next GHG inventory submission	FCCC/ARR/2017/ISL/KL.6	Technical correction will be conducted when the scientific papers related to the issue are published.	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/2017/ISL/KL.7	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	
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/2017/ISL/KL.8	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	
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	FCCC/ARR/2017/ISL/KL.9	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	afforestation lands has not yet occurred.			
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/2017/ISL/KL.10	Recommendation is appreciated. This is noted and will be included under planned improvements of the category	
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/2017/ISL/KL.11		
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/2017/ISL/KL.12	This is explained in the NIR.	

10.5.5 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.

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

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
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/ 2017/ISL/ W.1	The amount of waste deposited in solid waste disposal sites, categorized by type of waste, has been collected and is presented in the waste chapter. / Done	Waste Chapter - 7.2.2.3 Waste categories

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
5.A	Include in the NIR more information on landfill gas utilization (e.g. energy content of recovered gas, place of utilization)	FCCC/ARR/ 2017/ISL/ W.2	Relevant information is provided in the NIR (figure 7.5). Data on landfill gas recovery is delivered to EA in terms of CH_4 quantities, which is the relevant data. / Done	Waste Chapter - 7.2.4.2. Methane emissions, figure 7.5
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/ 2017/ISL/ W.3	Investigation of this issue revealed that there was insufficient justification of using a country specific value for the methane generation rate and half-life time for construction and demolition waste. Thus 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 recalculation were explained in the 2018 submission. / Done	Waste Chapter - 7.2 Solid Waste Disposal
5.A	The ERT recommends that Iceland correct the reference to the chapter of the NIR in which methane recovery from solid waste disposal on land is discussed	FCCC/ARR/ 2017/ISL/ W.4	This has been updated. / Done	Waste Chapter
5.A	The ERT recommends that Iceland report CO_2 emissions from the subcategories anaerobic managed waste disposal sites (5.A.1.a), unmanaged waste disposal sites (5.A.2) and uncategorized waste disposal sites (5.A.3) or, if the Party considers these emissions as insignificant, provide in the NIR sufficient information showing that the likely level of emissions meets the criteria in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines	FCCC/ARR/ 2017/ISL/ W.5	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. / Done	Waste Chapter
5.A.1	The ERT recommends that Iceland correct the inconsistency between the NIR and CRF table 5.A with regard to the amounts of CH_4 flared	FCCC/ARR/ 2017/ISL/ W.6	This has been updated. / Done	Waste Chapter
5.B.1	The ERT recommends that Iceland improve the transparency of its reporting by including information on the amount of waste composted for the whole time series in the NIR	FCCC/ARR/ 2017/ISL/ W.7	This has been updated. / Done	Waste Chapter
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	FCCC/ARR/ 2017/ISL/ W.8	Information on sludge removed and N-content in effluent has been added to the NIR (table 7.15), as well as information on where the emissions from sludge	Waste Chapter - 7.5.4.2. Nitrous Oxide, table 7.15

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	which category the resulting emissions are accounted for		removed are accounted for. / Done	
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/2017/ISL/W.9	This will be investigated for future submissions. / In progress	Waste Chapter
5.D	The ERT recommends that Iceland improve the transparency of its reporting by providing in the NIR the information used to estimate emissions from wastewater treatment and discharge, that is, population of the country, protein consumption and total organic matter in the wastewater, for the entire time series, and by ensuring this information is consistent between the NIR and the CRF tables	FCCC/ARR/2017/ISL/W.10	Information on the population of the country, protein consumption and total organic matter in the wastewater has been added to the NIR for this submission (table 7.12) / Done	Waste Chapter - 7.5.2 Activity data, table 7.12
5.D.2	The ERT recommends that Iceland correct the use of notation keys in the NIR to report CH_4 emissions from industrial wastewater and encourages Iceland to investigate the possibility to report CH_4 emissions from industrial wastewater and domestic wastewater separately	FCCC/ARR/2017/ISL/W.11	Notation keys for methane emissions industrial wastewater has been corrected to IE, and information has been added to the NIR (chapter 7.5.2.1) / Done	Waste Chapter - 7.5.2.1 Activity data
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 (5.B); CO2 emissions from domestic wastewater (5.D.1); and CO2 emissions from industrial wastewater (5.D.2).	FCCC/ARR/2017/ISL/W.12	Notation keys for the relevant categories have been changed; CO_2 emissions have been changed to "NO" in accordance with comment W.5 and N_2O emissions have been change to "NA". This can be seen in table 7.2. / Done	Waste chapter - 7.1.4 Completeness, table 7.2
5.B.1	The ERT recommends that Iceland estimate N2O emissions from composting using the default N2O EF for composting given in the ninth corrigenda for the 2006 IPCC Guidelines.	FCCC/ARR/2017/ISL/W.13	For the 2018 submission the emission factor for N2O was updated to 0.24 g/kg waste in accordance with the 2006 IPCC Guidelines. / Done	Waste chapter - 7.3.3 Emission factors

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 1990-2017. 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, 1955) (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 2020 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 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)) 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[11], 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)). These data were used to estimate C-stock changes in HWP (see above further descriptions in Chapter 6.11).

11.3.2.2 Revegetation

Losses in Revegetation are not specifically detected. The losses are assumed to be reflected as changes in the C-pool estimates of NIRA. Potential losses include losses in revegetated area, due to changes in land use. Losses in C-pools through grazing, biomass burning, and erosion are also recognized as potential. These losses are expected to be detected in the current NIRA upgrade and will be reported in future submissions.

11.3.2.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

No attempt is made to factor out indirect or natural GHG removals/emissions. This applies both for ARD, FM and Revegetation. Both AR and Revegetation have 1990 as base year. This short time window makes factoring out irrelevant.

11.3.2.4 Changes in data and methods since the previous submissions (Recalculations)

As explained in Chapter 6.4. 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 6.13).

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

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.

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 last year submission (Environment Agency of Iceland, 2018)and has not been updated in this year submission. Further technical correction will be done before 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 11.2) (Gunnarsson E., 2010; 2011; 2012; 2013; 2014; 2015; 2016; Gunnarsson & Brynleifsdóttir (2017))

Table 11.2 Annual wood production (in m^3 on bark) and sawnwood production (in m^3) in 1996 to 2016).

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

Year	Wood	Sawnwood
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

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 2017 has not yet been published. In the meantime, the sawnwood amount of 2017 is assumed to be the same as in 2016.

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 11.3 below shows the results of the key category analysis for Article 3.3 and Article 3.4 activities under the Kyoto Protocol.

Table 11.3 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 2017**	**Trend**
Article 3.3					
A.1	Afforestation and reforestation	CO_2		✓	
Article 3.4					
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 2018: 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, 2018.

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 2018. Iceland´s Standard Electronic Format (SEF) reports for 2018, for the second commitment period, are reported with the CRF data and NIR, and will be made available at the UNFCCC website[12]. 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

[12] 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

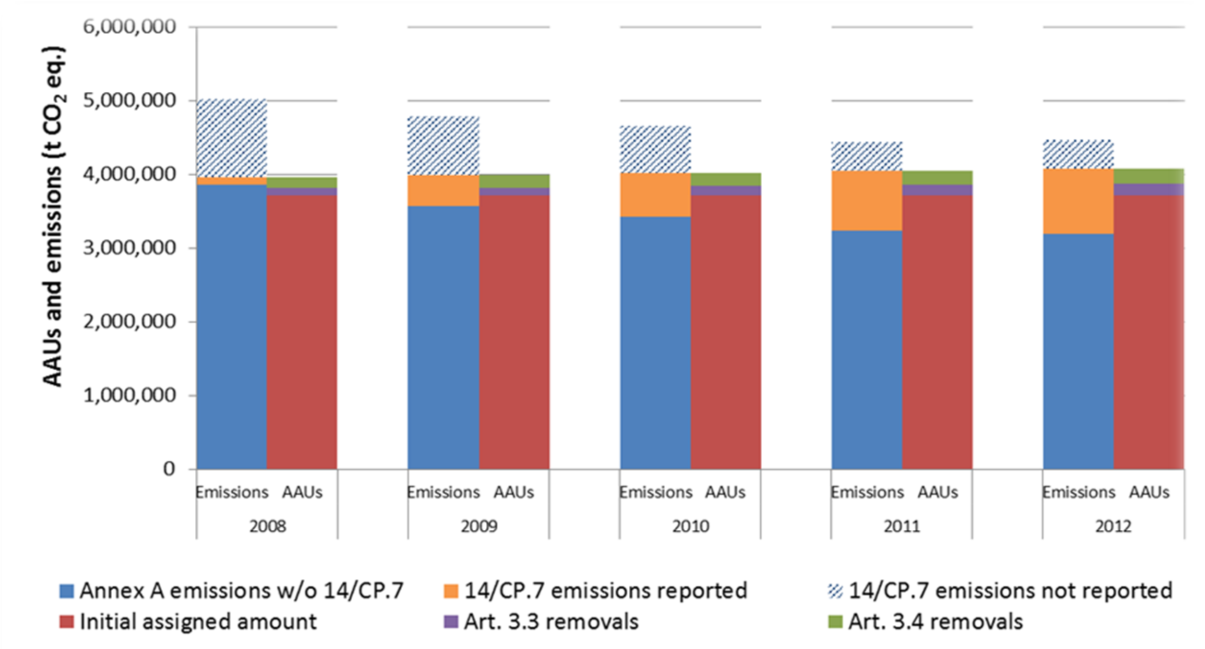

Figure 12.1 Summary of Kyoto accounting for CP1.

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[13]). 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.

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

Iceland's individual assigned amount was established at 15 327 217 assigned amount units (AAUs), in accordance with the notification of the terms of the agreement to fulfil the commitment jointly by the EU, its Member States, and Iceland (Council Decision (EU) 2015/1339).

12.2 Summary of Information Reported in the SEF Tables

Article 3 in part I 'General reporting instruction', to Annex 'Standard electronic format for reporting of information on Kyoto Protocol units', of decision 15CMP.1 says: … "each Annex I Party shall submit the SEF in the year following the calendar year in which the Party first transferred or acquired Kyoto Protocol units".

There were 18,420,881 AAUs from CP1 in Iceland's national registry at the end of the year 2018, 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 2018, 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 2017 SEF tables for second commitment period were submitted in March 2019. 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 2017.

Table 12.2 Discrepancies and notifications in 2018.

Annual Submission Item	Reporting Information
15/CMP.1 Annex 1.E paragraph 12: **List of discrepant transactions**	No discrepant transaction occurred in 2018
15/CMP.1 Annex 1.E paragraph 13 & 14: **List of CDM notifications**	No CDM notifications occurred in 2018
15/CMP.1 Annex 1.E paragraph 15: **List of non-replacements**	No non-replacements occurred in 2018
15/CMP.1 Annex 1.E paragraph 16: **List of invalid units**	No invalid units exist as of 31 December 2018
15/CMP.1 Annex 1.E paragraph 17: **Actions and changes to address discrepancies**	No discrepant transactions occurred in 2018

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 × 4,669,337 tonnes CO_2 equivalent
= 37,354,696tonnes 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 2018.

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 Calculated RMUs (in t CO_2e) from Art. 3.3 and Art. 3.4 activities for the first five years of 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 five years of CP2.

	2013	2014	2015	2016	2017
Article 3.3					
A.1 Afforestation/Reforestation	-185,447	-206,279	-227,432	-232,854	-258,847
A.2 Deforestation	155	111	647	269	462
Article 3.4					
B.1 Forest Management	-2,782	-5,970	-9,705	-14,627	-9,727
B.4 Revegetation	-199,815	-209,274	-219,634	-227,821	-245,131
Total RMUs	**-387,889**	**-421,413**	**-456,125**	**-475,034**	**-513,244**

13 Information on Changes in National System

No changes have been made in the National System since the 2018 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[14] 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.

Table 13.1 Table with summaries off 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 fulfill 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

[14] 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 righ**t - 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.	

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 2018. Note that the 2018 SIAR confirms that previous recommendations have been implemented and included in the annual report.

Table 14.1 Changes in the National Registry in 2017.

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**	The version of the EUCR released after 8.0.8 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was 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**	Changes introduced since version 8.0.8 of the national registry are listed in Annex B. 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 were successfully 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**	The registry internet address changed during the reported period. The new URL is https://unionregistry.ec.europa.eu/euregistry/IS/index.xhtml
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**	Changes introduced since version 8.0.8 of the national registry are listed in Annex B. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission.

15 Information on Minimization of Adverse Impacts in Accordance with Article 3, Paragraph 14 of the Kyoto Protocol

Actions	Implementation
The 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, in pursuit of the objective of the Convention	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	Icelandic researchers cooperate with French and U.S. colleagues on an experimental project (CarbFix) that is under way at the Hellisheiði geothermal plant, injecting CO_2 captured in geothermal steam back into the basaltic rock underground. The aim of the Carbfix Project is to study the feasibility of sequestering the greenhouse-gas 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.
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	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.
Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies	Iceland does not have support activities in this field.

16 References

Legislation

European

Council Decision (EU) 2015/1339 of 13 July 2015 on the conclusion, on behalf of the European Union, of the Doha Amendment to the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments thereunder OJ L 207, 4.8.2015, p. 1–5

Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC Text with EEA relevance *OJ L 165, 18.6.2013, p. 13–40*

Commission Implementing Regulation (EU) No 749/2014 of 30 June 2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council *OJ L 203, 11.7.2014, p. 23–90*

Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC *OJ L 275, 25.10.2003, p. 32–46*

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives OJ L 312, 22.11.2008, p. 3–30

Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 Text with EEA relevance *OJ L 150, 20.5.2014, p. 195–230*

Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases *OJ L 161, 14.6.2006, p. 1–11*

National (all in Icelandic)

3/1955 Lög um skógrækt – “Forestry Act”

70/2012 Lög um loftslagsmál – “Climate Act”

62/2015 Lög um breytingu á lögum um loftslagsmál, nr. 70/2012, með síðari breytingum (EES-reglur, geymsla koldíoxíðs, vistvæn ökutæki, Kyoto-bókunin). – “Act amending the Climate Act, no. 70/2012, with subsequent amendments (EEA regulations, storage of carbon dioxide, eco-friendly vehicles, Kyoto Protocol”

48/2007 Lög um breytingu á lögum nr. 87/2003, um Orkustofnun. – “Act amending Act no. 87/2003, on the National Energy Authority”

230/1998 Reglugerð um tiltekin efni sem stuðla að auknum gróðurhúsaáhrifum. – “Regulation on certain substances that contribute to increased greenhouse effect”

851/2002 Reglugerð um grænt bókhald. – “Regulation about Green Accounting”

244/2009 Reglugerð um skil atvinnurekstrar á upplýsingum um losun gróðurhúsalofttegunda. – “Regulation on the provision of information on greenhouse gas emissions to business operators”

834/2010 Reglugerð um flúoraðar gróðurhúsalofttegundir – “Regulation on fluorinated greenhouse gases”

520/2017 Reglugerð um gagnasöfnun og upplýsingagjöf stofnana vegna bókhalds Íslands yfir losun gróðurhúsalofttegunda og bindingu kolefnis úr andrúmslofti. – “Regulation of data collection and reporting of agencies for Icelands accounting of greenhouse gas emissions and carbon sequestration from the atmosphere”

Other:

Nielsen, O.-K., Plejdrup, M. S., Winther, M., Nielsen, M., Gyldenkærne, S., Mikkelsen, M., . . . Gunnleivsdóttir Hansen, M. (2018). *Denmark's National Inventory Report 2018. Emission Inventories 1990-2016.* Aarhus University, Danish Centre for Environment and Energy. Danish Centre for Environment and Energy. Von https://dce2.au.dk/pub/SR272.pdf abgerufen

Alþingi. (1955). *Lög um skógrækt nr. 3 6. mars.*

Alþingi. (2012). *Lög um loftslagsmál nr. 70/2012.* Lagasafn. Íslensk lög 15. september 2015. Útgáfa 144b. (In Icelandic).

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

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

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

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

Arnalds, Ó., Guðbergsson, G., & Guðmundsson, J. (2000). Carbon sequestration and reclamation of severely degraded soils in Iceland. *Búvísindi, 13*, 89-97.

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

Arnalds, Ó., Thorarinsdóttir, E., Metúsalemsson, S., Jónsson, Á., Gretarsson, E., & Árnason, A. (2001). *Soil Erosion in Iceland.* Reykjavík: Soil Conservation Service, Agricultural Research Institute.

ASHRAE. (1992). *Standard 34-1992 Number Designation and Safety Classification of Refrigerants.* ATLANTA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, INC. Abgerufen am 2019 von ashrae.iwrapper.com/ViewOnline/Standard_34-1992

Baldvinsson, Í., Þórisdóttir, Þ., & Ketilsson, J. (2011). *Gaslosun jarðvarmavirkjana á Íslandi 1970-2009.* Orkustofnun - National Energy Authority. Von www.os.is: http://www.os.is/gogn/Skyrslur/OS-2011/OS-2011-02.pdf abgerufen

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

Bossard, M., Feranec, J., & Otahel, J. (2000). *CORINE land cover technical guide - Addendum 2000.* Copenhagen: European Environment Agency. Von http://www.eea.europa.eu/publications/tech40add abgerufen

Carbon Recycling International. (2018). *Carbon Recycling International*. Von carbonrecycling.is/ abgerufen

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

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

Danish Center for Environment and Energy. (2016). *Denmark's National Inventory Report 2015 and 2016.* DCE.

Dugmore, A. J., Gisladottir, G., Simpson, I. A., & Newton, A. (2009). Conceptual Models of 1200 Years of Icelandic Soil Erosion Reconstructed Using Tephrochronology. *Journal of the North Atlantic*, 1-18.

Environment Agency of Iceland. (2016). *National Inventory Report: Emissions of Greenhouse Gases in Iceland 1990-2014.* The Environment Agency of Iceland.

Environment Agency of Iceland. (2017). *National Inventory Report: Emissions of Greenhouse Gases in Iceland 1990-2015.* The Environment Agency of Iceland.

Environment Agency of Iceland. (2018). *National Inventory Report 1990-2016.* Reykjavik.

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

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

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

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

Gísladottir, F., Guðmundsson, J., & Áskelsdóttir, S. (2010). Mapping and density analyses of drainage ditches in Iceland. *Mapping and monitoring of Nordic Vegetation and landscapes.* Hveragerði: Norsk Insitute for Skog og landskap.

Gísladóttir, F. Ó., Brink, S. H., & Arnalds, Ó. (2014). *Nytjaland.* Landbúnaðarháskóli Íslands, Rit Lbhí nr. 49.

Gísladóttir, F. Ó., Metúsalemsson, S., & Óskarsson, H. (2007). Áhrifasvæði skurða: Greining með fjarkönnunaraðferðum. *Fræðaþing landbúnaðarins*, *4*, S. 371-376. Reykjavík.

