Emissions of greenhouse gases in Iceland from 1990 to 2012

National Inventory Report 2014

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

ENVIRONMENT AGENCY OF ICELAND

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PREFACE

The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol to the Convention requires the parties to develop and to submit annually to the UNFCCC national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol.

To comply with this requirement, Iceland has prepared a National Inventory Report (NIR) for the year 2014. The NIR together with the associated Common Reporting Format tables (CRF) and the Standard Electronic format (SEF), which is reported for the first time, is Iceland's contribution to this round of reporting under the Convention and the Kyoto Protocol, and covers emissions and removals in the period 1990 – 2012.

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).

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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

Gigagrams (Gg) are repeatedly used in the inventory and are equal to 10^9 grams or 1,000 tonnes.

Global warming potentials (GWP) of greenhouse gases.

Greenhouse gas	Chemical formula	1995 IPCC GWP
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Sulphur hexafluoride	SF_6	23,900
Perfluorocarbons (PFCs)		
Tetrafluoromethane	CF_4	6,500
Hexafluoroethane	C_2F_6	9,200
Octafluoropropane	C_3F_8	7,000
Hydrofluorocarbons		
HFC-23	CHF_3	11,700
HFC-32	CH_2F_2	650
HFC-125	C_2HF_5	2,800
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1,300
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3,800
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140
HFC-227ea	C_3HF_7	2,900

Source: FCCC/CP/2002/8, p.15

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
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
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

EXECUTIVE SUMMARY

Background

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol requires that the Parties report annually on their greenhouse gas 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, 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 during the first commitment period. Iceland's obligations according to the Kyoto Protocol are as follows:

- For the first commitment period, from 2008 to 2012, the greenhouse gas emissions shall not increase more than 10% from the level of emissions in 1990. Iceland AAU's for the first commitment period amount to 18,523,847 tonnes of CO_2-equivalents.
- Decision 14/CP.7 on the "Impact of single projects 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.

Trends in Emissions and Removals

In 1990, the total emissions of greenhouse gases (excluding LULUCF) in Iceland were 3,538 Gg of CO_2-equivalents. In 2012, total emissions were 4,468 Gg CO_2-equivalents. This is an increase of 26% over the time period.

A summary of the Icelandic national emissions for 1990, 2008, 2009, 2010, 2011 and 2012 is presented in Table ES 1 (without LULUCF).

Table ES 1. Emissions of greenhouse gases during 1990, 2008, 2009, 2010, 2011, and 2012 in Gg CO_2-equivalents (excluding LULUCF).

	1990	2008	2009	2010	2011	2012	Changes ´90-´12	Changes ´11-´12
CO_2	2,160	3,605	3,572	3,432	3,333	3,324	53.87%	-0.27%
CH_4	437	490	488	488	473	457	4.64%	-3.35%
N_2O	521	504	469	453	448	458	-12.08%	2.18%
PFCs	420	349	153	146	63	80	-81.00%	26.14%
HFCs	NO	71	95	123	121	144	NA	18.76%
SF_6	1	3	3	5	3	6	384.33%	74.38%
Total emissions	3,538	5,022	4,779	4,646	4,441	4,468	26.28%	0.60%
CO_2 emissions fulfilling 14/CP.7*		1,161	1,205	1,225	1,209	1,279		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		3,861	3,574	3,421	3,232	3,189		

**Decision 14/CP.7 allows Iceland to exclude certain industrial process carbon dioxide emissions from national totals.*

The largest contributor of greenhouse gas emissions in Iceland in 2012 were Industrial Processes, followed by the Energy sector, then Agriculture, Waste, and Solvent and other Product Use (Table ES 2). From 1990 to 2012, the contribution of Industrial Processes increased from 25% to 42%, emissions from the Energy sector decreased from 50% to 38% during the same period.

Table ES 2. Total emissions of greenhouse gases by source 1990, 2008, 2009, 2010, 2011, and 2012 in Gg CO_2-eqivalents.

	1990	2008	2009	2010	2011	2012	Changes ´90-´12	Changes ´11-´12
Energy	1,779	2,075	2,021	1,869	1,770	1,718	-3.44%	-2.95%
Industrial Processes	869	2,020	1,861	1,890	1,798	1,883	116.70%	4.71%
Emissions fulfilling 14/CP.7		1,161	1,205	1,225	1,209	1,279		
Solvent and Other Product Use	9	7	6	6	6	6	-31.95%	-2.08%
Agriculture	737	704	680	671	669	678	-7.95%	1.42%
LULUCF	1,175	859	834	791	746	706	-39.91%	-5.30%
Waste	145	216	211	210	198	183	26.27%	-7.72%
Total emissions w/o LULUCF	3,538	5,022	4,779	4,646	4,441	4,468	26.28%	0.60%
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		3,861	3,574	3,421	3,232	3,189		
Removals from KP 3.3 and 3.4		256	275	307	338	366		

**Decision 14/CP.7 allows Iceland to exclude certain industrial process carbon dioxide emissions from national totals.*

The distribution of total greenhouse gas emissions over the UNFCCC sectors (dissecting the energy sector into fuel combustion and geothermal energy and excluding LULUCF) in 2012 is shown in Figure ES 1. Emissions from the Energy sector account for 38.4% (fuel combustion 34.6% and geothermal energy 3.9%) of the national total emissions, industrial processes account for 42.2% and agriculture for 15.2%. The Waste sector accounts for 4.1%, and Solvent and other Product Use for 0.1%.

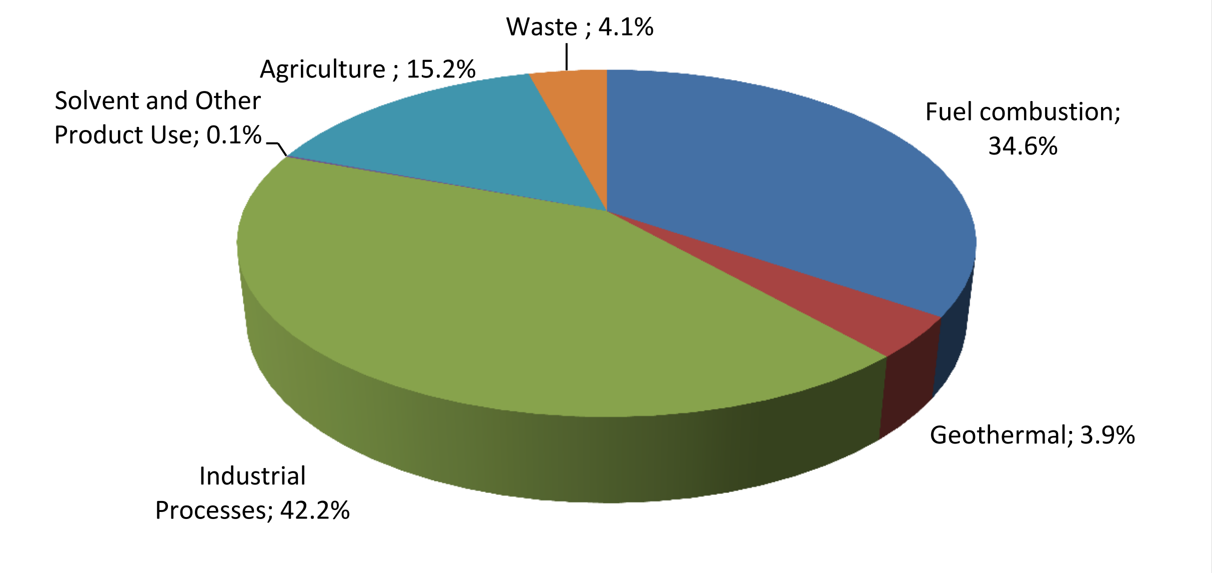

Figure ES 1. Emissions of greenhouse gases by UNFCCC sector in 2012.

Kyoto Accounting

Iceland's initial AAUs for the first commitment period amount 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 resulting in an available assigned amount of 20,065,807 AAUs.

Emissions from Annex A sources during CP1 were 23,356,066 tonnes CO_2-eq. This means that Annex A emissions were 3,290,264 tonnes CO_2 in excess of Iceland´s available assigned amount.

Total CO_2 emissions falling under Decision 14CP.7 during CP1 were 6,079,323 tonnes CO_2. Therefore, in order to comply with its goal for CP1, would Iceland report 3,290,264 tonnes of the CO_2 emissions falling under decision 14/CP.7 separately and not include them in national totals. Table ES.3 and Figure ES.2 demonstrate this.

The CRF tables accompanying the 2014 NIR, however, stll contain Iceland´s Annex A emissions in their entirety.

Table ES. 3. 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
KP-LULUCF Art. 3.3	RMUs	103,268	115,465	135,426	153,265	172,805	680,229
KP-LULUCF Art. 3.4	RMUs	152,293	159,608	171,719	184,453	193,658	861,730
Available assigned amount	AAUs	3,960,330	3,979,843	4,011,914	4,042,487	4,071,233	20,065,807
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.	1,061,456	799,424	634,247	398,639	396,497	3,290,264
Emissions falling under Decision 14/CP.7	t CO_2 eq.	1,160,862	1,205,354	1,225,141	1,209,095	1,278,871	6,079,323
Emissions falling under Decision 14/CP.7 reported under national totals	t CO_2 eq.	99,406	405,930	590,894	810,456	882,373	2,789,059
Emissions falling under Decision 14/CP.7 not reported under national totals	t CO_2 eq.	1,061,456	799,424	634,247	398,639	396,497	3,290,264

