NATIONAL INVENTORY REPORT

Emissions of Greenhouse Gases in Iceland from 1990 to 2015

Submitted in accordance to Monitoring Mechanism Regulation no. 525/2013 and the relevant articles and annexes in the implementing Regulation no. 749/2014 and the United Nations Framework Convention on Climate Change and the Kyoto Protocol

2017

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Reykjavík, 15 April 2017.

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 in the period 1990 – 2015.

The NIR is written by the Environment Agency of Iceland (EA), with major contributions by the Agricultural University of Iceland (AUI), Icelandic Forest Research (IFR), and the Soil Conservation Service of Iceland (SCSI).

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 2017.

Table of Contents

Index of Figures

Index of Tables

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
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2-eq	Carbon Dioxide Equivalent
COD	Chemical Oxygen Demand
COP	Conference of the Parties
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 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

Table continued	
KP	Kyoto Protocol
LULUCF	Land Use, Land-Use Change and Forestry
MAC	Mobile Air Conditioning
MAC	Mobile Air-Conditioning Systems
MCF	Methane Correction Factor
MSW	Municipal Solid Waste
N_2O	Nitrogen Dioxide
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
NNFI	New National Forest Inventory
NOx	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	Sulfur Hexafluoride
Si	Silicon
SiO	Silicon Monoxide
SiO_2	Quarts
SO_2	Sulfur Dioxide
SO_2-eq	Sulfur Dioxide Equivalents
SSPP	Systematic sampling of permanent plots
SWD	Solid Waste Disposal
SWDS	Solid Waste Disposal Sites
t/t	Tonne per Tonne
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

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, Regulation512/2013) and relevant articles and annexes in the implementing Regulation No 749/2014.

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol requires that the Parties report annually on their greenhouse gas emissions by sources and removals by sinks. In response to these requirements, Iceland has prepared the present National Inventory Report (NIR).

The IPCC Good Practice Guidance, IPCC Good Practice Guidance for LULUCF, the Revised 1996 Guidelines, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and national estimation methods are used in producing the greenhouse gas emissions inventory. The responsibility of producing the emissions data lies with the Environment Agency of Iceland (EA), which compiles and maintains the greenhouse gas inventory. Emissions and removals from the Land use, Land use change and forestry (LULUCF) sector are compiled by the Agricultural University of Iceland. The national inventory and reporting system is continually being developed and improved.

Iceland is a party to the UNFCCC and acceded to the Kyoto Protocol on May 23rd, 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 is to curb emissions of greenhouse gases so they do 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 greenhouse gases by 50-75% by the year 2050, using 1990 emissions figures as a baseline. An Action plan for climate change mitigation was adopted in 2010. The Action Plan builds on an expert study on mitigation potential and cost from 2009 and takes 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.

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

- For the first commitment period of the Kyoto Protocol, from 2008 to 2012, the greenhouse gas emissions were not to increase by more than 10% from the level of emissions in 1990. Iceland 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 CO_2-equivalents.
- 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 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 carbon dioxide 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 an agreement between the European Union, 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 entered into force. 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.

ES.2 Summary of national emission and removal related trends

For the current submission year, the total emissions of greenhouse gases in Iceland (excl. LULUCF) were estimated to be 3,541 kt. CO_2-eq. in 1990 and 4,536 kt. CO_2-eq. in 2015. This corresponds to an increase of around 28% over the time period.

A summary of the Icelandic national emissions for selected years between 1990 and 2015 is presented in Table ES. 1 (without LULUCF).

Table ES. 1 Total GHG emissions by gas since 1990 in kt. CO_2-eq (excluding LULUCF).

	1990	1995	2000	2005	2010	2014	2015	Changes ´90-´15	Changes ´14-´15
CO_2	2,148	2,312	2,757	2,848	3,427	3,285	3,357	**56%**	**2%**
CH_4	522	540	559	563	585	549	552	**6%**	**1%**
N_2O	375	347	352	316	313	335	314	**-16%**	**-6%**
PFCs	495	69	150	31	172	99	104	**-79%**	**5%**
HFCs	0.3	10.2	43.3	69.3	145.8	181.7	207.0	**-**	**14%**
SF_6	1.1	1.2	1.3	2.5	4.7	2.2	1.5	**40%**	**-31%**
Total emissions	**3,541**	**3,281**	**3,863**	**3,830**	**4,647**	**4,452**	**4,536**	**-**	**-**
Total change	-	-	-	-	-	-	-	**28%**	**2%**

ES.3 Overview of source and sink category emission estimates and trends

The largest contributor of greenhouse gas emissions in Iceland in 2015 when excluding LULUCF were Industrial Processes, followed by the Energy sector, then Agriculture and Waste. From 1990 to 2015, the contribution of Industrial Processes increased from 27% to 45%, emissions from the Energy sector decreased from 50% to 37% during the same period.

Table ES. 2 Total GHG emissions by source since 1990 (kt. CO_2-eq.).

	1990	2000	2010	2014	2015	Changes ´90-´15	Changes ´14-´15
1 Energy	1,777	2,034	1,859	1,682	1,695	-4.60%	0.80%
2 Industrial Processes	954	1,004	1,947	1,939	2,021	111.80%	4.23%
3 Agriculture	647	596	595	623	612	-5.31%	-1.74%
4 Land Use, Land Use Change and Forestry	10,134	10,140	10,338	10,324	10,288	1.52%	-0.35%
5 Waste	164	229	247	208	207	26.50%	-0.48%
Total emissions without LULUCF	**3,541**	**3863**	**4,647**	**4,452**	**4,536**	**28.07%**	**1.89%**
Total emissions with LULUCF	**13,675**	**14,003**	**14,985**	**14,776**	**14,824**	**8.40%**	**0.32%**

The distribution of total greenhouse gas emissions over the UNFCCC sectors (excl. LULUCF) 1990 to 2015 is shown in Figure ES. 1. Emissions from the Energy sector were estimated to account for 37% of the national total emissions in 2015, industrial processes for 45%, agriculture for 13% and the waste sector was estimated to account for 5%.

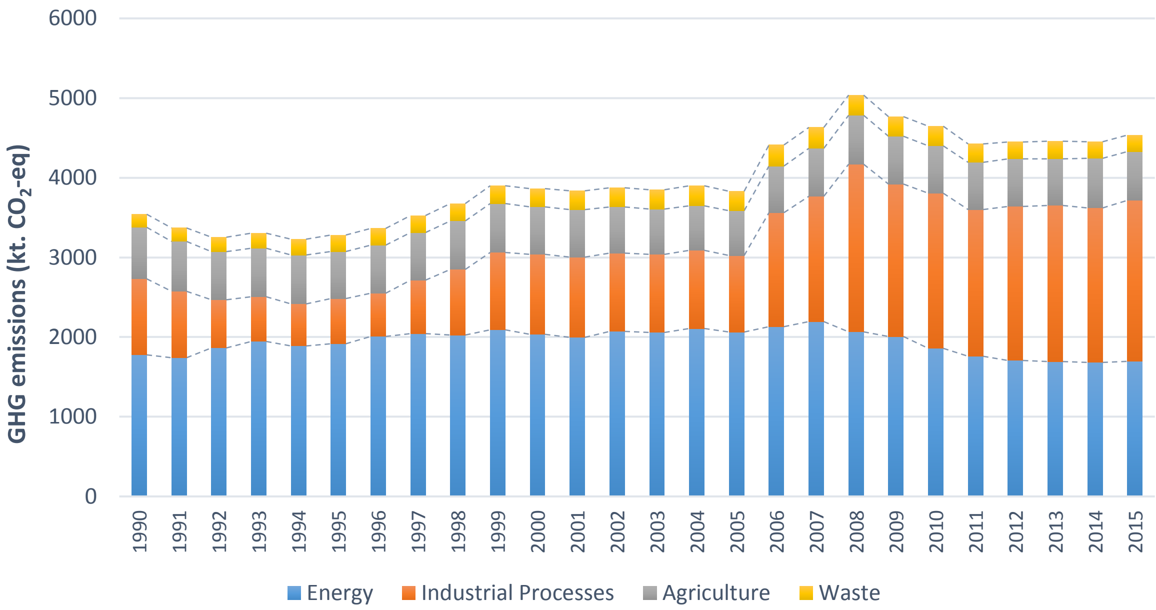

Figure ES. 1 Emissions of GHG by sector, without LULUCF, from 1990 to 2015 in kt. CO_2-eq.

ES.4 Other information – Kyoto Accounting

First commitment period

Iceland's initial AAUs for the first commitment period amounted to 18,523,847 tonnes of CO_2-equivalents for the period or 3,704,769 tonnes per year on average. Added to that are a total of 1,541,960 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_2-eq. 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 2017 NIR, however, still contain Iceland´s Annex A emissions in their entirety.

Second commitment period

The second Commitment Period started 1. January 2013 and will end 31. December 2020. The European Union, 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. Iceland's individual assigned amount was established at 15 327 217 AAUs.

As part of its submission to UNFCCC, Iceland submits SEF tables for the Kyoto Protocol units issued in 2015 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

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 512/2013) and relevant articles and annexes in the implementing Regulation 749/2014.

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 (GHG) not controlled by the Montreal Protocol, using methodologies agreed upon by the Conference of the Parties to the Convention (COP).

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 May 23rd 2002. The Kyoto Protocol commits Annex I Parties to individual, legally binding targets for their greenhouse gas emissions. Iceland's obligations according to the Kyoto Protocol have been and are as follows:

- For the first commitment period of the Kyoto Protocol, from 2008 to 2012, the greenhouse gas emissions shall were not to increase by more than 10% from the level of emissions in 1990. Iceland 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 CO_2-equivalents.
- 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 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 carbon dioxide 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, 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 European Union, 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.

A new 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 is to reduce net greenhouse gas emissions in Iceland by 50 – 75% by 2050, compared to 1990 levels. In the shorter term, Iceland aims to ensure that emissions of greenhouse gases will 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 (Ministry for Environment, 2010). The action plan proposes 10 major tasks to curb and reduce GHG emissions in six sectors, as well as provisions to increase carbon sequestration resulting from afforestation and revegetation programs. The main tasks are:

a) Implementing the EU Emission Trading Scheme (ETS)
b) Implementing carbon emission charge on fuel for domestic use
c) Changing of tax systems and fees on cars and fuel
d) Enhance the use of environmentally-friendly vehicles at governmental and municipality bodies
e) Promote alternative transport methods like walking, cycling, and public transport
f) Use of biofuel in the fishing fleet
g) Using electricity as an energy resource in the fishmeal industry
h) Increase afforestation and revegetation
i) Restoring wetlands
j) Increase research and innovation regarding climate issues

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.

The greenhouse gas emissions profile for Iceland is unusual in many respects. First, emissions from generation of electricity and from space heating are very low owing to the use of renewable energy sources (geothermal and hydropower). Second, almost 80% of emissions from the Energy sector stem from mobile sources (transport, mobile machinery and commercial fishing vessels). Third, emissions from the LULUCF sector are relatively high. Recent research has indicated that there are significant emissions of carbon dioxide 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. The fourth distinctive feature is that individual sources of industrial process emissions have a significant proportional impact on emissions at the national level. Most noticeable are increased emissions from aluminium production associated with the expanded production capacity of this industry. 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 fundamental issue associated with the significant proportional impact of single projects on emissions is the question of scale. In small economies such as Iceland, a single project can dominate the changes in emissions from year to year. When the impact of such projects becomes several times larger than the combined effects of available greenhouse gas 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 greenhouse gas emissions. A plant of the same size would have negligible effect on emissions in most industrialized countries. Decision 14/CP.7 sets a threshold for significant proportional impact of single projects at 5% of total carbon dioxide emissions of a party in 1990. Projects exceeding this threshold shall be reported separately and carbon dioxide emissions from them shall not be included in national totals to the extent that they would cause the party to exceed its assigned amount. The total amount that can be reported separately under this decision is set at 8 million tonnes of carbon dioxide. The scope of Decision 14/CP.7 is explicitly limited to small economies, defined as economies emitting less than 0.05% of total Annex I carbon dioxide emissions in 1990. In addition to the criteria above, which relate to the fundamental problem of scale, additional criteria are included that relate to the nature of the project and the emission savings resulting from it. Only projects where renewable energy is used and where this use of renewable energy results in a reduction in greenhouse gas emissions per unit of production will be eligible. The use of best environmental practice (BEP) and best available technology (BAT) is also required. It should be underlined that the decision only applies to carbon dioxide emissions from industrial processes. Other emissions, such as energy emissions or process emissions of other gases, such as PFCs, will not be affected.

The industrial process carbon dioxide emissions falling under Decision 14/CP.7 cannot be transferred by Iceland or acquired by another Party under Articles 6 and 17 of the Kyoto Protocol. If carbon dioxide emissions are reported separately according to the Decision that will imply that Iceland cannot transfer assigned amount units to other Parties through international emissions trading.

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. Emissions that fall under Decision 14/CP.7 are not excluded from national totals in this report, as Iceland undertook the accounting with respect to the Decision at the end of the 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 in the period 1990-2015. The methodologies used in calculating the emissions is according to the revised 1996 and 2006 IPCC Guidelines for National Greenhouse Gas Inventories as set out by the IPCC Good Practice Guidance and Good Practice Guidance for Land Use, Land-Use Change and Forestry.

As part of its submission to UNFCCC Iceland submits SEF tables for the Kyoto Protocol units issued in 2014. Annual external transactions consisted of additional 182 AAUs from SE and 5087 ERUs from EU, no subtractions were made. The total quantities of Kyoto Protocol units in Party holding accounts at the end of reported year were 18,524,029 AAUs and 5,087 ERUs.

The greenhouse gases 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 NO_X, NMVOC and CO as well as SO_2 are also included, in compliance with the reporting guidelines.

1.2 National System for Estimation of Greenhouse Gases

1.2.1 Institutional Arrangement

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 greenhouse gas emission inventory, except for LULUCF which is compiled by the Agricultural University of Iceland (AUI). EA reports to the Convention. Figure 1.1 illustrates the flow of information and allocation of responsibilities.

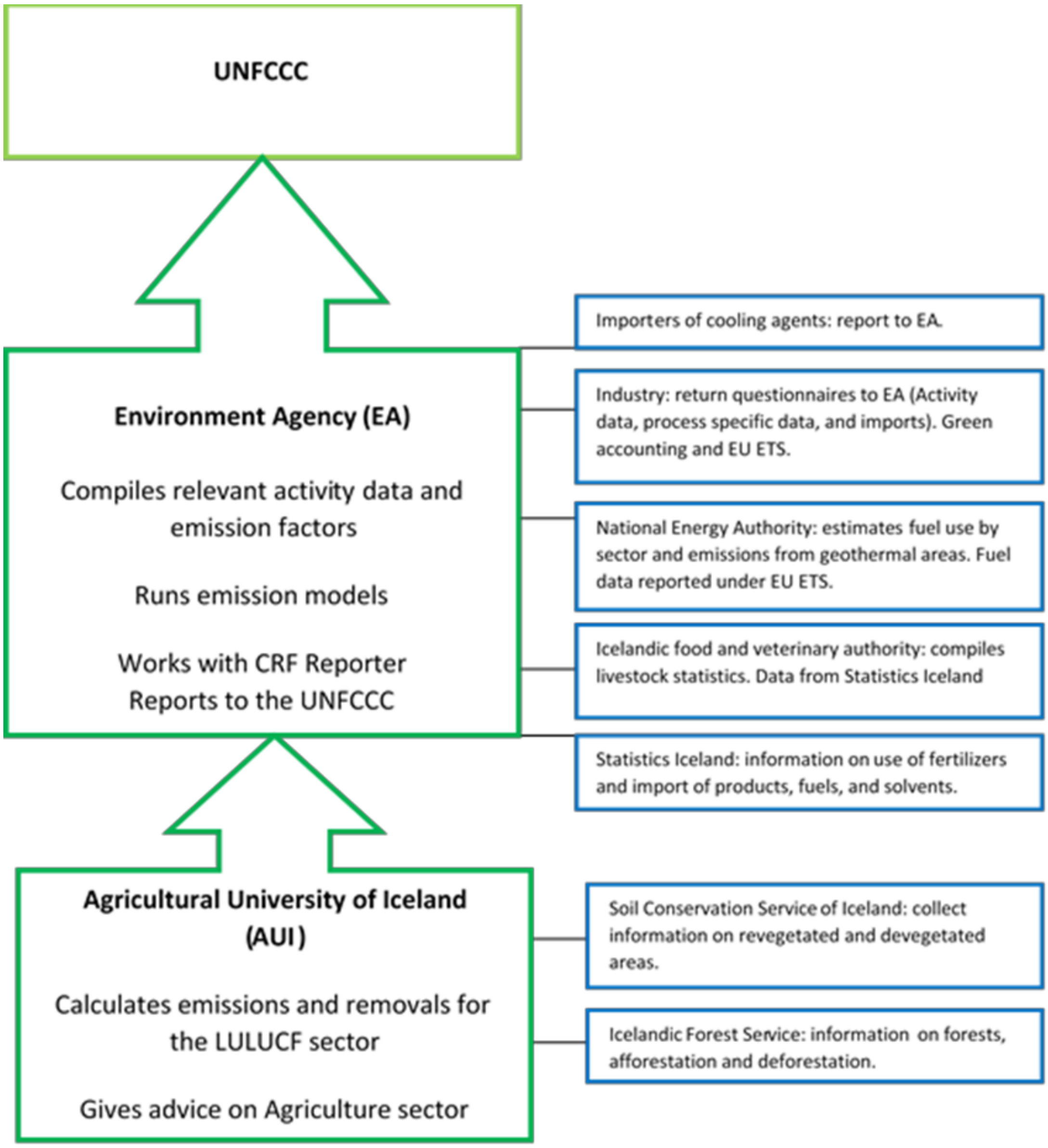

Figure 1.1 Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the UNFCCC.

A Coordinating Team was established in 2008 as a part of the national system and operated until 2012. The team had representatives from the Ministry for the Environment, the EA and the AUI not directly involved in preparing the inventory. Its official roles was to review the emissions inventory before submission to UNFCCC, plan the inventory cycle and formulate proposals on further development and improvement of the national inventory system. During each inventory cycle in the period 2008 to 2012 the Coordinating Team held several meetings, of which some meetings were only with the Coordinating Team's members and other meetings were held with the team members as well as major data providers. The work of the team led to improvement in cooperation between the different institutions involved with the inventory compilation, especially with regards to the LULUCF and Agriculture sectors. Some improvements proposed by the team were also incorporated into the inventory. The Coordinating Team ceased to operate in 2012 when a new Act no. 70/2012 on climate change was passed by the Icelandic legislature Althingi.

1.2.2 The Climate Change Act No 70/2012

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

- Reducing greenhouse gas 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 Environment Agency 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. Articles 7 to 15 of Act No 65/2007 regarding the allocation of allowances in the period 2008 to 2012 were in effect until the completion of reporting obligations for the period. Regulation No 244/2009, put forward on basis of Act No 65/2007 further elaborated on the reporting of information from the industrial plants falling under that part of Act No 65/2007. Based on Act No 65/2007 a three-member Emissions Allowance Allocation Committee, appointed by the Minister for the Environment with representatives of the Ministry of Industry, Ministry for the Environment and the Ministry of Finance, allocated emissions allowance for operators falling within the scope of the Act during the period 1 January 2008 to 31 December 2012.

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. The Act specifies that the EA is the responsible authority for the national accounting as well as the inventory of emissions and removals of greenhouse gases according to Iceland's international obligations.

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 changes the form of relations between the EA and other bodies concerning data handling. The Act states that the following institutions are obligated to collect data necessary for the GHG inventory and report it to the EA, further to be elaborated in regulations set by the Minister for the Environment and Natural Resources:

- Icelandic Forest Service (IFS)
- National Energy Authority (NEA)
- Agricultural University of Iceland (AUI)
- Iceland Food and Veterinary Authority
- Statistics Iceland
- The Road Traffic Directorate
- The Icelandic Recycling Fund
- Directorate of Customs

The relevant regulation regarding manner and deadlines of the said data has been drafted by the EA and sent to the Ministry for Environment and Natural Resources. From 2016 onwards, however, Iceland will submit its GHG inventory to the European Union before submitting it to the UNFCCC. The deadline for submission of GHG data and a NIR draft to the EU is January 15th. This makes it necessary to change dates proposed in the regulation draft. This will be done in unison with the main data providers later this year. Therefore, the regulation has not been published, yet. It is foreseen that the new regulation will facilitate the responsibilities, the data collection process and the timelines.

As the prospective regulation on data collection, based on Act No 70/2012, formalizes the cooperation and data collection process between the EA and all responsible institutions, it takes over the role of the Coordinating Team regarding the cooperation between different institutions. The other role of the Coordinating Team, i.e. reviewing the GHG inventory and facilitating improvements, has been taken over on a more informal basis by other employees of the EA not directly involved in the inventory preparation process. The scheduled cooperation with the EU regarding the GHG inventory entails elaborated QA/QC procedures by the EU and will lighten the need for domestic QA/QC procedures to some extent.

1.2.3 Joint Fulfilment Agreement

According to Article 4, cf. Annex I, of the 2015 Joint Fulfilment Agreement on Iceland´s participation in the joint fulfilment of the commitments of the European Union, its Member States and Iceland in the second commitment period of the Kyoto Protocol, Regulation (EU) No 525/2013[1] and current and future Delegated and Implementing Acts based on Regulation (EU) No 525/2013 shall be binding upon Iceland. The legal acts were rendered applicable in Iceland in 2015 with an amendment to Act No 70/2012, cf. Act No 62/2015.

1.2.4 Green Accounting

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 greenhouse gas 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 at the website of the EA.

[1] 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, OJ 2013 L165/13, as amended by Regulation (EU) No 662/2014, OJ 2014 L189/155.

1.3 Process of Inventory Preparation

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. The National Energy Authority (NEA) collects annual information on fuel sales from the oil companies. This information was until 2008 provided on an informal basis. From 2008 and onwards, Act No. 48/2007 enables the NEA to obtain sales statistics from the oil companies. Until 2011 the Farmers Association of Iceland (FAI), on behalf of the Ministry of Agriculture, was responsible for assessing the size of the animal population each year, when the Food and Veterinary Authority took over that responsibility. On request from the EA, the FAI assisted to come up with a method to account for young animals that are mostly excluded from national statistics on animal population. Animal statistics have been further developed to better account for replacement animals in accordance with recommendations from the ERT that came to Iceland for an in-country review in 2011. Statistics Iceland provides information on population, GDP, production of asphalt, food and beverages, imports of solvents and other products, the import of fertilizers and on the import and export of fuels. The EA collects various additional data directly. Annually an electronic questionnaire on imports, use of feedstock, and production and process specific information is sent out to industrial producers, in accordance with Regulation No 244/2009 Green Accounts submitted under Regulation No 851/2002 from the industry are also used. For this submission the data contained in applications for free allowances under the EU ETS is also used. Importers of HFCs submit reports on their annual imports by type of HFCs to the EA. The Icelandic Directorate of Customs supplies the EA with information on the identity of importers of open and closed-cell foam. The EA also estimates activity data with regard to waste. Emission factors are taken mainly from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC Good Practice Guidance, IPCCC Good Practice Guidance for LULUCF, and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, since limited information is available from measurements of emissions in Iceland.

The AUI receives information on revegetated areas from the Soil Conservation Service of Iceland and information on forests and afforestation from the Icelandic Forest Service. The AUI assesses other land use categories on the basis of its own geographical database and other available supplementary land use information. The AUI then calculates emissions and removals for the LULUCF sector and reports to the EA.

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

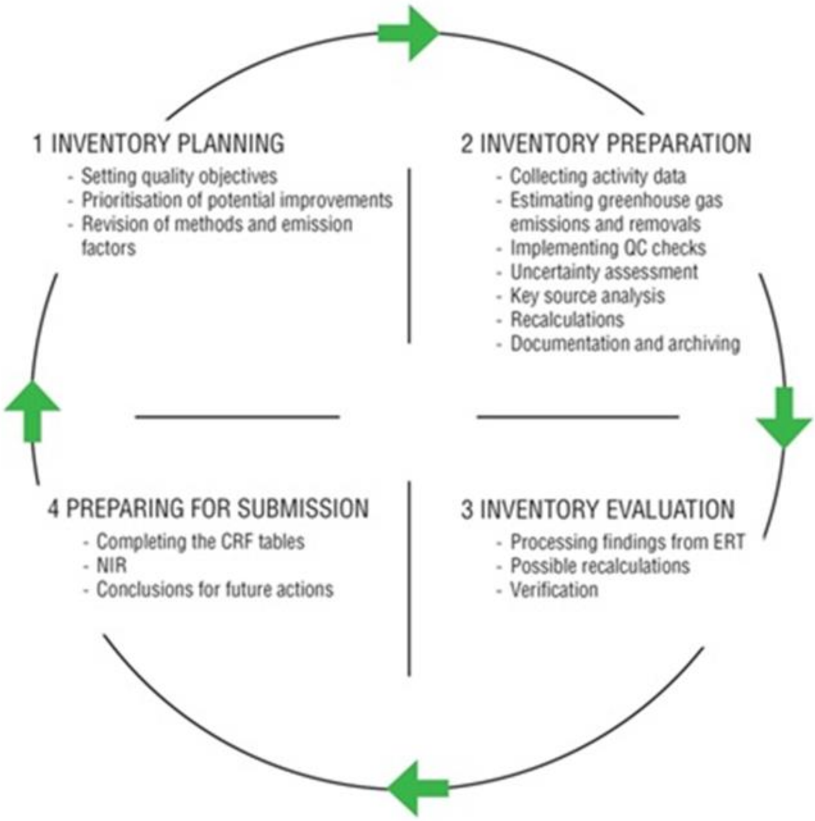

Figure 1.2 The annual inventory cycle.

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 (NEA, AUI, IFS and SCSI), taking into account the outcome of the internal and external review as well as the recommendations from the UNFCCC review. The initial planning is followed by a period assigned for compilation of the national inventory and improvement of the National System.

After compilation of activity data, emission estimates and uncertainties are calculated and quality checks performed to validate results. Emission data is received from the sectoral expert for LULUCF. All emission estimates are imported into the CRF Reporter software.

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 Decision 14/CP.7, other key source categories and for those categories where data and methodological changes have recently occurred.

After an approval by the director and the inventory team at the EA, the greenhouse gas inventory is submitted to the UNFCCC by the EA.

1.4 Methodologies & Data Sources

The estimation methods of all greenhouse gases are harmonized with the IPCC Guidelines for National Greenhouse Gas Inventories and are in accordance with IPCC's Good Practice Guidance.

The general emission model is based on the equation:

Emission (E) = Activity level (A) · Emission Factor (EF)

The model includes the greenhouse gases and in addition the precursors and indirect greenhouse gases NO_x, SO_2, NMVOC and CO, as well as some other pollutants (POPs).

Methodologies and data sources for LULUCF are described in Chapter 6.

1.5 Archiving

Gopro.net, a document management system running on .NET, is used to store email communications concerning the GHG inventory. Paper documents, e.g. written letters, are scanned and also stored in Gopro.net. 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 are emails 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 using VMWare software running on Dell Blade Servers.

Advania, a local IT company, hosts EA´s servers. Their hosting is fully ISO-9001 and ISO-27001 certified. Their hosting rooms are in two locations in Hafnarfjordur, a town very close to Reykjavik. One room is the primary server room while the other is a secondary backup room storing off-site backups, the rooms are separated by roughly 5 km.

Backups are taken daily and stored for 30 days. Every 3 months a full backup is taken and stored for 18 months. Backups are done with solutions from Veeam Backup & Replication using reverse incremental backup.

Hard copies of all references listed in the NIR are stored in the EA. 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.

1.6 Key Category Analysis

According to 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 greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both.

In the Icelandic Emission Inventory key categories are identified by means of Approach 1 method. The results of the key category analysis prepared for the 2017 submission are shown in Table 1.1. Tables showing the key category analysis (trend and level assessment) with a higher level of disaggregation can be found in Annex I. The key category analysis shown below includes LULUCF greenhouse gas sources. Key category analyses for each sector, excluding LULUCF, are presented in the respective chapters.

Table 1.1 Key source categories of Iceland's 2017 GHG inventory (including LULUCF). ✓= Key source category.

IPCC source category			Level 1990	Level 2015	Trend
		Energy (CRF sector 1)			
1A2	Fuel combustion - Manufacturing Industries and Construction	CO_2	✓		✓
1A3b	Road Transportation	CO_2	✓	✓	✓
1A4	Other Sectors - Liquid Fuels	CO_2	✓	✓	✓
1B2d	Fugitive Emissions from Fuels - Other	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)			
3A	Enteric Fermentation	CH_4	✓	✓	
3B	Manure Management	N_2O		✓	
3D1	Direct N_2O Emissions From Managed Soils	N_2O	✓	✓	
		Land use, Land use change and Forestry (CRF sector 4)			
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	✓	✓	✓
4(II).	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	✓	✓	
4(II).	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	✓	✓	✓
4H	Other: N_2O from grassland drained soils	N_2O	✓		
		Waste (CRF sector 5)			
5A	Solid Waste Disposal	CH_4	✓	✓	✓

1.7 Quality Assurance & Quality Control (QA/AC)

The objective of QA/QC activities in national greenhouse gas inventories is to improve transparency, consistency, comparability, completeness, accuracy, confidence and timeliness. A QA/QC plan for the annual greenhouse gas inventory of Iceland has been prepared and can be found on the EA's website (ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/Iceland_QAQC_plan.pdf). The document describes the quality assurance and quality control programme. It includes the quality objectives and an inventory quality assurance and quality control plan. It also describes the responsibilities and the time schedule for the performance of 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, measurements, estimating uncertainties, archiving information and reporting. Source category specific QC measures have been developed for several key source categories.

A quality manual for the Icelandic emission inventory has been prepared and can also be found on the EA's website (ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/Iceland_QAQC_manual.pdf). To further facilitate the QA/QC procedures all calculation sheets have been revised. They include a brief description of the method used. They are also provided with colour codes for major activity data entries and emissions results to allow immediate visible recognition of outliers.

1.8 Uncertainty Analysis

Uncertainty estimates are an essential element of a complete inventory and are not used to dispute the validity of the inventory but rather help 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 Greenhouse Gas Inventories where different gases are reviewed separately as CO_2-equivalents. Total base and current years´ emissions within a greenhouse gas 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.

Iceland is in the process of reviewing its uncertainty analysis and In February 2017, new templates were created for uncertainty estimates based on the 2006 IPCC guidelines, provided in Table 3.2 [2]. The new templates were not used for this submission, but implementation is in progress and they will be used for the 2018 submission.

For this submission Iceland's uncertainties were estimated for all greenhouse gas source and sink categories (i.e. including LULUCF) according to the IPCC Good Practice Guidance. Estimates for activity data uncertainties are mainly based on expert judgement whereas emission factor uncertainties are mainly based on IPCC source category defaults. Errors in the determination of EF uncertainty factors for the Agriculture and Waste sectors were corrected. All source category uncertainties were first weighted with 2012 emission estimates and then summarized using error propagation. This calculation yielded an overall uncertainty of the 2012 emission estimate of 33.5%.

Uncertainty estimates introduced on the trend of greenhouse gas emission estimates by uncertainties in activity data and emission factors are combined and then summarized by error propagation to obtain the total uncertainty of the trend. This calculation yielded a total trend uncertainty of 16%. The decrease from the value of the 2015 submission (16.7%) is caused by the above mentioned correction of errors.

There are two main challenges in calculating uncertainty estimates - estimating the uncertainty of activity data and implementing country-specific emission factors. The utilisation of the new uncertainty templates in future submissions will be accompanied by a review of uncertainties, and

[2] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_3_Ch3_Uncertainties.pdf Accessed 09/03/2017

will therefore improve the uncertainty estimates as well as providing more transparent documentation.

The results of the uncertainty estimate can be found in Annex II.

1.9 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 2015.

With regard to sectoral coverage few sources are not estimated.

The main sources not estimated are:

- Emissions of CO_2 and CH_4 from road paving with asphalt (2D3b).
- In the LULUCF sector the most important estimates remaining are the ones regarding emissions/removals of mineral soil in few categories.

The reason for not including the above activities/gases in the present submission is a lack of data and/or that additional work was impossible due to time constraints in the preparation of the emission inventory.

1.10 Planned and Implemented Improvements

Planned and implemented improvements to Iceland's GHG Inventory can be found in Chapter 0, and under each chapter.

2 Trends in Greenhouse Gas Emissions

2.1 Emission Trends in Aggregated GHG Emissions

Total amounts of greenhouse gases emitted in Iceland during the period 1990-2015 are presented in the following tables and figures, expressed in terms of contribution by gas and source.

Table 2.1 presents emission figures for greenhouse gases by sector in 1990, 2000, 2010, 2014 and 2015 expressed in kt. CO_2-equivalents along with percentage changes for both time periods 1990-2015 and 2014-2015. Table 2.2 presents emission figures for all greenhouse gases by gas in 1990, 2000, 2010, 2014, and 2015 expressed in kt. CO_2-equivalents along with percentage changes for both time periods 1990-2015 and 2014-2015.

Table 2.1 Emissions of GHG by sector in Iceland during the period 1990-2015 (kt. CO_2-eq.)

	1990	2000	2010	2014	2015	Changes ´90-´15	Changes ´14-´15
1 Energy	1,777	2,034	1,859	1,682	1,695	**-4.60%**	**0.80%**
2 Industrial Processes	954	1,004	1,947	1,939	2,021	**111.80%**	**4.23%**
3 Agriculture	647	596	594	623	616	**-4.88%**	**-1.74%**
4 Land Use, Land Use Change and Forestry	10,134	10,140	10,338	10,324	10,288	**1.52%**	**-0.35%**
5 Waste	164	229	247	208	207	**26.50%**	**-0.28%**
Total emissions without LULUCF	**3,541**	**3863**	**4,649**	**4,454**	**4,538**	**28.15%**	**1.88%**
Total emissions with LULUCF	**13,675**	**14,003**	**14,987**	**14,779**	**14,827**	**8.42%**	**0.32%**

Table 2.2 Emissions of greenhouse gases by gas in Iceland during the period 1990-2015 (without LULUCF) in kt. CO_2-eq..

	1990	2000	2010	2014	2015	1990	2000	Changes ´90-´15	Changes ´14-´15
CO_2	2,148	2,312	2,757	2,848	3,427	3,285	3,357	**56%**	**2%**
CH_4	522	540	559	563	585	549	552	**6%**	**1%**
N_2O	375	347	352	316	313	335	314	**-16%**	**-6%**
PFCs	495	69	150	31	172	99	104	**-79%**	**5%**
HFCs	0.3	10.2	43.3	69.3	145.8	181.7	207.0	**-**	**14%**
SF_6	1.1	1.2	1.3	2.5	4.7	2.2	1.5	**40%**	**-31%**
Total emissions	**3,541**	**3,281**	**3,863**	**3,830**	**4,647**	**4,452**	**4,536**	**-**	**-**
Total change	-	-	-	-	-	-	-	**28%**	**2%**

In 1990 total GHG emissions (excluding LULUCF) in Iceland were 3,541 kt.CO_2-equivalents. In 2015 total emissions were 4,538 k.t CO_2-equivalents. This is tantamount to an increase of 28% over the whole time period. Total emissions show a slight decrease between 1990 and 1994, with the exception of 1993. From 1995-1999 total emissions increased by 3 to 6% per year, then plateaued from 2000 to 2005. Between 2005 and 2008 emissions increased rapidly or by 5 to 15%% per year.

Between 2008 and 2010 annual emissions decreased again by on average 4% per year. Emissions increased by 2% between 2014 and 2015.

By the middle of the 1990's economic growth started to gain momentum in Iceland. Until 2007 Iceland experienced one of the highest GDP growth rate among OECD countries. 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. 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 greenhouse gases decreased from most sectors between 2008 and 2011.

The main driver behind increased emissions since 1990 has been 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. In 2015, 857,319 tonnes of aluminium were produced in three aluminium plants (primary aluminium production). Parallel investments in increased power capacity were needed to accommodate for this almost tenfold increase in aluminium production. The size of these investments is large compared to the size of Iceland´s economy.

The increase in GDP since 1990 further explains the general growth in emissions as well as the fact that the Icelandic population has grown by 30% from 1990 to 2015. This has resulted in higher emissions from most sources, but in particular from transport and the construction sector. Emissions from the transport sector have risen considerably since 1990, as a larger share of the population uses private cars for their daily travel. Since 2008 fuel prices have risen significantly leading to lower emissions from the sector compared to preceding years. 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. The construction sector collapsed in late 2008. Emissions from fuel combustion in the transport and construction sector decreased in 2008 by 5% compared to 2007, in 2009 by 8% compared to 2008, in 2010 by 7% compared to 2009 and in 2011 by 5% compared to 2010, because of the economic crises. In 2015 the emissions were 5% higher than in 2011, yet still 19% below the peak in 2007. Emissions from Cement production had decreased by 69% since 2007 (process emissions and emissions from fuel consumption) also as a result of the economic crises and the collapse of the construction sector. Cement production was shut down in late 2011.

The overall increasing trend of greenhouse gas 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 greenhouse gas emissions between 2006 and 2008, when emissions from the aluminium sector peaked. In 2015 total emissions from the aluminium sector were 12% lower than in 2008 due to less PFC emissions from the sector.

2.2 Emission Trends by Gas

All values in this chapter refer to Iceland´s total GHG emissions without LULUCF. As shown in Figure 2.1, the largest contributor by far to total GHG emissions in 2015 is CO_2 (74%), followed by CH_4 (12%), N_2O (7%) and fluorinated gases PFCs (2%), HFCs (5%), and SF_6(0,03%). In the year 2015, the changes in gas emissions compared to 1990 levels for PFCs and have decreased significantly -79% and -16% respectively. CO_2 have increased the most or by 56% (Table 2.2 and Figure 2.1).

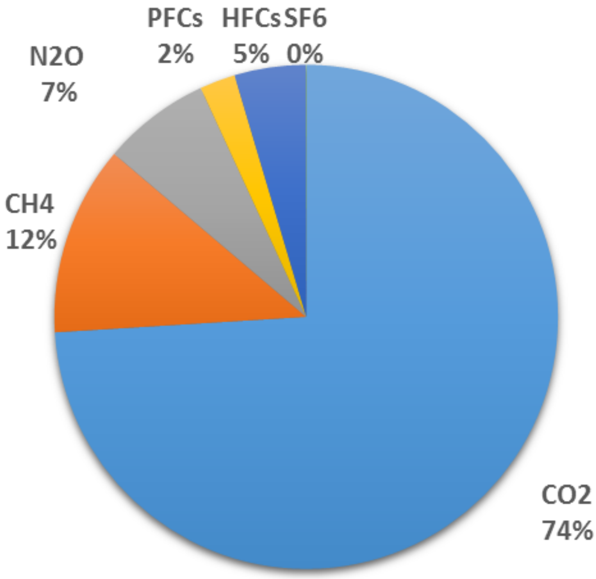

Figure 2.1 Distribution of emissions of GHG by gas in 2015.

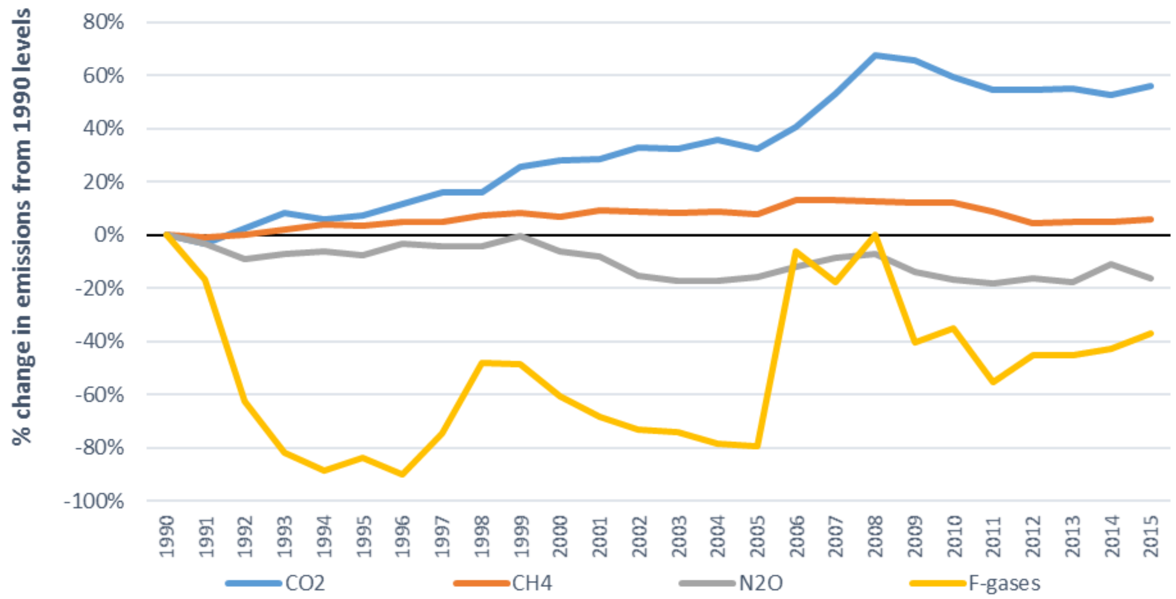

Figure 2.2 Percentage changes in emissions of GHG by gas 1990-2015, compared to 1990 levels.

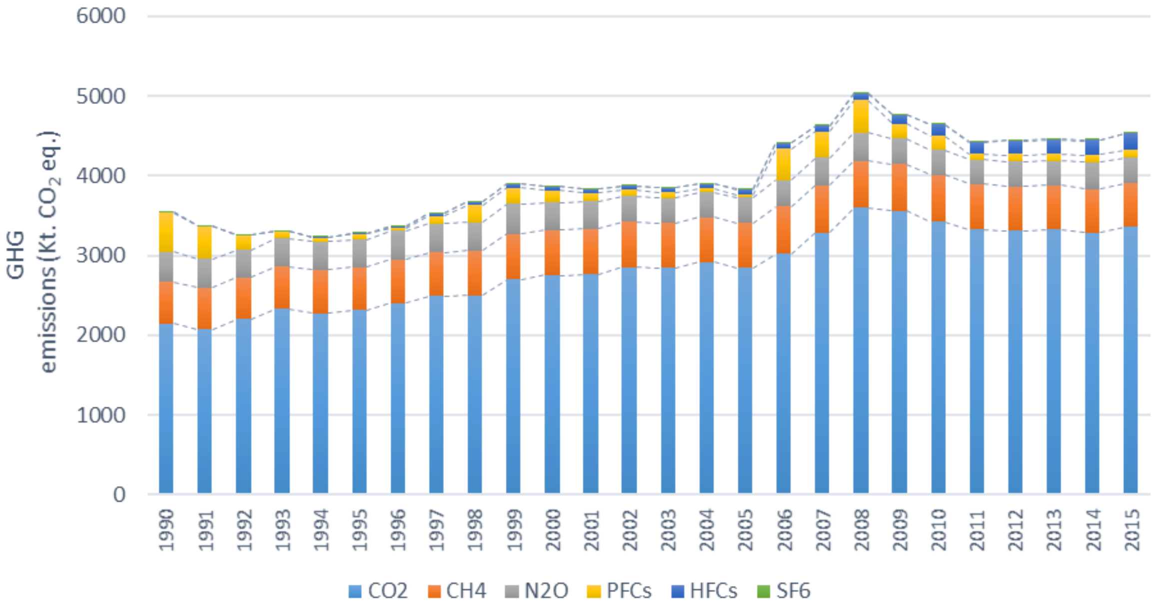

Figure 2.3 Emissions of greenhouse gases by gas, 1990-2015.

2.3 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 since 2008 than in the years before). Emissions from geothermal energy exploitation are considerable. Other sources consist mainly of emissions from non-road transport and waste incineration. Table 2.3 lists CO_2 emissions from the main source categories for the period 1990-2015. Figure 2.4 shows the percentage change in emissions of CO_2 by source from 1990 to 2015 compared with 1990 levels.

Table 2.3 Emissions f CO_2 (kt.) by sector 1990-2015.

	1990	1995	2000	2005	2010	2014	2015
1. Energy	1,736	1,866	1,969	1,991	1,801	1,626	1,643
2. Industrial processes	405	441	786	853	1,620	1,652	1,704
3. Agriculture	0	0	0	0	0	0	1
5. Waste	7	5	3	5	6	6	9
Total CO_2 emissions (kt.)	**2,148**	**2,312**	**2,757**	**2,848**	**3,427**	**3,285**	**3,357**

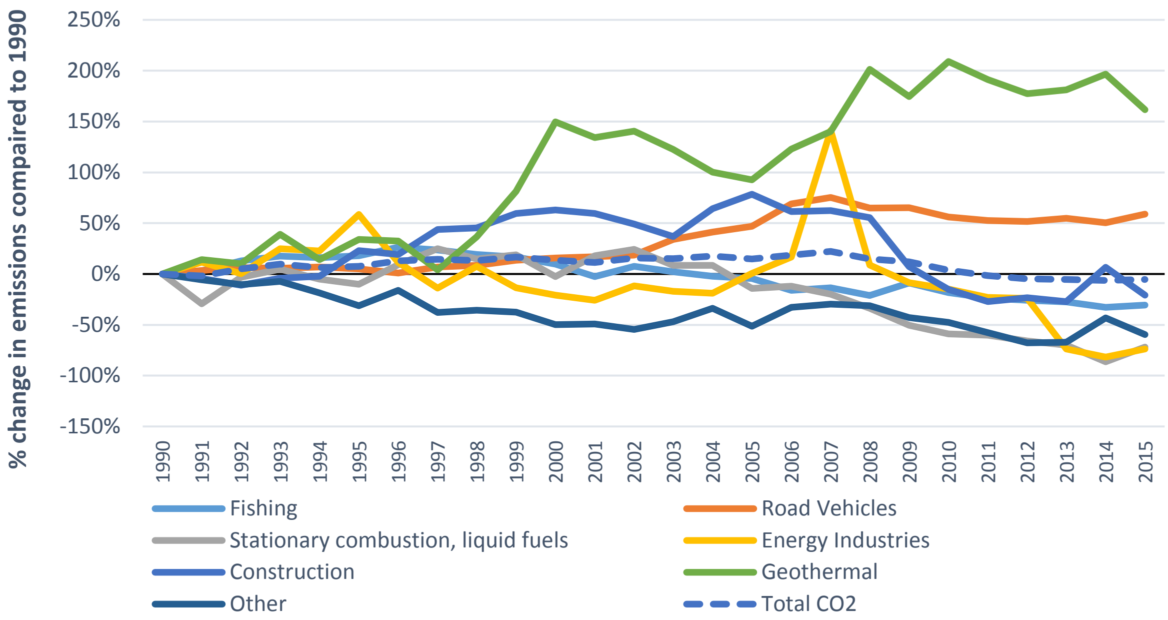

Figure 2.4 Percentage changes in CO_2 emissions by major sources 1990-2015, compared to 1990.

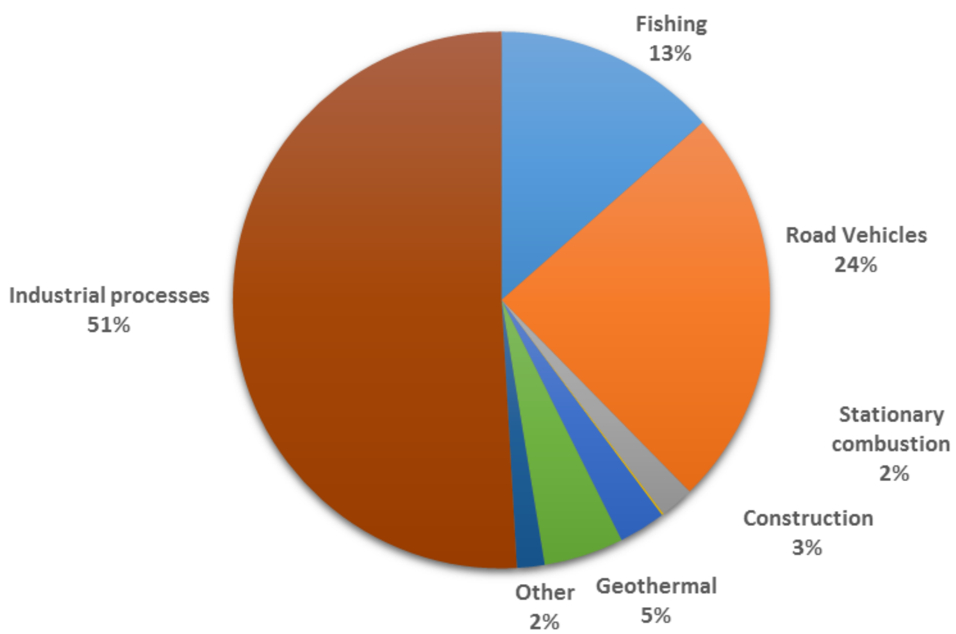

Figure 2.5 Distribution of CO_2 emissions by source in 2015.

In 2015, Iceland´s total CO_2 emissions were 3,357 kt. This is tantamount to an increase of 56.7% from 1990 levels and an increase of 2.4% from the preceding year. CO_2 emissions from Industrial Processes increased by 3.3% from 2014 to 2015 due to increase emissions from the mineral production, metal production, non-energy products from fuels and solvent use and fireworks. Emissions from geothermal energy exploitation decreased by 11.8% between 2014 and 2015. Emissions from road vehicles peaked in 2007 but were 9.6% lower in 2015 than in 2007. This decreasing trend is caused by significantly higher fuel prices, owing to the depreciation of the Icelandic króna since 2008, and by an increasing share of fuel efficient vehicles in the fleet. In 2009, 2010 and 2011 fuel prices continued to rise. In recent years more fuel efficient vehicles have been imported – a turn-over of the trend from the years 2002 to 2007 when larger vehicles were imported. This can be seen in less fuel consumption in 2010 than in 2009 despite the fact that driven mileage stayed almost the same. Driven mileage decreased by 5% for gasoline passenger cars and by 6% for diesel fueled cars between 2011 and 2012 but is on the rise again. Emissions from stationary combustion of liquid fuels increased by 102% from 2014 to 2015. Emissions from construction decreased by 26% and emissions from other sources decreased by 29% during the same time period.

The increase in CO_2 emissions between 1990 and 2015 can be explained by increased emissions from industrial processes (361%), road transport (59%) and geothermal energy utilisation (162%). Total CO_2 emissions from the commercial fishing on the other hand declined by 31% respectively. In 2007 residual oil use in energy industries increased significantly due to insufficient supply of electricity

The main driver behind increased emissions from industrial processes since 1990 has been the expansion of the metal production sector, in particular the aluminium sector. In 1990, 87,839 tonnes of aluminium were produced in one aluminium plant in Iceland. A second aluminium plant was established in 1998 and a third one in 2007. In 2015, a total of 857,319 tonnes of aluminium were produced in these three aluminium plants, corresponding to a 2.13% production increase since 2014.

CO_2 emissions from road transport have increased by 59% since 1990, owing to increases in population, number of cars per capita, more mileage driven, and - until 2007 - an increase in the share of larger vehicles. Since 1990 the vehicle fleet in Iceland has increased by 78%. Emissions from both domestic flights and navigation have declined since 1990.

Emissions from geothermal energy exploitation have increased 162% since 1990. Electricity production using geothermal energy has increased from 283 GWh in 1990 to 5,003 GWh in 2015, or close to 18-fold.

CO_2 emissions from commercial fishing rose from 1990 to 1996 because a substantial portion of the fishing fleet was operating in distant fishing grounds. From 1996 the emissions decreased again reaching 1990 levels in 2001. Emissions then increased again by 10% between 2001 and 2002, but in 2003 they dropped to 1990 levels. In 2015, the emissions were 31% below the 1990 levels and 3% below the 2014 levels. Annual changes in emissions reflect the inherent nature of the fishing industry.

Emissions from other sources decreased from 1990 to 2003, but rose again between 2004 and 2007 when they were 18% above the 1990 level. This is mainly due to changes in the cement industry where production had been slowly decreasing since 1990. The construction of the Kárahnjúkar hydropower plant (building time from 2002 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 this project was imported. In 2011, emissions from cement production were 67% lower than in 2007, due to the collapse of the construction sector. The sole cement plant ceased operation in late 2011. CO_2 emissions from other sources in 2015 were 4.9% below the 1990 levels and 30% below the 2014 level.

2.4 Methane (CH_4)

Agriculture and waste treatment have been the main sources of methane emissions since 1990. In 2015 they comprised 64% and 34% of total methane emissions, respectively (Table 2.4 and Figure 2.6). The main methane source in the agriculture sector is enteric fermentation, the main source in the waste sector is solid waste disposal on land. Together they accounted for roughly 87% of all methane emissions in 2015.

Methane emissions from agriculture decreased by 3.2% between 1990 and 2015 due to a decrease in livestock population. Emissions from waste, on the other hand, increased by 26.7% during the same period. Emissions from waste treatment increased sharply from 1990 to 2007 although the amount of waste landfilled had been oscillating between 300 and 350 kt.from 1986 to 2005. The increase was due to an increasing share of waste landfilled in well managed solid waste disposal sites which are characterised by a higher methane correction factors than unmanaged sites. The decrease in methane emissions from the waste sector since 2005 by 23% is due to a decrease in the amount of waste landfilled since 2005 (Table 2.4).

Table 2.4 Emissions of CH_4 by sector 1990-2015 (kt. CO_2-eq.).

	1990	1995	2000	2005	2010	2014	2015
1. Energy	6.5	6.4	6.2	6.2	8.5	7.6	7.7
2. Industrial processes	0.7	0.7	1.1	1.3	1.1	1.3	1.4
3. Agriculture	364	338	332	322	342	347	353
5. Waste	150	196	220	233	233	193	190
Total CH_4 emissions	**522**	**540**	**559**	**563**	**585**	**549**	**552**

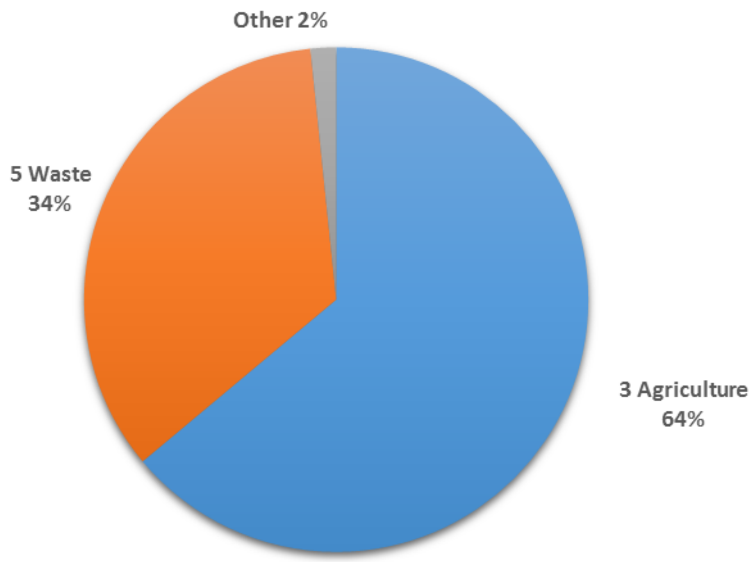

Figure 2.6 Distribution of CH_4 emissions by source in 2015.

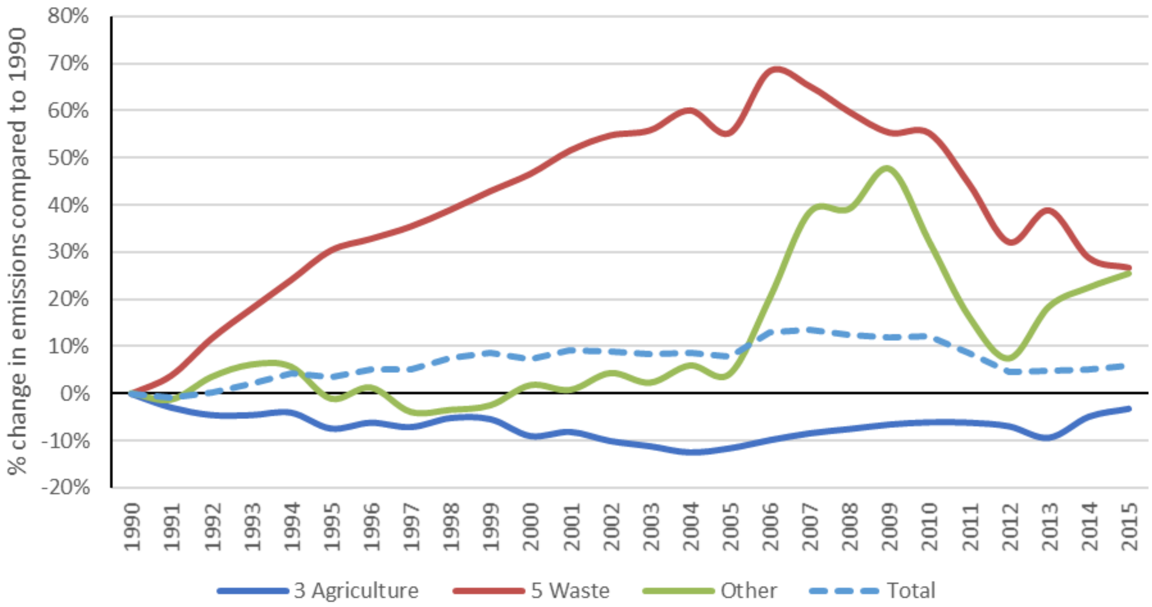

Figure 2.7 Percentage changes in CH_4 emissions by major sources 1990-2015, compared to 1990.

2.5 Nitrous Oxide (N_2O)

Agriculture has been the main source of N_2O emissions in Iceland and accounted for 82% of nitrous oxide emissions in 2015 (Table 2.5 and Figure 2.8). 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. Emissions from the agriculture sector decreased by 8% since 1990. This development was mainly due to a decrease in livestock populations accompanied by a decrease in manure production. The second most important source of N_2O, since the shutdown of the fertilizer plant in 2001, is road transport. Emissions increased rapidly when catalytic converters became obligatory in all new vehicles in 1995. N_2O is a by-product of NO_x reduction in catalytic converters. Total nitrous oxide emissions have decreased by 16% since 1990.

Table 2.5 Emissions of N_2O by sector 1990-2015 (kt. CO_2-eq.).

	1990	1995	2000	2005	2010	2014	2015
1 Energy	34	43	59	66	49	48	44
2 Industrial processes	52	45	22	3.4	3.6	2.9	2.9
3 Agriculture	282	253	264	240	252	276	259
5 Waste	6.4	6.3	6.1	6.3	7.7	8.3	8.4
Total N_2O emissions	**375**	**347**	**352**	**316**	**313**	**335**	**314**

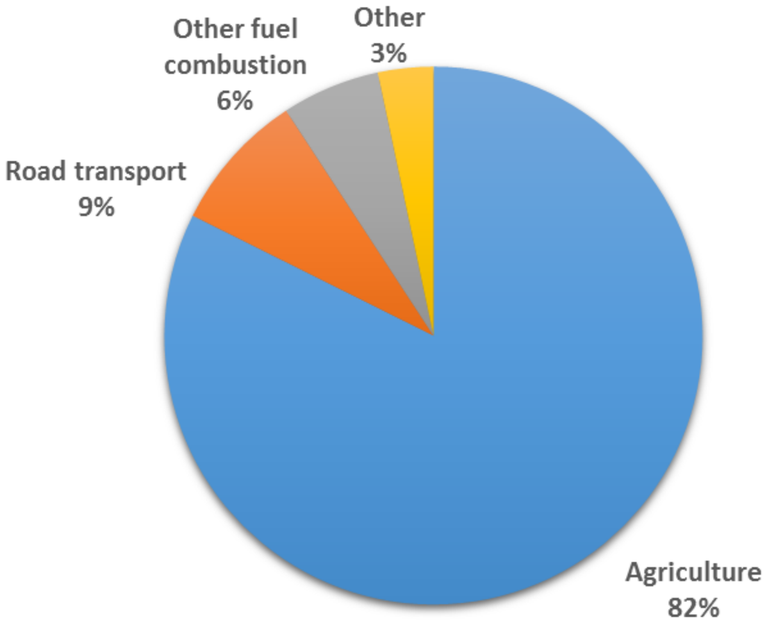

Figure 2.8 Distribution of N_2O emissions by source in 2015.

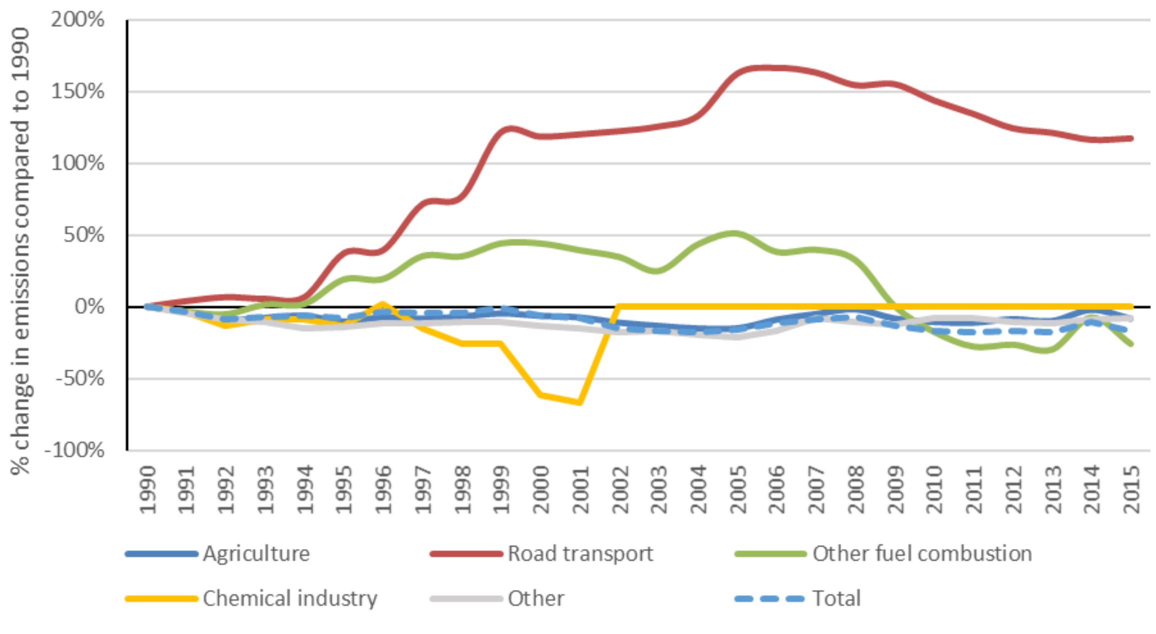

Figure 2.9 Changes in N_2O emission for major sources between 1990 and 2015. The trend for Chemical Industry stops in 2001, where the fertilizer factory shut down, thereby ending N_2O emissions from the Chemical industry.

2.6 Perfluorocarbons (PFCs)

Perfluorocarbon emissions in Iceland come from the aluminium industry (tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6)), and from refrigeration equipment (hexafluoroethane (C_2F_6) commercially known as PFC116, and octafluoropropane (C_3F_8), commercially known as PFC218)). The emissions of the perfluorocarbons, i.e. tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) from the aluminium industry were 86.4 and 17.3 kt.CO_2-equivalents respectively in 2015, or 103.7 kt. CO_2-equivalents in total. Emissions of PFCs (PFC 116 and PFC 218) from consumption of halocarbons in refrigeration and air conditioning equipment were 0.015 kt. CO_2-equivalents in 2015.

Total PFC emissions decreased by 79% in the period of 1990-2015. 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_2-equivalents per year) and C_3F_8 was used in refrigeration and air conditioning equipment for the first time in 2009.

Table 2.6 Emissions of PFCs 1990-2015 (kt. CO_2-eq.).

	1990	1995	2000	2005	2010	2014	2015
1 Energy	NO	NO	NO	NO	NO	NO	NO
2 Industrial processes	495	69	150	31	172	99	104
3 Agriculture	NO	NO	NO	NO	NO	NO	NO
5 Waste	NO	NO	NO	NO	NO	NO	NO
Total PFCs emissions	**495**	**69**	**150**	**31**	**172**	**99**	**104**

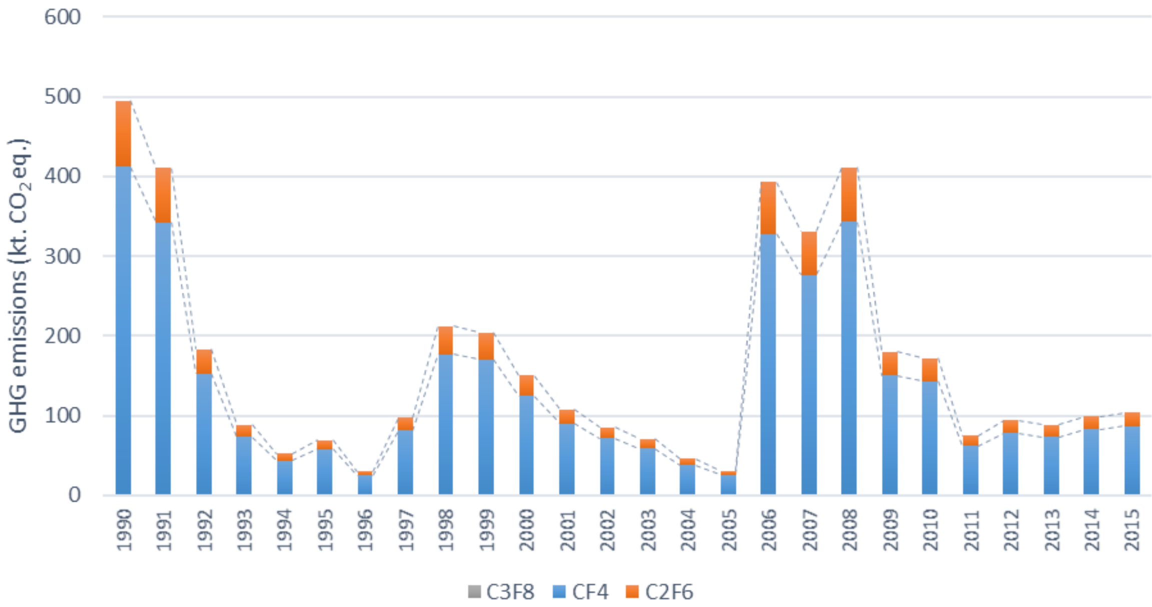

Figure 2.10 Emissions of PFCs from 1990 to 2015 (kt. CO_2-eq.).

2.7 Hydrofluorocarbons (HFCs)

Total emissions of HFCs, used as substitutes for ozone depleting substances (ODS), amounted to 207 kt. CO_2-equivalents in 2015 (Table 2.7; Figure 2.11). 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.

Table 2.7. Emissions of HFCs from 1990 to 2015 (kt. CO_2-eq.).

	1990	1995	2000	2005	2010	2014	2015
1 Energy	NO	NO	NO	NO	NO	NO	NO
2 Industrial processes	0.34	10.2	43.3	69.3	146	182	207
3 Agriculture	NO	NO	NO	NO	NO	NO	NO
5 Waste	NO	NO	NO	NO	NO	NO	NO
Total HFCs emissions	**0.34**	**10.2**	**43.3**	**69.3**	**146**	**182**	**207**

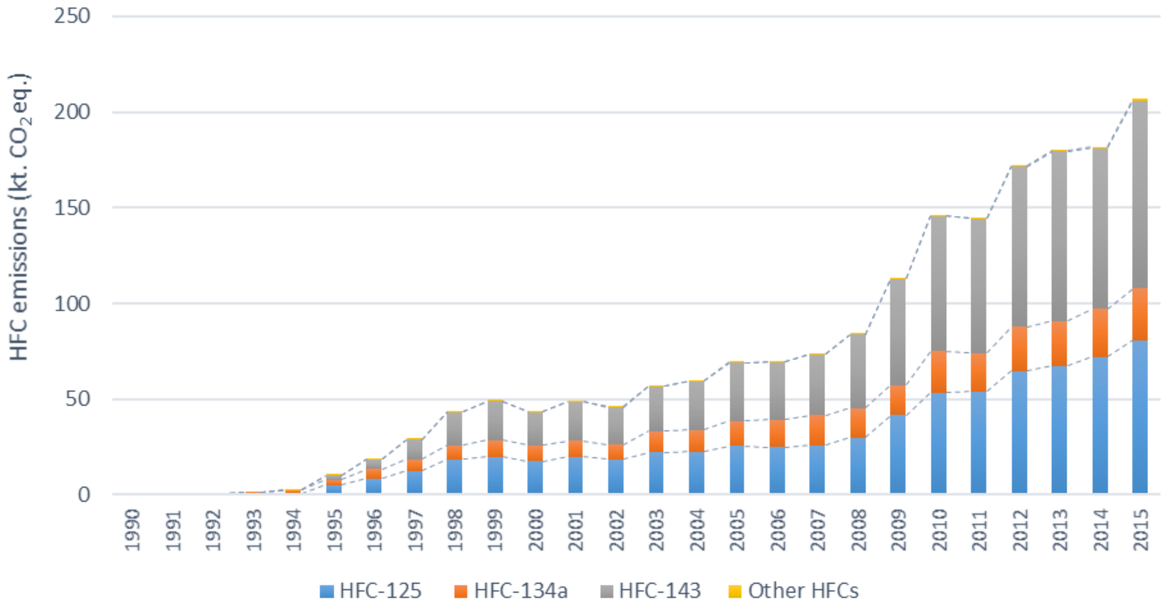

Figure 2.11 Emissions of HFCs from 1990 to 2015 (kt. CO_2-eq.).

2.8 Sulphur Hexafluoride (SF_6)

The sole source of SF_6 emissions in Iceland is leakage from electrical equipment. Total emissions in 2015 were 67.1 kg SF_6 which is tantamount to 1.53 kt. CO_2-equivalents. Emissions have increased by 39.5% since 1990. 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. The emission peak in 2010 was caused by two unrelated accidents during which the SF_6 amounts contained in the gear affected by the accidents was emitted (Figure 2.12). The emission peak in 2012 was caused by increased leakage in the transmission grid of Landsnet LLC.

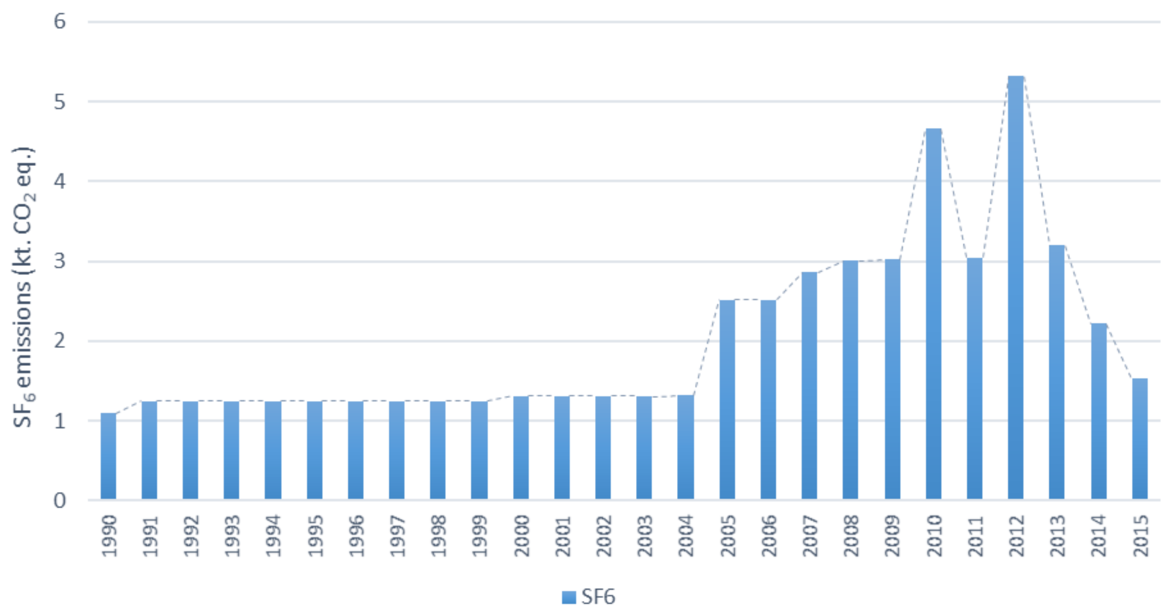

Figure 2.12 Emissions of SF_6 from 1990 to 2015 (kt. CO_2-eq.).

2.9 Emission Trends by Source

Industrial processes are the largest contributor of greenhouse gas emissions in Iceland (without LULUCF), followed by Energy, Agriculture, and Waste. The contribution of Industrial Processes to total net emissions (without LULUCF) increased from 27% in 1990 to 44% in 2015. The contribution of the Energy sector decreased from 50% in 1990 to 38% in 2015. Agriculture and the Waste sector accounted for 14% and 5% of 2015 emissions, respectively (cf. Table 2.1 and Figure 2.13).

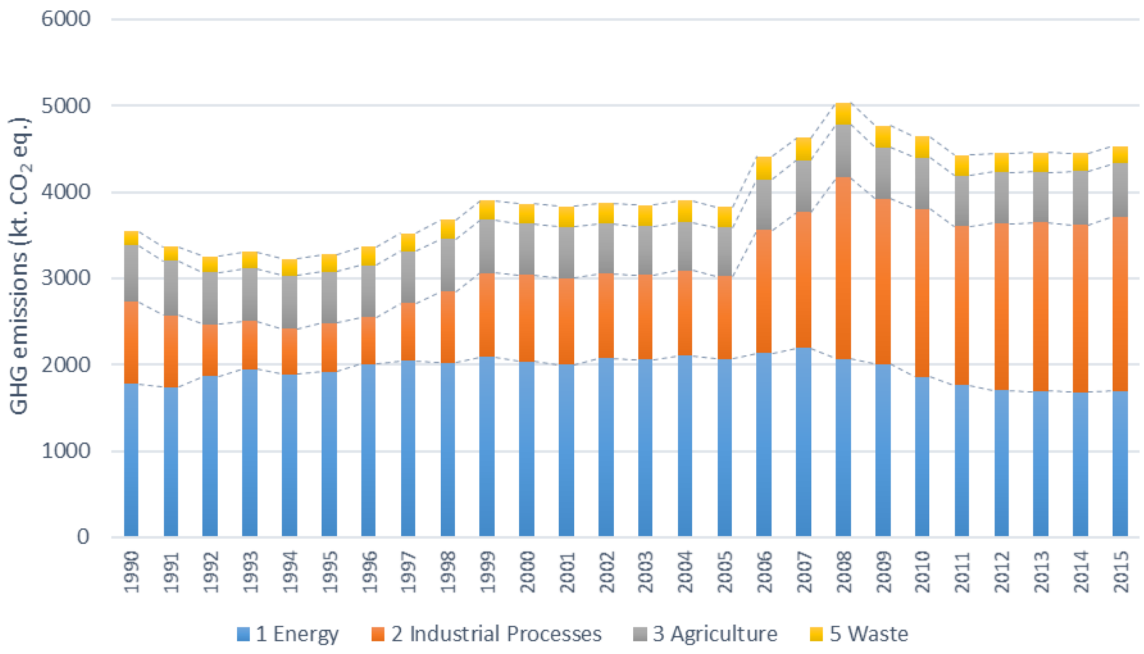

Figure 2.13 Emissions of GHG by UNFCCC sector, without LULUCF, from 1990 to 2015 (kt. CO_2-eq.).