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

Gísladóttir, F., Gudmundsson, J., & Áskelsdóttir, S. (2010). Mapping and density analyses of drainage ditches in Iceland. *Mapping and monitoring of Nordic Vegetation and landscapes - Norsk Institute for skog og landskap*, (S. 43-46). Hveragerði.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Icelandic Ministry for the Environment. (2010). *Aðgerðaáætlun í loftslagsmálum (Climate Change Action Plan).* Reykjavík: Ministry for the Environment and Natural Resources.

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

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

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

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

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

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

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

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

Jónmundsson, J. V., & Eyþórsdóttir, E. (2013). Erfðir og kynbætur sauðfjár. In R. Sigurðardóttir, *Sauðfjárrækt á Íslandi.* Reykjavík: Uppheimar.

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

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

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

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

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

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

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

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

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

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

NEA. (2016). *Gas Emissions of Geothermal Power Plants and Utilities 1969-2016*. Von The National Energy Authority: http://os.is/gogn/Talnaefni/OS-2017-T012-01.pdf abgerufen

Netherlands National Waterboard. (2008). *Emission estimates for diffuse sources, Netherlands Emission Inventory, Letting off fireworks.* Netherlands National Waterboard, Water Unit in cooperation with DELTARES and TNO. Von http://www.emissieregistratie.nl/erpubliek/documenten/Water/Factsheets/English/Fireworks.pdf abgerufen

Orkustofnun. (2018). *Gas Emissions of Geothermal Power Plants and Utilities 1969-2017.* Reykjavík: Orkustofnun. Von https://orkustofnun.is/gogn/Talnaefni/OS-2018-T003-02.pdf abgerufen

Orkustofnun. (2018). *Primary Energy Use in Iceland 1940-2017.* Reykjavík: Orkustofnun. Von https://orkustofnun.is/gogn/Talnaefni/OS-2018-T009-01.pdf abgerufen

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

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

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

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

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

Óskarsson, H., Arnalds, Ó., Guðmundsson, J., & Guðbergsson, G. (2004). Organic carbon in Icelandic Andosols: geographical variation and impact of erosion. *Catena, 56*(1-3), 225-238.

Óskarsson, M., & Eggertsson, M. (1991). *Áburðarfræði.* Reykjavík: Búnaðarfélag Íslands.

Raynolds, M., Magnusson, B., Metusalemsson, S., & Magnusson, S. H. (2015). Warming, Sheep and Volcanoes: Land Cover Changes in Iceland Evident in Satellite NDVI Trends. *Remote Sensing 7 (8)*, 9492-9506.

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

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

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

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

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

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

Sigurðsson, H. M. (2002). *Vatnsaflsvirkjanir á Íslandi.* Reykjavík: Verkfræðistofa Sigurðar Thoroddssen.

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

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

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

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

Snorrason, A., & Kjartansson, B. (2004). Íslensk skógarúttekt. Verkefni um landsúttekt á skóglendum á Íslandi. Kynning og fyrstu niðurstöður. *Skógræktarritið, 2*, S. 101-108.

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

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

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

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

Snæbjörnsson, A. H. (kein Datum). *Skýrsla nefndar um landnotkun. Athugun á notkun og varðveislu ræktanlegs lands.* Reykjavík: Sjávarútvegs- og Landbúnaðarráðuneytið.

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

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

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

Statistics Norway. (2011). *The Norwegian Emission Inventory.* Statistics Norway. Von https://www.ssb.no/a/english/publikasjoner/pdf/doc_201121_en/doc_201121_en.pdf abgerufen

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

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

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

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

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

Þórarinsson, Þ. (1974). Þjóðin lifði en skógurinn dó. *Ársrit Skógræktarfélags Íslands*, 16-29.

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

Annexes to the national inventory report

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 sources. Tables A1, A2 and A3 show the 1990 level, 2017 level and 1990-2017 trend assessment without LULUCF, and Table A4, A5 and A6 show the 1990 level, 2017 level and 1990-2017 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 CO2e, 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	20.5%	20.5%
1A3b	Road Transport	CO_2	509	14.1%	34.7%
2C3	Metal Production - aluminium Production	PFCs	495	13.7%	48.4%
1A2	Manufacturing Industries & Construction	CO_2	362	10.1%	58.5%
2C2	Metal Production - Ferroalloys	CO_2	209	5.8%	64.3%
3A2	Enteric Fermentation - Sheep	CH_4	173	4.8%	69.1%
3D1	Direct N2O emissions from managed soils	N_2O	170	4.7%	73.8%
2C3	Metal Production - aluminium Production	CO_2	139	3.9%	77.7%
5A2	Unmanaged waste disposal sites	CH_4	139	3.9%	81.5%
3A1	Enteric Fermentation - Cattle	CH_4	106	2.9%	84.5%
1B2d	Other emission from Energy Production - Geothermal	CO_2	61	1.7%	86.2%
1A3d	Water - borne Navigation	CO_2	60	1.7%	87.8%
2A1	Cement Production	CO_2	52	1.4%	89.3%
2B10	Other: Ferilizer production	N_2O	46	1.3%	90.6%
3A4 horses	Enteric Fermentation - Horses	CH_4	33	0.9%	91.5%
3D2	Indirect N2O emissions from managed soils	N_2O	33	0.9%	92.4%
1A3a	Domestic Aviation	CO_2	32	0.9%	93.3%
1A4b	Residential	CO_2	31	0.9%	94.1%
3B11	Manure Management - Cattle	CH_4	28	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 2017 in kt CO_2e, excluding LULUCF.

IPCC category code	IPCC category	Gas	2017 Emissions (kt CO_2e)	Level assessment (%)	Cumulative total of level (%)
2C3	Metal Production - aluminium Production	CO_2	1,324	27.9%	27.9%
1A3b	Road Transport	CO_2	934	19.6%	47.5%
1A4c	Agriculture/Fishing	CO_2	528	11.1%	58.6%
2C2	Metal Production - Ferroalloys	CO_2	428	9.0%	67.6%
2F1	Product Uses as Substitutes for ODS -Refrigeration and stationary air-conditioning	HFCs	192	4.0%	71.6%
5A1	Managed waste disposal sites	CH_4	179	3.8%	75.4%
1A2	Manufacturing Industries & Construction	CO_2	167	3.5%	78.9%
3D1	Direct N2O emissions from managed soils	N_2O	163	3.4%	82.3%
1B2d	Other emission from Energy Production - Geothermal	CO_2	146	3.1%	85.4%
3A2	Enteric Fermentation - Sheep	CH_4	145	3.0%	88.5%
3A1	Enteric Fermentation - Cattle	CH_4	122	2.6%	91.0%
2C3	Metal Production - aluminium Production	PFCs	68	1.4%	92.5%
1A3b	Road Transport	N_2O	38	0.8%	93.3%
3A4 horses	Enteric Fermentation - Horses	CH_4	33	0.7%	94.0%
3D2	Indirect N2O emissions from managed soils	N_2O	33	0.7%	94.7%
1A3d	Water - borne Navigation	CO_2	32	0.7%	95.3%
3B11	Manure Management - Cattle	CH_4	31	0.6%	96.0%

Table A1. 3 Key category analysis approach 1 1990-2017 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 (2017) 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	1,324	0.182	29.3%	29.3%
2C3	Metal Production - aluminium Production	PFCs	495	68	0.093	15.0%	44.3%
1A4c	Agriculture/Fishing	CO_2	738	528	0.071	11.5%	55.8%
1A2	Manufacturing Industries & Construction	CO_2	362	167	0.050	8.0%	63.8%
1A3b	Road Transport	CO_2	509	934	0.042	6.7%	70.5%
2F1a	Product Uses as Substitutes for ODS -Refrigeration and stationary air-conditioning	HFCs	0	192	0.031	4.9%	75.4%
5A2	Unmanaged waste disposal sites	CH_4	139	26	0.025	4.0%	79.4%
5A1	Managed waste disposal sites	CH_4	19	179	0.025	4.0%	83.4%
2C2	Metal Production - Ferroalloys	CO_2	209	428	0.024	3.9%	87.3%
3A2	Enteric Fermentation - Sheep	CH_4	173	145	0.013	2.2%	89.5%
1B2d	Other emission from Energy Production - Geothermal	CO_2	61	146	0.010	1.7%	91.1%
3D1	Direct N2O emissions from managed soils	N_2O	170	163	0.010	1.6%	92.7%
1A3d	Water - borne Navigation	CO_2	60	32	0.008	1.2%	93.9%
1A4b	Residential	CO_2	31	12	0.005	0.7%	94.7%
1A4a	Commercial/Institutional	CO_2	16	1	0.003	0.5%	95.2%
1A3a	Domestic Aviation	CO_2	32	23	0.003	0.5%	95.7%

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	3,251	20.4%	20.4%
4C1	Grassland remaining Grassland	CO_2	3,130	19.6%	40.0%
4C2	Land Converted to Grassland	CO_2	1,757	11.0%	51.0%
4D1	Wetlands remaining Wetlands	CO_2	-1,433	9.0%	60.0%
4B1	Cropland remaining Cropland	CO_2	1,217	7.6%	67.6%
1A4c	Agriculture/Fishing	CO_2	738	4.6%	72.2%
4B2	Land Converted to Cropland	CO_2	635	4.0%	76.2%
1A3b	Road Transport	CO_2	509	3.2%	79.4%
2C3	Metal Production - aluminium Production	PFCs	495	3.1%	82.5%
4(II) - Grassland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	374	2.3%	84.8%
1A2	Manufacturing Industries & Construction	CO_2	362	2.3%	87.1%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	209	1.3%	88.4%
2C2	Metal Production - Ferroalloys	CO_2	209	1.3%	89.7%
3A2	Enteric Fermentation - Sheep	CH_4	173	1.1%	90.8%
3D1	Direct N2O emissions from managed soils	N_2O	170	1.1%	91.9%
2C3	Metal Production - aluminium Production	CO_2	139	0.9%	92.8%
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	106	0.7%	95.0%
4(II) - Cropland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	95	0.6%	95.6%

Table A1. 5 Key category analysis approach 1 level for 2017 in kt CO_2e, including LULUCF

IPCC category code	IPCC category	Gas	2017 Emissions or Removals (kt CO_2e)	Level assessment (%)	Cumulative total of level (%)
4C1	Grassland remaining Grassland	CO_2	5,351	30.6%	30.6%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	3,127	17.9%	48.4%
4B1	Cropland remaining Cropland	CO_2	1,491	8.5%	56.9%
4D1	Wetlands remaining Wetlands	CO_2	-1,372	7.8%	64.7%
2C3	Metal Production - aluminium Production	CO_2	1,324	7.6%	72.3%
1A3b	Road Transport	CO_2	934	5.3%	77.6%
1A4c	Agriculture/Fishing	CO_2	528	3.0%	80.7%
4(II) - Grassland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	432	2.5%	83.1%
2C2	Metal Production - Ferroalloys	CO_2	428	2.4%	85.6%
4A2	Land converted to Forest Land	CO_2	-313	1.8%	87.4%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	200	1.1%	88.5%
2F1a	Product Uses as Substitutes for ODS -Refrigeration and stationary air-conditioning	HFCs	192	1.1%	89.6%
5A1	Managed waste disposal sites	CH_4	179	1.0%	90.6%
1A2	Manufacturing Industries & Construction	CO_2	167	1.0%	91.6%
3D1	Direct N2O emissions from managed soils	N_2O	163	0.9%	92.5%
1B2d	Other emission from Energy Production - Geothermal	CO_2	146	0.8%	93.3%
3A2	Enteric Fermentation - Sheep	CH_4	145	0.8%	94.2%
4(II) - Grassland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	128	0.7%	94.9%
3A1	Enteric Fermentation - Cattle	CH_4	122	0.7%	95.6%

Table A1. 6 Key category analysis approach 1 1990-2017 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 (2017) Estimate $E_{x,t}$ (kt CO_2e)	Trend Assessment $T_{x,t}$	Contribution to Trend (%)	Cumulative Total of trend (%)
4C1	Grassland remaining Grassland	CO_2	3,130	5,351	0.100	20.9%	20.9%
4C2	Land Converted to Grassland	CO_2	1,757	40	0.098	20.6%	41.4%
2C3	Metal Production - aluminium Production	CO_2	139	1324	0.061	12.8%	54.2%
4B2	Land Converted to Cropland	CO_2	635	91	0.032	6.6%	60.8%
2C3	Metal Production - aluminium Production	PFCs	495	68	0.025	5.2%	65.9%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	3,251	3,127	0.023	4.8%	70.7%
1A3b	Road Transport	CO_2	509	934	0.020	4.1%	74.8%
4A2	Land converted to Forest Land	CO_2	-27	-313	0.015	3.1%	77.9%
1A4c	Agriculture/Fishing	CO_2	738	528	0.015	3.1%	81.0%
1A2	Manufacturing Industries & Construction	CO_2	362	167	0.012	2.5%	83.5%
4D1	Wetlands remaining Wetlands	CO_2	-1,433	-1,372	0.010	2.2%	85.7%
2C2	Metal Production - Ferroalloys	CO_2	209	428	0.010	2.2%	87.9%
2F1a	Product Uses as Substitutes for ODS -Refrigeration and stationary air-conditioning	HFCs	0	192	0.010	2.1%	89.9%
5A1	Managed waste disposal sites	CH_4	19	179	0.008	1.7%	91.7%
4B1	Cropland remaining Cropland	CO_2	1,217	1,491	0.008	1.7%	93.4%
5A2	Unmanaged waste disposal sites	CH_4	139	26	0.007	1.4%	94.7%
1B2d	Other emission from Energy Production - Geothermal	CO_2	61	146	0.004	0.9%	95.6%

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

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 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	1.67	5.0%	5.0%	7.1%	7.8E-11	2.5E-02	1.4E-02	1.3E-03
1A1aiii Public electricity and heat production (heat plants)	CO_2	9.34	0.11	5.0%	5.0%	7.1%	3.4E-13	8.1E-02	8.9E-04	4.0E-03
1A2a Iron and Steel	CO_2	0.36	0.96	1.5%	5.0%	5.2%	1.4E-11	2.3E-03	7.8E-03	1.2E-04
1A2b Non-Ferrous Metals	CO_2	13.50	7.64	1.5%	5.0%	5.2%	8.9E-10	2.8E-02	6.2E-02	1.4E-03
1A2c Chemicals	CO_2	7.43	NO	5.0%	5.0%	7.1%	0.0E+00	3.3E-02	0.0E+00	1.6E-03
1A2e Food Processing, Beverages and Tobacco	CO_2	128.24	16.92	5.0%	5.0%	7.1%	8.0E-09	4.9E-01	1.4E-01	2.5E-02
1A2f Non-metallic minerals	CO_2	50.32	0.39	5.0%	5.0%	7.1%	4.3E-12	2.2E-01	3.2E-03	1.1E-02
1A2g Other manufacturing industries and Constructions	CO_2	161.82	140.99	5.0%	5.0%	7.1%	5.6E-07	1.4E-01	1.1E+00	7.2E-03
1A3a Domestic Aviation	CO_2	31.73	22.96	5.0%	5.0%	7.1%	1.5E-08	4.8E-02	1.9E-01	2.4E-03
1A3b Road Transport	CO_2	508.89	933.95	5.0%	5.0%	7.1%	2.4E-05	1.6E+00	7.6E+00	7.8E-02
1A3d Domestic Water - borne Navigation	CO_2	59.83	31.51	5.0%	5.0%	7.1%	2.8E-08	1.4E-01	2.6E-01	6.9E-03
1A4a Commercial/Institutional	CO_2	16.24	0.83	5.0%	5.0%	7.1%	1.9E-11	7.0E-02	6.7E-03	3.5E-03
1A4b Residential	CO_2	30.64	11.66	5.0%	5.0%	7.1%	3.8E-09	9.0E-02	9.4E-02	4.5E-03
1A4c Agriculture/Fishing	CO_2	738.31	527.64	5.0%	5.0%	7.1%	7.8E-06	1.1E+00	4.3E+00	5.7E-02
1B2a5 Oil - Distribution of oil products	CO_2	0.002	0.003	5.0%	5.0%	7.1%	5.8E-16	6.5E-06	3.7E-05	3.3E-07
1B2d Other emission from Energy Production	CO_2	61.36	146.47	10.0%	0.0%	10.0%	1.2E-06	3.5E-01	1.2E+00	0.0E+00
2A1 Cement Production	CO_2	51.56	0.00	5.0%	6.5%	8.2%	0.0E+00	2.5E-01	0.0E+00	1.6E-02
2A4d Other: Mineral Wool Production	CO_2	0.70	0.90	2.4%	2.0%	3.1%	4.4E-12	6.4E-04	7.3E-03	1.3E-05
2B10 Other: Silica production	CO_2	0.36	NO	3.0%	1.0%	3.2%	0.0E+00	1.7E-03	0.0E+00	1.7E-05
2C1 Metal Production - Iron and steel	CO_2	NO	0.00	10.0%	25.0%	26.9%	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2C2 Metal Production - Ferroalloys	CO_2	208.80	428.32	1.5%	3.0%	3.4%	1.2E-06	8.8E-01	3.5E+00	2.6E-02

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
2C3 Metal Production - Aluminium Production	CO_2	139.21	1,324.46	1.5%	3.0%	3.4%	1.1E-05	5.2E+00	1.1E+01	1.6E-01
2D1 Lubricants	CO_2	4.06	2.08	10.0%	50.1%	51.1%	6.4E-09	9.3E-03	1.7E-02	4.7E-03
2D2 Paraffin wax use	CO_2	0.31	0.35	10.0%	100.0%	100.5%	6.8E-10	1.3E-04	2.8E-03	1.3E-04
2D3 Solvents	CO_2	2.62	2.72	59.0%	170.0%	179.9%	1.3E-07	9.9E-05	2.2E-02	1.7E-03
2G4b Other: Fireworks	CO_2	0.01	0.03	11.3%	50.0%	51.3%	1.0E-12	8.9E-05	2.1E-04	4.5E-05
3G Liming	CO_2	0.00	2.31	20.0%	0.0%	20.0%	1.2E-09	1.0E-02	1.9E-02	0.0E+00
3H Urea application	CO_2	0.06	2.55	20.0%	0.0%	20.0%	1.5E-09	1.1E-02	2.1E-02	0.0E+00
5C Incineration and Open Burning of waste	CO_2	7.30	7.08	52.0%	40.0%	65.6%	1.2E-07	1.9E-03	5.7E-02	7.4E-04
1A1ai Public electricity and heat production (electricity generation)	CH_4	0.005	0.002	5.0%	100.0%	100.1%	1.6E-14	1.3E-05	1.4E-05	1.3E-05
1A1aiii Public electricity and heat production (heat plants)	CH_4	0.009	0.0001	5.0%	100.0%	100.1%	6.3E-17	4.1E-05	8.6E-07	4.1E-05
1A2a Iron and Steel	CH_4	0.0004	0.001	1.5%	100.0%	100.0%	5.3E-15	2.7E-06	7.9E-06	2.7E-06
1A2b Non-Ferrous Metals	CH_4	0.012	0.007	1.5%	100.0%	100.0%	2.7E-13	2.6E-05	5.7E-05	2.6E-05
1A2c Chemicals	CH_4	0.007	NO	5.0%	100.0%	100.1%	0.0E+00	3.3E-05	0.0E+00	3.3E-05
1A2e Food Processing, Beverages and Tobacco	CH_4	0.124	0.017	5.0%	100.0%	100.1%	1.6E-12	4.9E-04	1.4E-04	4.9E-04
1A2f Non-metallic minerals	CH_4	0.128	0.0004	5.0%	100.0%	100.1%	8.8E-16	5.9E-04	3.2E-06	5.9E-04
1A2g Other manufacturing industries and Constructions	CH_4	0.21	0.19	5.0%	100.0%	100.1%	1.9E-10	1.3E-04	1.5E-03	1.3E-04
1A3a Domestic Aviation	CH_4	0.01	0.004	5.0%	100.0%	100.1%	9.1E-14	7.6E-06	3.3E-05	7.6E-06
1A3b Road Transport	CH_4	3.77	2.67	5.0%	200.0%	200.1%	1.6E-07	5.3E-03	2.2E-02	1.1E-02
1A3d Domestic Water - borne Navigation	CH_4	0.14	0.07	5.0%	100.0%	100.1%	3.1E-11	3.1E-04	6.0E-04	3.1E-04
1A4a Commercial/Institutional	CH_4	1.01	0.002	5.0%	100.0%	100.1%	3.0E-14	4.6E-03	1.9 -05	4.6E-03
1A4b Residential	CH_4	0.10	0.03	5.0%	100.0%	100.1%	6.4E-12	3.2E-04	2.7E-04	3.2E-04
1A4c Agriculture/Fishing	CH_4	1.73	1.24	5.0%	100.0%	100.1%	8.6E-09	2.4E-03	1.0E-02	2.4E-03