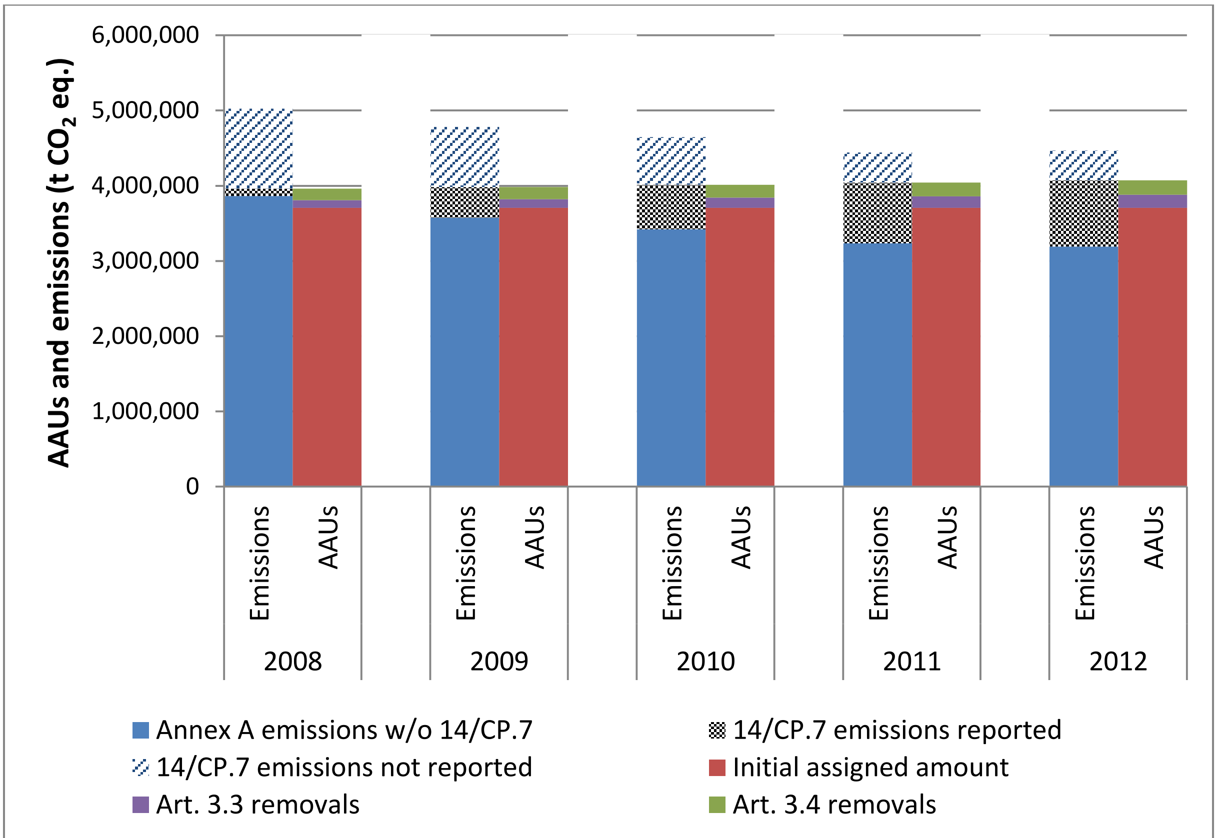

Figure ES 2. Summary of Kyoto accounting for CP1.

As part of its submission to UNFCCC Iceland submits SEF tables for the Kyoto Protocol units issued in 2013. 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.

1 INTRODUCTION

1.1 Background Information

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) was ratified by Iceland in 1993 and entered into force in 1994. One of the requirements under the Convention is that Parties are to report their national anthropogenic emissions by sources and removals by sinks of all greenhouse gases (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 in the first commitment period. Iceland's obligations according to the Kyoto Protocol are as follows:

- For the first commitment period, from 2008 to 2012, the greenhouse gas emissions shall not increase 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 amount 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" 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.

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 the 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 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 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 will undertake the accounting with respect to the Decision at the end of the commitment period. The projects, from which emissions fulfil the provisions of Decision 14/CP.7, are described in Chapter 4.5 and Fact sheets for the project can be found in Annex IV.

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 1990-2012. 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 2013. 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.

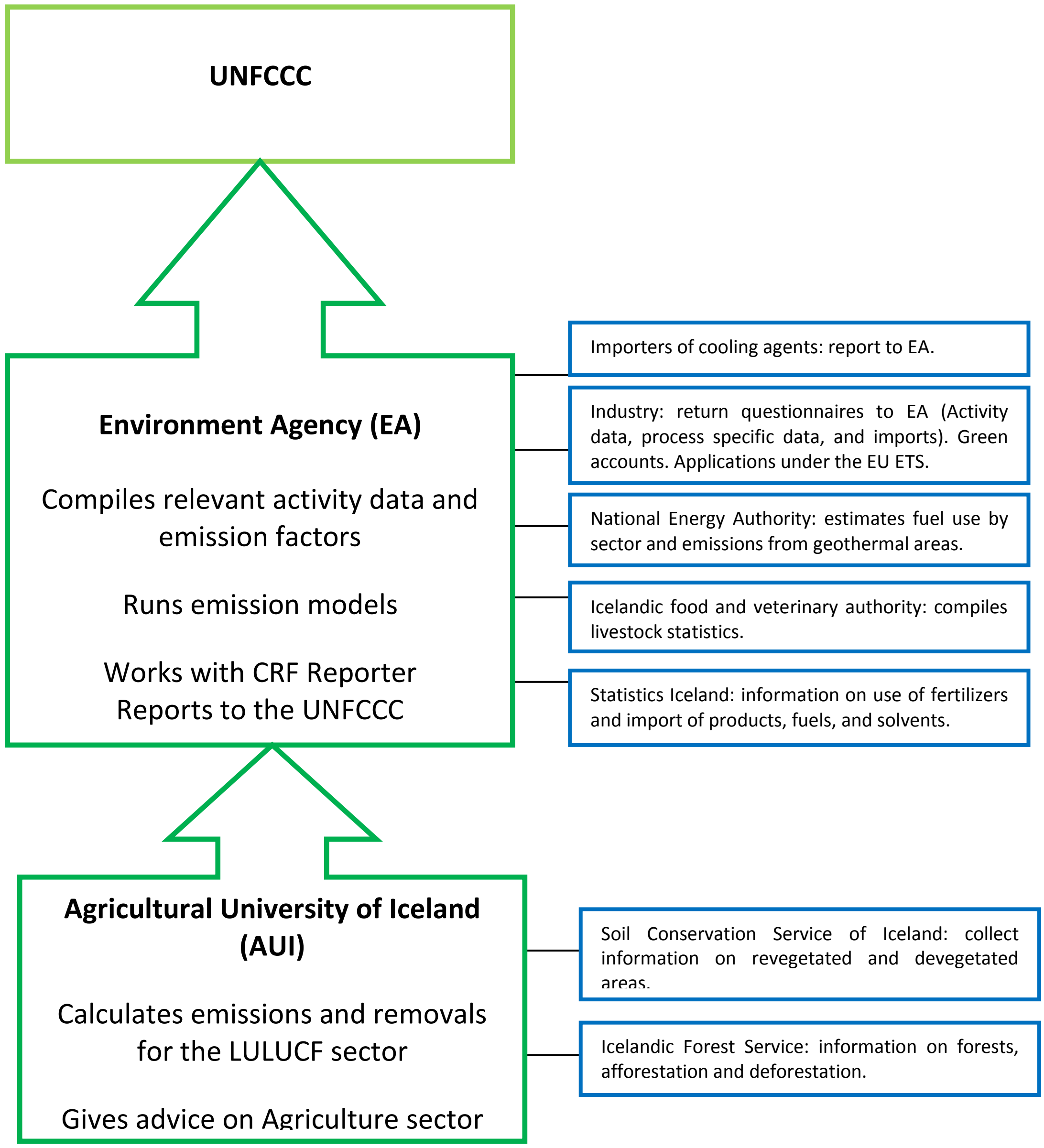

Figure 1.1. Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the UNFCCC.

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 *Act No. 70 from 2012*

In June 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 regarding climate change.

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 is based on these agreements. Articles 7 to 15 of Act 65/2007 regarding the allocation of allowances in the period 2008 to 2012 still stands. Regulation 244/2009, put forward on basis of Act 65/2007 further elaborates on the reporting of information from the industrial plants falling under that part of Act 65/2007. Based on Act 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 (see Chapter 4.5).

Act 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.

Paragraph 6 of Act 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 70/2012 changes the form of relations between the EA and other bodies concerning data handling. The law 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 (SCSI)
- Iceland 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 said data had been drafted by the EA and sent to the Ministry for Environment and Natural Resources. From next year 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 law will facilitate the responsibilities, the data collection process and the timeliness.

As the prospective regulation on data collection, 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 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 Green Accounts

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.

1.3 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.

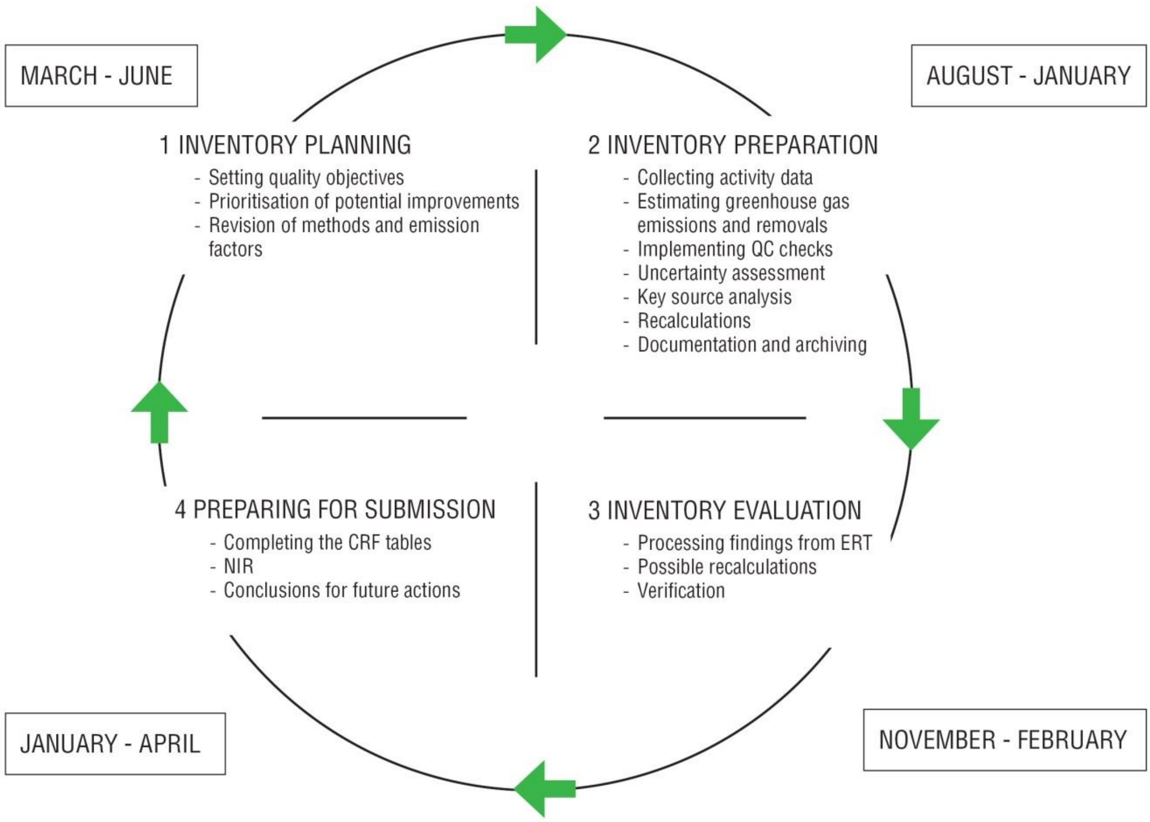

Figure 1.2. The annual inventory cycle.

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 and 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 7.