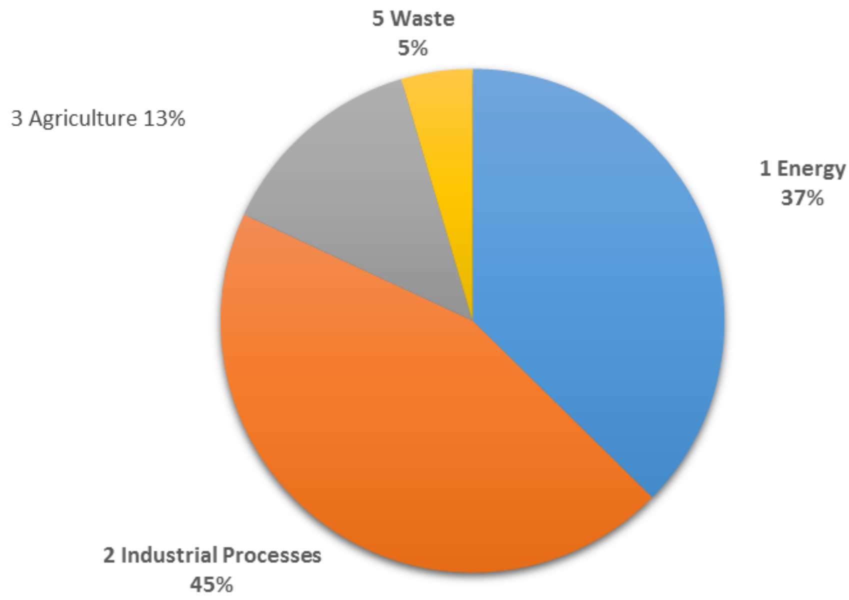

Figure 2.14 Emissions of GHG by UNFCCC sector in 2015 (CO_2-eq.).

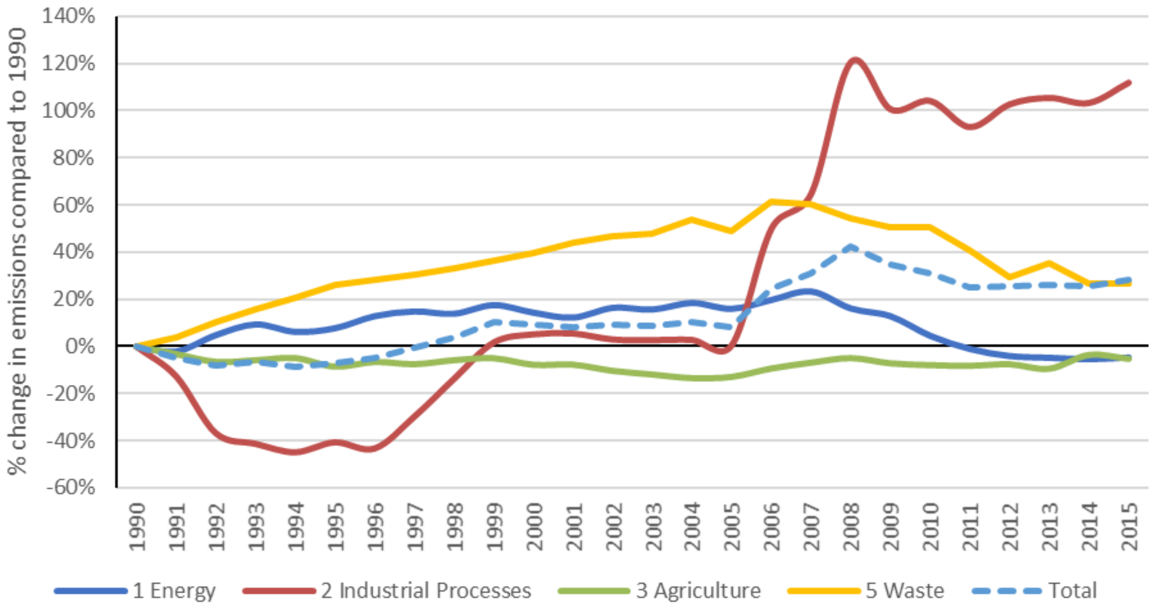

Figure 2.15 Percentage changes in total GHG emissions by sectors 1990-2015, compared to 1990.

2.9.1 Energy (CRF sector 1)

The Energy sector in Iceland is unique in many ways. Iceland ranks 1st among OECD countries in the per capita consumption of primary energy and in 2015 the consumption per capita was about 785 GJ. However, the proportion of domestic renewable energy in the total energy budget is 85.3%, which is a much higher share than in most other countries. The cool climate and sparse population calls for high energy use for space heating and transport. Also, key export industries such as fisheries and metal production are energy-intensive. The metal industry used around 75% of the total electricity produced in Iceland in 2015. 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. The first phase covered the electrification of the country and harnessing the most accessible geothermal fields, mainly for space heating. In the second phase, steps were taken to harness 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. In the third phase, 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.

Table 2.8 shows the distribution of emissions in 2015 by different source categories. The relative contributions of the various source categories to the total emissions of the Energy sector are shown in Figure 2.16. The percentage change in the various source categories in the Energy sector between 1990 and 2015, compared with 1990, is illustrated in Figure 2.16.

Table 2.8 Total GHG emissions from fuel combustion in Energy sector in 1990-2015(kt. CO_2-eq.).

	1990	1995	2000	2005	2010	2014	2015
1A1 Energy industries	14	22	11	14	12	3	4
1A2 Manufacturing industry and construction	244	219	237	209	100	33	68
1A3 Transport	617	622	660	831	884	855	886
1A4 Other Sectors	840	970	971	888	668	604	572
1B2 Fugitive Emissions from Fuels (Geothermal energy)	62	83	155	121	195	187	165
Total emissions (kt.)	**1,777**	**1,916**	**2,034**	**2,063**	**1,859**	**1,682**	**1,695**

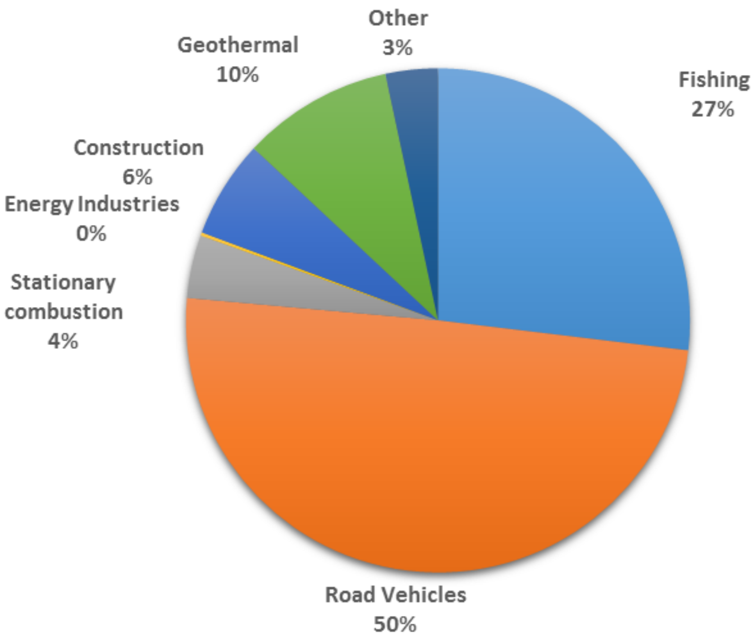

Figure 2.16 GHG emissions in the Energy sector 2015, distributed by source categories.

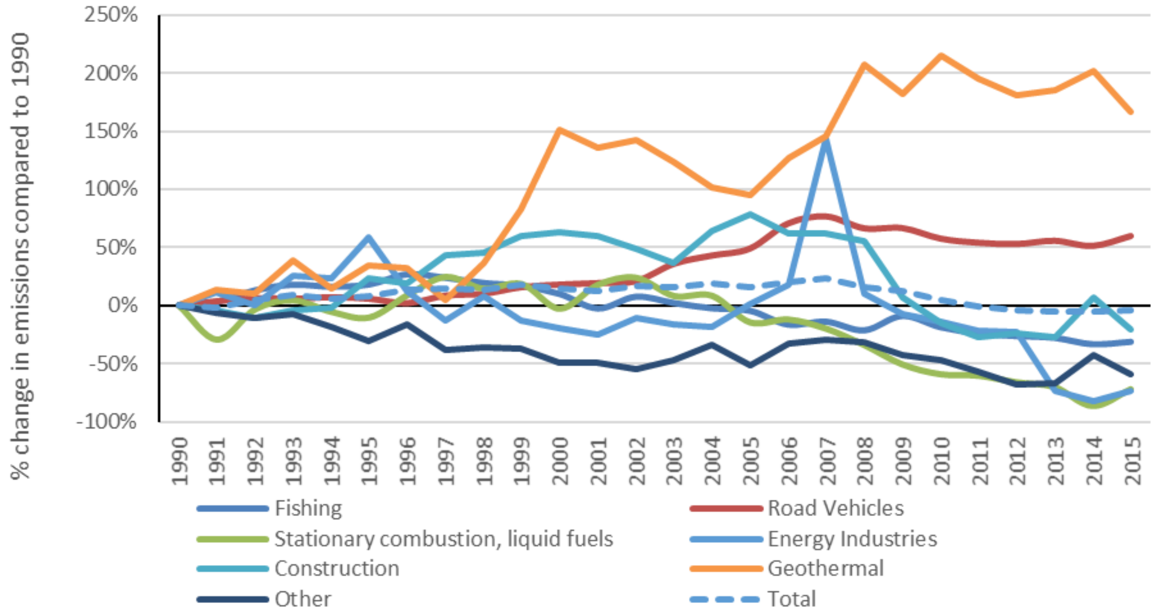

Figure 2.17 Percentage changes in GHG emissions for source categories in the Energy sector during 1990-2015, compared to 1990.

2.9.1.1 Fuel Combustion

Emissions from fuel combustion in the Energy sector accounted for 33.9% of the total greenhouse gas emissions in Iceland in 2015. Figure 2.17 shows that emissions from road vehicles have increased by 60% since 1990 as emissions from fishing have decreased by 31%. Emissions from energy industries are 74% below 1990 levels and emissions from manufacturing industries and construction are 21% below 1990 levels.

Energy include 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. Since 1997 emissions have been around 40% lower in normal years than in 1990. Emissions from energy industries accounted for 0.21% of the sector’s total and 0.1% of the total GHG emissions in Iceland in 2013. Electricity is produced with fuel combustion at 2 locations, which are located far from the distribution system (two islands, Flatey and Grimsey). Some electricity facilities have backup systems using fuel combustion which they use if problems occur in the distribution system. Some district heating facilities that 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 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 unfavorable 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. Because the Kárahnjúkar hydropower project was delayed, the aluminium plant was supplied for a while 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. This also has an effect on the implied emission factor (IEF) for energy industries, as waste and residual fuel oil have different emission factors. In years where more oil is used in the sector the IEF is considerably higher than in normal years.

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 crises 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.

Emissions from the Transport sector increased by 43% from 1990 to 2015. Emissions from road transport have increased by 60% 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 by 89%. Also, the Icelandic population has grown by 30% from 1990 to 2015. Emissions from road vehicles peaked in 2007 and have decreased by 9.6% since then. In recent years more fuel economic vehicles have been imported – a turn-over of the trend from the years 2002 to 2007 when larger vehicles were imported. Another factor in reducing fuel consumption is the fact that the mean mileage per vehicle has been in decline from 2010-2015. Emissions from both domestic flights and navigation have declined since 1990 and this decrease in navigation and aviation has compensated for rising emissions in the transport sector to some extent.

The fisheries dominate the Other sector as heating in Iceland relies on renewable energy sources. 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. In 2015 emissions were 31% below the 1990 level and 3% below the 2014 level. Annual changes are inherent to the nature of fisheries.

2.9.1.2 Geothermal Energy

Emissions from geothermal energy utilization accounts for 3.6% of the total greenhouse gas emissions in Iceland in 2015. Iceland relies heavily on geothermal energy for space heating (over 90% of the homes) and electricity production (27% of the total electricity production). The emissions from geothermal power plants are considerably less, or 19 times lower, than from fossil fuel power plants. Table 2.9 shows the emissions from geothermal energy from 1990 to 2015. Electricity production using geothermal power increased almost 18-fold during this period from 283 to 5,003 GWh. Emissions during the same time increased by 167%. 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 ofextraction.

Table 2.9. Emissions from geothermal energy from 1990 to 2015 (kt. CO_2-eq.).

	1990	1995	2000	2005	2010	2014	2015
Geothermal energy	62	83	155	121	195	187	165

2.9.1.3 Distribution of oil products

Emissions from distribution of oil products are a minor source in Iceland. Emissions are around 0.3 to 0.5 kt. per year.

2.9.1.4 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 2.10.

In 2015 greenhouse gas emissions from ships and aircrafts in international traffic bunkered in Iceland amounted to a total of 983 kt. CO_2-equivalents, which corresponds to about 22% of the total Icelandic greenhouse gas emissions. Greenhouse gas emissions from marine and aviation bunkers increased by 209% from 1990 to 2015; with an 24.5% increase between 2014 and 2015.

Looking at these two categories separately, it can be seen that greenhouse gas emissions from international marine bunkers increased by 212% from 1990 to 2015, while emissions from aircrafts increased by 207% during the same period. Between 2014 and 2015 emissions from marine bunkers increased by 34.3% while emissions from aviation bunkers increased by 20.5%. Emissions from international bunkers are rising again after decline since 2007. Foreign commercial fishing vessels dominate the fuel consumption from marine bunkers.

Table 2.10 GHG emissions from international aviation and international water-borne navigation 1990-2015 (kt. CO_2-eq.).

	1990	1995	2000	2005	2010	2014	2015
1A3ai Aviation	219	236	407	421	376	559	673
1A3di Marine	99	145	219	112	184	231	310
Total GHG emissions	**318**	**380**	**626**	**532**	**560**	**790**	**983**

2.9.2 Industrial Processes (CRF sector 2)

Production of raw materials is the main source of industrial process related emissions for both CO_2 and other greenhouse gases 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 accounts for 44% of the national greenhouse gas emissions. As can be seen in Table 2.11 and Figure 2.18 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 aluminum industry has increased. By 2015, emissions from the industrial processes sector were 140% above the 1990 level.

Table 2.11. GHG emissions from industrial processes 1990-2015 (kt. CO_2-eq.).

2 IPPU	**1990**	**1995**	**2000**	**2005**	**2010**	**2014**	**2015**
2A Mineral products	52	38	65	55	10	0.6	0.7
2B Chemical industry	47	41	18	NO	NO	NO	NO
2C Metal production	843	468	866	826	1,780	1,749	1,806
2D Non-Energy Products from Fuels and Solvent Use	4.4	4.8	4.3	3.9	2.6	2.6	2.9
2F Product Uses as Substitutes for Ozone Depleting Substances	0.3	10	43	69	146	182	207
2G Other Product Manufacture and Use	7.0	5.5	5.9	6.0	8.3	5.1	4.5
Total GHG emissions	**954**	**567**	**1,004**	**960**	**1,947**	**1,939**	**2,021**

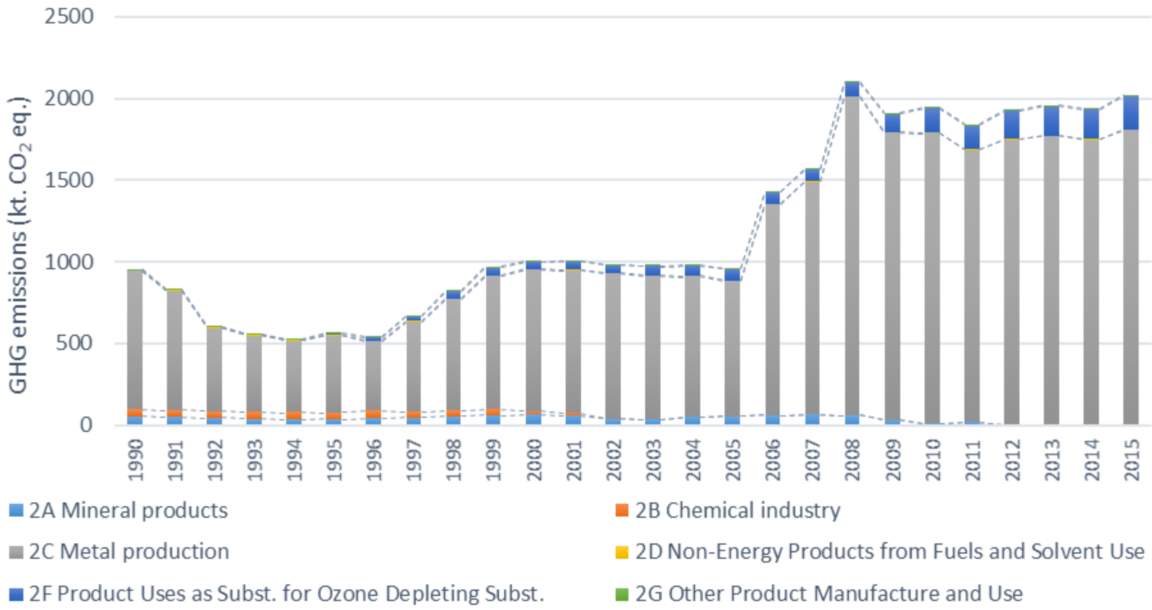

Figure 2.18 Total GHG emissions in the Industrial Process sector during 1990-2015 (kt. CO_2-eq.).

The significant category within the Industrial Processes sector is metal production, which accounted for 88% of the sector's emissions in 1990 and 91% in 2015. Aluminium production is the main source within the metal production category, accounting for 70% of the total Industrial Processes emissions in 2015. 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; from 4.78 tonnes CO_2-equivalents in 1990 to 0.10 tonnes CO_2-equivalents in 2005. In 2006 the PFC emissions rose significantly due to an expansion at Century Aluminium. PFC emissions per tonne of aluminium at the Century Aluminium plant went down from 2007 to 2011 through improved process technology, reaching 0.12 tonnes CO_2-equivalents per tonne aluminium in 2011. 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. In 2011 PFC emissions per tonne of aluminium at the Alcoa Fjarðaál went down to 0.07 tonnes CO_2-equivalents per tonne aluminium before increasing again to 0.2 tonnes CO_2-equivalents per tonne aluminium in 2015.

Production of ferroalloys is another major source of emissions, accounting for 20% of Industrial Processes emissions in 2015. 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 129% since 1990. Emissions in 2015 were 8.9% higher than in 2014.

Production of minerals accounted for only 0.1% of the emissions in 2011. 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.

Production of fertilizers, which used to be the main contributor to the 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 silicon 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 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 (Table 2.12Table 2.12).

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 2.12). The peak in 2010 was caused by two unrelated accidents during which the SF_6 contained in equipment leaked into the atmosphere. The peak in 2012 was caused by increased emissions from the operator of the Icelandic grid Landsnet LLC.

Table 2.12. HFC and SF_6 emissions from consumption of HFC and SF_6 (kt.CO_2 -eq.).

	1990	1995	2000	2005	2010	2014	2015
HFCs	0.3	10.2	43.3	69.3	146	182	207
PFCs	1.1	1.2	1.3	2.5	4.7	2.2	1.5
SF6	495	69	150	31	172	99	104

The use of solvents and products containing solvents leads to emissions of non-methane volatile organic compounds (NMVOC), which are regarded as indirect greenhouse gases as the NMVOC compounds are oxidized to CO_2 in the atmosphere over time. NMVOC emissions reported here include emissions from domestic solvent use, road paving with asphalt, coating applications, degreasing, dry-cleaning, chemical products, printing and wood preservation. Furthermore, NMVOC from food and beverage production are reported.

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.

2.9.3 Agriculture (CRF sector 3)

Emissions from agriculture are closely coupled with livestock population sizes, especially cattle and sheep. Since emission factors were assumed to be stable during the last two decades (with the exception of gross energy intake of dairy cows, whose increase reflects an increase in milk production), changes in activity data translated into proportional emission changes. The only other factor that had considerable impact on emission estimates was the amount of nitrogen in fertilizer applied annually to agricultural soils. A 17% decrease in livestock population size of sheep between 1990 and 2005 – partly counteracted by increases of livestock population sizes of horses, swine, and poultry - led to emission decreases from all subcategories and resulted in a 13% decrease of total agriculture emissions during the same period (Table 2.13 and Figure 2.19)

Since 2005 emissions from agriculture have increased by 8% due to an increase in livestock population size but still remain 5% below 1990 levels. This general trend is modified by the amount of synthetic nitrogen applied annually to agricultural soils. The largest sources of agricultural greenhouse gas emissions in 2015 were from enteric fermentation 49%, 34% from agricultural soils and manure management accounted for 17% of total agriculture emissions are methane and nitrous oxide emissions from manure management (Figure 2.19).

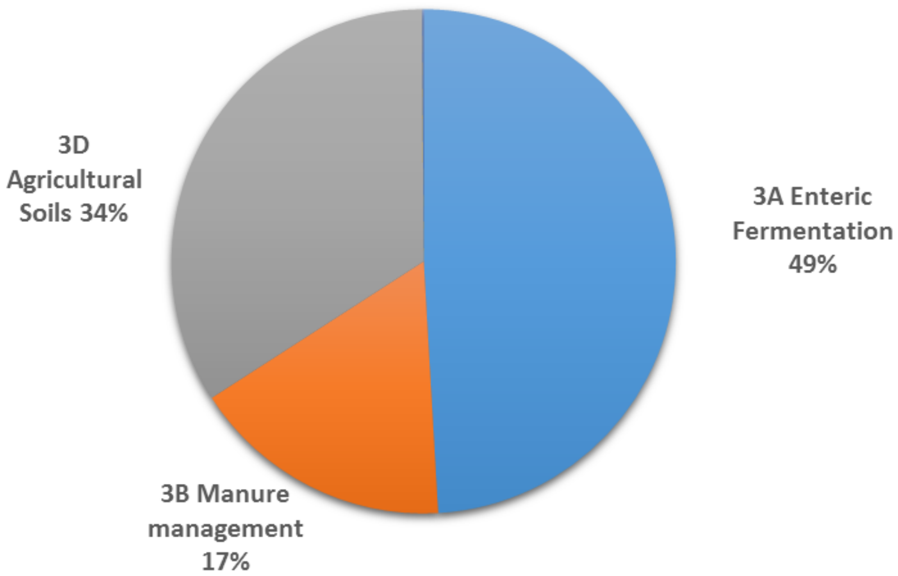

Figure 2.19 GHG emissions from the agriculture sector 2015, distributed by source categories.

Table 2.13. GHG emissions from agriculture sector from 1990 to 2015 (kt. CO_2-eq.).

3 Agriculture	1990	1995	2000	2005	2010	2014	2015
3A Enteric Fermentation	313.8	290.0	284.8	276.0	293.1	296.8	300.5
3B Manure management	109.4	95.3	96.8	94.3	98.9	100.8	102.9
3D Agricultural Soils	223.3	205.3	214.3	191.9	202.5	225.1	208.1
3G Liming	0.0	0.0	0.0	0.0	0.0	0.0	0.1
3H Urea Application	0.1	0.1	0.1	0.1	0.1	0.3	0.6
Total GHG emissions	**647**	**591**	**596**	**562**	**595**	**623**	**612**

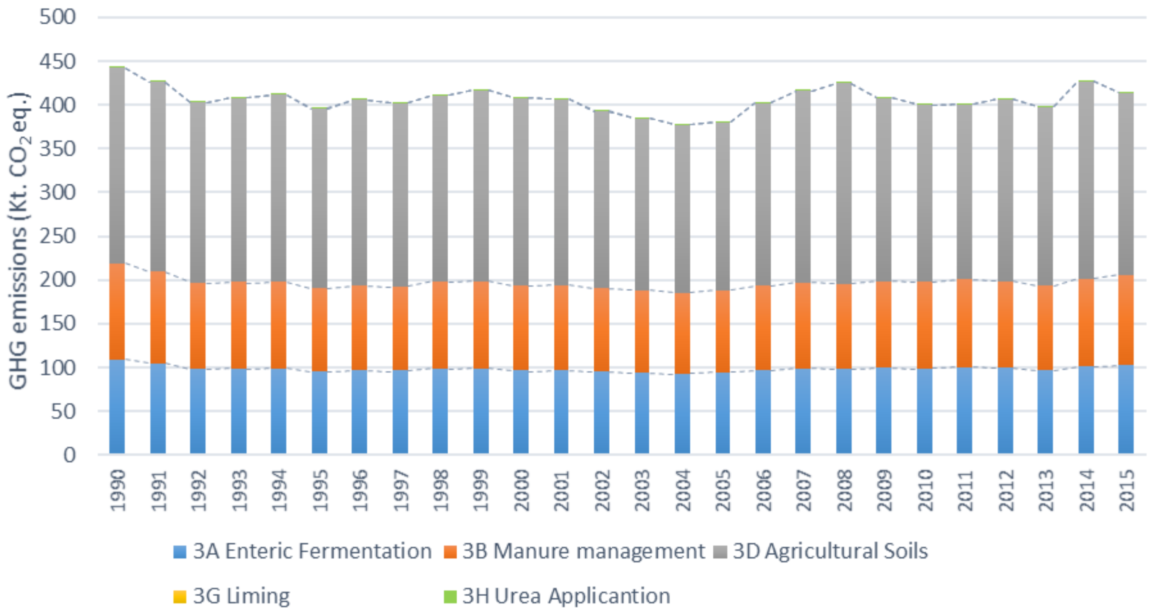

Figure 2.20 GHG emissions from agriculture 1990-2015, (kt. CO_2-eq.).

2.9.4 Land Use, Land-Use Change and Forestry (LULUC, CRF sector 4)

Net emissions from the LULUCF sector in Iceland are high; the sector had the highest net emissions 1990-2015. A large part of the absolute value of emissions from the sector in 2015 was from cropland and grassland on drained organic soil. The emissions can be attributed to drainage of wetlands in the latter half of the 20th century, which had largely ceased by 1990. Emissions of CO_2 from drained wetlands continue for a long time after drainage.

Net emissions (emissions – removals) in the sector have decreased over the time period, as can be seen in *Table 2.14*. This is explained by increased removals through afforestation and revegetation as well as a decrease in emissions from land converted to cropland. Increased removals in afforestation and revegetation are explained by the increased activity in those categories and changes in forest growth with stand age.

Table 2.14. GHG emissions from the LULUCF sector from 1990 to 2015 (kt. CO_2-eq.).

4 LULUCF	1990	1995	2000	2005	2010	2014	2015
4A Forest Land	-41	-63	-97	-148	-202	-284	-334
4B Cropland	2014	1969	1912	1859	1804	1761	1750
4C Grassland	6964	6992	7140	7322	7619	7747	7761
4D Wetlands	1116	1121	1101	1074	1035	1018	1016
4E Settlements	13	6	15	20	6	5	5
4G Harvested Wood Products	NO,NE	NO,NE	0,11	0,11	0,12	0,19	0,22
4H Other	66	67	69	71	74	75	76
Net emissions LULUCF	**10134**	**10092**	**10139**	**10198**	**10336**	**10322**	**10274**

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.

2.9.5 Waste (CRF sector 5)

Emissions from the Waste sector accounted for 5% of total GHG emissions in 2015. About 88% of these emissions were methane emissions from solid waste disposal on land. 5.6% were CH_4 and N_2O emissions from wastewater treatment and 4.5% were CO_2, CH_4 and N_2O emissions from waste incineration. The remaining 1.9% originated from biological treatment of waste, i.e. composting. Emissions from the waste sector increased steadily from 1990 to 2007 due to an increase in emissions from solid waste disposal on land (SWD) (*Table 2.15* and Figure 2.21). 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 2015 amounted to 28%.

Table 2.15. GHG emissions from the waste sector from 1990 to 2015 (kt. CO_2-eq.).

5 Waste	1990	1995	2000	2005	2010	2014	2015
5A Solid Waste Disposal	142	188	214	225	226	186	182
5B Biological Treatment of Solid Waste	NO	0.4	0.4	0.9	2.9	3.8	4.0
5C Incineration and Open Burning of Waste	15	10.3	6.0	5.5	6.5	6.9	9.3
5D Wastewater Treatment and Discharge	6.8	8.3	8.6	12.2	11.3	11.5	11.6
Total emissions	**164**	**207**	**229**	**244**	**247**	**208**	**207**

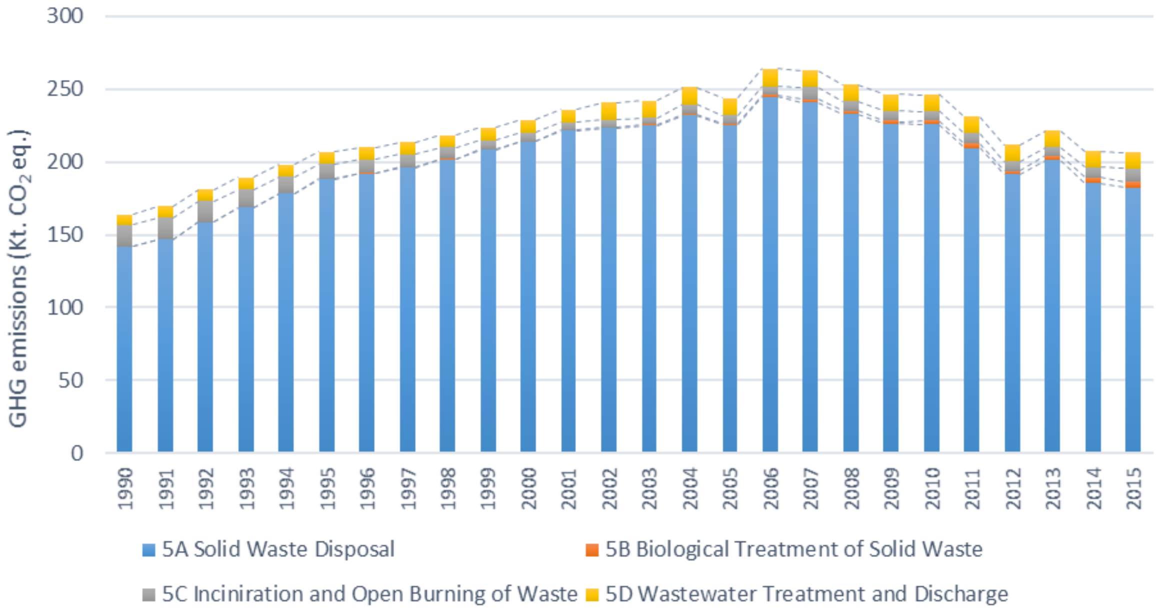

Figure 2.21 GHG emissions of the waste sector 1990-2015 (kt. CO_2-eq.).

Total wastewater handling emissions increased by 64% since 1990 due to increasing N_2O and CH_4 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. All other wastewater discharge pathways were assumed to emit no methane since the wastewater is either treated aerobically or discharged into fast running rivers or straight into the sea.

Emissions from waste incineration decreased by 39% between 1990 and 2015 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 of CO_2, CH_4 and N_2O per waste amount incinerated (Figure 2.22).

The CO_2 emission factor for waste incineration is slightly higher than for open burning of waste (oxidisation factor of 1 vs. 0.58), but the CH_4 emission factor for open burning of waste is, however, 27 times higher and the N_2O emission factor 2.5 times higher than the one for waste incineration.

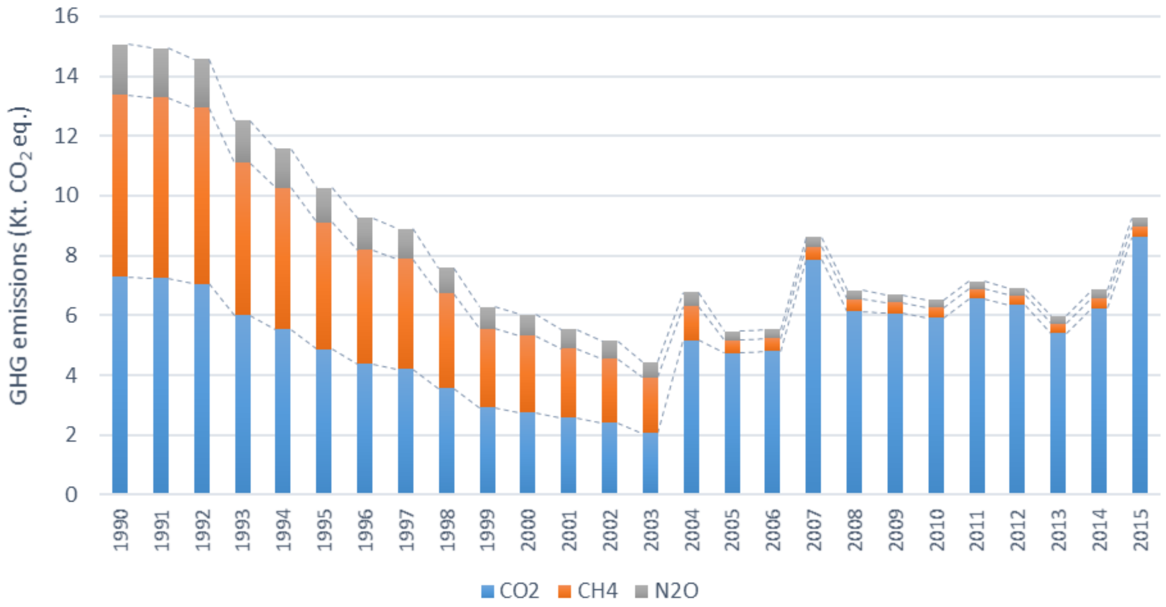

Figure 2.22 Emissions from incineration and open burning of waste 1990-2015 (kt. CO_2-eq.).

Emissions from composting have been steadily increasing from 1995 when composting started. Between 1995 and 2015 composting emissions increased tenfold due to increasing amounts of waste composted.

2.10 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 greenhouse gases, especially ozone. Sulphur dioxide (SO_2) affects climate by increasing the level of aerosols that have in turn a cooling effect on the atmosphere.

2.10.1 Nitrogen Oxides (NOx)

The main sources of nitrogen oxides in Iceland is the Energy sector, as can be seen in Figure 2.23. In 2015, the Energy sector accounted for 87% of the total 2015 NOx emissions. Main contributors to this sector are commercial fishing and transport, followed by manufacturing industries and construction. In industrial processes, the main NOx source is aluminium production.

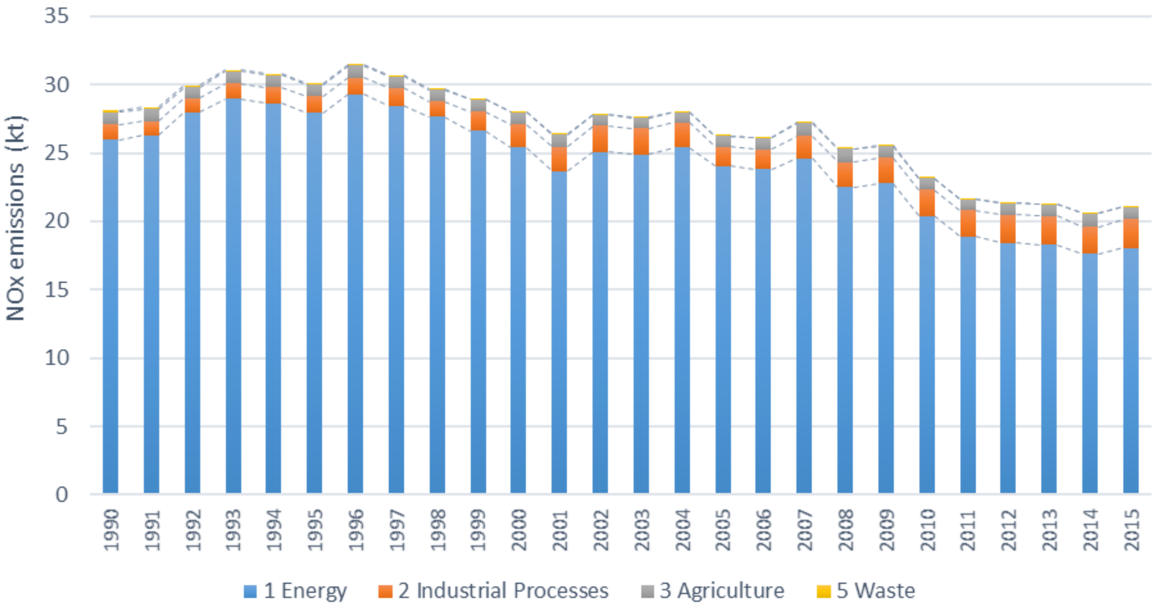

Figure 2.23 Emissions of NO_x by sector 1990-2015 in kt.

2.10.2 Non-Methane Volatile Organic Compounds (NMVOC)

The main sources of non-methane volatile organic compounds are the Energy sector, followed by Agriculture and Industrial processes as can be seen in Figure 2.24. 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. Emissions from solvent use have been around 1.2 kt. in recent years. 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 rose by 17% between 2014 and 2015. The emissions in 2015 were 45% below the 1990 level.

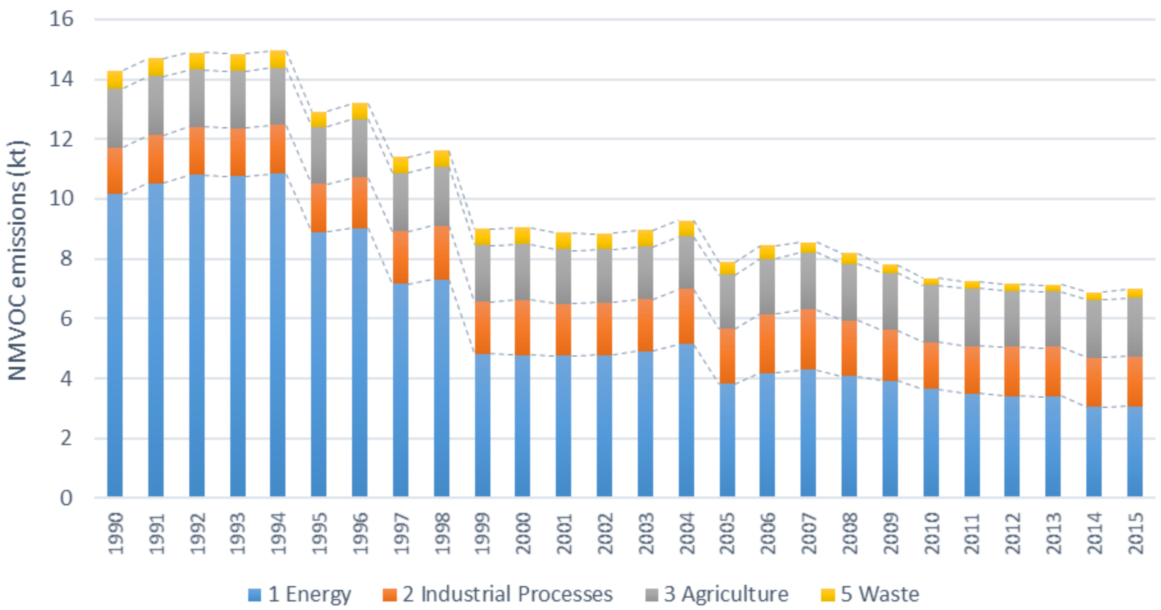

Figure 2.24 Emissions of NMVOC by sector 1990-2015 in kt.

2.10.3 Carbon Monoxide (CO)

Industrial Processes are the most prominent contributors to CO emissions in Iceland, as can be seen in Figure 2.25, being responsible for 88% of total CO emissions. Within industrial processes, almost 100% of 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. The emissions in 2015 were 98% above the 1990 level.

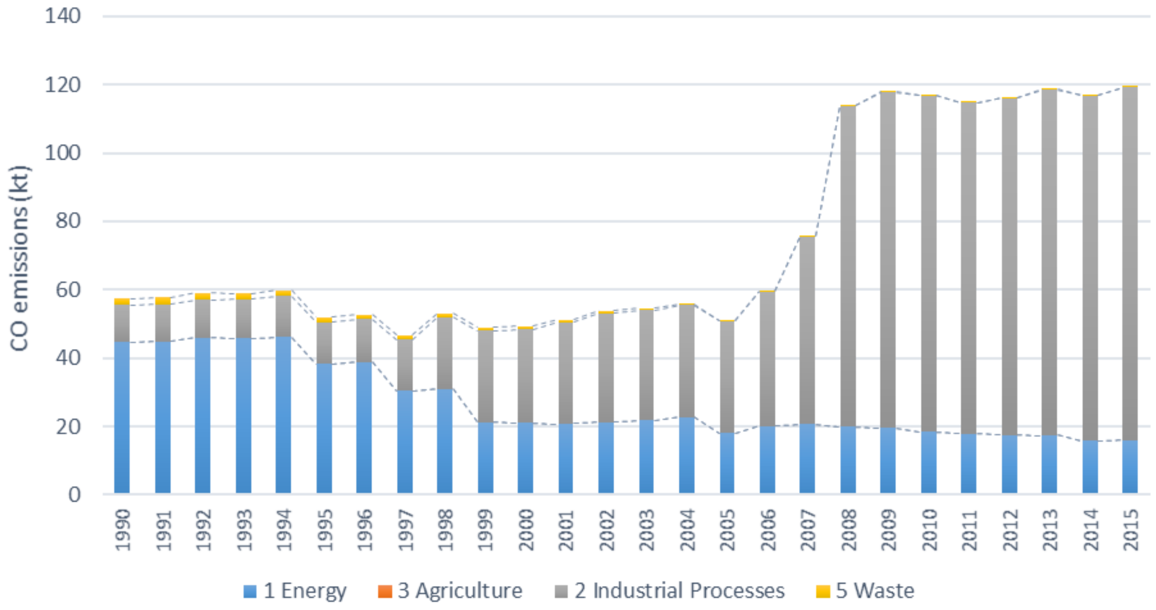

Figure 2.25 Emissions of CO by sector 1990-2015 in kt.

2.10.4 Sulphur Dioxide (SO_2)

Geothermal energy exploitation is by far the largest source of sulphur emissions in Iceland. Sulphur emitted from geothermal power plants is in the form of H_2S. Emissions have increased by 204% since 1990 due to increased activity in this field, as electricity production at geothermal power plants has increased more than 18-fold since 1990. Other significant sources of sulphur dioxide in Iceland are industrial processes, as can be seen in Figure 2.26.

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. In 1990, 87,839 tonnes of aluminium were produced at one plant and 62,792 tonnes of ferroalloys at one plant. In 2015 857,319 tonnes of aluminium were produced at three plants and 117,949 tonnes of ferroalloys were produced at one plant. This led to increased emissions of sulphur dioxide (167% increase from 1990 levels). The fishmeal industry is the main contributor to sulphur dioxide 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.

Sulphur emissions 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 sulphur emissions from the commercial fishing fleet in recent years. Emissions from the fishing fleet in 2015 were 22% below 1990 level although fuel consumption was 31% less.

In 2015 total sulphur emissions in Iceland, calculated as SO_2, were in 167% above the 1990 level, but 204% when excluding emissions from geothermal power plants.

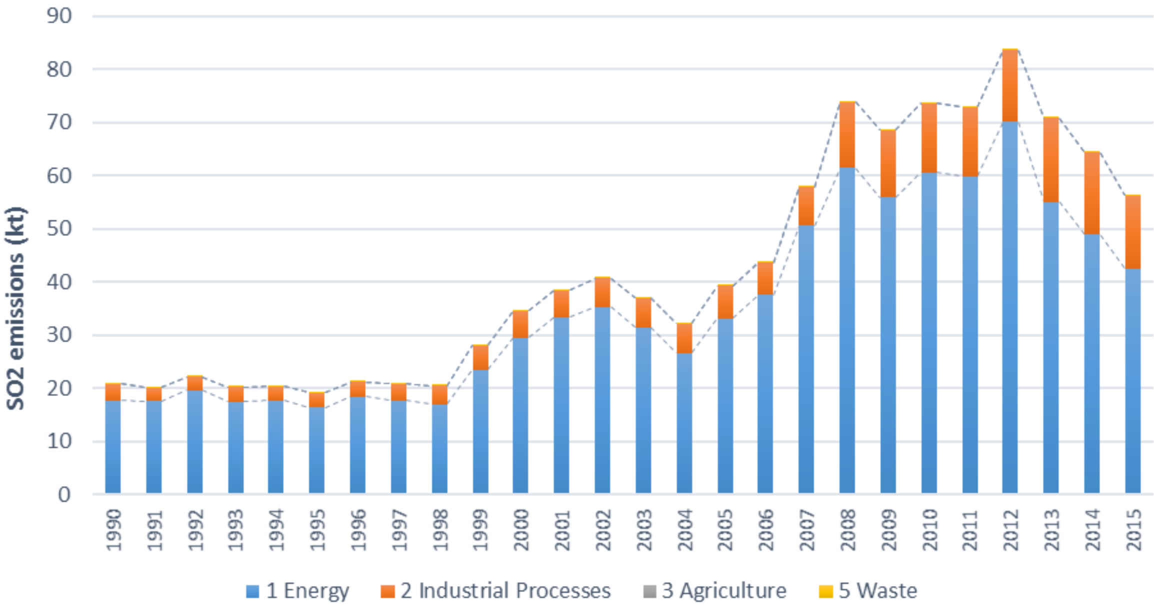

Figure 2.26 Emissions of S (sulphur) by sector 1990-2015 (kt. SO_2-eq.).

In 2010 the volcano Eyjafjallajökull started eruption. The eruption lasted from 14th of April until 23rd of May. During that time 127 kt. of SO_2 were emitted or 71% more than total anthropogenic emissions in 2010. In 2011 the volcano Grímsvötn started erupting. The eruption lasted from 21st until 28th of May. During that time around 1000 kt. of SO_2 were emitted or 12 times more than total man made emissions in 2011. These emissions are given here for information purposes and are not included in the inventory.

3 Energy (CRF sector 1)

3.1 Overview

The total GHG emissions from the energy sector in Iceland were estimated to 1695 kt. CO_2 equivalents in 2015. The 1990 emissions were estimated to be 1777 kt. CO_2 equivalents and the emissions from the energy sector have thus decreased by around 5% during this time. From reported sources of GHG emissions, fisheries and road transport are the sector's largest single contributors and estimated to account for around 76% of the total GHG emissions in the energy sector. CO_2 emissions account for 96.9% of the total GHG emissions 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. The division of fuel sales by sector does not reflect the 2006 IPCC sectors perfectly so EA has made adjustments to the data where needed to better reflect the IPCC categories. This applies for the sectors 1A1 Energy industries, 1A2 Manufacturing industry (stationary combustion) and 1A4 Residential. Tables explaining this adjustment are in Annex III. The first table in Annex III is named "Fuel sales (gas oil and residual fuel oil) by sectors 1A1a, 1A2 (stationary) and 1A4 (stationary) – as provided by the National Energy Authority". This table contains the original values. The adjustment is done in the following way for gasoil: First 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).

- In years where there is less fuel sale to energy industries, according to the sales statistics (1,185 tonnes in 2015), as would be needed for the electricity production (1006 tonnes in 2015), 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. In 2015 there was a surplus in the energy industries category, so 179 tonnes were added to the category 10X40 House heating and swimming pools. So now the category 10X40 has 1473 tonnes in 2015 (1294+179).
- 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 III. It is 300 tonnes in 2015. These values are subtracted from the adjusted 10X40 category, leaving 1173 tonnes in the category in 2015 (1473-300). This rest is then 1A4c – Residential.
- For years where there is still fuel in the category 10X90 Other (4767 tonnes were left in that category in 2015), this is added to the 10X5X Industry (originally with 5394 tonnes in 2015). This is the fuel use in 1A2 – Industry (5394+4767=10161 tonnes in 2015).

Explanation for the adjustment for residual fuel oil is given in Annex III.

Fuel combustion activities are divided into two main categories; stationary and mobile combustion. Stationary combustion includes Energy Industries, Manufacturing Industries and a part of the Other sectors (Residential and Commercial /Institutional sector). Mobile combustion includes Civil Aviation, Road Transport, Navigation, Fishing (part of the Other sectors), Mobile Combustion in Construction (part of Manufacturing Industries and Construction sector) and International Bunkers.

3.1.2 Key Category Analysis (KCA)

The key sources for 1990, 2015 and 1990-2015 trend in the Energy sector are as follows (compared to total emissions without LULUCF):

Table 3.1 Key Categories for Energy 1990, 2015 and trend (excluding LULUCF).

IPCC source category			Level 1990	Level 2015	Trend
Energy (CRF sector 1)					
1A2	Fuel combustion - Manufacturing Industries and	CO_2	✓	✓	✓
1A3a	Domestic aviation	CO_2	✓		✓
1A3b	Road Transportation	CO_2	✓	✓	✓
1A3d	Domestic Navigation - Liquid Fuels	CO_2	✓		✓
1A3b	Road Transportation	N_2O			
1A4	Other Sectors - Liquid Fuels	CO_2	✓	✓	✓
1B2d	Fugitive Emissions from Fuels - Other	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	**N O T O C C U R R I N G**									
1A1c Manufacture of Solid Fuels	**N O T O C C U R R I N G**									
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	NO	NO	NO	NA	NA	NA	NO	NO	NO	NO
1A2d Pulp, paper and print	**N O T O C C U R R I N G**									
1A2e Food Processing, Beverages and Tobacco	E	E	E	NA	NA	NA	E	E	E	E
1A2f Non-metallic minerals	E	E	E	NA	NA	NA	NO	NO	NO	NO
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	**N O T O C C U R R I N G**									
1A3d Domestic navigation	E	E	E	NA	NA	NA	E	E	E	E
1A3e Other Transportation	**N O T O C C U R R I N G**									
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	**N O T O C C U R R I N G**									
1B Fugitive Emissions from Fuels										
1B1 Solid Fuels	**N O T O C C U R R I N G**									
1B2 Oil and Natural Gas	E	E	NA	NA	NA	NA	NA	NA	E	NA
1B2di Geothermal Energy	E	NA	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.

3.2 Fuel Combustion (CRF sector 1A)

3.2.1 Energy Industries (CRF 1A1)

Iceland has extensively utilised renewable energy sources for electricity and heat production and the emissions from energy industries is therefore lower than for most other countries that utilize a higher share of energy technologies that utilize fossil fuels. Emissions from electricity and heat production were estimated to account for 0.025% of the energy industry total GHG emissions in 2015.

Activity data for the electricity and heat production are based on data provided by the NEA and adjusted by EA, see Annex III. The CO_2 emission factors reflect the average carbon content of fossil fuels. They are taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and presented in Table 3.5 along with sulphur content of the fuels. Emissions of SO_2 are calculated from the S-content of the fuels. Emission factors for other pollutants are taken from the 2006 IPCC Guidelines. The EF for CH_4 is based on the one for large diesel fuel engines (4 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

Electricity was produced from hydropower, geothermal energy, fuel combustion and wind power in 2015 (Table 3.3) with hydropower as the main source of electricity (Orkustofnun, 2015). Emissions from hydropower reservoirs are included in the LULUCF sector and emissions from geothermal power plants are reported in sector 1B3. 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	2014	2015
Hydropower	4,159	4,678	6,352	7,014	12,592	12,873	13,780
Geothermal	283	288	1,323	1,658	4,465	5,238	5,003
Fuel combustion	5.6	8.4	4.4	7.8	1.7	2.4	4.0
Wind power	0	0	0	0	0	8	11
Total	**4,447**	**4,975**	**7,679**	**8,680**	**17,059**	**18,122**	**18,798**

Activity Data

Activity data for electricity production is calculated from the information on electricity production, fuel use and the energy content of the gasoil (43.0 TJ/kt) assuming 34% efficiency. In 2015 less than 0.01% of the electricity in Iceland was produced with fuel combustion. Activity data for fuel combustion and the resulting emissions are given in Table 3.4.

Table 3.4 Fuel use (kt.) and result in emissions (GHG total, kt. CO_2-eq.) from electricity production.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil (kt.)	1.4	2.1	1.1	2.0	0.4	0.6	1.0
Emissions (kt.)	**4.5**	**6.8**	**3.6**	**6.3**	**1.4**	**1.9**	**3.2**

Emission Factor

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 Greenhouse Gas Inventories and the Good Practice Guidance. 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	0.98	3.18	0.2

The resulting greenhouse gas emissions from electricity produced from fuels in CO_2 equivalent per kWh amount to 790 g of CO_2 per kWh.

Emissions from hydropower reservoirs amounted to 20.4 kt. of CO_2-equivalents and emissions from geothermal power plants to 164 kt. of CO_2-equivalents, in 2015. The resulting emissions of GHG per kWh amount to 1.6 g CO_2-equivalents/kWh for hydropower plants and to 32.8 g CO_2-equivalents/kWh for geothermal energy. The weighted average GHG emissions from electricity production in Iceland in 2015 were thus 10.1 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 II.

3.2.2.2 Heat Plants

Geothermal energy was the main source of heat production in 2015. 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 (kt.) and resulting emissions (GHG total in kt. CO_2-eq.) from heat production.

	1990	1995	2000	2005	2007	2008	2009	2010	2014	2015
Residual fuel oil	2.99	3.08	0.07	0.20	0.00	0.19	0.14	2.99	3.08	0.07
Solid waste	NO	4.65	6.05	5.95	8.1059	NO	NO	NO	4.65	6.05
Emissions (GHG)	**9.4**	**15.2**	**7.5**	**7.8**	**10.6**	**0.6**	**0.4**	**9.4**	**15.2**	**7.5**

Emission Factors

Fuel combustion used for CO_2 emission factors (EF) reflects the average carbon content of fossil fuels. They are taken from the revised 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance. 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 section 7.4.3. 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	0.99	3.13	1.8
Gas/Diesel oil	43.00	20.20	0.99	3.18	0.2

[1] *mean value. Annual values vary between 0.44 and 0.78 t CO_2/t waste 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 II. Assessment of uncertainty (Including LULUCF).

3.3 Manufacturing Industries and Construction (CRF 1A2)

Emissions from the Manufacturing Industries and Construction account for 4% of the Energy sector's total and around 2% of total GHG emissions in Iceland in 2015.

3.3.1 Manufacturing Industries, Stationary Combustion

3.3.1.1 Activity Data

Information about the total amount of fuel used by the manufacturing industries was obtained from the National Energy Authority and adjusted by EA (see Annex III). The sales statistics for the manufacturing industry (as adjusted by EA) are given for the sector as a total. There is thus a given total, which the usage in the different subcategories must sum up to. The sales statistics do not 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 (metal production, cement) 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, but the numbers for 2003 to 2015 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 2015). The difference between the given total for the sector and the sum of the fuel use of the reporting industrial facilities are categorized as 1A2f other non-specified industry. Emissions are calculated by multiplying energy use with a pollutant specific emission factor (Table 3.8 and Table 3.9). Emissions from fuel use in the ferroalloys production is reported under 1A2a, Iron and Steel.

Table 3.8 Fuel use (kt.) and emissions (GHG, kt.CO_2-eq.) from stationary combustion in the manufacturing industry.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil	5.07	1.13	10.25	22.19	9.39	3.59	9.48
Residual fuel oil	55.93	56.22	46.21	25.01	16.55	4.99	10.18
LPG	0.48	0.39	0.86	0.93	1.05	1.19	0.50
Electrodes (residue)	0.80	0.29	1.50	0.00	0.40	0.00	0.00
Steam Coal	18.60	8.65	13.26	9.91	3.65	0.00	0.00
Petroleum coke	0.00	0.00	0.00	8.13	0.00	0.00	0.00
Waste oil	0.00	4.99	6.04	1.82	1.36	0.85	1.59
Total GHG Emissions (kt.)	**244**	**219**	**237**	**209**	**100**	**33**	**68**

3.3.1.2 Emission Factors

The emission factors (EF) used reflect the average carbon content of fossil fuels. They are, with the exception of NCV for steam coal, which was obtained from the cement industry which uses the coal, taken from the 2006 IPCC Guideline. They are presented in Table 3.9 along with the sulphur content of the various fuel types.

Table 3.9 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 CO_2/t fuel]	S-content [%]
Kerosene (heating and aviation)	44.1	19.5	0.99	3.15	0.2
Gasoline	44.3	18.9	0.99	3.07	0.035
Gas/Diesel oil	43	20.2	0.99	3.18	0.2
Residual fuel oil	40.4	21.1	0.99	3.13	1.8
Petroleum coke	32.5	26.6	0.99	3.17	IE*
LPG	47.3	17.2	0.99	2.98	0.05
Waste oil	40.2	20	0.99	2.95	NE
Electrodes (residue)	31.35	31.42	0.98	3.61	1.55
Steam coal	27.59	25.8	0.98	2.61	0.9

1: Sulphur emissions from use of petroleum coke occur in the cement industry. Further waste oil has mainly been used in the cement industry. Emission estimates for SO_2 for the cement industry are based on measurements.

SO_2 emissions are calculated from the S-content of the fuels. Emission factors for CH_4 and N_2O are taken from Table 2.7 and 2.8 of the 2006 IPCC Guideline. Where EFs were not available the default EF from Table 2.3 was used. Table 3.10 gives an overview of the EFs used.

Table 3.10 Emission factors CH_4 and N_2O in the manufacturing industry.

	CH_4 [kg/TJ]	N_2O [kg/TJ]
Gasoil: cement and silicium production	1.0	0.6
Gasoil: other use	3.0	0.6
Residual fuel oil: cement and silicium production	1.0	0.6
Residual fuel oil: fishmeal production, steam boilers	3.0	0.3
Residual fuel oil: fishmeal production, heaters	1.0	0.6
Residual fuel oil: other use	3.0	0.6
Waste oil: fishmeal production	3.0	0.3
Waste oil: cement production	1.0	0.6
LPG	1.0	0.1
Petroleum coke: cement production	1.0	0.6
Petroleum coke, coal, electrodes residues: cement production	1.0	1.5

3.3.1.3 Uncertainties

The estimation of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from manufacturing industries and constructions 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 II.

3.3.2 Manufacturing Industries, Mobile Combustion

3.3.2.1 Activity Data

Activity data for mobile combustion in the construction sector is provided by the NEA. Oil, which 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. Activity data for fuel combustion and the resulting emissions are given in Table 3.11.

Table 3.11 Fuel use (kt.) and resulting emissions (GHG kt. CO_2-eq.) from mobile combustion in the construction industry.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil	38	47	62	68	32	40	30
Emissions	**135**	**166**	**219**	**240**	**114**	**143**	**106**

3.3.2.2 Emission Factors

The CO_2 emission factors used reflect the average carbon content of fossil fuels. Emission factors for other pollutants are taken from Table 1.49 in the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. EF for CO_2, CH_4 and N_2O are presented in Table 3.12.

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/t fuel]	CH_4 EF [t CH_4/kt. fuel]	N_2O EF [t N_2O/kt. fuel]
Gas/Diesel Oil	43.00	20.20	0.99	3.18	0.7	1.3

3.3.2.3 Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from manufacturing industries and constructions 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 II.

3.4 Transport (CRF sector 1A3)

Emissions from the transport sector were estimated to accounted for 52% of the Energy sector's total and around 20% of the total GHG emissions in Iceland in 2015. Road transport (all types of road transport) was estimated to account for around 92% 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.

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. Activity data for fuel combustion and the resulting emissions are given in Table 3.13.

Table 3.13 Fuel use (kt.) and resulting emissions (GHG, kt. CO_2-eq.) from domestic aviation.

	1990	1995	2000	2005	2008	2009	2010	2014	2015
Jet kerosene	8.41	8.25	7.73	7.39	6.07	12.30	5.99	8.41	8.25
Gasoline	1.68	1.13	1.10	0.87	0.65	0.50	0.50	1.68	1.13
Total GHG Emissions	**31.68**	**29.49**	**27.75**	**25.97**	**21.11**	**40.28**	**20.41**	**31.68**	**29.49**

3.4.1.2 Emission Factors

The emission factors are taken from the 2006 IPCC Guidelines and are presented in Table 3.14 as tonne of gas per tonne of fuel. 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	0.99	3.12	0.011	2.E-05	0.0022	0.004	0.00009
Gasoline	44.30	19.10	0.99	3.07	0.011	2.E-05	0.0022	0.0044	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%) 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 II.

3.4.1.4 Planned Improvements

Planned improvements involve moving emission estimates from aviation to the Tier 2 methodology in future submissions, and to include Eurocontrol data from 2005.

3.4.2 Road Transportation (CRF 1A3b)

Emissions from Road Traffic 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.

3.4.2.1 Activity Data

Total use of diesel oil and gasoline are based on the NEA's annual sales statistics for fossil fuels (Table 3.15).

Table 3.15 Fuel use (kt.) and resulting emissions (GHG, kt. CO_2-eq) from road transport.

	1990	1995	2000	2005	2010	2014	2015
Gasoline	128	136	143	157	148	135	132
Diesel oil	37	37	47	83	106	113	126
Emissions	**526**	**555**	**619**	**783**	**828**	**795**	**839**

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 2015 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 2015 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.

The EA has estimated the amount of passenger cars by emission control technology. The proportion of passenger cars with three-way catalysts has steadily increased since 1995 when they became mandatory in all new cars. The assumptions are shown in Figure 3.1.

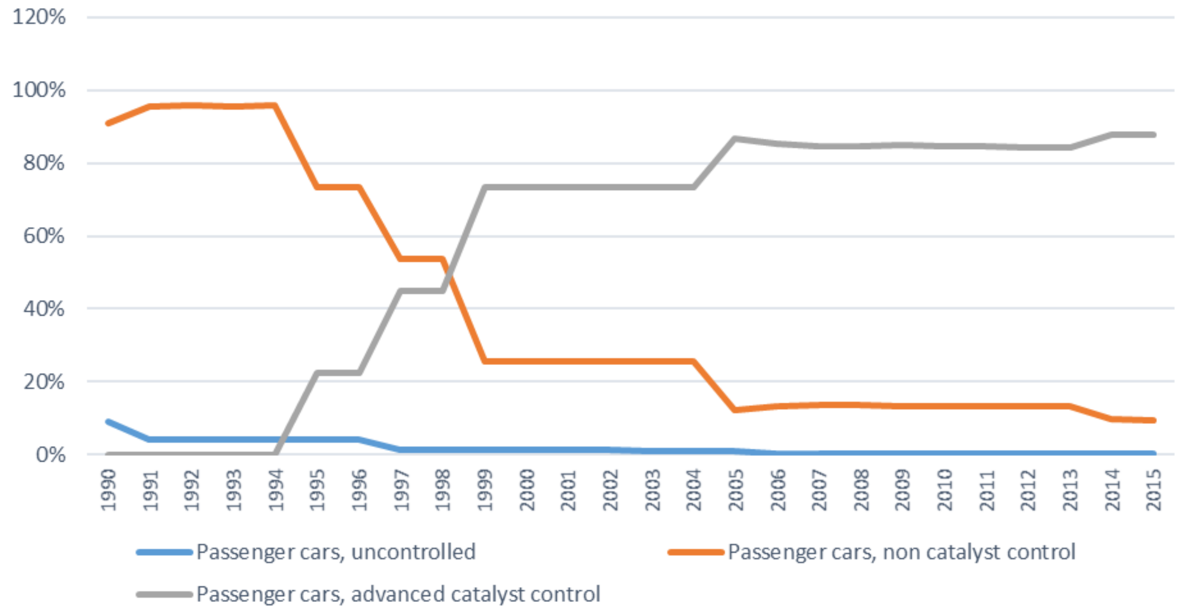

Figure 3.1 Passenger cars by emission control technology.

3.4.2.2 Emission Factors

Emission factors for CO_2, CH_4 and N_2O depend upon vehicle type and emission control. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 3.16.

Table 3.16 Emission factors for GHG from European vehicles, g/kg fuel.

	CO_2 (g/kg fuel)	CH_4 (g/kg fuel)	N_2O (g/kg fuel)
1A3bi 1 Passenger car with 3-way catalyst			
Gasoline	3,070	0.3	0.8
Diesel	-	-	-
1A3bi 2 Passenger car without 3-way catalyst			
Gasoline	3,070	1.1	0.35
Diesel	3,186	0.0034	0.0086
1A3bii 1 Light weight truck with 3-way catalyst			
Gasoline	3,070	0.8	0.06
Diesel	3,186	0.0026	0.0086
1A3bii 2 Light weight truck without 3-way catalyst			
Gasoline	3,070	0.8	0.06
Diesel	3,186	0.0026	0.0086
1A3biii Heavy duty Trucks and buses			
Gasoline	3,070	1.5	0.14
Diesel	3,186	0.0086	0.0043
1A3biv Motorcycles			
Gasoline	3,070	5.0	0.07
Diesel	-	-	-

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 50% (with an activity data uncertainty of 5% and emission factor uncertainty of 50%) and for CH_4 emissions it is 40% (with an activity data uncertainty of 5% and emission factor uncertainty of 40%). This can be seen in the quantitative uncertainty table in Annex II.

3.4.2.4 Planned Improvements

- A few emission factors in the energy calculations where EFs from the 1996 IPCC guidelines are still used, these EFs will be updated in accordance with the 2006 IPCC guidelines.
- Improvement of methodologies to estimate emissions from road transportation (use of COPERT).
- Estimate emissions from biomass fuel use in the transport sector (1A3)
- Synchronise the energy balance approach between CRF and Eurostat for sector 1A4c - fishing (reference and sectoral). Up till now fuel sold to foreign fishing vessels has not been included in CRF.
- Move estimates of emissions from aviation to the Tier 2 methodology with the use of data from EUROCONTROL.

3.4.3 Navigation (shipping) (CRF 1A3d)

Emissions are calculated by multiplying energy use with a pollutant 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. Activity data for fuel combustion and the resulting emissions are given in Table 3.17.

Table 3.17 Fuel use (kt.) and resulting emissions (GHG total, kt. CO_2-eq.) from national navigation.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil	11.7	7.0	3.4	6.2	8.5	4.3	7.9
Residual fuel oil	7.2	4.8	0.5	0.9	2.6	2.1	0.4
Emissions	**60**	**37**	**13**	**23**	**35**	**20**	**27**

3.4.3.2 Emission Factors

The emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships and are presented in Table 3.18.

Table 3.18. 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	0.99	3.18	2	0.086	7	0.30
Residual fuel oil	40.4	21.10	0.99	3.13	2	0.084	7	0.28

3.4.4 Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from national navigation is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%). This can be seen in the quantitative uncertainty table in Annex II.

3.4.5 International Bunker Fuels (CRF 1A3di)

Emissions are calculated by multiplying energy use with pollutant specific emission factors. 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. Emission estimates for aviation will be moved to Tier 2 methodology by next submissions. A better methodology for the fuel split between international and domestic aviation will be developed in the near future as Iceland will take part in the EU ETS for aviation from 2012 onward and better data will become available. Emission factors for aviation bunkers are taken from the IPCC. Planned improvements are using data from Eurocontrol in order for more accurate estimates. Iceland has started to analyse the Eurocontrol data and compare to Iceland’s data and started to use the Eurocontrol data for air pollutants (other than GHG). The aim is to use the Eurocontrol data for emission estimates for GHG in the 2018 submission.

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 (including foreign fishing vessels) and national navigation based on identification numbers which differ between Icelandic and foreign companies. The emission factors for marine bunkers are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships and are presented in Table 3.18 above.

3.5 Other Sectors (CRF sector 1A4)

Sector 1A4 consists of fuel use for commercial, institutional, and residential heating as well as fuel use in agriculture, forestry, and fishing. Since Iceland relies largely on its renewable energy sources, fuel use for residential, commercial, and institutional heating is low. Residentdial 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. Emissions from the fishing sector are high, since the fishing fleet is large. Emissions from fuel use in agriculture and forestry are included elsewhere; mainly in the Construction sector as well as in the Residential sector. Emissions from the Other sector were estimated to accounted for around 34% of the Energy sector's total and around 13% of total GHG emissions in Iceland 2015. Fishing were estimated to account for around 80% of the Other sector's total.

3.5.1 Commercial, Institutional, and Residential Fuel Combustion

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 adjusts the data provided by the NEA as further explained in Annex III. Activity data for fuel combustion the Commercial/Institutional sector and the resulting emissions are given in Table 3.19.

Table 3.19. Fuel use (kt.) and resulting emissions (GHG, kt. CO_2-eq.) from the commercial/institutional sector.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil	1.8	1.6	1.6	1	0.3	0.3	0.3
Waste oil	3.3	-	-	-	-	-	-
LPG	0.3	0.3	0.5	0.5	0.2	0.3	0.4
Solid waste	-	0.5	0.6	0.6	0.3	-	-
Emissions	**16.2**	**6.6**	**7.2**	**5.4**	**1.9**	**2.0**	**2.1**

Activity data for fuel combustion in the Residential sector and the resulting emissions are given in Table 3.20. As can be seen in the table the use of kerosene increased substantially from 2008 to 2011. Kerosene is used in summerhouses, but also to some extent in the Commercial sector for heating of commercial buildings. 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. 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 3.20. Fuel use (kt.) and resulting emissions (GHG kt. CO_2-eq.) from the residential sector.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil	8.7	6.4	6.0	3.2	1.9	3.6	1.2
LPG	0.4	0.4	0.7	0.9	1.4	0.8	0.9
Kerosene	0.5	0.2	0.1	0.2	1.2	0.8	0.2
Emissions	**30.7**	**22.1**	**21.8**	**13.7**	**14.3**	**16.3**	**7.1**

3.5.1.2 Emission Factors

The CO_2 emission factors (EF) used reflect the average carbon content of fossil fuels. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance. They are presented in Table 3.21 along with Sulphur content of the fuels. Emissions of SO_2 are calculated from the S-content of the fuels. Emission factors for other pollutants are taken from Table 1.18 and 1.19 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Default EFs from Tables 1.7 to 1.11 in the Reference Manual were used in cases where EFs were not available. Table 3.21 gives an overview of the used EFs.

Table 3.21. Emission factors for CH_4 and N_2O in the residential, commercial and institutional sector

	CH_4 [kg/TJ]	N_2O [kg/TJ]
Gasoil	3	0.6
LPG	1	0.1
Kerosene	3	0.6
Waste oil	30	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 7.4.4). 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 II.

3.5.2 Agriculture, Forestry and Fishing (CRF 1A4c)

Emissions from fuel use in agriculture and forestry are included elsewhere, mainly within the construction and Residential sectors; thus, emissions reported here only stem from the fishing fleet. Emissions from fishing are calculated by multiplying energy use with a pollutant specific emission factor.

3.5.2.1 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. Activity data for fuel combustion in the Fishing sector and the resulting emissions are given in Table 3.22.

Table 3.22. Fuel use (kt.) and resulting emissions (GHG, kt. CO_2-eq.) from the fishing sector.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil	174.9	191.1	211.1	171.7	128.2	102.2	116.3
Residual fuel oil	32.4	53.4	16.0	26.3	41.4	37.4	27.3
Emissions	**658.6**	**776.0**	**722.7**	**629.2**	**537.8**	**442.6**	**456.1**

3.5.2.2 Emission Factors

The emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships and are presented in Table 3.18 above.

3.5.2.3 Uncertainties

The estimation of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from fishing is 6% (with an activity data uncertainty of 3% and emission factor uncertainty of 5%), for CH_4 emissions it is 100% (with an activity data uncertainty of 3% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 3% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex II

3.6 Cross-Cutting Issues

3.6.1 Sectoral versus Reference Approach

As explained in Chapter 1, a formal agreement has been made between the EA and the National Energy Authority (NEA) to cover the responsibilities of NEA in relation to the inventory process. According to the formal agreement the NEA is to provide an energy balance every year, but has not yet fulfilled this provision. EA has therefore compiled data on import and export of fuels, made comparison with sales statistics, and assumptions regarding stock change. Exact information on stock change does not exist. This has been used to prepare the reference approach. As explained in Chapter 1.2.2 Act 70/2012 changes the form of relations between the EA and the NEA concerning data handling. The law states that the NEA, among other institutions, is obligated to collect data necessary for the GHG inventory and report it to the EA, further to be elaborated in regulations set by the Minister for the Environment and Natural Resources. The relevant regulation will be in place for the next inventory cycle and will clarify the role of NEA in the inventory process, so better data for use in the reference approach (energy balance) as well as better data for the fuel split for the sectoral approach will be obtained. The NEA has already started some projects to fulfil these commitments, with the aim to have a complete energy balance within two years.

Iceland is not a member of the International Energy Agency (IEA). The NEA has provided data to IEA on a voluntary basis. The data is provided in physical units and IEA uses its own conversion factors to estimate energy units. Further the IEA rounds the numbers provided by Iceland. In many cases the numbers are quite low so this rounding can have significant percentage difference. This explains partially the differences with the data used for the annual submission under UNFCCC.

3.6.2 Feedstock and Non-Energy Use of Fuels

Emissions from the Use of Feedstock are according to the Good Practice Guidance accounted for in the Industrial Processes sector in the Icelandic inventory. This includes all use of coking coal, coke-oven coke, and electrodes, except residues of electrodes combusted in the cement industry, which are accounted for under the Energy sector (Manufacturing industry and construction).

When compiling the data on import and export of fuels an error in the data has been discovered, as stocks of coking coal seem to have been building up since 2007 and at the same time as less import than use of coke has occurred. This can be explained by mistakes at the custom reports, where certain coke (imported cargo from Alabama) has been registered as coal instead of coke. Some mistakes seem to have occurred as well when registering steam coal and coking coal. As stated before the NEA is working on preparing an energy balance.

Iceland uses a carbon storage factor of 1 for bitumen and 0.5 for lubricants for the Non-Energy Use in the Reference Approach, CRF Table 1Ad.

3.7 Fugitive Emissions from Fuels (CRF sector 1B)

3.7.1 Distribution of oil products (CRF 1B2av)

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 2.16 in the 2000 IPCC GPG; 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. Data on total import of fuels are taken from Statistics Iceland. Activity data and resulting emissions are provided inTable 3.23.

Table 3.23. Fuel use (kt.) and resulting GHG emissions from distribution of oil products.