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 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 (%)
1B2a5 Oil - Distribution of oil products	CH_4	0.49	0.70	5.0%	100.0%	100.1%	2.8E-09	9.1E-04	5.7E-03	9.1E-04
1B2d Other emission from Energy Production	CH_4	0.20	2.63	25.0%	0.0%	25.0%	2.4E-09	1.1E-02	2.1E-02	0.0E+00
2C2 Metal Production - Ferroalloys	CH_4	1.57	3.13	1.5%	100.0%	100.0%	5.5E-08	6.7E-03	2.5E-02	6.7E-03
2G4a Other: Tobacco combustion	CH_4	0.04	0.02	11.3%	50.0%	51.3%	5.0E-13	1.2E-04	1.5E-04	6.1E-05
2G4b Other: Fireworks	CH_4	0.003	0.01	11.3%	50.0%	51.3%	2.3E-13	4.3E-05	1.0E-04	2.1E-05
3A1 Enteric Fermentation - Cattle	CH_4	105.89	121.70	5.0%	40.0%	40.3%	1.4E-05	5.7E-02	9.9E-01	2.3E-02
3A2 Enteric Fermentation - Sheep	CH_4	173.36	144.85	5.0%	40.0%	40.3%	1.9E-05	1.5E-01	1.2E+00	6.0E-02
3A3 Enteric Fermentation - Swine	CH_4	1.12	1.62	20.0%	40.0%	44.7%	2.9E-09	2.1E-03	1.3E-02	8.5E-04
3A4 goats Enteric Fermentation - Goats	CH_4	0.06	0.24	20.0%	40.0%	44.7%	6.3E-11	7.9E-04	1.9E-03	3.2E-04
3A4 horses Enteric Fermentation - Horses	CH_4	33.24	33.23	20.0%	40.0%	44.7%	1.2E-06	4.4E -03	2.7E-01	1.8E-03
3A4 other Enteric Fermentation - other - Fur animals	CH_4	0.12	0.09	20.0%	40.0%	44.7%	8.2E-12	1.7E-04	6.9E-04	6.7E-05
3A4 poultry Enteric Fermentation - Poultry	CH_4	0.34	0.42	20.0%	40.0%	44.7%	2.0E-10	3.2E-04	3.4E-03	1.3E-04
3B11 Manure Management - Cattle	CH_4	28.49	30.76	11.2%	20.0%	22.9%	2.8E-07	6.5E-03	2.5E-01	1.3E-03
3B12 Manure Management - Sheep	CH_4	13.55	11.33	25.5%	20.0%	32.4%	7.6E-08	1.2E-02	9.2E-02	2.4E-03
3B13 Manure Management - Swine	CH_4	4.47	6.48	20.0%	30.0%	36.1%	3.1E-08	8.6E-03	5.3 -02	2.6E-03
3B14 goats Manure Management - Goats	CH_4	0.001	0.01	20.0%	30.0%	36.1%	2.4E-14	1.9E-05	4.6E-05	5.7E-06
3B14 horses Manure Management - Horses	CH_4	2.01	2.01	20.0%	30.0%	36.1%	3.0E-09	2.7E-04	1.6E-02	8.0E-05
3B14 other Manure Management - other - Fur animals	CH_4	0.81	0.58	20.0%	30.0%	36.1%	2.5E-10	1.1E -03	4.7E-03	3.4E-04
3B14 poultry Manure Management - Poultry	CH_4	3.54	3.61	20.0%	30.0%	36.1%	9.5E-09	1.4E-04	2.9E-02	4.2E-05
5A1 Managed waste disposal sites	CH_4	18.89	179.11	52.0%	40.3%	65.8%	7.8E-05	7.2E-01	1.5E+00	2.9E-01

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 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 (%)
5A2 Unmanaged waste disposal sites	CH_4	138.95	26.28	52.0%	40.3%	65.8%	1.7E-06	5.2E-01	2.1E-01	2.1E-01
5B Biological treatment of solid waste	CH_4	0.00	2.17	52.0%	100.0%	112.7%	3.4E-08	9.9E-03	1.8E-02	9.9E-03
5C Incineration and Open Burning of waste	CH_4	6.09	0.36	52.0%	100.0%	112.7%	9.0E-10	2.7E-02	2.9E-03	2.7E-02
5D Wastewater Treatment and Discharge	CH_4	2.08	5.56	38.7%	58.3%	70.0%	8.5E-08	1.6E-02	4.5E-02	9.1E-03
1A1ai Public electricity and heat production (electricity generation)	N_2O	0.01	0.00	5.0%	150.0%	150.1%	2.1E-13	3.2E-05	3.3E-05	4.8E-05
1A1aiii Public electricity and heat production (heat plants)	N_2O	0.02	0.0003	5.0%	150.0%	150.1%	8.1E-16	1.0E-04	2.0E-06	1.5E-04
1A2a Iron and Steel	N_2O	0.001	0.002	1.5%	150.0%	150.0%	6.8E-14	6.6E-06	1.9E-05	9.9E-06
1A2b Non-Ferrous Metals	N_2O	0.03	0.02	1.5%	150.0%	150.0%	3.4E-12	6.1E-05	1.3E-04	9.2E-05
1A2c Chemicals	N_2O	0.02	NO	5.0%	150.0%	150.1%	0.0E+00	8.0E-05	0.0E+00	1.2E-04
1A2e Food Processing, Beverages and Tobacco	N_2O	0.30	0.04	5.0%	150.0%	150.1%	2.0E-11	1.2E-03	3.3E-04	1.8E-03
1A2f Non-metallic minerals	N_2O	0.23	0.001	5.0%	150.0%	150.1%	1.1E-14	1.1E-03	7.6E-06	1.6E-03
1A2g Other manufacturing industries and Constructions	N_2O	14.01	13.04	5.0%	150.0%	150.1%	2.2E-06	6.2E-03	1.1E-01	9.2E-03
1A3a Domestic Aviation	N_2O	0.27	0.19	5.0%	200.0%	200.1%	8.2E-10	3.7E-04	1.6E-03	7.4E-04
1A3b Road Transport	N_2O	14.79	38.45	5.0%	200.0%	200.1%	3.3E-05	1.1E-01	3.1E-01	2.1E-01
1A3d Domestic Water - borne Navigation	N_2O	0.47	0.25	5.0%	200.0%	200.1%	1.4E-09	1.1E-03	2.1E-03	2.1E-03
1A4a Commercial/Institutional	N_2O	0.17	0.00	5.0%	150.0%	150.1%	2.2E-14	8.0E-04	1.1E-05	1.2E-03
1A4b Residential	N_2O	0.07	0.02	5.0%	150.0%	150.1%	5.1E-12	2.4E-04	1.6E-04	3.7E-04
1A4c Agriculture/Fishing	N_2O	5.91	4.21	5.0%	200.0%	200.1%	4.0E-07	8.5E-03	3.4E-02	1.7E-02
2B10 Other: Ferilizer production	N_2O	46.49	NO	30.0%	40.0%	50.0%	0.0E+00	2.2E-01	0.0E+00	8.7E-02
2G3a Other Product Manufacture and Use - Medical Applications	N_2O	5.30	1.64	6.0%	5.0%	7.8%	9.3E-11	1.7E-02	1.3E-02	8.7E-04

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 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 (%)
2G3b Other Product Manufacture and Use - Other N_2O use	N_2O	0.47	0.09	6.0%	5.0%	7.8%	2.7E-13	1.8E-03	7.1E-04	9.0E-05
2G4a Other: Tobacco combustion	N_2O	0.01	0.004	11.3%	50.0%	51.3%	2.9E-14	3.0E-05	3.6E-05	1.5E-05
2G4b Other: Fireworks	N_2O	0.08	0.35	11.3%	50.0%	51.3%	1.8E-10	1.2E-03	2.8E-03	6.1E-04
3B11 Manure Management - Cattle	N_2O	0.69	0.78	51.2%	100.0%	112.4%	4.3E-09	3.2 -04	6.3E-03	3.2E-04
3B12 Manure Management - Sheep	N_2O	10.99	9.14	56.1%	100.0%	114.7%	6.2E-07	9.9E-03	7.4E-02	9.9E-03
3B14 goats Manure Management - Goats	N_2O	0.02	0.06	54.8%	100.0%	114.0%	2.8E-11	2.1E-04	5.0E-04	2.1E-04
3B14 horses Manure Management - Horses	N_2O	0.65	0.67	54.8%	100.0%	114.0%	3.3E-09	1.7E-04	5.4E-03	1.7E-04
3B14 other Manure Management - other - Fur animals	N_2O	0.11	0.06	54.8%	100.0%	114.0%	3.0E-11	2.0E-04	5.2E-04	2.0E-04
3B14 poultry Manure Management - Poultry	N_2O	0.36	0.20	54.8%	100.0%	114.0%	3.1E-10	7.6E-04	1.7E-03	7.6E-4
3B25 Indirect N_2O emissions (from manure management)	N_2O	10.25	9.37	100.0%	500.0%	509.9%	1.3E-05	5.4E-03	7.6E-02	2.7E-02
3D11 Inorganic N Fertilizers Inorganic N fertilizers	N_2O	58.40	61.16	20.0%	300.0%	300.7%	1.9E-04	5.0E-02	5.0E-01	1.5E-02
3D12 a. Animal Manure Applied to Soils Animal manure applied to soils	N_2O	35.51	32.71	56.1%	300.0%	305.2%	5.6E-05	1.8E-02	2.6E-01	5.3E-02
3D13 Urine and dung Deposited by Grazing Animals Urine and dung deposited by grazing animals	N_2O	46.51	44.16	59.4%	350.0%	355.0%	1.4E-04	1.7E-02	3.6E-01	5.9E-02
3D14 Crop Residues Crop residues	N_2O	0.07	0.08	200.0%	300.0%	360.6%	4.5E-10	3.8E-05	6.3E-04	1.1E-04
3D16 Cultivation of Organic Soils Cultivation of organic soils (i.e. histosols)	N_2O	29.27	24.99	20.0%	25.0%	32.0%	3.6E-07	2.4E-02	2.0E-01	5.9E-03
3D21 Atmospheric Deposition Atmospheric deposition	N_2O	17.22	16.95	56.2%	500.0%	503.1%	4.1E-05	3.5E -04	1.4E-01	1.8E-03

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 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 (%)
3D22 Nitrogen Leaching and Run-off Nitrogen leaching and run-off	N_2O	15.57	16.08	333.3%	500.0%	600.9%	5.2E-05	2.8E-03	1.3E-01	1.4E-02
5B Biological treatment of solid waste	N_2O	0.00	1.55	52.0%	150.0%	158.7%	3.4E-08	7.2E-03	1.3E-02	1.1E-02
5C Incineration and Open Burning of waste	N_2O	1.67	0.36	52.0%	100.0%	112.7%	9.3E-10	6.3E-03	2.9E-03	6.3E-03
5D Wastewater Treatment and Discharge	N_2O	5.91	7.16	38.7%	1000.0%	1000.7%	2.9E-05	5.0E-03	5.8E-02	5.0E-02
2C3 Metal Production - aluminium Production	PFCs	494.64	67.98	1.5%	3.0%	3.4%	2.9E-08	2.0E+00	5.5E-01	6.1E-02
2F1a Commercial refrigeration	HFCs	NO	25.96	200.0%	100.0%	223.6%	1.9E-05	1.2E-01	2.1E-01	1.2E-01
2F1a Commercial refrigeration	PFCs	NO	0.006	200.0%	100.0%	223.6%	1.0E-12	2.9E-05	4.9E-05	2.9E-05
2F1b Domestic refrigeration	HFCs	NO	0.04	500.0%	67.0%	504.5%	2.0E-10	1.8 -04	3.1E-04	1.2E-04
2F1c Industrial refrigeration	HFCs	NO	32.27	100.0%	150.0%	180.3%	1.9E-05	1.5E-01	2.6E-01	2.3E-01
2F1c Industrial refrigeration	PFCs	NO	0.008	100.0%	150.0%	180.3%	1.2E-12	3.8E-05	6.5E-05	5.7E-05
2F1d Transport refrigeration	HFCs	NO	132.24	100.0%	100.0%	141.4%	2.0E-04	6.3E-01	1.1E+00	6.3E-01
2F1d Transport refrigeration	PFCs	NO	0.04	100.0%	100.0%	141.4%	2.2E-11	2.1E-04	3.6E-04	2.1E-04
2F1e Mobile air-conditioning	HFCs	NO	12.21	100.0%	100.0%	141.4%	1.7E-06	5.8E-02	9.9E-02	5.8E-02
2F1f Stationary air-conditioning	HFCs	NO	1.25	200.0%	100.0%	223.6%	4.4E-08	5.9E-03	1.0E-01	5.9E-03
2F4 Product Uses as Substitutes for ODS -Aerosols	HFCs	0.69	0.94	5.0%	5.0%	7.1%	2.5E-11	1.0E-03	7.6E-03	5.2E-05
2G1 Other Product Manufacture and Use - Electrical equipment	SF_6	1.10	2.31	30.0%	0.0%	30.0%	2.7E-09	5.5E-03	1.9E-02	0.0E+00
4A1 Forest land remaining forest land	CO_2	-15.61	-34.43	14.0%	10.0%	17.2%	2.0E-07	8.6E-02	2.8E-01	8.6E-03
4A2 Land converted to forest land	CO_2	-27.06	-312.62	5.0%	10.0%	11.2%	6.9E-06	1.3E+00	2.5E+00	1.3E-01
4A Forest land	N_2O	0.12	0.82	5.0%	400.0%	400.0%	6.0E-08	3.3E-03	6.6E-03	1.3E-02
4B1 Cropland remaining Cropland	CO_2	1,216.70	1,490.53	20.0%	90.0%	92.2%	1.1E-02	9.8E-01	1.2E+01	8.8E-01
4B2 Land converted to Cropland	CO_2	634.84	90.95	20.0%	90.0%	92.2%	3.9E-05	2.9E+00	7.4E -01	2.6E+00
4C1 Wetland drained for more than 20 years	CO_2	3,080.97	5,203.45	20.0%	90.0%	92.2%	1.3E-01	9.8E+00	4.2E+01	8.8E+00

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 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 (%)
4C1 All other remaining Grassland	CO_2	49.24	147.20	20.0%	20.0%	28.3%	9.7E-06	6.2E-01	1.2E+00	1.2E-01
4C21/2/3/4 All other conversion to Grassland	CO_2	2,106.96	656.24	20.0%	90.0%	92.2%	2.1E-03	8.3E+00	5.3E+00	7.5E+00
4C25 Other land converted to Grassland, revegetation	CO_2	-349.82	-616.49	30.0%	25.0%	39.1%	3.3E-04	1.8E+00	5.0E+00	4.5E-01
4D Wetlands	CO_2	-1,224.01	-1,165.63	20.0%	50.0%	53.9%	2.2E-03	9.5E-01	9.4E+00	4.7E-01
4D Wetlands	CH_4	3,250.71	3,126.73	20.0%	50.0%	53.9%	1.6E-02	1.9E+00	2.5E+01	9.7E-01
4E Settlements	CO_2	23.61	5.83	5.0%	10.0%	11.2%	2.4E-09	1.6E -01	4.7E-02	1.6E-02
Total emissions		**12,344.92**	**13,347.21**							
Total Uncertainties	**% Uncertainty in total inventory (including LULUCF):**						**40%**	**Trend uncertainty:**		**19.2%**

Table A2. 2 Uncertainty Analysis excluding LULUCF

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 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	1.67	5.0%	5.0%	7.1%	6.16E-10	1.2E-01	4.6E-02	5.8E-03
1A1aiii Public electricity and heat production (heat plants)	CO_2	9.34	0.11	5.0%	5.0%	7.1%	2.65E-12	3.4E-01	3.0E-03	1.7E-02
1A2a Iron and Steel	CO_2	0.36	0.96	1.5%	5.0%	5.2%	1.12E-10	6.9E-03	2.7E-02	3.4E-04
1A2b Non-Ferrous Metals	CO_2	13.50	7.64	1.5%	5.0%	5.2%	7.04E-09	1.4E-01	2.1E-01	7.1E-03
1A2c Chemicals	CO_2	7.43	NO	5.0%	5.0%	7.1%	0.00E+00	1.4E-01	0.0E+00	6.9E-03
1A2e Food Processing, Beverages and Tobacco	CO_2	128.24	16.92	5.0%	5.0%	7.1%	6.33E -08	2.1E+00	4.7E-01	1.1E-01
1A2f Non-metallic minerals	CO_2	50.32	0.39	5.0%	5.0%	7.1%	3.37E-11	9.6E-01	1.1E-02	4.8E-02
1A2g Other manufacturing industries and Constructions	CO_2	161.82	140.99	5.0%	5.0%	7.1%	4.40E-06	1.1E+00	3.9E+00	5.6E -02
1A3a Domestic Aviation	CO_2	31.73	22.96	5.0%	5.0%	7.1%	1.17E-07	3.0E-01	6.4E-01	1.5E-02
1A3b Road Transport	CO_2	508.89	933.95	5.0%	5.0%	7.1%	1.93E-04	3.5E+00	2.6E+01	1.7E-01
1A3d Domestic Water - borne Navigation	CO_2	59.83	31.51	5.0%	5.0%	7.1%	2.20E-07	7.7E-01	8.8E-01	3.8E-02
1A4a Commercial/Institutional	CO_2	16.24	0.83	5.0%	5.0%	7.1%	1.51E-10	3.4E-01	2.3E-02	1.7E-02
1A4b Residential	CO_2	30.64	11.66	5.0%	5.0%	7.1%	3.01E-08	4.8E-01	3.2E-01	2.4E-02
1A4c Agriculture/Fishing	CO_2	738.31	527.64	5.0%	5.0%	7.1%	6.16E -05	7.6E+00	1.5E+01	3.8E-01
1B2a5 Oil - Distribution of oil products	CO_2	0.003	0.005	5.0%	5.0%	7.1%	4.60E-15	9.5E-06	1.3E-04	4.7E-07
1B2d Other emission from Energy Production	CO_2	61.36	146.47	10.0%	0.0%	10.0%	9.49E-06	1.1E+00	4.1E+00	0.0E+00
2A1 Cement Production	CO_2	51.56	NO	5.0%	6.5%	8.2%	0.00E+00	1.4E+00	0.0E+00	8.9E-02
2A4d Other: Mineral Wool Production	CO_2	0.70	0.90	2.4%	2.0%	3.1%	3.47E-11	1.9E -03	2.5E-02	3.7E-05
2B10 Other: Silica production	CO_2	0.36	NO	3.0%	1.0%	3.2%	0.00E+00	9.8E-03	0.0E+00	9.8E-05
2C1 Metal Production - Iron and steel	CO_2	NO	0.00	10.0%	25.0%	26.9%	0.00E+00	0.0E+00	0.0E+00	0.0E+00
2C2 Metal Production - Ferroalloys	CO_2	208.80	428.32	1.5%	3.0%	3.4%	9.13E-06	2.4E+00	1.2E+01	7.2E-02