1.5 Archiving

GoPro, a document management system running on a Lotus Domino server, is used to store email communications concerning the GHG inventory. Paper documents, e.g. written letters, are scanned and also stored in GoPro. Numerical data, calculations and other related documents are stored on a Windows 2003 file server. Both the Lotus Domino server and the Windows 2003 server are running as Vmware virtual machines on Dell Blade Servers. These servers are hosted by an external IT company called Advania and their server room is located elsewhere in Reykjavik. Daily backups are taken of all the servers and separate copies of the backups are stored off-site in a neighbouring town called Hafnarfjordur. 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 Forestry Service and Soil Conservation Service of Iceland, respectively.

1.6 Key source Categories

According to IPCC definition, a key source 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 source categories are identified by means of the Tier 1 method.

The results of the key source analysis prepared for the 2014 submission are shown in Table 1.1. Tables showing the key source analysis (trend and level assessment) can be found in Annex I. The key source analysis includes LULUCF greenhouse gas sources and sinks.

Table 1.1. Key source categories of Iceland´s 2013 GHG inventory. ✓= Key source category (✓) = Only key source category when LULUCF is excluded.

IPCC source category			Level 1990	Level 2012	Trend
1. Energy					
1.AA.1	Public electricity and heat production	CH_4			
1.AA.1	Public electricity and heat production	CO_2			
1.AA.1	Public electricity and heat production	N_2O			
1.AA.2	Manufacturing industry and construction	CH_4			
1.AA.2	Manufacturing industry and construction	CO_2	✓	✓	✓
1.AA.2	Manufacturing industry and construction	N_2O			
1.AA.3a/d	Transport	CH_4			
1.AA.3a/d	Transport	CO_2	✓		✓
1.AA.3a/d	Transport	N_2O			
1.AA.3b	Road transport	CH_4			
1.AA.3b	Road transport	CO_2	✓	✓	✓
1.AA.3b	Road transport	N_2O			✓
1.AA.4a/b	Residential/institutional/commercial	CH_4			
1.AA.4a/b	Residential/institutional/commercial	CO_2	(✓)		✓
1.AA.4a/b	Residential/institutional/commercial	N_2O			
1.AA.4c	Fishing	CH_4			
1.AA.4c	Fishing	CO_2	✓	✓	✓
1.AA.4c	Fishing	N_2O			
1.B	Fugitive emissions from fuels	CH_4			
1.B	Fugitive emissions from fuels	CO_2	✓	✓	✓
2. Industrial Processes					
2.A	Mineral production	CO_2	✓		✓
2.B	Chemical industry	CO_2			
2.B	Chemical industry	N_2O	✓		
2.C	Metal production	CH_4			
2.C.2	Ferroalloys	CO_2	✓	✓	✓
2.C.3	Aluminium	CO_2	✓	✓	✓
2.C.3	Aluminium	PFC	✓	✓	✓
2.F	Consumption of halocarbons and SF6, refrigeration	HFC		✓	✓
2.F	Consumption of halocarbons and SF6, refrigeration	PFC			
2.F	Consumption of halocarbons and SF6, electrical	SF_6			
3. Solvents and Other Product Use					
3	Solvent and other product use	CO_2			
3	Solvent and other product use	N_2O			
4. Agriculture					
4.A.1	Enteric fermentation, cattle	CH_4	✓	✓	
4.A.3	Enteric fermentation, sheep	CH_4	✓	✓	✓

Table 1.1. continued

IPCC source category			Level	Level	Trend
4.A.4-10	Enteric fermentation, rest	CH_4			
4.B	Manure management	CH_4		(✓)	
4.B	Manure management	N_2O	✓	✓	
4.D.1	Direct soil emissions	N_2O	✓	✓	
4.D.2	Animal production	N_2O	✓	✓	
4.D.3	Indirect soil emissions	N_2O	✓	✓	
	5. Land use, Land use change and Forestry				
5	LULUCF – Biomass burning	CH_4			
5	LULUCF – Biomass burning	N_2O			
5.A.1	Forest Land – Forest Land remaining Forest Land	CO_2			
5.A.2	Forest land – Land converted to Forest Land	CO_2		✓	✓
5.A.2	Forest land – Land converted to Forest Land	N_2O			
5.B.1	Cropland remaining Cropland	CO_2	✓	✓	✓
5.B.2	Land converted to Cropland	CO_2	✓	✓	✓
5.C.1	Wetlands drained for more than 20 years	CO_2	✓	✓	✓
5.C.1	All other remaining Grassland	CO_2			
5.C.2.2/3	All other conversion to Grassland	CO_2	✓	✓	✓
5.C.2.5	Other land converted to Grassland, revegetation	CO_2	✓	✓	✓
5.D	Wetlands	CH_4			
5.D	Wetlands	CO_2			
5.D	Wetlands	N_2O			
5.E	Settlements	CO_2			
5.G	Grassland non CO2-emissions	N_2O	✓	✓	
	6. Waste				
6.A.1	Managed waste disposal on land	CH_4		✓	✓
6.A.2	Unmanaged waste disposal sites	CH_4	✓		✓
6.B	Wastewater handling	CH_4			
6.B	Wastewater handling	N_2O			
6.C	Waste incineration	CH_4			
6.C	Waste incineration	CO_2			
6.C	Waste incineration	N_2O			
6.D	Other (composting)	CH_4			
6.D	Other (composting)	N_2O			

1.7 Quality Assurance and Quality Control (QA/QC)

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 at 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 (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 Evaluation

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.

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 2013 submission (16.7%) is caused by the above mentioned correction of errors.

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

1.9 General Assessment of the 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 2012.

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 (2A6).
- 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

Several improvements have been made since last submission. The main changes include:

- Improved reporting on projects falling under Decision 14/CP.7
- Country specific values for digestible energy content of cattle and sheep feed were determined and used in the calculation of methane emissions from livestock
- Revision of area of many landuse categories
- Inclusion of biomass burning under LULUCF

In the near future the following improvements for the inventory are planned:

- Preparation of a national energy balance. The NEA should prepare a national energy balance annually and submit to the EA. Work has already been initiated by the NEA, with the aim of producing the national energy balance within two years. The obligation of the NEA to provide national energy balance will be further elaborated in a regulation, to be set on basis of Act no 70/2012.
- Improvement of methodologies to estimate emissions from road transportation (use of COPERT).
- Move estimates of emissions from aviation to the Tier 2 methodology.
- Improvement of methodologies to estimate N_2O emissions from manure management.
- Developing a time series for the enhanced livestock population characterisation
- The division of land use into subcategories and improved time and spatial resolution of the land use information is an on-going task of the AUI.

- Repeated land classification based on new satellite images through remote sensing, updating and improving GIS-maps and continuing field surveys is included in the IGLUD project.
- Definition of baseline map that helps separating actual land use changes from seeming land use changes brought on by improved mapping and data management
- Improving the area estimate of drained land and of the effectiveness of drainage
- Revision of EF for drained organic soils
- Improving identification of former cropland categories and destination of abandoned cropland.
- Higher tier estimates of changes regarding the carbon stock in soil, dead organic material and other vegetation than trees on forest Land is expected in future reporting when data from re-measurement of the permanent sample plot will be available.
- Increase the accuracy of the new area estimate of the natural birch woodland and the changes in area with time
- 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. When implemented, these improvements will provide more accurate area and removal factor estimates for revegetation, subdivided according to management regime, regions and age.
- Improve area estimate of Settlement area and Other land
- Further improvement of the time series already presented.
- The provision of missing Annexes.

The following improvements are under consideration:

- Develop CS emission factors for fuels.
- Develop verification procedures for various data.
- Improvement of QA/QC for LULUCF.
- Revision of LULUCF emission/removal factors, in order to emphasize key sources and aim toward higher Tier levels.
- Evaluation of LULUCF factors, not estimated in present submission and disaggregation of components presently reported as aggregated emissions.
- Establishing country specific emission factors, including variability in soil classes, for Cropland categories
- Improvements regarding information on reservoir area and type of land Introduction of reservoir specific emission factors for more reservoirs is to be expected as information on land flooded is improved.
- Division of „Other Grassland“ into subcategories that reflect differences in management, vegetation condition and soil erosion is pending.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Emission Trends for Aggregated Greenhouse Gas Emissions

Total amounts of greenhouse gases emitted in Iceland during the period 1990-2012 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, 2008, 2009, 2010, 2011, and 2012 expressed in Gg CO_2-equivalents along with percentage changes for both time periods 1990-2012 and 2011-2012. Table 2.2 presents emission figures for all greenhouse gases by gas in 1990, 2008, 2009, 2010, 2011, and 2012 expressed in Gg CO_2-equivalents along with percentage changes for both time periods 1990-2012 and 2011-2012.

Table 2.1. Emissions of greenhouse gases by sector in Iceland during the period 1990-2012 in Gg CO_2-equivalents.

	1990	2008	2009	2010	2011	2012	Changes ´90-´12	Changes ´11-´12
1. Energy	1,779	2,075	2,021	1,869	1,770	1,718	-3.44%	-2.95%
1.A Fuel combustion	1,717	1,887	1,848	1,676	1,588	1,545	-10.01%	-2.71%
1.B Geothermal	62	188	173	193	182	172	179.82%	-5.05%
2. Industrial Processes	869	2,020	1,861	1,890	1,798	1,883	116.70%	4.71%
3. Solvent and Other Product Use	9	7	6	6	6	6	-31.95%	-2.08%
4. Agriculture	737	704	680	671	669	678	-7.95%	1.42%
5. Land Use, Land Use Change and Forestry	1,175	859	834	791	746	706	-39.91%	-5.30%
6. Waste	145	216	211	210	198	183	26.27%	-7.72%
Total emissions without LULUCF	3,538	5,022	4,779	4,646	4,441	4,468	26.28%	0.60%
CO_2 emissions fulfilling 14/CP.7*		1,161	1,205	1,225	1,209	1,279		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		3,861	3,574	3,421	3,232	3,189		

**Decision 14/CP.7 allows Iceland to exclude certain industrial process carbon dioxide emissions from national totals.*

Table 2.2. Emissions of greenhouse gases by gas in Iceland during the period 1990-2012 (without LULUCF) in Gg CO_2-equivalents.

	1990	2008	2009	2010	2011	2012	Changes ´90-´12	Changes ´11-´12
CO_2	2,160	3,605	3,572	3,432	3,333	3,324	53.87%	-0.27%
CH_4	437	490	488	488	473	457	4.64%	-3.35%
N_2O	521	504	469	453	448	458	-12.08%	2.18%
PFCs	420	349	153	146	63	80	-81.00%	26.14%
HFCs	NO	71	95	123	121	144	NA	18.76%
SF_6	1	3	3	5	3	6	384.33%	74.38%
Total emissions	3,538	5,022	4,779	4,646	4,441	4,468	26.28%	0.60%
CO_2 emissions fulfilling 14/CP.7*		**1,161**	**1,205**	**1,225**	**1,209**	**1,279**		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		**3,861**	**3,574**	**3,421**	**3,232**	**3,189**		

**Decision 14/CP.7 allows Iceland to exclude certain industrial process carbon dioxide emissions from national totals.*

As mentioned in Chapter 1.1, industrial process CO_2 emissions that fulfil the provisions of Decision 14/CP.7 shall be reported separately and not included in national totals to the extent they would cause Iceland to exceed its assigned amount.