	1990	1995	2000	2005	2010	2014	2015
Gasoline	129.4	132.2	153.4	164.2	144.5	133.4	139.3
Jet Kerosene	78.7	72.3	146.5	139.4	120.4	187.7	218.3
Other Kerosene	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gas/Diesel oil	335.8	309.3	427.9	418.2	292.3	288.1	342.1
Residual Fuel Oil	106.0	151.9	64.1	62.9	93.1	90.4	105.3
LPG	1.3	1.3	1.7	2.5	2.6	2.4	2.6
Emissions	**0.5**	**0.5**	**0.6**	**0.6**	**0.5**	**0.5**	**0.6**

3.7.2 Geothermal Energy (CRF 1B2d)

3.7.2.1 Overview

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 2015). Geothermal energy is generally considered to have a relatively low environmental impact. Emissions of CO_2 are commonly considered to be among the negative environmental effects of geothermal power production, even though they have been shown to be considerably less than from fossil fuel power plants, or 19 times (Baldvinsson, Þórisdóttir, & Kristjánsson, 2011). Very 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 Key Source Analysis

The key source analysis performed for 2015 has revealed that geothermal energy is a key source in terms of both level and trend, as indicated in Table 3.1

3.7.2.3 Methodology

Geothermal systems can be considered as geochemical reservoirs of CO_2. Degassing of mantle-derived magma is the sole source of CO_2 in these 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 total emissions estimate of CO_2 is based on direct measurements. The enthalpy and flow of each well are measured and the CO_2 concentration of the steam fraction determined at the wellhead pressure. The steam fraction of the fluid and its CO_2 concentration at the wellhead pressure and the geothermal plant inlet pressure are calculated for each well. Information about the period each well discharged in each year is then used to calculate the annual CO_2 discharge from each well and finally the total CO_2 is determined by adding up the CO_2 discharge from individual wells.

Emissions of CH_4 and H_2S are also calculated in a similar way that CO_2 is calculated, i.e. based on direct measurements. H_2S has been measured for the whole time series. Methane was measured in 2010, 2011 and 2012. Older measurements exist for the years 1995 to 1997. Based on the measurements from 1995 to 1997 and 2010 an average methane emission factor was calculated and used for the years where no information has been provided. The methane emissions for those years (1995, 1996, 1997 and 2010) range from 35.5 to 55.8 kg/GWh, with an average of 45.7 kg/GWh.

Table 3.24 shows the electricity production with geothermal energy and the total CO_2, CH_4 and Sulphur emissions (calculated as SO_2).

Table 3.24. Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2010	2014	2015
Electricity production (GWh)	283	288	1323	1658	4465	5238	5003
Carbon dioxide emissions (kt)	61	82	153	118	190	182	160
Methane emissions (kt. CO_2 eq)	0.3	0.4	1.5	1.9	4.4	4.0	3.9
Sulphur emissions (as SO_2, kt)	13	11	26	30	58	47	40

3.7.3 Uncertainties

The estimation of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from geothermal energy is 10% (with an activity data uncertainty of 10% and emission factor uncertainty of 1%). The uncertainty of CH_4 emissions from geothermal energy is 10% (with an activity data uncertainty of 6% and emission factor uncertainty of 8%). This can be seen in the quantitative uncertainty table in Annex II.

4 Industrial Processes and Product Use (CRF sector 2)

4.1 Overview

The production of raw materials is the main source of CO_2, N_2O and PFCs emissions related to Industrial Processes. Emissions also occur as a result of the use of HFCs as substitutes for ozone depleting substances and SF_6 from electrical equipment. The Industrial Processes sector accounted for 43% of the GHG emissions in Iceland in 2015. By 2015, emissions from the industrial processes sector were 102% above the 1990 level. This is mainly due to the expansion of energy-intensive industry, such as aluminium smeltering and ferroalloy production. The dominant category within the Industrial Process sector is metal production, which accounted for 90.5% of the sector's emissions in 2015. Figure 4.1 shows the location of major industrial plants in Iceland.

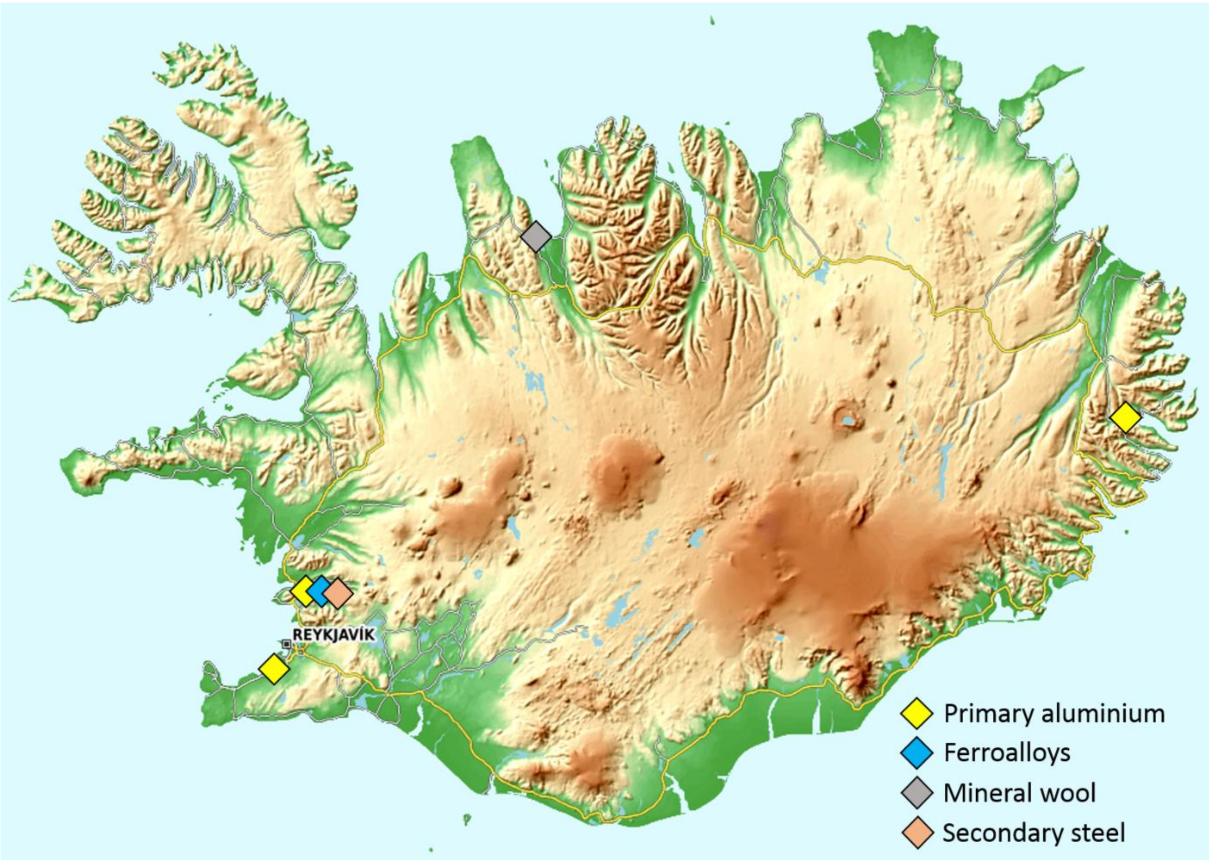

Figure 4.1 Location of major industrial sites in Iceland. This map shows only the sites that were operational in 2015, and that produce process-related emissions reported in this chapter.

Figure 4.2 shows the contribution of various industries to the total emissions of Sector 2. The total emissions for the sector have approximately doubled since 1990, and slightly increased since 2014. Since 2008, the main contribution has been CO_2 emissions generated by primary Aluminium production.

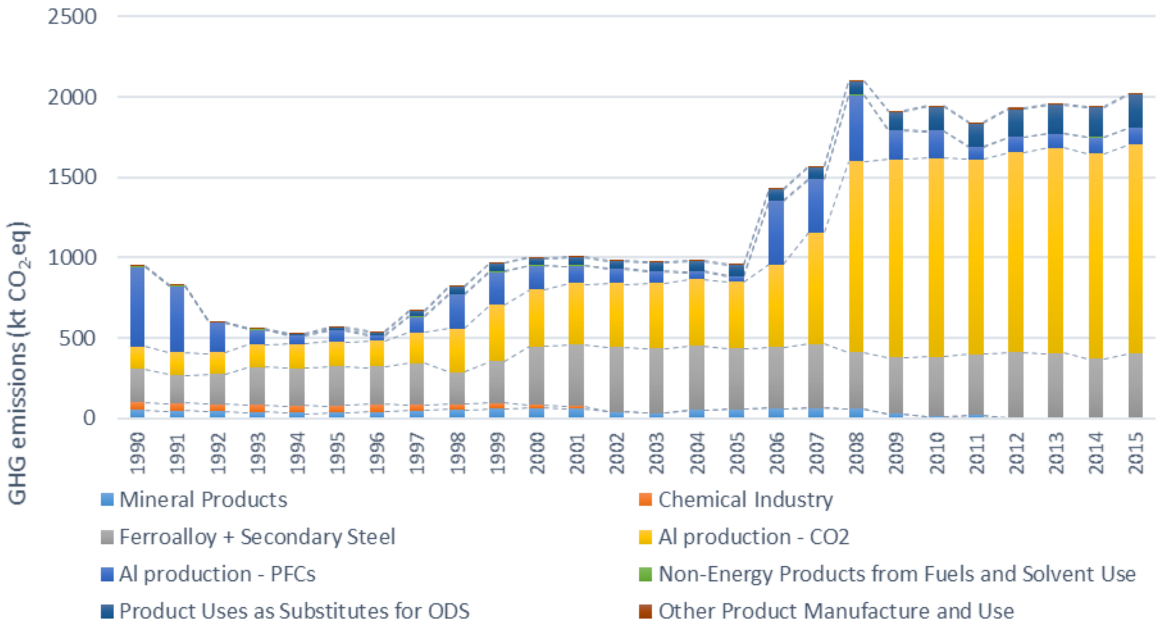

Figure 4.2 GHG emissions from the industrial processes sector, with contributions from various source streams.

4.1.1 Methodology

Greenhouse gas emissions from industrial processes are calculated according to methodologies described in the 2006 IPCC Guidelines and the IPCC Good Practice Guidance, using the highest possible tier. 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).

Key Category Analysis

The key sources for 1990, 2015 and 1990-2015 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, 2015 and trend (excluding LULUCF).

IPCC source category			Level 1990	Level 2015	Trend
IPPU (CRF sector 2)					
2A1	Cement Production	CO_2	✓		
2B10	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		✓	✓

4.1.2 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. NF_3 emissions have not been estimated, but are most likely minimum or not occurring. 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	NE	NE	NE	NE
2A4d	Mineral Wool, Ferrosilicon[2] production	E, IE[2]	NA	NA	NA	NA	NA	NE	E	NE	E
2B Chemical Industry											
2B1	Ammonia Production	NA	NA	IE[3]	NA	NA	NA	IE[3]	NA	NA	NA
2B2	Nitric Acid Production	NOT OCCURRING									
2B3	Adipic Acid Production	NOT OCCURRING									
2B4	Caprolactam, Glyoxal and Glyoxylic Acid Production	NOT OCCURRING									
2B5	Carbide Production	NOT OCCURRING									
2B6	Titanium Dioxide Production	NOT OCCURRING									
2B7	Soda Ash Production	NOT OCCURRING									
2B8a	Methanol production	IE[4]	IE[4]	NA	NA	NA	NA	NA	NA	NA	NA
2B9	Fluorochemical Production	NOT OCCURRING									
2B10	Other: Silicium 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	E	NE	NA	NA	NA	NA	NE	E	E	E
2C2	Ferroalloys Production	E	E	NA	NA	NA	NA	E	E	E	E

2C3	Aluminium Production	E	NE	NA	NA	E	NA	E	E	NE	E
2C4	Magnesium Production	NOT OCCURRING									

Sector		Greenhouse gases						Indirect greenhouse gases			
		CO_2	CH_4	N_2O	HFC	PFC	SF_6	NO_X	CO	NM-VOC	SO_2
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	NA	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3b	Road paving w. asphalt	NA	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3d	Coating applications	NA	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3e	Degreasing	NA	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3f	Dry cleaning	NA	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3g	Paint manufacturing	NA	NA	NA	NA	NA	NA	NE	NE	E	NE
2D3h	Printing	NA	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3i	Other: Creosote	NA	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3i	Other: Organic preservatives	NA	NA	NA	NA	NA	NA	NA	NA	E	NA
2E Electronics Industry		NOT OCCURRING									
2F Product Uses as Substitutes for Ozone Depleting Substances											
2F1a	Refrigeration and Stationary AC	NA	NA	NA	E	NO	E	NA	NA	NA	NA
2F1b	Mobile AC	NA	NA	NA	E	NO	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 Silicium production (Silicium production stopped in 2004)

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

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

[4] Methanol production uses geothermal fluids from a near-by geothermal power plants, therefore emissions linked to this activity are reported under 1B2 Geothermal Energy.

[5] SO_2 emissions were reported by the plant and included both process-related and combustion-related SO_2 emissions, and these emissions are all reported under 1A2.

4.1.3 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. Activity data from all major industry plants is collected through electronic surveys, allowing immediate QC checks. QC tests involve automatic t/t checks on certain emissions and activity data from this industry. Further information can be found in the QA/QC manual.

4.2 Mineral Products (CRF sector 2A)

4.2.1 Cement Production (CRF 2A1)

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. 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

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

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

4.2.1.1 Activity Data

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 69% less than in 2007, due to the collapse of the construction sector. Late 2011 the plant ceased operation.

Table 4.3 Clinker production and CO_2 emissions from cement production from 1990-2011. The cement factory closed down in 2011.

Year	Cement production [t]	Clinker production [t]	CaO content of clinker	EF_{cl}	CF_{ckd}	CO_2 emissions [kt]
1990	114,100	96,985	63%	0.495	107.5%	51.6
1991	106,174	90,248	63%	0.495	107.5%	48.0
1992	99,800	84,830	63%	0.495	107.5%	45.1
1993	86,419	73,456	63%	0.495	107.5%	39.1
1994	80,856	68,728	63%	0.495	107.5%	36.5
1995	81,514	69,287	63%	0.495	107.5%	36.8
1996	90,325	76,776	63%	0.495	107.5%	40.8
1997	100,625	85,531	63%	0.495	107.5%	45.5
1998	117,684	100,031	63%	0.495	107.5%	53.2
1999	133,647	113,600	63%	0.495	107.5%	60.4
2000	142,604	121,213	63%	0.495	107.5%	64.4
2001	127,660	108,511	63%	0.495	107.5%	57.7
2002	84,684	71,981	63%	0.495	107.5%	38.3
2003	75,314	60,403	63%	0.495	107.5%	32.1
2004	104,829	93,655	63%	0.495	107.5%	49.8
2005	126,123	99,170	63%	0.495	110%	53.9
2006	147,874	112,219	63%	0.495	110%	61.0
2007	148,348	114,668	64%	0.501	110%	63.2
2008	126,070	110,240	63.9%	0.502	110%	60.8
2009	59,290	51,864	63.9%	0.502	108%	28.1
2010	33,389	18,492	63.3%	0.497	108%	9.9
2011	38,048	35,441	64.2%	0.504	110%	19.6
2012	-	-	-	-	-	-

4.2.1.2 Emission Factors

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.

4.2.2 Other uses of soda ash (2A4b)

Emissions from the use of soda ash in the silicium industry are included in sector 2B10 Silicium production (production stopped in 2004), and are marked as "Included Elsewhere" in sector 2A4b in the CRF tables.

4.2.3 Other uses of carbonates: Mineral Wool Production, Limestone use in Ferrosilicon production (CRF 2A4d)

There is one Mineral Wool Production Plant in operation in Iceland. 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 of electrodes used. Emissions of CO are based on measurements performed at the plant in the year 2000 and mineral wool production. 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 after that).

Emissions from the mineral wool plant were 0.72 kt. CO_2 in 1990, 0.57 kt. In 2014 and 0.75 kt. In 2015. The 30% increase in CO_2 emissions from 2014 to 2015 are a result of the increased production, which was 8.2 kt. mineral wool in 2014 and 10.9 kt. in 2015.

Other process uses of Carbonates include the decarbonatisation of limestone during the ferroalloy production process (CRF 2C2), with associated CO_2 emissions. These emissions are included in 2C2 Ferroalloy production.

4.3 Chemical Industry (CRF sector 2B)

4.3.1 Methanol Production (CRF 2B8a)

A methanol production facility started its operation in 2012. The facility uses CO_2 from a geothermal power plant as a source of carbon. Emissions of CO_2 from this facility are, for now, allocated to the geothermal power plant and reported in the Energy Sector (CRF subcategory 1B2d). Future improvements involve an estimation of emissions from the methanol production facility and consequently the reduced emissions from the upstream geothermal power plant.

4.3.2 Other (CRF 2B10)

The only chemical industries that have existed in Iceland involve the production of silicium and fertilizer. The fertilizer production plant was closed in 2001 and the silicium production plant was closed in 2004.

At the silicium production plant, sludge containing silicium was burned to remove organic material, and soda ash was used as a fluxing agent. 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. CO_2 emissions from the silicic sludge derive from organic carbon and therefore are not included in the totals. CO_2 emissions that occured 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. The uncertainty of the CO_2 estimate is 3%, see Annex II.

When the fertilizer production plant was operational it reported its emissions of NO_x and N_2O to the EA. The uncertainty of the N_2O estimate is 50%, see Annex II. CO_2 and CH_4 emissions are considered insignificant from the process itself, as the fertilizer plant used H_2 from a geothermal powerplant.

4.4 Metal Production (CRF 2C)

4.4.1 Steel production (CRF 2C1)

Since 2014 a secondary steelmaking facility (GMR) has been operating in Grundartangi next to the ferrosilicon plant and the aluminium smelter Norðurál. GMR produces steel from scrap iron and steel from the aluminium smelters. Carbonates and slags are added to the smelting process. CO_2 emissions are calculated using production data provided by the plant, and the default Tier 1 emission factor for steel production in electric arc furnaces (Table 4.1, Chapter 4 of the 2006 IPCC Guidelines). The CO_2 emissions were 0.83 kt. CO_2 in 2014 and 0.34 kt. CO_2 in 2015. This activity is reported for the first time in this submission. Planned improvements include obtaining more information from the producer, including abatement technology, in order to refine the estimates.

4.4.2 Ferroalloys Production (CRF 2C2)

Ferrosilicon (FeSi, 75% Si) is produced at one plant, Elkem Iceland at Grundartangi. In the production process, raw ore, carbon material and slag forming materials are mixed and heated to high temperatures for reduction and smelting. The raw materials used are quartz (SiO_2) and iron ore. Ready-to-use carbon free iron pellets for the production are imported, so no additional emissions occur from the iron part of the FeSi production. The carbon materials used are coal, coke, and wood. Since 1999, the process also uses limestone as fluxing agent. Electric (submerged) arc furnaces with consumable Soederberg electrodes are used. The furnaces are semi-covered.

Emissions of CO_2 originate from the use of coal and coke as reducing agents, from the consumption of electrodes and from the calcination of the carbonate flux. Emissions are calculated according to the Tier 3 method from the 2006 IPCC Guidelines (Equation 4.17 Vol. 3), based on the consumption of reducing agents and electrodes and plant specific carbon content. Information on the carbon content of electrodes and reducing agents is provided by the plant. Emissions from limestone calcination are calculated based on the consumption of limestone 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.

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.

CO_2 emissions resulting from the use of wood and charcoal are calculated but not included in national totals. Non CO_2-emissions from the use of wood and charcoal are included in national totals.

4.4.2.1 Activity Data

The consumption of reducing agents, electrodes and limestone are collected from the plant by EA through an electronic reporting form based on the EU ETS. 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_2-eq) from Elkem Iceland.

	1990	1995	2000	2005	2010	2014	2015
Electrodes	3.8	3.9	5.7	6.0	4.8	4.3	4.9
Coking coal	45.1	52.4	73.2	86.9	96.1	103.0	115.1
Coke oven coke	24.9	30.1	46.6	42.6	30.3	29.5	30.9
Char coal	-	-	-	2.1	-	-	-
Waste wood	16.7	7.7	16.2	15.6	11.3	25.7	27.2
Limestone	-	-	0.5	1.6	0.5	2.4	2.2
Production (FeSi)	62.8	71.4	108.7	111.0	102.2	107.8	117.9
Coarse microsilica	0.9	1.0	1.4	1.6	1.1	1.4	1.4
Fine microsilica	13.2	15.0	21.4	24.3	17.0	21.0	20.8
Emissions (kt. CO_2-eq)	**209**	**245**	**364**	**378**	**371**	**370**	**402**

4.4.2.2 Emission Factors

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.

Emission factors for CH_4 and N_2O are default EF´s taken from Table 2.3, Vol. 2 of the 2006 IPCC guidelines. NOx, and NMVOC are taken from Tables 1.7, 1.9, and 1.11 in the IPCC Guidelines Reference Manual. Values for NCV are from Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. Emissions of SO_2 are calculated from the sulphur content of the reducing agents and electrodes for the period 1990 til 2002, and are provided directly by the factory since 2003. The emission factor for CO comes from Table 2.16 in the Reference Manual of the 1996 IPCC Guidelines.

Table 4.5 Carbon content of raw material and products at Elkem Iceland.

	1990	1995	2000	2005	2010	2014	2015
Electrodes	94%	94%	94%	94%	94%	95%	96%
Coal (Anthracite)	74.8%	74.8%	79.0%	75.5%	74.8%	72.2%	71.8%
Coke oven coke	78.8%	78.8%	76.6%	73.8%	80.8%	73.6%	70.4%
Charcoal	-	-	-	80.9%	-		
Waste wood	48.7%	48.7%	48.7%	48.7%	48.7%	50.0%	50.0%

4.4.2.3 Emissions

Figure 4.3 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 0.3% of the emissions from this plant.

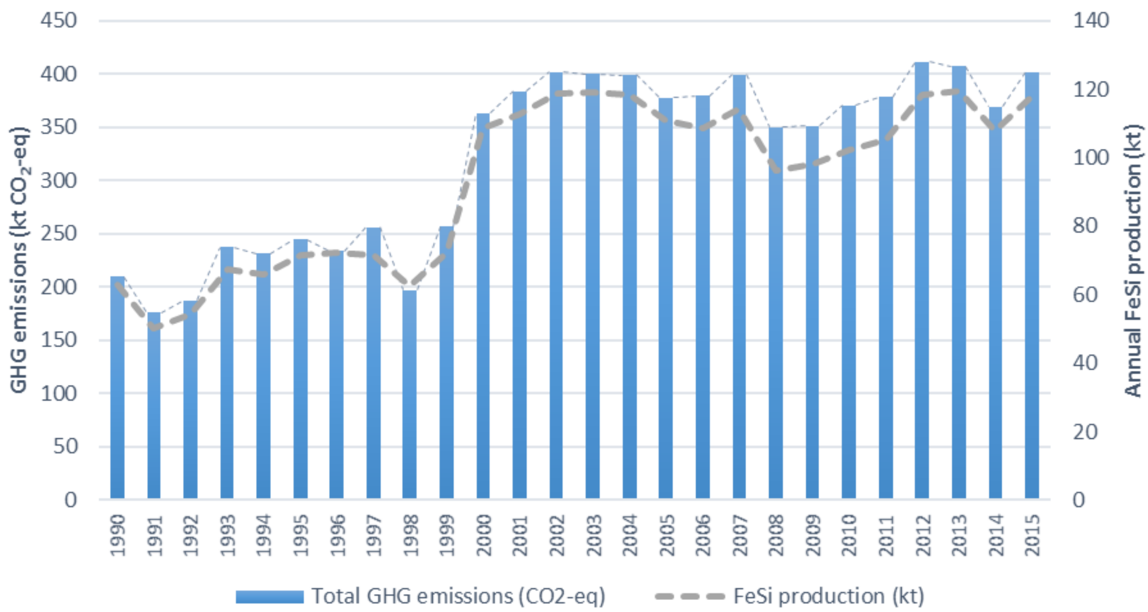

Figure 4.3 Total GHG emissions (CO_2 and CH_4) from the Ferrosilicon plant, and annual FeSi production (kt. CO_2-eq.).

4.4.2.4 Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from ferroalloys production is 1.8% (with an activity data uncertainty of 1.5% and emission factor uncertainty of 1%). 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 II.

4.4.2.5 Source specific QA/QC procedures

Activity data is collected through electronic reporting form, allowing immediate QC checks. QC tests involve automatic t/t checks on certain emissions and activity data from this industry. Further information can be found in the QA/QC manual.

4.4.2.6 Recalculations and planned improvements

Small recalculations were made since the last submission to correct for inaccurate activity data for raw materials (limestone, coke, coal, electrodes) as well as previously omitted carbonaceous materials (Carbon blocks and electrode casings, activity data of these is not available prior to 2013 when EU-ETS reporting was established). The NCV for coke, coal and wood were updated to the values from the 2006 IPCC guidelines, as well as the EF for CH_4. Furthermore, in previous submissions a correction factor was calculated from the carbon content of microsilica and final products and was substracted from the CO_2 emissions. However, new ETS reports from Elkem indicate a lack of robust carbon analyses in the products, therefore a conservative approach was chosen and no correction factor was used for the current submission. All these recalculations change the 1990 emissions by 1.34 kt. CO_2-eq (or 0.14% of the total GHG emissions of Sector 2) and for 2014 the change amounts to 2.5 kt. CO_2-eq (or 0.12% of the total GHG emissions of Sector 2).

Planned improvements include a complete revision of calculations of non-CO_2 emissions, including CO which according to the 2006 IPCC Guidelines should be considered to be completely oxidised and therefore is included in the calculations for CO_2.

4.4.3 Aluminium Production (CRF 2C3)

Aluminium production in Iceland occurs both in primary and secondary production facilities. Primary aluminium production occurs in 3 smelters, Rio Tinto Alcan in Straumsvík, Century Aluminium (Norðurál) in Grundartangi and Alcoa Fjarðarál in Reyðarfjörður. 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. (See location of major industrial sites in Iceland in Figure 4.1).

Primary aluminium production results in emissions of CO_2 and PFCs, whereas secondary aluminium production does not generate any significant amounts of greenhouse gases 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.

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. 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.

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 calculated according to the Tier 2 Slope Method, using equation 4.26 from the 2006 IPCC Guideline (see below). Default coefficients are taken from table 4.16 in the 2006 IPCC Guideline for Centre Worked Prebaked Technology.

EQUATION 4.26

$$\mathbf{E_{CF4} = S_{CF4} \cdot AEM \cdot MP}$$
and
$$\mathbf{E_{C2F6} = E_{CF4} \cdot F_{C2F6/CF4}}$$

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

4.4.3.1 Activity Data

The EA collects annual process specific data from the aluminium plants, through electronic reporting forms in according to 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 1990-2015.

Year	Primary aluminium production [kt]	CO_2 emissions [kt]	PFC emissions [kt. CO_2-eq]	CO_2 [t/t Al]	PFC [t CO_2-eq/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

4.4.3.2 Emission Factors

Emission factors for CO_2 are based on 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 2015 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%.

The default slope and weight fraction coefficients for the calculation of PFC emissions come from the 2006 IPCC Guideline for Centre Worked Prebaked Technology (0.143 for CF_4 and 0.121 for C_2F6/CF_4). Information on PFC emissions are also submitted by the producers under the EU-ETS. For high performing facilities that emit very small amounts of PFCs, the Tier 3 method will probably not provide a significant improvement in the overall facility GHG inventory in comparison with the Tier 2 Method. Consequently, it is good practice to identify these facilities prior to selecting methods in the interest of prioritising resources. The status of a facility as a high performing facility should be assessed annually because economic factors, such as the restarts of production lines after a period of inactivity or process factors, such as periods of power curtailments might cause temporary increases in anode effect frequency. In addition, over time, facilities that might not at first meet the requirements for high performers may become high performing facilities through implementation of new technology or improved work practices.

4.4.3.3 Emissions

GHG emissions from primary Al production have been relatively stable since 2008, with a slight increasing trend since 2011 (Figure 4.4). 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. Total GHG emissions from the primary Aluminium sector have risen by 121% since 1990, and increased by 1.8% from 2014 to 2015.

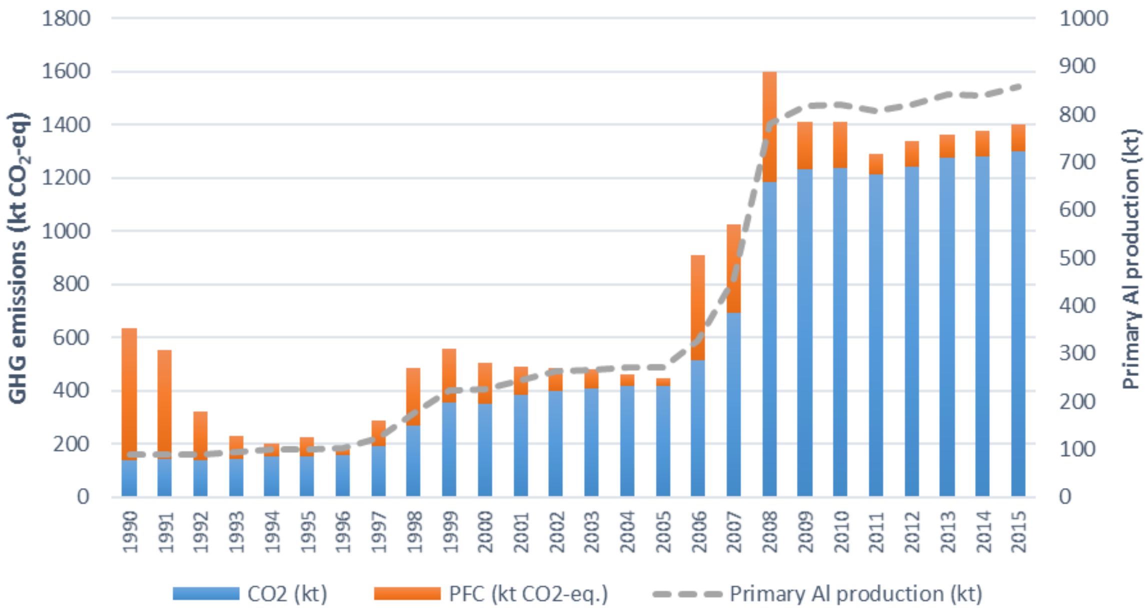

Figure 4.4: GHG emissions (CO_2 and PFC) from primary Al production, and annual production (kt.).

4.4.3.4 Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from aluminium production is 1.8% (with an activity data uncertainty of 1% and an emission factor uncertainty of 1.5%). This can be seen in the quantitative uncertainty table in Annex II.

The emission factors for calculating PFC emissions have more uncertainty. The preliminary estimate of quantitative uncertainty has revealed that the uncertainty of PFC emissions from aluminium production is 6% for CF_4 and 11% for C_2F_6.

4.4.3.5 Source specific QA/QC procedures

Activity data is collected through electronic reporting forms, allowing immediate QC checks. QC tests involve automatic t/t checks on certain emissions and activity data from this industry. Further information can be found in the QA/QC manual.

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

4.5.1 Lubricant Use (CRF 2D1)

4.5.1.1 Overview

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).

CO_2 emissions from lubricant use have been omitted up until now because of lack of adequate activity data. This submission now includes emission calculations for the time period 1990-2015. The according changes in total emissions for previous years is discussed in the section about recalculations and planned improvements.

Only CO_2 emissions are reported here. NMVOC are possibly also emitted, but there is no default methodology currently available to estimate those emissions.

4.5.1.2 Methodology

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. The amount of lubricant used as 2-stroke engine fuel is however likely to be very small, therefore we attribute all emissions from lubricants to this category (2D1), and none to combustion in the energy sector.

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).

4.5.1.3 Activity data

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.

4.5.1.4 Emissions

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 2.37 kt. and 2.54 kt. CO_2.

4.5.1.5 Recalculations and planned improvements

Since this is a newly reported category, the total CO_2 emissions are affected by the addition of these emissions. For 1990, the difference amounts to 4.06 kt. CO_2, or 1% of the total emissions from the industry sector (CRF Sector 2). For 2014, the difference amounts to 2.33 kt. CO_2, or 0.14% of the total emissions from the industry sector.

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)

4.5.2.1 Overview

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 in section 4.5.2.5.

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.

4.5.2.2 Methodology

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

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.

4.5.2.3 Activity data

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.

4.5.2.4 Emissions

The emissions from Paraffin Wax Use were estimated to be 0.31 kt. CO_2 in 1990 and 0.34 kt. CO_2 in 2015.

4.5.2.5 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)
4.5.3.1 Overview
This section describes non-methane volatile organic compounds (NMVOC) emissions from solvents use. 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. They are therefore considered as indirect greenhouse gases. No methodology is provided to estimate GHG emissions from these categories, therefore they are marked as NE (if considered possible but not significant) or NA (if considered not likely to occur) in the CRF reporting tables.

The various subgroups within 2D3 are taken from the 2016 EMEP/EEA 2016 guidebook.

In 1990 emissions from this category amounted to 1.19 kt. NMVOC, or 3.72 kt. CO_2 equivalents. Emissions increased by 1.3 % between 1990 and 2015 and were 1.21 kt. NMVOC, or 3.76 kt. CO_2 equivalents in 2015 accounting for roughly 0.1% of the total greenhouse gas emissions of Iceland in 2015. An overview of the emissions from the individual subcategories is given in Table 4.7 and is shown in Figure 4.6.

4.5.3.2 Methodology
NMVOC emissions are estimated according to the 2016 EMEP/EEA air pollutant emission inventory guidebook. 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.

4.5.3.3 Key Category analysis
The key source analysis performed for 2015 has revealed that the sector Non-Energy Products from Fuels and Solvent Use is neither a key source category in level nor in trend.

4.5.3.4 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 the QA/QC manual.

4.5.3.5 Recalculations
The subcategory 2D3a Domestic solvent use was recalculated for this submission, using the updated information in the EMEP/EEA 2016 Guidebook. The default emission factor in the EMEP/EEA 2013 Guidebook was 2.7 kg/capita, whereas the newest Guidebook recommends using 1.8 kg/capita for western European countries. The reduction in emission factor leads to a difference between the 2016 and the 2017 submission of -230t NMVOC for 1990 and -296t NMVOC for 2014.

The subcategory 2D3i Organic solvent-borne preservatives was recalculated because of erroneous emission data in the previous submission. The corrected data shows 0.73t NMVOC more in 1990 and 2.36t NMVOC more in 2014. This difference represents 0.06% of total NMVOC in 1990 in Sector 2D3, and 0.2% of total NMVOC in Sector 2D3 in 2014.

4.5.3.6 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 til 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 2015 3.1 t NMVOC, corresponding to an increase of 12.5%.

4.5.3.7 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, 2015) and on domestic production of paint since 1998 (Icelandic Recycling Fund). However, no data was available for this submission for 2015, therefore the activity data for 2015 was calculated using the average of the period 2009-2014. 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 2015 321.1 t NMVOC, corresponding to a decrease of 41.6%.

4.5.3.8 Degreasing and dry cleaning (2D3e, 2D3f)

The EMEP/EEA guidebook (EMAP/EEA, 2016) 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 (EMAP/EEA, 2016) 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 (EMAP/EEA, 2016) and calculated using demographic data. The NMVOC emission factor for open-circuit machines is 177g/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 EMEP/EEA guidebook (EMAP/EEA, 2016) reduction default value of 0.89.

In 1990 the NMVOC emissions for Degreasing were 76.2 t NMVOC, in 2015 46.3 t NMVOC, corresponding to a decrease of 39.3%. For Dry-cleaning the NMVOC emissions for Coating Application were 1.5 t NMVOC in 1990 and 1.9 t NMVOC in 2015, corresponding to an increase of 30%.

4.5.3.9 Chemical products, manufacturing and processing (2D3g)

The only activity identified for the subcategory chemical products, manufacture and processing is manufacture of paints. NMVOC emissions from the manufacture of paints were calculated using the EMEP/EEA guidebook (EMAP/EEA, 2016)Tier 2 emission factor of 11 g/kg product. The activity data consists of the amount of paint produced domestically.

In 1990 the NMVOC emissions for paint manufacturing were 15.6 t NMVOC, in 2015 3.2 t NMVOC, corresponding to a decrease of 79%.

4.5.3.10 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. This emission factor was changed from the one previously used (2.7 kg/inhabitant/year), following the recommendation in the EMAP/EEA 2016 guidebook. In 1990 the NMVOC emissions for domestic solvent use were 450.6 t NMVOC, in 2015 598.6 t NMVOC, corresponding to an increase of 29.9%.

NMVOC emissions for printing (2D3h) were calculated using the EMEP/EEA guidebook (EMAP/EEA, 2016) Tier 1 emission factor of 500g/kg ink used. Import data on ink was received from Statistics Iceland (Statistics Iceland, 2015). In 1990 the NMVOC emissions for printing were 77.5 t NMVOC, in 2015 206 t NMVOC, corresponding to an increase of 166%.

Emissions from wood preservation (2D3i) were calculated using the EMEP/EEA guidebook (EMAP/EEA, 2016) 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, 2015). . In 1990 the NMVOC emissions for Wood preservation were 8.7 t NMVOC, in 2015 26.5 t NMVOC, corresponding to an increase of 205%.

4.5.3.11 Emissions of Sector 2D3

Figure 4.6 and Table 4.7 show NMVOC emissions from the sector 2D3 from 1990-2015. NMVOC emissions were around 1.4 kt. from 1990 to 1995. Between 1996 and 2007 emissions oscillated between 1.5 and 1.8 kt. The decrease of emissions during the last years is mainly due to decreasing emissions from paint application, printing and organic wood preservatives.

Table 4.7 NMVOC emissions (in tonnes) from all sub-categories of sector 2D3.

	1990	1995	2000	2005	2010	2014	2015
2D3a Domestic solvent use	460.56	482.32	510.05	539.80	573.21	592.38	598.55
2D3b Road paving with asphalt	2.76	2.76	5.18	5.36	3.75	2.45	3.10
2D3d Coating applications	549.67	561.90	585.27	376.87	298.90	314.24	321.07
2D3e Degreasing	76.21	56.77	85.30	57.63	37.96	36.99	46.27
2D3f Dry cleaning	1.49	1.57	1.66	1.75	1.86	1.92	1.94
2D3g Paint manufacturing	15.60	15.60	12.22	5.42	3.20	3.44	3.27
2D3h Printing	77.49	109.12	198.18	309.20	188.94	209.05	206.80
2D3i Wood preservation	8.67	18.70	25.44	86.61	30.93	23.62	26.48
Total (t NMVOC)	**1192.46**	**1248.74**	**1423.28**	**1382.64**	**1138.75**	**1184.09**	**1207.47**

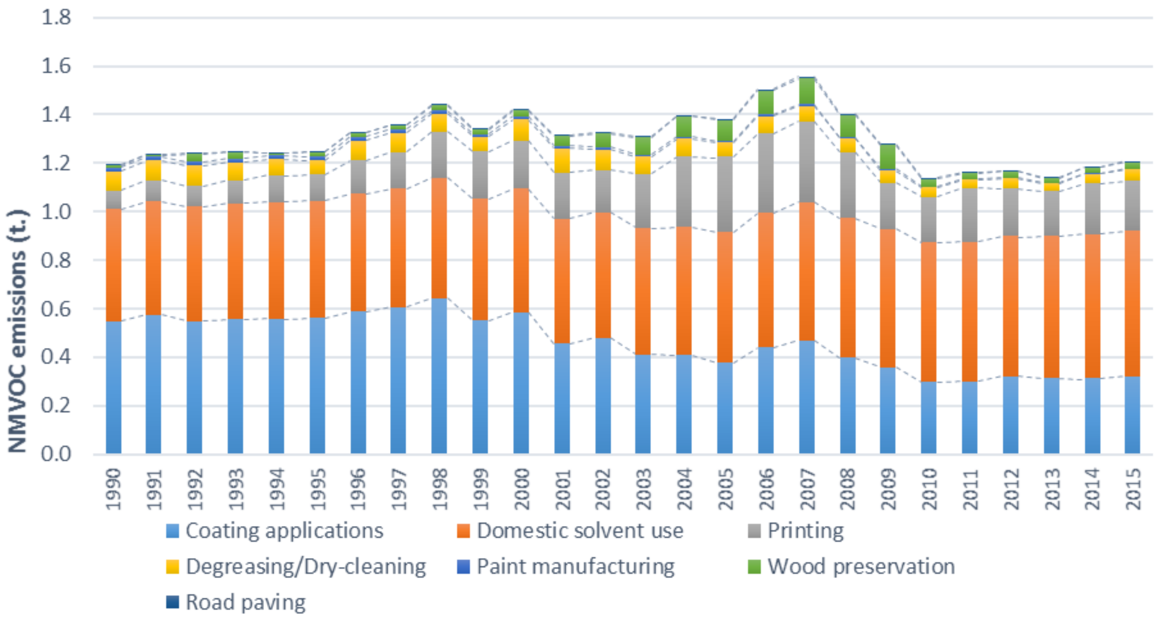

Figure 4.6 NMVOC emissions from all subgroups of Sector 2D3, other non-energy products from fuels and solvent use.

4.5.3.12 Uncertainties

Uncertainty estimates for emissions from Solvent use were revised in response to a remark by the ERT during the review of Iceland´s 2013 submission. NMVOC emissions along with respective uncertainty estimates were calculated for nine subcategories. Subsector AD and EF uncertainties were combined by multiplication using equation 3.1 (page 3.28) of the 2006 IPCC Guideline. The main source for EF uncertainties were uncertainties and value ranges given in the EMEP GB. The combined subsector uncertainties were then combined into one value due to the relative insignificance of CO_2 emissions from this sector. Combination of uncertainties was achieved by using equation 3.2 (page 6.28) using 2013 emissions as uncertain quantities. Combined AD uncertainty for the sector was 59%, combined EF uncertainty 170%. This resulted in 180% total uncertainty for CO2 emission from the sector. Table 4.7Table 4.8 shows the uncertainties for the subsectors and the respective references. s. For next year’s submission a major overhaul of all uncertainties calculations is planned.

Table 4.7 Subsector AD and EF uncertainties for CO_2 emissions from solvent use.

Subsector	AD uncertainty	EF uncertainty
2D3a Domestic solvent use	5[a]	200[b]
2D3b Road paving with asphalt	xx	xx
2D3d Coating applications	100[a]	57[b]
2D3e Degreasing	200[a]	96[b]
2D3f Dry cleaning	1000[b]	105[b]
2D3g Chemical product: Paint manufacturing	20[a]	500[b]
2D3h Printing	50[a]	320[b]
2D3i Other product use: creosote	100[a]	36[b]
2D3i Other product use: organic solvent-borne preservative	100[a]	44[b]

a = expert judgement; b = EMEP/EEA 2016

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

4.6.1 Overview

This chapter covers HFC and PFC emissions from product use as substitutes for Ozone Depleting Substances. In Iceland Hydrofluorocarbons (HFCs) are used mostly in refrigerants, and in metered dose inhalers to a smaller percentage (ca. 0.5% of total HFC+PFC from this sector in 2015) 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.

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), 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 contribution of PFCs to the total fluorinated gas emissions from this sector is very small, and since 2003 it has been below 0.01% of total HFC+PFC emissions (in CO_2-eq).

The use of HFCs and PFCs in the refrigeration and air conditioning sector (2F1) spans the following applications:

- 2F1a : Commercial refrigeration (HFCs and PFCs),
- 2F1b: Domestic refrigeration (HFCs and PFCs),
- 2F1c: Industrial refrigeration (HFCs and PFCs),
- 2F1d: Transport refrigeration (HFCs and PFCs),
- 2F1e: Mobile air conditioning (MAC) (HFCs).
- 2F1f: Stationary AC, including heat pumps (HFCs)

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, 2007). 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 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
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 such as fish farming, meat processing, and vegetable production
		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)		

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.

4.6.2 Refrigeration and Air Conditioning (CRF 2F1)

4.6.2.1 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 amount of units and their average charge could be collected. 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.

4.6.2.2 Source specific QA/QC procedures

The spread sheets employed in the calculation of HFC emissions from refrigeration and air conditioning equipment were designed thus that they included error diagnoses and control mechanisms. An example for such a control mechanism is the comparison between the HFC amounts imported for a certain refrigeration sub-source until 2013 and the sum of all sub-source emissions until 2013 and the amount allocated to the sub-sources 2015 stock. This difference had to be zero.

4.6.2.3 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. shows the quantity of HFCs and PFCs introduced to Iceland in bulk between 1993 and 2015.

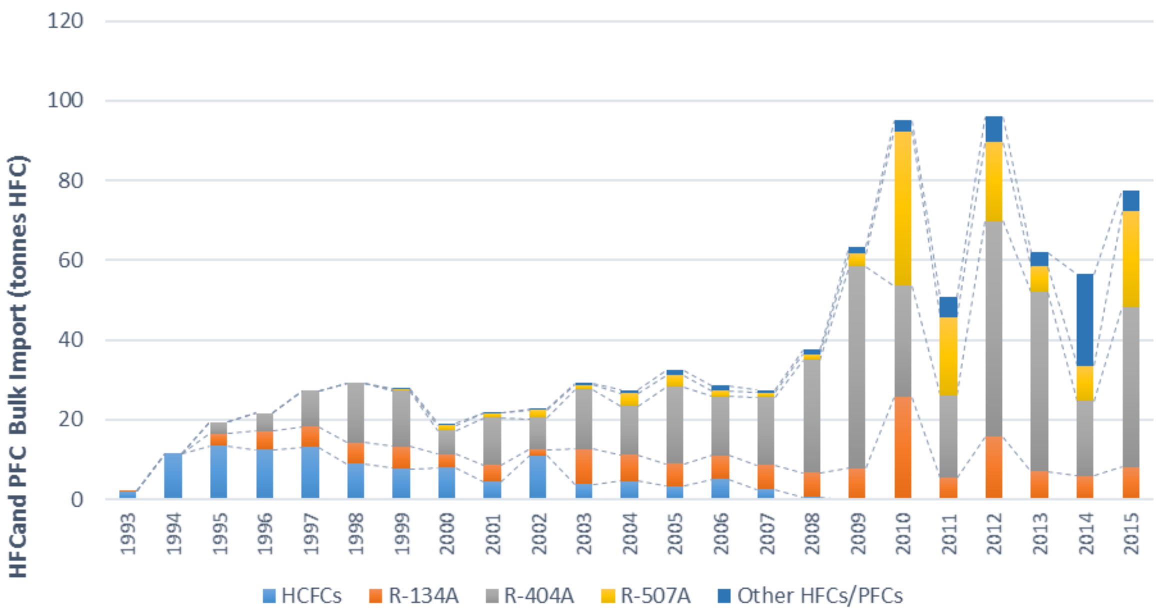

Figure 4.4 Quantity of HFCs imported in bulk to Iceland between 1993 and 2015.

Information on the amount 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 amount 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 amount of vehicles equipped with (R-134A containing) MACs. Based on a study by the EU (Schwarz et al., 2011) 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 GL 0.05-0.5 kg (Table 7.9, page 7.52).

4.6.2.4 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 shown below:

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.

4.6.2.5 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 CO_2 eq. All values and fractions below relating to aggregated emissions are expressed in CO_2 eq.

Total HFC and PFC emissions from all refrigeration and air conditioning equipment amounted to 206.12 kt. CO_2-eq in 2015, which corresponds to 14% increase compared to 2014 emissions Table 4.10. HFC emissions amounted to 206.10 kt. CO_2-eq, whereas PFC emissions amounted to 0.0175 kt. CO_2-eq, or 0.008% of total HFC + PFC emissions from this subsector.

Table 4.10 HFC and PFC emissions for all individual compounds, recalculated into kt. CO_2-eq using AR4 GWPs.

	1990	1995	2000	2005	2010	2014	2015
HFC-23	0.00	0.00	0.00	0.02	0.02	0.01	0.23
HFC-32	0.00	0.00	0.01	0.03	0.05	0.23	0.43
HFC-125	0.00	5.08	17.49	25.40	53.43	72.05	80.84
HFC-134a	0.00	1.92	7.49	12.36	20.65	24.19	26.18
HFC-143a	0.00	2.46	17.46	30.52	70.73	83.96	98.06
HFC-152a	0.00	0.04	0.07	0.05	0.02	0.01	0.01
HFC-227ea	0.00	0.00	0.00	0.08	0.03	0.34	0.35
total HFC emissions	**0.00**	**9.50**	**42.52**	**68.45**	**144.93**	**180.80**	**206.10**
C_2F_6 (PFC-116)	0.0000	0.0000	0.0000	0.0000	0.0005	0.0002	0.0003
C_3F_8 (PFC-218)	0.0000	0.0000	0.0000	0.0023	0.0066	0.0079	0.0172
total PFC emissions	0.0000	0.0000	0.0000	0.0023	0.0071	0.0081	0.0175
Total HFC+PFC emissions	**0.00**	**9.50**	**42.52**	**68.45**	**144.94**	**180.81**	**206.12**

Lifetime emissions are 87.4% of total emissions, 9.3% are end-of-life emissions and 3.2% are initial emissions (Figure 4.8). 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.

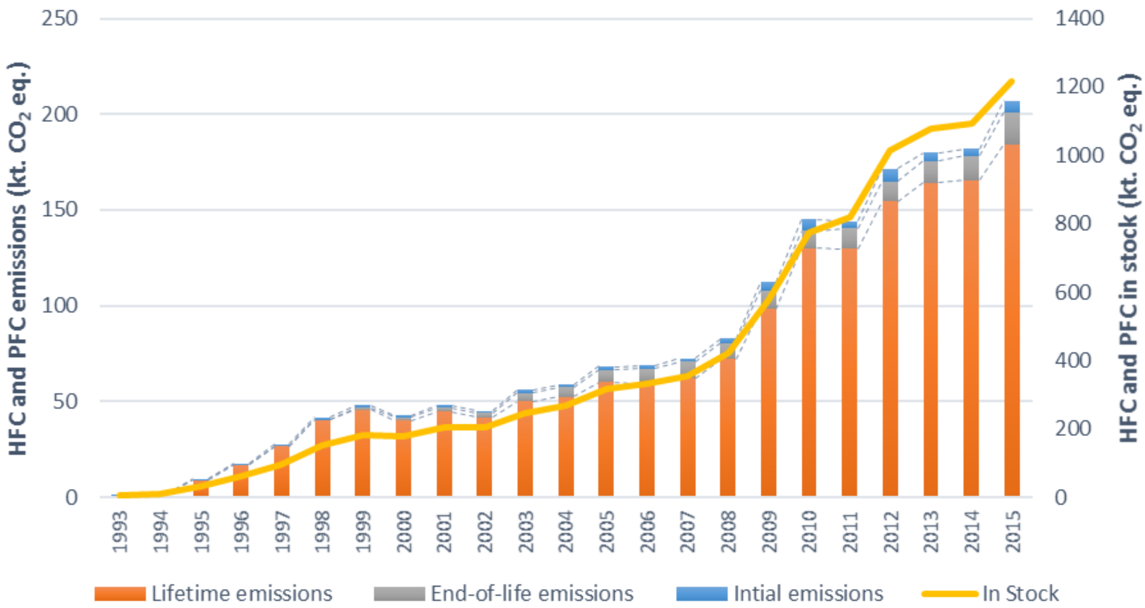

Figure 4.8 HFC/PFC stock (primary y-axis) and emissions (secondary y-axis) from refrigeration and air conditioning equipment. Included are domestic refrigeration, commercial refrigeration, industrial refrigeration (fishing vessels and reefers), stationary ACs and MACs.

60.4% of the 2015 emissions stem from refrigeration systems on fishing vessels. Total transport refrigeration emissions, i.e. including reefers, account for 63.6% of all HFC and PFC emissions. Other important sectors are industrial refrigeration (15.3%), commercial refrigeration (11.7%), and MACs (4.01%). Stationary AC emission shares are 0.5% 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 refrigerant amounts(Figure 4.6).

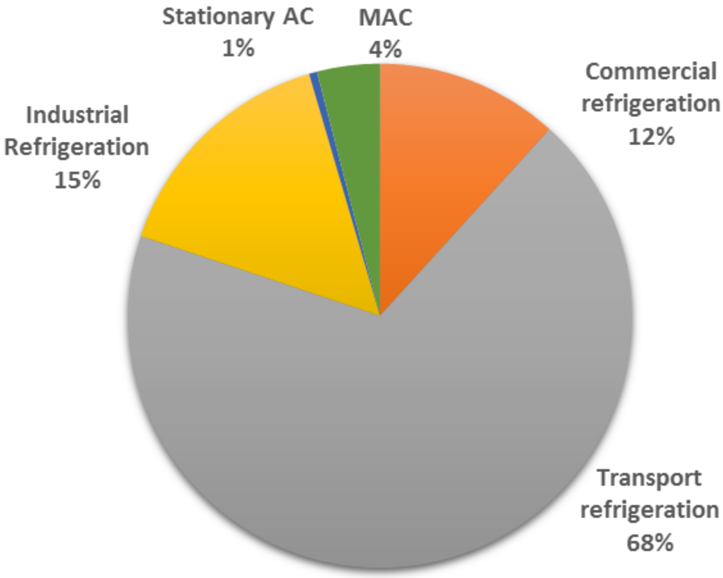

Figure 4.5 2015 emission distribution of refrigeration and AC sub-source categories

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 4.10) 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 decrease 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.

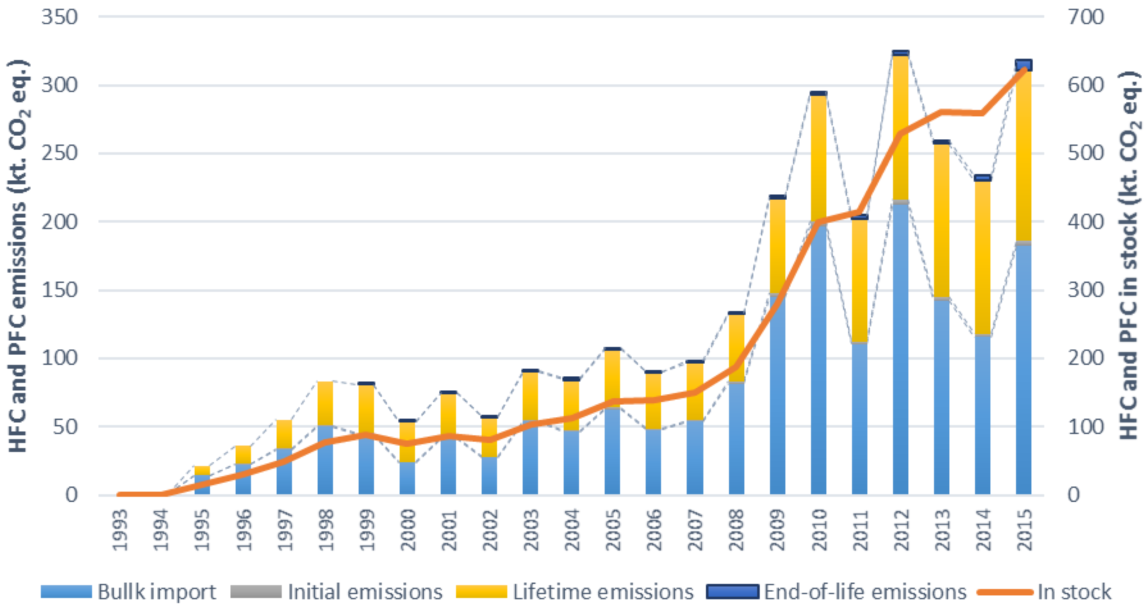

Figure 4.6 Import, stock development and emissions from refrigeration systems on fishing vessels between 1993 and 2015.

The graph for MACs (Figure 4.7) 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.

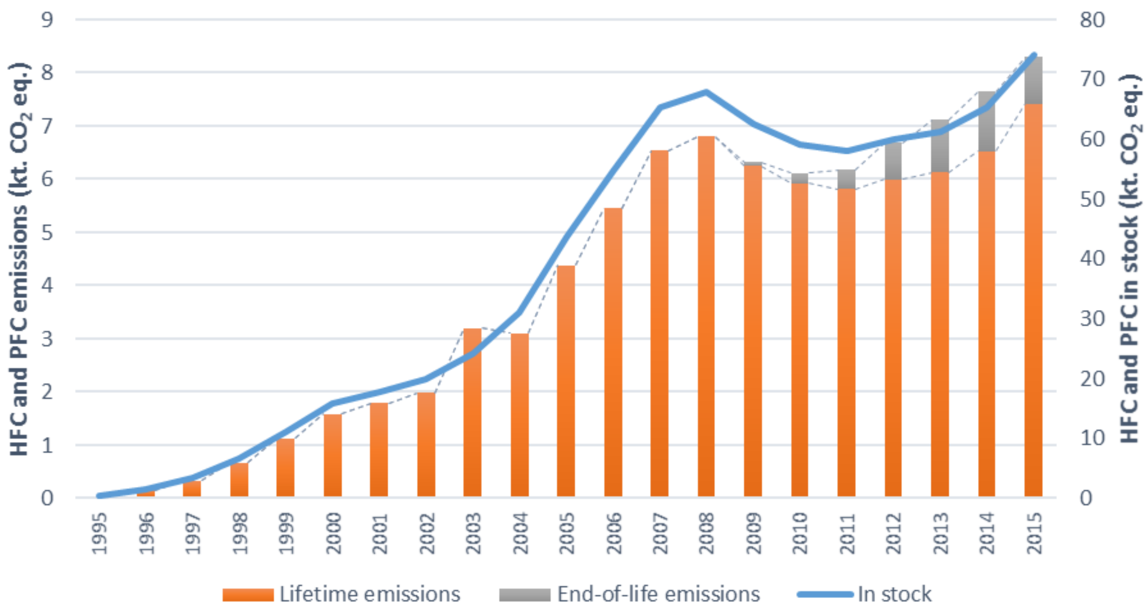

Figure 4.7 Emissions from mobile air conditioning (MACs).

4.6.2.6 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.

4.6.2.7 Uncertainties

Emission factor uncertainty of the refrigeration and air conditioning sector were calculated by relating the lifetime emission factor ranges given in tables 3.22 and 3.23 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. In order to comply with the methodology of uncertainty calculations for the inventory as a whole, sub-source EF and AD uncertainties were first summarized separately by weighting them with 2013 emission quantities. The resulting EF and AD certainties were then combined by multiplication. Uncertainty factors are summarized in Table 4.11.

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 2015 emission shares used to weight uncertainties

Value ranges (Lifetime EF)	EF, lower bound	EF, upper bound	Lifetime EF used	EF uncertainty (%)	AD uncertainty (%)	2015 emission share	Combined uncertainty (%)
Domestic ref.	0.1	0.5	0.3	67	500	0.03%	
Commercial ref.	5.5	20	10	100	200	13.32%	
Fishing vessels	15	50	35	57	200	60.4%	
Reefers	5	20	10	100	50	3.2%	
Industrial ref.	7	25	10	150	100	17.44%	
Residential AC	1	5	3	67	200	0.58%	
MAC	10	20	10	100	100	4.57%	
Weighted unc.				81	176		193

4.6.2.8 Recalculations and improvements

The lifetime emission factor for fishing vessels had previously been assumed to be at the upper end of the range for transport refrigeration (50%) initially, and was then lowered linearly to 20% in 2012, which equals 1.6% decrease each year. This 1.6% yearly decrease was then continued to reach 15% in 2015. However, as pointed out by the EMERT, reaching the lowest EF value indicated in the 2006 IPCC Guidelines is an unlikely scenario, and therefore the EF was revised and set to 20% since 2012. The latter value was determined after evaluation of information obtained through a poll amongst the major stakeholders. The change in EF for 2013 and 2014 affects the HFC and PFC emissions for this sector (2F1) by 0.05% and 0.1%, respectively, or 8.85 kt. and 16.17 kt. CO_2-eq, respectively.

Furthermore, various inaccuracies in HFC activity data and CRF upload files that occurred in the 2016 submission were corrected. For 2014, the difference due to those recalculations amounted to 1.71 kt. CO_2-eq, or 1.05% of total HFC emissions in this 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.

4.6.3 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.

4.6.3.1 Methodology

Emissions from MDIs are calculated using equation 7.6 in the 2006 IPCC guidelines (vol. 3, Chapter 7)

4.6.3.2 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 til 2015, and by using this average to calculate MDI imports as a function of population for the period 1990-2001. This was not done previously, thus increases total HFC emissions for the period 1990-2001 for the 2F sector (see recalculations below).

4.6.3.3 Emission factors

Following the 2006 IPCC Guidelines an EF of 50% is assumed for MDIs. This entails that 50% of R-134A imported in MDIs is emitted during the import year, whereas the remaining 50% are emitted during the following year along with 50% of that following year´s import.

4.6.3.4 Emissions

Emissions from MDIs in 2015 were 0.88 kt. CO_2 eq. which is 2% less than in 2014.

4.6.3.5 Uncertainties

Uncertainty of HFC emissions from MDIs was not calculated separately. Although uncertainty of emission estimates for MDIs is deemed less than uncertainty of emission estimates for refrigeration subsector uncertainty, it is implied in total HFC consumption uncertainty. This is justified by the relative insignificance of MDI emissions compared to refrigeration emissions.

4.6.3.6 Recalculations

Because of the lack of MDI import data for the time period 1990-2001, emissions from MDIs were previously not reported for that period. For this submission, the activity data was extrapolated for that period as outlined in section 4.6.3.2. The relative difference these recalculations cause on the total HFC+PFC emissions from sector 2F is large in the first part of the 90´s where HFC use for refrigeration and air-conditioning was rapidly growing in Iceland (see for instance Figure 4.5), but fall to below 5% after 1995.

4.7 Other Product Manufacture and Use (CRF sector 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.

4.7.1 Electrical Equipment (CRF 2G1)

4.7.1.1 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.

4.7.1.2 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.

4.7.1.3 Emissions

SF_6 emissions amounted to 67.1 kg (1.53 kt. CO_2-eq) in 2015 which is 31% than 2014 and less than 0.1% of Iceland´s total GHG emissions in 2015. Emissions increased by 39% since 1990. However, this increase is less than proportional compared to the net increase in SF_6 nameplate capacity since 1990.

Figure 4.12 shows both nameplate capacity development and emissions between 1990 and 2015. 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.

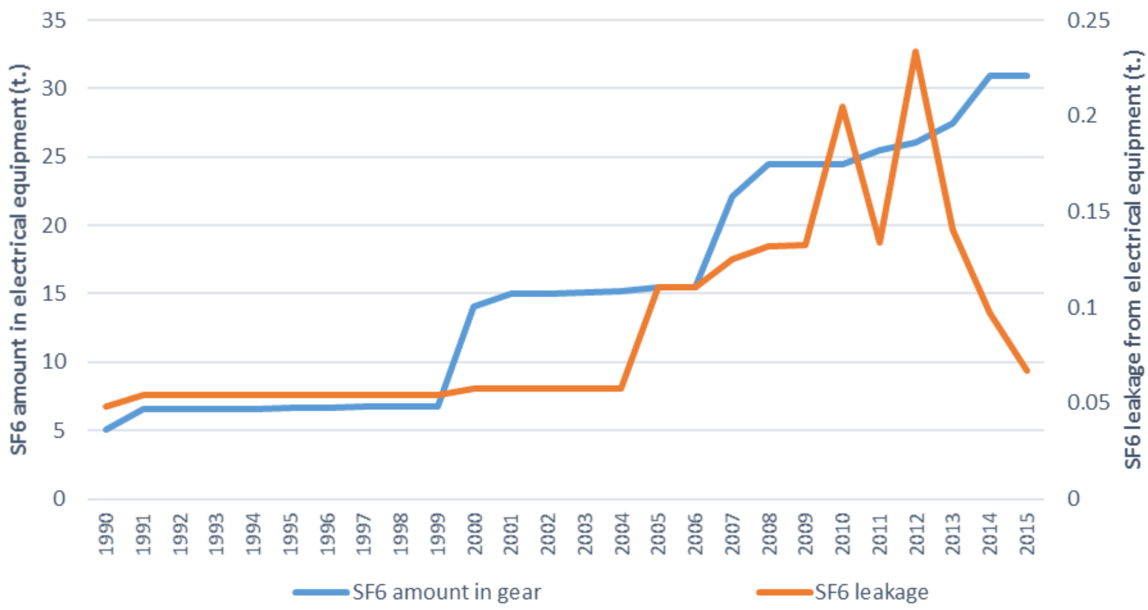

Figure 4.8 Total SF_6 amounts contained in and SF_6 leakage from electrical equipment (tonnes).

4.7.1.4 Uncertainty

Data regarding SF_6 nameplate capacity development during the last years is deemed to be accurate but deemed to be less accurate for the 1990s. The same holds true for emission estimates from the 1990s. Another source of uncertainty is a possible time lag between emissions and serving, i.e. that emissions detected by inspections performed less frequently than annual happened years ago. Monitoring devices, however, have greatly improved during the last years and the amounts in equipment and leaking from equipment are measured annually and known with good accuracy today. Uncertainty is divided into activity data uncertainty (measured amounts) and emission factor uncertainty (calculated amounts). By integrating the accuracy differences between more and less recent years AD uncertainty is estimated at 20% and EF uncertainty at 50% (expert judgement).

4.7.1.5 Planned improvements

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.

4.7.2 N_2O from Product Use (CRF 2G3)

4.7.2.1 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 in fire extinguishers and as fuel oxidant in auto racing (CRF subsector 2G3b).

4.7.2.2 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 two 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 are emitted in the same year and half of them in the year afterwards. The available activity data for 2015 does allow to determine the end use of the N_2O, therefore the average ratio of N_2O for medical use to N_2O for other uses for the period 2010 to 2014 is taken to allocate N_2O emissions to 2G3a and 2G3b.

EQUATION 8.24

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

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

4.7.2.3 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 17.8t N_2O in 1990 to 8.3t in 2014 and to 7.7t in 2015 (2.4 kt. CO_2-eq).

4.7.2.4 Emissions from Other product use (2G3b)

Emissions from other use of N_2O decreased from 1.6t N_2O in 1990 to 0.8t in 2014 and 0.4t in 2015 (0.19 kt. CO_2-eq).

4.7.2.5 Uncertainties

The 2006 IPCC Guideline methodology accounts for a time lag between N_2O sale and its application. Activity data used in the emission inventory did not consist of sales data but of import data. This means that the time lag might be greater than the 12 months the methodology accounts for, therefore AD uncertainty is estimated to be +- 20% accurate in spite of accurate data on imports (expert judgement). An EF uncertainty of 5% is estimated in compliance with the value used in Denmark´s NIR (Nielsen et al., 2012). Combined uncertainty for N_2O emissions from other product use is therefore estimated to be 21%.

4.7.2.6 Planned improvements

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

4.7.3 Other: Tobacco combustion and Fireworks use (CRF 2G4)

4.7.3.1 Tobacco

In previous submissions only NO_x, CO and NMVOC emissions from tobacco consumption were reported. For this submission CH_4 and N_2O were calculated in addition to the gases previously reported.

4.7.3.2 Methodology

Activity data for tobacco consumption is based on import data collected by Statistics Iceland, and includes all imports of tobacco (including loose tobacco, cigarettes, cigars and all other tobacco products). CH_4 and N_2O emissions are calculated using the Danish country-specific approach (Danish NIR 2016), 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.

4.7.3.3 Emissions

As can be seen in Figure 4.13, Tobacco consumption in Iceland has been steadily decreasing since 1990, with the 2015 imports (276 t) approximately 50% of the 1990 imports (561 t). Accordingly, the GHG emissions have also decreased by 50%, with 0.045 kt. CO_2-eq CH_4 and 0.011 kt. CO_2-eq N_2O in 1990 and 0.022 kt. CO_2-eq CH_4 and 0.005 kt. CO_2-eq N_2O in 2015. NOx decreased from 1.01t in 1990 to 0.5t in 2015, NMVOC decreased from 2.7t in 1990 to 1.3t in 2015, and CO decreased from 30.9t in 1990 to 15.2t in 2015.

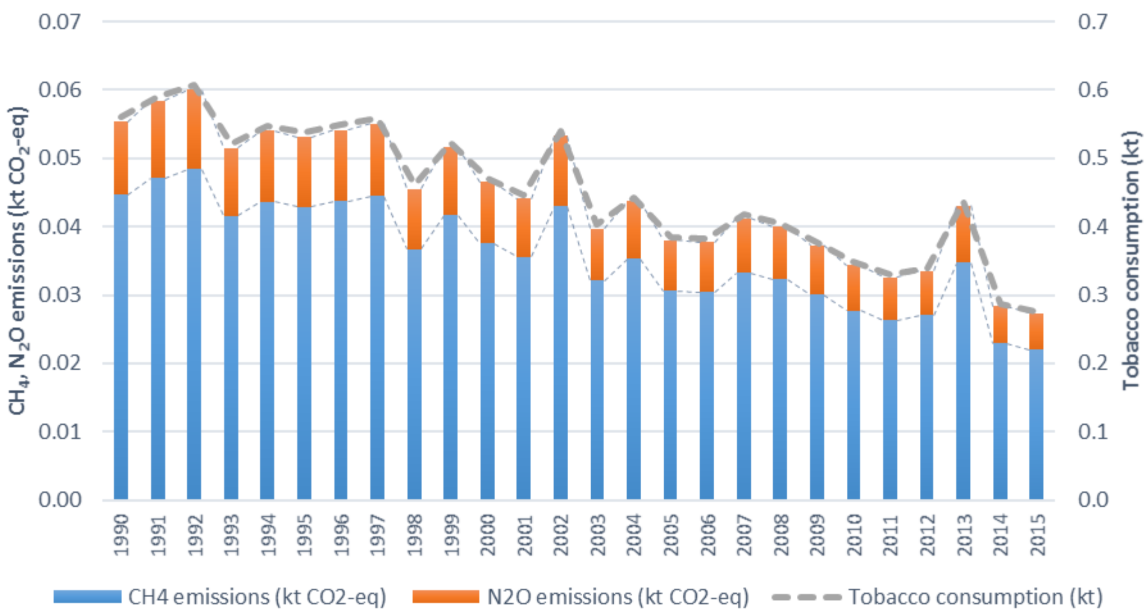

Figure 4.9 Tobacco import and GHG emissions (kt. CO_2-eq.) from tobacco use.

4.7.3.4 Recalculations and planned improvements

CH_4 and N_2O associated with tobacco use were not reported in previous submissions. The contribution of GHG emissions from tobacco to the total Industry sector (CRF sector 2) is 0.006% for 1990, and 0.001% for 2015.

4.7.3.5 Fireworks

Emissions due to fireworks use were not estimated in previous submissions. The present submission includes estimates for CO_2, CH_4, N_2O, NO_x, CO and SO_2 emissions.

4.7.3.6 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 (Emission estimates for diffuse sources, Netherlands Emission Inventory, Letting off fireworks, 2008). Emissions of SO_2, CO and NO_x were calculated using default Tier 2 emission factors from the EMEP/EEA 2016 Guidebook.

4.7.3.7 Emissions

Total fireworks use has been gradually increasing since the early 1990's, with associated increase in emissions (Figure 4.14). 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_2-eq in 2015. The main contributor to GHG emissions from fireworks is N_2O, with about 90% of total emissions (when calculated in CO_2-eq).

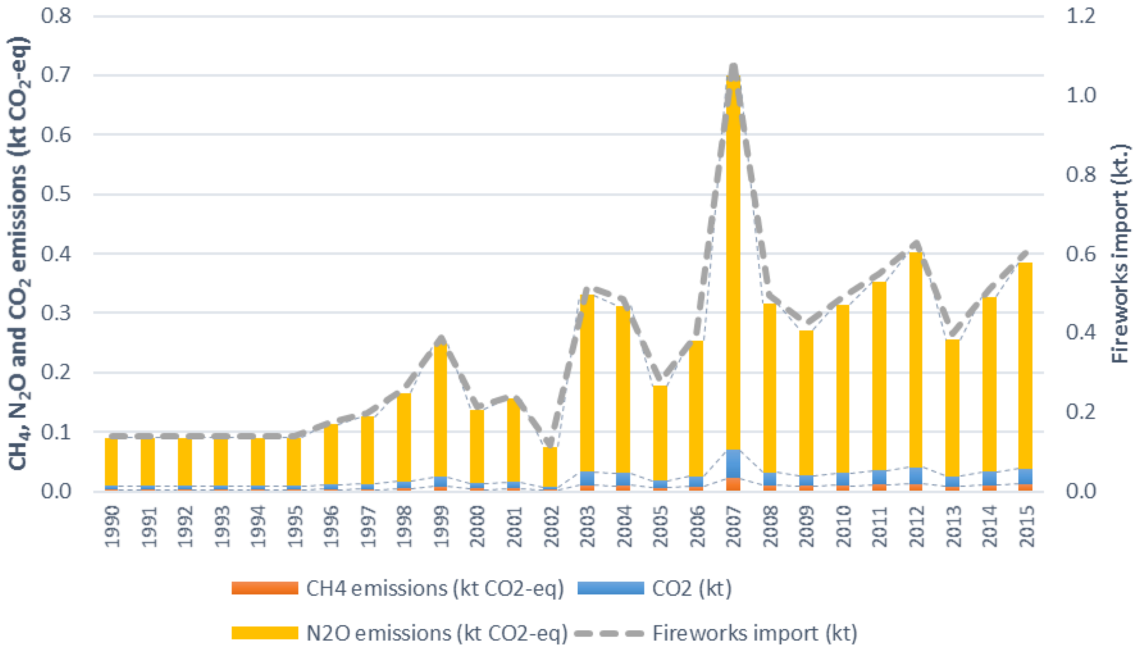

Figure 4.10 Fireworks import and GHG emissions (kt. CO_2-eq.) from firework use.

4.7.3.8 Recalculations and planned improvements

Emissions from fireworks were not reported in previous submissions. The contribution of GHG emissions from fireworks to the total Industry sector (CRF sector 2) is 0.009% for 1990, and 0.02% for 2015. No further improvements are currently planned.

4.7.4 Other (CRF sector 2H)

4.7.4.1 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.

4.7.4.2 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 (Figure 4.15). 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.

4.7.4.3 Emissions

In 2015 NMVOC emissions were estimated at 0.35 kt, which represents a 7.4% increase from the 1990 levels. Figure 4.15 shows the various subcategories contributing to the emissions from the food abnd beverage production industry. Fish, bread and animal feed are by far the largest contributors to the NMVOC emissions from this subsector. The emissions have been on a decreasing trend since 2013.