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 emissions (kt CO_2e)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to variance by category in year x	Uncertainty in trend introduced by emission factor (%)	Uncertainty introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
2C3 Metal Production - aluminium Production	CO_2	139.21	1,324.46	1.5%	3.0%	3.4%	8.73E-05	2.2E+01	3.7E+01	6.6E-01
2D1 Lubricants	CO_2	4.06	2.08	10.0%	50.1%	51.1%	5.01E-08	5.5E-02	5.8E-02	2.8E-02
2D2 Paraffin wax use	CO_2	0.31	0.35	10.0%	100.0%	100.5%	5.39E-09	4.3E-04	9.6E-03	4.3E-04
2D3 Solvents	CO_2	2.62	2.72	59.0%	170.0%	179.9%	1.06E-06	8.1E-03	7.6E-02	1.4E-02
2G4b Other: Fireworks	CO_2	0.01	0.03	11.3%	50.0%	51.3%	8.01E-12	3.8E-04	7.3E-04	1.9E-04
3G Liming	CO_2	0.00	2.31	20.0%	0.0%	20.0%	9.42E-09	4.6E-02	6.4E-02	0.0E+00
3H Urea application	CO_2	0.06	2.55	20.0%	0.0%	20.0%	1.15E-08	5.0E-02	7.1E-02	0.0E+00
5C Incineration and Open Burning of waste	CO_2	7.30	7.08	52.0%	40.0%	65.6%	9.54E-07	3.2E-02	2.0E-01	1.3E-02
1A1ai Public electricity and heat production (electricity generation)	CH_4	0.005	0.002	5.0%	100.0%	100.1%	1.27E-13	7.4E-05	4.7E-05	7.4E-05
1A1aiii Public electricity and heat production (heat plants)	CH_4	0.009	0.0001	5.0%	100.0%	100.1%	4.99E-16	2.1E-04	2.9E-06	2.1E-04
1A2a Iron and Steel	CH_4	0.0004	0.0010	1.5%	100.0%	100.0%	4.21E-14	1.1E-05	2.7E-05	1.1E-05
1A2b Non-Ferrous Metals	CH_4	0.01	0.01	1.5%	100.0%	100.0%	2.16E-12	1.6E-04	1.9E-04	1.6E-04
1A2c Chemicals	CH_4	0.01	NO	5.0%	100.0%	100.1%	0.00E+00	1.7E-04	0.0E+00	1.7E-04
1A2e Food Processing, Beverages and Tobacco	CH_4	0.12	0.02	5.0%	100.0%	100.1%	1.26E-11	2.6E-03	4.7E-04	2.6E-03
1A2f Non-metallic minerals	CH_4	0.13	0.0004	5.0%	100.0%	100.1%	6.92E-15	3.1E-03	1.1E-05	3.1E-03
1A2g Other manufacturing industries and Constructions	CH_4	0.21	0.19	5.0%	100.0%	100.1%	1.53E-09	1.3E-03	5.2E-03	1.3E-03
1A3a Domestic Aviation	CH_4	0.01	0.004	5.0%	100.0%	100.1%	7.16E-13	5.2E-05	1.1E-04	5.2E-05
1A3b Road Transport	CH_4	3.77	2.67	5.0%	200.0%	200.1%	1.26E-06	3.6E-02	7.4E-02	7.3E-02
1A3d Domestic Water - borne Navigation	CH_4	0.14	0.07	5.0%	100.0%	100.1%	2.46E-10	1.8E-03	2.1E-03	1.8E-03
1A4a Commercial/Institutional	CH_4	1.01	0.002	5.0%	100.0%	100.1%	2.35E-13	2.4E-02	6.4E-05	2.4E-02
1A4b Residential	CH_4	0.10	0.03	5.0%	100.0%	100.1%	5.02E-11	1.8E-03	9.3E-04	1.8E-03
1A4c Agriculture/Fishing	CH_4	1.73	1.24	5.0%	100.0%	100.1%	6.77E-08	1.7E-02	3.4E-02	1.7E-02

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 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 (%)
1B2a5 Oil - Distribution of oil products	CH_4	0.49	0.70	5.0%	100.0%	100.1%	2.20E-08	2.5E-03	2.0E -02	2.5E-03
1B2d Other emission from Energy Production	CH_4	0.20	2.63	25.0%	0.0%	25.0%	1.91E-08	4.8E-02	7.3E-02	0.0E+00
2C2 Metal Production - Ferroalloys	CH_4	1.57	3.13	1.5%	100.0%	100.0%	4.32E-07	2.5E-02	8.7E-02	2.5E-02
2G4a Other: Tobacco combustion	CH_4	0.04	0.02	11.3%	50.0%	51.3%	3.94E-12	7.0E -04	5.1E-04	3.5E-04
2G4b Other: Fireworks	CH_4	0.00	0.01	11.3%	50.0%	51.3%	1.82E-12	1.8E-04	3.5E-04	9.2E-05
3A1 Enteric Fermentation - Cattle	CH_4	105.89	121.70	5.0%	40.0%	40.3%	1.06E-04	8.5E-02	3.4E+00	3.4E-02
3A2 Enteric Fermentation - Sheep	CH_4	173.36	144.85	5.0%	40.0%	40.3%	1.51E-04	1.3E+00	4.0E+00	5.1E-01
3A3 Enteric Fermentation - Swine	CH_4	1.12	1.62	20.0%	40.0%	44.7%	2.32E-08	6.0E-03	4.5E-02	2.4E-03
3A4 goats Enteric Fermentation - Goats	CH_4	0.06	0.24	20.0%	40.0%	44.7%	4.98E-10	3.5E-03	6.6E-03	1.4E-03
3A4 horses Enteric Fermentation - Horses	CH_4	33.24	33.23	20.0%	40.0%	44.7%	9.77E-06	1.4E-01	9.2E-01	5.8E-02
3A4 other Enteric Fermentation - other - Fur animals	CH_4	0.12	0.09	20.0%	40.0%	44.7%	6.49E-11	1.3E-03	2.4E-03	5.0E-04
3A4 poultry Enteric Fermentation - Poultry	CH_4	0.34	0.42	20.0%	40.0%	44.7%	1.54E-09	2.5E-04	1.2E-02	1.0E-04
3B11 Manure Management - Cattle	CH_4	28.49	30.76	11.2%	20.0%	22.9%	2.20E-06	7.7E-02	8.5E-01	1.5E-02
3B12 Manure Management - Sheep	CH_4	13.55	11.33	25.5%	20.0%	32.4%	5.96E-07	1.1E-01	3.1E-01	2.2E-02
3B13 Manure Management - Swine	CH_4	4.47	6.48	20.0%	30.0%	36.1%	2.42E-07	2.4E-02	1.8E-01	7.2E-03
3B14 goats Manure Management - Goats	CH_4	0.00	0.01	20.0%	30.0%	36.1%	1.87E-13	8.6E-05	1.6E-04	2.6E-05
3B14 horses Manure Management - Horses	CH_4	2.01	2.01	20.0%	30.0%	36.1%	2.33E-08	9.0E-03	5.6E-02	2.7E-03
3B14 other Manure Management - other - Fur animals	CH_4	0.81	0.58	20.0%	30.0%	36.1%	1.95E-09	8.7E-03	1.6E-02	2.6E-03
3B14 poultry Manure Management - Poultry	CH_4	3.54	3.61	20.0%	30.0%	36.1%	7.48E-08	1.4E-02	1.0E-01	4.3E-03
5A1 Managed waste disposal sites	CH_4	18.89	179.11	52.0%	40.3%	65.8%	6.14E-04	3.4E+00	5.0E +00	1.4E+00

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5A2 Unmanaged waste disposal sites	CH_4	138.95	26.28	52.0%	40.3%	65.8%	1.32E-05	3.0E+00	7.3E-01	1.2E+00
5B Biological treatment of solid waste	CH_4	0.00	2.17	52.0%	100.0%	112.7%	2.65E-07	4.9E-02	6.0E-02	4.9E-02
5C Incineration and Open Burning of waste	CH_4	6.09	0.36	52.0%	100.0%	112.7%	7.13E -09	1.6E-01	9.9E-03	1.6E-01
5D Wastewater Treatment and Discharge	CH_4	2.08	5.56	38.7%	58.3%	70.0%	6.69E-07	6.9E-02	1.5E-01	4.0E-02
1A1ai Public electricity and heat production (electricity generation)	N_2O	0.01	0.00	5.0%	150.0%	150.1%	1.62E-12	2.0E-04	1.1E-04	3.0E-04
1A1aiii Public electricity and heat production (heat plants)	N_2O	0.02	0.0003	5.0%	150.0%	150.1%	6.37E-15	5.8E-04	7.0E-06	8.7E-04
1A2a Iron and Steel	N_2O	0.001	0.002	1.5%	150.0%	150.0%	5.38E-13	2.9E-05	6.5E-05	4.4E-05
1A2b Non-Ferrous Metals	N_2O	0.03	0.02	1.5%	150.0%	150.0%	2.66E-11	4.2E-04	4.5E-04	6.3E-04
1A2c Chemicals	N_2O	0.02	NO	5.0%	150.0%	150.1%	0.00E+00	4.7E-04	0.0E+00	7.0E-04
1A2e Food Processing, Beverages and Tobacco	N_2O	0.30	0.04	5.0%	150.0%	150.1%	1.61E-10	7.2E-03	1.1E-03	1.1E-02
1A2f Non-metallic minerals	N_2O	0.23	0.001	5.0%	150.0%	150.1%	8.84E-14	6.3E-03	2.6E-05	9.4E-03
1A2g Other manufacturing Industries and Constructions	N_2O	14.01	13.04	5.0%	150.0%	150.1%	1.69E-05	8.7E-02	3.6E-01	1.3E-01
1A3a Domestic Aviation	N_2O	0.27	0.19	5.0%	200.0%	200.1%	6.50E-09	2.9E-03	5.3E-03	5.8E-03
1A3b Road Transport	N_2O	14.79	38.45	5.0%	200.0%	200.1%	2.62E-04	4.7E-01	1.1E+00	9.4E-01
1A3d Domestic Water - borne Navigation	N_2O	0.47	0.25	5.0%	200.0%	200.1%	1.14E-08	7.2E-03	7.0E-03	1.4E-02
1A4a Commercial/ Institutional	N_2O	0.17	0.001	5.0%	150.0%	150.1%	1.73E-13	4.6E-03	3.7E-05	7.0E-03
1A4b Residential	N_2O	0.07	0.02	5.0%	150.0%	150.1%	4.05E-11	1.5E-03	5.6E-04	2.3E-03
1A4c Agriculture/ Fishing	N_2O	5.91	4.21	5.0%	200.0%	200.1%	3.14E-06	6.6E-02	1.2E-01	1.3E-01
2B10 Other: Fertilizer production	N_2O	46.49	NO	30.0%	40.0%	50.0%	0.00E+00	1.3E+00	0.0E+00	5.1E-01
2G3a Other Product Manufacture and Use - Medical Applications	N_2O	5.30	1.64	6.0%	5.0%	7.8%	7.30E-10	1.1E-01	4.6E-02	5.5E-03

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 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 (%)
2G3b Other Product Manufacture and Use - Other N_2O use	N_2O	0.47	0.09	6.0%	5.0%	7.8%	2.11E-12	1.1E-02	2.5E-03	5.6E-04
2G4a Other: Tobacco combustion	N_2O	0.01	0.00	11.3%	50.0%	51.3%	2.26E-13	2.0E-04	1.2E-04	9.9E-05
2G4b Other: Fireworks	N_2O	0.08	0.35	11.3%	50.0%	51.3%	1.42E-09	5.8E-03	9.7E-03	2.9E-03
3B11 Manure Management - Cattle	N_2O	0.69	0.78	51.2%	100.0%	112.4%	3.39E-08	1.4E-03	2.2E-02	1.4E-03
3B12 Manure Management - Sheep	N_2O	10.99	9.14	56.1%	100.0%	114.7%	4.86E-06	9.7E-02	2.5E-01	9.7E-02
3B14 goats Manure Management - Goats	N_2O	0.02	0.06	54.8%	100.0%	114.0%	2.18E-10	9.8E-04	1.7E-03	9.8E-04
3B14 horses Manure Management - Horses	N_2O	0.65	0.67	54.8%	100.0%	114.0%	2.58E-07	2.9E-03	1.9E-02	2.9E-03
3B14 other Manure Management - other - Fur animals	N_2O	0.11	0.06	54.8%	100.0%	114.0%	2.39E-10	1.5E-03	1.8E-0.3	1.5E-0.3
3B14 poultry Manure Management - Poultry	N_2O	0.36	0.20	54.8%	100.0%	114.0%	2.42E-09	5.4E-03	5.7E-03	5.4E-03
3B25 Indirect N_2O emissions (from manure management)	N_2O	10.25	9.37	100.0%	500.0%	509.9%	1.01E-04	7.1E-02	2.6E-01	3.6E-01
3D11 Inorganic N Fertilizers Inorganic N fertilizers	N_2O	58.40	61.16	20.0%	300.0%	300.7%	1.50E-03	2.3E-01	1.7E+00	6.9E-01
3D12 a. Animal Manure Applied to Soils Animal manure applied to soils	N_2O	35.51	32.71	56.1%	300.0%	305.2%	4.41E-04	2.5E-01	9.1E-01	7.5E-01
3D13 Urine and dung Deposited by Grazing Animals Urine and dung deposited by grazing animals	N_2O	46.51	44.16	59.4%	350.0%	355.0%	1.09E-03	3.0E-01	1.2E+00	1.0E+00
3D14 Crop Residues Crop residues	N_2O	0.07	0.08	200.0%	300.0%	360.6%	3.52E-09	1.2E-04	2.2E-03	3.6E-04
3D16 Cultivation of Organic Soils Cultivation of organic soils (i.e. histosols)	N_2O	29.27	24.99	20.0%	25.0%	32.0%	2.83E-06	2.6E-01	6.9E-01	6.5E-02
3D21 Atmospheric Deposition Atmospheric deposition	N_2O	17.22	16.95	56.2%	500.0%	503.1%	3.22E-04	1.0E-01	4.7E-01	5.0E-01

IPCC Category	Gas	1990 emissions (kt CO_2e)	2017 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 (%)
3D22 Nitrogen Leaching and Run-off Nitrogen leaching and run-off	N_2O	15.57	16.08	333.3%	500.0%	600.9%	4.13E-04	7.4E-02	4.5E-01	3.7E-01
5B Biological treatment of solid waste	N_2O	0.00	1.55	52.0%	150.0%	158.7%	2.69E-07	3.8E-02	4.3E-02	5.7E-02
5C Incineration and Open Burning of waste	N_2O	1.67	0.36	52.0%	100.0%	112.7%	7.31E-09	4.1E-02	1.0E-02	4.1E-02
5D Wastewater Treatment and Discharge	N_2O	5.91	7.16	38.7%	1000.0%	1000.7%	2.27E-04	2.6E-03	2.0E-01	2.6E-02
2C3 Metal Production - aluminium Production	PFCs	494.64	67.98	1.5%	3.0%	3.4%	2.30E-07	1.3E+01	1.9E+00	3.9E-01
2F1a Commercial refrigeration	HFCs	0.00	25.96	200.0%	100.0%	223.6%	1.49E-04	7.2E-01	7.2E-01	7.2E-01
2F1a Commercial refrigeration	PFCs	0.00	0.01	200.0%	100.0%	223.6%	8.01E-12	1.7E-04	1.7E-04	1.7E-04
2F1b Domestic refrigeration	HFCs	0.00	0.04	500.0%	67.0%	504.5%	1.60E-09	1.0E-03	1.0E-03	7.0E-04
2F1c Industrial refrigeration	HFCs	0.00	32.27	100.0%	150.0%	180.3%	1.50E-04	9.0E-01	9.0E-01	1.3E+00
2F1c Industrial refrigeration	PFCs	0.00	0.01	100.0%	150.0%	180.3%	9.14E-12	2.2E-04	2.2E-04	3.3E-04
2F1d Transport refrigeration	HFCs	0.00	132.24	100.0%	100.0%	141.4%	1.55E-03	3.7E+00	3.7E+00	3.7E+00
2F1d Transport refrigeration	PFCs	0.00	0.04	100.0%	100.0%	141.4%	1.72E-10	1.2E-03	1.2E-03	1.2E-03
2F1e Mobile air-conditioning	HFCs	0.00	12.21	100.0%	100.0%	141.4%	1.32E-05	3.4E-01	3.4E-01	3.4E-01
2F1f Stationary air-conditioning	HFCs	0.00	1.25	200.0%	100.0%	223.6%	3.45E-07	3.5E-02	3.5E-02	3.5E-02
2F4 Product Uses as Substitutes for ODS -Aerosols	HFCs	0.69	0.94	5.0%	5.0%	7.1%	1.95E-10	7.3E-04	2.6E-02	3.7E-05
2G1 Other Product Manufacture and Use - Electrical equipment	SF_6	1.10	2.31	30.0%	0.0%	30.0%	2.12E-08	2.4E-02	6.4E-02	0.0E+00
Total Emissions		**3,598.26**	**4,754.65**							
Total Uncertainties						**% Uncertainty in total inventory (excluding LULUCF):**	**8.7%**		**Trend uncertainty %:**	**9.1%**

Annex 3: National Energy Balance for the year 2017

The Icelandic energy balance is compiled by the Environment Agency using data from the National Energy Authority and Statistics Iceland. This is the first time that a National Energy Balance is reported in the National Inventory Report. The energy balance will need to be improved for next year's submission in collaboration with the agencies that provide the data.