In 1990 total GHG emissions (excluding LULUCF) in Iceland were 3,538 Gg CO_2-equivalents. In 2012 total emissions were 4,468 Gg CO_2-equivalents. This is tantamount to an increase of 26% 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 about 5% per year, then plateau from 2000 to 2005. Between 2005 and 2008 emissions increased rapidly or by 10% per year. Between 2008 and 2010 annual emissions decreased again by on average 4% per year. Emissions increased by 0.6% between 2011 and 2012.

By the middle of the 1990s economic growth started to gain momentum in Iceland. Until 2007 Iceland experienced one of the highest GDP growth rates 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 2012, 821,021 tonnes of aluminium were produced in three aluminium plants. Parallel investments in increased power capacity were needed to accommodate for this nine fold 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 26% from 1990 to 2012. 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. This decrease has slowed down and was only 0.5% between 2011 and 2012. The total decrease from 2007 to 2012 is therefore 23%. 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 stopped 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 2012 total emissions from the aluminium sector were 16% 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 is CO_2 (74%), followed by CH_4 (10%), N_2O (10%) and fluorinated gases (PFCs, HFCs, and SF_6, 5%). In the year 2012, the changes in gas emissions compared to 1990 levels for CO_2, CH_4, N_2O, and fluorinated gasses were 54%, 5%, -12%, and -45%, respectively (cf. Table 2.2 and Figure 2.3).

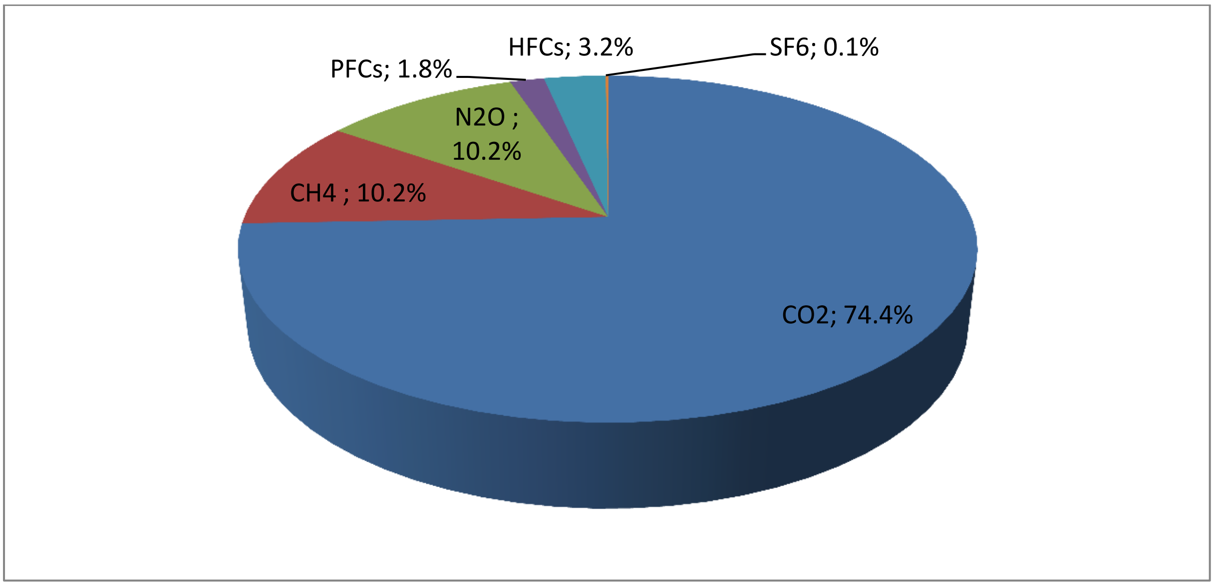

Figure 2.1. Distribution of emissions of greenhouse gases by gas in 2012.

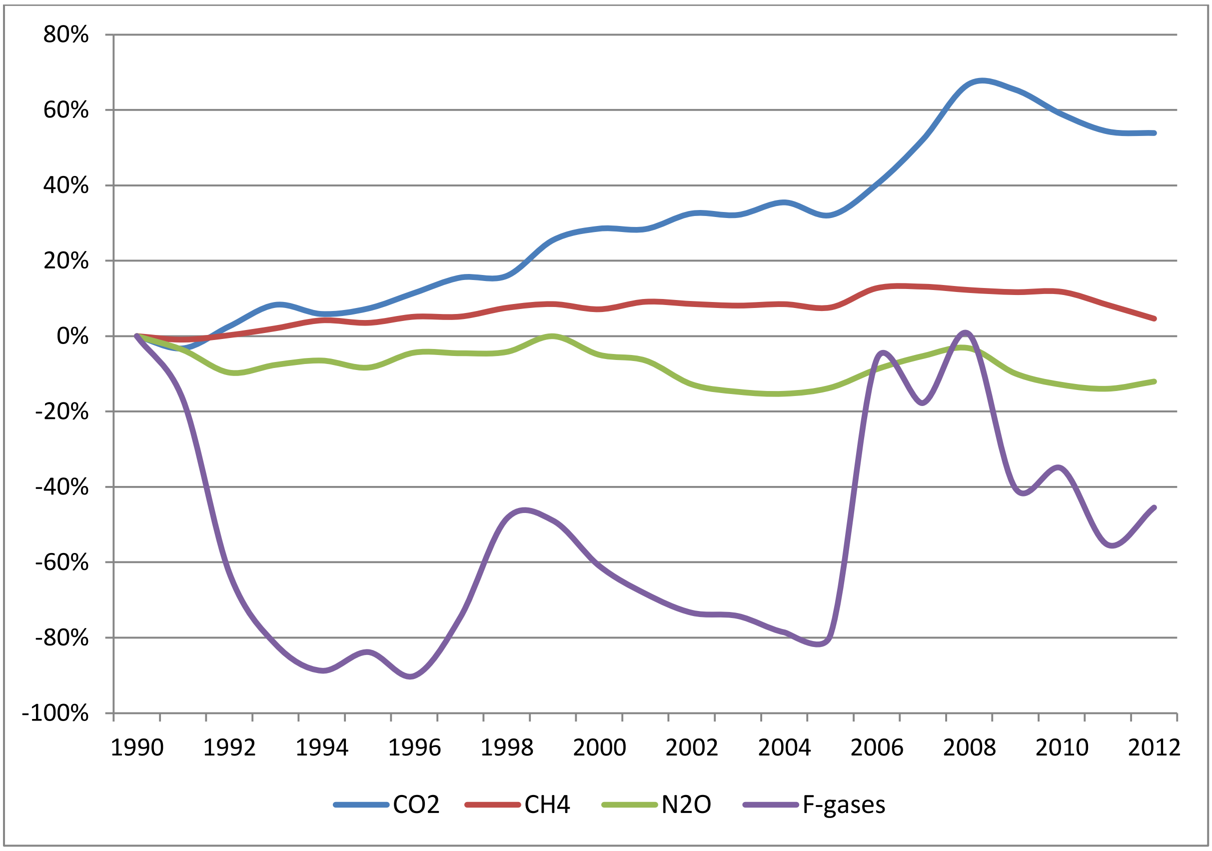

Figure 2.2. Percentage changes in emissions of GHG by gas 1990-2012, compared to 1990 levels.

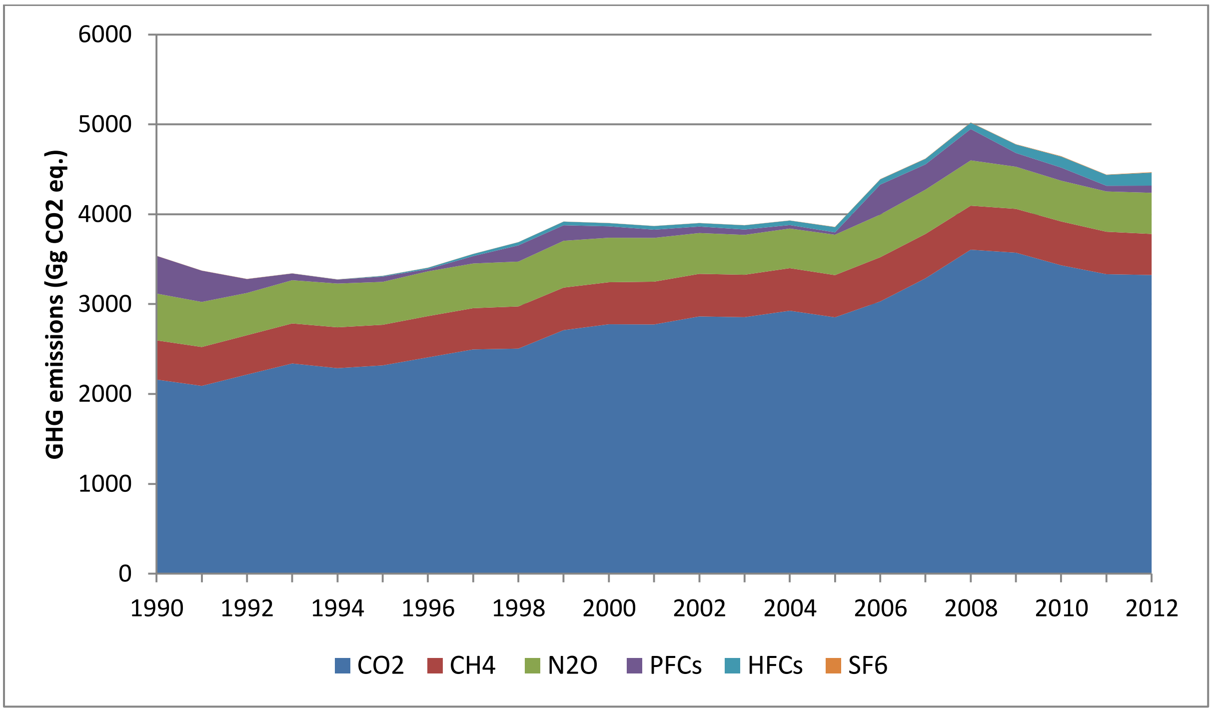

Figure 2.3. Emissions of greenhouse gases by gas, 1990-2012.

2.2.1 *Carbon Dioxide (CO2)*

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 coal combustion in the cement industry, emissions from non-road transport and waste incineration. Table 2.3 lists CO_2 emissions from the main source categories for the period 1990-2012. Figure 2.4 illustrates the distribution of CO_2 emissions by main source categories, and Figure 2.5 shows the percentage change in emissions of CO_2 by source from 1990 to 2012 compared with 1990 levels.