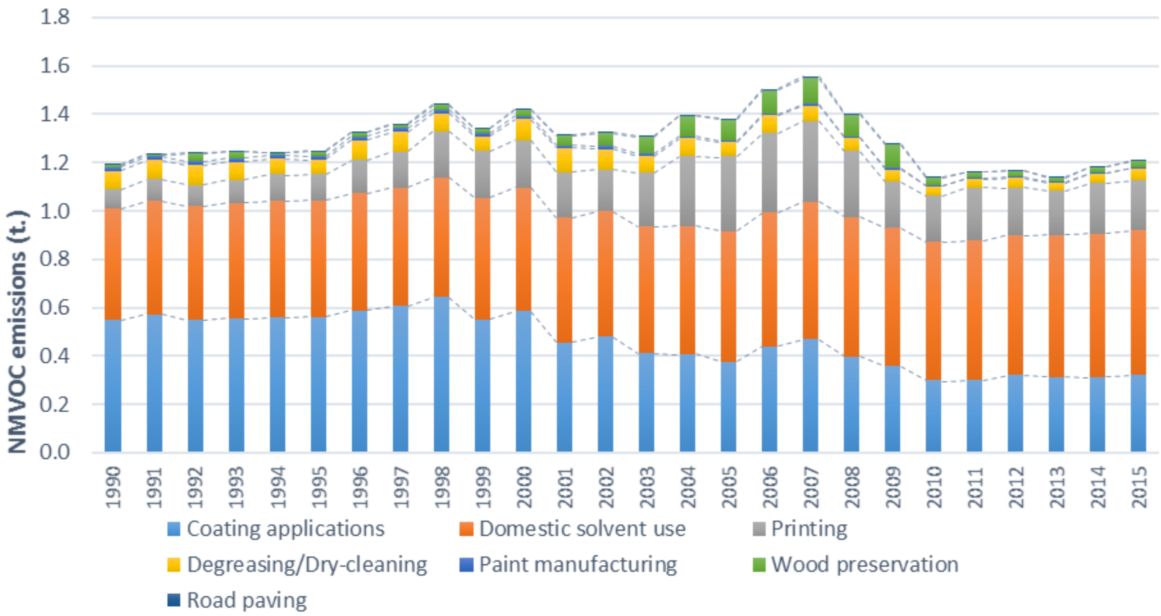

Figure 4.11 NMVOC emissions (in t NMVOC) for various food and beverage processing.

4.7.4.4 Recalculations and planned improvements

Small recalculations were done for this submission, with a changed EF for bread (Previously the default EF for North America was used (8 kg NMVOC/t), has now been replaced by the default EF for Europe (4.5 kg NMVOC/t). Additionally, inaccuracies in the calculations were corrected since the last submission. The overall difference is about 19% in 1990 and 20% in 2015.

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, but potatoes, barley, beets, and carrots are grown on limited acreage.

The total GHG emissions from Agriculture amounted to 616 kt. CO_2-eq in the year 2015 and were 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 and reduced fertilizer application reducing N_2O emissions from agricultural soils. 86% of CH_4 emissions were caused by enteric fermentation, the rest by manure management. 88% of N_2O emissions were caused by agricultural soils, the rest by manure management, i.e. storage of manure.

Significant changes in methodology were made in the chapter on Agriculture, in particular in the part on soil emissions. The changes are explained in 5.1.1. Methodology.

5.1.1 Methodology

The calculation of CH_4 emissions from agriculture is based on the methodologies presented in the 2006 IPCC Guidelines (IPCC, 2006). For estimating N_2O emissions, the methodology was improved to use a comprehensive nitrogen flow approach, as presented in the 2016 EMEP Emissions Inventory Guidebook. 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 2017 submission a large investment was made 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. Further improvements are to be made for the next submission (detailed later in this chapter).

Some changes are: in Manure management 3.B Indirect emissions of N_2O during manure management are now included in the emissions estimates, increasing emissions in all years. In 3.D. Managed soils, the EF used to estimate emissions from soils has been reduced from 0.0125 to 0.01 kg N_2O-N/kg N, in line with the latest information available in the 2006 IPCC Guidelines (Table 11.1). Emission of N_2O are reduced accordingly from the application of synthetic and organic fertilisers and crop residues. 3.D.1.3 Managed soils, grazing animals: In accordance with the IPCC2006 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. 3.Db2 Indirect emissions, Leaching & run-off: In accordance with the IPCC2006 Guidelines (Table 11.3), the EF used is 0.0075 kg N_2O-N/kg N leached. This is a substantial reduction on the value previously used, 0.025 kg N_2O-N/kg N.

The methodology for calculating methane emissions of cattle and sheep from enteric fermentation and manure management is based on the enhanced livestock population characterisation and therefore in accordance with tier 2 methodology. Tier 1 methodology is used to calculate methane emissions from enteric fermentation and manure management of other livestock. The methodology for calculating N_2O emissions from agricultural soils is in accordance with the Tier 1a method of the IPCC Good Practice Guidance, GPG (IPCC, 2000). The sub-source N in crop residue returned to soils, however, was calculated using the Tier 1b method. Indirect N_2O emissions from nitrogen used in agriculture were calculated using the Tier 1a method.

5.1.2 Key category Analysis

The key sources for 1990, 2015 and 1990-2015 trend in the Agriculture sector are as follows (compared to total emissions without LULUCF):

Table 5.1 Key source analysis for Agriculture, 1990, 2015 and trend (excluding LULUCF).

IPCC source category			Level 1990	Level 2015	Trend
Agriculture (CRF sector 3)					
3A	Enteric Fermentation	CH_4	✓	✓	✓
3B	Manure Management	CH_4	✓	✓	
3B	Manure Management	N_2O	✓	✓	
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 Agriculture – completeness (E: estimated, NE: not estimated, NA: not applicable, NO: not occurring).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	NOT OCCURING		
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	NOT OCCURING		
3F Field burning of Agricultural Residues	NE		
3G Other	E		

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 (36% and 250%, respectively). The number of swine, is twelve times higher in the NIR than in the national census.

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 is a history of underreporting due to taxation. According to expert opinion the total is around 75 thousand animals and has remained similar for the past few years, which is considerably higher than in than national census. (IFVA, oral information, 2016) The problem of underreporting in NIR has been seen since 2013 and has been corrected in the 2017 report for data from 2013 to 2015. Data for next year will hopefully be greatly improved. A new and improved system for reporting to the IFVA census will be put into use in 2017 and will improve the matter.

For poultry, not all farmers delivered census data, resulting in a big decrease in the reported population for 2015. Because of this, an estimate has been made for poultry based on veterinary visits by IFVA.

5.2.2 Livestock Population Characterization

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 principally for producing meat, and young cattle. The subcategories “cows used for producing meat”, “heifers”, and “steers used principally for producing meat” were aggregated in the category “other mature cattle”. The subcategory steers used principally 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: 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 and 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	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
other mature sheep	10.3	10.4	NA	NA	10.12	NA
animals for replacement1	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 2015. 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 2015. (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	126
Months in stall	8.71	1	8	11	12
Months on pasture	3.29	11	4	1	0
Mature body weight (kg)	430	500	430	515	515
Daily weight gain (kg)	NO	NO	0.5	1	0.5
Kg milk per day	16.0	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 2015.

Table 5.5. Animal performance data used in calculation of gross energy intake for sheep from 1990-2015 (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	0.2	NA	0.6	NA
Double birth fraction	0.7	NA	0.1	NA
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 V. These values are used for the 2016 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	71	64	7
other mature sheep	71	64	7
animals for replacement	71	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 242 MJ/day in 2015. 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 5.9 t in 2015.

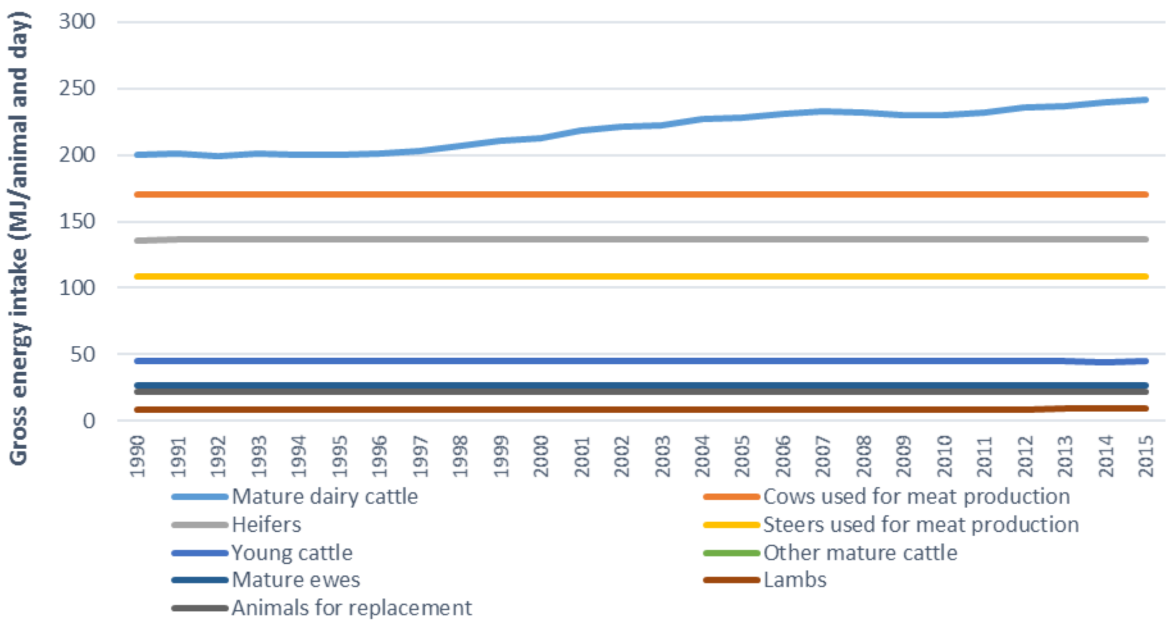

Figure 5.1 Gross energy intake (MJ/day) for cattle and sheep subcategories from 1990-2015.

5.2.4 Planned Improvements

For the next submission it is planned to utilize animal census data from the new systems from IFVA. In future submissions it is planned to update digestible energy content of feed for both cattle and sheep in order to reflect changes in animal nutrition that have occurred since 1990. There are also plans to review the gross energy intake (GE) in MJ per day for all cattle and sheep subcategories.

5.3 CH_4 Emissions from Enteric Fermentation in Domestic Livestock

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:

EGUATION 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

Gross energy intake is calculated in the livestock population characterisation. 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 5.7).

Table 5.7. Methane conversion rates for cattle and sheep (IPCC, 2006).

Category/subcategory	Cattle	Mature sheep	Lambs (<1 year old)
Y_m	0.06	0.07	0.05

For pseudo-ruminant and mono-gastric animal species methane emission factors were taken from the 2006 Guidelines. Values from the Norwegian NIR (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 factors: 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 5.8 are solely based on fluctuations in population size. The population size of mature dairy cattle has decreased by 15% between 1990 and 2015. Methane emissions, however, have increased by 3% from 2.54 kt. to 2.61 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 of population size, emissions from mature ewes decreased by 17% between 1990 and 2015 (from 5.4 to 4.5 kt). Similar decreases can be seen for other sheep subcategories. The only non-ruminant livestock category with substantial methane emissions is horses. A The population size of horses has not varied much since 1990, and consequently the emissions have remained around 1,32 kt.

The decrease in methane emissions from cattle and sheep caused total methane emissions from enteric fermentation in agricultural livestock to drop from 12.6 kt. in 1990 to 12.0 kt. in 2015, or by 5% (Table 5.8).

Table 5.8. Methane emissions from enteric fermentation from agricultural animals for years 1990, 1995, 2000, 2005, 2010 and 2014-2015 in t methane.

Livestock category	1990	1995	2000	2005	2010	2014	2015
Mature dairy cattle	2,540	2,395	2,267	2,201	2,323	2,463	2,612
Cows used for producing meat	0	49	64	91	112	123	137
Heifers	247	689	343	362	369	386	386
Steers used for producing meat	766	656	847	650	810	783	883
Young cattle	358	247	319	322	365	378	418
Mature ewes	5437	4541	4553	4397	4567	4634	4542
Other mature sheep	171	159	156	144	150	151	151
Animals for replacement	651	535	582	604	679	687	637
Lambs	987	823	831	808	846	859	837
Swine	44	47	48	57	61	54	64
Horses	1,332	1,447	1,364	1,382	1,422	1,328	1,328
Goats	2	2	3	3	5	7	7
Fur animals	5	4	4	4	4	5	5
Poultry	13	7	11	15	14	16	16
Total methane emissions	12,553	11,601	11,390	11,041	11,725	11,874	12,022
Emission reduction (year-base year)/base year	0	0	0	0	0	0	0

5.3.3 Recalculations

The largest revision within 3.A.4, enteric fermentation - other livestock is associated with emissions from horses. Horse census data is available as three classes, the horses being divided according to age. Some issues were raised with the quality of the data for 2013 onwards as it was considered that the horse numbers were being underestimated. A review was undertaken, and changes were made to the input data, resulting in an increase in horse numbers for all classes. For example, adult horse numbers for 2014 were revised up from 46,588 to 51,858.

Improvements were also made to CH_4 emissions from poultry, but these resulted in considerably smaller emissions and a downward recalculation.

5.3.4 Uncertainties

Uncertainties of CH_4 emission estimates for enteric fermentation were assessed separately for cattle, sheep and other livestock categories. Cattle and sheep AD uncertainties were calculated as combined uncertainties of livestock population and livestock characterisation. Cattle and sheep population data were deemed reliable and were therefore attributed with an uncertainty of +-5% (expert judgement). Livestock characterisation uncertainty was calculated by propagating uncertainties of net and digestible energies. A +-20% uncertainty was attributed to all net energies used in the calculation. Digestible energy was attributed with an uncertainty of +-10% (expert judgement). Propagation of uncertainty throughout the calculation of gross energy led to AD uncertainties between 15 and 19% for cattle (mean weighted with 2013 emissions = 17.8%) and 16 and 22 % for sheep (weighted mean = 17.2%). The combination of AD and EF uncertainties for cattle and sheep were therefore estimated to be 27 and 26 %, respectively. These values are also shown in Annex II.

Enteric fermentation emission estimates for other animals were calculated using Tier 1 methodology. This entailed that AD uncertainty stemmed from livestock population data only. Livestock population estimates of other livestock categories were deemed to be slightly more uncertain than the ones of cattle and sheep (+-20%, expert judgement). This is mainly due to the fact that the population of e.g. poultry at the time of the census does not allow for as good an estimate of the mean annual population as the population of other livestock categories. The GPG estimates EF accuracy between +-30 and +-50 % (page 4.27). This submission used a value of +-40%. This resulted in a combined uncertainty for CH_4 emissions from other animals of +- 45%.

5.4 CH_4 Emissions from Manure Management (CRF 3B)

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.

EGUATION 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.

EGUATION 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 5.9. 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 manag. 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 live span of lambs. 65% of the manure managed is managed as solid storage, the remaining 35% as liquid/slurry (Table 5.10).

Table 5.10. 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%		0%
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 5.11.

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

Table 5.11. Emission factors values, range and origin used to calculate methane emissions from manure management.

Livestock category	Emission factor 2015	Emission factor range 1990-2015	Source
	(kg CH_4/head year)	(kg CH_4/head year)	
Mature dairy cattle	28.71	24.4 - 28.7	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	0.08		2006 GL

1: Livestock population characterisation.

5.4.3 Emissions

As can be seen in Table 5.11 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 have 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 increase from 2.026 kt. in 1990 to 2.095 kt. in 2015 or by 2%.

Table 5.12. Methane emissions from manure management in tonnes.

Livestock category	1990	1995	2000	2005	2010	2014	2015
Mature dairy cattle	793	742	696	671	701	743	788
Cows used for producing meat	0	2	3	4	4	5	5
Heifers	49	137	68	72	73	77	77
Steers used for producing meat	213	182	235	180	225	212	234
Young cattle	86	59	76	77	87	90	95
Mature ewes	439	367	368	355	369	374	367
Other mature sheep	14	13	13	12	12	12	12
Animals for replacement	74	60	66	68	77	78	72
Lambs	16	13	14	13	14	14	14
Swine	178	187	194	231	243	217	255
Horses	81	87	82	84	86	80	80
Goats	0	0	0	0	0	0	0
Fur animals (minks and foxes)	32	26	28	25	25	35	32
Rabbits	0	0	0	0	0	0	0
Poultry	53	28	43	60	56	61	64
Total methane from manure management	2026	1904	1883	1852	1973	1999	2096
Emission reduction (year-base year)/base year	0%	-6%	-7%	-9%	-3%	-1%	3%

5.4.4 Recalculations

No recalculations were made for Manure Management for the 2016 submission.

5.4.5 Uncertainties

Uncertainties of CH_4 emission estimates for manure management were assessed separately for cattle, sheep and other livestock categories. Cattle and sheep AD uncertainty was calculated as combined uncertainty of livestock population and volatile solid excretion rate uncertainty. Cattle and sheep population data were deemed reliable and were therefore attributed with an uncertainty of +-5% (expert judgement). Uncertainty related to volatile solid excretion rates was calculated by propagating uncertainties throughout the calculation of VS: i.e. combination of gross energy intake uncertainty, feed digestibility uncertainty and ash content uncertainty (cf. chapter 6.3.3). VS uncertainties ranged between 26 and 33% for cattle and 23 and 36% for sheep. AD uncertainty category means were deducted by weighting means with 2013 emission estimates. The respective values for cattle and sheep were 28% and 24%, respectively. EF uncertainties were estimated by combining assumed uncertainties for maximum methane producing capacity and methane correction factor uncertainty. The latter was estimated to be higher (100%, expert judgement) than the former (30%, expert judgement).

Emissions from other animals were attributed with a livestock uncertainty of 20% and an EF uncertainty of 200% (both expert judgement).

The above mentioned AD and EF uncertainties were combined by weighting them with 2013 emission estimates. This was done in order not to unnecessarily fragment categories for key source and uncertainty analyses. Category AD uncertainty amounted to 25% and category EF uncertainty to

121% combining to a total uncertainty of 124% for methane emission estimates from manure management. These values are summarized in Annex II.

5.5 N_2O Emissions from Manure Management (CRF 3B)

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 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 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 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 NH_3-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 (f_{min}) to TAN before the gaseous emissions are calculated.
Step 10: Calculate the emissions of NH_3, N_2O, NO and N_2 (using the corresponding EFs).

Step 11: Calculate the total-N and TAN that is applied to the field (remembering to subtract the emissions of NH_3, N_2O, NO and N_2 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 NH_3-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 5.10.

Average annual nitrogen excretion rates were calculated using 2006 GL default values (*Table 5.13*). 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 2000-2015. 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 and Eggertsson, 1991).

Table 5.13 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	35.5
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, 2017.

N_2O EFs from the storage of manure are based on the IPCC 2006 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 IPCC 2006 Guidelines and the 2016 EMEP/EEA Emissions Inventory Guidebook (

Similarly, the EFs used for manure managed in solid storage is based on the default value of 0.02 kg N_2O-N emitted per kg of nitrogen excreted, but incorporates 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 137 tonnes N_2O in 2015 and 168 tonnes in 1990 (-15%).

Emissions from liquid systems make up only a small part of total emissions from managed systems or only 6% of total N_2O emissions from manure management systems in 2015. 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 72% in 2015, followed by solid storage of poultry manure (10%), horse manure (5.8%), and fur animal manure (5%).

Figure 5.2 N_2O emissions from manure management in kt. N_2O.

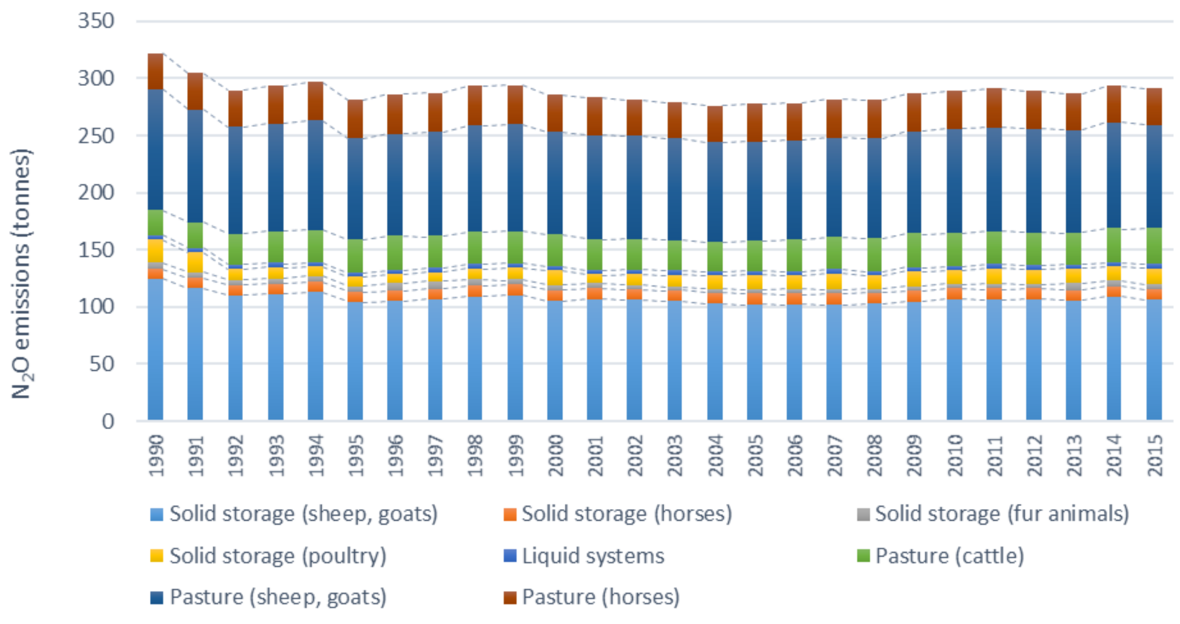

Figure 5.2 shows N_2O emissions from liquid systems and solid storage. It also includes emissions from manure deposited directly onto soils from farm animals. Although they are reported under emissions

from agricultural soils in national totals, they are included here to show their magnitude in comparison to other emissions. In 2015 N_2O emissions from manure spread on pasture by livestock amounted to 154 tonnes. Emissions from sheep manure were 90 tonnes, emissions from horse manure were 32 tonnes, and emissions from cattle manure amounted to 32 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 32 tonnes N_2O for 2015, increasing 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 Uncertainties

Uncertainty for N_2O emissions from manure management was estimated by combining cattle, sheep and other animal uncertainties. AD uncertainty was calculated as combined uncertainty of livestock population, nitrogen excretion and manure management system uncertainties. Livestock population uncertainties were 5 % for cattle and sheep and 20 % for all other animals (expert judgement). Nitrogen excretion rates were drawn from the 2006 GL which state their uncertainty as +-50% (page 10.66). Manure management system uncertainty is highest for sheep due to the variability in sheep manure management (25%) and less for other livestock categories (10%). These uncertainties were combined by multiplication for each of the three categories and then weighted by 2012 emission estimates, resulting in an AD uncertainty of 56%. Tables 4.12 and 4.13 in the 2006 GL attribute an EF uncertainty of 100% to N_2O emission factors from manure management. The weighted combined uncertainty for N_2O emissions from manure management was therefore estimated to be 114%.

Uncertainty estimates for emissions from animal production were calculated analogously and weighted with emissions from pasture, range, and paddock manure yielding a combined uncertainty of 114%.

5.5.7 Planned Improvements

The nitrogen excretion rate for cattle and sheep will be recalculated using data on feed and crude protein intake developed in the livestock population characterisation and default N retention rates to recalculate nitrogen intake. In addition, a review of the N_2O EFs for manure storage will be be undertaken before the next submission (as explained in 5.5.3 above).

5.6 Direct N_2O Emissions from Agricultural Soils (CRF 3D)

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 UN/ECE 2016 Guidebook, but retains full consistency with the higher tier methodologies in the IPCC 2006 Guidelines. The methodology applied to manure management is described in earlier sections of this chapter, and provides the amount of N leaving manure storage (both slurry and solid) that is available for application to land.

Improvements to Emission Factors

In accordance with the IPCC2006 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 3.Db2 Indirect emissions, Leaching & run-off. In accordance with the IPCC2006 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 2006 IPCC 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 2006 IPCC 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. The use of sewage sludge is however increasing and is estimated to increase in the next few years. Preliminary results indicate an approximate amount of 200 tonnes of stabilized sewage sludge used in all Iceland in the year 2015. This is a substantial increase since 2012-2014 where the total in Iceland is estimated to have been around 25 tonnes. Assuring proper channels for accurate data is ongoing work but 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 below in Figure 5.3.

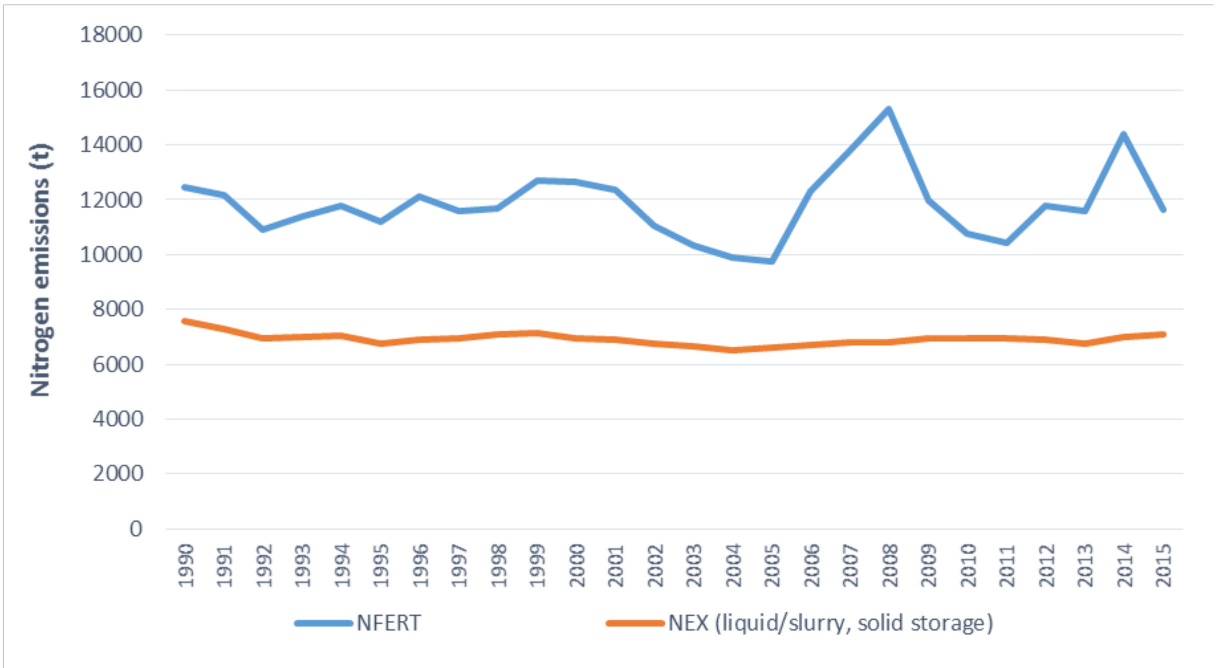

Figure 5.3 Amounts of nitrogen from synthetic fertilizer and animal manure application.

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 for the 2006 GL.

Residue/crop ratio, dry matter fraction and nitrogen fraction are IPCC default values. Dry matter fraction defaults, though, do not exist for potatoes and beet. By expert judgement, they are estimated to be 0.2 for both crops. No defaults exist for carrots, therefore beet defaults are applied. It is estimated that 80% of barley residue is used as fodder. Crop produce amounts are shown below in (**Error! Reference source not found.**).

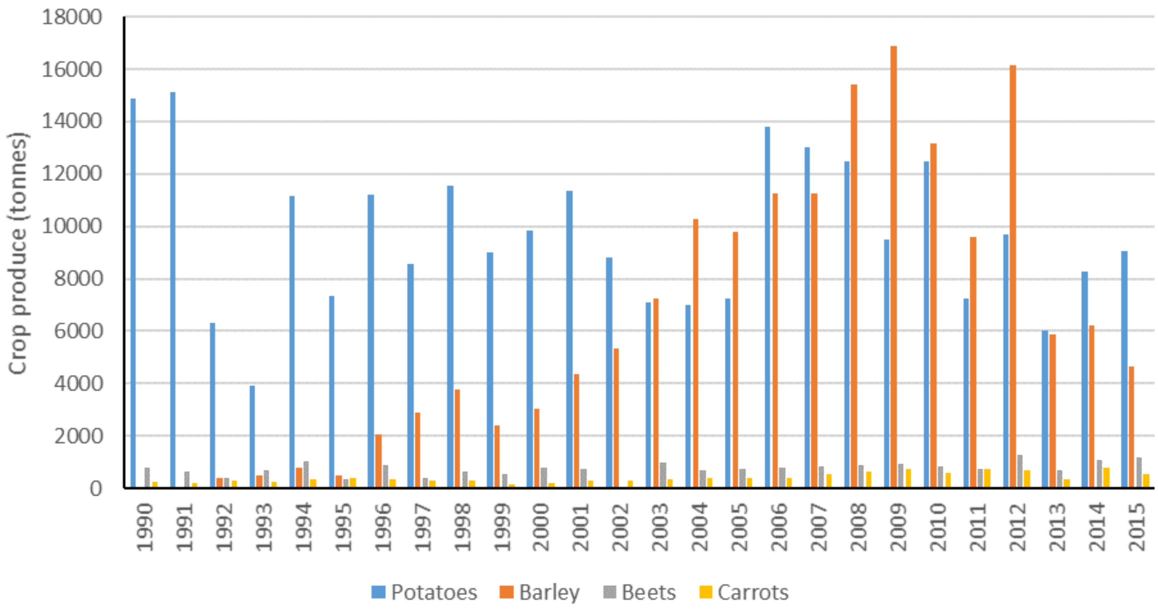

Figure 5.4 Crop produce in kilotonnes for 1990-2015.

The amount of nitrogen in crop residues returned to soils was lowest in 1993, when it amounted to roughly 5 tonnes and highest in 2008 when it amounted to roughly 27 tonnes. It has to be noted, however, that there is a very large difference in scale between amounts of nitrogen in crop residues returned to soils and N amounts in synthetic fertilizer and animal manure applied to soils. N inputs to soils from crop residues range between 10 and 20 tonnes per year, N inputs to soils from synthetic fertiliser application ranges from 5,000 – 15,000 tonnes per year.

5.6.6 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 estimate for cultivated organic soils in 1990 was 65 kha. This area has decreased steadily since then and was estimated to be less 56.3 kha in 2015.

A country specific emission factor of 0.97 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 (0.97 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, 2009).

Emissions

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 380 tonnes N_2O in 2015, which meant a silght decrease in comparison to 1990 emissions. (Figure 5.5).

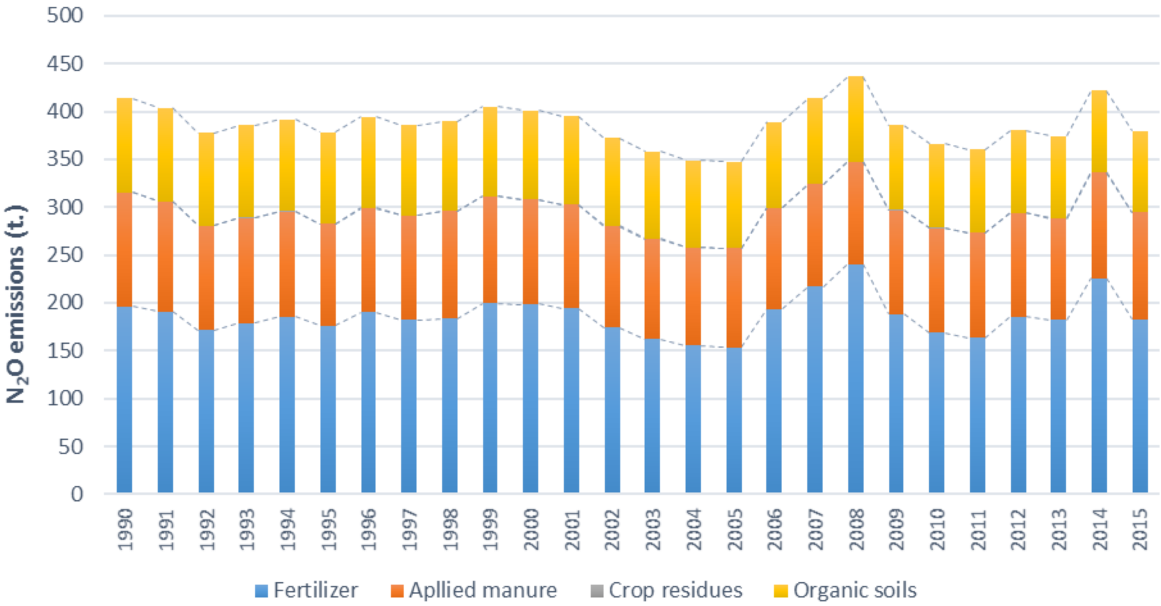

Figure 5.5 Direct N_2O emissions from soils (kt).

5.6.7 Uncertainties

Uncertainties from direct soil emissions were estimated for the category as a whole. To this end AD and EF uncertainties of fertilizer nitrogen, manure nitrogen, and area of organic soils cultivated annually were first weighted with respective 2013 emissions and then combined by multiplication in order to result in combined uncertainty estimates for the emission category. 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). The uncertainty in the amount of nitrogen in manure applied to soils was with higher (54%) as a result of multiplying NEX uncertainties (as described in chapter 6.5.4) with a livestock population uncertainty of 20%. The area of cultivated organic soils was attributed with an uncertainty of +-20% in accordance with area uncertainty estimates for cropland in LULUCF. Total AD uncertainty for direct N_2O emissions from soils weighted with 2012 emission estimates was therefore 31%.

AD uncertainty, however, is overshadowed by emission factor uncertainty related to nitrogen application to soils. According to the GPG the best estimate of the 95% confidence interval range from one fifth to five times the EF of 1.25%, i.e. 400% uncertainty. Uncertainty for the country specific value for N_2O emissions from cultivated organic soils is 25%. EF uncertainty was weighted in the same way as AD uncertainty resulting in a value of 326%. Combination of AD and EF uncertainties for direct soil emissions yielded a value of 328%.

5.6.8 Planned improvements

Preliminary results indicate an approximate amount of 200 tonnes of stabilized sewage sludge used in all Iceland in the year 2015. This is a substantial increase since 2012-2014 where the total in Iceland is estimated to have been around 25 tonnes. Assuring proper channels for accurate data is ongoing work but estimates will be included in next year´s submission.

5.7 Indirect N_2O emissions from nitrogen used in agriculture

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 1990-2015 - after conversion from nitrogen to nitrous oxide - is shown in Figure 5.6. N_2O emissions amounted to 165 tonnes N_2O in 2015, which decrease slightly from the 1990 value of 174 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.

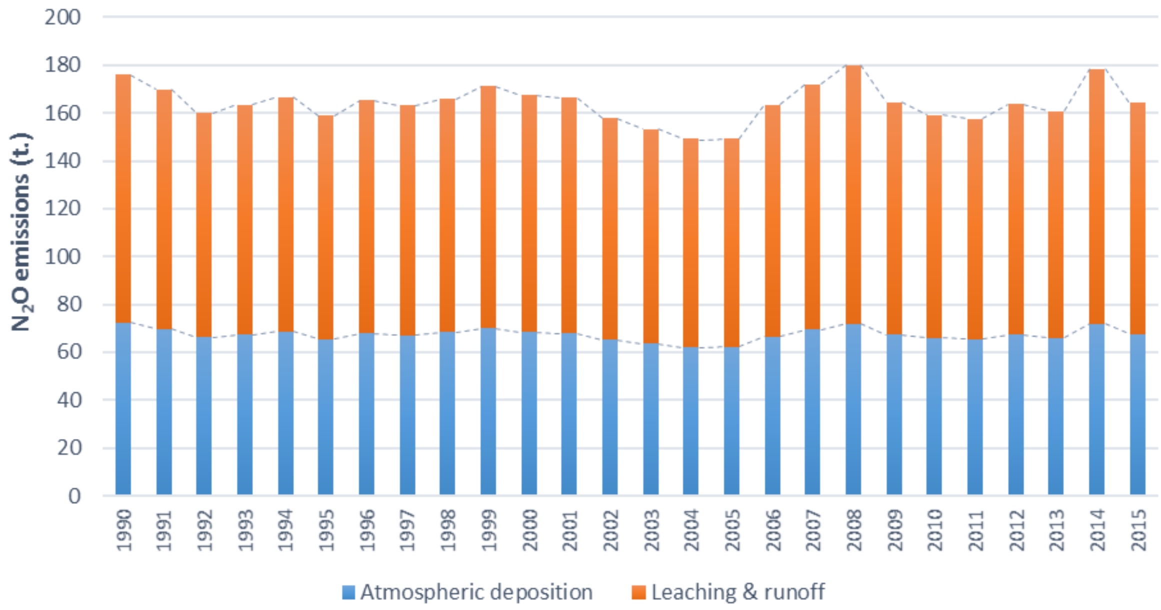

Figure 5.6 Indirect N_2O emissions from agricultural soils.

5.7.5 Uncertainties

Uncertainties from indirect soil emissions were estimated for the category as a whole. To this end AD and EF uncertainties of fertilizer nitrogen and manure nitrogen were first weighted with respective 2012 emissions and then combined by multiplication in order to result in combined uncertainty estimates for the emission category. AD uncertainty consists of AD the uncertainty regarding the amount of nitrogen in fertilizer and manure (cf. chapter 6.6.5) combined with uncertainty regarding the fraction of N that volatilizes, which is estimated by the GPG to be +-50% (p. 4.75). Combined weighted AD uncertainties of 67% are dwarfed by an order of magnitude uncertainty for the EF (GPG, page 4.75). Combined uncertainties are estimated to be 1002%.

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

6.1 Overview

This sector emissions and removals related to land use, land use changes and forestry (LULUCF). 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, the Icelandic Forest Research and the Soil Conservation Service of Iceland are responsible for preparing the inventory for this sector.

More than 90% of the total area of Iceland is included in two land use categories i.e. Grassland and Other Land. **Error! Reference source not found.** shows the relative division of the area of Iceland to the six main land use categories reported.

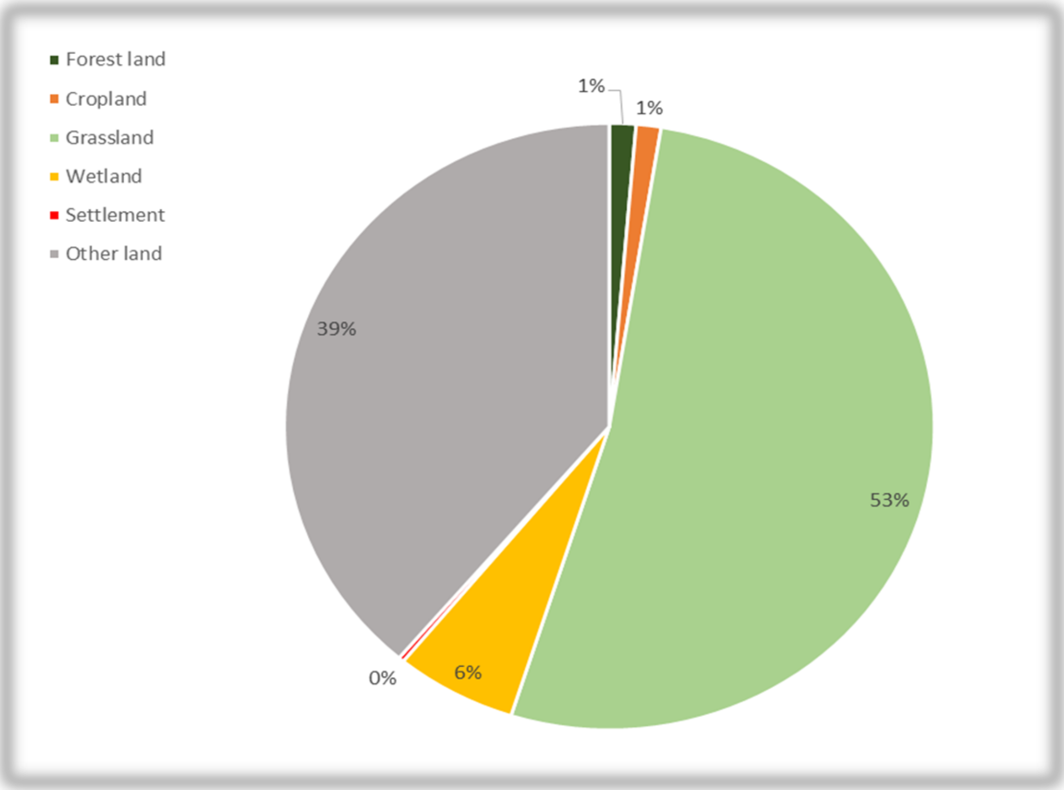

Figure 6.1 Relative size of land use categories in Iceland according to IGLUD land use map 2013 and other land use estimates available for the reporting.

Both emissions from sources and removals by sinks are reported for this sector. The net contribution of the main land use categories is summarized in **Error! Reference source not found.**, Table 6.1.

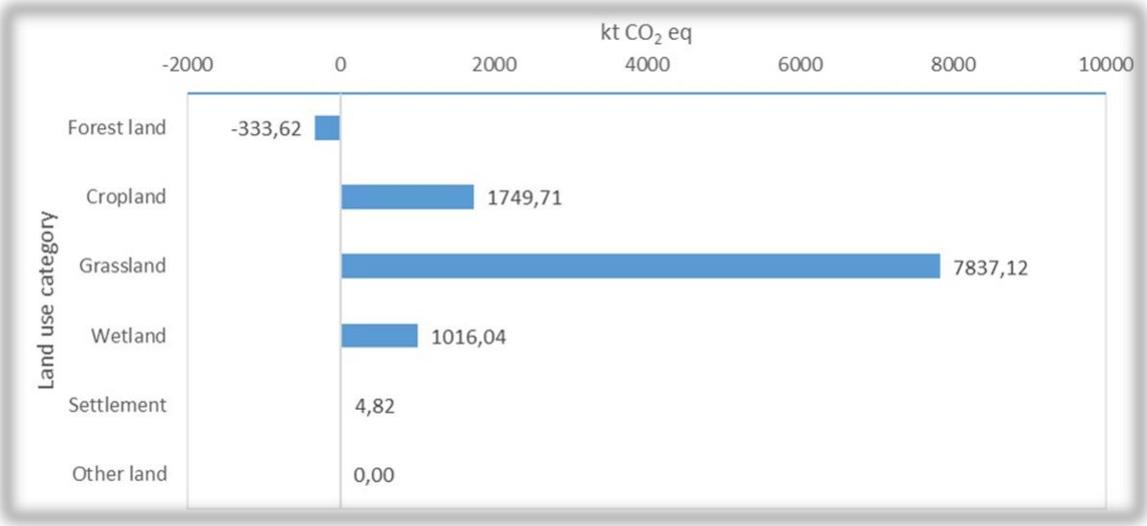

Figure 6.2 The net emission/removals of land use categories in kt. CO_2 eq., according to this submission. N_2O emission from drained Grassland is reported as LULUCF "Other (4H)", but included as Grassland emission here. The N_2O emission from Cropland management of organic soils is reported under Agricultural sector and not include here.

The sum of all emissions reported is 13,502 kt. CO_2 eq, and is dominated 87.0% by 11,747 kt. CO_2 eq emissions related to drainage of organic soils, mostly of included under Grassland, Cropland and small areas of "Forest land". Another important emission component 12.0% or 1,626 kt. CO_2 eq, 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 43.1 % or 700 kt. CO_2 eq, to biomass and SOC in revegetation 35.3 % or 572 kt. CO_2 eq, to biomass and SOC in forest 18.1 % or 293 kt. CO_2 eq. Other contributing components 3.7% 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 slightly or from 10,322 kt. CO_2 eq to 10,274 kt. CO_2 eq. Emission for several components is revised and the emission for the year 2014 in last year's submission was 11,890, reflecting the effect of this revision.

The CRF tables are prepared through new version of the CRF reporter (version 6.0.1). The information on all categories have the same structure as in last submission, except for "Forest land". The land classified as "Cropland converted to Forest land" in previous submissions is now included as "Grassland converted to Forest land" (see chapter 6.4).

6.2 Land use practise and consequences

The present state of vegetation and soils is the result of past and present climatic conditions, volcanic activity and land use history. The possible pattern of anthropogenic impact on the landscape and soil erosion in southern Iceland has been studied (Dugmore et al. 2009). There a two-stage process of soil erosion is suggested involving overgrazing causing patterns of damaged vegetation cover in the uplands followed by soil erosion and rapid total denudation of large areas of relatively shallow soils before beginning of the 16th century. Later the soil erosion on lowland areas started, triggered by disruption in vegetation cover. At the time of settlement the natural birch woodlands were widespread but by the end of the 19th century it was mostly exhausted as result of land clearance, intensive grazing, collection of firewood and charcoal making (Þórarinsson 1974).

At the onset of the 20th century, the country had suffered from extensive soil erosion and most of the woodland lost. Cultivation was limited and large part of livestock fodder came from uncultivated meadows and wetlands. In the 20th century cultivation was increased considerable especially in the period 1930 to 1990 (Figure 6.3) both on naturally drained soils and through drainage of wetland soils. The drainage of wetlands was far more extensive than what was ever cultivated leaving large areas as drained grassland.

The establishment of the Soil Conservation Service of Iceland (SCSI) at the beginning of the 20th century was to combat the progress of drifting sand threatening farmlands in many areas. The SCSI has ever since been combating soil erosion and actively re-vegetating land. The first mapping of soil erosion was at the end of the 20th century. The results showed still ongoing soil erosion and large areas of degraded land. The highland areas have almost completely lost their soil mantle and erosion has affected large areas in the lowland regions as well (Arnalds et al. 2001). At the beginning of 20th century, there was increased interest in protecting the remaining birch forest and cultivation of new forest. The Icelandic Forest Service, established in the beginning of the 20th century, has since worked on protection of remaining natural forest and cultivation of new forest.

The increased cultivation along with other factors lead to increased livestock number. The number of sheep reached a maximum in 1977 leading to over-production of lamb meat and high grazing pressure on many areas. Following this maximum in sheep number was a rapid decline in number until 1990 when present winterfeed, stock size level was reached (**Error! Reference source not found.**). This decline is almost but not entirely reflected in the decline in sheep numbers on the grazing areas as the average fertility has increased in the period (Jónmundson and Eyþórsdóttir 2013) and the time spent on highland grazing areas is better managed than before also affecting the overall grazing pressure.

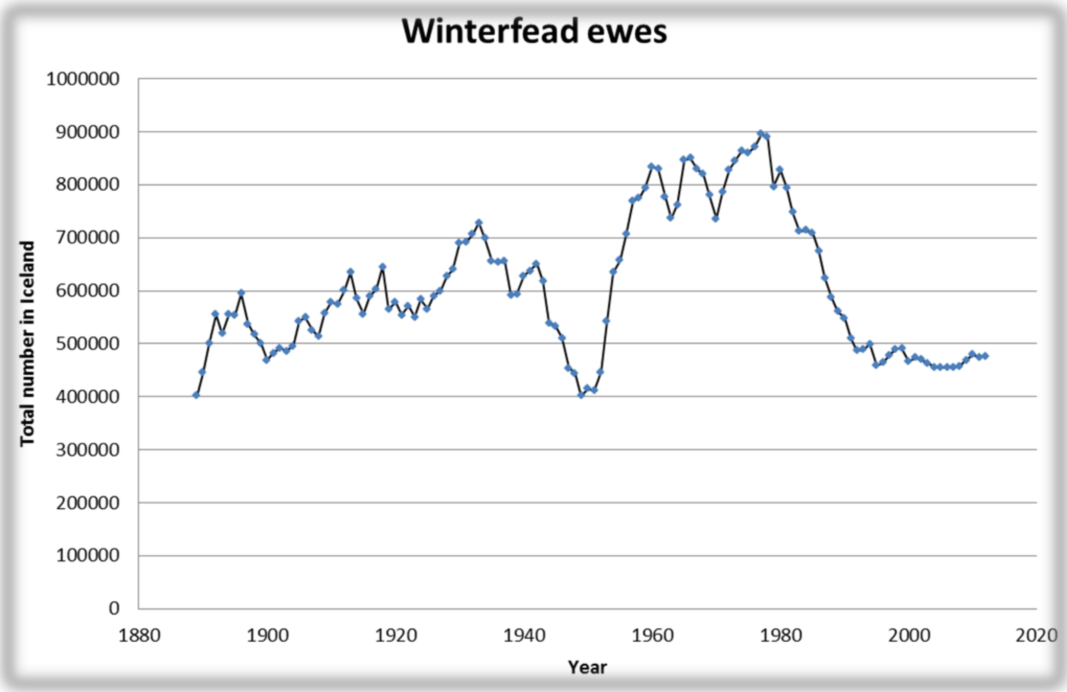

Figure 6.3 Changes in number of winterfed sheep as officially recorded (Statistic Iceland website 2014).

In the land-use history of Iceland, losses and degradation of natural resources including forest, other vegetation, soils and wetlands plays a big role. According to new mapping effort of natural birch forest and monitoring of afforestation, reforestation and deforestation by the Icelandic Forest Research, forest is presently increasing in area and accumulating carbon. Area of land in revegetation process is presently increasing and accumulating carbon in both vegetation and soil but monitoring of ongoing soil erosion and vegetation losses is fragmentary. The balance of soil formation and losses is thus unknown. According to information presented in this report the area of wetlands drained each year is still larger than the area rewetted. The drained wetland soil is in this inventory estimated to lose much more carbon than is accumulated in the un-drained wetlands.

The degradation of these resources in the past and those still ongoing holds in it potentials to prevent ongoing losses and restore their previous state. The degradation of these resources and their restoration has tight connection to the carbon stocks included. As clearly reflected in this report, the impact of the land use sector of Iceland is very large and consequently holds opportunities to change the emission profile of the nation drastically. Afforestation and revegetation are examples of this restoration work already practised in Iceland and acting as carbon sinks. The impact of the drainage of wetland soils on the emission profile is large as the potential for decreasing the net emission through wetland rewetting. The estimates on emissions and removals of greenhouse gasses through ongoing processes on land classified as “other Grassland” are still not available. These processes include losses of soil and vegetation through soil erosion and degradation, accumulation of soil carbon through soil thickening by deposition of new soil materials, carbon sequestration through increased vegetation. The following chapters provide discussion on the impact of these sinks and sources for the relevant land use category.

6.3 Data sources

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 Westfjord’s Natural History Institute and biomass estimation for relevant land categories obtained through IGLUD field sampling as described in (Gudmundsson et al. 2010).

The description of compilation of available geographical data into this year’s IGLUD land use map is in Ch. 6.3.1, and the methodology of the compilation process in Gudmundsson (2013). For several land use categories, other estimates than IGLUD land use map exist. The estimates considered more accurate than the land use map replace the mapped area estimate in the reporting. This applies e.g. to the total area of cultivated forest. The maps compiled to IGLUD land use map represent mapped forest and a buffer zone. The selection of sampling points for the forest inventory is from this area. Few of these sampling points do not include cultivated forest and consequently the total area of cultivated forest is smaller than the mapped area. Only the total area can be corrected, as the decrease in area is not geographically identifiable. The reporting of the area mapped as cultivated forest in IGLUD land use map, but not reported in the CRF has consequently to be under other land use category/ies. In other cases, the area reported is larger than the comparable mapping unit, as with land re-vegetated before 1990 then the difference in area has to be transferred from other land use categories to that category. The description of the adjustments of mapped area are in chapter 6.3.5.

6.3.1 The Icelandic Geographic Land Use Database (IGLUD)

6.3.1.1 Introduction

The objective of the Icelandic Geographic Land Use Database (IGLUD) is to compile information on land use and land use changes compliant to requirements of the AFOLU Guidelines (IPCC 2006), and the 2013 Supplement to the 2006 Guidelines: Wetlands (IPCC 2014). Second objective is to extract from this information reliable land use map containing the land use categories applied in the national inventory to the UNFCCC. The first step toward these objectives is to identify geographically all the six main land use classes defined in AFOLU guidelines (IPCC 2006). Important criteria regarding subdivision of land use categories is to recognise the land use practices most affecting the emission or removal of greenhouse gasses. Either this subdivision can be relative and thus not geographically identifiable or it can be geographically identifiable at various resolutions. The data on relative division can be for either a region or the whole country. Relative division data can be from ground surveys or other available additional information. To aid the geographical identification of land use categories the definitions of each category need to take in account as much as possible if the category is recognisable both through remote sensing and on the ground. This applies especially to those categories not otherwise systematically mapped.

The IGLUD database contains; map layers of diverse origin as explained below, 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 is in Gudmundsson et al. (2010).

A short description of the database is here below, a list of its main data sources, definitions of main land use categories as applied in IGLUD and present structure of subcategories.

6.3.1.2 Definitions of IGLUD land use categories

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.

Subcategories applied in IGLUD land use map

The land use map applied for this year's submission, shows sixteen land use categories.

Three forest map layers from IFR represent Forest land. The classes are "Forest planted 1908-1989", "Forest planted since 1990" and "Natural birch forest".

Two classes represent Cropland   i.e. "Cropland" and "Cropland on drained soils". The geographical separation of the latter is based on total area of drained croplands estimated through time series for Cropland and delineation of area of same size by choosing lower limits for the density of the ditches network, calculated as described in Gísladóttir et al. (2010).

Five classes in the land use map represent Grassland; "Natural birch shrubland" as mapped by IFR, "Revegetation before 1990" and "Revegetation since 1990" as mapped by SCSI, "Grassland drained" as identified on basis of the map layer drained land, and "Grassland other" as all other land included as Grassland.

Three classes in the land use map represent Wetland ; "Lakes and rivers", "Reservoirs", and "Other Wetland".

The class "Settlement" represent all settlement area in the land use map

Two classes represent Other land; "Glaciers and perpetual snow" and "Other land".

6.3.1.3 Main Data Sources compiled in IGLUD

The resulting classification of land use as presented in this submission is based on several sources, the most important listed here.

NYTJALAND - Icelandic Farmland Database (IFD): Geographical Database on Condition of Farming Land

The Agricultural University of Iceland and its predecessor the Agricultural Research Institute, in cooperation with other institutions, constructed a geographical database (IFD) on the condition of vegetation on all farms in Iceland.

Table 6.1 The original land cover classes of the IFD showing the full scale classes and the coarser class aggregation.

IFD full scale Classes (Icelandic name in brackets)	Short description	Coarse class name
Cultivated land (Ræktað land)	All cultivated land including hayfields and cropland.	Cropland and pasture
Grassland (Graslendi)	Land with perennial grasses as dominating vegetation including drained peat-land where upland vegetation has become dominating.	Grassland, heath-land shrubs and forest complex
Richly vegetated heath land (Ríkt mólendi)	Heath land with rich vegetation, good grazing plants common, dwarf shrubs often dominating, and mosses common.	Grassland, heath-land shrubs and forest complex
Poorly vegetated heath land (Rýrt mólendi)	Heath land with lower grazing values than richly vegetated heath land. Often dominated by less valuable grazing plants and dwarf shrubs, mosses and lichens apparent.	Grassland, heath-land shrubs and forest complex
Moss land (Mosi)	Land where moss covers more than 2/3 of the total plant cover. Other vegetation includes grasses and dwarf shrubs.	Grassland, heath-land shrubs and forest complex
Shrubs and forest (Kjarr og skóglendi)	Land where more than 50% of vertical projection is covered with trees or shrubs higher than 50 cm	Grassland, heath-land shrubs and forest complex
Semi-wetland-wetland-upland ecotone-(Hálfdeigja)	Land where vegetation is a mixture of upland and wetland species. Carex and Equisetum species are common as well as dwarf shrubs. Soil is generally wet but without standing water. This category includes drained land where vegetation is not yet dominated by upland species.	Semi-wetland/wetland complex
Wetland (Votlendi)	Mires and fens. Variability of vegetation is high but this class is dominated by Carex and Equisetum species and often shrubs.	Semi-wetland/wetland complex
Partially vegetated land (Hálfgróið)	Land where vegetation cover ranges between 20-50%. Generally infertile areas often on gravel soil. This class can both include areas where the vegetation is retreating or in progress.	Partly vegetated land
Sparsely vegetated land (Líttgróið)	Areas where less than 20% of the vertical projection is covered with vegetation. Many types of surfaces are included in this class.	Sparsely vegetated land
Lakes and rivers (Vötn og ár)	Lakes and rivers	Lakes and rivers
Glaciers (Jöklar)	Glaciers and perpetual snows	Glaciers

The project used two levels of classification. Full-scale mapping divides the land into twelve classes, ten for vegetation and two for lakes, rivers and glaciers. The coarser classification of has seven classes, modified according to CORINE requirements (Bossard et al. 2000). List of the classes used in IFD is in Table 6.2. The full-scale mapping covers approximately 60% of the country and 70% of the lowlands below 400 m elevation in Iceland. This geographical database is based on remote sensing using both *Landsat 7* and *Spot 5* images, existing maps of erosion and vegetation cover and various other sources. Adding these two levels of classification, i.e. one with seven classes and other with 12 classes, a whole country map layer of this classification is available. This work is has recently been summarised and ground truth work analysed revealing 76% overall accuracy (proportion of correctly classified- % PCC) for the whole picture applying clumped categories of the coarser classification for the full scale classification (Gísladóttir et al. 2014). This clumping is comparable to the merging of categories applied in IGLUD Land use map.

The pixel size in this database is 15×15 m and the reference scale is 1:30,000. The data was simplified by merging areas of a class covering less than 10 pixels to the nearest larger neighbour area, thus leaving 0.225 ha as the minimum mapping unit.

Before compiling the IFD classes into IGLUD each land cover class is converted to a separate map layer thereby creating 18 map layers.

The two level IFD modified as described above is the primary data source of IGLUD.

IS 50 V2013/2016

The IS 50 V2013 geographical database of the National Land Survey of Iceland (NLSI) includes eight map layers. From that database five map layers are used in IGLUD, i.e. “Towns and villages”, “Airports”, “Roads”, and “Glaciers and perpetual snows”. The roads in the IS 50V2013 database are linear features representing the centreline of the road. To allocate area to roads a buffer zone, defined according to road type, was added. The IGLUD land use map for 2015 contains a new map layer of lakes and rivers IS 50 V2016. These map layers are in vector format and before entering the IGLUD they are converted to raster format and resampled to 15x15m pixel size.

Maps of Forest and Other Wooded Land

All known woodland (synonym for forest and other wooded land) including both the natural birch woodland and the cultivated forest has been mapped at the IFR on the basis of aerial photographs, satellite images and activity reports. This map forms the geographical background for the National Forest Inventory (NFI) carried out by IFR. The control and correction of this map is part of the NFI work. The IFR has completed the revision of the map layers on birch forest and shrubland based on field mapping (Snorrason et al. 2016). The revised maps of these categories are applied in preparing the IGLUD land use map for this submission. The category Forest Land in IGLUD map is based on the IFR maps. The maps of natural birch forest and natural birch shrubland were split to two layers one with the area overlapping with the buffer on the drainage ditches and remaining area in the other layer. The area overlapping with the buffer is defined as potentially drained area. The maps are in vector format including classification attributes connected to each mapping unit. Before entering the IGLUD database they are; converted to raster format, resampled to 15x15m pixels and then divided to seven separate map layers according to their feature attributes. In this submission, updated version of the IFR map layers on cultivated forest is applied.

Maps of Land being re-vegetated

The SCSI collects information on revegetation activities. The majority of revegetation activities since 1990 are already mapped and available in vector format. Mapping of the activity “Farmers re-vegetate the land” (FRL) has now been completed and is also available in vector format. FRL is a cooperative revegetation activity between SCSI and voluntary participating farmers. These maps form the geographical background of the “National inventory of revegetation activities” (NIRA), carried out by SCSI. The recorded activities, which are currently not mapped are not included in the NIRA but will be added consequently as their mapping proceed. Unmapped activities are included as activity in CRF and the difference in maps and activity is balanced against other land use (see chapter 6.3.5). The SCSI has revised and updated all map layers of re-vegetated land, and those revisions are applied in the IGLUD land use map for this submission. The revegetation taking place before 1990 is presently far less mapped. The documentation of the activities at that time focuses more on site of the activity rather than its geographical delineation. Efforts are needed to locate and delineate currently un-located activities prior to 1990 based on available information and data. The activities before 1990 already mapped are available in vector format. The categories of Re-vegetated land in IGLUD are based on these maps.

Maps of Drained land

The extensive drainage that took place mostly in last century was not recorded geographically. Some of the ditches were included though in the NLSI topographical maps. All ditches recognizable on satellite images (SPOT 5) were digitized 2008 in a cooperative effort of the AUI and the NLSI.

The map layer “Drained land” was prepared by AUI from the map of ditches. The first step was to attach a 200 m buffer zone on every ditch. From the area such included the overlap with following map layers extracted form IFD was excluded; “Sparsely vegetated land” (ID: 603 and 604), “Partly vegetated land” (ID: 506 and 510), “Lakes and Rivers” (ID: 404), “Shrubs and forest” (ID: 507) and the IFR map layer Natural birch woodland <2 m (ID: 517). Additionally all areas where slope exceeded 10° or extended below seashore line were excluded. To exclude steep areas the AUI elevation model (unpublished), based on NLSI elevation maps, was used. The map layer is in raster format. This map layer of drained land 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 map layers of potentially drained area; natural birch forest (ID: 207), natural birch shrubland (ID: 518), and shrubs and forest (ID: 508) were prepared by extracting the overlap of layers ID: 206, 517 and 507 respectively with the 200 m buffer zone (where land with slope exceeding 10° and land included in the layer “Lakes and Rivers” excluded).

Maps of cultivated Land

The map layer Cropland was originally also produced in cooperation with NLSI. The digitization was then completed in 2009 by AUI. This map layer is the only source of identification of Cropland in IGLUD. The map layers identifying Cropland in IFD are not included as Cropland in IGLUD land use map, as considered far less accurate. The area of Cropland on drained wetland (“organic”) soils is included in the IGLUD land use map. The geographic identification of drained wetland soils within Cropland is ongoing project of AUI. The area shown as Cropland on drained soil is estimated by GIS processing by adjusting density classes of the ditch network to the area of cropland drained soils estimated through time series (see chapter 6.3.3).

Maps of reservoirs

Two map layers on reservoirs are available. One with the reservoirs of Landsvirkjun, which is the main hydropower company in Iceland. The map layer for the Landsvirkjun reservoirs was updated for the 2015 IGLUD land use map. The second layer was prepared by AUI on basis of available information (Sigurðsson 2002) and local knowledge. This second layer Includes many smaller reservoirs and reservoirs managed by others than Landsvirkjun. This map layer still needs to verification. These layers are available in vector format and are converted to raster and resampled to 15x15 m pixels before entering IGLUD.

Map of zone of recently retreated glaciers.

The comparison of previous map of glaciers and perpetual snows included in IFD to the one from IS50 V2013 reveals less area included in the IS 50V2013. This shrinkage of glaciers and perpetual snows exposes land not previously classified. This land is included as a separate map layer in IGLUD. This data is in raster format.

Map of pixels from the old layer of lakes and rivers with lost classification

In previous submissions (before 2014) two map layers were representing lakes and rivers, i.e. one from IFD and the other from IS 50 v3.2. In last year’s submission new IS 50 v2013 layer replaced these layers. The land use map of this year's submission includes a new updated layer from IS 50V2016. Small areas of land, which in the IFD was classified as lakes and rivers but is not included in the new IS 50V2016 layer, are not identified to any of the other map layers included. This land is included as separate layer while no classification is available. This map layer is prepared in raster format.

Map of unclassified land added through revision of outer boundaries.

In submissions prior to the year 2014 the outer boundaries of Iceland were represented by the total area classified in the IFD. In the 2014 submission the outer boundaries lines were extracted form IS 50V2013. This revision resulted in an addition of many small islands and islets and costal outline changes. This revision excluded some areas from the IFD classes and added new areas not previously classified. These new areas form a separate map layer in this submission.

Map of historical lava fields covered with mosses

To separate land with almost full vegetation cover but less than 20% cover of vascular plant, geological maps and vegetation maps were compared to identify areas of historical lava fields covered with mosses. The map of historical lava fields is from the Icelandic Institute of Natural History as well as vegetation maps identifying mosses in areas where only courser classification in IFD is available. In areas of IFD full scale classification the geological maps were compared to the IFD class "Mosses" to this purpose. From this comparison, two map layers in raster format were prepared.

6.3.1.4 Compilation of map layers to land use map

The process of compiling the data to a land use map is described in more details in Gudmundsson et al. (2013). Before entering the database, all map layers, if not already so, were converted to raster format and resampled to 15x15m pixel size. Layers in vector format were converted to raster. The compilation process is done by overlay analyses using "*ArcGIS version 10.3*" software. In that process the hierarchy of the map layers plays an essential role, as the map layer higher in the hierarchy replaces all overlaid pixels in a map layer of lower order with its own pixels. Thus e.g. the pixels common to the map layer "Reservoirs 1", and "Reservoirs 2", with hierarchy order 1 and 2, and the map layer, "Lakes and rivers" with hierarchy order 15 are defined as reservoirs. The criteria applied to determine the hierarchical order of map layers and the compilation process is further described in Gudmundsson et al. (2013). Before entering the compilation all map layers are cut by the outer boundaries lines were extracted form IS 50V2013, excluding all area outside these boundaries. The layer of all area within the new boundaries is then included at the bottom of the hierarchical order of map layers.

Each map layer is categorized to the relevant land use category considering its order in the compilation hierarchy. The category "Cultivated land" originating from the IFD database is categorized to other Grassland as the "Cropland" map layers are above it in the hierarchy and all cropland therefore excluded from that map layer as remaining after the compilation process. The map layers used in compiling the IGLUD land use map are listed in Table 6.1.

Table 6.2 List of map layers used in compiling the IGLUD map showing the categorization of layers and order of compilation.

Land use categories	Sub categories	Map layers included in land use category	ID	Hierarchy of map layers
1.Settlement		Towns and villages	101	4
		Airports	102	5
		Roads with buffer zone	103	6
2.Forest land	Cultivated forest	Forest cultivations 1908-1989	201	7
		Forest cultivations 1990-2015	203	8
			202	9
			204	10
			208	12
			205	11
	Natural birch forest	Natural birch forest- potentially on drained soils	207	13
		Natural birch forest	206	14
3.Cropland	Cropland	Cropland	301	16
	Cropland on drained soils	Cropland with ditch density 45-8 km km^{-2}	302	17
4.Wetland	Other wetlands	Semi-wetland (wetland upland eco-tone)	401	38
		Wetland	402	39
		Semi-wetland/wetland complex	403	40
	Lakes and rivers	Lakes and rivers	404	15
	Reservoirs	Reservoirs 1	405	1
		Reservoirs 2	406	2
5.Grassland	Other grassland	Grassland (true grassland)	501	27
		Richly vegetated heath land	502	28
		Cultivated land (as Identified in IFD)	503	36
		Poorly vegetated heath land	504	29
		Mosses	505	30
		Partly vegetated land (1)	506	31
		Shrubs and forest potentially on drained soils	508	23
		Shrubs and forest	507	27
		Grassland, heath-land shrubs and forest complex	509	34
		Partly vegetated land (2)	510	35
		Pasture	511	37
	Land revegetated before 1990	Farmers revegetation before 1990	512	19
		Revegetation before 1990	515	21
	Land revegetated since 1990	Farmers revegetation 1990-2013	513	20
		Revegetation activity 1990-2013	516	18
	Grassland on drained soils	Drained land	514	24
	Natural birch shrubland	Natural birch Woodland <2m –potentially on drained soils	518	22
		Natural birch Woodland <2m	517	25
6.Other land	Other land	Historical lava fields with mosses (1)	601	32
		Historical lava fields with mosses (2)	602	33
		Sparely vegetated land (1)	603	42
		Sparely vegetated land (2)	604	43
		Zone of recently retreated glaciers	606	41
		Unclassified of IFD lakes and rivers origin	607	43
		Unclassified of revised border origin.	608	42
	Glaciers	Glaciers and perpetual snow	605	3

The land use map resulting from the preparation of map layers and the compilation process is shown in (**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source**

not found., **Error! Reference source not found.**) and is also available at the website http://www.lbhi.is/vefsja.

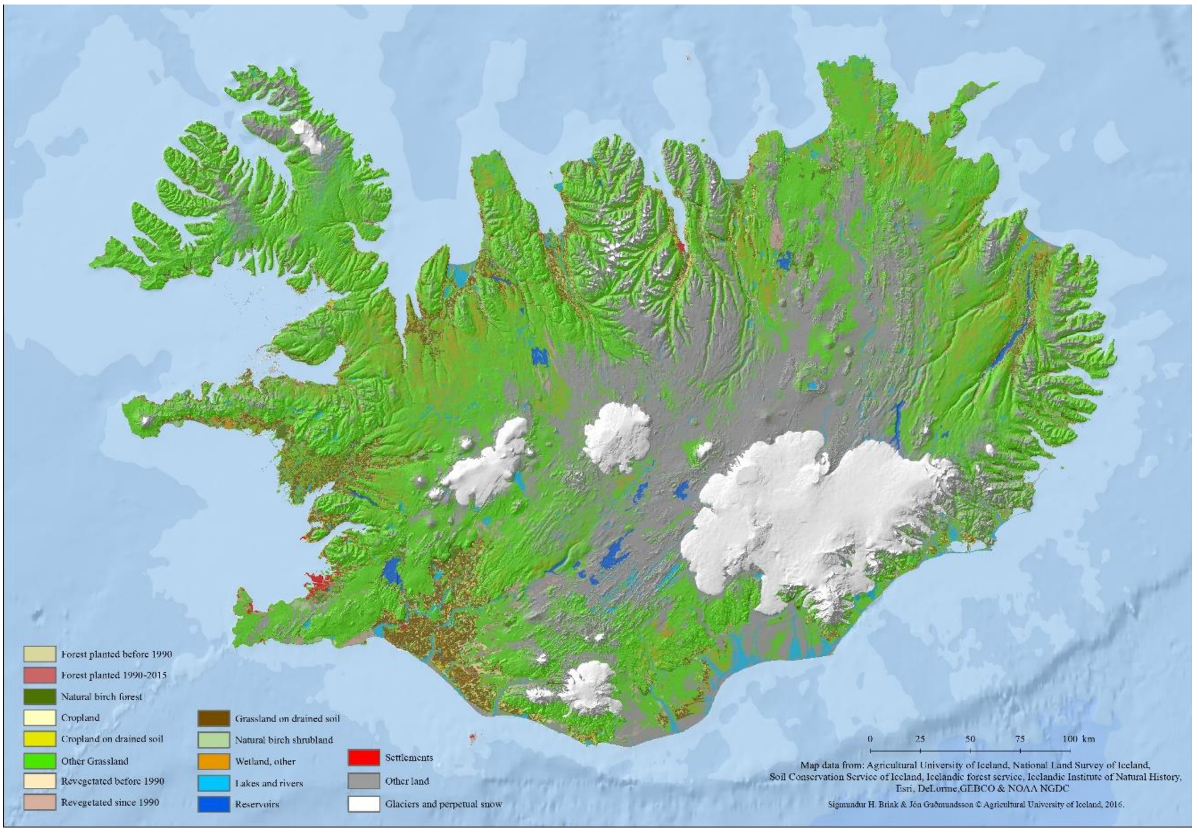

Figure 6.4 The land use map of IGLUD prepared for the year 2015.

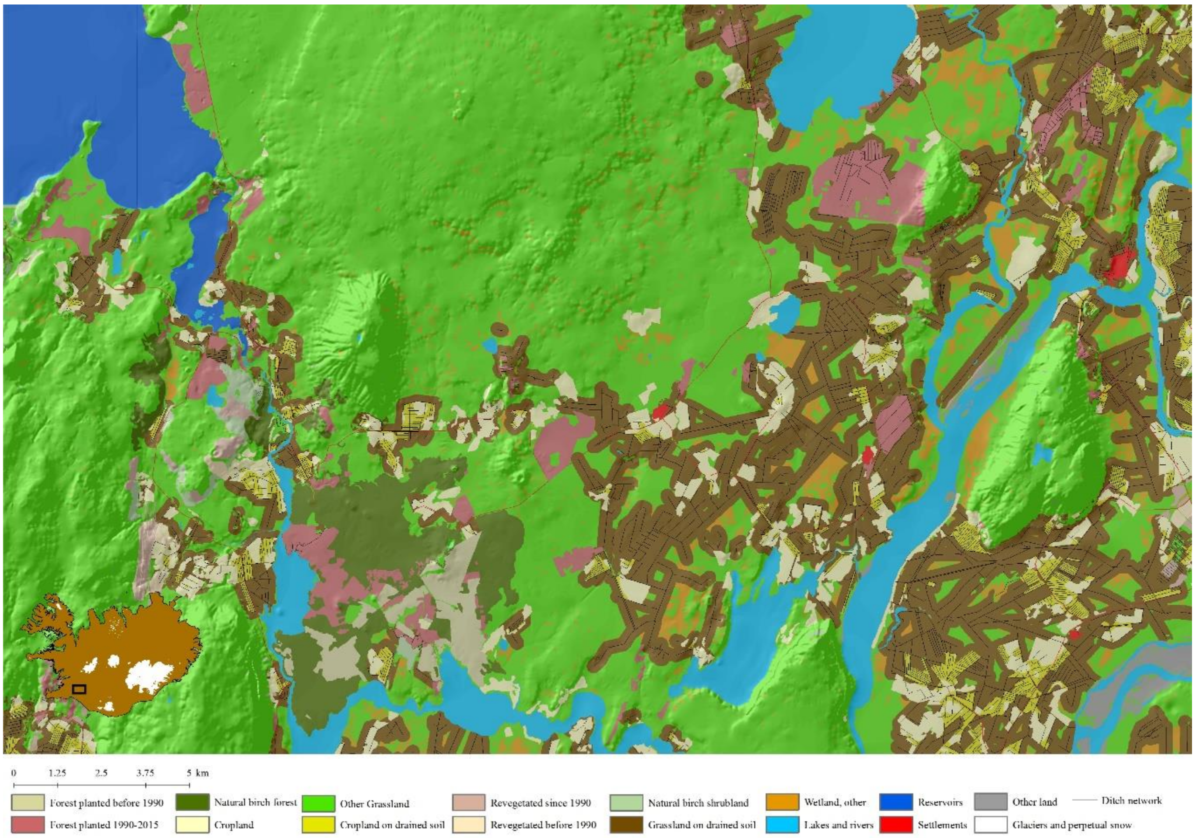

Figure 6.5 Enlargement of land use map emphasizing the different Forest land subcategories.