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 3325 TJ, which is 14% of the total energy consumption in Iceland in 2017. 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 for next year's submission.

Table A3. 1 National Energy Balance for 2017

2017 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	-	-	-	-	-	-	-	-	-	-	-	-	-	-	76
Imports	6,104	1,5178	1,4935	4,119	116	589	145	271	23	3397	616	0.1	14	680	-
Exports	-	-	-	-	-	-	-	-	108	-	-	0.0	-	-	-
International Bunkers	-	16,038	1,290	1,258	-	-	-	-	-	-	-	-	-	-	-
Stock Change	-17	-474	-383	89	-	-	-	-	-	-	-	-	-	-	-
Primary Energy Supply	6,122	-387	14,029	2,772	116	589	145	271	-85	3,397	616	0.1	14	680	76
Non-Energy Use of Fuels						589	145	271		3,397	616	0.1	14	680	
Available Final Energy Consumption	**6,122**	**-387**	**14,029**	**2,772**	**116**	**0**	**0**	**0**	**-85**	**0**	**0**	**0**	**0**	**0**	**76**
1A1ai - Electricity generation	-	-	23	-	-	-	-	-	-	-	-	-	-	-	-
1A1aiii - Heat Plants	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
1A2a - Iron and Steel	-	-	13	-	-	-	-	-	-	-	-	-	-	-	-
1A2b - Non-ferrous Metals	-	-	0	89	11	-	-	-	-	-	-	-	-	-	-
1A2e - Food processing, beverages and tobacco	-	-	140	84	-	-	-	-	-	-	-	-	-	-	-
1A2f - Non-metallic minerals (mineral wool)	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
1A2gvii - Off-road vehicles and mobile machinery	-	-	1,522	-	-	-	-	-	-	-	-	-	-	-	-
1A2gviii - Other industry	-	-	315	45	23	-	-	-	-	-	-	-	-	-	-
1A3a - Domestic Aviation	16	305	-	-	-	-	-	-	-	-	-	-	-	-	-
1A3b - Road Transport	5,926	-	7,062	-	-	-	-	-	-	-	-	-	-	-	76
1A3d - Domestic Navigation	-	-	425	-	-	-	-	-	-	-	-	-	-	-	-
1A4ai - Commercial/Institutional - Stationary combustion	-	-	6	-	6	-	-	-	-	-	-	-	-	-	-
1A4bi - Residential - Stationary combustion	-	2	100	-	65	-	-	-	-	-	-	-	-	-	-
1A4ciii - Fishing	-	-	5,640	1,420	-	-	-	-	-	-	-	-	-	-	-
Final Energy Consumption	**5,942**	**308**	**15,252**	**1,641**	**105**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**76**
Statistical Differences	-180	694	12,23	-1,131	-11	0	0	0	85	0	0	0	0	0	0

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	4731.5	1831.7	38.7%	
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	3591.4	1763.7	49.1%	

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	1697.2	NA	NA	
1.A Fuel combustion activities, stationary combustion [4]	CO_2	169.5	10.9	6.4%	
1.A.1 Energy industries	CO_2	1.8	NO		
1.A.1.a Public electricity and heat production	CO_2	1.8	NO		
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	429.3	428.3	99.8%	includes Ferroalloy/Silicon production
1.A.2. Manufacturing industries and construction	CO_2	166.9	10.9	6.5%	
1.A.2.a Iron and steel	CO_2	1.0	1.4	146.2%	
1.A.2.b Non-ferrous metals	CO_2	7.6	7.8	101.4%	
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	16.9	1.7	10.1%	
1.A.2.f Non-metallic minerals	CO_2	0.4	NO		
1.A.2.g Other	CO_2	141.0	0.0	0.04%	
1.A.3. Transport	CO_2	988.4	NO		
1.A.3.e Other transportation (pipeline transport)	CO_2	NO	NO		
1.A.4 Other sectors	CO_2	540.1	NO		
1.A.4.a Commercial / Institutional	CO_2	0.8	NO		
1.A.4.c Agriculture/ Forestry / Fisheries	CO_2	527.6	NO		
1.B Fugitive emissions from Fuels	CO_2	146.5	NO		
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	0.9	NO		
2.A.1 Cement Production	CO_2	NO	NO		
2.A.2. Lime production	CO_2	NO	NO		

CO_2 emissions					
Category [1]	**Gas**	**GHG inventory emissions [kt CO_2] [3]**	**Verified emissions under Directive 2003/87/EC [kt CO_2] [3]**	**Ratio in % (Verified emissions/ inventory emissions) [3]**	**Comment [2]**
2.A.3. Glass production	CO_2	NO	NO		
2.A.4. Other process uses of carbonates	CO_2	0.9	NO		
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	1752.8	1752.8	100.0%	
2.C.1. Iron and steel production	CO_2	NO	NO		
2.C.2 Ferroalloys production	CO_2	428.3	428.3	100.0%	
2.C.3 Aluminium production	CO_2	1324.5	1324.5	100.0%	
2.C.4 Magnesium production	CO_2	NO	NO		
2.C.5 Lead production	CO_2	NO	NO		
2.C.6 Zinc production	CO_2	NO	NO		
2.C.7 Other metal production	CO_2	NO	NO		

For footnotes, see under Table A4. 4 below.

Table A4. 3 GHG inventory N_2O emissions vs. emissions verified under the EU ETS, by CRF sector (in kt CO_2e).

N_2O emissions					
Category [1]	**Gas**	**GHG inventory emissions [kt CO_2e] [3]**	**Verified emissions under Directive 2003/87/EC [kt CO_2e] [3]**	**Ratio in % (Verified emissions/ inventory emissions) [3]**	**Comment [2]**
2.B.2. Nitric acid production	N_2O	NO	NO	NA	
2.B.3. Adipic acid production	N_2O	NO	NO	NA	
2.B.4. Caprolactam, glyoxal and glyoxylic acid production	N_2O	NO	NO	NA	

For footnotes, see under Table A4. 4 below.

Table A4. 4 GHG inventory PFC emissions vs. emissions verified under the EU ETS, by CRF sector (in kt CO_2e).

PFC emissions					
Category [1]	Gas	GHG inventory emissions [kt CO_2e] [3]	Verified emissions under Directive 2003/87/EC [kt CO_2e] [3]	Ratio in % (Verified emissions/ inventory emissions) [3]	Comment [2]
2.C.3 Aluminium production	PFC	68.0	68.0	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

The table below shows the status of implementation of each recommendation listed in the most recent review report from EU pursuant to Article 35(2), in accordance to Article 9(2) of the Implementation Regulation (EU) No 749/2014).

Table A5. 1 shows the responses to questions asked during the 2019 EU Stage 1review, as they were posted in EEA's Emission Review Tool (EMRT).

Table A5. 1 Responses to questions raised during the 2019 EU Review (EMRT web tool).

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
1A2f Non-metallic minerals	Blank cell in subcategory 1.A.2.f for 2017	EMRT/ IS-1A2f-2019-0001	This has been corrected for the March 2019 submission.	
1A3b Road transportation	Calculation of fossil fuels from biofuels	EMRT/ IS-1A3b-2019-0001	According to the National Energy Authority of Iceland (NEA), 100% of biogasoline used in Iceland is bioethanol which, according to the paper referred to in the question has a 0% fossil carbon. At this time the origin of biodiesel in Iceland is unknown, however work has begun to estimate the % of FAME in biodiesel in Iceland. If we assume that all 100% of biodiesel used in Iceland in 2017 (13.163 kt) was FAME it is possible to calculate the Fossil origin CO2 based on the equation given in the paper referred to on sharepoint, using default parameters; Fossil origin CO2 (kt) = 13.163 kt * 0.765 * 0.054 * 44/12 = 1.99 kt CO2. That is equivalent to 0.04% of Iceland's total emissions in 2017 (4783 kt) and is therefore below the threshold of significance. This information will be added to the NIR for the March 2019 submission. For the 2020 submission the Environment Agency will work with the NEA on estimating the % of FAME in biodiesel in Iceland.	Chapter 3, Section, 3.4.2 in NIR
1AB Reference approach	Blank cells in CRF Tables 1A(b) and 1A(d)	EMRT/ IS-1AB-2019-0001	This has been corrected for the March 2019 submission.	
2F2 Foam blowing agents	2F2 emissions reported as "NO"	EMRT/ IS-2F2-2019-0001	The ban on importing, producing and selling HFCs for other uses than in cooling and refrigeration systems and in drugs (metered dose inhalers) started with regulation 230/1998 of 14 April 1998, which was replaced by regulation 834/2010 of 15 October 2010. The latter regulation banned import, production and sale of HFCs with the same exemptions as 230/1998 until 31 December 2012 in accordance with Art. 9(3) of Regulation (EC) No 842/2006.	Chapter 4, Section 4.7.1 in NIR

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
			However, no use of HFCs in the 2F2 and the 2F3 categories are known.	
2F3 Fire protection	2.F.3 emissions not reported	EMRT/ IS-2F3-2019-0001	The ban on importing, producing and selling HFCs for other uses than in cooling and refrigeration systems and in drugs (metered dose inhalers) started with regulation 230/1998 of 14 April 1998, which was replaced by regulation 834/2010 of 15 October 2010. The latter regulation banned import, production and sale of HFCs with the same exemptions as 230/1998 until 31 December 2012 in accordance with Art. 9(3) of Regulation (EC) No 842/2006. However, no use of HFCs in the 2F2 and the 2F3 categories are known.	Chapter 4, Section 4.7.1 in NIR
3 Agriculture	Inventory completeness: categories 3.B.5, 3.D.1.2, 3.D.1.5	EMRT/ IS-3-2019-0001	(1) There are extremely limited measurement data on leaching and runoff losses from various manure management systems. The greatest N losses due to runoff and leaching typically occur where animals are on a drylot. In drier climates, runoff losses are smaller than in high rainfall areas and have been estimated in the range of 3 to 6% of N excreted (Eghball and Power, 1994). Studies by Bierman et al. (1999) found nitrogen lost in runoff was 5 to 19% of N excreted and 10 to 16% leached into soil, while other data show relatively low loss of nitrogen through leaching in solid storage (less than 5% of N excreted) but greater loss could also occur (Rotz, 2004). Further research is needed in this area to improve the estimated losses and the conditions and practices under which such losses occur. Equation 10.28 should only be used where there is country-specific information on the fraction of nitrogen loss due to leaching and runoff from manure management systems available. Therefore, estimation of N losses from leaching and runoff from manure management should be considered part of a Tier 2 or Tier 3 method. (2) Sewage sludge cannot be used on agricultural land in Iceland without proper treatment due to strict regulations. Its use in agriculture is therefore expected to be minimal. There have been unforeseen circumstances in the inventory team this year, and therefore we were unable to complete this improvement for this submission. Issues (2) and (3) will both be carried on and addressed in next year´s submission.	Chapter 5, NIR

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
3A Enteric fermentation	Milk yield increases along time while digestibility of feed remains constant	EMRT/ IS-3A-2019-0005	Feed digestibility is constant in Iceland for all cattle types and sheep types, except for young cattle. Feed digestibility of young cattle 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. The digestibility of heifers, steers and calves are constant along the time series. The feed digestibility is estimated based on parameters which are assumed to be constant over the time series. We will add looking into modifications in those parameters along the time series to our improvement plan.	
3A Enteric fermentation	3.A.3 - Piglets - 1990 - Weight (WEIGHT): Data has been identified as an outlier.	EMRT/ IS-3A-2019-0004	This is a connecting error in the CRF upload file and will be corrected for the March 2019 submission.	
3A Enteric fermentation	3.A.1 - Dairy Cattle - all years - Pregnant (PREGNANT): Data has been identified as an outlier.	EMRT/ IS-3A-2019-0002	This is a connecting error in the CRF upload file and will be corrected for the March 2019 submission.	
3A Enteric fermentation	3.A.2 - Sheep - all years - Pregnant (PREGNANT): Data has been identified as an outlier.	EMRT/ IS-3A-2019-0003	This is a connecting error in the CRF upload file and will be corrected for the March 2019 submission.	
3A Enteric fermentation	Missing information on methods used for the estimation of emissions from enteric fermentation in the NIR	EMRT/ IS-3A-2019-0001	This information will be included in the March 2019 submission.	Chapter 5, Section 5.3 in NIR
3B Manure management	3.B.2.4.4 - Goats - all years - Implied emission factor (IEF): Data has been identified as an outlier.	EMRT/ IS-3B-2019-0002	This issue was caused by our N2O emissions being based on the wrong N flow approach from the EMEP/EEA Guidebook and the N2O-N EF presented in the EMEP Guidebook. We used the EF in table A1.7 instead of table 3.8. This has now been resolved for all livestock categories, including goats, resulting in reduced N2O emissions from this category.	Chapter 5, Section 5.5 in NIR
3B Manure management	3.B.2.4.7 - Poultry - all years - Implied emission factor (IEF): Data has been identified as an outlier.	EMRT/ IS-3B-2019-0003	This issue was caused by our N2O emissions being based on the wrong N flow approach from the EMEP/EEA Guidebook and the N2O-N EF presented in the EMEP Guidebook. We used the EF in table A1.7 instead of table 3.8. This has now been resolved for all livestock categories, including poultry, resulting in reduced N2O emissions from this category.	Chapter 5, Section 5.5 in NIR

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
3B Manure management	3.B.2.4.8.1 - Rabbit - all years - Implied emission factor (IEF): Data has been identified as an outlier.	EMRT/ IS-3B-2019-0004	This issue was caused by our N2O emissions being based on the wrong N flow approach from the EMEP/EEA Guidebook and the N2O-N EF presented in the EMEP Guidebook. We used the EF in table A1.7 instead of table 3.8. This has now been resolved for all livestock categories, including rabbits, resulting in reduced N2O emissions from this category.	Chapter 5, Section 5.5 in NIR
3B Manure management	3.B.1.1- Cattle and sheep- all years- Methane Conversion Factor (MCF) expressed in the wrong units	EMRT/ IS-3B-2019-0001	This was indeed a unit error and will be corrected for the March 2019 submission.	
3D1 Direct N2O emissions from managed soils	3.D.1.1- Direct N2O emissions from the application of synthetic fertilisers to soils	EMRT/ IS-3D1-2019-0002	This was indeed a unit error and will be corrected for the March 2019 submission.	
3D1 Direct N2O emissions from managed soils	NE reported for emission category 3.D.1.2.b-Sewage Sludge Applied to Soils	EMRT/ IS-3D1-2019-0001	No improvements were undertaken for the submission this year due to unforeseen circumstances in the inventory team. The issue will be addressed for next year´s submission.	
3G Liming	Values reported for category 3.G.1-CO2 Emissions from Limestone Application are the same for 2016 and 2017	EMRT/ IS-3G-2019-0001	No improvements were undertaken for the submission this year due to unforeseen circumstances in the inventory team. The issue will be addressed for next year´s submission.	
4 Land use, land-use change and forestry	Table 4.1 is empty	EMRT/ IS-4-2019-0001	CRF table 4.1 has been added to CRF, and the total land area is consistent with Table NIR-2. Remaining discrepancies between Other Land area in Table 4.1 and 4.F (0.15% of surface area difference) will be addressed in next submission.	
4 Land use, land-use change and forestry	Empty cells in CRF tables 4, 4(I), 4 (III), 4(IV)	EMRT/ IS-4-2019-0002	The tables have been completed.	
4D Wetlands	Recalculations in activity data and emissions in the category 4.D.1	EMRT/ IS-4D-2019-0001	The area is considerably larger as in previous submissions as it was calculated from the new HMI based IGLUD land use map. The new estimation of area led to a recalculation of the emissions. Further explanations can be found in the NIR, chapter 6.8.1.	Chapter 6, Section 6.8.1 NIR
7 KP LULUCF	Table 4(KP-I)A.2 lacks information in cell P15	EMRT/ IS-7-2019-0005	No deforestation occurred in 2017 and therefore the notation key NO is appropriate in this cell. This will be fixed in the march 2019 submission.	
7 KP LULUCF	Inconsistencies between total country area at the end of the current inventory year reported in table NIR-2 and final area reported in table 4.1 for the year 2017	EMRT/ IS-7-2019-0004	The total land area reported in Table 4.1 matches Table NIR-2. Remaining discrepancies between Other Land area in Table 4.1 and 4.F (0.15% of surface area difference) will be addressed in next submission	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
7 KP LULUCF	Lack of information for KC analysis in Table NIR-3	EMRT/ IS-7-2019-0001	We do not know how to add this information into CRF. When exporting the Excel table NIR-3 for importing into CRF we do not get the same layout as Table NIR-3 in the reporting tables. However, information on key categories for KP activities is reported in our NIR, in Chapter 11.7.1. Attached is the excel table NIR-3 as exported from CRF, to illustrate our issue; as well as the calculations used to generate the KCA information as reported in our NIR.	
7 KP LULUCF	Missing information for FM cap value in the “accounting” table	EMRT/ IS-7-2019-0002	This has been added for the March 2019 submission.	
7 KP LULUCF	Empty cells in KP CRF tables 4, 4(KP-I)B.2, 4(KP-II)2, 4(KP-II)3, 4(KP-II)4	EMRT/ IS-7-2019-0003	This has been corrected for the March 2019 submission.	