Table 2.3. Emissions of CO_2 by sector 1990-2012 in Gg.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Fishing	655	772	720	626	517	597	535	500	485
Road vehicles	521	547	602	761	851	852	806	788	782
Stationary combustion, liquid fuels	243	228	214	172	109	112	97	89	87
Industrial processes	399	435	793	846	1,596	1,609	1,616	1,610	1,653
Construction	121	148	197	215	188	129	102	88	92
Geothermal	61	82	153	116	184	168	189	179	170
Other	159	107	97	116	160	104	88	80	54
Total CO_2 emissions	2,160	2,318	2,776	2,853	3,605	3,572	3,432	3,333	3,324

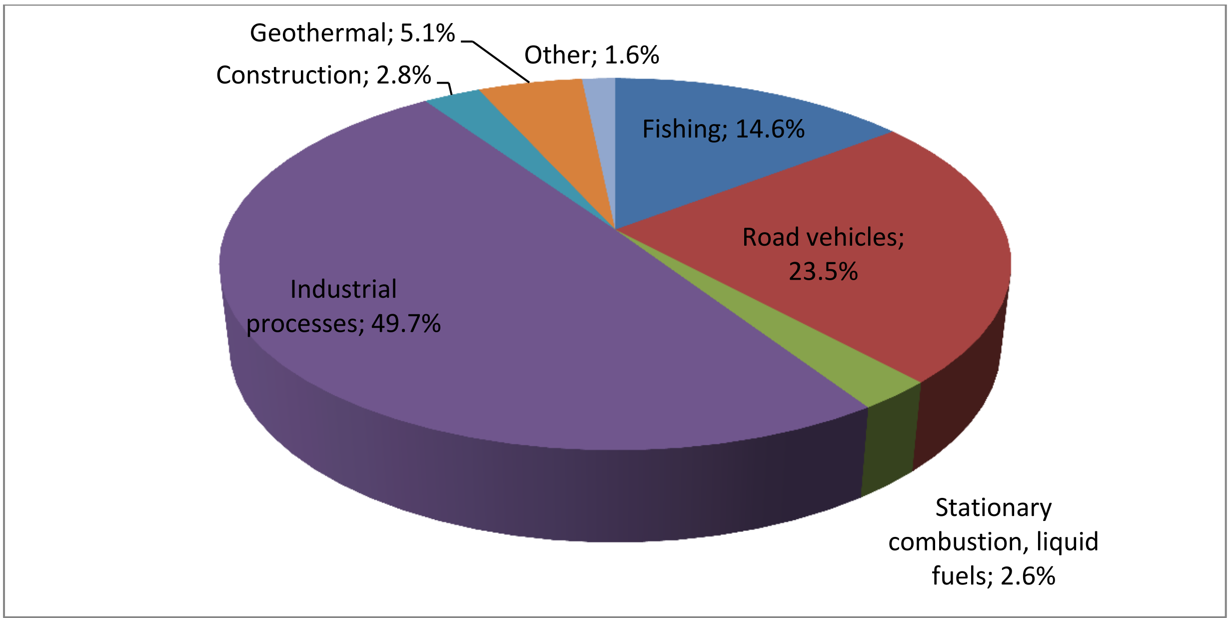

Figure 2.4. Distribution of CO_2 emissions by source in 2012.

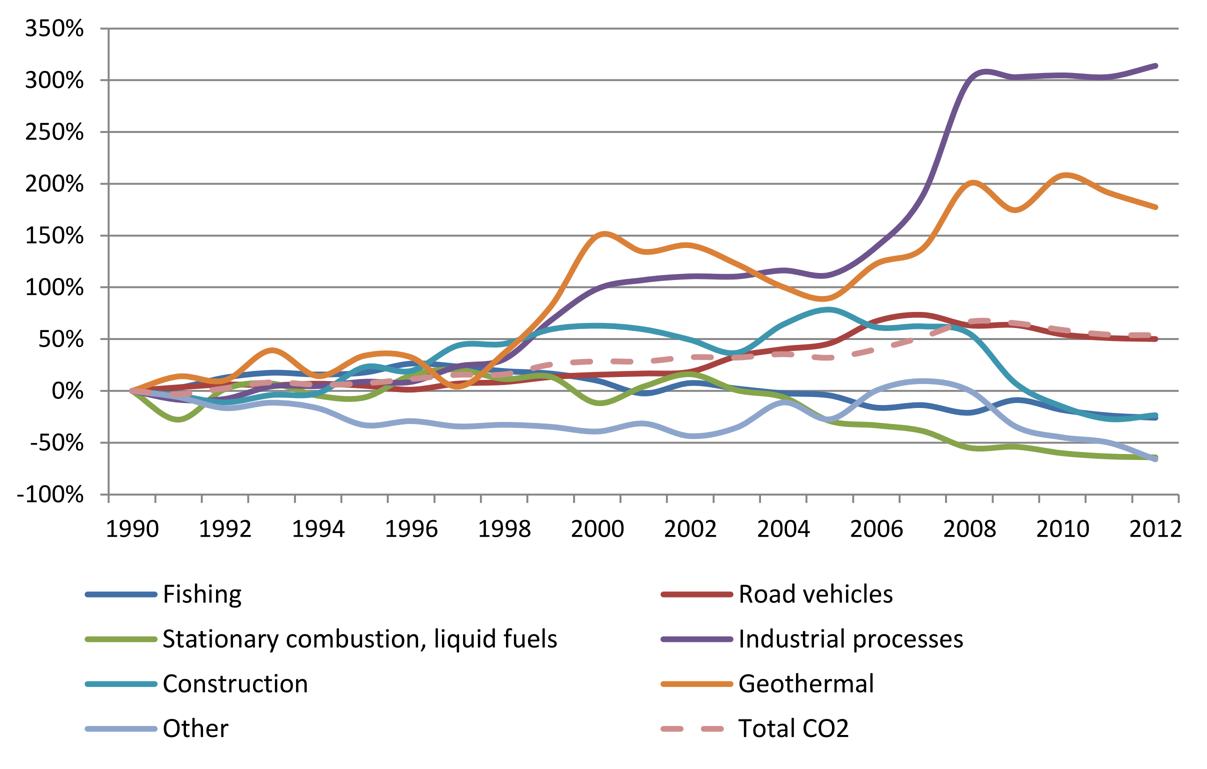

Figure 2.5. Percentage changes in emissions of CO_2 by major sources 1990-2012, compared to 1990 levels.

In 2012, Iceland´s total CO_2 emissions were 3,324 Gg. This is tantamount to an increase of 54% from 1990 levels and a decrease of 0.3% from the preceding year. CO_2 emissions from Industrial Processes increased by 2.7% from 2011 to 2012 due to more emissions from metal production, but are partly counteracted by the ceasing of emissions from the cement industry due to the shutdown of the single existing plant in late 2011. Emissions from geothermal energy exploitation decreased by 5% between 2011 and 2012. Emissions from road vehicles peaked in 2007 but have decreased by 13% since then. This decreasing trend is caused by significantly higher fuel prices, owing to the depreciation of the Icelandic króna since 2008, and by the an increasing share of fuel efficient vehicles in the fleet. This can also be seen in decreased international aviation in 2008 and 2009 (Table 2.15). In 2009, 2010 and 2011 fuel prices continued to rise. 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. 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 fueld cars between 2010 and 2012. This is the main driver behind the decrease in emissions from road transport since then. Emissions from stationary combustion of liquid fuels decreased by 2% from 2011 to 2012. Emissions from construction increased by 5% and emissions from other sources decreased by 3% during the same time period.

The increase in CO_2 emissions between 1990 and 2012 can be explained by increased emissions from industrial processes (314%), road transport (50%), and geothermal energy utilisation (177%). Total CO_2 emissions from the commercial fishing and construction sectors, on the other hand, declined by 26% and 23%, respectively.

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 2012, a total of 821,021 tonnes of aluminium were produced in these three aluminium plants, slightly more than in 2011.

CO_2 emissions from road transport have increased by 50% 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 76%. Emissions from both domestic flights and navigation have declined since 1990.

Emissions from geothermal energy exploitation have increased by 177% since 1990. Electricity production using geothermal energy has increased from 283 GWh in 1990 to 5,210 GWh in 2012, or more than 17-fold.

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 2012, the emissions were 26% below the 1990 levels and 3% below the 2011 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 which led to a further decrease of other CO2 emissions of 32% between 2011 and 2012.

2.2.2 Methane (CH_4)

Agriculture and waste treatment have been the main sources of methane emissions since 1990. In 2012 they comprised 62% and 36% 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 90% of sector methane emissions.

Methane emissions from agriculture decreased by 7% between 1990 and 2012 due to a decrease in livestock population. Emissions from waste, on the other hand, increased by 32% 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 Gg 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 2007 by 20% is due to a decrease in the amount of waste landfilled since 2005 (Figure 2.7).

Table 2.4. Emissions of CH_4 by sector 1990-2012 (Gg CO_2-eqivalents).

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Agriculture	305	282	277	269	281	284	286	285	284
Waste	126	164	184	195	200	195	194	181	167
Other	6	6	6	6	8	9	8	7	6
Total	437	452	468	470	490	488	488	473	457

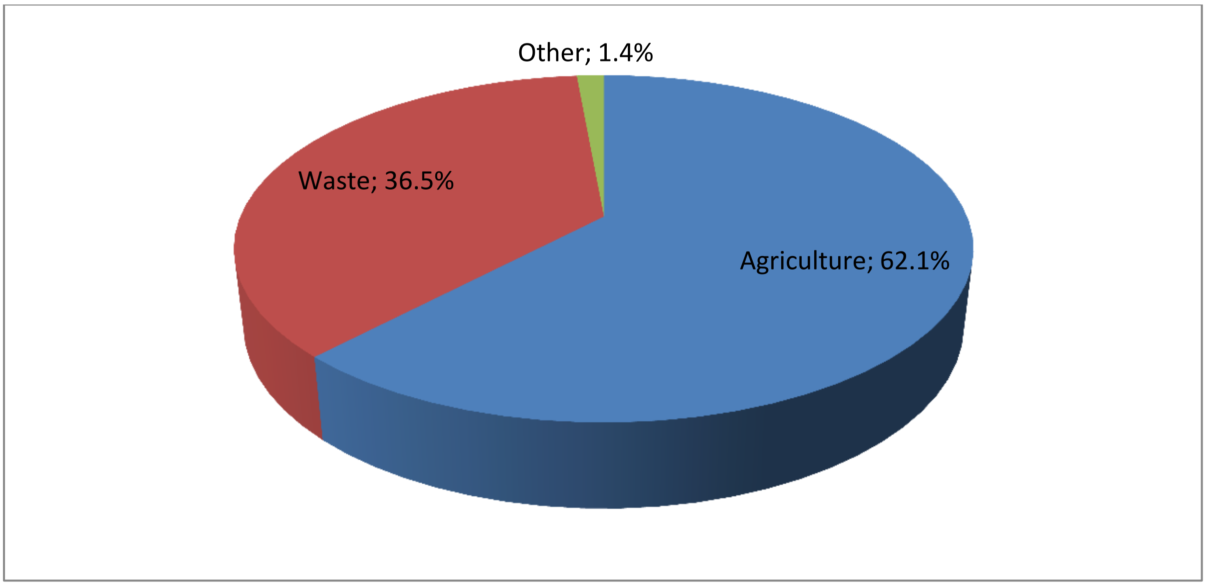

Figure 2.6. Distribution of CH_4 emissions by source in 2012.