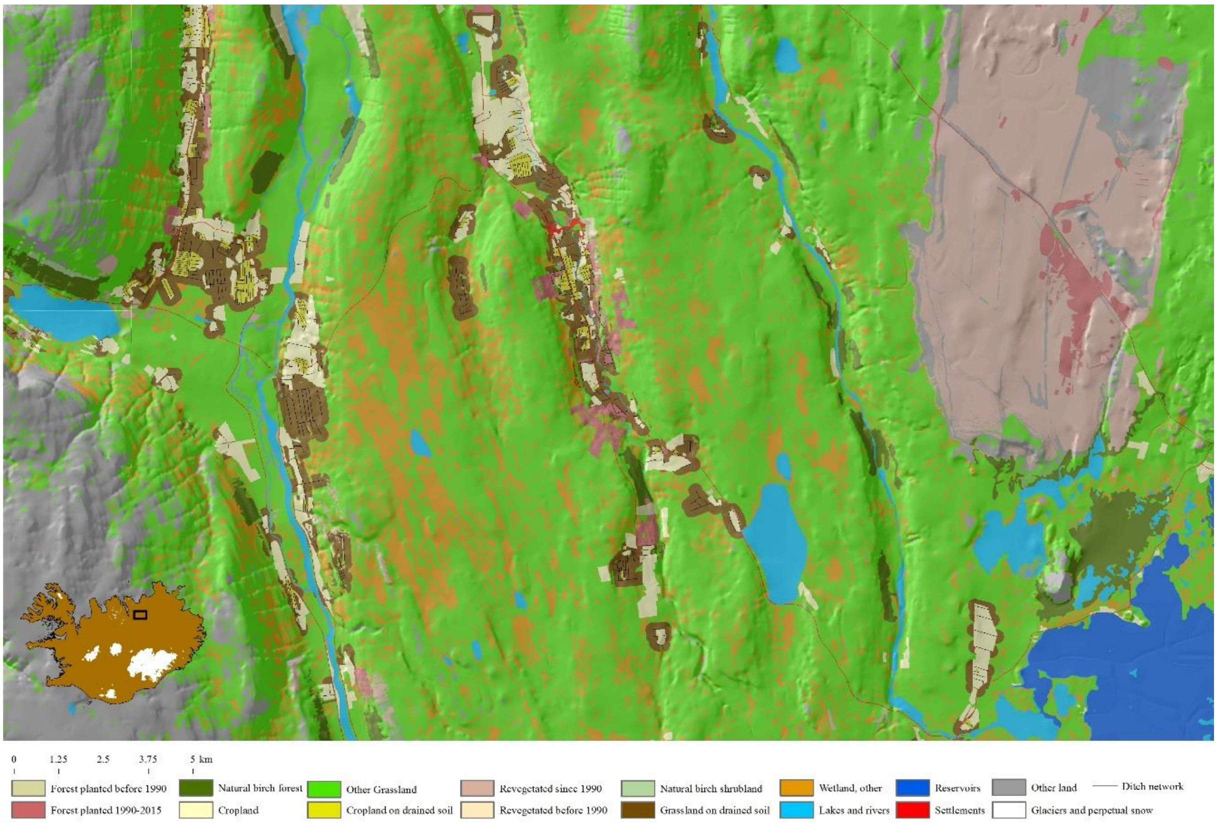

Figure 6.6 Enlargement of land use map emphasizing the Revegetation area mapped.

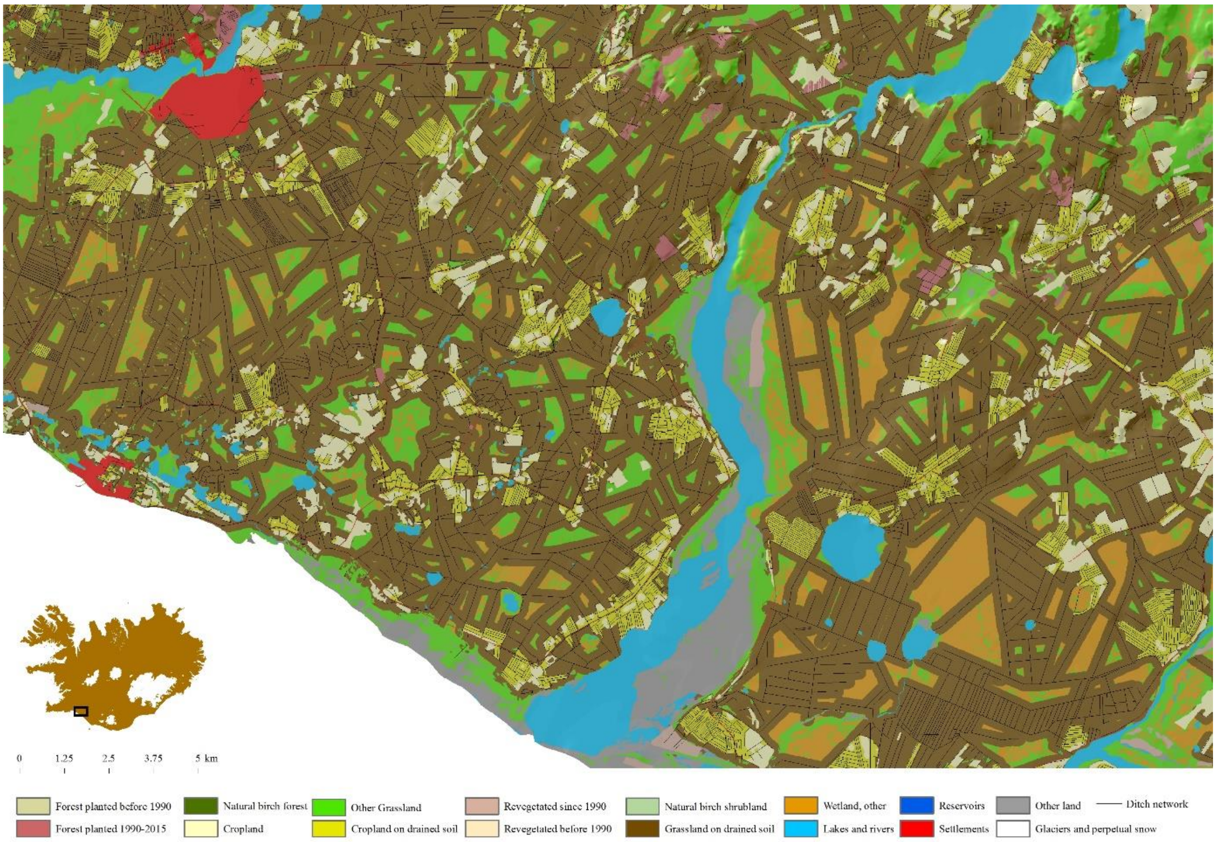

Figure 6.7 Enlargement of land use map emphasizing the subcategory Grassland on drained soils.

6.3.2 Changes in land use map

Revised map layers included in the land use map for this submission are; Reservoirs of the power company Landsvirkjun (Reservoir1), Forest cultivations 1908-1989, Forest cultivations 1990-2015, Lakes and rivers, Revegetation before 1990, Farmers revegetation before 1990, Revegetation 1990-2015, and Farmers revegetation 1990-2015. These revisions especially the new map layer “Lakes and rivers” affect other map layers both directly and through the compilation process.

6.3.3 Time series

Land use map does not provide all the information needed for estimating the area of each land use category requested. The map summarizes geographical data extending over long period and can accordingly not be taken as accurate land use at a specific year nor can land use maps changes from one year to the next be interpreted as land use changes unless relevant map layer was updated. To estimate the changes in land use and separate the area within each category remaining in category and land being converted to the category time series are needed. From available data, independent time series have been created for; afforestation, deforestation, expansions of natural birch forest and shrubland, other land converted to forest land, wetland drainage, land converted to cropland, cropland abandonment, revegetation, settlements and establishment of new reservoirs. All other reported time series on land use are derivatives from these time series adjusted to the area of the category as emerging from the land use map. All land use categories, for which emission or removal is reported, are now represented by time series.

Most of the data the time series are based on, hold information about changes, i.e. new input or output to or from the area of the respective category, without assigning the origin of the input or destination of the output to certain other land use category. The time series for cropland are thus constructed from data based on records of new cultivations each year and available estimates of abandoned cropland at specific points in time. This data does not specifically state which land use categories were turned to cropland or what became of the abandoned fields.

Extensive drainage of Icelandic wetlands took place in the period 1940-1985 and is still ongoing at a lower rate. This drainage was aided by governmental subsidies. The outcome of this drainage effort was that the larger part of the lowland wetlands in Iceland was converted to Grassland or Cropland. Only a small portion of these drained areas was turned to hayfields or cultivated. Part of this land has since been afforested or converted to Settlement. The governmental subsides involved official recording of the drainage, kept by the Farmers Association. The subsidies of new drainage ended in 1987 (Gísladóttir et al. 2007). Since then, the recording of drainage has been limited, and no official recording is presently available and only one region updates its records annually (Kristján Bjarndal Jónsson personal communication). These records are applied to estimate the new drainage in the country. These records of excavation of drainage ditches are applied to construct the time series of conversion of wetland soils to other land use categories.

The evaluation of cropland origin as it appears in the time series is based on two assumptions. First assumption is that land that has been converted to cropland originated mostly from either Grassland on mineral soil or from wetlands. The second assumption is that the ratio of new cropland of wetland origin has been constant. This ratio has in the construction of the time series been adjusted to ratio of wetland originated hayfields evaluated in the period 1990-1993 (Þorvaldsson 1994).

The destination of abandoned cropland is assumed as first approach to be all to the Grassland category, and the ratio of organic and mineral soil of abandoned cropland is the same as the ratio within the cropland category on the year of abandonment.

The time series for settlements are prepared from total basal area of all buildings in towns and villages. It is assumed that the ratio of total area of towns and villages and of other settlements to the basal area of buildings has remained the same as in 2013, extracted from the IS50 V2013 map. The settlement area is then assumed to have changed proportionally to the basal area. Records from Register Iceland, on basal area in towns and villages is available from 1990 to 2011. From 2011 the area is assumed to have increased annually as between 2010 and 2011.

6.3.4 CRF subcategories and their relation to land use map

In the CRF tables land use categories are divided to subcategories. This division, and how the subcategories are related to the categories of the land use map, is described below.

6.3.4.1 Forest land

Two subcategories of Forest land are defined on the land use map, natural birch forest and cultivated forest. The resolution applied in land use map of last year’s submission is revised omitting the separation of individual map layers on the land use map applied in that submission. Both categories are in the CRF tables divided further according to age of forest to land remaining forest land and land converted to forest land. The IFR newly finished map all natural birch forest and shrubland. The mapping effort took five years (2010-2014) and the resulting area is reported as the area in the year 2012. The total area of natural birch forest reported in this submission is bit larger than the mapped area, representing the ongoing expansion of natural birch forests. Accordingly, the land use map unit Natural birch forest represent all CRF categories of Natural birch forest except new expansions in the years 2013 - 2015. Individual CRF categories of natural birch forest can't be related to specific mapping units.

All of the cultivated forest reported in the CRF tables is included in the mapping unit Cultivated forest and as no further division of that mapping unit is applied the CRF subdivision are not tracked.

6.3.4.2 Cropland

Two subcategories of Cropland are defined on the Land use map, "Cropland" and "Cropland on drained soils". As explained above the mapping unit Cropland on drained soils is approximation of the geographical location of drained soils assuming fixed ditch density to separate between the freely drained soils and those drained through the ditches network. Accordingly, it is assumed that most of the soils reported in CRF as organic are include in the land use map unit Cropland on drained soils and the mineral soils likewise in the mapping unit Cropland. In the CRF tables Cropland is as other land use category divided to "Cropland remaining Cropland" and "Land converted to Cropland". The category "Land converted to Cropland" is in the CRF reported from two sources, i.e. "Grassland converted to Cropland" and "Wetland converted to Cropland". The separation to land remaining and land converted to Cropland is not 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.

6.3.4.3 Grassland

Grassland is represented by five subcategories on the Land use map, i.e. "Other grassland", "Revegetated before 1990", "Revegetated 1990-2015", "Grassland on drained soils", and "Natural birch shrubland". In CRF twelve land use subcategories are reported under Grassland. Two of them i.e. "Cropland converted to Grassland" and "Cropland abandoned for more than 20 years" are related to the land use map unit Cropland. The two CRF categories "Wetland drained for more than 20 years" and "Wetland converted to Grassland" are together mostly represented by the mapping unit Grassland on drained soil. Some part of the latter category is still to be found under the mapping category "Other wetlands". The area of the CRF categories "Natural birch shrubland -old" and "Natural birch shrubland -recently expanded into other grassland" is represented by the mapping unit "Natural birch shrubland", except for small area of expected shrubland expansion in the years 2013-2015. Revegetation is on the land use map represented by two mapping units, i.e. "Revegetated before 1990" and "Revegetated 1990-2015". The CRF two categories "Revegetation since 1990 – protected from grazing" and "Revegetation since 1990 – limited grazing allowed" are fully covered by the mapping category "Land re-vegetated since 1990", leaving some excess area within the mapping unit. Only a small part of the area of the remaining two CRF categories of revegetation, "Re-vegetated land older than 60 years" and "Revegetation before 1990" are represented by the map unit "Revegetation before 1990". The remaining area is assumed to be found within the map unit "Other grassland". Natural birch shrubland is divided to three categories in the CRF. These categories are almost completely covered by the map unit "Natural birch shrubland", the area missing is the expansion of shrubland in 2013 and 2015. The CRF subcategory Other Grassland is represented by the mapping unit "Other Grassland" taken into account the claims of other CRF categories to that mapping unit as described above.

6.3.4.4 Wetland

Wetlands are in the land use map represented by three mapping units; "Lakes and rivers", "Reservoirs" and "Other wetlands". In CRF, Wetland is reported in eight subcategories. The CRF category “Lakes and rivers” is almost fully represented by the land use mapping unit with same name. Only one refilled lake is included in map unit “Other grassland”. The map unit “Reservoirs” represents fully the CRF units of “Mires converted to reservoirs”, “Lakes and rivers converted to reservoirs”, “Medium SOC to reservoirs”, “Low SOC to reservoirs”. The CRF category “Intact mires” is all included in the map unit “Other wetland”. The CRF category “Refilled lakes and ponds”, is included in land use map unit “Lakes and rivers”, except one lake. The CRF category “Rewetted wetland soil” has no matching land use map unit yet, but is assumed to be included in the map units, “Other wetlands” and “Grassland on drained soils”.

6.3.4.5 Settlement

Settlement is represented in the land use map by two map units, “Settlement- towns”, and “Settlement –other”. In CRF Settlements are reported under four categories “Settlements remaining Settlements”, “Forest converted to Settlements”, “Natural birch shrubland converted to Settlements” and “all other Grassland categories converted to Settlements”. The CRF categories are not directly connected to either of the map units, but collectively their area matches the area of the map units.

6.3.4.6 Other land

In the land use map “Other land” is represented by two map units, “Glaciers and perpetual snow” and “Other land”. In CRF all of the area in land use category “Other land” is reported as “Other land remaining Other land”.

6.3.5 Combining different estimates of land use area

For many of the land use categories information on area is available from time series or through direct estimates. For other categories the land use map unit is the only source of area estimate available. To obtain as good estimate of the area of land use categories relying on land use map estimate, it is necessary to harmonize the area of land use map units to other estimates. For those categories where the map unit cover larger area than the more reliable estimate used, some area has to be transferred to other land use categories and vice versa where area estimate is larger than the relevant mapping unit. These area adjustment are summarized in Table 6.3. Area estimates considered more accurate than relevant land use map unit are available for eight land use map units listed in Table 6.3.

The IFR provides estimates for the categories; “Cultivated forest”, “Natural birch forest” and “Natural birch shrubland”. The area of cultivated forest estimated in the National Forest Inventory and is annually updated. The IFR finished in 2014 revised mapping of all Natural birch forest and birch shrubland, and the resulting estimate is set as the area of the mid-year of the mapping i.e. 2012.

The area of Cropland in use is estimated from time series prepared by AUI from official statistics on annual new cultivations and available data on abandoned cropland. The ratio of drained Cropland abandoned is also estimated by the Cropland time series. The excess area of the cropland map unit is transferred to “Grassland drained soils” and “other Grassland” accordingly.

Drainage of Icelandic wetlands mostly in the period 1940- 1990 was aided by governmental subsides and included certain recording of the excavation. The time series of new drainage are constructed from these records, plus additional data on drainage since 1990, drained soils under other land use categories, and known area of rewetting. The land use map unit “Grassland on drained soils” is an underestimate compared to estimate of the time series. Both sources are based on conversion of ditches length to drained area but the time series include ditches excavated since 2008 when the ditch network was digitized and also the drained area included in abandoned Cropland. Most of the difference in area is clarified by drained soils of abandoned Cropland but remaining difference is assumed new drainage and transferred to the category from the category “other wetlands”.

The reported revegetation activities since 1990 is bit less than the comparative land use map unit. The excess area is divided equally between “Other Grassland” and “Other land”. The land use map unit “Revegetation before 1990” is largely under representative of the area reported by SCSI as re-vegetated in that period. The revegetation activities are recorded as successful and should have been detected as vegetated area in the IFD. Accordingly the area lacking in the land use map unit is transferred from the land use map unit “Other Grassland”.

The land use map unit “Lakes and rivers was checked against the lakes and ponds recorded as refilled and one lake identified as not appearing in the land use map unit. The area of that lake was accordingly transferred from “Grassland on drained soil” to the category.

The area of three land use map unit “Grassland Other”, “Wetland other” and “Other land” is changed through the above area transfers. The resulting area estimates are reported for those land use categories in the year 2014.

Table 6.3 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								7,702						
FL NB														
CL				16,338				30,943						
GL. drained									509	8				
GL. Nb. shrub														
RV before. "90														
RV since. "90								408					408	
O.GL		1,158			1,038	162,164						282		
WL.O				11,937										
WL. L&R														
WL. Reserv.														
Settlements														
OL														
Other														
Other estimate	42,122	97,046	125,260	366,980	55,138	165,356	111,703					27,750		
Map area	49,825	95,888	172,540	339,222	54,100	3,192	112,520	4,804,716	360,853	217,449	58,340	27,468	2,885,598	1,086,578
Difference	7,703	-1,158	47,281	-27,758	-1,038	-162,164	817							
Corrected area	42,122	97,046	125,260	366,980	55,138	165,356	111,703	4,679,126	349,425	217,457	58,340	27,750	2,886,007	10,865,781
Total area [ha]														**10,268,287**

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

These area transfers do not affect the map unit "Glaciers".

6.3.6 Land use changes

Land use changes are reported as land being converted from one category to another. For each land use conversion a conversion period is defined as the period it takes the C-pools of the land converted to reach stable level. Land converted stays in the category "land converted to" until end of conversion period then it is transferred to the category "Land remaining in category". The default conversion period suggested in IPCC 2006 Guidelines (IPCC 2006) is 20 years. The land reported as converted to a category is thus the cumulative area converted for the number of years defined as conversion period of the category. In this submission 20 categories of land conversion involving conversion between main land use categories, are reported. Beside those conversion four changes in land use within main land categories are reported involving; expansion of Natural birch shrubland into other grassland, conversion of intact mires to reservoirs, plantation in natural birch forest and conversion of lakes and rivers to reservoirs. In available records of land use change the previous land use of the land converted are in many cases not recorded. This applies e.g. to land converted to

Cropland and, Revegetated land and to some extent afforested land. Assigning the land converted to these categories therefore is based on assumptions regarding the origin of the land. New Cropland is thus assumed to come from either the Grassland or the Wetland category. In some instances “Other land” might have been the previous land use category or Natural birch forest, but no data is available to estimate the proportion of these land use categories in land converted to Cropland at different times. Revegetated land is assumed to be conversion of “Other land” to Grassland, although previous land use category was not recorded at the initiation of the revegetation process. The conversion of “Other land” to Forest land has already been excluded for the category Revegetated land. The assumptions made regarding the categories of land use changes reported are discussed in the chapters on land converted to each land use category.

In the new CRF Reporter v 6.0.1 and the reporting tables created by the reporter there is a discrepancy in what is included under the categories “Land converted to a category”, between the Land Transition matrix and the division to “Land remaining in a category” and “Land converted to a category” in the main land use categories. In the Land Transition matrix and specially the reporting table created from it (CRF table 4.1) land converted to a category is supposed to include only land converted the relevant year and land remaining in category is the area included the previous year still not converted to other categories. In the division between “land remaining in a category” and “land converted to the category” in the main land use categories land remains as land being converted to throughout the defined conversion period when it is moved to the category. The ongoing land use conversions are summarized in Table 6.4. The final area is the total area of the land use category in that column in the inventory year. The initial area is area of land defined as remaining in a category plus the cumulative area of all conversion from the category over the conversion period for the land use category converted to. The initial area can’t therefore not be pinpointed to a specific year as the conversion period is variable.

Table 6.4 Summary of land use conversions in the inventory year.

Land is defined as being converted throughout the defined conversion period. The final area is the total area of the land use category in that column in the inventory year. The initial area is area of land defined as remaining in a category plus the cumulative area of all conversion from the category over the conversion period for the land use category converted to. The initial area can't therefore not be pinpointed to a specific year as the conversion period is variable. Net change is the difference between the initial and the final area negative values meaning decrease in the category at the column heading.

TO:	Forest land (managed)	Forest land unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetlands (managed)	Wetlands (unmanaged)	Settlements	Other land	Total unmanaged land	Initial area
FROM:	(kha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest land (managed)	89.86	NO	NO	NO	NO	NO	NO	0.05	NO	NO	89.91
Forest land (unmanaged)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Cropland	NO	NO	120.00	23.46	NO	NO	NO	IE	NO	NO	143.46
Grassland (managed)	38.86	NO	2.53	5,046.36	NO	7.81	NO	0.14	NO	NO	5,095.71
Grassland (unmanaged)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Wetlands (managed)	IE	NO	2.73	33.64	NO	381.16	NO	IE	NO	NO	417.54
Wetlands (unmanaged)	NO	NO	NO	NO	NO	31.26	217.34	NO	NO	NO	248.60
Settlements	NO	NO	NO	NO	NO	NO	NO	27.55	NO	NO	27.55
Other land	10.45	NO	IE	275.46	NO	NO	NO	IE	3,972.58	NO	4,258.50
Total unmanaged land	IE	NO	IE	IE	NO	IE	NO	IE	NO	IE	IENO
Final area	139.17	NO	125.26	5,378.93	NO	420.23	217.34	27.74	3,972.58	IENO	10,281.26
Net change	49.26	NO	-18.20	283.22	NO	2.69	-31.26	0.19	-285.92	IENO	0.00

6.3.7 Uncertainties QA/QC of land use estimates

The bulk of the area in the land use map (80%) is classified on the basis of map layers from the IFD. A report on the IFD was recently published, describing thoroughly the methodology applied its data sources and analysing the resulting land cover classification (Gísladóttir et al. 2014). The overall accuracy of the classification as applied in the land use map is estimated 76 %. Many factors contribute to the classification error observed, including the basic classification problem the land cover being gradient rather than distinctive classes with clear boundaries. Large part of the control points in IFD incorrectly identified is thus confusion between similar categories.

The classification of the area in the land use map not classified from IFD data is based on map layers originating through direct mapping in field, on screen digitation from satellite images or aerial photographs, or through GIS processing of other map layers supported by additional data and assumptions. The uncertainty of some of these map layers has been estimated but for others no estimate is available. For some map layers like roads the location can be considered highly accurate but the conversion of the vector data to raster data and estimate of area covered by the roads is not as accurate. The compilation of the map layers and determination of its hierarchical order in that process can potentially both increase or decrease the area wrongly classified. Of 2,336 sampling points in IGLUD, 72% are correctly related to the present land use map according to preliminary results. That estimate is presently the only specific estimate available on the land use map classification as presented. The area of most of the land use categories applied in the CRF reporting is further affected by the transfer of area described above to adjust the land use map estimates to other available data. The effects of these transfers on the uncertainty of area estimates is not known. The uncertainty of area estimate of one land use category has different impact on the emission/removal reported depending on the emission/removal per land unit of the category. Small uncertainty of e.g. drained Grassland has much more impact on the emission the relatively high uncertainty of classifying land to e.g. other land or the less vegetated areas included as other grassland.

6.3.8 Planned improvements regarding Land use identification and area estimates

As outlined above the uncertainty of the area estimate of reported land use categories is relatively high. For other categories e.g. Natural birch forest and Natural birch shrubland new mapping effort is assumed to have decreased considerably the uncertainty of the area estimates. A survey on the drainage efficiency of the ditch network in Grassland was completed in 2014. The analyses of the data is pending and expected to enable revision of the area estimate of that category. New digital elevation model (DEM) is available for large part of Iceland. That model will soon be available for the whole country. New high resolutions satellite images for most of the country are available. This new data and the survey on drainage efficiency will enable new digitation of drainage ditches and major revision of the map layer “Grassland on drained soils”. This revision is expected to finish in next two years. Besides those specific improvements, the land use identification will be updated as new information becomes available.

6.3.9 Completeness and method

The reporting is as in last submission in line with the 2006 IPCC guidelines (IPCC 2006), the 2013 Supplement to those on Wetland (IPCC 2014), and CRF reporter v 6.0.1. The completeness is further explained and discussed in chapters on emissions/removals of individual land use categories.

The emission and removals for each main land use category are separated to three groups in the CRF reporter and the CRF reporting tables; emission and removals of “Land remaining in a land uses category”, of “Land converted to a category”, and “From drainage and rewetting and other management of organic and mineral soils”. The separation of the emission/removal components is not self-evident. The carbon stock change in drained soils could be identified as “emissions and removals from drainage”, and the “Off-site emission from waterborne carbon losses” could be identified as additional carbon stock changes. In this submission off-site emission of waterborne carbon losses and methane emission from drained land and managed wetlands is included in the category “Emission and removals from drainage and rewetting and other management of organic and mineral soils”

Summary of method and emission factors used is provided in Table 6.5, Table 6.6, Table 6.7.

Table 6.5 Summary of method and emission factors applied on CO_2 emission calculation, including area and calculated emission/removals.

Source/sink	Area (kha)	Method	EF	kt. CO_2 Emission(+) /Removal (-)
Forest Land	139.17			-339.78
Carbon stock changes	139.17			-341.38
Forest Land remaining Forest Land	89.86			-31.95
Natural Birch forest	87.72			-13.02
Living biomass		T3		-13.14
Dead wood		NE		
Litter		NE		
Mineral soil	87.64	NE		
Organic soil	0.08	T1	D	0.11
Afforestation older than 50 years	0. 95			-7.56
Living biomass		T3		-7.62
Dead wood		IE		
Litter		NE		
Mineral soil	0.91	NE		
Organic soil	0.05	T1	D	0,06
Plantations in natural birch forest	1.19			-11.36
Living biomass		T3		-11.36
Dead wood		IE		
Litter		NE		
Mineral soil	1.19	NE		
Organic soil		NO		
Land converted to Forest Land	49.31			-309.43
Grassland converted to Forest Land	38.86			-230.00
Afforestation Natural birch forest 1 -50 years old	7.12			-18.37
Living biomass		T2	CS	-6.33
Dead wood		IE		
Litter		T2	CS	-3.68
Mineral soil	6.69	T2	CS	-8.94
Organic soil	0.43	T1	D	0.59
Afforestation 1-50 years old -Cultivated forest	31.74			-211.63
Living biomass		T3	CS	-160.96
Dead wood		NO		
Litter		T3	CS	-16.41
Mineral soil	28.67	T2	CS	-38.42
Organic soil	3.07	T1	D	4.16
Other land converted to Forest land	10.45			79.43
Afforestation 1-50 years old -Cultivated forest	8.24			-72.17
Living biomass		T3		-52.42
Dead wood		IE		
Litter		T2	CS	-4.26
Mineral soil	7.78	T2	CS	-15.50
Organic soil	NO			
Afforestation natural birch forest 1-50 years old	2.21			-7.26
Living biomass		T2	CS	-1.96
Dead wood		NE		
Litter		T2	CS	-1.14
Mineral soil	2.21	T2	CS	-4.15

Organic soil	NO	*Table continues on next page*		
Table 6.5 continued				
Source/sink	**Area (kha)**	**Method**	**EF**	**kt. CO_2 Emission(+) /Removal (-)**
Off-site emission via waterborne carbon losses from drained soils	3.36			1.60
FL remaining FL Afforestation more than 50 years old	0.05	T1	D	0.02
FL remaining FL Natural birch forest older than 50 years	0.08	T1	D	0.04
GL converted to Natural birch forest	0.43	T1	D	0.19
GL converted to FL Afforestation 1-50 years old	2.80	T1	D	1.35
Cropland	125.26			1,667.71
Carbon stock changes	125.26			1,642.94
Cropland remaining Cropland	120,00			1,551.99
Living biomass		T1		NO
Dead organic matter		T1		NO
Mineral soil	66.42	T2	CS	
Organic soil	53.58	T1	D	1,551.99
Land converted to Cropland	5.26			90.95
Grassland converted to Cropland	2.53			3.95
Living biomass		T1	CS	4.92
Dead organic matter		IE		
Mineral soil		T1	CS	-0.97
Organic soil	NO			
Wetlands converted to Cropland	2.73			87.00
Living biomass		NE		7.94
Dead organic matter		IE		
Mineral soil	NO			
Organic soil	2.73	T1	D	79.06
Off-site emission via waterborne carbon losses from drained soils	56.31			24.78
CL remaining CL	53.58	T1	D	23.57
WL converted to CL	2.73	T1	D	1.20
Grassland	5,373.15			7,225.39
Carbon stock changes	5,373.15			7,063.71
Grassland remaining Grassland	5,046.36			6,761.80
Cropland abandoned for > 20 years	24.75			136.89
Living biomass		NO		
Dead organic matter		NO		
Mineral soil	18.20	NO		
Organic soil	6.55	T1	D	136.89
Natural birch shrubland-old	49.97			-1.67
Living biomass		T2	CS	-3.69
Dead organic matter	NE			
Mineral soil	NE			
Organic soil	0.26	T1	D	5.36
Natural birch shrubland -recently expanded into Other Grassland	2.49			-2.01
Living biomass		T2	CS	-2.22

Dead organic matter		T2	CS	-1.29
Table continues on next page				
Table 6.5 continued				
Source/sink	Area (kha)	Method	EF	kt. CO_2 Emission(+) /Removal (-)
Mineral soil	2.27	T2	CS	-3.05
Organic soil	0.22	T1	D	4.54
Other Grassland	4,648.96	NE		
Re-vegetated land older than 60 years	3.19	NO		
Wetland drained for > 20 years	317.00			6,625.25
Living biomass		NE		
Dead organic matter		NO		
Mineral soil		NO		
Organic soil	317.00	T1	D	6,625.25
Land converted to Grassland	332.56			289.83
Cropland converted to Grassland	23.46			164.28
Living biomass		T1	CS	-45.51
Dead organic matter		IE		
Mineral soil	13.67	T2	CS	5.22
Organic soil	9.79	T1	D	204.58
Wetlands converted to Grassland	33.64			703.18
Living biomass		NO		
Dead organic matter		NO		
Mineral soil	NO	NA		
Organic soil	33.64	T1	D	703.18
Other Land converted to Grassland	275.46			-577.63
Other land converted to natural birch shrubland	1.60			-5.24
Living biomass		T2	CS	-1.41
Dead organic matter		T2	CS	-0.82
Mineral soil	1.60	T2	CS	-3.00
Organic soil	NO			
Revegetation before 1990	162.17			-338.93
Living biomass		T2	CS	-33.89
Dead organic matter		IE		
Mineral soil	162.17	T2	CS	-305.04
Organic soil	NO			
Revegetation since 1990	111.70			-233.46
Revegetation since 1990- limited grazing allowed	11.26			23.53
Living biomass		T2	CS	-2.35
Dead organic matter		IE		
Mineral soil	11.26	T2	CS	-21.18
Organic soil	NO			
Revegetation since 1990- protected from grazing	100.44			-209.93
Living biomass		T2	CS	-20.99
Dead organic matter		IE		
Mineral soil	100.44	T2	CS	-188.93
Organic soil	NO			
Off-site emission via waterborne carbon losses from drained soils[1)]	367.45			161.68
Wetland	625.73			-592.77
Carbon stock changes	625.73			-695.74
Wetlands remaining Wetlands	599.01			-701.93

Mires converted to Reservoirs –High SOC	0.99			2.75
Living biomass		IE		
Table continues on next page				

Table 6.5 continued				
Source/sink	Area (kha)	Method	EF	kt. CO_2 Emission(+) /Removal (-)
Dead organic matter		IE		
Mineral soil		NO		
Organic soil	0.99	RA/T2	CS	2.75
Reservoirs on former Lakes and rivers	31.26	NA		
Other wetlands- intact mires	349.42			-704.67
Living biomass		NO		
Dead organic matter		IE		
Mineral soil		IE		
Organic soil	349.42	T1	D	-704.67
Lakes and rivers	217.34	NA		
Land converted to Wetlands	26.72			6.19
Grassland converted to Wetlands	7.80			5.31
Grassland converted to Reservoirs - Medium SOC	7.19	RA/T2	CS	6.32
Living biomass		IE		
Dead organic matter		IE		
Mineral soil	7.19	RA/T2	CS	6.32
Organic soil		NO		
Grassland converted to Refilled lakes and ponds	0.12			
Living biomass		NE		
Dead organic matter		NE		
Mineral soil		NE		
Organic soil		NE		
Grassland converted to Rewetted wetland soil	0.51			-1.03
Living biomass		IE		
Dead organic matter		IE		
Mineral soil		IE		
Organic soil	0.51	T1	D	-1.03
Other Land converted to Wetlands	18.91			0.90
Low SOC CO2	18.91	RA/T2	CS	0.90
Living biomass		IE		
Dead organic matter		IE		
Mineral soil	18.91	RA/T2	CS	0.90
Organic soil		NO		
Off-site emission via waterborne carbon losses from wet soils	377.13			102.97
Mires converted to Reservoirs –High SOC	0.99	T1	D	0.29
Other wetlands- intact mires	349.42	T1	D	102.50
Refilled lakes and ponds	0.12	T1	D	0.03
Rewetted wetland soils	0.51	T1	D	0.15
Grassland converted to Reservoirs- Medium SOC	7.19	NA		
Other land converted to Reservoirs- Low SOC	18.91	NA		
Settlement	27.75			4.82
Carbon stock changes	27.75			4.82

Settlements remaining Settlements	27.55	NA		
Land converted to Settlement	0.20			4.82
Table continues on next page				
Table 6.5 continued				
Source/sink	**Area (kha)**	**Method**	**EF**	**kt. CO_2 Emission(+) /Removal (-)**
Forest land converted to Settlement	0.05			0.22
Living biomass		T3	CS	0.08
Dead organic matter		T2	CS	0.03
Mineral soil	0.05	T2	CS	0.12
Organic soil		NO		
Grassland converted to Settlement	0.15			4.59
Natural birch shrubland to Settlement	0.01			
Living biomass		NO		
Dead organic matter		NE		
Mineral soil		NE		
Organic soil		NO		
All other grassland to Settlement	0.14			4.59
Living biomass		T2	CS	4.59
Dead organic matter		IE		
Mineral soil		NE		
Organic soil		NE		
Other Land remaining Other Land	3,972.58	NA		
Harvested wood products	NA	NE		0.22
EF = emission factor, D = default (IPCC), CS = country specific, RA= reference approach, NA = not applicable, NE= not estimated, NO = not occurring, IE=included elsewhere, T1 = Tier 1, T2 = Tier 2 and T3 = Tier 3.				
[1)] disaggregation to subcategories is in chapter on relevant category				

Table 6.6 Summary of method and emission factors applied on CH_4 emission calculations, including area and calculated emission.

Source/sink	Area kha	Method	EF	kt. CH_4 Emission	kt. CO_2 –eq emitted
Forest land				0.03	0.67
Drained soils of	3.36			0.03	0.67
Forest land remaining Forest land	0.13			0.00	0.02
Afforestation older than 50 years	0,05	T1	D	0.00	0.01
Natural birch forest older than 50 year	0.08	T1	D	0.00	0.02
Land converted to Forest land				0.03	0.64
Grassland converted to Natural birch forest	0.43	T1	D	0.00	0.08
Grassland converted to Cultivated forest	2.80	T1	D	0.02	0.56
Biomass burning- wildfire	0.00	T2	CS,D	0.00	0.00
Cropland				3.28	82.00
Drained soils of	56.31			3.28	82.00
Cropland remaining Cropland	53.58	T1	D	3.12	78.02
Land converted to Cropland	2.73			0.16	3.97
Wetland converted to Cropland	2.73	T1	D	0.16	3.97
Biomass burning	NO				
Grassland				21.90	547.48
Drained soils of	367.45			21.89	547.32
Grassland remaining Grassland	324.03			19.31	482.63
Cropland abandoned for more than 20 years	6.55	T1	D	0.39	9.76
Natural birch shrubland old	0.26	T1	D	0.02	0.38
Natural birch shrubland recently expanded	0.22	T1	D	0.01	0.32
Wetlands drained for more than 20 years	317.00	T1	D	18.89	472.17
Land converted to Grassland	43.43			2.58	64.69
Cropland converted to Grassland	9.79	T1	D	0.58	14.58
Wetland converted to Grassland	33.64	T1	D	2.00	50.11
Biomass burning	0.27	T2	CS,D	0.01	0.16
Wetland (managed)	377.14			64.35	1,608.76
Wetland remaining Wetland	350.41			63.94	1,598.53
Intact mires	349.42	T1	D	63.83	1,595.70
Flooded land- Mires converted to reservoirs	0.99	RA/T2	CS	0.11	2.83
Land converted to wetland	26.73			0.41	10.12
Grassland converted to reservoirs	7.19	RA/T2	CS	0.05	1.13
Other land converted to reservoirs	18.91	RA/T2	CS	0.25	6.19
Grassland rewetted					
Refilled lakes and ponds	0.12	T1	D	0.02	0.53
Rewetted wetland soils	0.51	T1	D	0.09	2.27
Biomass burning	0.06	T2	CS,D	0.00	0.04
Other land					
Biomass burning-wildfire	0.00	T2	CS,D	0.00	0.00
EF = emission factor, D = default (IPCC), CS = country specific, RA= reference approach, NA = not applicable, NE= not estimated, NO = not occurring, IE=included elsewhere, T1 = Tier 1, T2 = Tier 2 and T3 = Tier 3.					

Table 6.7. Summary of method and emission factors applied on N_2O emission calculations

Source/sink	Area kha	Method	EF	kt. Emission / Removal (-)	kt. CO_2 eq
Indirect N_2O emission from managed soils	NA	IE		IE	
Forest land				0.02	5.50
Forest land remaining Forest land					
Direct N_2O emission from N-input to managed soils	NO				
Direct N_2O emission from N mineralization / immobilization	NE				
Biomass burning- wildfires	NO				
Drained soils of					
Afforestation more than 50 years old	0.05	T1	D	0.00	0.07
Natural birch forest older than 50 years	0.08	T1	D	0.00	0.12
Land converted to forest land					
Direct N_2O emission from N-input to managed soils	NA	T1	D	0.00	0.05
Direct N_2O emission from N mineralization / immobilization	NE				
Biomass burning- wildfires	0.00	T2	CS,D	0.00	0.00
Drained soils of					
Grassland converted to Natural birch forest	0.43	T1	D	0.00	0.65
Grassland converted to Forest land- Afforestation 1 to 50 years old	2.80	T1	D	0.02	4.60
Cropland					
Direct N_2O emission from N-input to managed soils		IE			
Direct N_2O emission from N mineralization / immobilization		IE			
Biomass burning	NO				
Grassland[1)]				0.00	0.66
Grassland remaining Grassland [2)]					
Direct N_2O emission from N mineralization / immobilization		NE			
Land converted to Grassland [2)]					
Direct N_2O emission from N mineralization / immobilization[1)]	13.67	T1,T2	D,CS	0.00	0.44
Biomass burning					
Biomass burning- wildfire	0.27	T2	CS,D	0.00	0.18
Wetland				0.00	0.04
Direct N_2O emission from N-input to managed soils	NO				
Direct N_2O emission from N mineralization / immobilization	NO				
Biomass burning- wildfire	0.06	T2	CS,D	0.00	0.04
Flooded land					
Mires converted to reservoirs	0.99	RA/T2	CS	NO	
Grassland converted to reservoirs	7.19	RA/T2	CS	NO	
Other land converted to reservoirs	18.91	RA/T2	CS	NO	
Settlements					
Direct N_2O emission from N-input to managed soils	IE			0.00	0.00
Direct N_2O emission from N mineralization / immobilization	NE				
Other land					
Biomass burning wildfire	0.00	T2	CS,D	0.00	0.00

Table continues on next pages					
Continuation of table 6.7					
Source/sink	Area kha	Method	EF	kt. Emission / Removal (-)	kt. CO2 eq
Other[1)]				0.25	75.71
Drained soils of					
Grassland remaining Grassland[2)]	324.02	T2	CS	0.22	66.76
Land converted to Grassland					
Cropland converted to Grassland	9.79	T2	CS	0.01	2.02
Wetland converted to Grassland	33.64	T2	CS	0.02	6.93
EF = emission factor, D = default (IPCC), CS = country specific, RA= reference approach, NA = not applicable, NE= not estimated, NO = not occurring, IE=included elsewhere, T1 = Tier 1, T2 = Tier 2 and T3 = Tier 3.					
[1)] The emission of N_2O from drained Grassland remaining Grasslands is reported in the category Other **[2)] Disaggregation to subcategories is shown under chapter on relevant category**					

6.4 Forest land

In accordance to the GPG arising from the Kyoto Protocol a country-specific definition of forest has been adopted. The minimal crown cover of forest is 10%, the minimal height 2 m, minimal area 0.5 ha and minimal width 20 m. This definition is also used in the National Forest Inventory (NFI). All forest, both naturally regenerated and planted, is defined as managed as it is all directly affected by human activity. The natural birch woodland has been under continuous usage for many centuries. Until the middle of the last 19th century it was the main source for fuel wood for house heating and cooking in Iceland (Ministry for the Environment 2007). Most of the woodland was used for grazing and still is, although some areas have been protected from grazing.

Natural birch woodland is included in the IFR national forest inventory (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 consisting of tree plantation, direct seeding or natural regeneration originating from cultivated forest. The sampling fraction in the natural birch woodland is lower than in the cultivated forest. Each 200 m2 plot is placed on the intersection of 1.5 x 3.0 km grid (Snorrason 2010). The part of natural birch woodland defined as forest (reaching 2 m or greater in height at maturity in situ) is estimated on basis of new map of natural birch woodlands mapped in 2010-2014.

By analyzing the age structure in the natural birch woodland that does not merge geographically the old map from the survey in 1987-1991; it is possible to re-estimate the area of natural birch woodland in 1987-1991 and the area of birch woodland today. Preliminary results of these estimates are that the area of birch woodland was 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 of woodland that was missed in the earlier survey. Current area of natural birch woodland is estimated to 150.65 kha. The difference of 12.95 kha is an estimate of a natural expansion of the woodland over the time 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 the natural birch woodland that can reach 2 m height in mature state and is defined a forest was 64% of the total area. Natural birch forest is accordingly estimated 87.72 kha in 1989 and 95.97 kha in 2012, the former figure categorizing the natural birch forest classified as Forest remaining Forest and the differences between the two figures (8.25 kha) as natural birch forest classified as Grassland converted to forest land or Other land converted to forest land with mean annual increase of 0.36 kha.

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. The conversion period for afforestation on Grassland soil is accordingly 50 years. Conversion period for land use changes to “Forest land” from “Other land” is also assumed to be 50 years.

The area of cultivated forest in 2015 is estimated in NFI as 42.12 kha (±1.47 kha 95% CL) whereof; 31.74 kha (±1.66 kha 95% CL) are Afforestation 1-50 years old on “Grassland converted to Forest land”, 8.24 kha (±1.17 kha 95% CL) are Afforestation 1-50 years old on “Other Land converted to Forest land”, 1.19 kha (±0.48kha 95% CL) are Plantations in natural birch forests and 0.95 (±0.42 kha 95% CL) are Afforestation older than 50 years.

The total area of Forest land other than natural birch forest was revised on basis of new data obtained in NFI sample plot measurements from the year of 2016. In 2016 submission this area was estimated 39.91 kha (±1.53 kha 95% CL) in 2014 but in this year’s submission the estimate for 2014 is 41.10 kha (±1.50 kha 95% CL) reflecting the effect of the recalculation.

The area of Forest land other than natural birch forest on organic soil was also revised according to new data from NFI. The area of organic soil in the cultivated forest was for the inventory year 2014 reported 3.08 kha (±0.75 kha 95% CL) in 2016 submission but is estimated 3.62 kha (±0.81 kha 95% CL) for 2014 in this year’s submission reflecting the recalculation.

The area of “Forest remaining foreest” for natural birch forest is unchanged is unchanged from last submission. Expansion of natural birch forest in 2014 was estimated to 8.36 kha in last year submission but in this year submission 8.24 kha.

As the area estimate of natural birch forest is entirely built on in field mapping a sample error propagation as for the natural birch forest is not applicable. It can be stated that areal errors of in field mapping are much lower than systematic sample errors and not significant in an uncertainty estimate of C-stock change.

The area of the cultivated forest used in land use class Forest Land in the CRF is based on the NFI sample plot measurements and is updated with new field measurements annually. Maps provided by IFR shows a larger area of cultivated forests than the NFI sample plot estimate. Map of cultivated forest cover is built on an aggregation of maps used in forest management plans and reports that is revised with new activity data annually. This overestimation of the area of cultivated forest on these maps is known (Traustason and Snorrason 2008) but the differences between these two approaches decreases every year as the quality of the maps sources increase.

6.4.1 Carbon Stock Changes

C-stock changes of natural birch forest are estimated with same method as in last year submission. In 1987 a tree data sampling was conducted to i.a. estimate the biomass of the natural birch woodland in Iceland (Jónsson 2004). These data have now been used to estimate the woody C-stock of the natural birch woodland in 1987. The new estimate take into account 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. The new estimate is built on same newly made biomass equations as used to estimate current C-stock. C-stock in above ground biomass of birch trees and shrubs in natural birch woodlands 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 (Sigurðsson and Snorrason 2000). A new estimate of the current C-stock of the natural birch woodland built on the sample plot inventory of 2005-2011 is 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 is 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. Carbon stock changes in Forest land is recognized as key sources/sinks in level 2015 and in trend.

Carbon Stock Changes in Living Biomass

Carbon stock gain of the living biomass of trees in the cultivated forest is estimated based on data from direct sample plot field measurement of the NFI. The figures provided by IFR are based on the inventory data from the first national forest inventory conducted in 2005-2009 (Snorrason 2010). In 2010 the second inventory 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 currently living trees is estimated by estimating the differences between current biomass and the biomass five years ago. Trees that die or are cut and removed in this 5 years period are not included so the C-stock gain estimated is not a gross gain.

Carbon stock losses in the living woody biomass are estimated 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 thinning of forest (Gunnarsson 2010; Gunnarsson 2011; Gunnarsson 2012; Gunnarsson 2013, Gunnarsson 2014, Gunnarsson 2016). Most of the cultivated forests in Iceland are relatively young, only 27% older than 20 years, and clear cutting has not started. Commercial thinning is taking place in some of the oldest 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. The volume of the wood from the natural birch forest cannot be distinguished from reported annual volume of cultivated forest.

2 Dead wood measurements on sample plots. (See description of dead wood definition and measurements in next chapter: Net Carbon Stock Changes in Dead Organic Matter). Dead wood measured is reported as C-stock losses in the assessed year of death.

In the natural birch forest only a net C-stock change in living biomass of the trees is estimated:

1 In the natural birch forest, classified as Forest remaining Forest: 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 method is in accordance to Equation 3.1.2 in GPG for LULUCF (page 3.16).

2 In the natural birch forest expansion since 1987: by using a linear regression between biomass per area unit in trees on measurement plots in natural birch woodland and measured age of sample trees ($N=147$, $P < 0.0001$) to measure net annual C-stock change.

In both cases all losses are included in the estimate of the net C-stock change and reported as IE

In the already mentioned ICEWOODS research project, the carbon stock in other vegetation than trees did show a very low increase 50 years after afforestation by the most commonly used tree species, Siberian larch, although the variation inside this period was considerable. Carbon stock samples of other vegetation than trees are collected on field plots under the field measurement in NFI. Estimate of carbon stock changes in other vegetation than trees will be available from NFI data when sampling plots will be revisited in the second inventory and the samples will be analyzed.

6.4.1.1 Net Carbon Stock Changes in Dead Organic Matter

As for other vegetation than trees, 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 be available from the NFI data when sampling plots have been revisited in the second inventory and samples analyzed.

In the meantime, results from two separate researches of carbon stock change are used to estimate carbon stock change in litter. (Snorrason et al. 2000; Snorrason et al. 2003; Sigurdsson et al. 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 (2003 and 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 year. 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}.

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 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 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.

6.4.1.2 Net carbon Stock Change in Soils

Drained organic soil is reported as a source of C-emission. In this year’s submission forest on drained organic soil is reported in the category “Grassland converted to Forest Land - Afforestation 1-50 years old – Cultivated forest”, “Grassland converted to Forest Land – Afforestation 1-50 years old – Natural birch forest”, “ “Forest Land remaining Forest Land” – subcategory “Afforestation older than

50 years" and subcategory "Natural birch forest". Drained organic soil is not occurring in other categories reported.

Research results do 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 et al. 2003; Sigurðsson et al. 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 CO2 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 at Grassland and Cropland 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 et al. 2003). New experimental research result 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 et al. 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 of 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.

6.4.2 Emissions and removals from drainage and rewetting and other management of organic and mineral soils

In the CRF-web Reporter emissions and removals from drainage and rewetting and other management of organic and mineral soils is included as separate emission category . The 2013 Supplement to the 2006 Guidelines: Wetlands (IPCC 2014), provides guidelines for estimation of emissions related to two factors not previously estimated. These factors are the off-site decomposition of dissolved organic carbon (DOC) and emission and removal of CH_4 from drained soils.

6.4.2.1 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). This emission is calculated for the four categories of Forest land reported with organic soils, i.e. "Afforestation more than 50 years old", "Natural birch forest older than 50 years", "Grassland converted to Natural birch Forest", "Grassland converted to Cultivated Forest". The total emission calculated is 1.60 kt. CO_2 for organic soils of Forest land.

6.4.2.2 CH_4 emission and removals from drained Forest land soils

The CH_4 emission from drained land is calculated according to T1 applying equation 2.6 in 2013 wetland supplement (IPCC 2014). The equations separate the emission into two components, i.e. emission from the drained land and the emission from the ditches. The total emission reported is 0.03 kt. CH_4 or 0.67 kt. CO_2 eq. 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 (IPCC 2014) is applied.

6.4.2.3 N_2O emission from drained soils of Forest land

The N_2O emissions from drained soils under Forest land is estimated according to T1 applying equation 2.7 in the 2013 wetland supplement (IPCC 2014). The total emission calculated for drained Forest land is 0.02 kt. N_2O or 5.45 kt. CO_2 eq.

6.4.2.4 Rewetted soils under Cropland

No rewetting of soils in land included as Forest land 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.

6.4.3 Other Emissions (4(I), 4(III))

Direct N_2O emission from use of N fertilizers is reported only for Land converted to Forest Land in cultivated forest since fertilization is usually only done at planting. Fertilization on Forest Land remaining Forest Land and in Natural birch forest expansion is not occurring. The reported use of N fertilizers is based on data collected by IFR from the Icelandic forestry sector. Direct N_2O emission from N mineralization/mobilization is not estimated as all C-stock changes estimates show increase in stock. Potential emission from mineral soils is in the categories where changes are still not estimated.

6.4.4 Land converted to Forest Land.

The AFOLU Guidelines define land use conversion period as the time until the soil carbon under the new land use reaches a stable level. Land converted to forest land is reported as converted from the land use categories “Grassland” and “Other Land”. Small part of the land converted to Forest land is converted from Wetland, but this land is included as Grassland converted to Forest land as data for separating these categories is unavailable.

6.4.5 Methodological Issues

One of the main data sources of the NFI is a systematic sampling consisting of a total of around 1000 permanent plots for field measurement and data sampling. One fifth of the plots in cultivated forest are visited and measured each year. Same plots are revisited at five year intervals for the cultivated forest and at ten years intervals for the natural birch forest. Currently the sampling is used to estimate both the division of the area into subcategories and C-stock changes over time for the cultivated forest and the current C-stock of the natural birch forest as already described(Snorrason 2010). Preparation of this work started in 2001 and the measurement of field plots started in 2005. The first forest inventory was finished in 2009 and in 2010 the second one started with re-measurements of the plots measured in cultivated forest in 2005 together with new plots on afforested land since 2005. The second forest inventory of the cultivated forest is now finalized and the third started in 2015. The figures provided by IFR are based on the inventory data of the first forest inventory of both cultivated and natural forest and the second and partially the third inventory of the cultivated forest. The sample population for the natural birch forest is the mapped area of natural birch woodland in earlier inventories. The sample population of cultivated forest is an aggregation of maps of forest management plans and 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 24 m.

Historical area of cultivated forest is estimated by the age distribution of the forest in the sample.

The biomass stock change estimates of the C-stock of cultivated forest are for each year built on five years sample plot measurements (Table 6.8). The most accurate estimates are for 2007-2014 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 2015 the estimated is forwarded one year compared to the midvalue for 2014. As relative growth rate decreases with age the 2013 estimate is an overestimate and was calibrated by 0.86, which is the relative difference between the midvalue and a forwarded value of the period 2008-2014. 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 later years (1990-2005) a species specific growth model that is calibrated towards the inventory results is used to estimate annual stock changes.

Table 6.8 Measurement years used to estimate different annual estimates of biomass stock change.

Mid value estimates	Forwarded estimates	Backwarded estimates	Built on measure-ment years
	2015		2012-2016
2014			2012-2016
2013			2011-2015
2012			2010-2014
2011			2009-2013
2010			2008-2012
2009			2007-2011
2008			2006-2010
2007			2005-2009
		2006	2005-2009
		2005	2005-2009

Changes in the area of natural birch forest is estimated by comparing estimated area in old surveys with estimated area in newly finished remapping. As no historical data before 1987 exists, a time series for changes in area and C-stock of natural birch forest is only available since 1989. They are built on interpolation between 1989 and the mid-year of the remapping 2010-2014 and extrapolations from 2012 with even annual increase in area.

A mean annual change in the area of the natural birch forest was estimated to 0.359 kha increase between 1989 and 2012.

As for the area, the biomass stock change estimates of the C-stock of natural birch forest are built on comparison of an estimate of historical biomass stock in the year of 1987 using a stock sampling inventory conducted in 1987 and the NFI inventory of 2005-2011. The difference between these inventories shows a slight increase in biomass C-stock between 1987 and 2007. Same increase rate is used for 2008-2015. The method used only gives a mean net annual C-stock change in the period 1990-2015, not gains and losses.

6.4.6 Emission/Removal Factors

Tier 3 approaches is used to estimate the carbon stock change in living biomass of the trees in both cultivated forest and the natural birch forest through the data from NFI and older surveys.

The losses reported in living biomass removed as wood are estimated by Tier 3 on basis of activity data of annual wood utilization from Icelandic forest (Gunnarsson 2016).

Carbon stock change in living biomass in other vegetation than trees is currently not estimated. In-country research results (Sigurdsson et al. 2005) did show small or no changes of carbon stocks in these sources.

Tier 2, country specific factors are used to estimate annual increase in carbon stock in mineral soil and litter. The removal factor (0.365 Mg C ha^{-1} yr^{-1}) for the mineral soil of the Grassland conversion is taken from the already mentioned study of Bjarnadóttir (2009). For the mineral soil of “Other land” converted to Forest land the same removal factor is used as for revegetation 0.51 t C ha^{-1} yr^{-1}. Revegetation and afforestation on non-vegetated soil are very similar processes, except that the latter includes tree-planting and tree layer formation. A removal factor of 0,141 Mg C ha^{-1} yr^{-1} a nominal average of two separate research (Snorrason et al. 2000; Snorrason et al. 2003; Sigurdsson et al. 2005) is used to estimate increase in carbon stock in the litter layer.

Tier 3 approach is used to estimate changes in dead wood stock. As already described dead wood meeting the minimum criteria of 10 cm in diameter and 1 m in length is measured in the field sample plot inventory. Decay class and initiation year are also assessed. Dead wood is then reported in the dead wood stock at the initial year. The changes in litter and dead wood stock are reported together as changes in dead organic matter stock.

Tier 1 and default factors from the new “2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands” are used for both CO_2, N_2O and CH_4 emission on forested drained wetland. The emission factor of carbon stock changes of drained organic soils is 0.37 t C ha^{-1} yr^{-1} from table 2.1 in the “2013 Supplement”. Off-site CO_2 emission is estimated applying emission factor 0.12 t C ha^{-1} yr^{-1} from table 2.2 in the “2013 Supplement Chosen default factor of N_2O emission from drained organic soils is 3.2 kg N_2O-N ha^{-1} yr^{-1}. (Table 2.5 in the “2013 Supplement”). For CH_4 emission compound factor of 7.375 kg CH_4 ha^{-1} yr^{-1} is used were the default factor for the ditches is 217 kg CH_4 ha^{-1} yr^{-1} and for other part of the drained land 2.0 kg CH_4 ha^{-1} yr^{-1} (Table 2.3. and 2.4 in “2013 Supplement”).

For direct N_2O emission from N fertilization Tier 1 and default emission factor of 1.25% [kg N_2O-N/kg N input] (GPG2000) is used.

In accordance to the Forest Law in Iceland, the Icelandic Forest Service holds a register on planned activity that can lead to deforestation (Skógrækt ríkisins 2008). Deforestation activities has to be announced to the Icelandic Forest Service. IFR has sampled 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. Deforestation is reported for the inventory years 2004-2007, 2011, 2013 and 2015. Two rather different types of deforestation has occurred in these years. The first and most common type is road building, house building and construction of snow avalanche defences. This type is occurring in all years mentioned. 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. According to the 2006 IPCC Guidelines Tier 1 method for dead organic matter of Forest Land converted to settlements (Vol. 4-2, 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 situation of the vegetation cover. On treeless medium to fertile sites a mean litter C stock of 1.04 ton 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 ton 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 ton 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 ton ha^{-1} (n=5, SE: 0.03). A litter C-stock of a 10 year old afforestation site would be 1.51 ton C ha^{-1}. Using the same ratio between poor and fully vegetated land as in last year submission, i.e. 17% and 83%, accordingly, will give 2.29 tons C ha^{-1} as weighted C-stock of 10 year old afforestation. 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 tons C ha^{-1}, for fully vegetated areas with thick developed andosol layers it was 72.9 tons C ha^{-1} (n=40; down to 30 cm soil depth). Annual increase in poor soil according to this year submission is 0.513 ton C ha^{-1} yr^{-1} for poorly vegetated sites and 0.365 ton C ha^{-1} yr^{-1} for fully vegetated sites. Accordingly, ten year old forests will then have a C-stock of 20 and 76.6 tons ha^{-1} on poor and fully vegetated sites, respectively. Weighted C-stock of treeless land is then 66.9 tons ha^{-1}. According to the 2006 IPCC guidelines Tier 1 method for mineral soil stock change of land converted to Settlements, land that is paved over is attributed a soil stock change factor of 0.8. Using a 20 year conversion period this means an estimated carbon stock loss of 1% during the year of conversion, i.e. the annual emission from SOC will be 0.67 ton 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 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.

6.4.7 Uncertainties and QA/QC

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 et al. 2003; Sigurðsson et al. 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 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 relative lower statistical error of the biomass C-stock of cultivated forest then for the natural birch woodland.

6.4.8 Recalculations

As described above the emission/removal estimate for forest land has been slightly revised in comparison to previous submissions. The C-stock changes are based on direct stock measurements (Tier 3) as in last year’s submission but reviewed on basis of additional data obtained and new approaches used. Time series built on direct stock measurement is calculated and reported for cultivated forest. Estimates for the natural birch forest are built on the same methodology as in last year´s submission.

As a result of these recalculations the total reported removal has decreased from -289.91 kt. CO_2-equivalents for the year 2014 as reported in 2016 submission to -284.44 kt. CO_2-equivalents in this year's submission or a 1.0% decrease in removal. The changes in reported emission removal of the category reflect the improvement in data well as development in the methodology applied for estimating this category.

6.4.9 Planned Improvements regarding Forest Land

Data from NFI are used for the ninth 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 is expected in future reporting when data from re-measurement of the permanent sample plot will be available and analysed for C-content

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

6.5 Cropland

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.

Carbon dioxide emissions from Carbon stock changes in "Cropland remaining Cropland" is recognized as key source/sink in level and trend in 2015 and "Land converted to Cropland" as key category of trend 2015.

The Cropland map layer was digitized from satellite images supported by aerial photographs in 2008 by AUI and NLSI in cooperation. This map layer was then revised by AUI in 2009. The total area of Cropland emerging from this map layer through the IGLUD processing, taking into account the order of compilation applied, is 172.54 kha. The mapped area includes both Cropland in use and abandoned Cropland reported as Grassland. The area reported in CRF as Cropland is 125.25 kha, whereof 56.31 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. These time series are shown in **Error! Reference source not found.**.

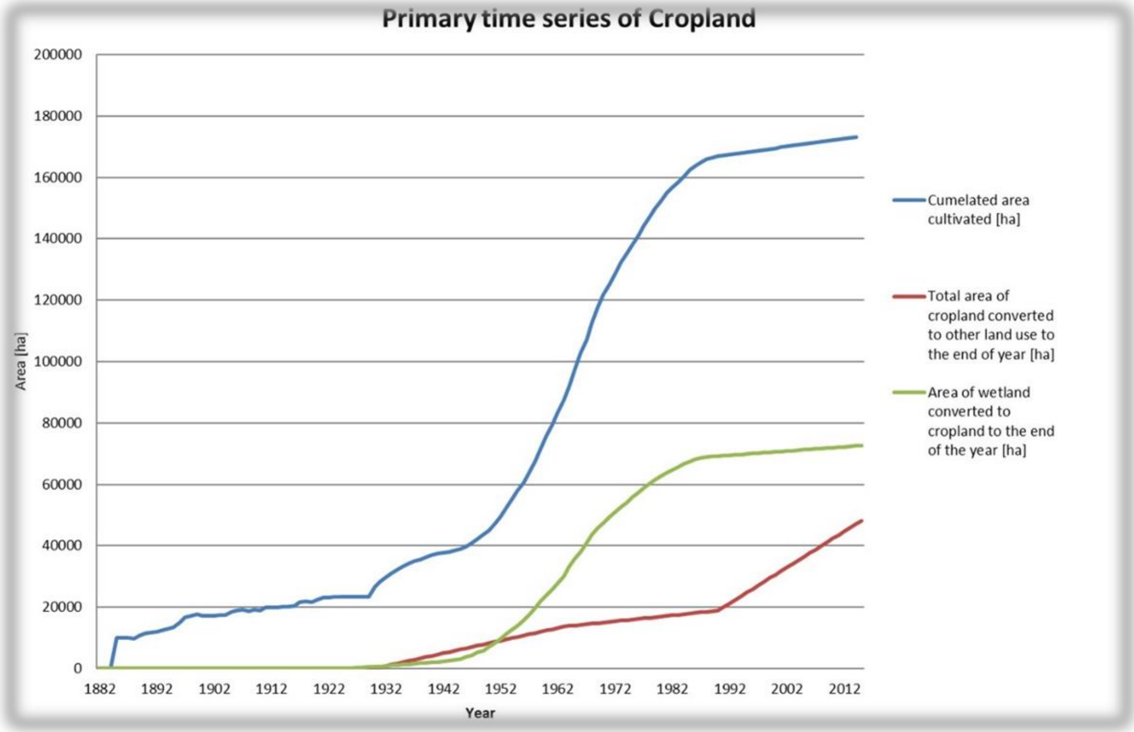

Figure 6.8 Primary time series of Cropland area: Cumulated area represents all land that has been cultivated to that time. Area of wetland converted to cropland represents the part of that area on organic soil. Total area converted to other land use represents the estimated area of abandoned Cropland.

From these primary time series, secondary times series of Cropland remaining Cropland, total area and area on organic soil, Grassland converted to Cropland and Wetland converted to Cropland are calculated (**Error! Reference source not found.**).

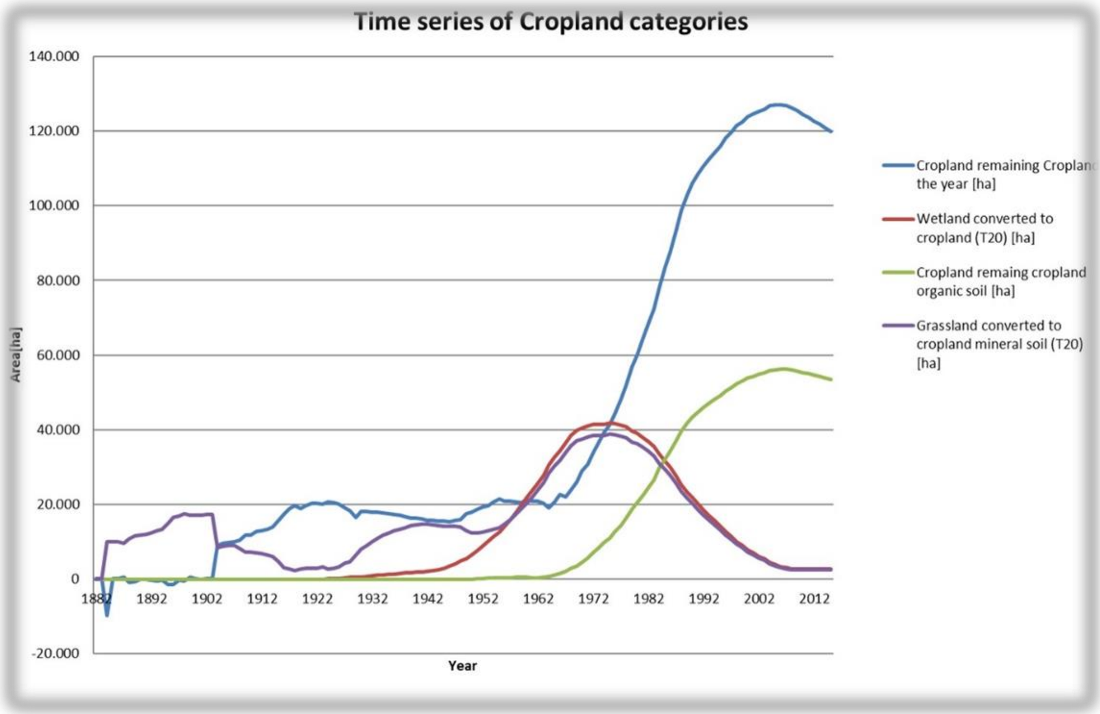

Figure 6.9 Time series of Cropland as reported. Area in hectares as estimated at the end of the year.

The area of Cropland organic soils is estimated through the time series available as described above (chapter 6.3.3). 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 ongoing. The results of this project is 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.

6.5.1 Carbon stock changes

6.5.1.1 Carbon stock changes in living biomass

As no perennial woody crops are cultivated in Iceland, no biomass changes needs to be reported. Shelterbelts, not reaching the definitions of forest land, do occur but are not common. This might be considered as cropland woody biomass. No attempt is made to estimate the carbon stock change in this biomass. Time series for land converted to Cropland applied in last year's submission are extended to the present inventory year. Changes in living biomass in connection with conversion of land to Cropland are, 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 (Gudmundsson et al. 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, 5.89and 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. The net loss is 3.51 kt. C for all land converted or emission of 12.85 kt. CO_2.

6.5.1.2 Carbon stock changes in dead organic matter

The AFOULU 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. Changes in DOM in the year of conversion and in the first year of growth after conversion are included in the changes estimated for living biomass.

6.5.1.3 Carbon stock changes in soils

Net carbon stock changes in mineral cropland soil for the category "Grassland converted to Cropland" are estimated according to Tier 1 method. Most croplands in Iceland are hayfields with perennial grasses, harvested once or twice during the growing season. Ploughing or harrowing is only occasionally (10 years interval). Livestock grazing on hayfields for part of the growing season, spring and autumn in case of sheep farming, is also common. Most hayfields are fertilized with both synthetic fertilizers and manure. Changes in SOC for mineral soil of land converted to Cropland are calculated according to T1 using equation 2.25 in 2006 IPPC guidelines. Default relative stock change factors considered applicable to hayfields with perennial grasses were selected from Table 5.5 in 2006 IPCC guidelines (IPCC 2006). For Land use the "set aside-dry" FLU = 0.93 was selected based on the descriptions in Table 5.5 as best describing the hayfields in Iceland. For management and input, FMG =1.10 no tillage- temperate boreal -dry and FI =1.00 medium input, were selected. The SOC_{REF}, 90.5 t C ha^{-1}, is the average SOC (0-30 cm) from IGLUD field sampling for Grassland (AUI unpublished data). The initial mineral soil organic C stock is accordingly SOC_0 = 90.5 tC ha^{-1} * 0.93*1.10*1.00 = 92.6 t C ha^{-1}. For the 20 year conversion period the annual change in $\Delta C_{Mineral}$ = 0.10 t C ha^{-1} for Grassland converted to Cropland. The area of Grassland on mineral soil converted to Cropland is estimated from the above described time series as 2.53 kha and the C-stock of these soils as increasing by 0.26 kt C in the inventory year. Consequently, these soils are estimated as removing 0.97 kt CO_2 from the atmosphere. No mineral soil is assumed under Wetland converted to Cropland. Changes in C-stock of mineral soils under "Cropland remaining Cropland" are not estimated as no information on changes in management is available.

Changes in SOC of organic soils are calculated according to T1 applying equation 2.3 in the 2013 Supplement to the 2006 Guidelines: Wetlands (IPCC 2014). Organic soils of Cropland are reported in two categories i.e. Cropland remaining Cropland and Wetland converted to Cropland 53.58 kha and 2.73 kha respectively. These organic soils are estimated to annually lose 423.27 kt C and 21.56 kt. C in the same order. The consequent emission is estimated as 1551.99 kt CO_2 for organic soils of Cropland remaining Cropland and 79.06 kt. CO_2 for soils of Wetland converted to Cropland. All soils of Wetland converted to Cropland are assumed to be organic.

6.5.2 Land converted to Cropland

The conversion of land to Cropland is reported in two categories. It is thus assumed that all mineral Cropland originates from Grassland and Cropland on organic soil originates directly from Wetland. Some of the Cropland on organic soils may have been drained Grassland for some period before converted to Cropland. Also, some areas of Cropland on mineral soil may have originated from other land use categories such as "Other land" or "Forest land" (Natural birch forests). There is presently no data available for the separation of conversion into more categories and until then all conversions are reported as aggregates area under the two categories. The default conversion period 20 years is applied for Grassland converted to Cropland and Wetland converted to Cropland.

6.5.3 Emissions and removals from drainage and rewetting and other management of organic and mineral soils

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.

6.5.3.1 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 two categories of organic Cropland soils, the emission calculated is

23.57 kt. CO_2 for organic soils of Cropland remaining Cropland and 1.20 kt. CO_2 for soils of Wetland converted to Cropland.

6.5.3.2 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 (IPCC 2014). 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 emission reported is 3.28 kt. CH_4 or 82.00 kt. CO_2 eq. 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 (IPCC 2014) is applied.

6.5.3.3 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.

6.5.4 Other emissions

6.5.4.1 Direct N_2O emission from N Mineralization/Immobilization

The C- stock of mineral soils of land converted to Cropland is estimated as increasing (see chapter 6.5.1.3). Nitrogen immobilization and no N_2O emission is accordingly assumed. Changes of SOC of mineral soils under Cropland remaining Cropland are not estimated and accordingly not possible associated N_2O emissions. This is reported under the Agricultural sector 3.D.1.5.

6.5.4.2 N_2O emission from drained inland soils

All N_2O emissions from drainage of organic soils are reported under the Agriculture sector 3.D.1.6-Cultivation of Histosols. N_2O emissions from disturbance associated with conversion of land to cropland

6.5.5 Biomass burning

No biomass burning of cropland occurred in the inventory year and reported as such. Method for estimating area of biomass burned is described in chapter 6.12.

6.5.6 Emission factors

The CO_2 emission from C- stock changes in Cropland organic soil are calculated according to a Tier 1 methodology using the EF= 7.9 t CO_2-C ha-1yr-1 from table 2.1 in 2013 wetland supplement (IPCC 2014).

The off-site CO_2 emission via waterborne losses from drained cropland soils is calculated according to T1 using EF = 0.12 t C ha-1yr-1 from table 2.2 in 2013 wetland supplement (IPCC 2014).

The emissions of CO_2 caused by conversion of land to Cropland is calculated on the basis of country specific estimate of C stock in living biomass, litter and standing dead biomass 1.27 ± 0.24 kg C m^{-2} and 1.80 ± 0.51 kg C m^{-2} for Grassland and Wetland respectively as estimated from field sampling. Methods are described in Gudmundsson et al. (2010). The Cropland biomass after one year of growth is 2.1 t C ha^{-1} from Table 5.9 in 2006 IPCC guidelines (IPCC 2006). The SOC_{Ref} = 90.5 ±28.2 t C ha^{-1}, for mineral soils of Grassland converted to Cropland is country specific and based on preliminary results from IGLUD soil sampling. For the 20 years conversion period, the annual change is in ΔC Mineral = 0.10 t C ha^{-1} for Grassland converted to Cropland. This EF is further supported by study effects of different synthetic N fertilizers over 28 years indicating comparable increase in C % in uppermost 20 cm of the soil (Helgason 1975). The CH_4 emission and removal from drained cropland is calculated according to T1 applying EF_{CH4_land} = 0 and EF_{CH4_ditch} = 1165 kg CH_4 ha^{-1} yr^{-1} from table 2.3 and 2.4 in 2013 wetland supplement (IPCC 2014) respectively.

6.5.7 Uncertainties and QA/QC

According to the time series for Cropland the cumulated area of cultivated land is in good agreement with the area mapped as Cropland 172.5 kha versus 173.5 kha. Abandoned cropland is included in both estimates.

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 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 accordingly 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%.

The off-site CO_2 emission via waterborne losses from drained cropland soils is calculated based on default EF from table 2.2 in 2013 wetland supplement (IPCC 2014) with range ± 50%.

Emission of CH_4 from drained Cropland only includes emission from drainage ditches and is calculated according to EF from table 2.4 in 2013 wetland supplement (IPCC 2014) with range ± 70%.

6.5.8 Recalculations

There are no recalculations for this category in this submission.

6.5.9 Planned improvements regarding Cropland

In this submission as in last year’s submissions, time series of Cropland categories were used to estimate the area of each category. Further improvements of the mapping and subdivision are still needed as e.g. revealed through the cropland mapping survey described above. The area of land converted to Cropland from other categories than Grassland or Wetland needs to be determined. Continued field controlling of mapping, improved mapping quality and division of cropland to soil classes and cultivated crops is planned in coming years. As the introduction of time series revealed that, a considerable area of the mapping unit Cropland is abandoned cropland. Identifying the abandoned cropland within the mapping unit is considered of high importance. 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 both “Cropland remaining Cropland” and “Land converted to Cropland” are recognized as key sources, it is important to move to a higher tier in estimating that factor. Data, obtained through fertilization experiments, on carbon content of cultivated soils is available at the AUI. The data is currently being processed and is expected to yield information on changes in carbon content of cultivated soils over time.

The emission components of offsite CO_2 emission and CH_4 emissions from Cropland have not gained much attention in Iceland. Data on that emissions and area involved is needed for Iceland e.g. the ratio of dich area. It is therefore considered important to promote the research needed and improve the estimate of relevant area.

6.6 Grassland

Grassland is the largest land use category identified by present land use mapping as described above. The total area of the Grassland category is reported as 5,373.15 kha, making it by far the largest land use category in Iceland. Grassland is a very diverse category with regard to vegetation, soil type, erosion and management.