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

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	1995	2000	2005	2010	2015	2016*	2017*
		Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Gas/Diesel Oil									
10X40	**house heating and swimming pools**	**10,623**	**8,535**	**7,625**	**4,240**	**1,637**	**1,294**	**1,048**	**2,294**
10X5X	**industry**	**5,072**	**1,129**	**8,920**	**15,196**	**6,663**	**5,394**	**9,446**	**3,459**
10X60	**energy industries**	**1,300**	**1,091**	**1,065**	**21**	**1,012**	**1,185**	**726**	**695**
10X90	**other**	**0**	**458**	**1,386**	**8,928**	**2,728**	**4,767**	**4,549**	**7,558**
Residual Fuel Oil									
10840	**house heating and swimming pools**	**2,989**	**3,079**	**122**	**195**	**0**	**137**	**19**	**35**
1085X	**industry**	**55,934**	**56,172**	**46,146**	**25,005**	**14,917**	**10,183**	**8649**	**5,425**
10860	**energy industries**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
10890	**other**	**39**	**52**	**67**	**0**	**1,629**	**0**	**0**	**0**

*** For the years 2016 and 2017, the NEA provided data disaggregated for the most part according to the IPCC subcategories. This annex shows those two years for information.**

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	2005	2010	2015	2016	2017
Swimming pools	1,800	1,600	1,600	1,000	300	300	150	150

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[15,16]	amount/day (kg dm)	dry matter digestibility (%)	ash (%)
Hay	10.0	72.0	7.0
Barley	3.0	86.0	3.0
pulp	0.7	67.0	4.0
concentrate	2.5	85.0	8.0
sum	16.2		
average		76.4	6.3
2. Dairy cattle, stallfed, non-lactation [1,2]	**amount/day (kg dm)**	**dry matter digestibility (%)**	**ash (%)**
Hay	12.0	68.0	8.0
SUM	12.0		
Average		68.0	8.0
3. Dairy cattle, pasture, lactation period[1,2]	**amount/day (kg dm)**	**dry matter digestibility (%)**	**ash (%)**
Pasture	12.0	70.0	8.0
Concentrate	3.0	85.0	8.0
SUM	15.0		
average		73.0	8.0
4. Dairy cattle, pasture, non-lactation[1,2]	amount/day (kg dm)	dry matter digestibility (%)	ash (%)
pasture	14.0	70.0	8.0
sum	14.0		
average		70.0	8.0
Duration of periods[1,2]	**days for periods**	**dry matter digestibility (%)**	**ash (%)**
1. Dairy cattle, stallfed, lactation period	230.0		
2. Dairy cattle, stallfed, non-lactation	35.0		
3. Dairy cattle, pasture, lactation period	75.0		
4. Dairy cattle, pasture, non-lactation	25.0		
annual average	15.4	74.4	6.9

[15] Jóhannes Sveinbjörnsson og Grétar H. Harðarson, 2008. Þungi og átgeta íslenskra mjólkurkúa. Fræðaþing landbúnaðarins: 336-344

[16] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

Table A8. 2 Values used in Calculation of Digestible Energy of Feed: Cows Used for Producing Meat

1. Cows used for prod. meat, stallfed[17]	amount/day (kg dm)	dry matter digestibility (%)	ash (%)
hay	10.0	70.0	7.0
sum	10.0		
average		70.0	7.0
2. Cows used for prod. meat, 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[3,18]	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

[17] Jóhannes Sveinbjörnsson og Bragi L. Ólafsson, 1999. Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi. Ráðunautafundur 1999: 204-217.
[18] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

Table A8. 4 Values used in Calculation of Digestible Energy of Feed: Steers

1. Steers[19,20]	amount/day (kg dm)	dry matter digestibility (%)	ash (%)
Hay	5.0	70.0	7.0
Concentrate	1.0	85.0	8.0
Sum	6.0		
Average		72.5	7.2
Duration of periods	days for periods	dry matter digestibility (%)	ash (%)
1. Steers	365.0		
annual average	6.0	72.5	7.2

Table A8. 5 Values used in Calculation of Digestible Energy of Feed: Calves

1. Calves, first 90 days[21]	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

[19] Jóhannes Sveinbjörnsson og Bragi L. Ólafsson, 1999. Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi. Ráðunautafundur 1999: 204-217.
[20] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers
[21] Grétar H. Harðarson, Eiríkur Þórkelsson og Jóhannes Sveinbjörnsson, 2007. Uppeldi kálfa: Áhrif kjarnfóðurs með mismiklu tréni á vöxt og heilbrigði kálfa. Fræðaþing landbúnaðarins 2007: 234-239

Table A8. 6 Values used in Calculation of Digestible Energy of Feed: Sheep

1. Sheep, stallfed[22]	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[23]	**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[24]	**amount/day (kg dm)**	**dry matter digestibility (%)**	**ash (%)**
gras/vegetation	1.8	70.0	7.0
Sum	1.8		
Average		70.0	7.0
Duration of periods	**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

[22] Jóhannes Sveinbjörnsson, 2013: Fóðrun og fóðurþarfir sauðfjár. Kafli 4 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.
[23] Jóhannes Sveinbjörnsson, 2013: Fóðuröflun og beit á ræktað land. Kafli 5 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.
[24] Ólafur Guðmundsson, 1987: Átgeta búfjár og nýting beitar. Ráðunautafundur 1987: 181-192

Table A8. 7 Values used in Calculation of Digestible Energy of Feed: Lambs

1. Lambs, pre-weaning[25,26]	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[27,12]	**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
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

[25] Ólafur Guðmundsson, 1987: Átgeta búfjár og nýting beitar. Ráðunautafundur 1987: 181-192

[26] 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)

[27] Jóhannes Sveinbjörnsson, 2013: Fóðuröflun og beit á ræktað land. Kafli 5 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.

Annex 9: CRF (Common Reporting Format) Summary 2 Tables for 1990-2017

1990

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2019 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)]	7872.55	4262.56	373.84	0.69	494.64	1.10	NO,NA	NO,NA	13005.38
1. Energy	1822.45	7.93	36.30						1866.69
A. Fuel combustion (sectoral approach)	1761.09	7.25	36.30						1804.64
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	600.45	3.91	15.53						619.90
4. Other sectors	785.19	2.84	6.15						794.18
5. Other	NO	NO	NO						NO
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	407.62	1.62	52.35	0.69	494.64	1.10	NO,NA	NO,NA	958.01
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	6.99	NE,NA	NE,NA						6.99
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				0.69	NO	NO	NO	NO	0.69
G. Other product manufacture and use	0.01	0.05	5.86		NO	1.10			7.01
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	367.01	225.62						592.68
A. Enteric fermentation		314.13							314.13
B. Manure management		52.88	23.08						75.95
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	202.54						202.54
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5635.13	3720.00	51.98						9407.11
A. Forest land	-42.61	0.09	0.12						-42.39
B. Cropland	1880.20	94.83	NO,NE,NA						1975.03
C. Grassland	4997.93	374.37	0.07						5372.37
D. Wetlands	-1224.01	3250.71	NO,NA,NE						2026.70
E. Settlements	23.61	NE	NO,NE,IE						23.61
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	51.79						51.79
5. Waste	7.30	166.01	7.59						180.89
A. Solid waste disposal	NO	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		2.08	5.91						8.00
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									3598.27
Total CO_2 equivalent emissions with land use, land-use change and forestry									13005.38
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1991

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1991
Submission 2019 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)]	7746.35	4261.49	364.78	0.70	410.61	1.24	NO,NA	NO,NA	12785.18
1. Energy	1737.15	8.00	35.76						1780.91
A. Fuel combustion (sectoral approach)	1667.20	7.41	35.76						1710.37
1. Energy industries	15.39	0.02	0.04						15.44
2. Manufacturing industries and construction	285.42	0.40	13.78						299.59
3. Transport	611.73	4.04	16.03						631.79
4. Other sectors	754.67	2.95	5.92						763.54
5. Other	NO	NO	NO						NO
B. Fugitive emissions from fuels	69.95	0.59	NO,NA						70.54
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	69.95	0.59	NA,NO						70.54
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	373.26	1.31	50.31	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	6.89	NE,NA	NE,NA						6.89
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	5.31		NO	1.24			6.61
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	357.05	218.91						576.01
A. Enteric fermentation		305.31							305.31
B. Manure management		51.74	21.91						73.65
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	196.99						196.99
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5628.65	3722.70	52.18						9403.53
A. Forest land	-44.26	0.14	0.18						-43.94
B. Cropland	1870.50	94.32	NO,NE,NA						1964.82
C. Grassland	5003.13	375.24	0.09						5378.46
D. Wetlands	-1217.10	3253.00	NO,NA,NE						2035.89
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	NO,NA								NO,NA
H. Other	IE	IE	51.91						51.91
5. Waste	7.24	172.44	7.62						187.30
A. Solid waste disposal	NO	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		3.15	5.96						9.11
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	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									3381.65
Total CO_2 equivalent emissions with land use, land-use change and forestry									12785.18
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1992

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1992
Submission 2019 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)]	7880.80	4272.20	348.20	0.70	183.04	1.24	NO,NA	NO,NA	12686.19
1. Energy	1879.55	8.05	35.96						1923.55
A. Fuel combustion (sectoral approach)	1811.93	7.40	35.96						1855.29
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	621.83	4.14	16.40						642.36
4. Other sectors	834.54	2.82	6.53						843.89
5. Other	NO	NO	NO						NO
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	376.38	1.41	44.96	0.70	183.04	1.24	NO,NA	NO,NA	607.73
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	6.90	NE,NA	NE,NA						6.90
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				0.70	NO	NO	NO	NO	0.70
G. Other product manufacture and use	0.01	0.05	4.73		NO	1.24			6.03
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	352.27	207.23						559.55
A. Enteric fermentation		301.63							301.63
B. Manure management		50.64	20.56						71.20
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	186.67						186.67
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5617.78	3722.07	52.38						9392.23
A. Forest land	-48.80	0.19	0.24						-48.37
B. Cropland	1860.19	93.81	NO,NE,NA						1954.00
C. Grassland	5006.71	376.12	0.11						5382.94
D. Wetlands	-1216.71	3251.95	NO,NA,NE						2035.24
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	NO,NA								NO,NA
H. Other	IE	IE	52.03						52.03
5. Waste	7.04	188.40	7.68						203.12
A. Solid waste disposal	NO	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		3.20	6.06						9.26
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									3293.96
Total CO_2 equivalent emissions with land use, land-use change and forestry									12686.19
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1993

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1993
Submission 2019 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)]	8038.52	4284.61	355.57	1.45	88.24	1.24	NO,NA	NO,NA	12769.63
1. Energy	1989.60	8.45	37.48						2035.54
A. Fuel combustion (sectoral approach)	1904.22	7.80	37.48						1949.50
1. Energy industries	17.22	0.03	0.10						17.35
2. Manufacturing industries and construction	368.87	0.47	14.03						383.36
3. Transport	622.46	4.11	16.30						642.87
4. Other sectors	895.67	3.19	7.06						905.92
5. Other	NO	NO	NO						NO
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	425.37	1.73	46.97	1.45	88.24	1.24	NO,NA	NO,NA	565.00
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	7.19	NE,NA	NE,NA						7.19
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				1.45	NO	NO	NO	NO	1.45
G. Other product manufacture and use	0.01	0.04	4.65		NO	1.24			5.94
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	351.54	211.06						562.66
A. Enteric fermentation		301.20							301.20
B. Manure management		50.34	20.73						71.07
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	190.33						190.33
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5617.49	3721.42	52.53						9391.45
A. Forest land	-53.97	0.20	0.25						-53.52
B. Cropland	1849.90	93.30	NO,NE,NA						1943.20
C. Grassland	5011.86	376.99	0.13						5388.98
D. Wetlands	-1216.31	3250.92	NO,NA,NE						2034.61
E. Settlements	26.02	NE	NO,NE,IE						26.02
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	52.15						52.15
5. Waste	6.00	201.47	7.53						215.00
A. Solid waste disposal	NO	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		3.23	6.12						9.36
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									3378.19
Total CO_2 equivalent emissions with land use, land-use change and forestry									12769.63
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1994

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1994
Submission 2019 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)]	7956.04	4296.74	359.12	2.33	52.53	1.24	NO,NA	NO,NA	12668.01
1. Energy	1929.86	7.36	37.55						1974.78
A. Fuel combustion (sectoral approach)	1859.74	6.70	37.55						1903.99
1. Energy industries	16.89	0.03	0.09						17.02
2. Manufacturing industries and construction	346.98	0.44	14.22						361.65
3. Transport	624.98	4.15	16.46						645.59
4. Other sectors	870.89	2.07	6.77						879.73
5. Other	NO	NO	NO						NO
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	426.46	1.70	46.83	2.33	52.53	1.24	NO,NA	NO,NA	531.10
A. Mineral industry	37.35								37.35
B. Chemical industry	0.35	NO,NA	42.61	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	42.97
C. Metal industry	381.64	1.65	NO	NO	52.53	NO	NO	NO	435.82
D. Non-energy products from fuels and solvent use	7.11	NE,NA	NE,NA						7.11
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				2.33	NO	NO	NO	NO	2.33
G. Other product manufacture and use	0.01	0.05	4.22		NO	1.24			5.52
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	353.56	214.53						568.15
A. Enteric fermentation		303.37							303.37
B. Manure management		50.19	20.85						71.04
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	193.68						193.68
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5594.13	3720.28	52.72						9367.13
A. Forest land	-56.80	0.22	0.27						-56.32
B. Cropland	1839.63	92.79	NO,NE,NA						1932.42
C. Grassland	5019.22	378.10	0.15						5397.47
D. Wetlands	-1215.65	3249.17	NO,NA,NE						2033.53
E. Settlements	7.73	NE	NO,NE,IE						7.73
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	52.30						52.30
5. Waste	5.53	213.83	7.49						226.85
A. Solid waste disposal	NO	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		3.27	6.18						9.45
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO

Memo items:[(2)]									
International bunkers	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									3300.88
Total CO_2 equivalent emissions with land use, land-use change and forestry									12668.01
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1995

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1995
Submission 2019 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)]	8054.36	4295.04	356.84	10.22	69.36	1.24	NO,NA	NO,NA	12787.07
1. Energy	2016.37	6.90	45.38						2068.65
A. Fuel combustion (sectoral approach)	1934.13	6.21	45.38						1985.72
1. Energy industries	21.85	0.04	0.12						22.02
2. Manufacturing industries and construction	366.16	0.46	17.68						384.30
3. Transport	600.57	3.46	20.19						624.23
4. Other sectors	945.55	2.24	7.39						955.18
5. Other	NO	NO	NO						NO
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	443.81	1.83	44.75	10.22	69.36	1.24	NO,NA	NO,NA	571.21
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	7.57	NE,NA	NE,NA						7.57
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				10.22	NO	NO	NO	NO	10.22
G. Other product manufacture and use	0.01	0.05	4.22		NO	1.24			5.51
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	341.37	206.18						547.61
A. Enteric fermentation		291.90							291.90
B. Manure management		49.47	19.82						69.28
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	186.37						186.37
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5589.25	3718.68	52.96						9360.90
A. Forest land	-66.43	0.25	0.31						-65.87
B. Cropland	1829.34	92.28	NO,NE,NA						1921.62
C. Grassland	5027.75	379.44	0.17						5407.35
D. Wetlands	-1214.72	3246.71	NO,NA,NE						2031.99
E. Settlements	13.31	NE	NO,NE,IE						13.31
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	52.49						52.49
5. Waste	4.87	226.26	7.57						238.70
A. Solid waste disposal	NO	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		3.29	6.26						9.55
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									3426.18
Total CO_2 equivalent emissions with land use, land-use change and forestry									12787.07
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1996

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1996
Submission 2019 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)]	8106.82	4305.52	371.45	18.59	29.64	1.24	NO,NA	NO,NA	12833.28
1. Energy	2072.51	7.13	45.13						2124.77
A. Fuel combustion (sectoral approach)	1991.24	6.35	45.13						2042.73
1. Energy industries	15.35	0.04	0.13						15.52
2. Manufacturing industries and construction	408.79	0.49	17.26						426.54
3. Transport	591.00	3.50	20.15						614.65
4. Other sectors	976.10	2.33	7.59						986.01
5. Other	NO	NO	NO						NO
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	443.20	1.86	52.02	18.59	29.64	1.24	NO,NA	NO,NA	546.56
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	7.56	NE,NA	NE,NA						7.56
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				18.59	NO	NO	NO	NO	18.59
G. Other product manufacture and use	0.01	0.05	4.64		NO	1.24			5.94
H. Other	NA	NA	NA						NA
3. Agriculture	0.07	346.53	213.65						560.24
A. Enteric fermentation		296.52							296.52
B. Manure management		50.01	20.10						70.11
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	193.55						193.55
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5586.69	3719.10	53.17						9358.96
A. Forest land	-70.70	0.27	0.32						-70.10
B. Cropland	1819.02	91.77	NO,NE,NA						1910.78
C. Grassland	5035.72	380.67	0.19						5416.57
D. Wetlands	-1212.36	3246.40	NO,NA,NE						2034.04
E. Settlements	15.01	NE	NO,NE,IE						15.01
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	52.66						52.66
5. Waste	4.37	230.90	7.48						242.74
A. Solid waste disposal	NO	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		3.30	6.28						9.58
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									3474.32
Total CO_2 equivalent emissions with land use, land-use change and forestry									12833.28
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

(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 2019 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)	8203.81	4303.51	368.55	28.77	97.08	1.24	NO,NA	NO,NA	13002.96
1. Energy	2109.00	6.56	52.98						2168.53
A. Fuel combustion (sectoral approach)	2042.14	5.76	52.98						2100.88
1. Energy industries	11.86	0.04	0.12						12.02
2. Manufacturing industries and construction	475.93	0.58	20.78						497.29
3. Transport	602.50	2.87	24.63						630.01
4. Other sectors	951.85	2.26	7.46						961.57
5. Other	NO	NO	NO						NO
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	502.37	1.83	44.17	28.77	97.08	1.24	NO,NA	NO,NA	675.46
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	7.40	NE,NA	NE,NA						7.40
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				28.77	NO	NO	NO	NO	28.77
G. Other product manufacture and use	0.01	0.05	4.65		NO	1.24			5.95
H. Other	NA	NA	NA						NA
3. Agriculture	0.06	342.93	210.45						553.44
A. Enteric fermentation		293.88							293.88
B. Manure management		49.05	20.26						69.31
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	190.19						190.19
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5588.17	3716.55	53.47						9358.19
A. Forest land	-77.50	0.30	0.35						-76.85
B. Cropland	1808.73	91.25	NO,NE,NA						1899.99
C. Grassland	5051.82	382.53	0.20						5434.55
D. Wetlands	-1210.85	3242.47	NO,NA,NE						2031.62
E. Settlements	15.97	NE	NO,NE,IE						15.97
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	52.92						52.92
5. Waste	4.21	235.65	7.47						247.33
A. Solid waste disposal	NO	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		3.32	6.32						9.65
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
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									3644.77
Total CO_2 equivalent emissions with land use, land-use change and forestry									13002.96
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1998

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1998
Submission 2019 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)]	8229.93	4313.74	367.65	43.22	212.33	1.24	NO,NA	NO,NA	13168.11
1. Energy	2101.63	6.80	53.66						2162.10
A. Fuel combustion (sectoral approach)	2017.91	5.79	53.66						2077.37
1. Energy industries	14.84	0.04	0.13						15.01
2. Manufacturing industries and construction	452.82	0.57	20.96						474.35
3. Transport	605.24	2.92	25.21						633.37
4. Other sectors	945.02	2.25	7.36						954.64
5. Other	NO	NO	NO						NO
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	530.18	1.60	39.26	43.22	212.33	1.24	NO,NA	NO,NA	827.83
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	7.51	NE,NA	NE,NA						7.51
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				43.22	NO	NO	NO	NO	43.22
G. Other product manufacture and use	0.01	0.04	4.81		NO	1.24			6.10
H. Other	NA	NA	NA						NA
3. Agriculture	0.08	349.98	213.46						563.52
A. Enteric fermentation		299.54							299.54
B. Manure management		50.44	20.80						71.24
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	192.67						192.67
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5594.48	3712.79	53.88						9361.14
A. Forest land	-85.97	0.34	0.40						-85.23
B. Cropland	1798.43	90.74	NO,NE,NA						1889.18
C. Grassland	5074.26	384.99	0.22						5459.47
D. Wetlands	-1208.48	3236.72	NO,NA,NE						2028.23
E. Settlements	16.25	NE	NO,NE,IE						16.25
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	-0.01								-0.01
H. Other	IE	IE	53.26						53.26
5. Waste	3.57	242.56	7.39						253.51
A. Solid waste disposal	NO	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		3.36	6.38						9.74
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									3806.97
Total CO_2 equivalent emissions with land use, land-use change and forestry									13168.11
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1999