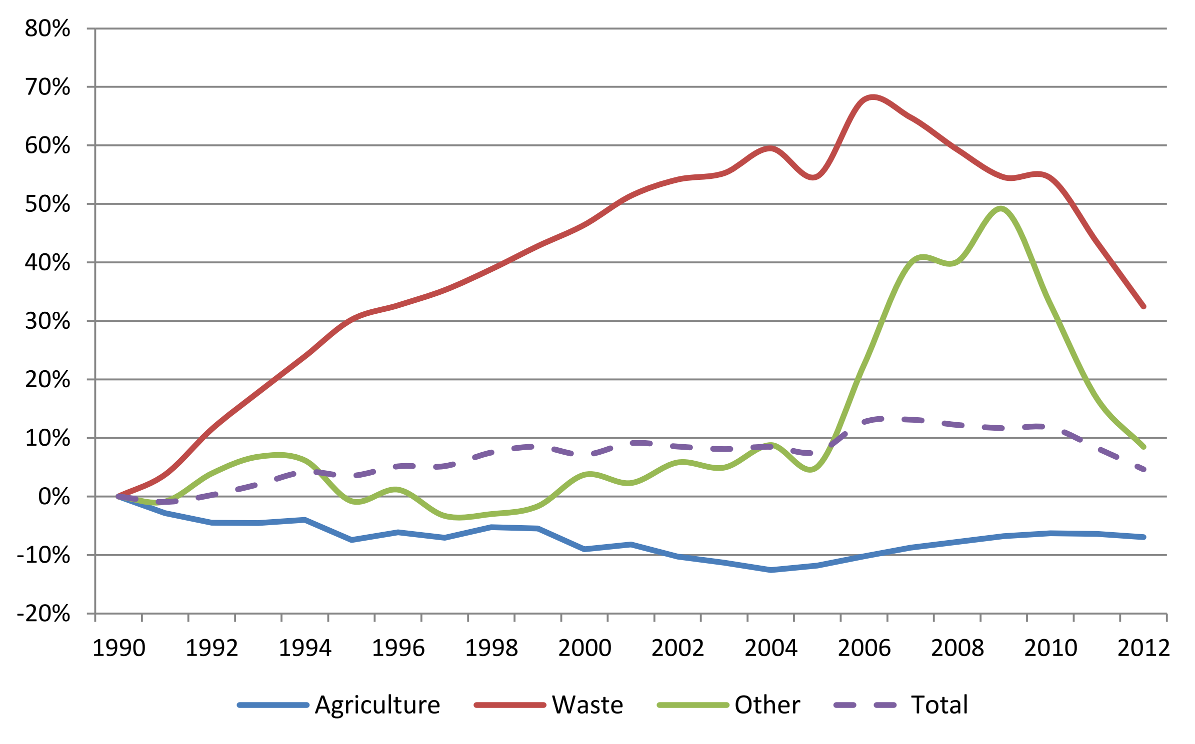

Figure 2.7. Percentage changes in emissions of CH_4 by major sources 1990-2012, compared to 1990 levels.

2.2.3 *Nitrous Oxide (N_2O)*

Agriculture has been the main source of N_2O emissions in Iceland and accounted for 86% of nitrous oxide emissions in 2012 (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 9% 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 12% since 1990 (Figure 2.9).

Table 2.5. Emissions of N_2O by sector 1990-2012 (Gg CO_2-equivalents).

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Agriculture	432	385	403	366	423	396	385	383	394
Road transport	5	12	29	38	38	38	37	35	34
Other fuel combustion	22	27	32	34	29	22	18	16	16
Chemical industry	48	42	19	NO	NO	NO	NO	NO	NO
Other	14	12	12	11	13	13	13	13	13
Total	521	477	495	449	504	469	453	448	458

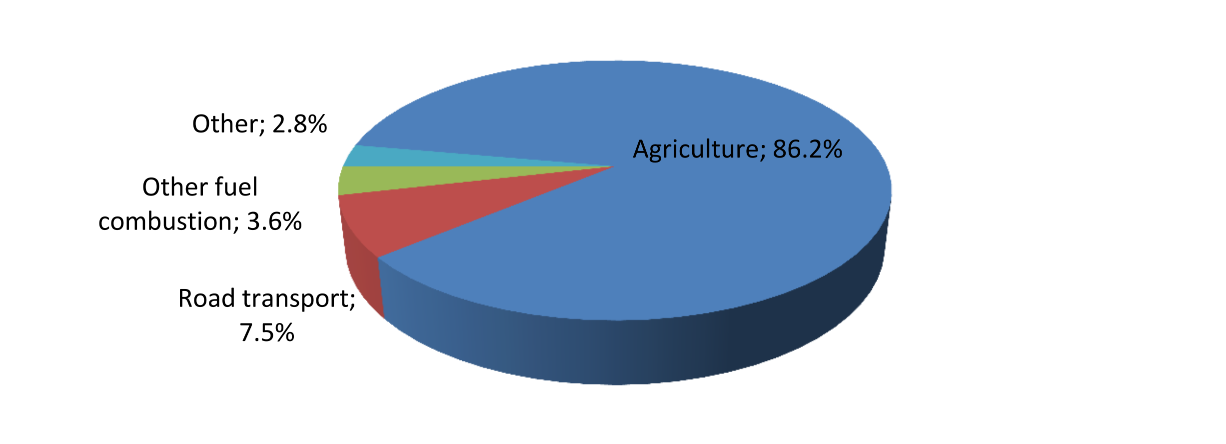

Figure 2.8. Distribution of N_2O emissions by source in 2012.

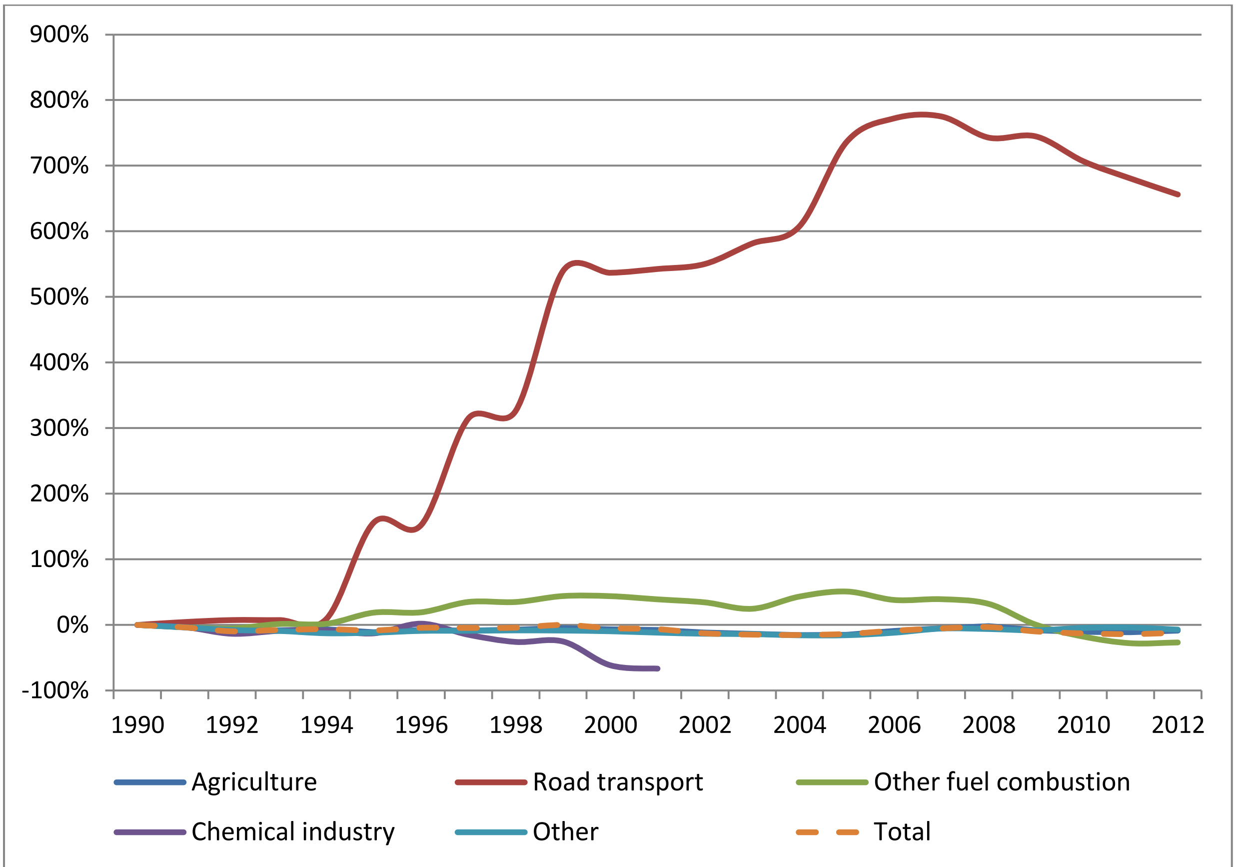

Figure 2.9. Changes in N_2O emission for major sources between 1990 and 2012.

2.2.4 *Perfluorocarbons (PFCs)*

The emissions of the perfluorocarbons, i.e. tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) from the aluminium industry were 67.5 and 12.3 Gg CO_2-equivalents respectively in 2013, or roughly 80 Gg CO_2-equivalents in total. Emissions of PFCs (PFC 116 and PFC 218) from consumption of halocarbons in refrigeration and air conditioning equipment were 0.003 Gg CO_2-equivalents in 2012 (Table 2.6).