The Grassland category is divided into twelve subcategories in this year´s submission. The Grassland time series reported are prepared from three primary time series (Figure 6.10), and an independent time series for expansion of birch shrubland into other grassland. 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.

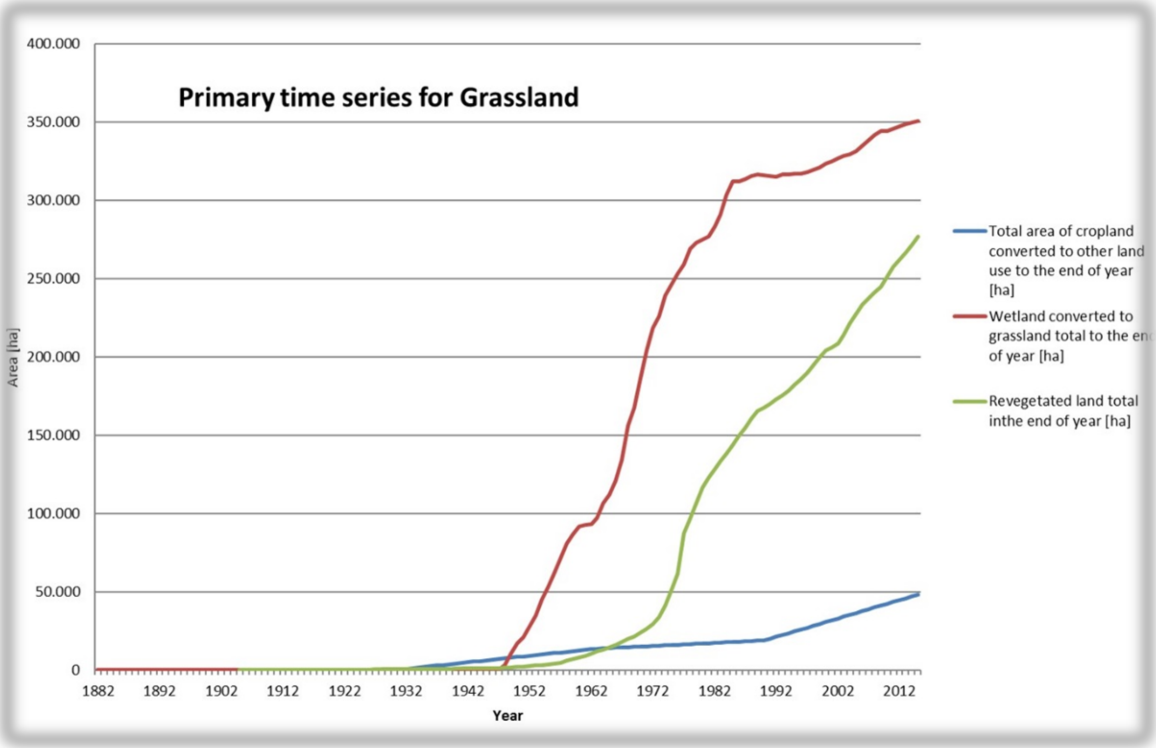

Figure 6.10 Primary time series for Grassland: Total area of Cropland converted to other land uses at the end of the year, Wetland converted to Grassland at the end of the year, Revegetated land at the end of the year. All graphs showing cumulative area at the end of the year from the beginning of time series.

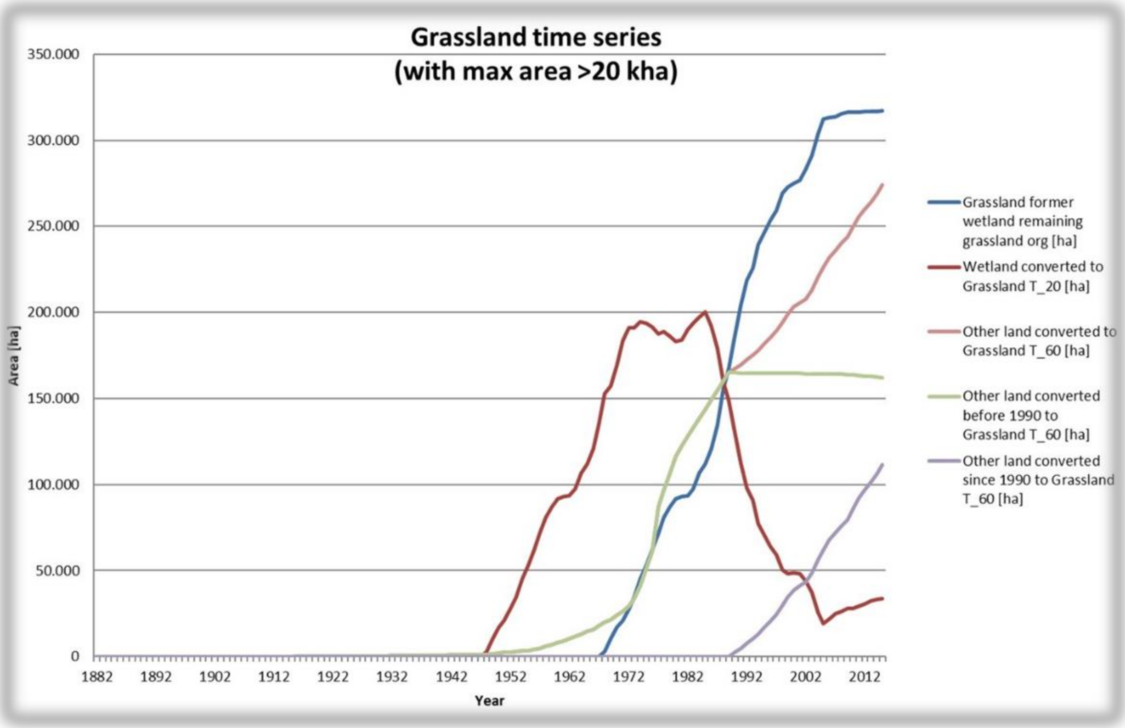

Figure 6.11 Time series of reported Grassland categories with max area >20 kha: Grassland former Wetland remaining Grassland organic soil, Wetland converted to Grassland T_20, Other land converted to Grassland T_60, Other land converted to Grassland before 1990 T_60, Other land converted to Grassland since 1990 T_60. All graphs showing the area in hectares at the end of the year.

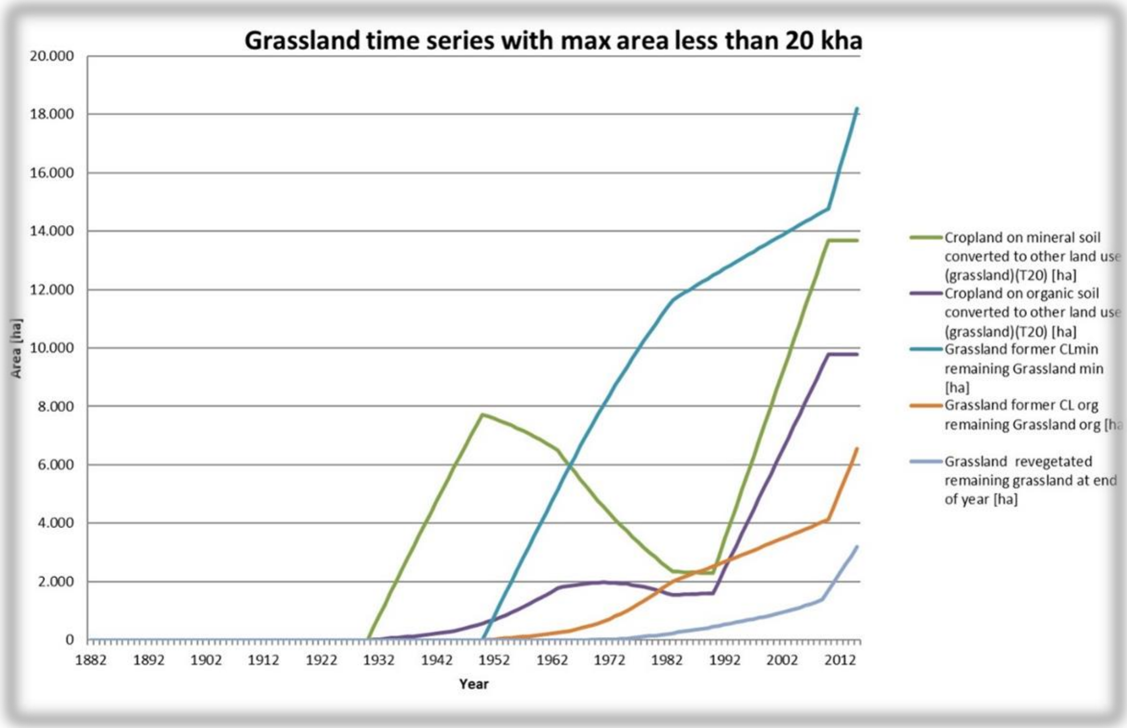

Figure 6.12 Time series of reported Grassland categories with max area <20 kha: Cropland on mineral soil converted to Grassland T_20, Cropland on organic soil converted to Grassland T_20, Grassland former Cropland remaining Grassland mineral soil, Grassland former Cropland remaining Grassland organic soil, Grassland former revegetated Other land remaining Grassland. All graphs showing the area in hectares at the end of the year.

6.6.1 Grassland remaining Grassland

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.

6.6.1.1 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 24.75 kha whereof 6.55 kha is organic soil.

6.6.1.2 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. “Natural birch shrubland – recently expanded from Other Grassland” 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 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 organic soil.

6.6.1.3 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, higher ranked than Grassland in the hierarchy (table 1), are excluded a priory. The map layers classified as Land converted to grassland are all ranked above the map layers included in the category “Other grassland”. The land in this category is e.g. heath-lands with dwarf shrubs, small bushes other than birch (Betula pubescens), grasses and mosses in variable combinations (respecting the 20% minimum vascular plant cover), fertile grasslands, and partly vegetated land. The area mapped is then adjusted to other Grassland categories (chapter 6.3.5) and the time series prepared as described above. The total area reported in this year’s submission for this category is 4,648.96 kha.

Large areas in Iceland suffer from severe degradation where the vegetation cover is severely damaged or absent and the soil is partly eroded but the remaining Andic soil still has high amounts of carbon. Recent research indicates that the carbon budget of such areas might be negative, resulting in CO_2 emission to the atmosphere (AUI unpublished data). This land has not been identified in the IGLUD maps, but is likely to be included in this category to a large extent.

Since the settlement of Iceland a large share of the former vegetated areas has been severely eroded and large areas have lost their entire soil mantle. It has been estimated that a total of 60-250×103 kt. C has been oxidized and released into the atmosphere in the past millennium (Óskarsson et al. 2004). The estimated current on-going loss of SOC due to erosion is 50-100 kt. C yr-1 according to the same study. That study only takes in account the soil lost through one type of erosion i.e. erosion escarpments. This loss is comparable to 183-366 kt. CO_2 if all of this lost SOC is decomposed or 92-183 kt. CO_2 if 50% of it is decomposed as argued for in the paper (Óskarsson et al. 2004). This loss is at present not included in the CRF, but the possible amount of C being lost is in the same order of magnitude as CO_2 removal reported as revegetation since 1990 (221 kt. CO_2). The revegetation of deserted areas sequesters carbon back into vegetation and soil and thereby counteracts these losses.

The vegetation cover in many other Grassland areas in Iceland is at was noted to be increasing in both vigour and continuity (Magnússon et al. 2006). This increase has in another recent study been shown to have slowed down or even turned to a decrease in some areas (Raynolds et al. 2015). In these areas, the annual carbon budget might have been positive for a period with C being sequestered from the atmosphere. Whether these changes in vegetation are related to changes in climate, management or a combination of both is not clear.

The subdivision of Grassland, according to land degradation or improvement is one of the IGLUD objectives as described in (Gudmundsson et al. 2010). Through this subdivision estimates of both ongoing losses and gains can be attempted. Subdivision based on management regimes, i.e. unmanaged and managed and the latter further according to grazing intensity is pending but not implemented.

6.6.1.4 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 category. The total area of the category is in this year’s submission 3.19 kha. This area is not at present recognised 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 chapter 6.3.1.3 - *Maps of Land being re-vegetated*).

6.6.1.5 Wetland drained for more than 20 years.

This category also appears as result of time series and application of default 20 years conversion period for “Wetland converted to Grassland”. 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 317.00 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”. The preparation of that mapping unit is described in (chapter 6.3.1.3 – *Maps of drained land*).

6.6.2 Land converted to Grassland

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.

6.6.2.1 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 9.79 kha on organic soil.

6.6.2.2 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 33.64 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.

6.6.2.3 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 275.46 kha, with 162.17 kha as revegetation before 1990, 111.70 kha as revegetation since 1990, and 1.6 kha as other land converted to Natural birch shrubland.

Revegetation

The revegetation activity where no afforestation is included the land 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, according to the SCSI. Accordingly, this land does not meet the definition of Grasslands and is all classified as “Other land being converted to Grassland”.

The SCSI was established in 1907. Its main purpose is the prevention of on-going land degradation and erosion, the revegetation of eroded areas, restoration of lost ecosystem and to ensure sustainable grazing land use. The reclamation work until 1990 was mostly confined to 170 enclosures, covering approximately 3% of the total land area. The exclusion of grazing livestock from the reclamation areas, and other means of improving livestock land use, is estimated to have resulted in autogenic soil carbon sequestration, but the quantities remain to be determined. Record keeping of soil conservation and revegetation efforts until 1960 was limited. From 1958 to 1990, most of the activities involved spreading of seeds and/or fertilizer by airplanes and direct seeding of

Lyme grass (Leymus arenarius L.) and other graminoids. These activities are to a large extent recorded. The emphasis on aerial spreading has decreased since 1990 as other methods, such as increased participation and cooperation with farmers and other groups interested in land reclamation work, have proven more efficient. Methods for the recording of activities have been improved at the same time, most noticeably by using aerial photographs and GPS-positioning systems. Since 2002, GPS tracking has increasingly been used to record activities in real time, e.g. spreading of seeds and/or fertilizer. Since 2008 almost all activities have been recorded simultaneously with GPS-units (Thorsson et al. in prep.).

The SCSI now keeps a national inventory on revegetation areas since 1990 based on best available data. The detailed description of methods will be published elsewhere (Thorsson et al. in prep.). The objectives of this inventory are to monitor the changes in C-stocks, control and improve the existing mapping and gather data to improve current methodology. Activities which started prior to 1990 are not included in this inventory at present. The National Inventory on Revegetation Area (NIRA) is based on systematic sampling on predefined grid points in the same grid as is used by the IFR for NFI (Snorrason and Kjartansson. 2004) and in IGLUD field sampling. The basic unit of this grid as applied by SCSI and IFS is a rectangular, 1.0 x 1.0 km in size. A subset of approximately 1000 grid points that fall within the land mapped as revegetation since 1990 was selected randomly and have been visited although all data from the survey is still not available. Points found to fall within areas where fertilizer, seeds, or other land reclamation efforts have been applied, will be 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 will be used for soil and vegetation sampling for C-stock estimation.

A conversion period of 60 year has been defined on basis of NIRA data sampling. The length of the conversion period is preliminary as the data remains to be analysed further. 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 subdivision of land revegetated since 1990 is based on different management regimes as some land has been opened up for grazing of limited intensity.

The area of Revegetation since 1990 reported for the year 2015 is 111.70 kha compared to 105.62 kha reported for the year 2014 in last year´s submission.

The area reported as Revegetation before 1990 is calculated from the best available data of revegetation before 1990. The mapping of these areas is still subjected to high uncertainty and only small portion of this land is presented in IGLUD map layer Revegetation before 1990. The area not included in that map layer is assumed to be located within the SCSI’s designated areas. Estimation on total revegetation area before 1990 is finished based on best available documentation and is presented here, but mapping has not been finished at this point but will be provided in next year’s submission (Thorsson J. personal communication).

Other land converted to Natural birch shrubland.

The forth subcategory is “Other land converted to Natural birch shrubland”. That area the is expansion of natural birch shrubland into poorly vegetated land. As no historical data before 1987 exists, a time series for changes C-stock of natural birch shrubland only exist after 1987 and in C-stock after 1989. They are built on interpolation between 1989 and 2007 and extrapolations to 2015 with even annual increase in area.

This category emerges from the expansion of Natural birch shrubland noted in the NFI mapping of birch woodlands. The shrubland has compared to the 1989 survey expanded into “Other land” by 1.59 kha.

6.6.3 Carbon stock changes

Carbon stock changes are estimated for all subcategories included both under Grassland remaining Grassland and Land converted to Grassland. The C-stock changes of “Revegetated land older than 60 years” and “Other Grassland” are presently estimated as not occurring. Carbon stock changes of “Grassland remaining Grassland” and “Land converted tor Grassland” are recognized as key categories of both level and trend in 2015.

6.6.3.1 Carbon stock changes in living biomass

The changes in living biomass 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 0.60 kt. C respectively removing 3.69 kt. CO_2 and 2.22 kt. CO_2 from the atmosphere. 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.

Carbon stock changes in living biomass are estimated for all categories of Land converted to Grassland where conversion is reported to occur. Conversions of “Forest land” and “Settlements” to Grassland are reported as not occurring. Changes in living biomass in the category Wetland converted to Grassland are reported as not occurring as vegetation is 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 (IPCC 2006)) and average C stock in living biomass, litter and standing dead biomass of Grassland as estimated from IGLUD field sampling (see chapter 6.5.1.1). The living biomass of this category is estimated to have increased by 12.41 kt. C in 2015, 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 et al. 2000, Arnalds et al. 2000). The total C-stock increase is estimated on basis of NIRA sampling. Increase of the carbon stock in living biomass on revegetated land is estimated as 15.61 kt. C and thereby removing 57.23 kt. CO_2 from the atmosphere. This increase is divided to three subcategories, , Revegetation before 1990 9.24 kt. C (33,89 kt. CO_2), Revegetation since 1990-protected from grazing 5.73 kt. C (20.99 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 0.39 kt. C removing 1.42 kt. CO_2 from the atmosphere.

6.6.3.2 Carbon stock changes in dead organic matter

Changes in carbon stock of dead organic matter are estimated for the category “Natural birch shrubland-recently expanded into Other Grassland” and the category “Other land converted to Natural birch shrubland” by the IFR in the NFI. The carbon stock in dead organic matter of these categories is estimated to have increased by 0.35 kt. C for “Natural birch shrubland-recently expanded into Other Grassland” and 0.22 kt. C for “Other land converted to Natural birch shrubland” in the year 2015 and accordingly removing 1.28 kt. CO_2 and 0.82 kt. CO_2 respectively 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 et al. 2000).

Changes in dead organic matter of “Wetland converted to Grassland” are reported as not occurring consequent with no changes in living biomass.

6.6.3.3 Carbon stock changes in soils

Mineral soil

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 0.83 kt. C in the year 2015 and thereby removing a total of 3.05 kt. CO_2 form the atmosphere. 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 (F_{LU}, F_{MG}, and F_I) are unchanged over a period.

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 5.22 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 140.49 kt. C, removing 515.14 kt. CO_2 from the atmosphere. This increase is divided on three subcategories, “Revegetation before 1990” 83.19 kt. C (305.04 kt. CO_2), “Revegetation since 1990 – protected from grazing” 51.53 kt. C (188.93 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 0.82 kt. C and to have removed 3.00 kt. CO_2 from the atmosphere.

Organic soils

Organic soils are reported for the Grassland subcategories “Cropland abandoned for more than 20 years”, “Natural birch shrubland- old”, “Natural birch shrubland recently expanded into Other Grassland”, “Wetland drained for more than 20 years”, “Cropland converted to Grassland”, and “Wetland converted to Grassland”. The carbon stock changes in organic soils of land under these categories are estimated applying Tier 1 methodology. Three soil types; Histosol, Histic Andosol and Gleyic Andosol are included. The two organic soil types are Histic Andosol and Histosol. Although Gleyic Andosol is not classified as organic, it is included here. The carbon stock in drained organic soils included under the Grassland subcategories is estimated to have decreased by 2094.49 kt. C in the inventory year emitting 7,679.80 kt. CO_2. The disaggregation of these numbers to the subcategories involved is shown in Table 6.9.

Table 6.9 Drained soils, estimated C losses and on site CO_2 emission of Grassland categories/subcategories.

Category/subcategory	Drained "organic" soils [kha]	Carbon stock changes in organic soils [kt. C]	Emission [kt. CO_2]
Grassland remaining Grassland	324.03	-1846.92	6772.04
Cropland abandoned for more than 20 years	6.55	-37.33	136.89
Natural birch shrubland (N.b.s)- old	0.26	-1.46	5.36
N.b.s.- recently expanded into Other Grassland	0.22	-1.24	4.54
Wetland drained for more than 20 years	317.00	-1806.89	6625.25
Land converted to Grassland	43.43	-247.57	907.75
Cropland converted to Grassland	9.79	-55.79	204.58
Wetland converted to Grassland	33.64	-191.78	703.18
Total	**367.45**	**-2094.49**	**7679.80**

6.6.4 Emissions and removals from drainage and rewetting and other management of organic and mineral soils

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.

6.6.4.1 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 (IPCC 2014) applying T1 methodology. The off-site emission is reported for all Grassland subcategories with drained soils. The total emission for Grassland is estimated as 161.68 kt. CO_2. The disaggregation of these numbers to the subcategories involved is shown in Table 6.10.

Table 6.10 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	324.03	142.57
Cropland abandoned for more than 20 years	6.55	2.88
Natural birch shrubland (N.b.s)- old	0.26	0.11
N.b.s.- recently expanded into Other Grassland	0.22	0.10
Wetland drained for more than 20 years	317.00	139.48
Land converted to Grassland	43.43	19.11
Cropland converted to Grassland	9.79	4.31
Wetland converted to Grassland	33.64	14.80
Total	**367.45**	**161.68**

6.6.4.2 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 (IPCC 2014). 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 (IPCC 2014) is applied. In general the drainage ditches in Iceland are deep 1.5m-4m and EF for Grassland ditches selected accordingly. The emission of CH_4 is reported for all the Grassland subcategories including drained soils. The total emission reported is 21.89 kt. CH_4 or 547.32 kt. CO_2 eq. Of this emission 22.32 kt. CH_4 is reported from the ditches while only 0.48 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 6.11.

Table 6.11 Drained soils, estimated CH_4 emission from drained land and ditches of Grassland categories/subcategories.

Category/subcategory	Drained "organic" soils [kha]	$CH_{4\ land}$ [kt. CH_4]	$CH_{4\ ditches}$ [kt. CH_4]	$CH_{4\ total}$	
				[kt. CH_4]	[kt. CO_2 eq]
Grassland remaining Grassland	324.03	0.43	18.86	19.31	482.63
Cropland abandoned for more than 20 years	6.55	0.01	0.38	0.39	9.76
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	0.22	0.00	0.01	0.01	0.32
Wetland drained for more than 20 years	317.00	0.42	18.46	18.89	472.17
Land converted to Grassland	43.43	0.06	2.53	2.58	64.69
Cropland converted to Grassland	9.79	0.01	0.57	0.58	14.58
Wetland converted to Grassland	33.64	0.04	1.96	2.00	50.11
Total	**367.45**	**0.49**	**21.39**	**21.89**	**54732.25**

6.6.4.3 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.

6.6.5 Other emissions

6.6.5.1 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 total emission of N_2O reported under 4H is 0.25 kt. N_2O or 75.71 kt. CO_2 eq. The disaggregation of this emission to subcategories is shown in Table 6.12.

Table 6.12 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_2 eq]
Grassland remaining Grassland	324.03	0.22	66.76
Cropland abandoned for more than 20 years	6.55	0.00	1.35
Natural birch shrubland (N.b.s)- old	0.26	0,00	0,05
N.b.s.- recently expanded into Other Grassland	0.22	0,00	0,04
Wetland drained for more than 20 years	317.00	0.22	65.32
Land converted to Grassland	43.43	0.03	8.95
Cropland converted to Grassland	9.79	0,01	2.02
Wetland converted to Grassland	33.64	0.02	6.93
Total	**367.45**	0.25	75.71

6.6.5.2 Direct N_2O emissions from N Mineralization/Immobilization

Conversion of Cropland on mineral soils to Grassland 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 t N_2O or 0.44 kt. CO_2 eq.

6.6.6 Biomass burning

Biomass burning on Grassland is reported for Grassland remaining Grassland. All subcategories are reported as aggregate number but emission is estimated separately from estimated biomass of each subcategory. Only wildfires are included in the present estimate. The methodology for estimating the biomass burned and the consequent emissions is explained in chapter 6.12. The area of Grassland burned in the inventory year in wildfires is estimated from available maps of the burned area. Overlays of that area on the IGLUD land use map reveal 272.5 ha of Grassland remaining Grassland. The emission caused by these fires is estimated as 6.49 Mg CH_4 plus 0.59 Mg N_2O for Grassland remaining Grassland. This emission is equivalent to total 162.27 Mg CO_2.

6.6.7 Emission factors

The CO_2 emissions from C- stock changes in Grassland drained soils is calculated according to a Tier 1 methodology using the EF= 5.7 t CO_2-C $ha^{-1}yr^{-1}$ from table 2.1 in 2013 wetland supplement (IPCC 2014).

The C-stock changes in living biomass of Natural birch shrubland is in the NFI applying T3 methodology of direct estimate of stock changes.

The changes in annual living biomass (including litter and dead organic matter) of Cropland converted to Grassland are estimated from C stock in living biomass, litter and standing dead biomass of Grassland as estimated from IGLUD sampling 1.27 ± 0.24 kg C m^{-2} (12.7 t C ha^{-1}) and default Cropland biomass 2.1 t C ha^{-1} from Table 5.9 in 2006 IPCC guidelines (IPCC 2006). The average annual increase in living biomass including dead organic matter is accordingly estimated as 0.53 t C ha^{-1} yr^{-1} with 20 years conversion period.

The Soil Conservation Service of Iceland records the revegetation efforts conducted. A special governmental program to sequester carbon with revegetation and afforestation was initiated in 1998-2000 and has continued since then. A parallel research program focusing on carbon sequestration rate in revegetation areas was started the same time (Aradóttir et al. 2000; Arnalds et al. 2000). The contribution of changes in carbon stock of living biomass (including dead organic matter) and soil were estimated as 10% and 90% respectively is based on these studies. The SCSI has since 2007 been running National Inventory on Revegetation area (NIRA), including sampling of soil and vegetation. Emission factors for changes in C-stocks are based on analyses of these samples (Thorsson et al. in prep). The CS emission factors applied for C-stock changes in living biomass (including dead organic matter) and mineral soils of land under the category “Other land converted to Grassland“ are -0.06 and -0.51 t C/ha/yr respectively. All revegetated areas 60 years old or less are assumed to accumulate carbon stock at the same rate. The changes in C-sock of mineral soils of the category “Other land converted to Natural birch shrubland” is estimated applying the same EF as for revegetation activities.

The C- stock changes in mineral soils of the subcategory “Natural birch shrubland–recently expanded into Other Grassland” are estimated applying same EF (0.365 t C ha^{-1} yr^{-1}) as for mineral soils of afforested Grassland (Bjarnadóttir 2009)

Carbon stock changes for mineral soil of Cropland converted to Grassland are estimated as the reversal of changes in opposite land use changes i.e. Grassland converted to Cropland (see chapter 0) EF= -0.10 t C ha^{-1}.

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 (IPCC 2014)

The CH_4 emission and removal from drained Grassland is calculated according to T1 applying EFCH4_land = 1.4 and EF_{CH4_ditch} = 1165 kg CH_4 ha^{-1} yr^{-1} from table 2.3 and 2.4 in 2013 wetland supplement (IPCC 2014) respectively.

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 (Gudmundsson 2009).

6.6.8 Uncertainties and QA/QC

The uncertainty of area of the categories reported is estimate 20% except for Revegetation where the currently estimated uncertainty in area is 10% according to SCSI. 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 10.1.3). 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. 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 size of the drained area is in this year’s submission estimated from IGLUD as described above. In the summer 2011 a survey of drained Grassland was initiated. The results of that survey have not yet been analysed, but subsample analysis indicate a 20-30% area uncertainty. 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 500*500 m were controlled for ditches. Preliminary results show that 91% of the ditches mapped were confirmed and 5% of ditches in the squares were not already mapped. The 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 et al. 2007). The AUI launched in 2011 project to check the validity of this number. The field work was finished in 2014, but analyses of the data is pending. 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. The decision to rank the map layers of wetland, semi-wetland and wetland/semi-wetland complex lower than drained land most certainly included some areas as drained although still wet.

It can be assumed that the area with drained soil decreases as time passes, simply because the drained soil decomposes and is “eaten” down to the lowered water level and thus becomes wet again. On the other hand the decomposition of the soil also results in sloping surface toward the ditch, which potentially increases runoff from the area and less water becomes available to maintain the water level. No attempt has been made to evaluate the effects of these factors for drained areas.

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 2016).

Carbon stock changes of living biomass in land remaining Grassland is estimated for “Natural birch shrubland-old” and “Natural birch shrubland recently expanded to Other grassland” The C-stock changes of these categories are estimated by IFR through NFI, and subjected to the same uncertainty as other estimates obtained through NFI. These estimates shows that changes are occurring in the living biomass of that category. Comparable changes in other pools of that category are expected until the area reaches a new equilibrium. As no specific actions have been taken to increase the living biomass of that category, the observed changes indicate that this is the result of some general causes e.g. changes in climate or management (grazing pressure). The same components would be likely to act similarly on other categories. Considering the severe erosion in large areas included as Grassland, this category could potentially be a large source. These emissions might be counteracted or even annulated by carbon sequestration in areas where vegetation is recovering from previous degradation (Magnússon et al. 2006, Guðmundsson 2016).

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 ± 10%. 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%.

The off-site CO_2 emission via waterborne losses from drained Grassland soils is calculated based on default EF from table 2.2 in 2013 wetland supplement (IPCC 2014) with range ± 50%.

Emission of CH_4 from drained Grassland includes emission from drained land and drainage ditches and is calculated according to EF's from table 2.3 and 2.4 in 2013 wetland supplement (IPCC 2014) the 95% confidence interval is ± 3.0 kg CH_4 ha-1 yr-1 (approx. 200%) and ± 830 kg CH_4 ha^{-1} yr^{-1} (approx. 70%), for drained land and ditches respectively.

The emission of N_2O from drained soils of Grassland categories is estimated by applying CS EF from in country measurements (Gudmundsson 2009). The standard error of the average emission is 22%, and total emission at least subjected to that uncertainty.

Applying the same EF's for all drained land also involves many uncertainties. The emissions vary according to age of drainage, e.g. due to changes in the quality of the soil organic matter, it can also vary according to depth of the drained soil and type of soil drained among other factors. This uncertainty has not been evaluated.

6.6.9 Recalculations

The area of mineral soils of "Grassland remaining Grassland" subcategory "Cropland abandoned for more than 20 years" is revised for all years since 1990. This revision does not affect any emissions reported. Minor change in length of new ditches in the year 2014 and accordingly drained area of Cropland and Grassland slightly changes the emissions estimate based on that area.

Area of Natural birch shrubland categories for the years 1990-2014 is revised from last submission changing both the area of drained organic soils and mineral soils under those categories. The relevant emissions are revised accordingly.

6.6.10 Planned improvements regarding 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 is in this submission 8,464.51 kt. CO_2 eq. making that component the far largest identified anthropogenic source of GHG in Iceland. 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.

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 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 data sampling in this project was finished in 2014, analyses of the data is pending. The results of this project are expected to improve the area estimate of drained land and of effectiveness of drainage. As described in chapter 6.3.8 new satellite images and new DME model will enable major revision of the area of drained soils in next two years.

A pilot study on emission from different types of wetland soils indicate some difference in emissions between wetland soil types. It is important to continue research on variability of emissions between and within different wetland soil types.

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.

Age of drainage can be an important component affecting the emissions from the drained soil, the effectiveness of the drainage can also be assumed to depend on drainage age. Therefore geographical identification of drained areas of different age is planned in near future.

The T1 EF for C-stock changes of drained soils is comparable to new data from in country studies (Guðmundsson and 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). Processing of the IGLUD dataset is expected to give results in the next few years.

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.

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. Three main improvements are planned and currently being carried out in part. The first is the improvement in activity recording, including both location (area) and description of activities and management. This is already being actively implemented and all data will be in acceptable form beginning in 2012. Data on older activities started after 1990 are currently under revision and are planned to be finished next years. Mapping of all activities since 1990 is verified by visiting points within the 1×1 km inventory grid. Recording of activities initiated before 1990 is also on-going. The second improvement is pre-activity sampling to establish a zero-activity baseline for future comparisons of SOC. This has been implemented for all new areas established in 2010 and later (Thorsson et al. in prep.). The third improvement is the introduction of a sample based approach, combined with GIS mapping, to identify land being revegetated, and to improve emission/removal factors and quality control on different activity practices. The approach is designed to confirm that areas registered as subjected to revegetation efforts are correctly registered and to monitor changes in carbon stocks.

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

6.7 Wetland

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 625.73 kha. Wetlands include lakes and rivers as unmanaged land and reservoirs and intact and rewetted mires and fens as managed land. The Mires and fens are included in the rangeland grazed by livestock and are grazed to some extent and accordingly included as managed land. The area of wetland is revised in this submission according to new map layer for lakes and rivers. Since 1990 the total area has decreased from 649.02 kha or by 23.29 kha as new drainages exceeds land rewetted or impounded by hydropower reservoirs. The net emission from the wetland category is reported as 1016.04 kt. CO_2 eq.

In this year's submission emission is reported for following land use categories; "Flooded land remaining Flooded land- Mires converted to reservoirs", "Other wetlands remaining Other wetlands- Lakes and rivers converted to reservoirs", "Other wetlands remaining Other wetlands- intact mires", "Grassland converted to flooded land- Medium SOC to reservoirs", "Other land converted to flooded land- Low SOC to reservoirs", "Grassland converted to other wetlands- Refilled lakes and ponds" and "Grassland converted to other wetlands- Rewetted wetland soils".

6.7.1 Wetland remaining Wetland

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. Channeling 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"

6.7.1.1 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.

6.7.1.2 Lakes and rivers

The area estimation of this category is described in chapter 6.3.1.

6.7.1.3 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.

6.7.1.4 Intact mires

In the new 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 349.42 kha compared to 391.43 kha in the year 1990. All the area is included as organic soils.

6.7.2 Land converted to Wetland

Four categories of land converted to wetland are identified. Two are tracked to the flooding of land by reservoirs i.e. "Grassland converted to flooded land- Medium SOC to reservoirs", and "Other land converted to flooded land- Low SOC to reservoirs". The remaining two are results of wetland restoration activity i.e. "Grassland converted to other wetlands- Refilled lakes and ponds", and "Grassland converted to other wetlands- Rewetted wetland soils".

6.7.2.1 Grassland converted to flooded land

This category contains inundated land of reservoirs with medium SOC content defined as:

> Grassland with medium soil organic content (Medium SOC). SOC 5-50 kg C m-2. This land includes most grassland, cropland and forestland soils except the drained wetland soils.

The total area of this category reported is 7.19 kha as in last year's submission. The area estimate is based on reservoir mapping and available data on inundated land.

6.7.2.2 Other land converted to flooded land

This category contains inundated land of reservoirs with low SOC content defined as:

> Other land with low soil organic content (Low SOC). SOC less than 5 kg C m-2. This category includes land with barren soils or sparsely vegetated areas previously categorized under "Other land".

The total area of this category reported is 18.90 kha as in last year's submission. The area estimate is based on reservoir mapping and available data on inundated land.

6.7.2.3 Grassland converted to other wetland

This category contains all land turned to wetland through wetland restoration activities. This category is reported for the first time in this year's submission. Most wetland restorations in Iceland hitherto have been to restore habitats rather than as act of greenhouse gas mitigation. In some cases the driver has been to get rid of, unnecessary ditches even acting as traps for livestock. This category is divided to two subcategories depending on the end result of the conversion, i.e. "Refilled lakes and ponds", which included in the map layer "Lakes and rivers", and "Rewetted wetland soils", which are included under map layer "Other wetlands". The area reported for these categories is 0.12 kha and 0.51 kha for "Refilled lakes and ponds", and "Rewetted wetland soils" respectively.

6.7.3 Carbon stock changes

The CO_2 removal due to carbon stock changes in category "Other wetlands remaining Other wetlands" is recognized as key category of level in 2015.

6.7.3.1 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.

6.7.3.2 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 and Guðmundsson 2008). For the three new reservoirs established 2009 and one established 2007 new reservoir specific emission factors were calculated according to (Óskarsson and Guðmundsson 2008) from the estimated amount of inundated carbon. The inundated carbon of these reservoirs was estimated by (Óskarsson and Guðmundsson 2001) and (Óskarsson and Gudmundsson in prep.). Reservoir classification is based on information, from the hydro-power companies using 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 in 2013 wetland supplement (IPCC 2014). The total removal reported is 704.67 kt. CO_2 and 1.03 kt. CO_2 respectively.

6.7.4 Emissions and removals from drainage and rewetting and other management of organic and mineral soils

Included in this category is off-site CO_2 emission and CH_4 emission from wet organic soils.

6.7.4.1 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 reported emission is 0.29 kt. CO_2, 102.50 kt. CO_2, 0.03 kt. CO_2, and 0.15 kt. CO_2 for these categories in the above order.

6.7.4.2 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 and Guðmundsson 2008). In cases where information was available, the emissions were calculated from inundated carbon. Estimated CH_4 emission from reservoirs is 0.41 kt. CH_4 (10.15 kt. CO_2 eq).

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 CH4 for these categories is estimated according to T1 applying equation 3.8 in 2013 wetland supplement (IPCC 2014). The reported emission is 63.83, 0.02, and 0.09 kt. CH_4 for “Intact mires”, “Refilled lakes and ponds”, and “Rewetted organic soils” respectively. This is equivalent to 1,595.71, 0.53, and 2.32 kt. CO_2 eq, in the same order.

6.7.5 Other emissions

6.7.5.1 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 and 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.

6.7.6 Biomass burning

Biomass burning on Wetland is reported. All subcategories are reported as aggregate. Only wildfires are included in the present estimate. The methodology for estimating the biomass burned and the consequent emissions is explained in chapter 6.13. The area of Wetland burned in the inventory year in wildfires is estimated from available maps of the burned area and overlays of the IGLUD land use map as 61.24 ha. The emission caused by these fires is estimated as 1.63 Mg CH_4 plus 0.15 Mg N_2O. This emission is equivalent to total 85.43 Mg CO_2.

6.7.7 Emission factors

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 6.13).

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 6.13 Emission factors applied to estimate emissions from flooded land based (Óskarsson and Guðmundsson 2001, Óskarsson and Guðmundsson 2008; Óskarsson and Gudmundsson in prep.).

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

Selection of emission factors for other land use categories than those included as flooded land is described below.

The CO_2 emissions from C-stock changes in soil of "Intact mires" and "Rewetted wetland soils", is calculated according to T1 using, 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 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 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 EF's for CH_4 from reservoirs are described above.

6.7.8 Uncertainties and QA/QC

The area estimate 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 IFD mapping is estimated 76 %, and higher ranked map layers exclude part of the area mapped. Therefore, potentially the uncertainty of the area estimate of intact mires is large. The higher ranked map layers only exclude some areas and the accuracy control of IFD mapping also revealed underestimate of wetland classes.

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 (Gudmundsson 2009) and 63-98 kg CH_4-C ha^{-1} yr^{-1} for highland mire

(Óskarsson and Guðmundsson 2008). The default EF 137 kg CH_4-C ha^{-1} yr^{-1} is thus in good agreement with those estimates. The comparison also indicate that uncertainty might decrease by subdividing intact mires to emission categories by altitude or regions. The second EF comparison is on N_2O emission through surface of intact mires. The default EF is zero emission but Icelandic measurements for lowland mires the emission was estimated 0.04 kg N_2O-N ha^{-1} yr^{-1} (Gudmundsson 2009) but for highland mire no emission was detected (Óskarsson and 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%.

6.7.9 Recalculations

The revised area of intact mires for the years 1990-2014, according to new map layers included in the land use map, affect all emissions based on that area.

6.7.10 Planned improvements regarding Wetland

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 development of IGLUD in the coming years is expected to improve area estimates for wetland and its subcategories. 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 digitation 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.

6.8 Settlements

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 consist of two components represented in IGLUD land use map i.e. towns and villages 15.20 kha and other settlements 12.55 kha in the inventory year. The total area reported in this submission is 27.75 kha.

6.8.1 Settlement remaining Settlement

The area of Settlement remaining Settlement is set as the total area of Settlement the year before minus the recorded conversions from Forest and birch shrubland.

6.8.2 Land converted to Settlement

6.8.2.1 Forest land converted to Settlement

IFR estimates the area, of this category, as deforestation activities. All permanent deforestation reported to the Icelandic Forest service has been converted to settlements. It is assumed that all deforestation is included in Settlements maps, although comparison of maps have not been carried out.

6.8.2.2 Grassland converted to settlements.

Time series for Natural birch shrubland converted to settlements are available but no maps have been included for this conversion. The remaining area of annual increase in Settlement extent is assumed being converted from category “Other grassland”.

6.8.3 Carbon stock changes

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 2015 as 0.01 kha, and “All other Grassland subcategories converted to Settlement”, 0.14 kha.

6.8.3.1 Carbon stock changes in living biomass

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 -1.25 kt. C or 4.59 kt. CO_2 emitted from the category “all other grassland converted to Settlement”. Changes in living biomass of “Forest land converted to Settlement” is reported with -0.02 kt. C emission in the inventory year.

6.8.3.2 Carbon stock changes in dead organic matter

The changes in C-stock in dead organic matter in “All other Grassland subcategories converted to Settlements” are included under changes in living biomass of the categories.

6.8.3.3 Carbon stock changes in soils

Carbon stock changes in soil are only reported for “Forest land converted to Settlement”. The methodology for the estimate of changes in soil carbon stock is described above. The total changes in stock reported are -0.03 kt. C causing emission of 0.12 kt. CO_2.

6.8.4 Emissions and removals from drainage and rewetting and other management of organic and mineral soils

No emission from this component is reported for Settlements in this submission. There is no data on extent of organic soils or drainage within the Settlement category.

6.8.5 Other emissions

No other sinks or sources of removal/emission are recognized for the Settlement category.

6.8.6 Biomass burning

No biomass burning is recorded for this category.

6.8.7 Emission factors

The changes in living biomass of Grassland converted to Settlement is calculated according T2 applying EF= 8.88 t C ha-1 based on estimate of Grassland stock and ratio of vegetation cover removed in conversion. The calculation of EF for changes of C-stock in soil of “Forest land converted to Settlement is described in . The EF= 5.94 for “Natural birch shrubland converted to Settlements” is calculated from NFI estimate of C stock in living biomass of Natural birch shrubland.

6.8.8 Uncertainties and QA/QC

No quantitative estimate on uncertainty of the map layers is currently available.

6.8.9 Recalculations

No recalculations were done for this category in this submission.

6.8.10 Planned improvements regarding Settlement

Overlay comparison of maps of “Forest converted to Settlement” and the IS 50 map layer for Settlement for improving estimates of both categories is planned. To refine the categorization of land converted to Settlements comparison of extent of some selected towns at different time to other land cover information is planned.

6.9 Other land

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, 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.

6.9.1.1 Biomass burning

Biomass burning on 2.48 ha of “Other land” is recorded for the inventory year. The emission of 0.05 Mg CH_4 and 0.005 Mg N_2O or equivalent to 2.79 Mg CO_2.

6.10 The emission of N_2O from N mineralization and immobilization

Refers to mineralization/immobilization of N associated with loss of C in mineral soils and can't be included in emissions from organic soils. For calculation of N mineralized or immobilized equation 11.8 in AFOLU guidelines should be applied. The equation request losses of C in mineral soil to be estimated.

Forest land: No losses of C from mineral soils under Forest land is reported. C –stock of several Forest land categories is to the contrary considered increasing (see above). The emission of N_2O from N mineralization/immobilization is as such not estimated in Forest land remaining Forest land or Land converted to Forest land. Components to consider could be ploughing as part of the planting, thinning of older forests. Until this is estimated the notation key is NE for those categories where C-stock of mineral soil is not reported as increasing.

Cropland: Changes in C stock of mineral soil of Cropland remaining Cropland are not estimated and likewise the associated N_2O emission should be noted as NE. Land converted to Cropland is reported as aggregate number of Grassland converted to Cropland and C-stock of mineral soils is reported as increasing. The reporting of this emission is under 3.D. 1.5 in the Agricultural sector and not requested in LULUCF CRF part.

Grassland: For the category Grassland remaining Grassland changes in C-stock of mineral soils is only reported for the subcategory "Natural birch shrubland recently expanded to Other Grassland" where increase is reported. The category "Land converted to Grassland" the overall changes in C-stock of mineral soils is an increase, owing to conversion of "Other land to Grassland" through revegetation and expansion of "Natural birch shrubland". The category "Cropland converted to Grassland" involves loss of C of mineral soils, accordingly the N_2O emission associated with that loss should be estimated according to AFOLU equation 11.8.

Settlement: Area estimated in Emissions and removals from N mineralization/immobilization is the area estimated as remaining vegetated. The mineralization of N of in those areas is not estimated. In the area where the vegetation "and soil" is removed all soil C stock could be estimated as lost and the N mineralized (according to Eq 11.8. AFOLU). No information are available on removed soils or its destiny.

6.11 Indirect N_2O emissions from managed soils

This components includes 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.

6.12 Biomass burning

Accounting for biomass burning in all land use categories is addressed commonly in this section. The Icelandic Institute of Natural History has in cooperation with regional Natural History Institutes started recently to record incidences of biomass burning categorized as wildfire. This recording includes mapping the area burned. These maps are used to classify the burned area according to IGLUD land use map. Based on this classification, biomass burning is in this submission reported for the land use categories; "Forest land remaining Forest land", Grassland remaining Grassland, and

"Land converted to Grassland". 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 AFULU guidelines (IPCC 2006).

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

Equation 1. Equation 2.27 from AFULU 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 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.

6.12.1 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.

6.13 Other

6.13.1 Harvested Wood products

Emissions/removals related to harvested wood products (HWP) are estimated for the first 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 (Gunnarsson 2010; Gunnarsson 2011; Gunnarsson 2012; Gunnarsson 2013, Gunnarsson 2014; Gunnarsson 2016). These data were used to estimate C-stock changes in HWP. Sawnwood is only a small fragment of commercial wood removal. In 2015 only 127 m^3 (2.7%) of 4744 m^3 of total commercial wood removal were used to produce sawnwood (Gunnarsson 2016). Other HWP than sawnwood are not produced from domestic wood.

6.13.2 N_2O from Grassland drained soils

The N_2O emission form drained Grassland soils is reported her. This emission is discussed in chapter 6.6.5.1.

6.14 Key factors of no target within LULUCF

Two categories within LULUCF with land as source but no target land use category pinpointed are recognized as key categories of level 2015, i.e. CH_4 and CO_2 classified as “Emissions and removals from drainage and rewetting and other management of organic and mineral soils. The emissions of CH_4 and of this category is recognized as key factors in trend 2015.

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 for 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. For the last few years the waste sector has 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. In 2015, total hazardous waste was 35,371 tonnes. 15,672 tonnes of hazardous waste were landfilled, 1502 tonnes were incinerated whereof 630 tonnes were incinerated in Iceland (the rest abroad). 17567 tonnes of hazardous waste were recycled or reused.

Clinical waste has been incinerated in incinerators either at hospitals or at waste incineration plants. In 2015, 287 tonnes of clinical waste were incinerated in Kalka, 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. In 2015, 81% of all landfilled waste was 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 publically known waste treatment option and a number of composting facilities have been commissioned.

In 2015, 20.6% of all waste generated was landfilled, 75.3% recycled or recovered, 1.6% incinerated, and 2.5% composted.

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%.

Aggregated greenhouse gas emissions from the waste sector were estimated to be 207 kt. CO_2 equivalents in 2015, which is tantamount to a 27% increase since 1990. Between 2014 and 2015, emissions from the waste sector decrease by 0.3% in the current submission. Around 88% of all emissions from the waste sector in 2015 are estimated to be caused by solid waste disposal, 2% by composting, 5% by waste incineration without energy recovery, and 5% by wastewater treatment. The development of greenhouse gas emissions from the waste sector is shown in Figure 7.1.

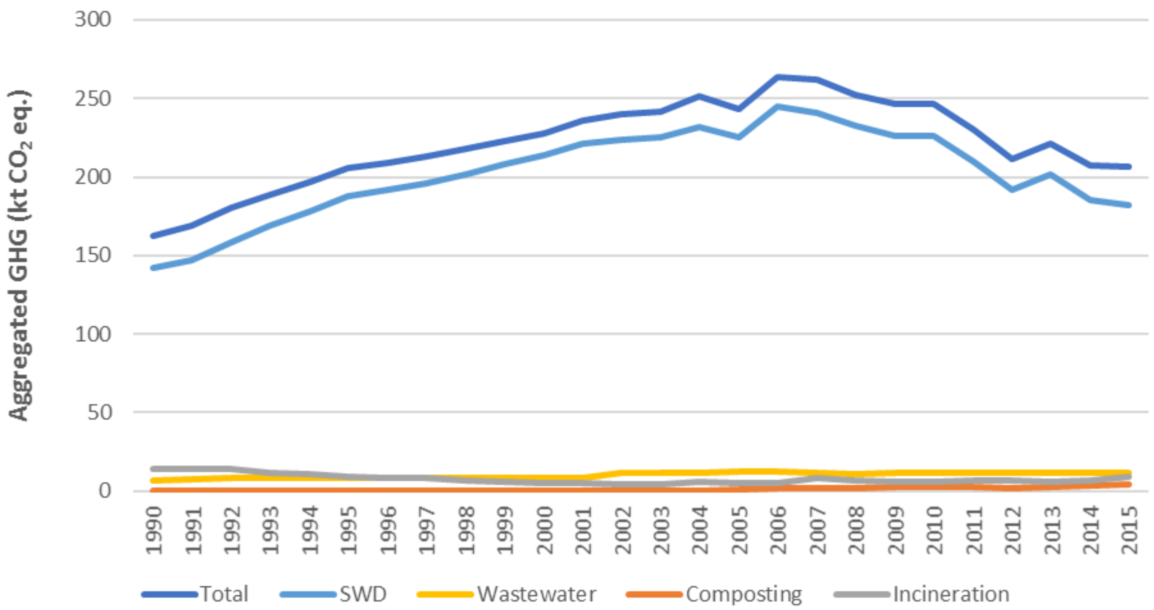

Figure 7.1 Greenhouse gas emissions estimates from the waste sector in Iceland the year 2015 in kt. CO_2 eq. CO_2, CH_4, and N_2O emissions were aggregated by calculating CO_2 eq. for CH_4 and N_2O (factors 25 and 298, respectively).

7.1.1 Methodology

The calculation of greenhouse gas emissions from waste is based on the methodologies suggested by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 GL). Methodology for each greenhouse gas source category within the waste sector is described separately below.

7.1.2 Activity data

In recent years the data has been based on questionnaires sent to the waste industry, which returns them with weighted waste amounts landfilled, incinerated, composted, or recycled. 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: first the material (mainly unpainted timber) that went into one of the country´s largest bonfires was weight and its mass correlated with the height and diameter of the timber pile. Then 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 2015. The result was projected back in time using expert judgement.

Until the year 2011 the annual amount of landfilled manure was estimated at 10,000 tonnes. Closer inquiries revealed that the amounts actually landfilled were much smaller. The remaining amounts were so negligible that the waste category manure was suspended and allocated to the category sludge. Waste from metal production was not included because the amounts recorded by the EA are inconsistent between years. Estimation of waste from metal production started in 2002 and was assumed to be between 10 and 11 kt. annually until 2007. Since 2008 data collection is more comprehensive and based on reports by the metal industry. Since then amounts are estimated to be in excess of 100 kt. Because of the data inconsistency and that the material is inert (with regard to CH_4 production) and recycled, it is left out of the data used to estimate waste generation before 1995. These are the main reasons that data reported here, deviates from data reported to, and published by, Statistics Iceland.

7.1.3 Key category analysis

The key sources for 1990, 2015 and 1990-2015 trend in the Waste sector are as follows (compared to total emissions without LULUCF):

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

IPCC source category			Level 1990	Level 2015	Trend
Waste (CRF sector 5)					
5A	Solid 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 greenhouse gas emission sources in the waste sector.

Table 7.2. Waste sector – completeness (E: estimated, NE: not estimated, IE: included elsewhere, NO: not occurring).

	Direct GHG			Indirect GHG		
Waste Categories	**CO_2**	**CH_4**	**N_2O**	**NO_x**	**CO**	**NMVOC**
5A Solid waste disposal on land						
5A1 Managed	NE	E	NE	NE	NE	E[1]
5A2 Unmanaged	NE	E	NE	NE	NE	E[1]
5A3 Uncategorised	NO	NO	NO	NO	NO	NO
5B Biological treatment of solid waste	NE	E	E	NE	E[1]	NE
5C Waste incineration and open burning of waste						
5C1 Waste incineration	E	E	E	E[1]	E[1]	E[1]
5C2 Open burning	E	E	E	E[1]	E[1]	E[1]
5D Wastewater treatment and discharge						
5D1 Domestic	NE	E	E	NE	NE	NE
5D2 Industrial	NE	IE[2]	IE[2]	NE	NE	NE
5E Other	NO	NO	NO	NO	NO	NO

1: Data also submitted under CLRTAP; 2: included in 5D1.

7.1.5 Source Specific QA/QC Procedures

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

7.2 Solid Waste Disposal (CRF sector 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 uses the First Order Decay method (FOD) for calculations. 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 carbon dioxide emissions. The method was expanded to include additional waste categories.

No methodology is given in the 2006 IPCC guidelines for the estimation of CO_2 emissions from landfill 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 (Statistics Iceland, 2015). 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.

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:

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

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).

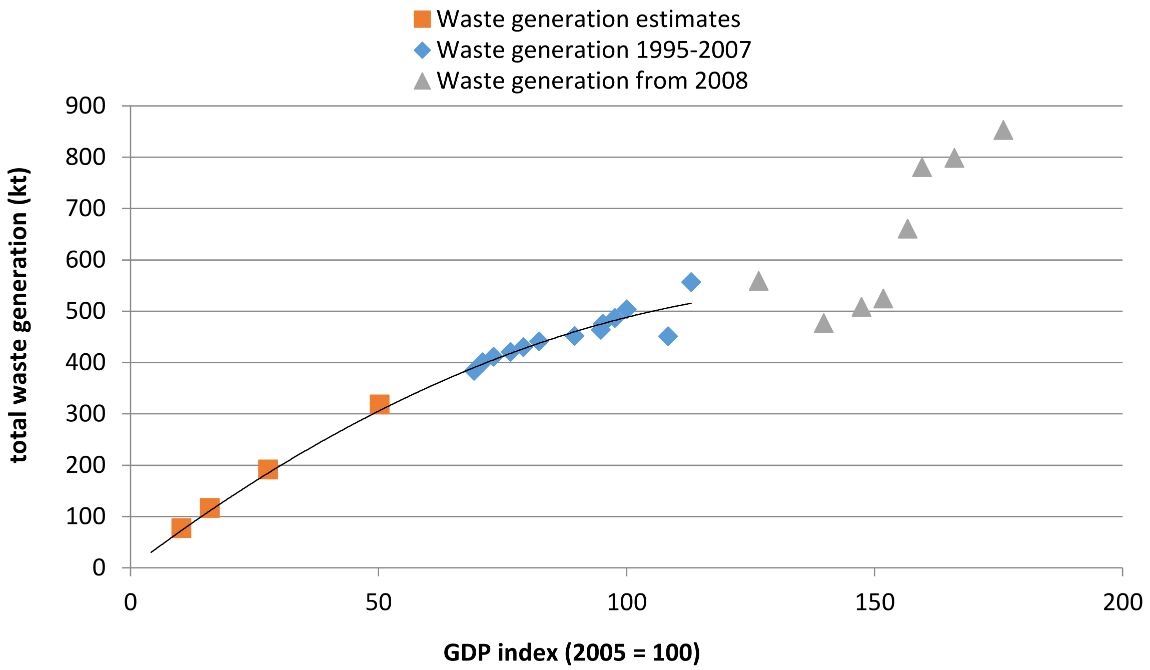

Figure 7.2 Waste generation from 1950-2015. Blue rhombuses denote waste generation between 1995 and 2007 and were used to calculate waste amounts before 1995, which are shown as red squares in 10 year intervals along the trend line.

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 1950-2015 are shown in Figure 7.3.

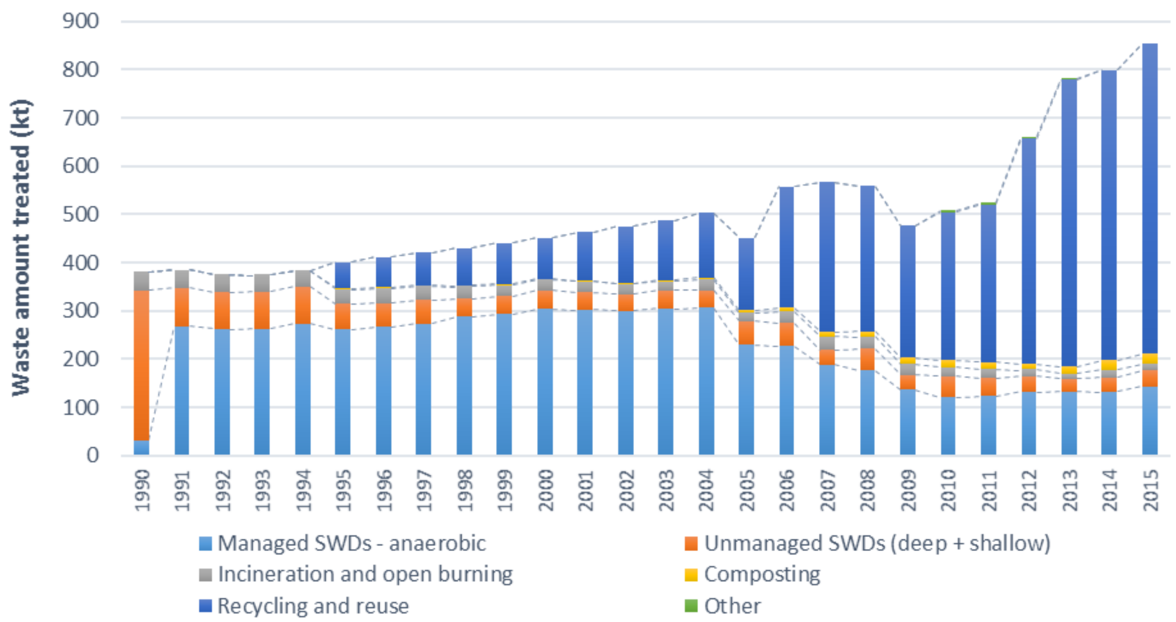

Figure 7.3 Waste amount and allocation to incineration/open burning, solid waste disposal, recycling and composting.

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 and 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 and 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 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. The change in data origin explains the rise in fraction of waste landfilled going to shallow sites in (Figure 7.4) i.e. shallow landfill sites receive a disproportionate amount of waste compared to the share of population they are serving.

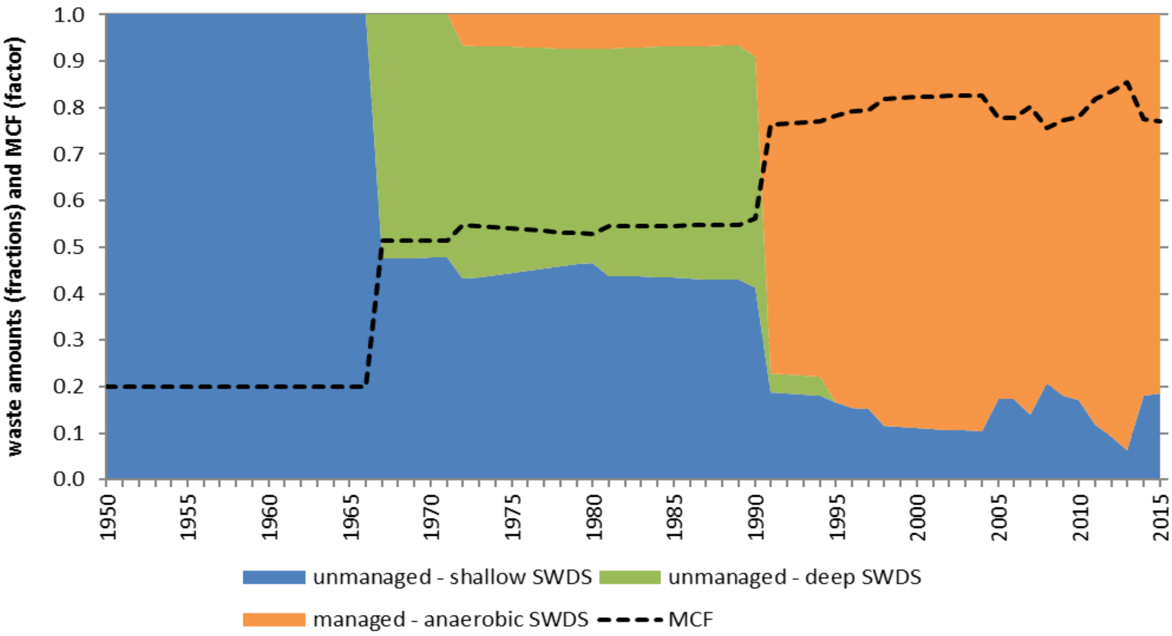

Figure 7.4 Fractions of total waste disposed of in unmanaged and managed SWDS and corresponding methane correction factor.

Waste composition

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 greenhouse gas 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 7.3.

Table 7.3. 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 amount that other categories were reduced by	Expert judgement and trend in data from study by Sorpa ltd.

These adjustments led to the waste category fractions presented for a choice of years in Table 7.4. The increase in the food waste fraction between 2010 and 2011 can be explained by a more thorough sorting process before weighing in the study by Sorpa ltd. as well as an actual increase of the fraction due to a relative decrease of other fractions due to increased recycling.

Table 7.4. Waste category fractions for selected years since 1950.

Year	Food	Food industry	Paper	Textiles	Wood	Garden	Diapers	Demolition	Sludge	Inert
1950	48.2%	7.0%	9.4%	2.5%	3.3%	3.4%	0.0%	5.7%	1.8%	18.7%
1960	42.8%	7.0%	11.7%	2.5%	3.3%	3.4%	0.0%	5.7%	1.8%	21.7%
1970	37.3%	7.0%	14.1%	2.5%	3.3%	3.4%	0.0%	5.7%	1.8%	24.8%
1980	31.9%	7.0%	16.4%	2.5%	3.3%	3.4%	0.0%	5.7%	1.8%	27.9%
1990	16.2%	7.0%	18.8%	2.5%	3.3%	3.4%	4.1%	5.7%	1.8%	37.1%
2005	15.2%	5.5%	20.9%	1.7%	4.7%	0.7%	3.6%	7.9%	0.5%	39.3%
2006	10.7%	5.2%	19.2%	1.9%	2.0%	5.5%	2.2%	9.1%	2.2%	42.0%
2007	13.0%	6.4%	18.8%	2.7%	5.9%	5.6%	3.4%	9.1%	2.2%	32.9%
2008	14.7%	8.3%	20.7%	3.3%	3.1%	4.0%	3.8%	2.1%	2.3%	37.7%
2009	19.0%	10.8%	11.2%	4.5%	3.1%	3.0%	5.8%	2.2%	2.2%	38.3%
2010	18.0%	8.6%	18.8%	1.9%	1.3%	1.7%	6.3%	1.3%	1.5%	40.5%
2011	31.0%	6.7%	19.4%	2.3%	1.9%	2.0%	6.5%	4.2%	1.6%	24.2%
2012	30.1%	8.7%	16.6%	2.1%	2.4%	3.2%	5.2%	2.0%	1.4%	28.3%
2013	38.0%	9.3%	7.1%	2.9%	2.7%	3.4%	7.2%	0.6%	1.5%	27.5%
2014	35.7%	5.8%	8.8%	2.2%	1.1%	0.5%	5.4%	3.1%	2.8%	34.4%
2015	34.9%	7.3%	8.8%	2.2%	1.7%	0.6%	5.4%	1.3%	3.0%	34.8%

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
- RT = 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 7.5.

Table 7.5. Emission factors and parameters used to calculate methane generated.

Emission factors/parameters	Values
Degradable organic carbon in the year of deposition (DOC)	Table 7.6
Fraction of DOC that can decompose (DOC_f)	0.5
Methane correction factor for aerobic decomposition (MCF)	Table 7.7
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 7.6
Half-life time of waste in years (y)	Table 7.6
Delay time in months	6

DOC, k, and y (which is a function of k) are defined for individual waste categories. The respective values for most of the ten categories are 2006 GL defaults, except where indicated otherwise (Table 7.6).

Table 7.6. Degradable organic carbon (fraction), methane generation rate and half-life time (years) of ten different waste categories.

Cate-gory	Food	Food industry[1]	Paper	Tex-tiles	Wood	Garden	Diapers	Demolition	Sludge	Inert
DOC	0.15	0.1	0.4	0.24	0.43	0.2	0.24	0.04	0.05	0
k	0.185	0.1	0.06	0.06	0.03	0.1	0.1	0.03	0.185	NA
y	4	7	12	12	23	7	7	23	4	NA

[1] *Country specific value aggregated for waste from fish and meat processing.*

The DOC of waste going to SWDS each year was weighted by multiplying individual waste category fractions (cf. Table 7.4) 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 7.7. The default for managed, anaerobic sites however, was lowered from 1 to 0.9 by expert judgement. The rationale behind this reduction was that - although the five SWDS contained in the category managed, anaerobic classify for it by the definition used by the 2006 GL - two of them (Þernunes and Kirkjuferjuhjáleiga) have reduced CH_4 production. This was found out by the two landfill gas studies already mentioned (Kamsma and Meyles, 2003; Júlíusson, 2011). The same studies reported no methane production 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 7.7. IPCC methane correction factors and MCFs used in NIR 2017.

SWDS type	Managed, anaerobic	Unmanaged, deep	Unmanaged, shallow
MCF (IPCC default)	1	0.8	0.4
MCF used	0.9	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
- DDOCmaT = DDOCm accumulated in the SWDS at the end of year T, kt
- DDOCmaT-1 = DDOCm accumulated in the SWDS at the end of year (T-1), kt
- DDOCmdT = DDOCm deposited into the SWDS in year T, kt
- DDOCm decompT = 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

The only SWDS recovering landfill gas is Álfsnes which has served the capital area since 1996. Data on the amount of landfill gas recovered stems from the operator Sorpa ltd. (Hjarðar, written communication). Data for the years 1996-2004 are based on estimations whereas data since 2005 are mainly based on measurements. For the earlier time period landfill gas recovery 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. 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 7.5 gives an overview of the annual methane amounts segregated by utilization. Recovery increased steadily between its beginning in 1996 and 2005. In 2006 the burner was damaged which led to a drop in the amount of methane recovered. Since then, amounts have oscillated but show a strong increasing trend since 2010. In 2012 the recovered amounts surpassed the 2005 level but in 2013 a decrease in methane recovery is evident. The amount incinerated dropped in 2003, 2006, and 2010 because of damage to the burner.

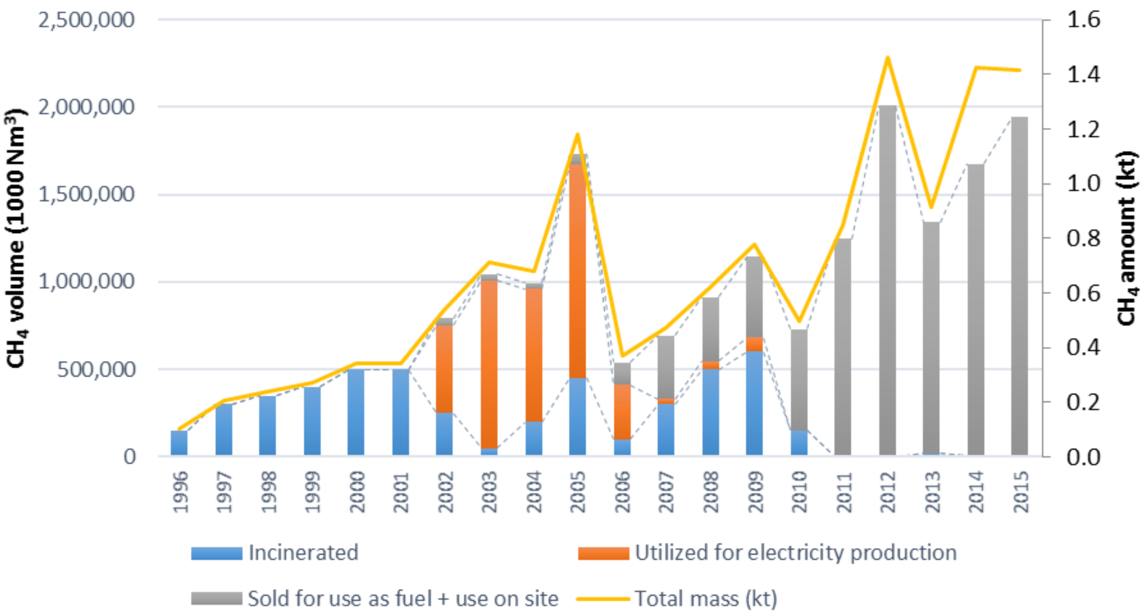

Figure 7.5 Methane recovery at Álfsnes solid waste disposal site (1000 Nm³) 1990-2015.

7.2.4.2 Methane emissions

In 1990 methane emissions from SWDS amounted to 5.7 Gg CH_4 and increased to 9.8 Gg in 2006. Since 2006 they decreased again and were estimated at 7.3 Gg in 2015. This equals an increase of 28% between 1990 and 2015.

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 favor of managed SWDS. The shift in emissions from unmanaged to managed SWDS can be seen in Figure 7.6. In 1990 the fraction of CH_4 emissions from managed SWDS amounted to only 11% of all SWDS emissions, whereas the fraction of emissions from unmanaged SWDS accounted for 89%. This trend has been reversed since then and in 2015 85% 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.

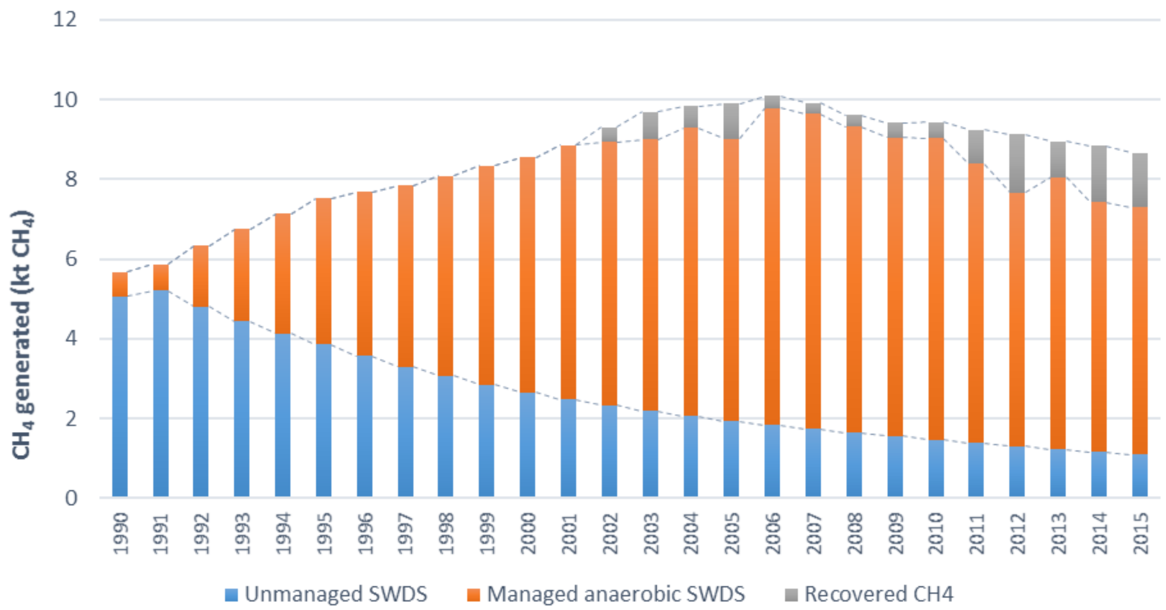

Figure 7.6 Methane generated from SWDS, separated into SWDS types. The amount of methane recovered at the managed SWDS Álfsnes is shown as purple area (reducing the size of the green area for emissions from managed SWDS).

7.2.5 Uncertainties

Uncertainty analysis for CH_4 emissions from solid waste disposal was carried out in two steps. In the first step the uncertainty of total methane generation potential was calculated independent of the year during which emissions take place. In the second step k-values are manipulated in a sensitivity analysis to determine uncertainty regarding emission distribution over the years.

Total methane generation potential can be calculated by combining equations 3.2 and 3.3 in the 2006 GL (page 3.9) as product of

- mass of waste deposited (W)
- DOC
- DOC_F
- MCF
- Fraction F of methane in generated landfill gas,
- and the molecular weight ratio CH_4/C

The total waste amount and its composition constitute the activity data in these calculations. The uncertainty range for countries where waste is weighed at SWDS is in the range of +-10% according to table 3.5 in the 2006 GL (page 3.27). Since this practice has been implemented only in recent years and since data for the years before relies on assumptions and models, the higher value for countries collecting data on waste generation on a regular basis was chosen (+-30%). Waste composition is based on periodic sampling. Therefore the guideline value of +-30% uncertainty was chosen. These two values resulted in a combined AD uncertainty of 42%.

EF uncertainty consisted of the combined uncertainties of DOC, DOC_f, MCF and F. DOC, DOC_f and F were attributed with 2006 GL default uncertainties of 20, 20, and 5%, respectively. Different MCF uncertainties were attributed to each of the three SWDS types managed, unmanaged – deep, and unmanaged – shallow. The default MCF of 1 for managed SWDS is attributed with an uncertainty of -10%. Since Iceland lowered the default MCF to 0.9 a level of uncertainty was assumed to be +-10%. The MCF for unmanaged – deep SWDS was attributed with the default uncertainty of +-20%. The uncertainty of the MCF for unmanaged – shallow SWDS, which had been lowered from 0.4 to 0.2 was estimated to be 100% in order to include the default value in the uncertainty range. This led to different combined methane generation potential EF uncertainties for the three pathways of 30% for managed, 35% for deep, and 112% for shallow, unmanaged SWDS.