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1999
Submission 2019 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)]	8449.70	4315.26	382.42	48.85	204.17	1.24	NO,NA	NO,NA	13401.65
1. Energy	2159.24	6.41	61.61						2227.26
A. Fuel combustion (sectoral approach)	2047.97	5.04	61.61						2114.61
1. Energy industries	11.92	0.04	0.12						12.08
2. Manufacturing industries and construction	479.86	0.61	22.93						503.40
3. Transport	626.75	2.17	31.29						660.21
4. Other sectors	929.44	2.23	7.26						938.93
5. Other	NO	NO	NO						NO
B. Fugitive emissions from fuels	111.27	1.37	NO,NA						112.64
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	111.27	1.37	NA,NO						112.64
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	679.04	1.86	39.64	48.85	204.17	1.24	NO,NA	NO,NA	974.81
A. Mineral industry	61.41								61.41
B. Chemical industry	0.43	NO,NA	34.78	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	35.21
C. Metal industry	610.13	1.81	NO	NO	204.17	NO	NO	NO	816.11
D. Non-energy products from fuels and solvent use	7.05	NE,NA	NE,NA						7.05
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				48.85	NO	NO	NO	NO	48.85
G. Other product manufacture and use	0.02	0.05	4.87		NO	1.24			6.18
H. Other	NA	NA	NA						NA
3. Agriculture	0.07	348.44	219.55						568.06
A. Enteric fermentation		298.30							298.30
B. Manure management		50.14	20.91						71.05
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	198.64						198.64
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5608.43	3708.40	54.29						9371.13
A. Forest land	-92.35	0.36	0.42						-91.57
B. Cropland	1788.20	90.23	NO,NE,NA						1878.43
C. Grassland	5100.05	387.68	0.24						5487.98
D. Wetlands	-1206.00	3230.13	NO,NA,NE						2024.13
E. Settlements	18.53	NE	NO,NE,IE						18.53
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	53.63						53.63
5. Waste	2.92	250.15	7.33						260.39
A. Solid waste disposal	NO	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		3.40	6.46						9.85
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									4030.52
Total CO_2 equivalent emissions with land use, land-use change and forestry									13401.65
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2000

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2000
Submission 2019 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)]	8563.47	4304.24	362.43	43.28	149.89	1.31	NO,NA	NO,NA	13424.62
1. Energy	2142.32	6.45	61.70						2210.48
A. Fuel combustion (sectoral approach)	1989.18	4.94	61.70						2055.82
1. Energy industries	10.90	0.04	0.12						11.06
2. Manufacturing industries and construction	432.30	0.57	23.31						456.18
3. Transport	629.40	2.15	31.08						662.63
4. Other sectors	916.58	2.18	7.19						925.95
5. Other	NO	NO	NO						NO
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	788.85	2.76	22.47	43.28	149.89	1.31	NO,NA	NO,NA	1008.56
A. Mineral industry	65.45								65.45
B. Chemical industry	0.41	NO,NA	17.91	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	18.32
C. Metal industry	715.56	2.72	NO	NO	149.89	NO	NO	NO	868.17
D. Non-energy products from fuels and solvent use	7.42	NE,NA	NE,NA						7.42
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				43.28	NO	NO	NO	NO	43.28
G. Other product manufacture and use	0.01	0.04	4.56		NO	1.31			5.92
H. Other	NA	NA	NA						NA
3. Agriculture	0.07	335.75	215.93						551.75
A. Enteric fermentation		286.57							286.57
B. Manure management		49.18	20.35						69.53
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	195.58						195.58
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5629.49	3702.51	54.95						9386.94
A. Forest land	-102.24	0.44	0.58						-101.22
B. Cropland	1777.93	89.72	NO,NE,NA						1867.65
C. Grassland	5138.26	391.12	0.26						5529.64
D. Wetlands	-1202.64	3221.23	NO,NA,NE						2018.59
E. Settlements	18.18	NE	NO,NE,IE						18.18
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	54.10						54.10
5. Waste	2.74	256.77	7.38						266.89
A. Solid waste disposal	NO	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		3.44	6.53						9.97
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	4037.68
Total CO_2 equivalent emissions with land use, land-use change and forestry	13424.62
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

(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 2019 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)]	8507.60	4312.02	356.66	48.69	108.05	1.31	NO,NA	NO,NA	13334.33
1. Energy	2028.93	6.18	60.37						2095.48
A. Fuel combustion (sectoral approach)	1885.16	4.65	60.37						1950.18
1. Energy industries	10.21	0.04	0.12						10.37
2. Manufacturing industries and construction	477.45	0.62	22.95						501.02
3. Transport	640.15	2.18	31.37						673.70
4. Other sectors	757.35	1.80	5.93						765.08
5. Other	NO	NO	NO						NO
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	831.08	2.86	19.79	48.69	108.05	1.31	NO,NA	NO,NA	1011.78
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	6.55	NE,NA	NE,NA						6.55
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				48.69	0.01	NO	NO	NO	48.70
G. Other product manufacture and use	0.01	0.04	4.26		NO	1.31			5.62
H. Other	NA	NA	NA						NA
3. Agriculture	0.08	337.99	213.75						551.82
A. Enteric fermentation		288.19							288.19
B. Manure management		49.80	20.17						69.97
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	193.58						193.58
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5644.92	3698.78	55.34						9399.03
A. Forest land	-108.01	0.46	0.60						-106.95
B. Cropland	1767.73	89.21	NO,NE,NA						1856.93
C. Grassland	5167.53	393.66	0.28						5561.47
D. Wetlands	-1200.30	3215.45	NO,NA,NE						2015.14
E. Settlements	17.97	NE	NO,NE,IE						17.97
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	54.46						54.46
5. Waste	2.58	266.21	7.42						276.21
A. Solid waste disposal	NO	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		3.49	6.64						10.13
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)]	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
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									3935.29
Total CO_2 equivalent emissions with land use, land-use change and forestry									13334.33
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

[(1)] For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

[(2)] See footnote 7 to table Summary 1.A.

[(3)] In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2002

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2002
Submission 2019 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	8661.45	4304.62	330.43	45.76	85.51	1.31	NA,NO	NA,NO	13429.08
1. Energy	2136.89	6.41	60.08						2203.38
A. Fuel combustion (sectoral approach)	1989.48	4.87	60.08						2054.43
1. Energy industries	12.19	0.04	0.12						12.35
2. Manufacturing industries and construction	480.72	0.60	21.55						502.86
3. Transport	643.72	2.20	31.69						677.61
4. Other sectors	852.86	2.03	6.72						861.61
5. Other	NO	NO	NO						NO
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	848.37	3.02	3.95	45.76	85.51	1.31	NA,NO	NA,NO	987.92
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	6.76	NE,NA	NE,NA						6.76
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				45.76	0.01	NO	NO	NO	45.77
G. Other product manufacture and use	0.01	0.05	3.95		NO	1.31			5.31
H. Other	NA	NA	NA						NA
3. Agriculture	0.08	331.25	203.89						535.21
A. Enteric fermentation		282.70							282.70
B. Manure management		48.54	19.96						68.51
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	183.92						183.92
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5673.71	3693.59	55.88						9423.18
A. Forest land	-117.26	0.50	0.66						-116.10
B. Cropland	1757.54	88.69	NO,NE,NA						1846.23
C. Grassland	5208.10	397.03	0.30						5605.42
D. Wetlands	-1197.26	3207.38	NO,NA,NE						2010.12
E. Settlements	22.59	NE	NO,NE,IE						22.59
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	54.92						54.92
5. Waste	2.40	270.35	6.63						279.39
A. Solid waste disposal	NO	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		6.47	5.90						12.37
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:[(2)]									
International bunkers	395.00	0.26	3.27						398.52
Aviation	309.54	0.05	2.58						312.18
Navigation	85.46	0.20	0.69						86.35
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,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									4005.90
Total CO_2 equivalent emissions with land use, land-use change and forestry									13429.08
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2003

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2003
Submission 2019 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)]	8649.46	4298.16	324.62	56.75	70.47	1.31	NA,NO	NA,NO	13400.78
1. Energy	2128.11	6.36	59.63						2194.10
A. Fuel combustion (sectoral approach)	1991.77	4.86	59.63						2056.26
1. Energy industries	11.45	0.04	0.12						11.61
2. Manufacturing industries and construction	427.45	0.54	19.72						447.71
3. Transport	738.52	2.35	33.35						774.22
4. Other sectors	814.35	1.93	6.45						822.73
5. Other	NO	NO	NO						NO
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	849.27	3.02	4.03	56.75	70.47	1.31	NA,NO	NA,NO	984.86
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	6.45	NE,NA	NE,NA						6.45
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				56.75	0.00	NO	NO	NO	56.76
G. Other product manufacture and use	0.02	0.04	4.03		NO	1.31			5.41
H. Other	NA	NA	NA						NA
3. Agriculture	0.08	326.94	198.06						525.09
A. Enteric fermentation		279.31							279.31
B. Manure management		47.64	19.77						67.40
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	178.29						178.29
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5669.95	3690.38	56.23						9416.56
A. Forest land	-128.25	0.53	0.69						-127.03
B. Cropland	1747.34	88.18	NO,NE,NA						1835.52
C. Grassland	5227.11	399.27	0.32						5626.70
D. Wetlands	-1195.38	3202.41	NO,NA,NE						2007.03
E. Settlements	19.12	NE	NO,NE,IE						19.12
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	55.23						55.23
5. Waste	2.05	271.46	6.66						280.18
A. Solid waste disposal	NO	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		6.51	5.93						12.45
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	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									3984.22
Total CO_2 equivalent emissions with land use, land-use change and forestry									13400.78
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2004

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2019 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]	8777.52	4298.68	325.46	59.54	45.48	1.31	NA,NO	NA,NO	13508.00
1. Energy	2223.02	6.74	65.06						2294.83
A. Fuel combustion (sectoral approach)	2100.12	5.12	65.06						2170.30
1. Energy industries	11.17	0.04	0.12						11.33
2. Manufacturing industries and construction	460.15	0.61	23.57						484.32
3. Transport	790.49	2.48	34.76						827.73
4. Other sectors	838.31	1.99	6.62						846.92
5. Other	NO	NO	NO						NO
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	872.97	3.01	3.72	59.54	45.48	1.31	NA,NO	NA,NO	986.03
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	7.20	NE,NA	NE,NA						7.20
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				59.54	0.00	NO	NO	NO	59.55
G. Other product manufacture and use	0.02	0.05	3.72		NO	1.31			5.10
H. Other	NA	NA	NA						NA
3. Agriculture	0.08	322.39	193.41						515.88
A. Enteric fermentation		275.49							275.49
B. Manure management		46.90	19.45						66.35
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	173.96						173.96
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[1]	5676.28	3686.84	56.61						9419.73
A. Forest land	-134.46	0.54	0.72						-133.20
B. Cropland	1737.10	87.67	NO,NE,NA						1824.77
C. Grassland	5242.21	401.58	0.33						5644.13
D. Wetlands	-1193.36	3197.05	NO,NA,NE						2003.69
E. Settlements	24.79	NE	0.00						24.79
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	55.55						55.55
5. Waste	5.17	279.70	6.66						291.53
A. Solid waste disposal	NO	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		6.56	5.98						12.54
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	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									4088.27
Total CO_2 equivalent emissions with land use, land-use change and forestry									13508.00
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

[1] For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

[2] See footnote 7 to table Summary 1.A.

[3] In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2005

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2005
Submission 2019 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)	8657.21	4284.21	330.57	69.28	30.76	2.52	NO	NO	13374.55
1. Energy	2108.19	6.20	70.05						2184.44
A. Fuel combustion (sectoral approach)	1990.03	4.46	70.05						2064.54
1. Energy industries	13.88	0.04	0.12						14.05
2. Manufacturing industries and construction	422.79	0.54	25.37						448.70
3. Transport	795.65	2.08	38.60						836.33
4. Other sectors	757.71	1.79	5.96						765.46
5. Other	NO	NO	NO						NO
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	855.93	2.81	3.39	69.28	30.76	2.52	NO	NO	964.69
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	6.95	NE,NA	NE,NA						6.95
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				69.28	0.00	NO	NO	NO	69.28
G. Other product manufacture and use	0.01	0.04	3.39		NO	2.52			5.95
H. Other	NA	NA	NA						NA
3. Agriculture	0.07	325.36	193.32						518.75
A. Enteric fermentation		277.80							277.80
B. Manure management		47.56	19.54						67.10
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	173.78						173.78
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5688.28	3681.89	57.07						9427.24
A. Forest land	-154.08	0.57	0.74						-152.77
B. Cropland	1726.94	87.15	NO,NE,NA						1814.09
C. Grassland	5271.53	404.65	0.35						5676.53
D. Wetlands	-1190.52	3189.52	NO,NA,NE						1999.00
E. Settlements	34.41	NE	0.00						34.42
F. Other land	NA,NE	NE,NA	NA,NE						NA,NE
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	55.98						55.98
5. Waste	4.73	267.96	6.75						279.44
A. Solid waste disposal	NO	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		6.63	6.09						12.72
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO

Memo items:(2)									
International bunkers	422.96	0.08	3.52						426.57
Aviation	421.23	0.07	3.51						424.81
Navigation	1.74	0.00	0.01						1.76
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	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									3947.31
Total CO_2 equivalent emissions with land use, land-use change and forestry									13374.55
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2006

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2006
Submission 2019 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)]	8886.70	4323.48	353.63	69.54	392.79	2.52	NO	NO	14028.66
1. Energy	2177.24	7.19	69.43						2253.87
A. Fuel combustion (sectoral approach)	2049.81	4.78	69.43						2124.02
1. Energy industries	16.09	0.07	0.20						16.36
2. Manufacturing industries and construction	407.77	0.53	23.04						431.34
3. Transport	939.20	2.56	40.79						982.55
4. Other sectors	686.75	1.62	5.41						693.77
5. Other	NO	NO	NO						NO
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	964.93	2.76	3.47	69.54	392.79	2.52	NO	NO	1436.00
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	7.72	NE,NA	NE,NA						7.72
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				69.54	0.00	NO	NO	NO	69.54
G. Other product manufacture and use	0.02	0.04	3.47		NO	2.52			6.04
H. Other	NA	NA	NA						NA
3. Agriculture	0.08	332.51	210.31						542.90
A. Enteric fermentation		282.58							282.58
B. Manure management		49.93	19.72						69.64
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	190.60						190.60
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5739.66	3678.05	63.30						9481.01
A. Forest land	-160.25	0.59	0.77						-158.89
B. Cropland	1716.80	86.65	0.02						1803.47
C. Grassland	5326.83	413.52	4.72						5745.07
D. Wetlands	-1185.51	3177.29	1.13						1992.90
E. Settlements	41.79	NE	0.01						41.80
F. Other land	NA,NE	0.01	0.01						0.01
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	56.65						56.65
5. Waste	4.79	302.97	7.11						314.88
A. Solid waste disposal	NO	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		6.77	6.23						13.01
E. Other	NA	NO	NO						NA,NO
6. Other ***(as specified in summary 1.A)***	NO	NO	NO	NO	NO	NO	NO	NO	NO

Memo items:[(2)]									
International bunkers	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	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									4547.65
Total CO_2 equivalent emissions with land use, land-use change and forestry									14028.66
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2007

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2007
Submission 2019 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)]	9279.35	4313.00	361.65	73.34	331.39	2.86	NO	NO	14361.59
1. Energy	2323.22	8.27	70.50						2402.00
A. Fuel combustion (sectoral approach)	2175.85	5.18	70.50						2251.54
1. Energy industries	33.26	0.09	0.25						33.60
2. Manufacturing industries and construction	388.18	0.56	23.18						411.93
3. Transport	974.97	2.70	40.95						1018.62
4. Other sectors	779.43	1.83	6.12						787.38
5. Other	NO	NO	NO						NO
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	1162.74	2.91	4.29	73.34	331.39	2.86	NO	NO	1577.52
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	7.22	NE,NA	NE,NA						7.22
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				73.34	0.00	NO	NO	NO	73.34
G. Other product manufacture and use	0.05	0.06	4.29		NO	2.86			7.25
H. Other	NA	NA	NA						NA
3. Agriculture	0.13	338.56	220.87						559.56
A. Enteric fermentation		287.22							287.22
B. Manure management		51.34	20.02						71.36
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	200.85						200.85
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.13								0.13
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5785.39	3664.44	58.55						9508.38
A. Forest land	-167.94	0.60	0.81						-166.52
B. Cropland	1706.68	86.12	NO,NA						1792.80
C. Grassland	5386.98	414.47	0.40						5801.84
D. Wetlands	-1179.93	3163.25	NO,NA,NE						1983.33
E. Settlements	39.59	NE	0.01						39.60
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	57.33						57.33
5. Waste	7.86	298.82	7.45						314.13
A. Solid waste disposal	NO	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		5.50	6.40						11.89
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	0.49								0.49
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									4853.21
Total CO_2 equivalent emissions with land use, land-use change and forestry									14361.59
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2008

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2008
Submission 2019 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)]	9605.37	4295.75	368.10	83.72	411.38	3.01	NO	NO	14767.32
1. Energy	2184.31	8.02	67.20						2259.53
A. Fuel combustion (sectoral approach)	1998.37	4.90	67.20						2070.47
1. Energy industries	15.01	0.06	0.19						15.26
2. Manufacturing industries and construction	346.02	0.50	22.12						368.64
3. Transport	920.64	2.64	39.26						962.54
4. Other sectors	716.71	1.69	5.63						724.03
5. Other	NO	NO	NO						NO
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	1604.36	2.45	3.78	83.72	411.38	3.01	NO	NO	2108.70
A. Mineral industry	61.80								61.80
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1536.09	2.41	NO	NO	411.38	NO	NO	NO	1949.88
D. Non-energy products from fuels and solvent use	6.44	NE,NA	NE,NA						6.44
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				83.72	0.00	NO	NO	NO	83.72
G. Other product manufacture and use	0.02	0.04	3.78		NO	3.01			6.85
H. Other	NA	NA	NA						NA
3. Agriculture	0.15	341.71	230.27						572.13
A. Enteric fermentation		290.13							290.13
B. Manure management		51.58	19.93						71.51
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	210.34						210.34
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.15								0.15
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5810.41	3656.24	59.27						9525.93
A. Forest land	-172.12	0.62	0.80						-170.70
B. Cropland	1696.59	85.61	NO,NA						1782.20
C. Grassland	5441.30	419.09	0.48						5860.87
D. Wetlands	-1175.27	3150.92	0.02						1975.68
E. Settlements	19.92	NE	0.01						19.93
F. Other land	NA,NE	0.00	0.00						0.00
G. Harvested wood products	-0.01								-0.01
H. Other	IE	IE	57.96						57.96
5. Waste	6.13	287.33	7.58						301.04
A. Solid waste disposal	NO	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		5.18	6.52						11.70
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO

Memo items:[(2)]									
International bunkers	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	1.72								1.72
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									5241.40
Total CO_2 equivalent emissions with land use, land-use change and forestry									14767.32
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2009

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2009
Submission 2019 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)]	9516.73	4287.86	342.10	113.06	180.05	3.02	NO	NO	14442.83
1. Energy	2109.12	7.69	60.57						2177.38
A. Fuel combustion (sectoral approach)	1939.01	4.84	60.57						2004.42
1. Energy industries	12.62	0.05	0.15						12.82
2. Manufacturing industries and construction	248.48	0.34	15.24						264.06
3. Transport	893.79	2.60	39.10						935.48
4. Other sectors	784.11	1.85	6.09						792.05
5. Other	NO	NO	NO						NO
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	1615.76	2.49	3.28	113.06	180.05	3.02	NO	NO	1917.66
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	4.95	NE,NA	NE,NA						4.95
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				113.06	0.00	NO	NO	NO	113.06
G. Other product manufacture and use	0.02	0.04	3.28		NO	3.02			6.36
H. Other	NA	NA	NA						NA
3. Agriculture	0.16	345.85	210.97						556.98
A. Enteric fermentation		293.99							293.99
B. Manure management		51.86	20.32						72.18
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	190.65						190.65
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.16								0.16
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5785.64	3654.73	59.43						9499.80
A. Forest land	-186.35	0.64	0.83						-184.88
B. Cropland	1686.53	85.09	NO,NA						1771.62
C. Grassland	5452.84	420.51	0.43						5873.78
D. Wetlands	-1174.18	3148.48	NO,NA,NE						1974.30
E. Settlements	6.81	NE	0.01						6.82
F. Other land	NA,NE	0.00	0.00						0.00
G. Harvested wood products	-0.01								-0.01
H. Other	IE	IE	58.17						58.17
5. Waste	6.06	277.10	7.85						291.01
A. Solid waste disposal	NO	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		5.25	6.67						11.92
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	341.70	0.08	2.84						344.62
Aviation	333.55	0.06	2.78						336.38
Navigation	8.15	0.02	0.06						8.23
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	1.30								1.30
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									4943.03
Total CO_2 equivalent emissions with land use, land-use change and forestry									14442.83
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for
(2) See footnote 7 to table Summary 1.A.
(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2010

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2010
Submission 2019 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)]	9380.23	4285.33	329.05	145.83	171.67	4.66	NO	NO	14316.77
1. Energy	1992.10	9.62	55.26						2056.98
A. Fuel combustion (sectoral approach)	1802.45	4.55	55.26						1862.27
1. Energy industries	11.74	0.05	0.15						11.94
2. Manufacturing industries and construction	201.73	0.26	12.06						214.05
3. Transport	850.40	2.51	37.27						890.19
4. Other sectors	738.58	1.73	5.77						746.09
5. Other	NO	NO	NO						NO
B. Fugitive emissions from fuels	189.64	5.07	NO,NA						194.71
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	189.64	5.07	NA,NO						194.71
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1622.81	2.59	3.57	145.83	171.67	4.66	NO	NO	1951.13
A. Mineral industry	10.40								10.40
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1607.25	2.56	NO	NO	171.66	NO	NO	NO	1781.47
D. Non-energy products from fuels and solvent use	5.13	NE,NA	NE,NA						5.13
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				145.83	0.01	NO	NO	NO	145.84
G. Other product manufacture and use	0.02	0.04	3.57		NO	4.66			8.29
H. Other	NA	NA	NA						NA
3. Agriculture	0.13	343.06	202.55						545.73
A. Enteric fermentation		293.43							293.43
B. Manure management		49.63	20.11						69.73
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	182.44						182.44
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.13								0.13
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5759.29	3652.98	59.67						9471.94
A. Forest land	-209.37	0.65	0.84						-207.88
B. Cropland	1676.47	84.58	NO,NA						1761.05
C. Grassland	5459.58	422.00	0.45						5882.03
D. Wetlands	-1173.15	3145.75	0.00						1972.60
E. Settlements	5.79	NE	0.01						5.80
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	58.38						58.38
5. Waste	5.91	277.08	8.00						290.99
A. Solid waste disposal	NO	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		5.22	6.66						11.88
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	1.64								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									4844.82
Total CO_2 equivalent emissions with land use, land-use change and forestry									14316.77
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2011

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2011
Submission 2019 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)]	9217.30	4260.21	324.14	144.50	74.52	3.05	NO	NO	14023.70
1. Energy	1862.39	8.35	51.74						1922.49
A. Fuel combustion (sectoral approach)	1682.88	4.34	51.74						1738.97
1. Energy industries	10.61	0.04	0.12						10.77
2. Manufacturing industries and construction	183.54	0.25	10.40						194.18
3. Transport	815.63	2.47	35.99						854.09
4. Other sectors	673.10	1.59	5.24						679.92
5. Other	NO	NO	NO						NO
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	1617.31	2.67	3.68	144.50	74.52	3.05	NO	NO	1845.72
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	5.37	NE,NA,NO	NE,NA,NO						5.37
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				144.50	0.00	NO	NO	NO	144.51
G. Other product manufacture and use	0.02	0.04	3.68		NO	3.05			6.79
H. Other	NA	NA	NA						NA
3. Agriculture	0.15	344.75	200.83						545.73
A. Enteric fermentation		293.68							293.68
B. Manure management		51.07	20.26						71.33
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	180.57						180.57
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.15								0.15
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5730.89	3651.27	59.91						9442.06
A. Forest land	-236.57	0.67	0.87						-235.03
B. Cropland	1666.41	84.06	NO,NA						1750.48
C. Grassland	5467.39	423.49	0.44						5891.32
D. Wetlands	-1172.11	3143.06	NO,NA,NE						1970.94
E. Settlements	5.80	NE	0.01						5.81
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	58.58						58.58
5. Waste	6.55	253.17	7.98						267.70
A. Solid waste disposal	NO	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		5.23	6.70						11.93
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	3.05								3.05
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									4581.64
Total CO_2 equivalent emissions with land use, land-use change and forestry									14023.70
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2012

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2012
Submission 2019 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)]	9211.26	4222.02	329.81	171.47	94.00	5.32	NO	NO	14033.88
1. Energy	1822.05	7.54	51.00						1880.60
A. Fuel combustion (sectoral approach)	1650.00	4.27	51.00						1705.27
1. Energy industries	10.46	0.04	0.11						10.61
2. Manufacturing industries and construction	174.72	0.21	10.84						185.76
3. Transport	806.94	2.48	34.89						844.31
4. Other sectors	657.88	1.54	5.17						664.59
5. Other	NO	NO	NO						NO
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	3.58	171.47	94.00	5.32	NO	NO	1937.49
A. Mineral industry	0.51								0.51
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1654.33	2.96	NO	NO	94.00	NO	NO	NO	1751.28
D. Non-energy products from fuels and solvent use	5.25	NE,NA,NO	NE,NA,NO						5.25
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				171.47	0.00	NO	NO	NO	171.48
G. Other product manufacture and use	0.03	0.04	3.58		NO	5.32			8.97
H. Other	NA	NA	NA						NA
3. Agriculture	0.17	337.50	207.39						545.06
A. Enteric fermentation		288.95							288.95
B. Manure management		48.55	19.98						68.53
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	187.41						187.41
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	IE								IE
H. Urea application	0.17								0.17
I. Other carbon-containing fertilizers	IE								IE
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5722.58	3649.41	60.08						9432.07
A. Forest land	-247.17	0.68	0.82						-245.67
B. Cropland	1656.35	83.55	NO,NA						1739.89
C. Grassland	5478.71	424.99	0.46						5904.15
D. Wetlands	-1171.03	3140.20	NO,NA,NE						1969.17
E. Settlements	5.82	NE	0.01						5.83
F. Other land	NA,NE	0.00	0.00						0.00
G. Harvested wood products	-0.08								-0.08
H. Other	IE	IE	58.79						58.79
5. Waste	6.35	224.57	7.75						238.67
A. Solid waste disposal	NO	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		5.25	6.72						11.97
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	4.52								4.52
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									4601.81
Total CO_2 equivalent emissions with land use, land-use change and forestry									14033.88
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

(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 2019 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)]	9188.00	4228.76	325.59	179.15	88.16	3.20	NO	NO	14012.86
1. Energy	1786.08	8.14	50.13						1844.35
A. Fuel combustion (sectoral approach)	1612.94	4.15	50.13						1667.22
1. Energy industries	3.63	0.01	0.02						3.66
2. Manufacturing industries and construction	165.35	0.20	10.31						175.85
3. Transport	822.57	2.49	34.93						859.99
4. Other sectors	621.38	1.45	4.87						627.71
5. Other	NO	NO	NO						NO
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	1686.08	3.03	3.13	179.15	88.16	3.20	NO	NO	1962.75
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	5.16	NE,NA,NO	NE,NA,NO						5.16
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				179.15	0.00	NO	NO	NO	179.15
G. Other product manufacture and use	0.02	0.04	3.13		NO	3.20			6.39
H. Other	NA	NA	NA						NA
3. Agriculture	4.24	331.52	203.93						539.68
A. Enteric fermentation		284.07							284.07
B. Manure management		47.45	19.58						67.02
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	184.35						184.35
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	0.21								0.21
I. Other carbon-containing fertilizers	1.72								1.72
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5706.21	3647.61	60.32						9414.14
A. Forest land	-266.27	0.68	0.83						-264.75
B. Cropland	1646.28	83.03	NO,NA						1729.31
C. Grassland	5490.49	426.49	0.48						5917.46
D. Wetlands	-1169.98	3137.40	NO,NA,NE						1967.42
E. Settlements	5.76	NE	0.01						5.77
F. Other land	NA,NE	NA	NA						NA,NE
G. Harvested wood products	-0.07								-0.07
H. Other	IE	IE	58.99						58.99
5. Waste	5.39	238.45	8.09						251.93
A. Solid waste disposal	NO	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		5.29	6.77						12.06
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	10.87								10.87
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									4598.72
Total CO_2 equivalent emissions with land use, land-use change and forestry									14012.86
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2014

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2014
Submission 2019 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)]	9145.92	4244.73	352.76	180.48	99.03	2.22	NO	NO	14025.14
1. Energy	1796.72	8.67	54.08						1859.47
A. Fuel combustion (sectoral approach)	1613.77	4.13	54.08						1671.97
1. Energy industries	2.52	0.00	0.01						2.53
2. Manufacturing industries and construction	165.05	0.21	14.91						180.17
3. Transport	825.29	2.45	34.35						862.09
4. Other sectors	620.91	1.46	4.82						627.18
5. Other	NO	NO	NO						NO
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	1654.52	2.73	2.88	180.48	99.03	2.22	NO	NO	1941.85
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	5.18	NE,NA,NO	NE,NA,NO						5.18
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				180.48	0.01	NO	NO	NO	180.49
G. Other product manufacture and use	0.02	0.03	2.88		NO	2.22			5.15
H. Other	NA	NA	NA						NA
3. Agriculture	4.37	352.35	226.57						583.30
A. Enteric fermentation		300.19							300.19
B. Manure management		52.16	20.70						72.87
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	205.87						205.87
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	0.35								0.35
I. Other carbon-containing fertilizers	1.72								1.72
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5684.21	3645.94	60.50						9390.65
A. Forest land	-290.26	0.69	0.80						-288.77
B. Cropland	1636.20	82.51	NO,NA						1718.71
C. Grassland	5501.15	427.99	0.49						5929.63
D. Wetlands	-1168.64	3134.74	0.01						1966.11
E. Settlements	5.82	NE	0.01						5.83
F. Other land	NA,NE	NA	NA						NA,NE
G. Harvested wood products	-0.06								-0.06
H. Other	IE	IE	59.20						59.20
5. Waste	6.11	235.04	8.73						249.88
A. Solid waste disposal	NO	227.34							227.34
B. Biological treatment of solid waste		2.01	1.44						3.45
C. Incineration and open burning of waste	6.11	0.34	0.39						6.84
D. Waste water treatment and discharge		5.35	6.90						12.24
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	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	10.87								10.87
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									4634.49
Total CO_2 equivalent emissions with land use, land-use change and forestry									14025.14
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2015

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2015
Submission 2019 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)]	9191.55	4242.96	333.90	204.76	103.70	1.53	NO	NO	14078.41
1. Energy	1816.09	8.82	52.02						1876.94
A. Fuel combustion (sectoral approach)	1652.96	4.27	52.02						1709.24
1. Energy industries	3.63	0.00	0.01						3.64
2. Manufacturing industries and construction	166.03	0.20	11.17						177.41
3. Transport	856.31	2.59	35.91						894.81
4. Other sectors	626.98	1.47	4.93						633.38
5. Other	NO	NO	NO						NO
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	1707.10	2.98	2.92	204.76	103.70	1.53	NO	NO	2023.00
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	5.54	NE,NA,NO	NE,NA,NO						5.54
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				204.76	0.02	NO	NO	NO	204.78
G. Other product manufacture and use	0.03	0.03	2.92		NO	1.53			4.51
H. Other	NA	NA	NA						NA
3. Agriculture	4.60	356.63	209.28						570.52
A. Enteric fermentation		303.60							303.60
B. Manure management		53.03	20.49						73.52
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	188.80						188.80
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	0.58								0.58
I. Other carbon-containing fertilizers	1.72								1.72
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5658.18	3644.22	60.92						9363.32
A. Forest land	-315.14	0.69	0.84						-313.61
B. Cropland	1625.46	82.00	NO,NA						1707.45
C. Grassland	5509.71	429.60	0.62						5939.94
D. Wetlands	-1167.56	3131.92	0.04						1964.41
E. Settlements	5.83	NE	0.01						5.85
F. Other land	NE,NA	0.00	0.00						0.00
G. Harvested wood products	-0.12								-0.12
H. Other	IE	IE	59.41						59.41
5. Waste	5.58	230.30	8.76						244.64
A. Solid waste disposal	NO	222.43							222.43
B. Biological treatment of solid waste		2.13	1.52						3.65
C. Incineration and open burning of waste	5.58	0.34	0.29						6.21
D. Waste water treatment and discharge		5.41	6.94						12.35
E. Other	NA	NO	NO						NO,NA
6. Other ***(as specified in summary 1.A)***	NO	NO	NO	NO	NO	NO	NO	NO	NO

Memo items: [(2)]									
International bunkers	822.27	0.46	6.80						829.53
Aviation	673.99	0.12	5.62						679.73
Navigation	148.28	0.35	1.18						149.80
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	43.54								43.54
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									4715.09
Total CO_2 equivalent emissions with land use, land-use change and forestry									14078.41
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2016

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2016
Submission 2019 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)]	9132.00	4235.98	332.13	191.96	91.86	1.28	NO	NO	13985.21
1. Energy	1794.92	7.80	54.90						1857.62
A. Fuel combustion (sectoral approach)	1645.96	4.27	54.90						1705.13
1. Energy industries	2.21	0.00	0.01						2.21
2. Manufacturing industries and construction	185.53	0.23	12.68						198.45
3. Transport	934.35	2.81	38.08						975.24
4. Other sectors	523.87	1.23	4.13						529.23
5. Other	NO	NO	NO						NO
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	2.29	191.96	91.86	1.28	NO	NO	1973.99
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				191.96	0.02	NO	NO	NO	191.98
G. Other product manufacture and use	0.03	0.03	2.29		NO	1.28			3.62
H. Other	NA	NA	NA						NA
3. Agriculture	4.72	361.33	205.09						571.14
A. Enteric fermentation		306.73							306.73
B. Manure management		54.60	20.81						75.40
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	184.28						184.28
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	0.69								0.69
I. Other carbon-containing fertilizers	1.72								1.72
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5642.03	3642.41	60.86						9345.30
A. Forest land	-325.52	0.70	0.79						-324.04
B. Cropland	1615.91	81.48	NO,NA						1697.39
C. Grassland	5512.44	430.93	0.44						5943.81
D. Wetlands	-1166.59	3129.30	NO,NE,NA						1962.71
E. Settlements	5.83	NE	0.01						5.85
F. Other land	NE,NA	NA	NA						NE,NA
G. Harvested wood products	-0.04								-0.04
H. Other	IE	IE	59.61						59.61
5. Waste	6.75	221.42	8.99						237.16
A. Solid waste disposal	NO	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		5.46	7.03						12.50
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	48.10								48.10
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									4639.91
Total CO_2 equivalent emissions with land use, land-use change and forestry									13985.21
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2017

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2017
Submission 2019 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]	9232.07	4221.95	346.16	204.91	68.04	2.31	NO	NO	14075.44
1. Energy	1843.71	7.56	56.22						1907.49
A. Fuel combustion (sectoral approach)	1697.23	4.23	56.22						1757.68
1. Energy industries	1.78	0.00	0.00						1.78
2. Manufacturing industries and construction	166.90	0.21	13.09						180.20
3. Transport	988.42	2.75	38.89						1030.06
4. Other sectors	540.13	1.27	4.23						545.63
5. Other	NO	NO	NO						NO
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	1758.85	3.16	2.08	204.91	68.04	2.31	NO	NO	2039.34
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	5.15	NO,NE,NA	NO,NE,NA						5.15
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				204.91	0.06	NO	NO	NO	204.96
G. Other product manufacture and use	0.03	0.03	2.08		NO	2.31			4.45
H. Other	NA	NA	NA						NA
3. Agriculture	4.85	356.91	216.43						578.19
A. Enteric fermentation		302.13							302.13
B. Manure management		54.78	20.30						75.08
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	196.13						196.13
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	0.83								0.83
I. Other carbon-containing fertilizers	1.72								1.72
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [1]	5617.58	3640.85	62.36						9320.78
A. Forest land	-346.59	0.70	0.82						-345.07
B. Cropland	1605.94	80.96	NO,NA						1686.90
C. Grassland	5518.13	432.45	0.48						5951.05
D. Wetlands	-1165.63	3126.73	0.01						1961.11
E. Settlements	5.83	NE	0.01						5.84
F. Other land	NE,NA	0.00	0.00						0.00
G. Harvested wood products	-0.09								-0.09
H. Other	IE	IE	61.04						61.04
5. Waste	7.08	213.47	9.08						229.63
A. Solid waste disposal	NO	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		5.56	7.16						12.72
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	1339.56	0.65	11.08						1351.29
Aviation	1146.71	0.20	9.56						1156.47
Navigation	192.85	0.45	1.52						194.82
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	53.50								53.50
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO						
Indirect CO_2 [3]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4754.65
Total CO_2 equivalent emissions with land use, land-use change and forestry									14075.44
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.