Total PFC emissions decreased by 81% in the period of 1990-2012. 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. The extent of the increase can be explained by technical difficulties experienced during the expansion. 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 0.003 Gg 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 1990-2012 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
CF_4	355	50	108	22	295	129	123	53	67
C_2F_6	65	9	20	4	54	24	22	10	12
C_3F_8	NO	NO	nO	NO	NO	0.001	0.000	0.000	0.000
Total	420	59	127	26	349	153	146	63	80

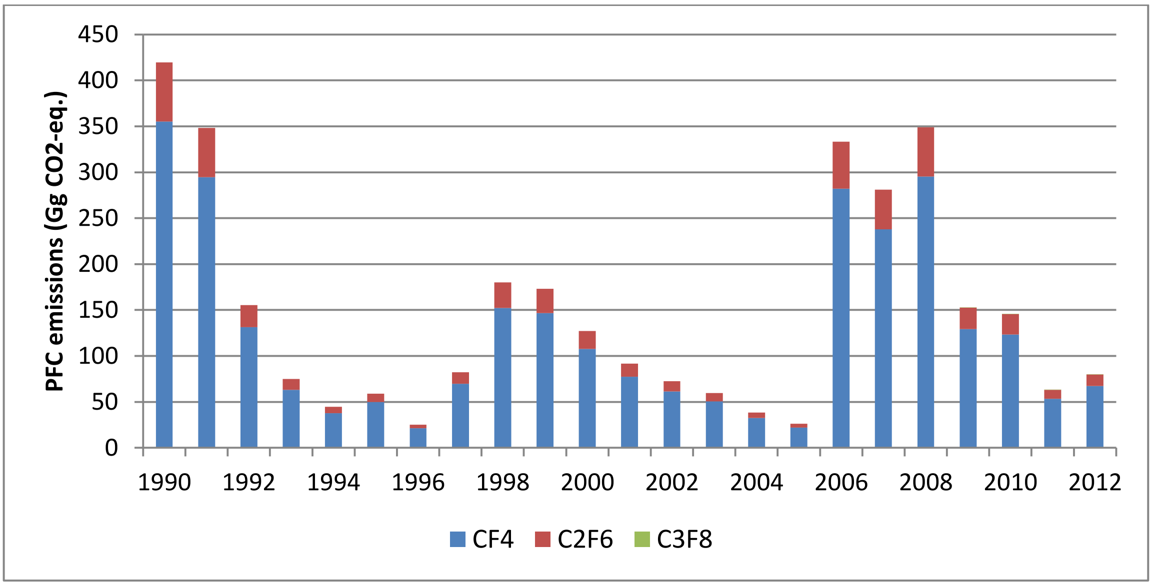

Figure 2.10. Emissions of PFCs from 1990 to 2011, Gg CO_2-equivalents.

2.2.5 Hydrofluorocarbons (HFCs)

Total actual emissions of HFCs, used as substitutes for ozone depleting substances (ODS), amounted to 144 Gg CO_2-equivalents in 2012 (Table 2.7). 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. Bulk import increased again strongly leading to a 19% emission increase between 2011 and 2012. Refrigeration and air-conditioning were by far the largest sources of HFC emissions and the fishing industry plays an eminent role.

Over the years, the use of ozone depleting substances (ODS) in the fishing industry has been decreasing due to restrictions on ODS import. The ban on importing new R-22, which became effective in 2010 and the impending ban on importing recovered R-22 mean a price increase for R-22 and add urgency to the process of retrofitting and replacing refrigerant systems in the fishing industry (Figure 2.11). Between 2008 and 2010 the import of HFCs had increased more than twofold. Total HFC emissions amounted to to 144 Gg in 2012 which is a 19% increase compared to 2011. This increase is due to the combination of a build-up in HFC stock and a pronounced increase in the quantity of imported HFCs between 2011 and 2012.

Table 2.7. Emissions of HFCs 1990-2012 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
HFC-23	NO	NO	NO	0.02	0.01	0.01	0.02	0.01	0.01
HFC-32a	NO	NO	0.00	0.02	0.04	0.04	0.05	0.07	0.09
HFC-125	NO	4.07	14.00	20.32	23.86	33.16	42.74	43.05	51.77
HFC-134a	NO	1.74	6.81	11.97	14.11	14.55	19.54	18.35	20.90
HFC-143	NO	2.09	14.85	25.95	32.55	47.19	60.13	59.84	71.29
HFC152a	NO	0.05	0.07	0.05	0.04	0.03	0.02	0.02	0.02
HFC-227ea	NO	NO	NO	0.07	0.03	0.02	0.03	0.01	0.04
Total	NO	7.95	35.73	58.40	70.63	94.99	122.5	121.3	144.1

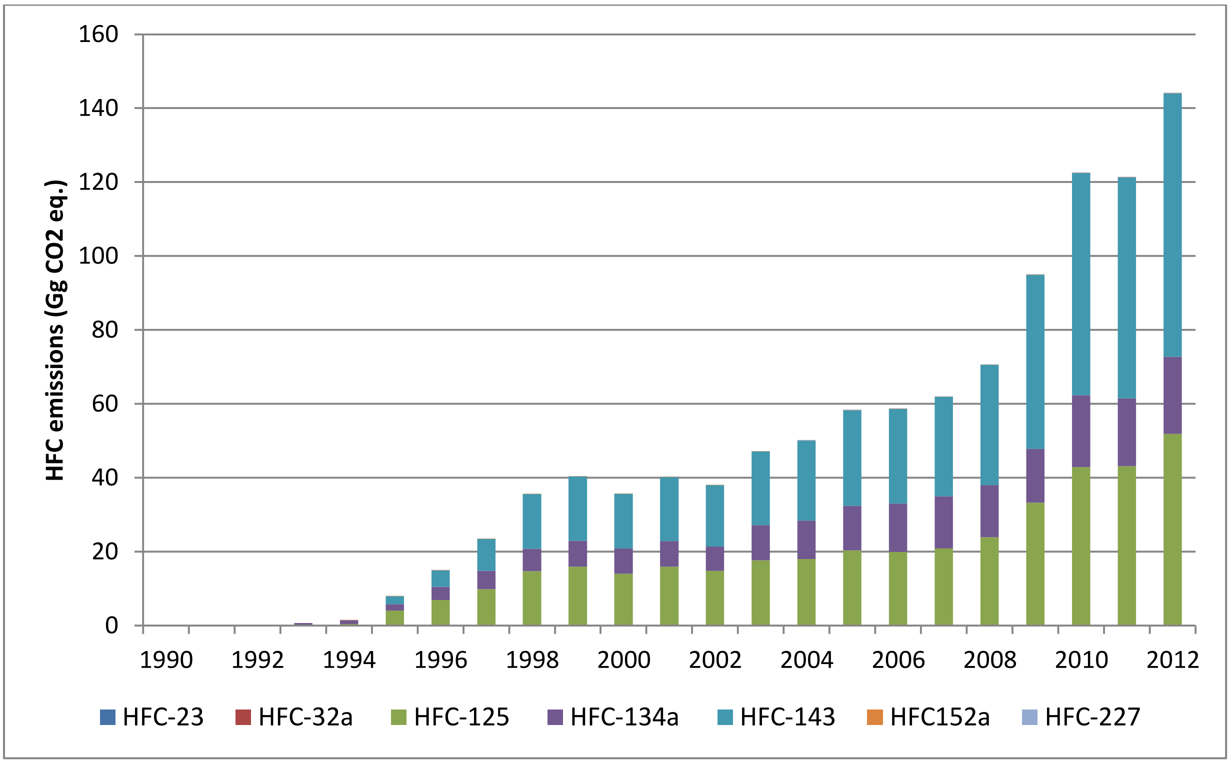

Figure 2.11. Actual emissions of HFCs 1990-2012, Gg CO_2-equivalents (HFC-23, HFC-32, HFC-152 and HFC-227 cannot be seen in figure due to proportionally low levels compared to three major HFCs).

2.2.6 Sulphur Hexafluoride (SF_6)

The sole source of SF_6 emissions in Iceland is leakage from electrical equipment. Total emissions in 2012 were 233 kg SF_6 which is tantamount to 5.6 Gg CO_2-equivalents. Emissions have increased by 384% 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.

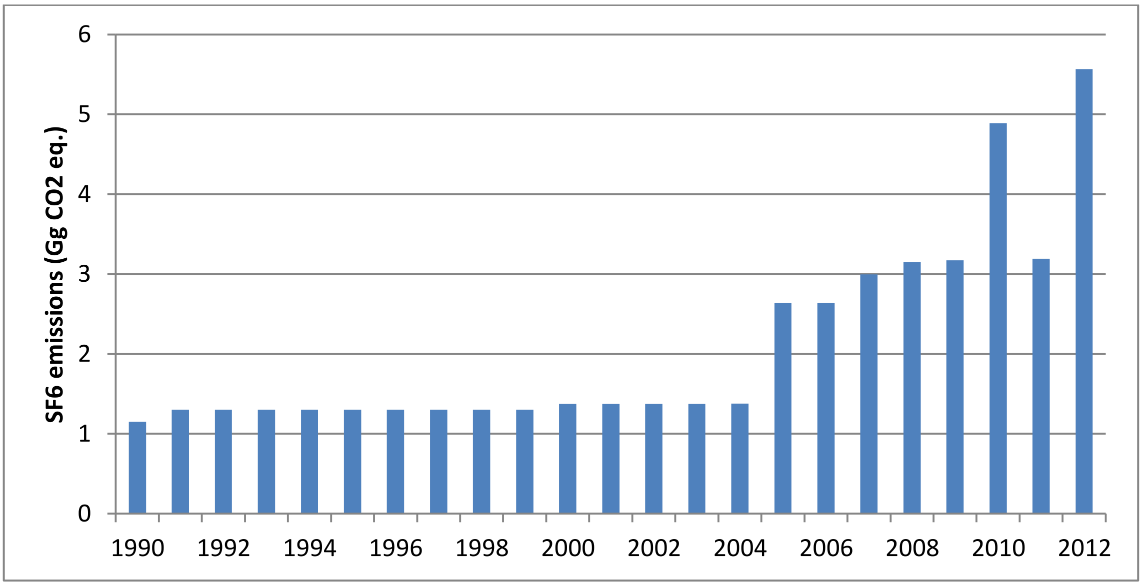

Figure 2.12. Emissions of SF_6 from 1990 to 2012 in Gg CO2-eq.

2.3 Emission Trends by Source

Industrial processes are the largest contributor of greenhouse gas emissions in Iceland (without LULUCF), followed by Energy, Agriculture, Waste, and Solvent and other Product Use. The contribution of Industrial Processes to total net emissions (without LULUCF) increased from 25% in 1990 to 42% in 2012. The contribution of the Energy sector decreased from 51% in 1990 to 38% in 2012. Agriculture and the Waste sector accounted for 15% and 4% of 2012 emissions, respectively (cf. Table 2.1 and Figure 2.13 to Figure 2.15).