In order to assign the uncertainty of emission distributions over years, k-values were manipulated in a sensitivity analysis. The first order of decay model distributes methane emissions from SWDS by applying k-values and related half times to all waste categories. These k-values were varied within the error ranges given in the 2006 GL (Table 3.3, page 3.17). To that end the model was run first with default k-values, then with the lowest values of the range for each waste category (=slowest decay) and finally with the ranges´ highest values (= fastest decay). Resulting were three distinct emission progressions over time for each of the three SWDS management types. Generally, lower k-values mean less emissions (than default k-value emissions) during the early lifetime of SWDS followed by more emissions after a certain point in time (assuming similar waste amounts deposited annually). This general development can be seen for unmanaged SWDS but not yet for managed SWDS since the waste amounts deposited there have been increasing until recently. Percentile uncertainties were quantified by dividing the highest absolute difference between the default k emissions and low/high emissions with the default emissions. Thus mean uncertainties of 19% and 13% resulted for managed and unmanaged SWDS, respectively. These uncertainties were combined with above mentioned EF uncertainties of the total methane generation potential. This increased total EF uncertainties slightly to 36% for managed SWDS and 35% and 104% for deep and shallow unmanaged SWDS, respectively. The latter two were combined by weighting them with 2014 emissions leading to a total EF uncertainties of unmanaged SWDS of 51%.

AD and EF uncertainties combined were 56% for managed SWDS and 67% for unmanaged SWDS.

7.3 Biological treatment of solid waste: composting (CRF sector 5B)

7.3.1 Overview

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. The amount of waste composted has been increasing from 2 kt. in 2002 to about 20 kt. in 2015.

7.3.2 Methodology

Estimation of CH_4 and N_2O emissions from composting are calculated using the Tier 1 method of the 2006 GL.

7.3.3 Activity data

There exists data about the amount of waste composted since 1995. Table 7.8 shows the amount of composted waste in Iceland for selected years since 1990 and Figure 7.7 show the annual development. 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 21.3 kt. in 2015. There exists data on the composition of waste composted since 2007. In 2015 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 7.8 Waste amount composted since 1990.

	1990	1995	2000	2005	2010	2014	2015
Waste amounts composted (kt)	NO	2.0	2.0	5.0	15.2	20.1	21.3

7.3.4 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
- 0.3 g N_2O/kg waste treated
-

7.3.5 Emissions

CH_4 emissions from composting amounted to 0.09 Gg CH_4 or 2.13 kt. CO_2 equivalents in 2015. N_2O emissions amounted to 0.006 Gg N_2O or 1.9 kt. CO_2 equivalents in 2015. This is shown in Figure 7.7.

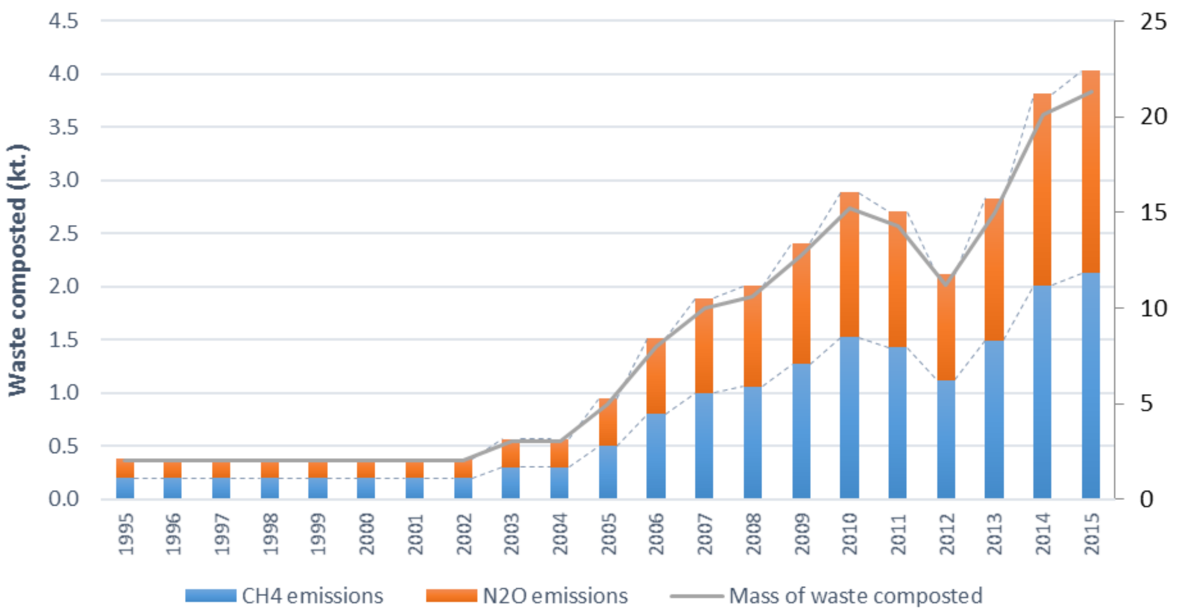

Figure 7.7 Mass of waste composted and resulting CH_4 and N_2O emissions (kt. CO_2 -eq.).

7.3.6 Uncertainties

Uncertainty for emissions from composting was calculated using value ranges from the 2006 GL (table 4.1, page 4.6). CH_4 emission factors from composting range from 0.03-8 g/kg wet waste treated. Thus uncertainty was calculated to be (8-4)/4 = 100%. N_2O emission factors from composting range from 0.06-0.6 g/kg wet waste treated. Thus uncertainty was calculated to be (0.6-0.3)/0.3 = 100%. Combined with AD uncertainties of 20% this resulted in combined uncertainties for both CH_4 and N_2O of 102%.

7.4 Waste incineration and open burning of waste (CRF sector 5C)

7.4.1 Overview

This This chapter deals with incineration and open burning of waste. Open burning of waste includes now 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 (4C).

The amount of waste burned in open pits decreased rapidly since the early 1990s, when more than 30 kilotons of waste were burned. Between 2005 and 2010 there was only one place burning waste in open pits: 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 2015. 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 greenhouse gas emissions from waste incineration decreased from 14.2 Gg CO_2 eq. in 1990 to 9.3 Gg CO_2 eq. in 2015.

7.4.2 Methodology

The methodology for calculating carbon dioxide 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 2013.

7.4.3 Activity data

7.4.3.1 Amount of waste incinerated

Methodology for activity data generation was inherited from the Icelandic submission to CLRTAP. The amount of waste burned openly is estimated using information on population in municipalities that were known to utilize open burning of waste and an assumed waste amount burned of 500 kg per head. The amount of waste burned in bonfires on New Year was calculated by weighing the wood of a sample bonfire and correlating the weight to the more readily measurable parameters pile height and diameter. These parameters were recorded for the majority of all bonfires and added up. The result was projected back in time using expert judgement. The amounts of waste incinerated are based on actual data from the incineration sites since 2004. The marginal amounts incinerated between 2001 and 2004 are based on expert judgement. The amounts of waste incinerated are shown in Figure 7.8.

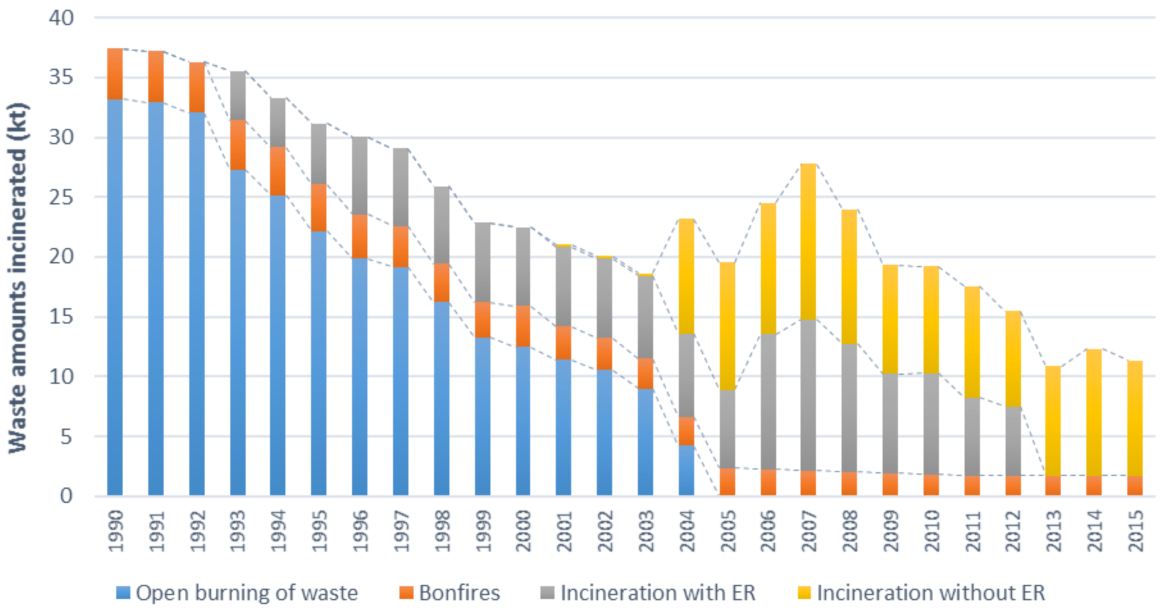

Figure 7.8 Amounts of waste incinerated with and without energy recovery, burned openly and amount of wood burned in bonfires 1990-2015.

Figure 7.8 shows that waste was only burned openly (here this includes waste incinerators with low/varying combustion temperatures) and in bonfires during the 1990s. A small incineration plant operated in Tálknafjörður in northwest Iceland from 2001-2004. The incineration plant Kalka in southwest Iceland, which started operation in 2004, is the only incineration plant in Iceland as of 2015.

7.4.3.2 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 7.9 along with their weight fractions from 2005 to 2015. 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.

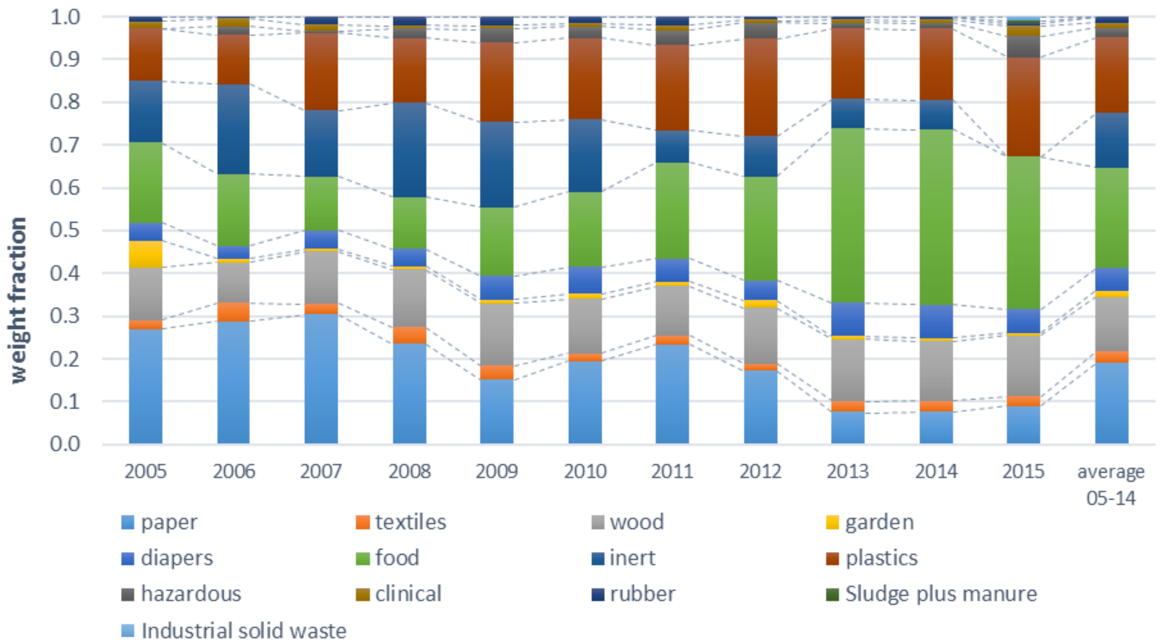

Figure 7.9 Waste categories for incineration along with weight fractions for 2005-2015 and the average weight fraction of whole period.

This data exists only for waste incineration and for the years from 2005 to 2013. 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).

7.4.4 Emission factors

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 oxidisation) 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 2015 in Table 7.9.

Table 7.9. Calculation of fossil carbon amount incinerated in 2015. The column "fossil carbon (wet weight basis), fraction" is the product of the three columns preceding it.

	Mass of incinerated waste (tonnes)	Fraction (f) of incinerated waste	(f) Dry matter	(f) Carbon in dry matter	(f) fossil carbon in total carbon	Fossil carbon (tonnes)
Paper	976	0.09	0.9	0.46	0.01	0
Textiles	241	0.02	0.8	0.5	0.2	0
Wood	1528	0.14	0.85	0.5	0	0
Garden	57	0.01	0.4	0.49	0	0
Diapers	595	0.06	0.4	0.7	0.1	1
Food	3855	0.36	0.4	0.38	0	0
Plastics	2489	0.23	1	0.75	1	431
Hazardous	544	0.05	0.84	NA	0.28	6
Clinical	248	0.02	0.65	NA	0.25	1
Rubber	72	0.01	0.84	0.67	0.2	0
Sludge plus manure	57	0.01	0.4	0.45	0	0
Industrial solid waste	108	0.01	0.4	0.38	0	0
Sum	10769	1				440

1: Both values generated to result in 2006 GL default fossil carbon content of 0.25.

The input for individual years from 2005 to 2011 differs from Table 7.10 in the distribution of waste category fractions and total waste amount incinerated. For the time period from 1990-2004 the weighted average waste category fractions from 2005-2011 were combined with annual amounts incinerated. The same fractions were used for open burning of waste. In bonfires only timber (packaging, pallets, etc.), which does not contain fossil carbon, is burned. Therefore, no CO_2 emissions from bonfires were reported.

7.4.4.1 CH_4, N_2O, NO_x, CO, and NMVOC 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, 2009), chapter 6.C.c: Municipal waste incineration. The EMEP guidebook defaults are applied to both open burning and incineration of waste. Defaults for these greenhouse gases are shown in Table 7.10.

Table 7.10. Emission factors (EF) for incineration and open burning of waste. All values are in g/tonne wet waste except where indicated otherwise.

Greenhouse gas	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Incineration (MSW) EF	237	60	1071	41	5.9	87
Incineration (ISW, hazardous) EF	237	100	870	70	7400	47
Incineration (clinical) EF	237	100	2300	190	700	540
Open burning EF	6500	150	3180	55830	1230	110

1: g/tonne dry waste.

7.4.5 Emissions

GHG emissions from incineration and open burning of waste are shown in Figure 7.10. Total GHG emissions estimates have decreased from 15.1 kt. CO_2 eq. in 1990 to 9.3 kt. CO_2 eq. in 2015. 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_2 eq. in 1990 to 0.3 kt. CO_2 eq. in 2015 and N_2O emissions have decreased from 1.7 kt. CO_2 eq. in 1990 to 0.3 kt. CO_2 eq. in 2015.

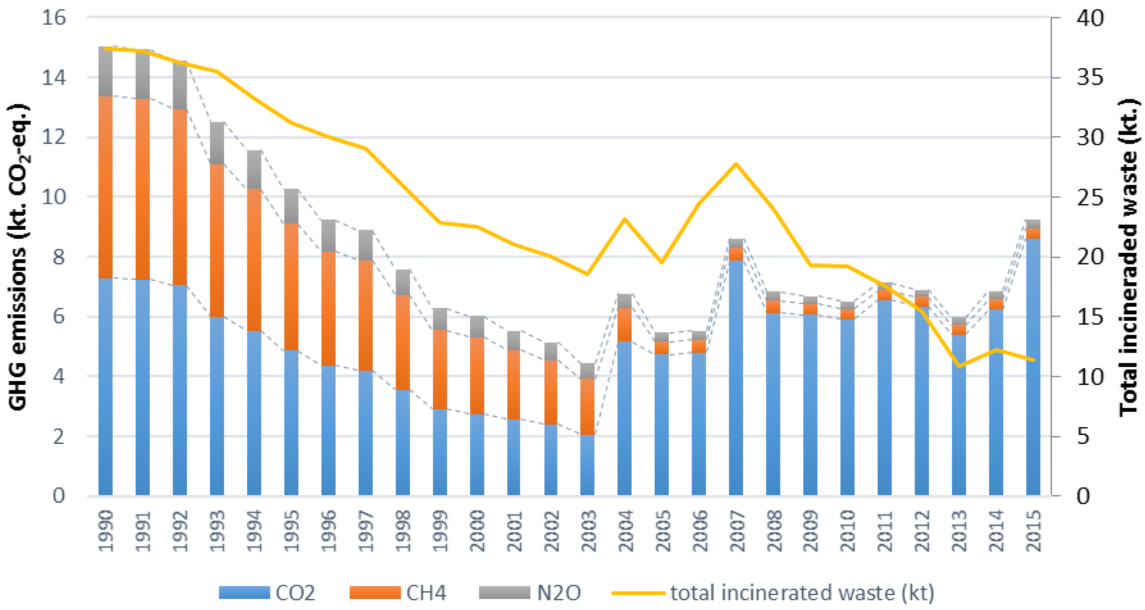

Figure 7.10 GHG emissions from incineration and open burning of waste in kt. 1990-2015.

7.4.6 Uncertainties

AD uncertainty of CO_2 emissions from incineration and open burning of waste was estimated by propagating uncertainty estimates of each step throughout the five step calculation process of determining the fossil carbon content of each of the waste categories incinerated. This process includes estimating and combining uncertainties of the total amount of waste incinerated, of waste category fractions, dry matter fractions, total carbon fractions, and fossil carbon fractions. The uncertainty of the total amount of waste incinerated was assumed to be ±20%. Waste categorization was also assumed to be known with ±20% accuracy. That means that the amount of each waste category incinerated was assumed to be known with a 28% uncertainty (combining total waste amount and waste composition uncertainties). Dry matter fractions of all waste categories were assumed to be known with 20% accuracy (expert judgement). Each waste category was then assigned total and fossil carbon fraction uncertainties by applying the ranges for the default values given in table 2.4 on page 2.14 of the 2006 GL. All five uncertainties were combined by multiplication (equation 6.4 of the GPG) for each waste category resulting in an estimate of the uncertainty of the each category´s fossil carbon fraction. These fractions were combined by addition using equation 6.3 on page 6.12 of the GPG. The equation demands uncertain quantities. The absolute fossil carbon fractions of waste incinerated from 2005-2011 acted as uncertain quantities in the equation in order to weight waste categories due to their relative importance for the CO_2 emission estimate. The total AD uncertainty was thus estimated to be 34%.

Emission factor uncertainties for open burning were calculated by applying the EF range given in table 5.2 on page 5.18 of the 2006 GL, resulting in an EF uncertainty of 18% for open burning. Uncertainty of the oxidation factor of 1 for incineration was estimated to be 5% (expert judgement). These differing EF uncertainties were integrated over the whole period from 1990-2015 by weighting them with the sum of all years´ CO_2 emissions resulting in an EF uncertainty of 14% and a total uncertainty of CO_2 emissions from waste incineration of 37%.

Uncertainties of CH_4 and N_2O emissions were estimated by combining AD uncertainty of waste amount (=20%) with EF uncertainty (=100%) suppliedby the 2006 GL (page 5.23). This resulted in combined uncertainties of 102% for both GHGs.

7.5 Wastewater Treatment and Discharge (CRF sector 5D)

7.6 Overview

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 11.6 Gg CO_2 equivalents in 2015. Compared to 1990 emissions of 6.8 Gg CO_2 equivalents this means an increase of 58%

7.6.1 Methodology

The calculation of greenhouse gas 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 domestic and industrial wastewater. To estimate the N_2O emissions from wastewater handling the default method given by the 2006 IPCC Guidelines was used.

7.6.2 Activity data - methane emissions from wastewater

7.6.2.1 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 2015 annual TOW increased proportionally to population from 7.0 Gg to 9.0 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)

7.6.2.2 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 as not occurring.

7.6.3 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 7.11.

Table 7.11. Default parameters used to calculate amount of nitrogen in the wastewater effluent.

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	Because of significant fish processing plants the upper limit of the range (1.5) was chosen.

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 et al., 2002; Þorgeirsdóttir et al., 2012) and for children of different ages (Þórsdóttir and Gunnarsdóttir, 2006; Gunnarsdóttir et al., 2008). The studies showed a high protein intake of Icelanders of all age classes. Adults and adolescents consumed on average 90 g per day, 9 year olds 78 g and 5 year olds 50 g. These values as well as further values for infants were integrated over the whole population resulting in an average intake of 85 g per day and Icelander regardless of age.

The amount of sludge removed was multiplied with a literature value of 2% (N content of domestic septage; McFarland, 2000). This reduced total nitrogen content of wastewater by 3.8% (average 1990-2013).

7.6.4 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 7.12 along with respective shares of total wastewater discharge and MCFs.

Table 7.12. Wastewater discharge pathways fractions and population of Iceland from 1990 to 2015.

	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
2008	0.57	0.33	0.02	0.08	315,459
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
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.

7.6.5 Emissions – 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 7.11. 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 Gg. 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.

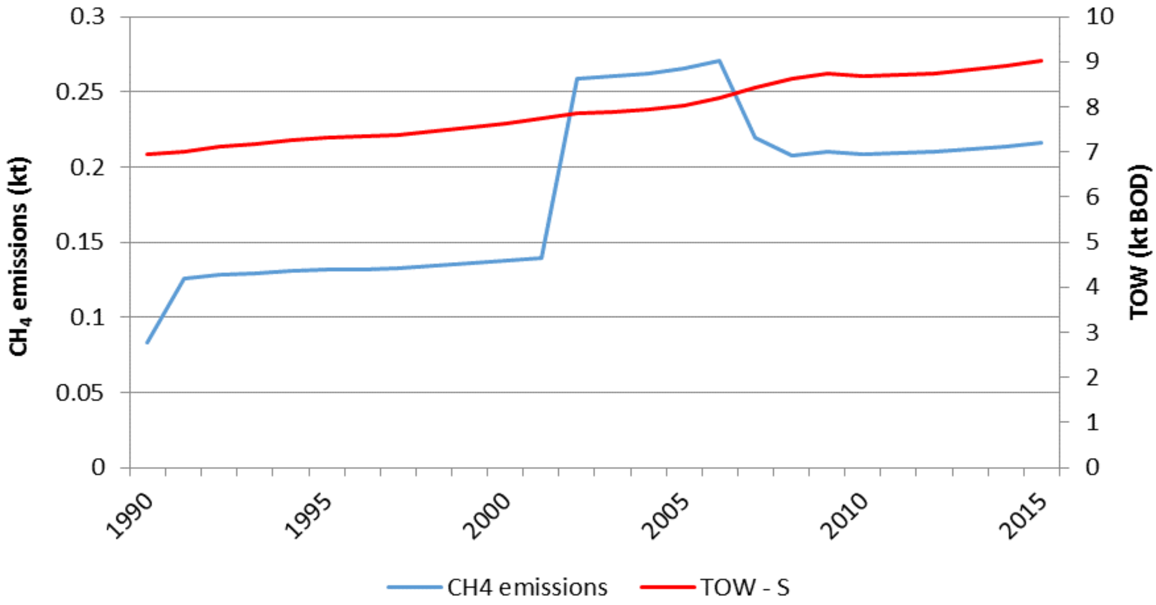

Figure 7.11 Methane emissions and total organics in wastewater in Iceland from 1990 to 2015.

7.6.6 Emissions – Nitrous Oxide (N_2O)

In order to estimate N_2O emissions from wastewater effluent, the nitrogen in the effluent is multiplied with the EF and then converted from N_2O-N to N_2O by multiplying it with 44/28 (molecular weight of N_2O/molecular weight of N_2). The resulting emissions are shown in Figure 7.12. Emissions rose from 0.016 Gg in 1990 to 0.021 in 2015. This is tantamount to an increase of 32%. The main driver behind this development was a 30% increase of population during the same time.

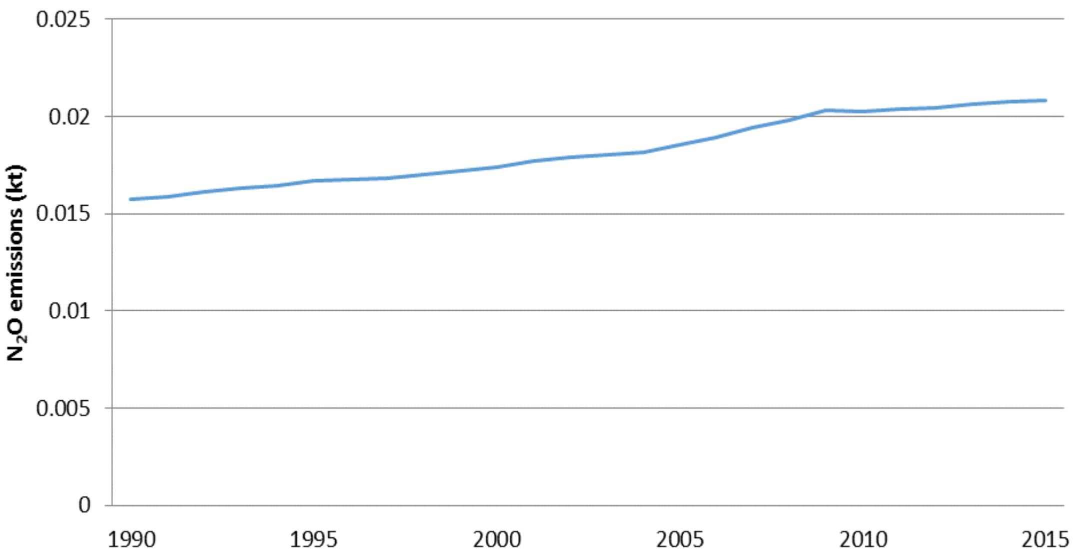

Figure 7.12 N_2O emissions from wastewater effluent from 1990 to 2015 in kt.

7.6.7 Uncertainties

AD uncertainty for N_2O emissions from wastewater were calculated by multiplying uncertainties of the five factors in the calculation of the amount of N in the wastewater effluent: population, protein content in diet, N content of protein and the two factors for additional N discharged by non-consumption and industry. Combined AD uncertainty was 46% 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%. This can be seen in the quantitative uncertainty table in Annex II.

7.7 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 the QA/QC manual.

7.8 Source Specific Recalculations

As part of the Environment Agency of Iceland's improvements plan, methodologies and activity data for the waste sector have been reviewed and updated in line with the IPCC 2006 Guidelines for this submission. These updates have resulted in a number of new estimates and recalculations, with the main implications outlined in the following sections.

7.8.1 Solid Waste Disposal (5A)

- CH_4 emissions from managed waste disposal sites (anaerobic) have been recalculated for 2014 due to an error in the previous submission where methane recovery was not included in the IPCC Waste Model. The result is a reduction in emissions of approximately 45kt. CO_2 equivalent for the category in 2014.
- Indirect GHG emissions (NMVOC) have been split between managed (5A1) and unmanaged sites (5A2) in this submission. Previously all were included under 5A1.

7.8.2 Biological Treatment of Solid Waste (5B)

- Methods and data reviewed. IPCC Tier 1 method in place and maintained for CH_4 and N_2O.
- Indirect GHG emissions have been estimated for carbon monoxide (CO) for the first time.

7.8.3 Waste Incineration and Open Burning (5C)

Waste incineration (5C1):

- Activity data from this category has been reviewed and significantly improved. A complete time series of activity data has been compiled, which is considered more reliable than activity data used in previous submissions.
- New sub-categories have been estimated with data for 2015, including estimates from the incineration of industrial solid waste, clinical waste and sewage sludge.
- Indirect GHGs have been aligned between AQ and GHG inventories.
- Tier 1 IPCC 2006 emission factors have been applied throughout.

Open Burning of Waste (5C2)

- Activity data has been reviewed and Tier 1 IPCC 2006 emission factors have been applied throughout.
- Indirect GHGs have been estimated and included under this category for the first time.

7.8.4 Wastewater Treatment and Discharge (5D)

- Country-specific activity data has been reviewed and simplified due to unreliability.
- An IPCC 2006 Tier 1 approach is now implemented. The result is an increase of approximately 25% (1kt. CO_2 equivalent) in CH_4 emissions and a reduction of approximately 10% (0.6kt. CO_2 equivalent) in N_2O emissions across all years.

7.9 Source specific planned improvements

In the year 2014 there was an update on the Icelandic directive regarding waste according to directive no 969/2014. This update implement in more detail than before classifications between waste categories. This classification is not fully implemented in this inventory.

8 Other (CRF sector 6)

Iceland has no activities and emissions to report under the CRF sector 6.

9 Indirect CO_2 and nitrous oxide emissions

No indirect emissions of CO_2 are reported in the Icelandic inventory.

10 Recalculations and Improvements

10.1 Recalculations

The Icelandic 2017 greenhouse gas emission inventory has been recalculated for several sources.

An updated recalculation file has been used for the 2017 submission. This QAQC file compares the latest year (2014) with the base year (1990) for the current and previous submissions. The data has been compiled to enable any changes in the data to be easily identified and justifications for changes provided where required. The current recalculation check considers CO_2, CH_4 and N_2O emissions. As far as possible, the recalculation check includes all reported sectors. Not all sectors are included due to a lack of consistency in the current and previous data files. The re-structing of compilation files is a recognised improvement. This includes replacing the current NFR codes within the output data file with CRF codes.

The current recalculations check 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. Where a recalculation change occurs, documentation is provided. In addition, where differences occur the cells are highlighted for ease of reference. This process of identifying recalculation changes and the documentation of changes is in line with Chapter 7 of the IPCC Good Practice guidelines[3] 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 and all pollutants is not difficult, and will be implemented in future submissions.

Table 10.1. Total recalculations in 2017 submission compared to 2016 submission (without LULUCF), kt. CO_2-eq..

Inventory year	2016 submission	2017 submission	Increase (kt.)	Increase (%)
1990	3,634	3,541	93	2.61%
1995	3,389	3,281	108	3.29%
2000	3,963	3,863	100	2.59%
2005	3,897	3,833	64	1.66%
2010	4,730	4,649	81	1.75%
2012	4,550	4,452	98	2.21%
2013	4,535	4,461	74	1.65%
2014	4,596	4,454	142	3.18%

[3] http://www.ipcc-nggip.iges.or.jp/public/gp/english/7_Methodological.pdf Accessed 09/03/2017

Specific description of recalculations:

10.1.1 Energy

Minimal recalculations were made for the energy sector between the 2016 and 2017 submissions. The main changes were in the sector 1A2 Manufacturing industries and construction.

10.1.2 Industrial Processes and Product use

Several recalculations were made in the IPPU chapter, and are described specifically in the relevant paragraphs. The most significant recalculations were done for the years 2013-2015 in HFC/PFC emissions from commercial fishing (Paragraph 4.6.2.8), and amount to 8.85 kt. CO_2-eq. in 2013 and 16.17 kt. CO_2-eq in 2014.

10.1.3 Agriculture

For this 2017 submission, calculations were thoroughly revised for the section on agriculture in order to increase transparency throughout the calculation files and improve the accuracy of the reported data.

Significant changes in methodology were made in the section on Agriculture, in particular soil emissions. For estimating N_2O emissions, the methodology was improved to use a comprehensive nitrogen flow approach, as presented in the 2016 EMEP Emissions Inventory Guidebook. 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).

In Manure management 3.B Indirect emissions of N_2O during manure management are now included in the emissions estimates, increasing emissions in all years. Further improvements and recalculations are explained in more detail in the section on agriculture.

10.1.4 LULUCF

Forest land

As described in chapter 6 the emission/removal estimate for forest land has been slightly revised in comparison to previous submissions. The C-stock changes are based on direct stock measurements (Tier 3) as in last year’s submission but reviewed on basis of additional data obtained and new approaches used. Time series built on direct stock measurement is calculated and reported for cultivated forest. Estimates for the natural birch forest are built on the same methodology as in last year´s submission.

As a result of these recalculations the total reported removal has decreased from -289.91 kt. CO_2-equivalents for the year 2014 as reported in 2016 submission to -284.44 kt. CO_2-equivalents in this year’s submission or a 1.0% decrease in removal. The changes in reported emission removal of the category reflect the improvement in data well as development in the methodology applied for estimating this category.

Grassland

The area of mineral soils of “Grassland remaining Grassland” subcategory “Cropland abandoned for more than 20 years” is revised for all years since 1990. This revision does not affect any emissions reported. Minor change in length of new ditches in the year 2014 and accordingly drained area of Cropland and Grassland slightly changes the emissions estimate based on that area.

Area of Natural birch shrubland categories for the years 1990-2014 is revised from last submission changing both the area of drained organic soils and mineral soils under those categories. The relevant emissions are revised accordingly.

Wetland

The revised area of intact mires for the years 1990-2014, according to new map layers included in the land use map, affect all emissions based on that area.

No recalculations were done for other categories of the LULUCF in this submission.

10.1.5 Waste

As part of the Environment Agency of Iceland's improvements plan, methodologies and activity data for the waste sector have been reviewed and updated in line with the IPCC 2006 Guidelines for this submission. These updates have resulted in a number of new estimates and recalculations, with the main implications outlined in the following sections.

Solid Waste Disposal (5A)

- CH_4 emissions from managed waste disposal sites (anaerobic) have been recalculated for 2014 due to an error in the previous submission where methane recovery was not included in the IPCC Waste Model. The result is a reduction in emissions of approximately 45kt. CO_2 equivalent for the category in 2014.
- Indirect GHG emissions (NMVOC) have been split between managed (5A1) and unmanaged sites (5A2) in this submission. Previously all were included under 5A1.

Biological Treatment of Solid Waste (5B)

- Methods and data reviewed. IPCC Tier 1 method in place and maintained for CH_4 and N_2O.
- Indirect GHG emissions have been estimated for carbon monoxide (CO) for the first time.

Waste Incineration and Open Burning (5C)

Waste incineration (5C1):

- Activity data from this category has been reviewed and significantly improved. A complete time series of activity data has been compiled, which is considered more reliable than activity data used in previous submissions.
- New sub-categories have been estimated with data for 2015, including estimates from the incineration of industrial solid waste, clinical waste and sewage sludge.
- Indirect GHGs have been aligned between AQ and GHG inventories.
- Tier 1 IPCC 2006 emission factors have been applied throughout.

Open Burning of Waste (5C2):

- Activity data has been reviewed and Tier 1 IPCC 2006 emission factors have been applied throughout.

- Indirect GHGs have been estimated and included under this category for the first time.

Wastewater Treatment and Discharge (5D)

- Country-specific activity data has been reviewed and simplified due to unreliability.
- An IPCC 2006 Tier 1 approach is now implemented. The result is an increase of approximately 25% (1kt. CO_2 equivalent) in CH_4 emissions and a reduction of approximately 10% (0.6kt. CO_2 equivalent) in N_2O emissions across all years.

10.2 Planned improvements

The Environment Agency of Iceland is in the process of carrying out a significant review and update of inventory methodologies (Iceland is engaging in this activity with consultants, Aether) as part of its ongoing improvements plan. For this submission, a specific review has been conducted on both the agriculture and waste sectors, with methodologies implemented in line with IPCC 2006 Guidelines.

Activity data and emission factors have been reviewed and updated where possible, although further work is planned for future submissions. Further information is provided in the agriculture and waste chapters of this report. The Agency will engage in similar reviews for the Energy, IPPU and Land Use sectors in future years.

The following improvements for the inventory are specifically planned:

10.2.1 Energy

- A few emission factors in the energy calculations where EFs from the 1996 IPCC guidelines are still used, these EFs will be updated in accordance with the 2006 IPCC guidelines.
- Improvement of methodologies to estimate emissions from road transportation (use of COPERT).
- Estimate emissions from biomass fuel use in the transport sector (1A3)
- Synchronise the energy balance approach between CRF and Eurostat for sector 1A4c - fishing (reference and sectoral). Up till now fuel sold to foreign fishing vessels has not been included in CRF.
- Move estimates of emissions from aviation to the Tier 2 methodology with the use of data from EUROCONTROL.
-

10.2.2 Industrial Processes and Product Use

- Revise the approach of calculating non-CO_2 emissions from 2C2 Ferroalloy production
- Revise the data, calculations and emissions for Sector 2F1 refrigeration
- Revise the approach of calculating recovery for the category “product uses as substitutes for ozone depleting substances” in the industrial processes sector.
- Emissions from lubricant use are planned to be reported in future submissions in the industrial sector under "non-energy products from fuels and solvents use".

10.2.3 Agriculture

- More accurate data is expected for a few emission sources for next years submissions with new database systems.

- Emission factors will be updated, in particular, a review of the N_2O EFs for manure storage will be undertaken before the next submission.
- In future submissions, it is planned to update digestible energy content of feed for both cattle and sheep in order to reflect changes in animal nutrition that have occurred since 1990. There are also plans to review the gross energy intake (GE) in MJ per day and nitrogen excretion rate for all cattle and sheep subcategories.

10.2.4 LULUCF

- **Land use identification and area estimates:** The uncertainty of the area estimate of reported land use categories is relatively high. For other categories e.g. Natural birch forest and Natural birch shrubland new mapping effort is assumed to have decreased considerably the uncertainty of the area estimates. A survey on the drainage efficiency of the ditch network in Grassland was completed in 2014. The analyses of the data is pending and expected to enable revision of the area estimate of that category. New digital elevation model (DEM) is available for large part of Iceland. That model will soon be available for the whole country. New high resolutions satellite images for most of the country are available. This new data and the survey on drainage efficiency will enable new digitation of drainage ditches and major revision of the map layer “Grassland on drained soils”. This revision is expected to finish in next two years. Besides those specific improvements, the land use identification will be updated as new information becomes available.
- **Forest Land:** Data from NFI are used for the ninth 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 is expected in future reporting when data from re-measurement of the permanent sample plot will be available and analysed for C-content
- One can therefore expect gradually improved estimates of carbon stock and carbon stock changes regarding forest and forestry in Iceland. As mentioned before improvements in forest inventories will also improve uncertainty estimates both on area and stock changes.
- **Cropland:** In this submission as in last year’s submissions, time series of Cropland categories were used to estimate the area of each category. Further improvements of the mapping and subdivision are still needed as e.g. revealed through the cropland mapping survey described above. The area of land converted to Cropland from other categories than Grassland or Wetland needs to be determined. Continued field controlling of mapping, improved mapping quality and division of cropland to soil classes and cultivated crops is planned in coming years. As the introduction of time series revealed that, a considerable area of the mapping unit Cropland is abandoned cropland. Identifying the abandoned cropland within the mapping unit is considered of high importance. 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 both “Cropland remaining Cropland” and “Land converted to Cropland” are recognized as key sources, it is important to move to a higher tier in estimating that factor. Data, obtained through fertilization experiments, on carbon content of cultivated soils is available at the AUI. The data is currently being processed and is expected to yield information on changes in carbon content of cultivated soils over time.

The emission components of offsite CO_2 emission and CH_4 emissions from Cropland have not gained much attention in Iceland. Data on that emissions and area involved is needed for Iceland e.g. the ratio of dich area. It is therefore considered important to promote the research needed and improve the estimate of relevant area.

– **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 is in this submission 8,464.51 kt. CO_2 eq. making that component the far largest identified anthropogenic source of GHG in Iceland. 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.

  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 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 data sampling in this project was finished in 2014, analyses of the data is pending. The results of this project are expected to improve the area estimate of drained land and of effectiveness of drainage. As described in chapter 6.3.8 new satellite images and new DME model will enable major revision of the area of drained soils in next two years.

  A pilot study on emission from different types of wetland soils indicate some difference in emissions between wetland soil types. It is important to continue research on variability of emissions between and within different wetland soil types.

  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.

  Age of drainage can be an important component affecting the emissions from the drained soil, the effectiveness of the drainage can also be assumed to depend on drainage age. Therefore geographical identification of drained areas of different age is planned in near future.

  The T1 EF for C-stock changes of drained soils is comparable to new data from in country studies (Guðmundsson and 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). Processing of the IGLUD dataset is expected to give results in the next few years.

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.

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. Three main improvements are planned and currently being carried out in part. The first is the improvement in activity recording, including both location (area) and description of activities and management. This is already being actively implemented and all data will be in acceptable form beginning in 2012. Data on older activities started after 1990 are currently under revision and are planned to be finished next years. Mapping of all activities since 1990 is verified by visiting points within the 1×1 km inventory grid. Recording of activities initiated before 1990 is also on-going. The second improvement is pre-activity sampling to establish a zero-activity baseline for future comparisons of SOC. This has been implemented for all new areas established in 2010 and later (Thorsson et al. in prep.). The third improvement is the introduction of a sample based approach, combined with GIS mapping, to identify land being revegetated, and to improve emission/removal factors and quality control on different activity practices. The approach is designed to confirm that areas registered as subjected to revegetation efforts are correctly registered and to monitor changes in carbon stocks.

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

– **Wetland:** 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 development of IGLUD in the coming years is expected to improve area estimates for wetland and its subcategories. 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 digitation 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.

- **Settlement:** Overlay comparison of maps of “Forest converted to Settlement” and the IS 50 map layer for Settlement for improving estimates of both categories is planned. To refine the categorization of land converted to Settlements comparison of extent of some selected towns at different time to other land cover information is planned.

- **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.

10.2.5 Waste

- In the year 2014 there was an update on the Icelandic directive regarding waste according to directive no 969/2014. This update implement in more detail than before classifications between waste categories. This classification is not fully implemented in this inventory.

11 Information on Accounting of Kyoto Units

11.1 Background Information

The national registry is maintained by the Environment Agency of Iceland. The registry holds as of 31st of December 2016: 50 EU ETS accounts, thereof 7 Operator holding accounts, 33 Aircraft operator holding accounts, 8 Verifier accounts, 1 National holding account and 1 Party holding account.

Iceland's AAUs were 0 tonnes of CO_2-equivalents, on December 31st 2016. 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) 389/2012.

In the year 2015 Iceland acquired 10,435 CERs and 10,435 ERUs from AAU from EU in January 2012 under Art.58 of the Registry Regulation (EU) 389/2013. In August 2015 861,730 RMUs (RV) and 681,031 RMUs (AR) in relation to LULUCF were added to the Party Holding Account, and 802 AAU (Deforestation) were cancelled based on the review of the 2014 inventory report of Iceland, paragraphs 94-96.[4]

102,346 AAUs were then returned to the EU in accordance with art 73.a of the delegated act amending Registry Regulation 389/2013 which left the total sum of AAUs in the Icelandic Party Holding account: 18,420,881.

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.

In December 2015, Iceland retired 20,098,931 Kyoto Protocol units valid for the first commitment period. In order to not exceed the quantities of emission reduction units (ERUs), certified emission reductions (CERs), temporary CERs (tCERs), long- term CERs (lCERs), assigned amount units (AAUs) and removal units (RMUs) in the retirement account of the Party for the first commitment period, Iceland reported 3,257,140 t CO_2 eq separately, being 55,1% of the emissions from the eligible industrial installations under decision 14/CP.7.

No transactions on any units took place in the year 2016.

11.2 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 14/CMP.1 says: … "each Annex I Party shall submit the SEF in the year following the calendar year in which the Party first transferred or acquired Kyoto Protocol units". Iceland submitted the SEF tables for the first time in April 2014 for the issued

[4] http://unfccc.int/resource/docs/2015/arr/isl.pdf

Kyoto Protocol units in 2013 and the 2015 SEF tables for second commitment period were submitted in March 2016. The Kyoto Protocol party holding account did not hold any units at the end of reported year 2015. No problems were found in Iceland's SEF table when performing completeness check and consistency check.

11.3 Discrepancies and Notifications

No discrepancies or notifications have occurred in relation to Iceland's accounting of Kyoto units in 2016.

11.4 Publicly Accessible Information

A set of information regarding the registry and guidance on accessing registry accounts has been updated on the homepage of the 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 European Union Translation 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

11.5 Calculation of the Commitment Period Reserve (CPR)

The Annex to Decision 11/CMP.1 specifies that: "each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90% of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8 of the Kyoto Protocol, or 100% of eight times its most recently reviewed inventory, whichever is lowest".

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 × 4,467,730 tonnes CO_2 equivalent
= 35,741,840tonnes CO_2 equivalent

This means Iceland's Commitment Period Reserve is 13,794,495 tonnes CO_2-equivalent, calculated as 90% of Iceland's assigned amount.

11.6 KP-LULUCF Accounting

Iceland accounted for Article 3.3 and 3.4 LULUCF activities for the entire first commitment period. Iceland elected Revegetation under Article 3.4. Removals from Article 3.3 amounted to 103,268 tonnes CO_2 in 2008, 115,465 tonnes CO_2 in 2009, 135,426 tonnes CO_2 in 2010, 153,265 tonnes CO_2 in 2011, and 172,805 tonnes CO_2 in 2012. Removals from Article 3.4 (Net-Net accounting) amounted to 152,293 tonnes CO_2 in 2008, 159,608tonnes CO_2 in 2009, 171,719 tonnes CO_2 in 2010, 184,453 tonnes CO_2 in 2011, and 193,658 tonnes CO_2 in 2012. This allowed issuance of 1,542,761 RMUs (Table 11.1).

Table 11.1. Removals from activities under Article 3.3 and 3.4 and resulting RMUs.

	2008	2009	2010	2011	2012	CP1
Art. 73a international credits (CERs & ERUs)					102.346	102.346
Art. 73a credits returned (AAUs)					-102.346	-102.346
KP-LULUCF Art. 3.3	103.428	115.625	135.586	153.426	172.966	681.031
KP-LULUCF Art. 3.4	152.293	159.608	171.719	184.453	193.658	861.730
RMUs	**255.721**	**275.233**	**307.305**	**337.879**	**366.624**	**1.542.761**

11.7 Kyoto accounting for the first Commitment Period – CP1

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_2-eq. This means that Annex A emissions were 3,257,140 tonnes CO_2 in excess of Iceland´s available assigned amount.

Decision 14/CP.7 on the “Impact of single project on emissions in the commitment period” allows Iceland to report certain industrial process carbon dioxide emissions separately and not include them in national totals; to the extent they would cause Iceland to exceed its assigned amount. For the first commitment period, from 2008 to 2012, the carbon dioxide emissions falling under decision 14/CP.7 shall not exceed 8,000,000 tonnes. Iceland undertook the accounting with respect to Decision 14/CP.7 at the end of the commitment period.

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_2-eq. Emissions with the exeption of decision 14/CP.7 were 17,443,107.

That means that 3,257,140 tonnes were reported separately under decision 14/CP.7 in December 2015 and not included in national totals.

The CRF tables accompanying the 2017 NIR, however, still contain Iceland´s Annex A emissions in their entirety.

Table 11.2 and Figure 11.1 demonstrate this.

Table 11.2. 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
Available assigned amount	AAUs	3,960,490	3,980,002	4,012,074	4,042,648	4,103,716	20,098,931
Emissions from Annex A sources	t CO_2 eq.	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_2 eq.	1,061,296	799,265	634,087	398,479	364,014	3,257,140
Emissions falling under Decision 14/CP.7	t CO_2 eq.	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_2 eq.	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_2 eq.	1,061,296	799,265	634,087	398,479	364,014	3,257,140

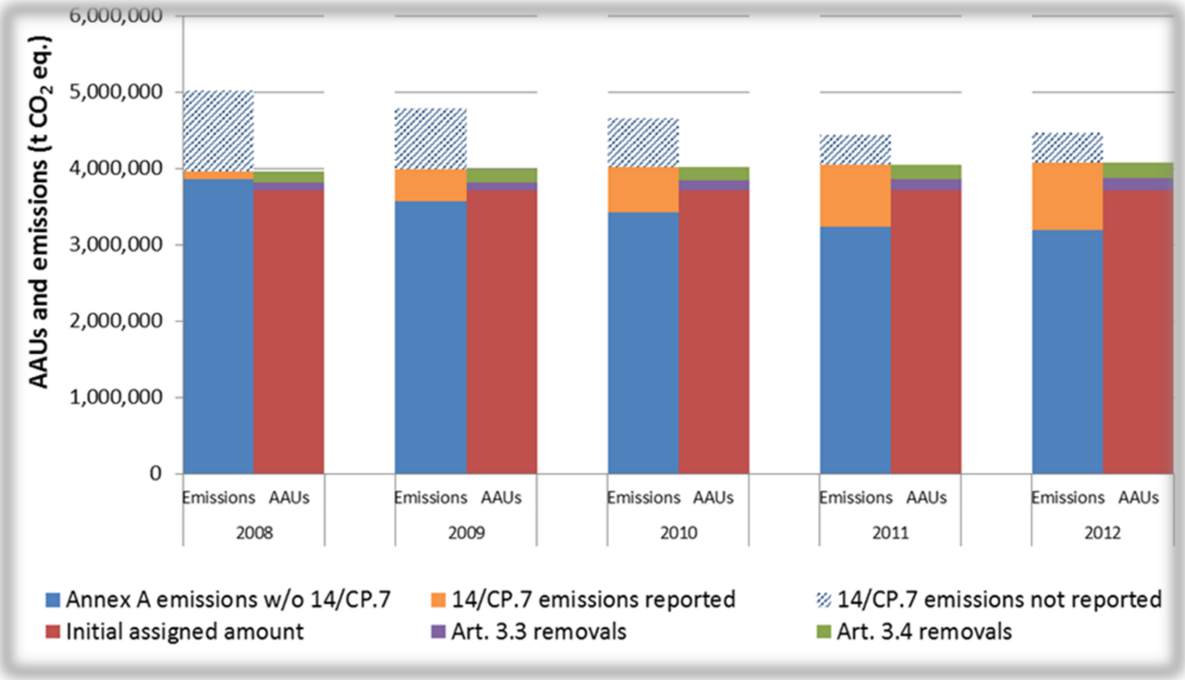

Figure 11.1 Summary of Kyoto accounting for CP1.

11.8 Second Commitment Period – CP2

The second Commitment Period started 1. January 2013 and will end 31. December 2020. The European Union, 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 Council Decision (EU) 2015/1339 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.

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 European Union, its Member States, and Iceland (Council Decision (EU) 2015/1339).

Calculation of the Commitment Period Reserve (CPR) can be found in chapter 9.5 of this report.

12 Kyoto Protocol – LULUCF

12.1 General Information

The Icelandic greenhouse gas emission inventory for the KP LULUCF is prepared in cooperation by IFR, AUI and SCSI. The general methods applied to estimate the sinks and sources reported are described in Chapter 6 of this report.

In the first commitment period Iceland reported the mandatory activity of Afforestation, Reforestation and Deforestation (ARD) and the elected activity of Revegetation. In this submission the mandatory activity of Forest Management (FM) is too included. Other optional activities as Cropland Management, Grassland Management and Wetland Drainage and Rewetting are not reported.

12.1.1 Definition of Forest and Any 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, with the exception of 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 a 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 12.1.

Table 12.1. 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.

12.1.2 Activities under Article 3, Paragraph 4

In the first commitment period of the Kyoto Protocol Iceland elected Revegetation, defined in Paragraph 6 in the Annex to Decision 16/CMP.1 as "additional human activities related to changes in greenhouse gas by source and removals by sinks in the agricultural soils and the land-use change and forestry categories", defined by Article 3, paragraph 4 of the Kyoto Protocol.

In the second commitment period Revegetation and FM are reported.

12.1.2.1 Interpretation of Revegetation

Revegetation is defined in Paragraph 1(e) in the Annex to Decision 16/CMP.1 as "a direct human-induced activity to increase carbon stocks on sites through the establishment of vegetation that covers a minimum area of 0.05 hectares and does not meet the definitions of afforestation and reforestation".

Iceland interprets the definition of Revegetation as following, recalling the LULUCF-Good Practice Guidance:

- A direct human-induced activity to increase carbon stocks on eroding or eroded/desertified sites through the establishment of vegetation or the reinforcement of existing vegetation that covers a minimum area of 0.5 hectares and does not meet the definitions of afforestation or reforestation.
- It includes direct human-induced activities related to emissions of greenhouse gas and/or decreases in carbon stocks on sites which have been categorized as revegetation areas and do not meet the definition of deforestation.

12.1.2.2 Hierarchy among activities under Article 3.4

In accordance to the hierarchy of land use classes in UNFCCC reporting Forest Management takes precedence over Revegetation.

Iceland has elected reporting method 1 to report land areas subject to Article 3.3 and Article 3.4 activities as described in LULUCF-Good Practice Guidance, page 4.24, section 4.2.2.2. Only one stratum, Region 1 is defined covering all land areas in Iceland.

12.1.2.3 ARD and FM

Afforestation and FM is 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) will be 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. At each plot, 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 (no. 3/1955) (See further description in Chapter 10.4).

Within Region 1 all CF and NBF are already mapped. Remapping of the NBF was finished in 2014. Only SSPP which are within mapped area and adjacent buffer zone are visited. The results from the NFI are used to determine the ratio of the mapped area meeting the definition of forest land. At the SSPP, data on C-pools is collected as described above (see Chapter 6). New land being afforested by cultivation is recorded annually in GIS by the IFR on basis of spatial activity data aggregated from major actors in afforestation in Iceland and consequently added to the mapped area of CF. The SSPP falling on these new area are then included in the NFI. New areas of NBF following changes in land use are considered as afforestation. Annual increase in the area of NBF is found by the difference between the old and the newly finished mapping survey. Beyond the periods between mapping survey estimates of new areas of NBF are built on extrapolation of the mean annual increase of the area between the old and the new survey.

All forest areas that are not defined as afforestation, reforestation or deforestation are defined as forest under the Forest Management activity. These are of CF afforestation areas before 1990 and plantations in the NBF. Of the NBF these are the estimated area at the end of year 1989. All expansions of NBF since 1990 are reported as afforestation in accordance to article 3.3. as described above.

12.1.2.4 Revegetation

The SCSI is responsible for the National Inventory of Revegetation Activity (NIRA). As with the NFI the whole country is defined as one region. Within Region 1 all known revegetation areas are mapped. The SSPP falling within these maps are visited in NIRA and occurrence of activity determined (see below). At selected SSPPs (see 10.1.4 below) samples to assess relevant C-pools are collected. The onset of activity is determined according to the existing records of SCSI. New areas of Revegetation activity are recorded by the SCSI and mapped. The SSPP falling within these new areas are then subsequently included in NIRA.

The SSPP will be revisited at five year intervals according to the original sampling plan. The NIRA started in 2007 and the first sampling phase ended in 2011. However, due to severe budget cuts at the SCSI, not all samples have been analysed to date and the second sampling phase, resampling older sites and sampling new sites since 2011, has not started. This delays final data submission based on the first sampling phase and concurrently restricts the submitted data to estimates based only on the available data. In the present submission the data already available from the NIRA regarding occurrence of activity at the SSPP is used to correct the activity area. Presently the sinks and sources are estimated according to Tier 2 methods described in Chapter 7.7 of this report.

The NIRA was designed to detect changes in C-pools and area of revegetation activity since 1990. The estimation of revegetation activity in the base year and of relevant sinks and sources is based on same methods as described in Chapter 7 of this report. The maps of revegetation activity before 1990 are far less accurate than the maps of activity since 1990. To secure clear separation of activities before and since 1990 the SCSI is improving these maps using both existing archives and on-ground mapping. On basis of those maps the NIRA will be extended to include the revegetation activity before 1990, albeit at a coarser scale than activities since 1990. This work is currently estimated to be concluded in 2016.

12.1.3 Description of Precedence Conditions and/or Hierarchy among Article 3.4 Activities, and how they have been Consistently Applied in Determining 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.

Organized revegetation and land reclamation activities date back to 1907 when the Soil Conservation Service of Iceland (SCSI) was established. Initial efforts were focused on halting accelerated erosion and serious land degradation, both directly and indirectly. Direct efforts included seeding lymegrass (*Leymus arenarius*) and erecting fences to halt sand-encroachment, but indirect efforts included excluding grazing animals by fencing off degraded lands. Recordkeeping until 1990 was fragmented, with emphasis mostly on activities but less on their spatial extent and some of the oldest records were lost in a house-fire. Activities since 1990 have better spatial documentation as aerial and satellite imagery has been used for boundary determination, and since 2002 most activities are recorded in real-time using GPS.

Data on post-1990 revegetation areas are kept in a SCSI database containing best available data on reclamation areas at any given time. One objective of initiating NIRA was to monitor changes in carbon stocks of revegetation area, using systematic sampling on predefined 1 x 1 km grid points. The grid was constructed by the Icelandic Forest Research (IFR) from a randomly chosen point of origin, and is used for the KP LULUCF reporting (Snorrason and Kjartansson 2004).

Layers containing land reclamation areas documented as active since 1990 are overlaid with the sampling grid in a GIS to preselect potential sampling points. They are later located in the field using land-survey grade GPS units. All points that fall undoubtedly within areas where land reclamation efforts have taken place are selected as sampling points. Points falling outside are either discarded or selected as controls.

Sampling takes place within a 10 x 10 m sampling plot, using the sampling point as the SW plot corner. Five 0.5 x 0.5 m subplots are randomly selected within the sampling plot for C-stock estimation in both vegetation and soils. The KP LULUCF sampling started in 2007. During the first five years of the program, 932 sampling points have been selected as potential sampling points. 358 have been discarded after site visits or are still undetermined, (24%), 532 been sampled (57%), and 46 (5%) have been identified as controls. Points were randomly selected from all parts of the country in 2007 and 2008. Differences in numbers compared to last year's report are due to emphasis on covering as much of the remaining potential sampling points as possible before the end of this five years sampling period. A different approach was used in 2009, as emphasis was put on three key areas, each representing different a climatic zone but also having wide variety of land reclamation activities. As each of these three sites also has similar soils, they will give good information on carbon sequestration potential between activities and climate zones. Each sampling period is expected to last for five years. Re-sampling of the plots established in 2007 has yet not started due to budget cuts as explained above. Same applies to data analysis for the years subsequent to 2009.

The 1 x 1 km sampling grid is also used to add sampling points from new reclamation areas to the NIRA database, following the same methodology as described above. Quantities of pre-1990 reclamation sites remains to be determined (see information on Article 3.4 above).

12.2 Land-Related Information

12.2.1 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 major actors in afforestation in Iceland. Although they can be used to locate forests, they are not precise and overestimate areas of the 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. 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. 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 6.7 for further description of estimation methods).

12.2.2 Methodology Used to Develop the Land Transition Matrix

Land transition matrix was prepared based on data for activity area in the years 1990, 2008-2013. 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.

12.2.3 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 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 can be partially identified by the geographical distribution of the systematic sample plots identified as ARD. Deforestation, on the other hand, is mapped separately and will be 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 estimate 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. 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. Only mapped areas are included in the NIRA and new areas will be mapped prior to reporting.

12.3 Activity-Specific Information

12.3.1 Methods for Carbon Stock Change and GHG Emission and Removal Estimates

Description of the methodologies and the underlying assumptions used.

12.3.1.1 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 of trees according to species specific single tree biomass functions (Snorrason and Einarsson 2006) and measured root-to-shoot ratios (Snorrason et al. 2003). Wood removal after 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 2010; Gunnarsson 2011; Gunnarsson 2012; Gunnarsson 2013, Gunnarsson 2014, Gunnarsson 2016) 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. 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, carbon stock changes of afforestation of the NBF are on the other hand 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 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 method is in accordance to Equation 3.1.2 in GPG for LULUCF (page 3.16).

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 organic soils 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.

12.3.1.2 Revegetation

The changes in carbon stocks at revegetation sites are estimated on the basis of a country specific EF covering all carbon pools. In this submission a revised EF is used. Current, but unpublished, results from NIRA for 2007-2009 indicate considerable variation between reclamation methods and land types, as well as intrinsically lower values than previously reported. The data has not been fully analyzed, but to cover the total variability and sequestration decrease, a reduction of 10% in EF is used in this submission as suggested by SCSI. It is expected that before next submission the data will be fully analysed and new EF will be available. 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.

12.3.1.3 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and Article 3.4

12.3.1.4 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 (Sigurdsson et al. 2005).

Harvested Wood Products are estimated for the first time in this year submission. Athough 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 such 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 (Gunnarsson 2010; Gunnarsson 2011; Gunnarsson 2012; Gunnarsson 2013, Gunnarsson 2014; Gunnarsson 2016). These data were used to estimate C-stock changes in HWP (see above further descriptions in chapter 6.13.1).

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 NIRA, and will not be included until then.

12.3.1.5 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.

12.3.1.6 Changes in Data and Methods since the Previous Submission (Recalculations)

The emission/removal factor and the area estimate for the Revegetation activity have been revised since last year's submission. Removals due to AR activities have not been revised.

12.3.1.7 Uncertainty Estimates

An error estimate is available for the area of afforestation of cultivated forest. The area of afforestation since 1990 is estimated at 32.25 kha (±1.69 kha 95% CL).

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

12.3.1.8 Information on Other Methodological Issues

The Year of the Onset of an Activity, if after 2008: For FM 2013.

12.4 Article 3.3

12.4.1 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. Natural birch forests are self-seeded areas in the neighbourhood of older natural 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.

12.4.2 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.

12.4.3 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.

12.5 Article 3.4

12.5.1 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.

12.5.2 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 7.7.

12.5.3 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.

12.6 Harvested Wood products

Emissions/removals related to harvested wood products (HWP) are for the first 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 (Gunnarsson 2010; Gunnarsson 2011; Gunnarsson 2012; Gunnarsson 2013, Gunnarsson 2014; Gunnarsson 2016). These data were used to estimate C-stock changes in HWP. Sawnwood is only a small fragment of commercial wood removal. In 2015 only 127 m^3 (2.7%) of 4744 m^3 of total commercial wood removal were used to produce sawnwood (Gunnarsson 2016). Other HWP than sawnwood are not produced from domestic wood. All HWP are still originating from FM forest.

12.7 Other Information

12.7.1 Key Category Analysis for Article 3.3 Activities and any Activities under Article 3.4

Of the three categories reported under Article 3.3 and Article 3.4 both "Revegetation" and "Afforestation and Reforestation" are larger than N_2O from manure management (CRF: 4.B), 43.29 kt. CO_2 equivalents the smallest key category of level including LULUCF in the year 2012.

13 Information on Changes in National System

In June of 2012 the Icelandic Parliament passed a new law on climate change (Act 70/2012). The objectives of the Act are:

- reducing greenhouse gas 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 in the climate of Iceland.

The law supersedes Act 65/2007 on which basis the Environment Agency 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 timeliness and uncertainty estimates. The data collection for this submission was based on these agreements. The articles in Act 65/2007 regarding the allocation committee still stand.

Act 70/2012 changes the form of relations between the EA and other bodies concerning data handling. Paragraph 6 of the law 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. The paragraph also states that the following institutions are obligated to collect data necessary for the GHG inventory and report it to the EA, further to be elaborated in regulations set by the Minister for the Environment and Natural Resources:

- Soil Conservation Service of Iceland
- Iceland Forest Service
- National Energy Authority
- Agricultural University of Iceland
- Iceland Food and Veterinary Authority
- Statistics Iceland
- The Road Traffic Directorate
- The Icelandic Recycling Fund
- Directorate of Customs

The relevant regulation regarding the manner and deadlines of said data is in preparation; a first order draft is in place. The regulation will be in place for the next inventory cycle. It is foreseen that the new law will facilitate the responsibilities, the data collection process and the timelines.

The Coordinating Team that operated from 2008 to 2012 had the function of reviewing the emissions inventory before submission to UNFCCC as described in Chapter 1.2. The Coordinating Team led to improvements in cooperation between the different institutions involved with the inventory compilation, especially with regard to the LULUCF and Agriculture sectors. Improvements proposed by the team were incorporated into the inventory. As the prospective regulation based on Act 70/2012 formalizes the cooperation and data collection process between the EA and all responsible institutions, it takes over the role of the Coordinating Team as regards the cooperation between different institutions. The role of the Coordinating Team as regards the review will be done through external review according to prioritization plan. The external review will focus on key sources and categories where methodological changes have occured. Further all chapters will be reviewed on periodic basis. Internal review within the EA, involving experts not directly involved in the preparation of the GHG inventory, will continue. The role as regards the final review before submission to the UNFCCC will be replaced by an approval meeting with the inventory team at the EA and the director of the EA, where the emission inventory is approved before submission to the UNFCCC.

14 Information on Change in the National Registry

The following changes to the national registry of Iceland have occurred in 2016.

Table 14.1 Changes to national registry.

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	New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality. Versions of the CSEUR released after 6.7.3 (the production version at the time of the last Chapter 14 submission) introduced other 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, including the new tables, 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 6.7.3 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). Annex H testing was completed in January 2017 and the test report is provided. 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.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The mandatory use of hard tokens for authentication and signature was introduced for registry administrators.
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 reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 6.7.3 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; the report is attached as Annex B. Annex H testing was carried out in January 2017 and the test report is provided.

15 Information on Minimization of Adverse Impacts in Accordance with Art.3 p.14

No changes have been made regarding the information of adverse impact since last submission.

Table 15.1 Summary of actions specified in Decision 15/CMP.1

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

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Annex I. 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 1.1 lists identified key sources. Tables A1, A2 and A3 show the 1990 level, 2015 level and 1990-2015 trend assessment without LULUCF, and Table A4, A5 and A6 show the 1990 level, 2015 level and 1990-2015 trend assessment with LULUCF.

Table A1: Key Category analysis approach 1 Level Assessment for 1990 in kt. CO_2-eq, excluding LULUCF.

IPCC category code	IPCC category	Gas	Base year (1990) Estimate	Level w/o LULUCF	Cumulative total level
1A4c	Agriculture/Fishing	CO_2	772	21.8%	21.8%
1A3b	Road Transport	CO_2	509	14.4%	36.2%
2C3	Metal Production - aluminium Production	PFCs	495	14.0%	50.1%
1A2	Manufacturing Industries & Construction	CO_2	243	6.9%	57.0%
2C2	Metal Production - Ferroalloys	CO_2	209	5.9%	62.9%
3A2	Enteric Fermentation - Sheep	CH_4	181	5.1%	68.0%
3D1	Direct N_2O emissions from managed soils	N_2O	171	4.8%	72.8%
2C3	Metal Production - aluminium Production	CO_2	139	3.9%	76.7%
5A2	Unmanaged waste disposal sites	CH_4	127	3.6%	80.3%
3A1	Enteric Fermentation - Cattle	CH_4	98	2.8%	83.1%
1B2d	Other emission from Energy Production	CO_2	61	1.7%	84.8%
1A3d	Water - borne Navigation	CO_2	59	1.7%	86.5%
3D2	Indirect N_2O emissions from managed soils	N_2O	52	1.5%	88.0%
2A1	Cement Production	CO_2	52	1.5%	89.4%
2B10	Other: Ferilizer production	N_2O	46	1.3%	90.7%
3B22	Manure Management - Sheep	N_2O	37	1.1%	91.8%
3A4	Enteric Fermentation - Horses	CH_4	33	0.9%	92.7%
1A3a	Domestic Aviation	CO_2	31	0.9%	93.6%
1A4b	Residential	CO_2	31	0.9%	94.5%
3B11	Manure Management - Cattle	CH_4	28	0.8%	95.3%

Table A2: Key category analysis approach 1 level for 2015 in kt.CO_2-eq, excluding LULUCF.

IPCC category code	IPCC category	Gas	Current year (2015) estimate	Level w/o LULUCF	Cumulative total level
2C3	**Metal Production - aluminium Production**	CO_2	1300	28.6%	28.6%
1A3b	**Road Transport**	CO_2	809	17.8%	46.5%
1A4c	**Agriculture/Fishing**	CO_2	546	12.0%	58.5%
2C2	**Metal Production - Ferroalloys**	CO_2	401	8.8%	67.3%
2F1a	**Refrigeration and stationary air-conditioning**	HFCs	198	4.4%	71.7%
1B2d	**Other emission from Energy Production**	CO_2	160	3.5%	75.2%
3D1	**Direct N_2O emissions from managed soils**	N_2O	159	3.5%	78.7%
5A1	**Managed waste disposal sites**	CH_4	155	3.4%	82.2%
3A2	**Enteric Fermentation - Sheep**	CH_4	154	3.4%	85.6%
3A1	**Enteric Fermentation - Cattle**	CH_4	111	2.4%	88.0%
2C3	**Metal Production - aluminium Production**	PFCs	104	2.3%	90.3%
1A2	**Manufacturing Industries & Construction**	CO_2	68	1.5%	91.8%
3D2	**Indirect N_2O emissions from managed soils**	N_2O	49	1.1%	92.9%
3A4 horses	**Enteric Fermentation - Horses**	CH_4	33	0.7%	93.6%
3B22	**Manure Management - Sheep**	N_2O	32	0.7%	94.3%
3B11	**Manure Management - Cattle**	CH_4	30	0.7%	95.0%
1A3b	**Road Transport**	N_2O	28	0.6%	95.6%

Table A3: Key category analysis approach 1 trend assessment in kt. CO_2-eq, excluding LULUCF.

IPCC Category code	IPCC Category	Gas	Base Year (1990) Estimate $E_{x,0}$	Current Year (2015) Estimate $E_{x,t}$	Trend Assessment $T_{x,t}$	% Contribution to Trend w/o LULUCF	Cumulative Total
2C3	**Metal Production - aluminium Production**	CO_2	139	1300	0.193	31.1%	31.1%
2C3	**Metal Production - aluminium Production**	PFCs	495	104	0.091	14.7%	45.9%
1A4c	**Agriculture/Fishing**	CO_2	772	546	0.076	12.3%	58.2%
1A2	**Manufacturing Industries & Construction**	CO_2	243	68	0.042	6.7%	64.9%
2F1a	**Refrigeration and stationary air-conditioning**	HFCs	0	198	0.034	5.5%	70.4%
1A3b	**Road Transport**	CO_2	509	809	0.027	4.4%	74.8%
5A1	**Managed waste disposal sites**	CH_4	15	155	0.023	3.8%	78.5%
5A2	**Unmanaged waste disposal sites**	CH_4	127	27	0.023	3.7%	82.3%
2C2	**Metal Production - Ferroalloys**	CO_2	209	401	0.023	3.7%	86.0%
1B2d	**Other emission from Energy Production**	CO_2	61	160	0.014	2.3%	88.3%
3A2	**Enteric Fermentation - Sheep**	CH_4	181	154	0.013	2.2%	90.4%
3D1	**Direct N_2O emissions from managed soils**	N_2O	171	159	0.010	1.7%	92.1%
1A3d	**Water - borne Navigation**	CO_2	59	26	0.009	1.4%	93.5%
1A4b	**Residential**	CO_2	31	7	0.006	0.9%	94.4%
1A3a	**Domestic Aviation**	CO_2	31	20	0.003	0.6%	94.9%
1A4a	**Commercial/Institutional**	CO_2	16	2	0.003	0.5%	95.4%

Table A4: Key Category analysis approach 1 Level Assessment for 1990 in kt CO_2-eq, including LULUCF.

IPCC category code	IPCC category	Gas	Base year (1990) Estimate	Level with LULUCF	Cumulative total level
4C1	**Grassland remaining Grassland**	CO_2	3945	27.2%	27.2%
4C2	**Land Converted to Grassland**	CO_2	2400	16.5%	43.7%
4(II) - Wetlands	**Emissions and removals from drainage and rewetting and other managment of organic and mineral soils**	CH_4	1789	12.3%	56.1%
4B1	**Cropland remaining Cropland**	CO_2	1256	8.7%	64.7%
1A4c	**Agriculture/Fishing**	CO_2	772	5.3%	70.1%
4B2	**Land Converted to Cropland**	CO_2	635	4.4%	74.4%
1A3b	**Road Transport**	CO_2	509	3.5%	77.9%
2C3	**Metal Production - aluminium Production**	PFCs	495	3.4%	81.4%
4(II) - Grassland	**Emissions and removals from drainage and rewetting and other managment of organic and mineral soils**	CH_4	478	3.3%	84.6%
1A2	**Manufacturing Industries & Construction**	CO_2	243	1.7%	86.3%
2C2	**Metal Production - Ferroalloys**	CO_2	209	1.4%	87.8%
3A2	**Enteric Fermentation - Sheep**	CH_4	181	1.2%	89.0%
3D1	**Direct N_2O emissions from managed soils**	N_2O	171	1.2%	90.2%
4(II) - Grassland	**Emissions and removals from drainage and rewetting and other managment of organic and mineral soils**	CO_2	141	1.0%	91.2%
2C3	**Metal Production - aluminium Production**	CO_2	139	1.0%	92.1%
5A2	**Unmanaged waste disposal sites**	CH_4	127	0.9%	93.0%
4(II) - Wetlands	**Emissions and removals from drainage and rewetting and other managment of organic and mineral soils**	CO_2	115	0.8%	93.8%
3A1	**Enteric Fermentation - Cattle**	CH_4	98	0.7%	94.5%
4(II) - Cropland	**Emissions and removals from drainage and rewetting and other managment of organic and mineral soils**	CH_4	95	0.7%	95.1%
4H	**Other: N_2O from Grassland drained soils**	N_2O	66	0.5%	95.6%

Table A5: Key category analysis approach 1 level for 2015 in kt. CO_2-eq, including LULUCF.

IPCC category code	IPCC category	Gas	Current year (2015) Estimate	Level with LULUCF	Cumulative total level
4C1	**Grassland remaining Grassland**	CO_2	6762	42.6%	42.6%
4(II) - Wetlands	**Emissions and removals from drainage and rewetting and other managment of organic and mineral soils**	CH_4	1609	10.1%	52.8%
4B1	**Cropland remaining Cropland**	CO_2	1552	9.8%	62.6%
2C3	**Metal Production - aluminium Production**	CO_2	1300	8.2%	70.8%
1A3b	**Road Transport**	CO_2	809	5.1%	75.9%
4(II) - Grassland	**Emissions and removals from drainage and rewetting and other managment of organic and mineral soils**	CH_4	547	3.5%	79.3%
1A4c	**Agriculture/Fishing**	CO_2	546	3.4%	82.8%
2C2	**Metal Production - Ferroalloys**	CO_2	401	2.5%	85.3%
4C2	**Land Converted to Grassland**	CO_2	290	1.8%	87.1%
2F1a	**Product Uses as Substitutes for ODS -Refrigeration and stationary air-conditioning**	HFCs	198	1.2%	88.4%
4(II) - Grassland	**Emissions and removals from drainage and rewetting and other managment of organic and mineral soils**	CO_2	162	1.0%	89.4%
1B2d	**Other emission from Energy Production**	CO_2	160	1.0%	90.4%
3D1	**Direct N_2O emissions from managed soils**	N_2O	159	1.0%	91.4%
5A1	**Managed waste disposal sites**	CH_4	155	1.0%	92.4%
3A2	**Enteric Fermentation - Sheep**	CH_4	154	1.0%	93.4%
3A1	**Enteric Fermentation - Cattle**	CH_4	111	0.7%	94.1%
2C3	**Metal Production - aluminium Production**	PFCs	104	0.7%	94.7%
4(II) - Wetlands	**Emissions and removals from drainage and rewetting and other managment of organic and mineral soils**	CO_2	103	0.6%	95.4%

Table A6: Key category analysis approach 1 trend assessment in kt. CO_2-eq, including LULUCF.

IPCC Category code	IPCC Category	Gas	Base Year (1990) Estimate $E_{x,0}$	Current Year (2015) Estimate $E_{x,t}$	Trend Assessment $T_{x,t}$	% Contribution to Trend with LULUCF	Cumulative Total
4C1	**Grassland remaining Grassland**	CO_2	3945	6762	0.141	26.2%	26.2%
4C2	**Land Converted to Grassland**	CO_2	2400	290	0.135	25.0%	51.2%
2C3	**Metal Production - aluminium Production**	CO_2	139	1300	0.066	12.3%	63.5%
4B2	**Land Converted to Cropland**	CO_2	635	91	0.035	6.5%	69.9%
2C3	**Metal Production - aluminium Production**	PFCs	495	104	0.025	4.7%	74.6%
4(II) - Wetlands	**Emissions and removals from drainage and rewetting and other managment of organic and mineral soils**	CH_4	1789	1609	0.020	3.7%	78.3%
1A4c	**Agriculture/Fishing**	CO_2	772	546	0.017	3.2%	81.5%
1A3b	**Road Transport**	CO_2	509	809	0.015	2.7%	84.2%
2F1a	**Product Uses as Substitutes for ODS - Refrigeration and stationary air-conditioning**	HFCs	0	198	0.011	2.1%	86.3%
1A2	**Manufacturing Industries & Construction**	CO_2	243	68	0.011	2.1%	88.4%
4B1	**Cropland remaining Cropland**	CO_2	1256	1552	0.010	1.9%	90.3%
2C2	**Metal Production - Ferroalloys**	CO_2	209	401	0.010	1.8%	92.2%
5A1	**Managed waste disposal sites**	CH_4	15	155	0.008	1.5%	93.7%
5A2	**Unmanaged waste disposal sites**	CH_4	127	27	0.006	1.2%	94.9%
1B2d	**Other emission from Energy Production**	CO_2	61	160	0.005	1.0%	95.9%

Annex II. Assessment of uncertainty (Including LULUCF)

IPCC Source category	IPCC Source category	Gas	Activity data uncer-tainty	Emission factor uncer-tainty	Combined uncer-tainty	Combine uncertainty as % of total national emissions in year 2012	Type A sensi-tivity	Type B sensi-tivity	Uncer-tainty in emission trend introduced by EF uncer-tainty	Uncer-tainty in emission trend introduced by AD uncer-tainty	Uncer-tainty introdu-ced into the trend in total national emissions
1AA1	Public electricity and heat production	CO_2	5.0	5.0	7.1	0.010	-0.002	0.002	-0.008	0.011	0.014
1AA1	Public electricity and heat production	CH_4	5.0	100.0	100.1	0.001	0.000	0.000	0.000	0.000	0.001
1AA1	Public electricity and heat production	N_2O	5.0	150.0	150.1	0.003	0.000	0.000	0.003	0.000	0.003
1AA2	Manufacturing industry and construction	CO_2	5.0	5.0	7.1	0.235	-0.047	0.037	-0.237	0.258	0.351
1AA2	Manufacturing industry and construction	CH_4	5.0	100.0	100.1	0.003	0.000	0.000	-0.003	0.000	0.003
1AA2	Manufacturing industry and construction	N_2O	5.0	150.0	150.1	0.344	-0.001	0.003	-0.178	0.018	0.179
1AA3a/d	Transport	CO_2	5.0	5.0	7.1	0.047	-0.014	0.007	-0.069	0.052	0.087
1AA3a/d	Transport	CH_4	5.0	100.0	100.1	0.001	0.000	0.000	-0.002	0.000	0.002
1AA3a/d	Transport	N_2O	5.0	200.0	200.1	0.012	0.000	0.000	-0.023	0.000	0.023
1AA3b	Road transport	CO_2	5.0	5.0	7.1	1.070	0.045	0.166	0.223	1.174	1.195
1AA3b	Road transport	CH_4	5.0	40.0	40.3	0.011	0.000	0.000	-0.015	0.002	0.015
1AA3b	Road transport	N_2O	5.0	50.0	50.2	0.334	0.006	0.007	0.312	0.052	0.316
1AA4a/b	Residential/institutional/commercial	CO_2	5.0	5.0	7.1	0.014	-0.008	0.002	-0.039	0.015	0.042
1AA4a/b	Residential/institutional/commercial	CH_4	5.0	100.0	100.1	0.000	0.000	0.000	0.000	0.000	0.000
1AA4a/b	Residential/institutional/commercial	N_2O	5.0	150.0	150.1	0.001	0.000	0.000	-0.003	0.000	0.003
1AA4c	Fishing	CO_2	3.0	5.0	5.8	0.547	-0.050	0.103	-0.248	0.437	0.502

1AA4c	Fishing	CH_4	3.0	100.0	100.0	0.019	0.000	0.000	-0.010	0.001	0.010
1AA4c	Fishing	N_2O	3.0	150.0	150.0	0.118	0.000	0.001	-0.063	0.004	0.063
1B	Fugitive emissions from fuels	CO2	10.0	1.0	10.0	0.331	0.022	0.036	0.022	0.511	0.511
1B	Fugitive emissions from fuels	CH_4	6.0	8.0	10.0	0.005	0.000	0.001	0.003	0.005	0.006
2A	Mineral production	CO_2	5.0	6.5	8.2	0.003	-0.012	0.000	-0.077	0.002	0.077
2B	Chemical industry	CO_2	3.0	1.0	3.2	0.000	0.000	0.000	0.000	0.000	0.000
2B	Chemical industry	N_2O	30.0	40.0	50.0	0.000	-0.011	0.000	-0.450	0.000	0.450
2C	Metal production	CH_4	1.5	100.00	100.0	0.022	0.000	0.000	0.009	0.001	0.009
2C2	Ferroalloys	CO_2	1.5	1.0	1.8	0.142	0.038	0.086	0.038	0.183	0.187
2C3	Aluminium	CO_2	1.5	1.0	1.8	0.434	0.232	0.264	0.232	0.560	0.606
2C3	Aluminium	PFC	5.0	9.3	10.6	0.163	-0.081	0.017	-0.751	0.120	0.761
2F	Consumption of halocarbons and SF6, refrigeration	HFC	176.0	79.6	193.2	5.383	0.031	0.031	2.432	7.611	7.991
2F	Consumption of halocarbons and SF6, refrigeration	PFC	176.0	79.6	193.2	0.000	0.000	0.000	0.000	0.000	0.000
2F	Consumption of halocarbons and SF6, electrical equipment	SF6	20.0	50.0	53.9	0.058	0.001	0.001	0.046	0.033	0.057
2	Solvent and other product use	N_2O	20.0	5.0	20.6	0.013	-0.001	0.001	-0.003	0.020	0.020
2	Solvent and other product use	CO_2	61.3	167.5	178.4	0.098	0.000	0.001	-0.019	0.052	0.055
3A1	Enteric fermentation, cattle	CH_4	17.8	20.0	26.8	0.426	-0.002	0.017	-0.033	0.441	0.442
3A3	Enteric fermentation, sheep	CH_4	17.2	20.0	26.4	0.666	-0.008	0.028	-0.154	0.674	0.691
3A4-10	Enteric fermentation, rest	CH_4	20.0	40.0	44.7	0.272	0.000	0.007	-0.006	0.189	0.189
3B	Manure management	N_2O	55.7	100.0	114.4	0.958	-0.003	0.009	-0.293	0.723	0.780
3B	Manure management	CH_4	50.9	126.9	136.7	1.039	-0.001	0.008	-0.158	0.601	0.621
3D1	Direct soil emissions	N_2O	31.1	326.1	327.6	8.636	-0.006	0.029	-1.843	1.273	2.240
3D2	Animal production	N_2O	55.8	100.0	114.5	1.853	-0.003	0.018	-0.314	1.401	1.436
3D3	Indirect soil emissions	N_2O	66.9	1,000.0	1,002.2	25.397	-0.005	0.028	-5.121	2.632	5.758
4A1	Forest land remaining forest land	CO_2	14.0	10.0	17.2	-0.119	-0.004	-0.008	-0.041	-0.150	0.155
4A2	Land converted to forest land	CO_2	5.0	10.0	11.2	-0.503	-0.043	-0.049	-0.432	-0.349	0.556

4A	Forest land	N_2O	5.0	400.0	400.0	0.092	0.000	0.000	0.071	0.002	0.071
4B1	Cropland remaining Cropland	CO_2	20.0	90.0	92.2	17.886	0.035	0.213	3.144	6.021	6.793
4B2	Land converted to Cropland	CO_2	20.0	90.0	92.2	1.149	-0.087	0.014	-7.863	0.387	7.872
4C1	Wetland drained for more than 20 years	CO_2	20.0	90.0	92.2	5.142	0.022	0.061	1.953	1.731	2.609
4C1	All other remaining Grassland	CO_2	20.0	20.0	28.3	-0.080	-0.003	-0.003	-0.054	-0.088	0.103
4C21/2/3/4	All other conversion to Grassland	CO_2	20.0	90.0	92.2	1.393	-0.013	0.017	-1.175	0.469	1.265
4C25	Other land converted to Grassland, revegetation	CO_2	30.0	25.0	39.1	-4.101	-0.034	-0.115	-0.848	-4.889	4.962
4D	Wetlands	CO_2	20.0	50.0	53.9	0.101	0.002	0.002	0.082	0.058	0.100
44D	Wetlands	CH_4	20.0	50.0	53.9	0.087	0.001	0.002	0.070	0.050	0.086
4E21	Settlements	CO_2	5.0	10.0	11.2	0.000	0.000	0.000	0.000	0.000	0.000
4	LULUCF, wildfires	CH_4	10.0	70.0	70.7	0.000	0.000	0.000	0.000	0.000	0.000
4	LULUCF, wildfires	N_2O	10.0	70.0	70.7	0.000	0.000	0.000	0.000	0.000	0.000
4G	Grassland non CO2-emissions	N_2O	20.0	25.0	32.0	0.487	0.001	0.017	0.018	0.472	0.472
5A.1	Managed waste disposal on land	CH_4	42.4	35.9	55.6	1.448	0.026	0.029	0.918	1.716	1.946
5A2	Unmanaged waste disposal sites	CH_4	42.4	51.4	66.7	0.350	-0.019	0.006	-0.976	0.346	1.035
5B	Wastewater handling	CH_4	36.4	58.3	68.7	0.047	0.000	0.001	0.025	0.039	0.046
5B	Wastewater handling	N_2O	45.7	1,000.0	1,001.0	1.556	0.000	0.002	0.256	0.110	0.279
5C	Waste incineration	CO_2	33.9	13.8	36.6	0.048	-0.001	0.001	-0.016	0.069	0.070
5C	Waste incineration	N_2O	20.0	100.0	102.0	0.004	0.000	0.000	-0.028	0.001	0.028
5C	Waste incineration	CH_4	20.0	100.0	102.0	0.005	-0.001	0.000	-0.115	0.002	0.115
5D	Other (composting)	CH_4	20.0	100.0	102.0	0.019	0.000	0.000	0.020	0.006	0.021
5D	Other (composting)	N_2O	20.0	100.0	102.0	0.021	0.000	0.000	0.022	0.006	0.023
	Totals					**33.6**					**16.0**

Annex III. Explanation of EA's adjustment of data on fuel sales

Fuel sales (gas oil and residual fuel oil) by sectors 1A1a, 1A2 (stationary) and 1A4 (stationary) – as provided by the National Energy Authority

No.	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
		Tonnes	Tonnes	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	1,595	1,745	1,585	3,109	1,294
10X5X	industry	5,072	1,129	10,253	22,177	9,391	4,919	5,412	7,575	4,571	10,161
10X60	energy industries	1,300	1,091	1,065	21	1,012	683	955	1,090	1,423	1,185
10X90	other	0	458	1,386	8,928	2,728	1,136	260	768	214	4767
Residual Fuel Oil											
10840	house heating and swimming pools	2,989	3,079	122	195	0	0	0	0	191	137
1085X	industry	55,934	56,224	46,213	25,005	16,546	17,294	17,839	13,789	4,989	10,183
10860	energy industries	0	0	0	0	0	0	135	125	0	0
10890	other	39	52	67	0	1,629	780	0	0	0	0

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	2011	2012	2013	2014	2015
Swimming pools	1800	1600	1600	1000	300	300	300	300	300	300

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 IV. CRF Table Summary 2 for 1990-2015.

1990

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2017 v5
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]	9852.69	2883.91	443.72	0.34	494.64	1.10	NO,NA	NO,NA	13676.40
1. Energy	1735.96	6.51	34.59						1777.06
A. Fuel combustion (sectoral approach)	1674.60	5.77	34.59						1714.97
1. Energy industries	13.79	0.01	0.02						13.82
2. Manufacturing industries and construction	242.82	0.16	0.60						243.58
3. Transport	599.53	3.76	13.76						617.06
4. Other sectors	818.46	1.84	20.21						840.51
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	61.36	0.74	NO,NA						62.10
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	61.36	0.74	NA,NO						62.10
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	405.03	0.75	52.35	0.34	494.64	1.10	NO,NA	NO,NA	954.20
A. Mineral industry	52.28								52.28
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	0.70	NO	NO	494.64	NO	NO	NO	843.35
D. Non-energy products from fuels and solvent use	4.37	NE,NA	NE,NA						4.37
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				0.34	NO				0.34
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	364.30	282.11						646.47
A. Enteric fermentation		313.80							313.80
B. Manure management		50.50	58.69						109.20
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	223.42						223.42
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry[1]	7704.35	2362.26	67.03						10133.65
A. Forest land	-42.21	0.10	0.84						-41.26
B. Cropland	1919.45	94.83	NA,NE,IE						2014.28
C. Grassland	6486.49	477.89	0.07						6964.45
D. Wetlands	-672.57	1789.44	NO,NA,NE						1116.87
E. Settlements	13.19	NE	NE,IE						13.19
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	NO,NE								NO,NE
H. Other	IE	IE	66.11						66.11
5. Waste	7.30	150.09	7.63						165.01
A. Solid waste disposal	NO,NE,NA	142.00							142.00
B. Biological treatment of solid waste		NA	NA						NA
C. Incineration and open burning of waste	7.30	6.09	1.67						15.05
D. Waste water treatment and discharge		2.00	5.96						7.96
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	315.49	0.27	2.63						318.39
Aviation	217.24	0.04	1.83						219.11
Navigation	98.25	0.23	0.80						99.28
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NA								NO,NA
CO_2 captured	NA,NO								NA,NO
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									3542.75
Total CO_2 equivalent emissions with land use, land-use change and forestry									13676.40
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1991

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1991
Submission 2017 v5
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)]	9783.03	2880.53	431.69	0.70	410.61	1.24	NO,NA	NO,NA	13507.79
1. Energy	1699.88	6.56	34.44						1740.88
A. Fuel combustion (sectoral approach)	1629.93	5.90	34.44						1670.27
1. Energy industries	15.39	0.01	0.02						15.42
2. Manufacturing industries and construction	171.89	0.11	0.46						172.47
3. Transport	610.86	3.89	14.22						628.97
4. Other sectors	831.79	1.89	19.73						853.41
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	69.95	0.66	NO,NA						70.61
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	69.95	0.66	NA,NO						70.61
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	370.56	0.63	50.31	0.70	410.61	1.24	NO,NA	NO,NA	834.05
A. Mineral industry	48.65								48.65
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	0.58	NO	NO	410.61	NO	NO	NO	728.61
D. Non-energy products from fuels and solvent use	4.17	NE,NA	NE,NA						4.17
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				0.70	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	353.30	271.79						625.15
A. Enteric fermentation		303.80							303.80
B. Manure management		49.50	54.96						104.46
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	216.83						216.83
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	7705.29	2364.00	67.52						10136.81
A. Forest land	-43.76	0.15	1.21						-42.40
B. Cropland	1910.44	94.32	NA,NE,IE						2004.76
C. Grassland	6490.76	478.68	0.09						6969.54
D. Wetlands	-665.33	1790.85	NO,NA,NE						1125.52
E. Settlements	13.19	NE	NE,IE						13.19
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	NO,NE								NO,NE
H. Other	IE	IE	66.22						66.22
5. Waste	7.24	156.04	7.62						170.90
A. Solid waste disposal	NO,NE,NA	146.75							146.75
B. Biological treatment of solid waste		NA	NA						NA
C. Incineration and open burning of waste	7.24	6.04	1.66						14.94
D. Waste water treatment and discharge		3.25	5.96						9.21
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	256.92	0.13	2.15						259.20
Aviation	219.55	0.04	1.85						221.43
Navigation	37.37	0.09	0.30						37.76
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NA								NO,NA
CO_2 captured	NA,NO								NA,NO
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									3370.98
Total CO_2 equivalent emissions with land use, land-use change and forestry									13507.79
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 2017 v5
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)]	9898.46	2885.38	410.88	0.70	183.04	1.24	NO,NA	NO,NA	13379.70
1. Energy	1823.10	6.89	34.34						1864.33
A. Fuel combustion (sectoral approach)	1755.49	6.15	34.34						1795.97
1. Energy industries	13.83	0.01	0.02						13.86
2. Manufacturing industries and construction	235.48	0.16	0.53						236.17
3. Transport	621.00	3.98	14.54						639.53
4. Other sectors	885.18	2.00	19.24						906.42
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	67.61	0.74	NO,NA						68.35
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	67.61	0.74	NA,NO						68.35
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	373.67	0.65	44.96	0.70	183.04	1.24	NO,NA	NO,NA	604.27
A. Mineral industry	45.69								45.69
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	0.60	NO	NO	183.04	NO	NO	NO	507.18
D. Non-energy products from fuels and solvent use	4.17	NE,NA	NE,NA						4.17
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				0.70	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	348.00	255.92						603.98
A. Enteric fermentation		299.75							299.75
B. Manure management		48.25	49.94						98.19
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NE,NA,NO	205.98						205.98
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	7694.59	2362.18	68.09						10124.85
A. Forest land	-48.20	0.20	1.65						-46.36
B. Cropland	1900.69	93.81	NA,NE,IE						1994.50
C. Grassland	6493.43	479.47	0.11						6973.01
D. Wetlands	-664.52	1788.70	NO,NA,NE						1124.18
E. Settlements	13.19	NE	NE,IE						13.19
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	NO,NE								NO,NE
H. Other	IE	IE	66.33						66.33
5. Waste	7.04	167.65	7.58						182.27
A. Solid waste disposal	NO,NE,NA	158.50							158.50
B. Biological treatment of solid waste		NA	NA						NA
C. Incineration and open burning of waste	7.04	5.90	1.62						14.56
D. Waste water treatment and discharge		3.25	5.96						9.21
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	260.91	0.18	2.18						263.26
Aviation	201.39	0.04	1.69						203.12
Navigation	59.52	0.14	0.48						60.14
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NA								NO,NA
CO_2 captured	NA,NO								NA,NO
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									3254.85
Total CO_2 equivalent emissions with land use, land-use change and forestry									13379.70
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.

1993

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1993
Submission 2017 v5
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)]	10015.64	2894.57	420.79	1.45	88.24	1.24	NO,NA	NO,NA	13421.94
1. Energy	1902.67	7.04	37.97						1947.69
A. Fuel combustion (sectoral approach)	1817.30	6.31	37.97						1861.58
1. Energy industries	17.22	0.01	0.02						17.25
2. Manufacturing industries and construction	254.25	0.17	0.58						254.99
3. Transport	621.60	3.95	14.42						639.97
4. Other sectors	924.23	2.18	22.96						949.36
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	85.37	0.73	NO,NA						86.10
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	85.37	0.73	NA,NO						86.10
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	422.65	0.73	46.97	1.45	88.24	1.24	NO,NA	NO,NA	561.29
A. Mineral industry	39.68								39.68
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	0.69	NO	NO	88.24	NO	NO	NO	467.20
D. Non-energy products from fuels and solvent use	4.45	NE,NA	NE,NA						4.45
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				1.45	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	348.28	260.19						608.53
A. Enteric fermentation		299.78							299.78
B. Manure management		48.50	50.43						98.93
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	209.76						209.76
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	7684.26	2361.41	68.29						10113.97
A. Forest land	-53.36	0.21	1.73						-51.42
B. Cropland	1890.88	93.30	NA,NE,IE						1984.18
C. Grassland	6497.66	480.26	0.13						6978.05
D. Wetlands	-664.11	1787.64	NO,NA,NE						1123.53
E. Settlements	13.19	NE	NE,IE						13.19
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	NO,NE								NO,NE
H. Other	IE	IE	66.44						66.44
5. Waste	6.00	177.11	7.37						190.47
A. Solid waste disposal	NO,NE,NA	168.75							168.75
B. Biological treatment of solid waste		NA	NA						NA
C. Incineration and open burning of waste	6.00	5.11	1.41						12.51
D. Waste water treatment and discharge		3.25	5.96						9.21
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	290.17	0.26	2.41						292.85
Aviation	193.49	0.03	1.63						195.15
Navigation	96.68	0.23	0.78						97.69
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.31								0.31
CO_2 captured	NA,NO								NA,NO
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									3307.97
Total CO_2 equivalent emissions with land use, land-use change and forestry									13421.94
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1994

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1994
Submission 2017 v5
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)]	9958.21	2904.48	424.76	2.33	52.53	1.24	NO,NA	NO,NA	13343.56
1. Energy	1846.13	6.93	38.04						1891.10
A. Fuel combustion (sectoral approach)	1776.01	6.19	38.04						1820.24
1. Energy industries	16.90	0.01	0.02						16.92
2. Manufacturing industries and construction	230.15	0.15	0.52						230.82
3. Transport	624.17	3.99	14.54						642.70
4. Other sectors	904.79	2.04	22.96						929.79
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	70.12	0.74	NO,NA						70.86
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	70.12	0.74	NA,NO						70.86
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	423.75	0.70	46.83	2.33	52.53	1.24	NO,NA	NO,NA	527.39
A. Mineral industry	37.37								37.37
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	0.66	NO	NO	52.53	NO	NO	NO	434.83
D. Non-energy products from fuels and solvent use	4.38	NE,NA	NE,NA						4.38
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				2.33	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	350.05	264.10						614.21
A. Enteric fermentation		301.80							301.80
B. Manure management		48.25	50.64						98.90
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NE,NA,NO	213.46						213.46
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	7682.74	2360.55	68.53						10111.82
A. Forest land	-56.14	0.22	1.83						-54.08
B. Cropland	1881.04	92.79	NA,NE,IE						1973.83
C. Grassland	6500.71	481.05	0.15						6981.91
D. Wetlands	-663.67	1786.49	NO,NA,NE						1122.82
E. Settlements	20.81	NE	NE,IE						20.81
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	NO,NE								NO,NE
H. Other	IE	IE	66.54						66.54
5. Waste	5.53	186.24	7.26						199.03
A. Solid waste disposal	NO,NE,NA	178.25							178.25
B. Biological treatment of solid waste		NA	NA						NA
C. Incineration and open burning of waste	5.53	4.74	1.30						11.57
D. Waste water treatment and discharge		3.25	5.96						9.21
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	304.15	0.26	2.53						306.94
Aviation	211.28	0.04	1.78						213.09
Navigation	92.87	0.22	0.75						93.84
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.31								0.31
CO_2 captured	NA,NO								NA,NO
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									3231.74
Total CO_2 equivalent emissions with land use, land-use change and forestry									13343.56
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1995

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1995
Submission 2017 v5
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)]	9971.07	2898.36	419.84	10.22	69.36	1.24	NO,NA	NO,NA	13370.10
1. Energy	1866.31	6.57	45.65						1918.53
A. Fuel combustion (sectoral approach)	1784.08	5.58	45.65						1835.30
1. Energy industries	21.85	0.01	0.03						21.88
2. Manufacturing industries and construction	218.31	0.14	0.46						218.91
3. Transport	599.90	3.32	18.41						621.63
4. Other sectors	944.02	2.11	26.75						972.88
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	82.23	1.00	NO,NA						83.23
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	82.23	1.00	NA,NO						83.23
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	441.09	0.73	44.75	10.22	69.36	1.24	NO,NA	NO,NA	567.39
A. Mineral industry	37.87								37.87
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	0.68	NO	NO	69.36	NO	NO	NO	467.98
D. Non-energy products from fuels and solvent use	4.83	NE,NA	NE,NA						4.83
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				10.22	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	337.30	253.13						590.49
A. Enteric fermentation		289.80							289.80
B. Manure management		47.50	47.80						95.30
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	205.33						205.33
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	7658.74	2358.08	69.01						10085.83
A. Forest land	-65.76	0.26	2.11						-63.39
B. Cropland	1871.22	92.28	NA,NE,IE						1963.50
C. Grassland	6509.48	482.38	0.17						6992.03
D. Wetlands	-662.41	1783.16	NO,NA,NE						1120.75
E. Settlements	6.22	NE	NE,IE						6.22
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	NO,NE								NO,NE
H. Other	IE	IE	66.73						66.73
5. Waste	4.87	195.68	7.30						207.86
A. Solid waste disposal	NO,NE,NA	188.00							188.00
B. Biological treatment of solid waste		0.20	0.18						0.38
C. Incineration and open burning of waste	4.87	4.23	1.17						10.27
D. Waste water treatment and discharge		3.25	5.96						9.21
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	376.61	0.38	3.12						380.11
Aviation	233.56	0.04	1.97						235.56
Navigation	143.05	0.34	1.16						144.55
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.31								0.31
CO_2 captured	NA,NO								NA,NO
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									3284.28
Total CO_2 equivalent emissions with land use, land-use change and forestry									13370.10
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for
(2) See footnote 7 to table Summary 1.A.
(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1996

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1996
Submission 2017 v5
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)]	10061.78	2907.18	436.00	18.59	29.64	1.24	NO,NA	NO,NA	13454.45
1. Energy	1957.46	6.60	46.03						2010.08
A. Fuel combustion (sectoral approach)	1876.20	5.81	46.03						1928.03
1. Energy industries	15.35	0.01	0.01						15.36
2. Manufacturing industries and construction	265.17	0.17	0.53						265.87
3. Transport	590.24	3.38	18.78						612.40
4. Other sectors	1005.44	2.25	26.70						1034.39
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	81.26	0.79	NO,NA						82.05
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	81.26	0.79	NA,NO						82.05
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	440.31	0.70	52.02	18.59	29.64	1.24	NO,NA	NO,NA	542.52
A. Mineral industry	41.78								41.78
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	0.66	NO	NO	29.64	NO	NO	NO	423.77
D. Non-energy products from fuels and solvent use	4.64	NE,NA	NE,NA						4.64
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				18.59	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	342.58	261.46						604.10
A. Enteric fermentation		294.08							294.08
B. Manure management		48.50	48.59						97.09
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	212.86						212.86
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry[(1)]	7659.58	2358.02	69.31						10086.91
A. Forest land	-69.95	0.27	2.23						-67.45
B. Cropland	1861.43	91.77	NA,NE,IE						1953.20
C. Grassland	6517.18	483.56	0.19						7000.93
D. Wetlands	-659.90	1782.42	NO,NA,NE						1122.53
E. Settlements	10.71	NE	NE,IE						10.71
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	66.89						66.89
5. Waste	4.37	199.28	7.19						210.84
A. Solid waste disposal	NO,NE,NA	192.00							192.00
B. Biological treatment of solid waste		0.20	0.18						0.38
C. Incineration and open burning of waste	4.37	3.83	1.05						9.25
D. Waste water treatment and discharge		3.25	5.96						9.21
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	391.67	0.34	3.26						395.27
Aviation	268.53	0.05	2.26						270.84
Navigation	123.14	0.29	1.00						124.43
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.31								0.31
CO_2 captured	NA,NO								NA,NO
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									3367.54
Total CO_2 equivalent emissions with land use, land-use change and forestry									13454.45
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 2017 v5
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)]	10154.56	2903.51	433.34	28.77	97.08	1.24	NO,NA	NO,NA	13618.50
1. Energy	1985.80	6.20	53.56						2045.56
A. Fuel combustion (sectoral approach)	1921.95	5.16	53.56						1980.67
1. Energy industries	11.86	0.00	0.01						11.87
2. Manufacturing industries and construction	303.23	0.20	0.64						304.07
3. Transport	601.93	2.72	22.80						627.45
4. Other sectors	1004.93	2.24	30.12						1037.28
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	63.85	1.04	NO,NA						64.89
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	63.85	1.04	NA,NO						64.89
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	499.40	0.74	44.17	28.77	97.08	1.24	NO,NA	NO,NA	671.40
A. Mineral industry	46.55								46.55
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	0.69	NO	NO	97.08	NO	NO	NO	545.78
D. Non-energy products from fuels and solvent use	4.41	NE,NA	NE,NA						4.41
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				28.77	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	339.08	258.67						597.81
A. Enteric fermentation		291.83							291.83
B. Manure management		47.25	49.24						96.49
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NE,NA,NO	209.43						209.43
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.06								0.06
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	7665.09	2354.37	69.80						10089.25
A. Forest land	-76.69	0.30	2.42						-73.98
B. Cropland	1851.56	91.25	NA,NE,IE						1942.82
C. Grassland	6535.93	485.59	0.20						7021.73
D. Wetlands	-657.90	1777.22	NO,NA,NE						1119.32
E. Settlements	12.08	NE	NE,IE						12.08
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	67.17						67.17
5. Waste	4.21	203.12	7.15						214.48
A. Solid waste disposal	NO,NE,NA	196.00							196.00
B. Biological treatment of solid waste		0.20	0.18						0.38
C. Incineration and open burning of waste	4.21	3.67	1.01						8.89
D. Waste water treatment and discharge		3.25	5.96						9.21
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	436.71	0.40	3.63						440.74
Aviation	288.91	0.05	2.43						291.39
Navigation	147.80	0.35	1.19						149.35
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.31								0.31
CO_2 captured	NA,NO								NA,NO
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									3529.25
Total CO_2 equivalent emissions with land use, land-use change and forestry									13618.50
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 2017 v5
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)]	10176.89	2909.83	434.00	43.22	212.33	1.24	NO,NA	NO,NA	13777.51
1. Energy	1967.50	6.46	54.25						2028.21
A. Fuel combustion (sectoral approach)	1883.80	5.15	54.25						1943.20
1. Energy industries	14.83	0.01	0.01						14.85
2. Manufacturing industries and construction	278.49	0.19	0.63						279.31
3. Transport	604.72	2.77	23.46						630.96
4. Other sectors	985.76	2.18	30.14						1018.08
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	83.70	1.31	NO,NA						85.01
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	83.70	1.31	NA,NO						85.01
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	527.03	0.55	39.26	43.22	212.33	1.24	NO,NA	NO,NA	823.64
A. Mineral industry	54.39								54.39
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	0.51	NO	NO	212.33	NO	NO	NO	680.74
D. Non-energy products from fuels and solvent use	4.34	NE,NA	NE,NA						4.34
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				43.22	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	345.35	262.97						608.40
A. Enteric fermentation		296.60							296.60
B. Manure management		48.75	50.49						99.24
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	212.48						212.48
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry[(1)]	7678.71	2348.86	70.52						10098.09
A. Forest land	-85.00	0.33	2.73						-81.93
B. Cropland	1841.71	90.74	NA,NE,IE						1932.45
C. Grassland	6563.79	488.41	0.22						7052.43
D. Wetlands	-654.75	1769.38	NO,NA,NE						1114.63
E. Settlements	12.85	NE	NE,IE						12.85
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	67.56						67.56
5. Waste	3.57	208.60	7.01						219.18
A. Solid waste disposal	NO,NE,NA	202.00							202.00
B. Biological treatment of solid waste		0.20	0.18						0.38
C. Incineration and open burning of waste	3.57	3.15	0.87						7.59
D. Waste water treatment and discharge		3.25	5.96						9.21
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	510.00	0.48	4.23						514.71
Aviation	334.42	0.06	2.82						337.30
Navigation	175.58	0.42	1.42						177.41
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.31								0.31
CO_2 captured	NA,NO								NA,NO
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									3679.42
Total CO_2 equivalent emissions with land use, land-use change and forestry									13777.51
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 2017 v5
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)]	10402.47	2909.02	449.24	48.85	204.17	1.24	NO,NA	NO,NA	14015.00
1. Energy	2025.32	6.22	62.75						2094.29
A. Fuel combustion (sectoral approach)	1914.05	4.39	62.75						1981.18
1. Energy industries	11.91	0.00	0.01						11.93
2. Manufacturing industries and construction	288.48	0.19	0.65						289.33
3. Transport	626.24	2.00	29.29						657.53
4. Other sectors	987.41	2.19	32.79						1022.40
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	111.27	1.84	NO,NA						113.11
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	111.27	1.84	NA,NO						113.11
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	676.11	0.82	39.64	48.85	204.17	1.24	NO,NA	NO,NA	970.85
A. Mineral industry	61.43								61.43
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	0.77	NO	NO	204.17	NO	NO	NO	815.08
D. Non-energy products from fuels and solvent use	4.10	NE,NA	NE,NA						4.10
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				48.85	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	344.33	268.86						613.26
A. Enteric fermentation		296.33							296.33
B. Manure management		48.00	50.86						98.86
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NE,NA,NO	218.01						218.01
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	7698.05	2343.06	71.12						10112.23
A. Forest land	-91.35	0.35	2.89						-88.11
B. Cropland	1831.74	90.23	NA,NE,IE						1921.97
C. Grassland	6596.04	491.53	0.24						7087.81
D. Wetlands	-651.57	1760.94	NO,NA,NE						1109.38
E. Settlements	13.07	NE	NE,IE						13.07
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	67.99						67.99
5. Waste	2.92	214.59	6.86						224.37
A. Solid waste disposal	NO,NE,NA	208.25							208.25
B. Biological treatment of solid waste		0.20	0.18						0.38
C. Incineration and open burning of waste	2.92	2.64	0.73						6.28
D. Waste water treatment and discharge		3.50	5.96						9.46
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	522.10	0.45	4.35						526.90
Aviation	359.38	0.06	3.03						362.47
Navigation	162.72	0.39	1.32						164.43
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.40								0.40
CO_2 captured	NA,NO								NA,NO
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	3902.77
Total CO_2 equivalent emissions with land use, land-use change and forestry	14015.00
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2000

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2000
Submission 2017 v5
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)]	10490.79	2893.05	428.27	43.28	149.89	1.31	NO,NA	NO,NA	14006.60
1. Energy	1968.90	6.30	62.32						2037.52
A. Fuel combustion (sectoral approach)	1815.76	4.20	62.32						1882.28
1. Energy industries	10.90	0.00	0.01						10.91
2. Manufacturing industries and construction	236.66	0.15	0.57						237.38
3. Transport	628.98	1.96	28.80						659.74
4. Other sectors	939.22	2.08	32.94						974.25
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	153.14	2.10	NO,NA						155.24
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	153.14	2.10	NA,NO						155.24
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	785.74	1.09	22.47	43.28	149.89	1.31	NO,NA	NO,NA	1003.78
A. Mineral industry	65.48								65.48
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	1.05	NO	NO	149.89	NO	NO	NO	866.50
D. Non-energy products from fuels and solvent use	4.29	NE,NA	NE,NA						4.29
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				43.28	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	331.83	264.15						596.05
A. Enteric fermentation		284.58							284.58
B. Manure management		47.25	49.68						96.93
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NE,NA,NO	214.47						214.47
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	7733.33	2333.56	72.48						10139.38
A. Forest land	-101.06	0.44	3.66						-96.96
B. Cropland	1821.81	89.72	NA,NE,IE						1911.53
C. Grassland	6644.16	495.64	0.26						7140.06
D. Wetlands	-646.60	1747.77	NO,NA,NE						1101.17
E. Settlements	14.91	NE	NE,IE						14.91
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	68.56						68.56
5. Waste	2.74	220.28	6.85						229.87
A. Solid waste disposal	NO,NE,NA	214.00							214.00
B. Biological treatment of solid waste		0.20	0.18						0.38
C. Incineration and open burning of waste	2.74	2.58	0.71						6.03
D. Waste water treatment and discharge		3.50	5.96						9.46
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	620.47	0.59	5.15						626.21
Aviation	403.26	0.07	3.40						406.72
Navigation	217.21	0.52	1.76						219.48
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.40								0.40
CO_2 captured	NA,NO								NA,NO
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									3867.22
Total CO_2 equivalent emissions with land use, land-use change and forestry									14006.60
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2001

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2001
Submission 2017 v5
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)]	10518.14	2898.08	422.23	48.69	108.05	1.31	NO,NA	NO,NA	13996.50
1. Energy	1931.98	6.34	61.48						1999.81
A. Fuel combustion (sectoral approach)	1788.21	4.06	61.48						1853.75
1. Energy industries	10.21	0.00	0.01						10.22
2. Manufacturing industries and construction	286.64	0.19	0.68						287.51
3. Transport	639.70	1.99	29.05						670.73
4. Other sectors	851.66	1.88	31.75						885.29
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	143.77	2.28	NO,NA						146.05
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	143.77	2.28	NA,NO						146.05
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	828.22	1.07	19.79	48.69	108.05	1.31	NO,NA	NO,NA	1007.12
A. Mineral industry	58.69								58.69
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	1.03	NO	NO	108.04	NO	NO	NO	874.44
D. Non-energy products from fuels and solvent use	3.66	NE,NA	NE,NA						3.66
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				48.69	0.01				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	334.85	261.17						596.10
A. Enteric fermentation		286.35							286.35
B. Manure management		48.50	48.66						97.16
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	212.52						212.52
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	7755.28	2328.31	73.01						10156.59
A. Forest land	-106.86	0.45	3.76						-102.64
B. Cropland	1811.76	89.21	NA,NE,IE						1900.96
C. Grassland	6679.19	498.56	0.28						7178.03
D. Wetlands	-643.54	1740.09	NO,NA,NE						1096.55
E. Settlements	14.63	NE	NE,IE						14.63
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	68.97						68.97
5. Waste	2.58	227.51	6.78						236.87
A. Solid waste disposal	NO,NE,NA	221.50							221.50
B. Biological treatment of solid waste		0.20	0.18						0.38
C. Incineration and open burning of waste	2.58	2.31	0.64						5.53
D. Waste water treatment and discharge		3.50	5.96						9.46
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	493.27	0.41	4.11						497.79
Aviation	345.29	0.06	2.91						348.26
Navigation	147.98	0.35	1.20						149.53
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.40								0.40
CO_2 captured	NA,NO								NA,NO
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									3839.90
Total CO_2 equivalent emissions with land use, land-use change and forestry									13996.50
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 2017 v5
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)]	10645.19	2887.94	395.94	45.74	85.51	1.31	NA,NO	NA,NO	14061.63
1. Energy	2006.83	6.53	60.77						2074.14
A. Fuel combustion (sectoral approach)	1859.27	4.23	60.77						1924.27
1. Energy industries	12.18	0.01	0.01						12.20
2. Manufacturing industries and construction	301.69	0.21	0.67						302.57
3. Transport	643.32	2.00	29.29						674.61
4. Other sectors	902.07	2.02	30.79						934.88
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	147.56	2.30	NO,NA						149.86
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	147.56	2.30	NA,NO						149.86
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	845.48	1.15	3.95	45.74	85.51	1.31	NA,NO	NA,NO	983.14
A. Mineral industry	39.34								39.34
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	1.11	NO	NO	85.50	NO	NO	NO	888.44
D. Non-energy products from fuels and solvent use	3.85	NE,NA	NE,NA						3.85
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				45.74	0.01				45.75
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	327.80	250.62						578.50
A. Enteric fermentation		281.05							281.05
B. Manure management		46.75	48.25						95.00
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	202.37						202.37
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	NE								NE
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry[(1)]	7790.40	2320.35	73.86						10184.61
A. Forest land	-115.96	0.49	4.04						-111.43
B. Cropland	1801.68	88.69	NA,NE,IE						1890.37
C. Grassland	6729.32	502.57	0.30						7232.18
D. Wetlands	-639.21	1728.60	NO,NA,NE						1089.39
E. Settlements	14.46	NE	NE,IE						14.46
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	69.52						69.52
5. Waste	2.40	232.10	6.73						241.24
A. Solid waste disposal	NO,NE,NA	223.25							223.25
B. Biological treatment of solid waste		0.20	0.18						0.38
C. Incineration and open burning of waste	2.40	2.15	0.59						5.15
D. Waste water treatment and discharge		6.50	5.96						12.46
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	512.30	0.54	4.25						517.09
Aviation	306.45	0.05	2.58						309.08
Navigation	205.85	0.49	1.67						208.01
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.40								0.40
CO_2 captured	NA,NO								NA,NO
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									3877.02
Total CO_2 equivalent emissions with land use, land-use change and forestry									14061.63
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.

2003

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2003
Submission 2017 v5
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)]	10645.69	2880.31	390.43	56.79	70.47	1.31	NA,NO	NA,NO	14044.99
1. Energy	1995.82	6.23	60.52						2062.57
A. Fuel combustion (sectoral approach)	1859.31	4.21	60.52						1924.04
1. Energy industries	11.44	0.01	0.01						11.46
2. Manufacturing industries and construction	263.38	0.20	0.57						264.14
3. Transport	737.96	2.06	29.84						769.86
4. Other sectors	846.52	1.95	30.10						878.57
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	136.51	2.02	NO,NA						138.53
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	136.51	2.02	NA,NO						138.53
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	846.42	1.12	4.03	56.79	70.47	1.31	NA,NO	NA,NO	980.14
A. Mineral industry	33.00								33.00
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	1.08	NO	NO	70.47	NO	NO	NO	880.89
D. Non-energy products from fuels and solvent use	3.58	NE,NA	NE,NA						3.58
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				56.79	0.00				56.79
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	2.45	323.80	244.65						570.89
A. Enteric fermentation		278.05							278.05
B. Manure management		45.75	48.23						93.98
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	196.42						196.42
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.36								2.36
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry[(1)]	7798.95	2315.48	74.48						10188.91
A. Forest land	-127.04	0.52	4.29						-122.22
B. Cropland	1791.59	88.18	NA,NE,IE						1879.77
C. Grassland	6752.72	505.09	0.32						7258.13
D. Wetlands	-636.60	1721.69	NO,NA,NE						1085.09
E. Settlements	18.17	NE	NE,IE						18.17
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	69.87						69.87
5. Waste	2.05	233.67	6.75						242.47
A. Solid waste disposal	NO,NE,NA	225.00							225.00
B. Biological treatment of solid waste		0.30	0.27						0.57
C. Incineration and open burning of waste	2.05	1.87	0.52						4.45
D. Waste water treatment and discharge		6.50	5.96						12.46
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	472.14	0.40	3.93						476.47
Aviation	329.34	0.06	2.77						332.17
Navigation	142.80	0.34	1.16						144.30
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.59								0.59
CO_2 captured	NA,NO								NA,NO
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									3856.08
Total CO_2 equivalent emissions with land use, land-use change and forestry									14044.99
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2004

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2017 v5
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)]	10720.00	2877.58	389.82	59.52	45.48	1.31	NA,NO	NA,NO	14093.72
1. Energy	2040.10	6.62	64.94						2111.66
A. Fuel combustion (sectoral approach)	1917.20	4.27	64.94						1986.41
1. Energy industries	11.17	0.01	0.01						11.19
2. Manufacturing industries and construction	263.65	0.19	0.64						264.48
3. Transport	789.78	2.16	30.93						822.87
4. Other sectors	852.59	1.91	33.36						887.87
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	122.90	2.35	NO,NA						125.26
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	122.90	2.35	NA,NO						125.26
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	869.93	1.15	3.72	59.52	45.48	1.31	NA,NO	NA,NO	981.11
A. Mineral industry	50.84								50.84
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	1.10	NO	NO	45.47	NO	NO	NO	861.11
D. Non-energy products from fuels and solvent use	4.14	NE,NA	NE,NA						4.14
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				59.52	0.00				59.53
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	2.60	318.78	239.49						560.86
A. Enteric fermentation		274.03							274.03
B. Manure management		44.75	47.65						92.40
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	191.84						191.84
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.52								2.52
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry[(1)]	7802.20	2310.85	74.98						10188.03
A. Forest land	-133.24	0.53	4.41						-128.29
B. Cropland	1781.56	87.67	NA,NE,IE						1869.22
C. Grassland	6772.54	507.71	0.33						7280.59
D. Wetlands	-634.05	1714.94	NO,NA,NE						1080.89
E. Settlements	15.28	NE	NE,IE						15.28
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	70.23						70.23
5. Waste	5.17	240.19	6.70						252.06
A. Solid waste disposal	NO,NE,NA	232.25							232.25
B. Biological treatment of solid waste		0.30	0.27						0.57
C. Incineration and open burning of waste	5.17	1.14	0.47						6.78
D. Waste water treatment and discharge		6.50	5.96						12.46
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	570.73	0.53	4.74						576.00
Aviation	375.83	0.07	3.17						379.06
Navigation	194.90	0.46	1.58						196.94
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.52								0.52
CO_2 captured	NA,NO								NA,NO
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									3905.69
Total CO_2 equivalent emissions with land use, land-use change and forestry									14093.72
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2005

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2005
Submission 2017 v5
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)]	10670.45	2866.38	395.06	69.26	30.76	2.52	NO	NO	14034.43
1. Energy	1990.68	6.36	69.20						2066.24
A. Fuel combustion (sectoral approach)	1872.52	3.76	69.20						1945.48
1. Energy industries	13.89	0.01	0.02						13.91
2. Manufacturing industries and construction	208.07	0.14	0.46						208.67
3. Transport	795.18	1.75	34.58						831.51
4. Other sectors	855.38	1.86	34.14						891.39
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	118.16	2.59	NO,NA						120.76
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	118.16	2.59	NA,NO						120.76
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	852.92	1.30	3.39	69.26	30.76	2.52	NO	NO	960.15
A. Mineral industry	55.01								55.01
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	793.98	1.27	NO	NO	30.76	NO	NO	NO	826.01
D. Non-energy products from fuels and solvent use	3.92	NE,NA	NE,NA						3.92
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				69.26	0.00				69.26
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	3.53	322.08	240.01						565.61
A. Enteric fermentation		275.83							275.83
B. Manure management		46.25	48.20						94.45
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	191.81						191.81
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.46								3.46
H. Urea application	0.07								0.07
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry[(1)]	7818.59	2303.70	75.76						10198.05
A. Forest land	-152.74	0.56	4.67						-147.50
B. Cropland	1771.40	87.15	NA,NE,IE						1858.55
C. Grassland	6810.05	511.33	0.35						7321.73
D. Wetlands	-630.17	1704.66	NO,NA,NE						1074.49
E. Settlements	19.95	NE	NE,IE						19.95
F. Other land	NA,NE	NE	NA,NE						NA,NE
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	70.73						70.73
5. Waste	4.73	232.94	6.71						244.38
A. Solid waste disposal	NO,NE,NA	225.25							225.25
B. Biological treatment of solid waste		0.50	0.45						0.95
C. Incineration and open burning of waste	4.73	0.44	0.30						5.48
D. Waste water treatment and discharge		6.75	5.96						12.71
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	527.40	0.33	4.40						532.13
Aviation	417.02	0.07	3.51						420.60
Navigation	110.38	0.26	0.89						111.53
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.39								0.39
CO_2 captured	NA,NO								NA,NO
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									3836.38
Total CO_2 equivalent emissions with land use, land-use change and forestry									14034.43
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2006

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2006
Submission 2017 v5
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)]	10918.15	2886.93	416.66	69.55	392.79	2.52	NO	NO	14686.60
1. Energy	2059.05	7.49	67.09						2133.63
A. Fuel combustion (sectoral approach)	1922.41	3.89	67.09						1993.39
1. Energy industries	16.09	0.01	0.01						16.10
2. Manufacturing industries and construction	214.03	0.15	0.52						214.70
3. Transport	938.40	2.08	35.35						975.83
4. Other sectors	753.90	1.65	31.21						786.76
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	136.64	3.60	NO,NA						140.24
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	136.64	3.60	NA,NO						140.24
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	961.66	1.18	3.47	69.55	392.79	2.52	NO	NO	1431.16
A. Mineral industry	62.20								62.20
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	895.02	1.15	NO	NO	392.79	NO	NO	NO	1288.96
D. Non-energy products from fuels and solvent use	4.41	NE,NA	NE,NA						4.41
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				69.55	0.00				69.55
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	3.61	328.58	256.83						589.02
A. Enteric fermentation		280.33							280.33
B. Manure management		48.25	47.97						96.22
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	208.86						208.86
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.54								3.54
H. Urea application	0.08								0.08
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry[(1)]	7889.03	2296.95	82.29						10268.28
A. Forest land	-158.86	0.59	4.86						-153.42
B. Cropland	1761.18	86.65	0.02						1847.84
C. Grassland	6881.81	521.32	4.72						7407.85
D. Wetlands	-623.64	1688.38	1.13						1065.87
E. Settlements	28.45	NE	NE,IE						28.45
F. Other land	NA,NE	0.01	0.01						0.01
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	71.56						71.56
5. Waste	4.79	252.73	6.99						264.51
A. Solid waste disposal	NO,NE,NA	244.75							244.75
B. Biological treatment of solid waste		0.80	0.72						1.52
C. Incineration and open burning of waste	4.79	0.43	0.31						5.53
D. Waste water treatment and discharge		6.75	5.96						12.71
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	630.95	0.41	5.26						636.63
Aviation	494.41	0.09	4.16						498.66
Navigation	136.54	0.32	1.10						137.96
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.40								0.40
CO_2 captured	NA,NO								NA,NO
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									4418.32
Total CO_2 equivalent emissions with land use, land-use change and forestry									14686.60
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2007

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2007
Submission 2017 v5
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)]	11253.18	2872.06	424.65	73.33	331.39	2.86	NO	NO	14957.46
1. Energy	2121.34	8.62	67.68						2197.64
A. Fuel combustion (sectoral approach)	1973.97	4.00	67.68						2045.65
1. Energy industries	33.27	0.01	0.02						33.30
2. Manufacturing industries and construction	194.64	0.13	0.54						195.31
3. Transport	974.14	2.16	34.95						1011.25
4. Other sectors	771.92	1.71	32.18						805.80
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	147.37	4.62	NO,NA						151.99
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	147.37	4.62	NA,NO						151.99
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1159.35	1.30	4.29	73.33	331.39	2.86	NO	NO	1572.51
A. Mineral industry	64.36								64.36
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1091.13	1.24	NO	NO	331.38	NO	NO	NO	1423.76
D. Non-energy products from fuels and solvent use	3.80	NE,NA	NE,NA						3.80
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				73.33	0.00				73.33
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	4.93	333.85	267.72						606.50
A. Enteric fermentation		284.35							284.35
B. Manure management		49.50	48.85						98.35
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	218.87						218.87
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	4.80								4.80
H. Urea application	0.13								0.13
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	7959.69	2280.62	77.78						10318.09
A. Forest land	-166.52	0.60	4.97						-160.95
B. Cropland	1750.91	86.12	NA,IE						1837.04
C. Grassland	6958.77	523.42	0.40						7482.59
D. Wetlands	-616.59	1670.47	NO,NA,NE						1053.88
E. Settlements	33.02	NE	NE,IE						33.02
F. Other land	NO,NA,NE	NO	NO,NA						NO,NA,NE
G. Harvested wood products	0.10								0.10
H. Other	IE	IE	72.41						72.41
5. Waste	7.86	247.67	7.19						262.73
A. Solid waste disposal	NO,NE,NA	240.75							240.75
B. Biological treatment of solid waste		1.00	0.89						1.89
C. Incineration and open burning of waste	7.86	0.42	0.34						8.62
D. Waste water treatment and discharge		5.50	5.96						11.46
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	712.06	0.57	5.91						718.55
Aviation	505.92	0.09	4.26						510.27
Navigation	206.14	0.49	1.65						208.28
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.54								0.54
CO_2 captured	NA,NO								NA,NO
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									4639.38
Total CO_2 equivalent emissions with land use, land-use change and forestry									14957.46
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 2017 v5
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)]	11627.84	2856.33	430.03	83.75	411.38	3.01	NO	NO	15412.34
1. Energy	1995.22	8.85	63.45						2067.52
A. Fuel combustion (sectoral approach)	1810.24	3.78	63.45						1877.48
1. Energy industries	15.01	0.00	0.01						15.02
2. Manufacturing industries and construction	160.54	0.10	0.45						161.09
3. Transport	919.83	2.14	33.80						955.77
4. Other sectors	714.87	1.54	29.20						745.60
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	184.97	5.07	NO,NA						190.04
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	184.97	5.07	NA,NO						190.04
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1601.30	1.06	3.78	83.75	411.38	3.01	NO	NO	2104.28
A. Mineral industry	61.84								61.84
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1536.09	1.02	NO	NO	411.38	NO	NO	NO	1948.49
D. Non-energy products from fuels and solvent use	3.36	NE,NA	NE,NA						3.36
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				83.75	0.00				83.75
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	5.67	336.83	276.83						619.33
A. Enteric fermentation		287.08							287.08
B. Manure management		49.75	48.26						98.01
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	228.57						228.57
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	5.52								5.52
H. Urea application	0.15								0.15
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry[(1)]	8019.52	2269.88	78.75						10368.15
A. Forest land	-170.74	0.61	5.07						-165.05
B. Cropland	1740.59	85.61	NA,IE						1826.20
C. Grassland	7028.17	529.08	0.48						7557.72
D. Wetlands	-610.59	1654.57	0.02						1044.01
E. Settlements	31.97	NE	NE,IE						31.97
F. Other land	NA,NE	0.00	0.00						0.00
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	73.18						73.18
5. Waste	6.13	239.71	7.21						253.05
A. Solid waste disposal	NO,NE,NA	233.00							233.00
B. Biological treatment of solid waste		1.06	0.95						2.01
C. Incineration and open burning of waste	6.13	0.40	0.30						6.83
D. Waste water treatment and discharge		5.25	5.96						11.21
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO

Memo items:[(2)]									
International bunkers	651.24	0.61	5.38						657.22
Aviation	423.13	0.07	3.56						426.76
Navigation	228.11	0.53	1.82						230.46
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.28								0.28
CO_2 captured	NA,NO								NA,NO
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									5044.18
Total CO_2 equivalent emissions with land use, land-use change and forestry									15412.34
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 2017 v5
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)	11606.88	2846.61	405.40	113.06	180.05	3.02	NO	NO	15155.03
1. Energy	1943.04	9.61	56.43						2009.09
A. Fuel combustion (sectoral approach)	1774.59	3.81	56.43						1834.84
1. Energy industries	12.62	0.00	0.01						12.63
2. Manufacturing industries and construction	120.13	0.09	0.30						120.52
3. Transport	893.25	2.07	33.67						928.99
4. Other sectors	748.59	1.65	22.46						772.70
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	168.45	5.80	NO,NA						174.25
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	168.45	5.80	NA,NO						174.25
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1612.97	1.09	3.28	113.06	180.05	3.02	NO	NO	1913.47
A. Mineral industry	28.70								28.70
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1582.10	1.05	NO	NO	180.05	NO	NO	NO	1763.20
D. Non-energy products from fuels and solvent use	2.14	NE,NA	NE,NA						2.14
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				113.06	0.00				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	4.17	341.60	258.89						604.66
A. Enteric fermentation		291.35							291.35
B. Manure management		50.25	49.39						99.65
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	209.49						209.49
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	4.02								4.02
H. Urea application	0.16								0.16
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry(1)	8040.64	2261.16	79.44						10381.24
A. Forest land	-184.84	0.63	5.20						-179.01
B. Cropland	1730.21	85.09	NA,IE						1815.31
C. Grassland	7084.72	533.62	0.43						7618.77
D. Wetlands	-605.61	1641.82	NO,NA,NE						1036.21
E. Settlements	16.05	NE	NE,IE						16.05
F. Other land	NA,NE	0.00	0.00						0.00
G. Harvested wood products	0.11								0.11
H. Other	IE	IE	73.82						73.82
5. Waste	6.06	233.14	7.36						246.56
A. Solid waste disposal	NO,NE,NA	226.25							226.25
B. Biological treatment of solid waste		1.27	1.14						2.41
C. Incineration and open burning of waste	6.06	0.37	0.26						6.69
D. Waste water treatment and discharge		5.25	5.96						11.21
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	494.79	0.44	4.09						499.32
Aviation	330.21	0.06	2.78						333.05
Navigation	164.58	0.38	1.31						166.28
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.21								0.21
CO_2 captured	NA,NO								NA,NO
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									4773.78
Total CO_2 equivalent emissions with land use, land-use change and forestry									15155.03
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2010

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2010
Submission 2017 v5
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)]	11425.76	2845.09	393.86	145.78	171.67	4.66	NO	NO	14986.81
1. Energy	1800.71	8.55	51.09						1860.35
A. Fuel combustion (sectoral approach)	1611.11	3.56	51.09						1665.76
1. Energy industries	11.73	0.00	0.00						11.74
2. Manufacturing industries and construction	99.49	0.08	0.22						99.79
3. Transport	849.84	2.02	32.20						884.06
4. Other sectors	650.05	1.46	18.66						670.17
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	189.60	4.99	NO,NA						194.59
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	189.60	4.99	NA,NO						194.59
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1620.32	1.06	3.57	145.78	171.67	4.66	NO	NO	1947.05
A. Mineral industry	10.42								10.42
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1607.25	1.02	NO	NO	171.66	NO	NO	NO	1779.93
D. Non-energy products from fuels and solvent use	2.63	NE,NA	NE,NA						2.63
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				145.78	0.01				145.78
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	2.41	342.60	251.92						596.92
A. Enteric fermentation		293.10							293.10
B. Manure management		49.50	49.58						99.08
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	202.34						202.34
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.28								2.28
H. Urea application	0.13								0.13
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	7996.40	2260.01	79.71						10336.12
A. Forest land	-207.96	0.65	5.31						-202.00
B. Cropland	1719.81	84.58	NA,IE						1804.39
C. Grassland	7083.94	534.56	0.45						7618.95
D. Wetlands	-605.01	1640.22	0.00						1035.21
E. Settlements	5.50	NE	NE,IE						5.50
F. Other land	NO,NA,NE	NO	NO,NA						NO,NA,NE
G. Harvested wood products	0.12								0.12
H. Other	IE	IE	73.95						73.95
5. Waste	5.91	232.87	7.57						246.36
A. Solid waste disposal	NO,NE,NA	225.75							225.75
B. Biological treatment of solid waste		1.52	1.36						2.89
C. Incineration and open burning of waste	5.91	0.35	0.25						6.51
D. Waste water treatment and discharge		5.25	5.96						11.21
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	555.19	0.49	4.59						560.27
Aviation	373.12	0.07	3.14						376.33
Navigation	182.07	0.43	1.45						183.95
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.22								0.22
CO_2 captured	NA,NO								NA,NO
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									4650.69
Total CO_2 equivalent emissions with land use, land-use change and forestry									14986.81
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(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 2017 v5
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]	11314.17	2823.10	370.94	144.50	74.52	3.05	NO	NO	14730.27
1. Energy	1705.87	7.35	47.00						1760.21
A. Fuel combustion (sectoral approach)	1527.08	3.34	47.00						1577.42
1. Energy industries	10.61	0.00	0.00						10.62
2. Manufacturing industries and construction	96.38	0.07	0.24						96.69
3. Transport	815.23	1.92	30.85						848.01
4. Other sectors	604.86	1.34	15.90						622.11
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	178.78	4.01	NO,NA						182.79
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	178.78	4.01	NA,NO						182.79
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1614.77	1.03	3.68	144.50	74.52	3.05	NO	NO	1841.54
A. Mineral industry	20.16								20.16
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1591.77	0.99	NO	NO	74.52	NO	NO	NO	1667.28
D. Non-energy products from fuels and solvent use	2.82	NE,NA,NO	NE,NA,NO						2.82
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				144.50	0.00				144.50
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	2.37	342.35	232.68						577.40
A. Enteric fermentation		292.35							292.35
B. Manure management		50.00	50.22						100.22
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	182.45						182.45
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.22								2.22
H. Urea application	0.15								0.15
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry[1]	7984.60	2255.60	80.09						10320.30
A. Forest land	-235.45	0.64	5.34						-229.46
B. Cropland	1709.40	84.06	NA,IE						1793.46
C. Grassland	7108.36	537.19	0.44						7645.99
D. Wetlands	-602.53	1633.71	NO,NA,NE						1031.18
E. Settlements	4.68	NE	NE,IE						4.68
F. Other land	NO,NA,NE	NO	NO,NA						NO,NA,NE
G. Harvested wood products	0.13								0.13
H. Other	IE	IE	74.31						74.31
5. Waste	6.55	216.76	7.49						230.81
A. Solid waste disposal	NO,NE,NA	209.75							209.75
B. Biological treatment of solid waste		1.43	1.28						2.70
C. Incineration and open burning of waste	6.55	0.34	0.26						7.15
D. Waste water treatment and discharge		5.25	5.96						11.21
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	615.73	0.54	5.09						621.36
Aviation	417.30	0.07	3.51						420.88
Navigation	198.43	0.46	1.58						200.47
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.15								0.15
CO_2 captured	NA,NO								NA,NO
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									4409.97
Total CO_2 equivalent emissions with land use, land-use change and forestry									14730.27
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2012

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2012
Submission 2017 v5
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)]	11323.01	2795.20	394.66	171.73	94.00	5.32	NO	NO	14783.93
1. Energy	1654.76	6.49	45.83						1707.08
A. Fuel combustion (sectoral approach)	1484.58	3.23	45.83						1533.64
1. Energy industries	10.47	0.00	0.01						10.47
2. Manufacturing industries and construction	82.64	0.06	0.15						82.85
3. Transport	806.60	1.86	29.51						837.98
4. Other sectors	584.87	1.30	16.17						602.34
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	170.18	3.26	NO,NA						173.44
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	170.18	3.26	NA,NO						173.44
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1657.57	1.30	3.58	171.73	94.00	5.32	NO	NO	1933.50
A. Mineral industry	0.53								0.53
B. Chemical industry	NO,IE	NO,IE	NO	NO	NO	NO	NO	NO	NO,IE
C. Metal industry	1654.33	1.26	NO	NO	94.00	NO	NO	NO	1749.59
D. Non-energy products from fuels and solvent use	2.68	NE,NA,NO	NE,NA,NO						2.68
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				171.73	0.00				171.73
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	4.20	339.13	257.46						600.78
A. Enteric fermentation		290.13							290.13
B. Manure management		49.00	49.78						98.78
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	207.68						207.68
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	4.03								4.03
H. Urea application	0.17								0.17
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry [(1)]	8000.14	2250.09	80.60						10330.83
A. Forest land	-246.21	0.66	5.42						-240.13
B. Cropland	1698.99	83.55	NA,IE						1782.53
C. Grassland	7142.00	540.22	0.46						7682.67
D. Wetlands	-599.49	1625.67	NO,NA,NE						1026.18
E. Settlements	4.70	NE	NE,IE						4.70
F. Other land	NA,NE	0.00	0.00						0.00
G. Harvested wood products	0.15								0.15
H. Other	IE	IE	74.73						74.73
5. Waste	6.35	198.20	7.19						211.73
A. Solid waste disposal	NO,NE,NA	191.50							191.50
B. Biological treatment of solid waste		1.12	1.00						2.12
C. Incineration and open burning of waste	6.35	0.33	0.23						6.90
D. Waste water treatment and discharge		5.25	5.96						11.21
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	619.05	0.50	5.13						624.69
Aviation	437.30	0.08	3.68						441.06
Navigation	181.75	0.43	1.45						183.62
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.11								0.11
CO_2 captured	NA,NO								NA,NO
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									4453.09
Total CO_2 equivalent emissions with land use, land-use change and forestry									14783.93
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 2017 v5
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]	11340.48	2792.38	389.39	179.91	88.16	3.20	NO	NO	14793.52
1. Energy	1641.72	7.17	43.78						1692.68
A. Fuel combustion (sectoral approach)	1469.26	3.16	43.78						1516.20
1. Energy industries	3.63	0.00	0.01						3.64
2. Manufacturing industries and construction	72.56	0.06	0.13						72.76
3. Transport	822.20	1.85	29.10						853.16
4. Other sectors	570.87	1.24	14.54						586.65
5. Other	NO,NA	NO,NA	NO,NA						NO,NA
B. Fugitive emissions from fuels	172.46	4.01	NO,NA						176.48
1. Solid fuels	NO,NA	NO,NA	NO,NA						NO,NA
2. Oil and natural gas	172.46	4.01	NA,NO						176.48
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1683.60	1.37	3.13	179.91	88.16	3.20	NO	NO	1959.36
A. Mineral industry	0.58								0.58
B. Chemical industry	NO,IE	NO,IE	NO	NO	NO	NO	NO	NO	NO,IE
C. Metal industry	1680.35	1.32	NO	NO	88.16	NO	NO	NO	1769.83
D. Non-energy products from fuels and solvent use	2.65	NE,NA,NO	NE,NA,NO						2.65
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				179.91	0.00				179.91
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	3.82	330.15	253.87						587.85
A. Enteric fermentation		283.65							283.65
B. Manure management		46.50	49.75						96.25
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	204.13						204.13
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.61								3.61
H. Urea application	0.21								0.21
I. Other carbon-containing fertilizers	NE								NE
J. Other		NA	NA						NA
4. Land use, land-use change and forestry[1]	8005.94	2245.10	81.06						10332.10
A. Forest land	-265.51	0.66	5.45						-259.40
B. Cropland	1688.57	83.03	NA,IE						1771.60
C. Grassland	7174.76	543.16	0.48						7718.40
D. Wetlands	-596.69	1618.25	NO,NA,NE						1021.56
E. Settlements	4.64	NE	NE,IE						4.64
F. Other land	NA,NE	NA	NA						NA,NE
G. Harvested wood products	0.17								0.17
H. Other	IE	IE	75.13						75.13
5. Waste	5.39	208.58	7.54						221.52
A. Solid waste disposal	NO,NE,NA	201.50							201.50
B. Biological treatment of solid waste		1.50	1.34						2.83
C. Incineration and open burning of waste	5.39	0.33	0.25						5.97
D. Waste water treatment and discharge		5.25	5.96						11.21
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	702.66	0.58	5.82						709.06
Aviation	493.58	0.09	4.16						497.83
Navigation	209.08	0.49	1.66						211.23
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NA								NO,NA
CO_2 captured	NA,NO								NA,NO
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									4461.41
Total CO_2 equivalent emissions with land use, land-use change and forestry									14793.52
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 2017 v5
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)]	11288.53	2790.00	415.95	181.70	99.03	2.22	NO	NO	14777.43
1. Energy	1626.85	7.62	47.98						1682.45
A. Fuel combustion (sectoral approach)	1444.79	3.09	47.98						1495.86
1. Energy industries	2.52	0.00	0.01						2.53
2. Manufacturing industries and construction	33.73	0.03	0.06						33.82
3. Transport	824.70	1.84	28.68						855.22
4. Other sectors	583.84	1.22	19.23						604.29
5. Other									
B. Fugitive emissions from fuels	182.06	4.53	NA,NO						186.59
1. Solid fuels	NA,NO	NA,NO	NA,NO						NA,NO
2. Oil and natural gas	182.06	4.53	NA,NO						186.59
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1651.94	1.26	2.88	181.70	99.03	2.22	NO	NO	1939.02
A. Mineral industry	0.57								0.57
B. Chemical industry	NO,IE	NO,IE	NO	NO	NO	NO	NO	NO	NO,IE
C. Metal industry	1648.76	1.23	NO	NO	99.03	NO	NO	NO	1749.01
D. Non-energy products from fuels and solvent use	2.58	NE,NA,NO	NE,NA,NO						2.58
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				181.70	0.01				181.71
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	3.96	346.65	275.63						626.24
A. Enteric fermentation		296.90							296.90
B. Manure management		49.75	50.51						100.26
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	225.12						225.12
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.61								3.61
H. Urea application	0.35								0.35
I. Other carbon-containing fertilizers	NE								NE
J. Other		NO							NO
4. Land use, land-use change and forestry[(1)]	7999.55	2241.35	81.43						10322.33
A. Forest land	-289.98	0.67	5.47						-283.85
B. Cropland	1678.14	82.51	NA,IE						1760.66
C. Grassland	7200.71	545.61	0.49						7746.80
D. Wetlands	-594.21	1612.56	0.01						1018.36
E. Settlements	4.70	NE	NE,IE						4.70
F. Other land	NA,NE	NA	NA						NA,NE
G. Harvested wood products	0.19								0.19
H. Other	IE	IE	75.47						75.47
5. Waste	6.24	193.11	8.03						207.38
A. Solid waste disposal	NO,NE,NA	185.50							185.50
B. Biological treatment of solid waste		2.01	1.80						3.81
C. Incineration and open burning of waste	6.24	0.34	0.27						6.85
D. Waste water treatment and discharge		5.25	5.96						11.21
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	782.74	0.63	6.48						789.85
Aviation	553.99	0.10	4.66						558.75
Navigation	228.75	0.53	1.82						231.10
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NA,NO								NA,NO
CO_2 captured	NA,NO								NA,NO
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									4455.09
Total CO_2 equivalent emissions with land use, land-use change and forestry									14777.43
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2015

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2015
Submission 2017 v5
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)]	11314.16	2791.18	395.73	206.98	103.70	1.53	NO	NO	14813.28
1. Energy	1643.37	7.74	44.12						1695.23
A. Fuel combustion (sectoral approach)	1482.89	3.13	44.12						1530.14
1. Energy industries	3.63	0.00	0.01						3.64
2. Manufacturing industries and construction	68.21	0.06	0.14						68.41
3. Transport	855.85	1.86	28.69						886.41
4. Other sectors	555.20	1.20	15.28						571.69
5. Other									
B. Fugitive emissions from fuels	160.48	4.61	NA,NO						165.09
1. Solid fuels	NO	NO	NA,NO						NA,NO
2. Oil and natural gas	160.48	4.61	NA,NO						165.09
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1704.47	1.37	2.92	206.98	103.70	1.53	NO	NO	2020.97
A. Mineral industry	0.75								0.75
B. Chemical industry	NO,IE	NO,IE	NO	NO	NO	NO	NO	NO	NO,IE
C. Metal industry	1700.82	1.34	NO	NO	103.69	NO	NO	NO	1805.84
D. Non-energy products from fuels and solvent use	2.88	NE,NA,NO	NE,NA,NO						2.88
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				206.98	0.02				206.99
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	4.19	352.93	258.65						615.77
A. Enteric fermentation		300.93							300.93
B. Manure management		52.00	50.61						102.61
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	208.04						208.04
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.61								3.61
H. Urea application	0.58								0.58
I. Other carbon-containing fertilizers	NE								NE
J. Other		NO							NO
4. Land use, land-use change and forestry[(1)]	7953.51	2238.92	81.88						10274.30
A. Forest land	-339.78	0.67	5.50						-333.62
B. Cropland	1667.71	82.00	NA,IE						1749.71
C. Grassland	7213.31	547.49	0.62						7761.41
D. Wetlands	-592.77	1608.76	0.04						1016.04
E. Settlements	4.82	NE	NE,IE						4.82
F. Other land	NE,NA	0.00	0.00						0.00
G. Harvested wood products	0.22								0.22
H. Other	IE	IE	75.71						75.71
5. Waste	8.62	190.22	8.16						207.00
A. Solid waste disposal	NO,NE,NA	182.25							182.25
B. Biological treatment of solid waste		2.13	1.90						4.03
C. Incineration and open burning of waste	8.62	0.34	0.30						9.26
D. Waste water treatment and discharge		5.50	5.96						11.46
E. Other									
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO

Memo items:[(2)]									
International bunkers	974.34	0.84	8.07						983.25
Aviation	667.26	0.12	5.62						672.99
Navigation	307.08	0.72	2.46						310.26
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NA,NO								NA,NO
CO_2 captured	NA,NO								NA,NO
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									4538.98
Total CO_2 equivalent emissions with land use, land-use change and forestry									14813.28
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.

Annex V. Values used in Calculation of Digestible Energy of Cattle and Sheep Feed

a) Mature Dairy Cattle

1. Dairy cattle, stallfed, lactation period[5,6]	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

[5] Jóhannes Sveinbjörnsson og Grétar H. Harðarson, 2008. Þungi og átgeta íslenskra mjólkurkúa. Fræðaþing landbúnaðarins: 336-344

[6] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

b) Cows Used for Producing Meat

1. Cows used for prod. meat, stallfed[7]	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

c) Heifers

1. Heifers, stallfed[3,8]	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

[7] Jóhannes Sveinbjörnsson og Bragi L. Ólafsson, 1999. Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi. Ráðunautafundur 1999: 204-217.

[8] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

d) Steers

1. Steers[9,10]	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

e) Calves

1. Calves, first 90 days[11]	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

[9] Jóhannes Sveinbjörnsson og Bragi L. Ólafsson, 1999. Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi. Ráðunautafundur 1999: 204-217.

[10] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

[11] 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

f) Sheep

1. Sheep, stallfed[12]	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[13]	**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[14]	**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

g) Lambs

1. Lambs, pre-weaning[15,16]	amount/day (kg dm)	dry matter digestibility (%)	ash (%)

[12] Jóhannes Sveinbjörnsson, 2013: Fóðrun og fóðurþarfir sauðfjár. Kafli 4 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.
[13] Jóhannes Sveinbjörnsson, 2013: Fóðuröflun og beit á ræktað land. Kafli 5 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.
[14] Ólafur Guðmundsson, 1987: Átgeta búfjár og nýting beitar. Ráðunautafundur 1987: 181-192
[15] Ólafur Guðmundsson, 1987: Átgeta búfjár og nýting beitar. Ráðunautafundur 1987: 181-192
[16] 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)

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[17,12]	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

h) Conversion of DMD into DE

	dry matter digestibility	organic matter digestibility	metabolisable energy	metabolizality	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

[17] Jóhannes Sveinbjörnsson, 2013: Fóðuröflun og beit á ræktað land. Kafli 5 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.

Annex VI. EU ETS in Iceland and comparison to the national inventory

Installations subject to the EU ETS in 2015	Number of operators
Aluminium production	3
Ferroalloys production	1
Fishmeal production	1
Data center	1
Total	**6**

	Greenhouse gas inventory emissions [kt CO_2eq]	Verified emissions under Directive 2003/87/EC [kt. CO_2eq]	Ratio %
Greenhouse gas 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)	4,538.38	1,812.05	39.93%
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)	3,359.96	1,708.36	50.84%

Category	CO_2 emissions		
	Greenhouse gas inventory emissions [kt]	Verified emissions under Directive 2003/87/EC [kt]	Ratio %
1 Fuel combustion activates, total	1482.8	7.9	0.5%
1A Fuel combustion activities, stationary combustion	81.0	7.9	9.7%
1A1 Energy Industries	3.6	NO	NA
1A2 Manufacturing industries and construction	68.2	7.9	12%
1A3 Transport	855.8	NO	NA
1A4 Other sectors	548.1	NO	NA
1B Fugitive emissions from fuels	160.5	NO	NA
2 Industrial Processes, total	1,700.5	1,700.5	100%
2C2 Ferroalloys production	400.9	400.92	100%
2C3 Aluminium production	1,299.6	1,299.60	100%
Total CO_2 emissions (kt.)	**3,183.3**	**1,708.4**	**53.7%**

Category	PFC emissions		
	Greenhouse gas inventory emissions [kt]	Verified emissions under Directive 2003/87/EC [kt]	Ratio %
2C3 Aluminium production	103,69	103.69	100%

Annex VII. CSEUR Database Structure