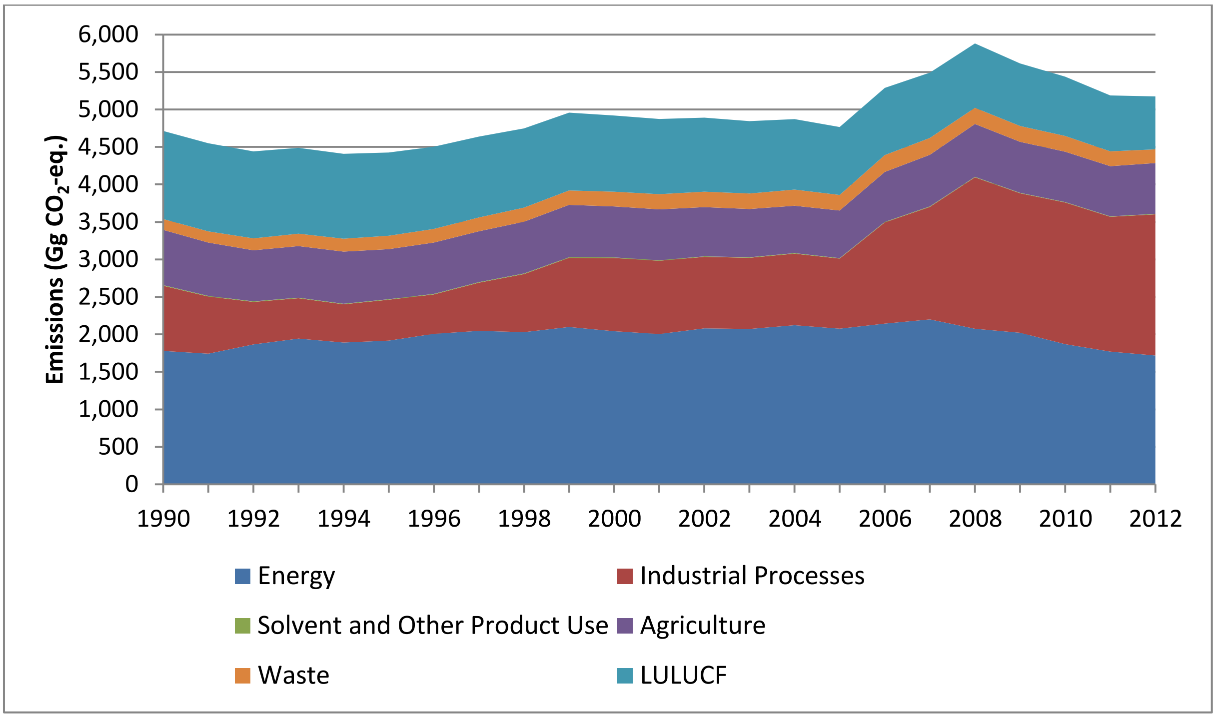

Figure 2.13. Emissions of GHG by sector from 1990 to 2012 in CO_2-equivalents.

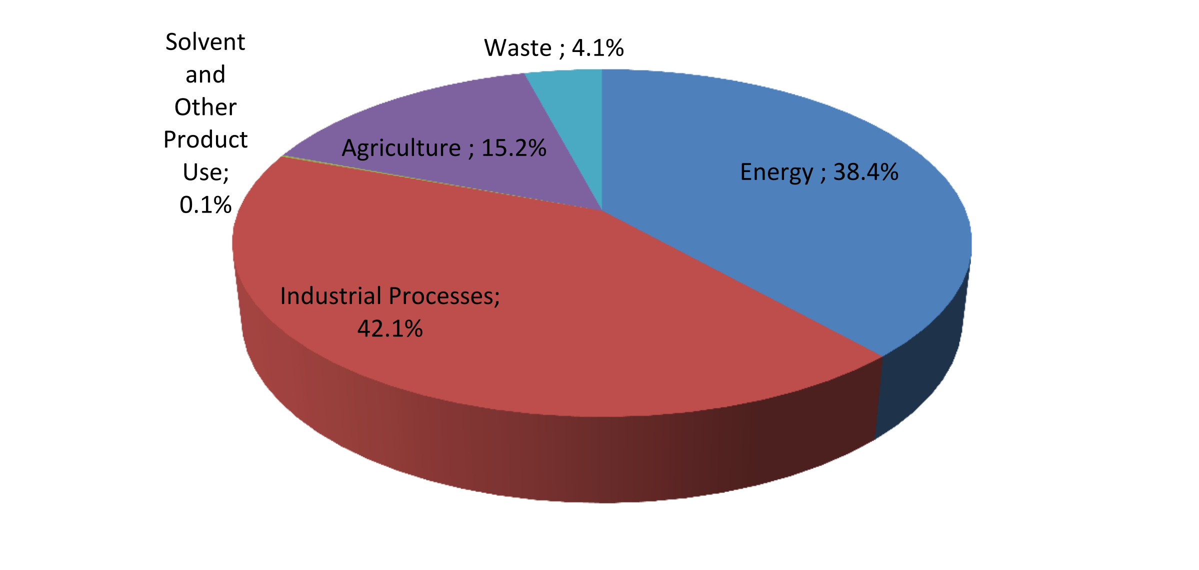

Figure 2.14. Emissions of greenhouse gases by UNFCCC sector in 2012.

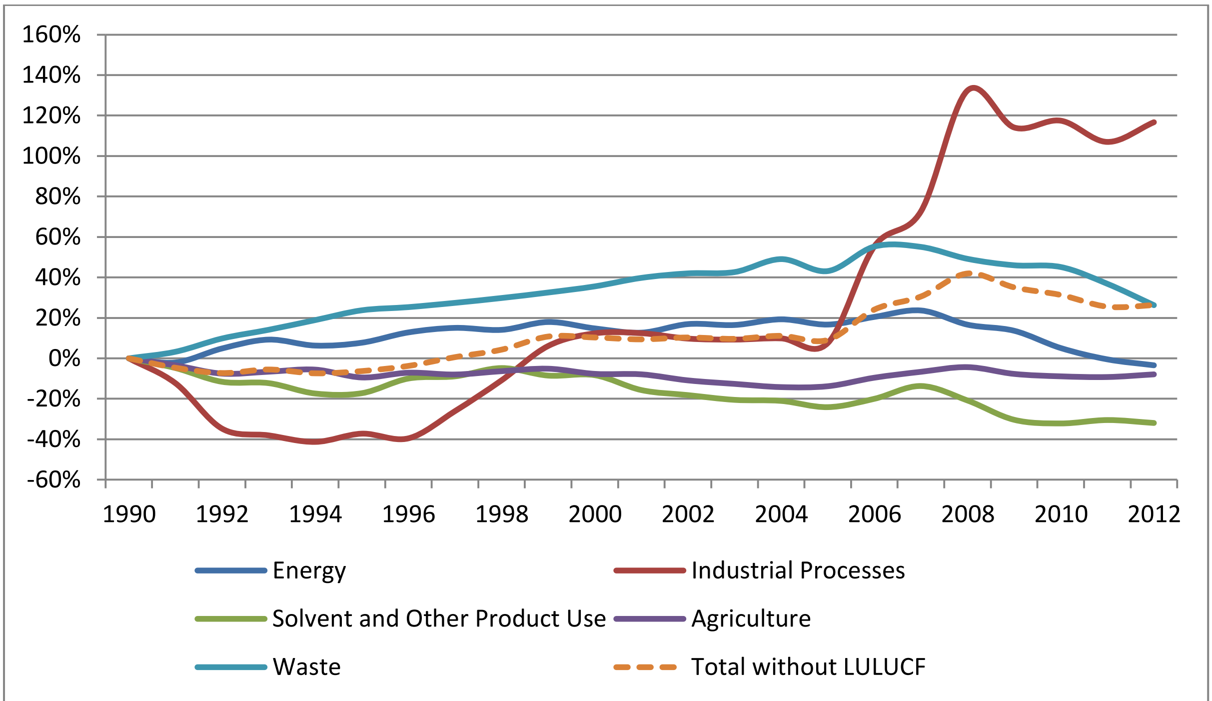

Figure 2.15. Percentage changes in emissions of total greenhouse gas emissions by UNFCCC source categories during the period 1990-2012, compared to 1990 levels.

2.3.1 Energy

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 2012 the consumption per capita was about 786 GJ. However, the proportion of domestic renewable energy in the total energy budget is 85%, 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 80% of the total electricity produced in Iceland in 2012. Iceland relies heavily on its geothermal energy sources for space heating (over 90% of all homes) and electricity production (27% of the electricity) and on hydropower for electricity production (73% 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.

Fuel Combustion

The total emissions of greenhouse gases from fuel combustion in the Energy sector over the period 1990 to 2012 are listed in Table 2.8. Emissions from fuel combustion in the Energy sector accounted for 38% of the total greenhouse gas emissions in Iceland in 2012.

Figure 2.16 shows the distribution of emissions in 2012 by different source categories. The percentage change in the various source categories in the Energy sector between 1990 and 2012, compared with 1990, are illustrated in Figure 2.17.

Table 2.8. Total emissions of GHG from the fuel combustion in the Energy sector in 1990-2012, CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Energy industries	14	19	7	9	8	9	7	7	7
Manufacturing industry and construction	377	378	450	447	369	264	213	193	184
Transport	621	628	674	849	973	946	900	864	853
Road	529	561	633	800	891	892	844	824	818
Other	92	67	41	49	82	54	57	39	35
Other sectors	705	808	756	651	536	629	556	524	500
Fishing	662	780	728	633	523	603	540	505	490
Residential/ commercial	43	28	29	19	14	25	16	18	10
Total	1,717	1,833	1,887	1,957	1,886	1,848	1,676	1,588	1,545

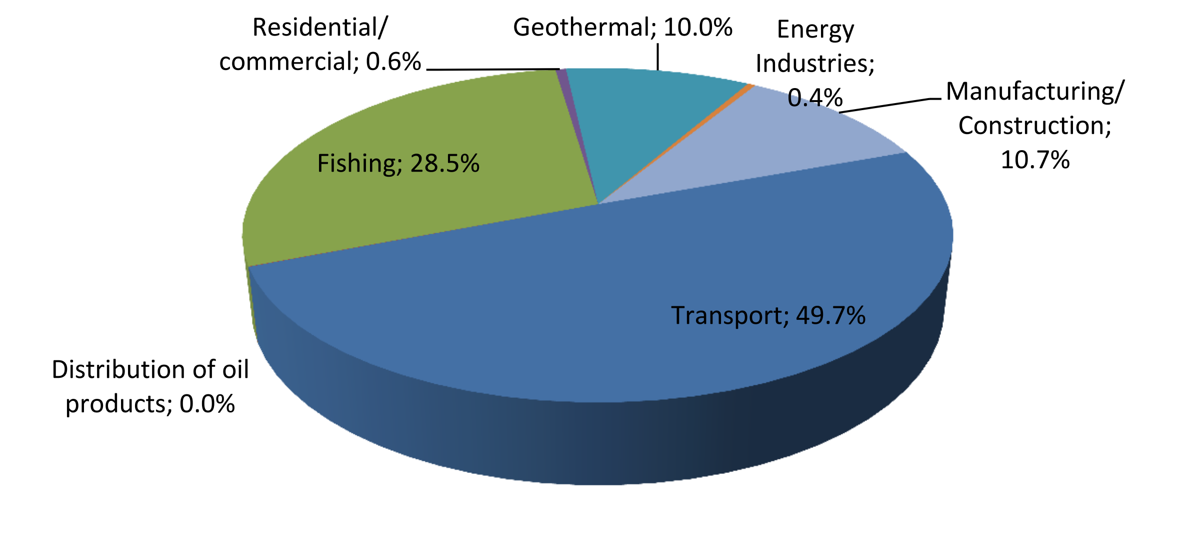

Figure 2.16. Greenhouse gas emissions in the Energy sector 2012, distributed by source categories.

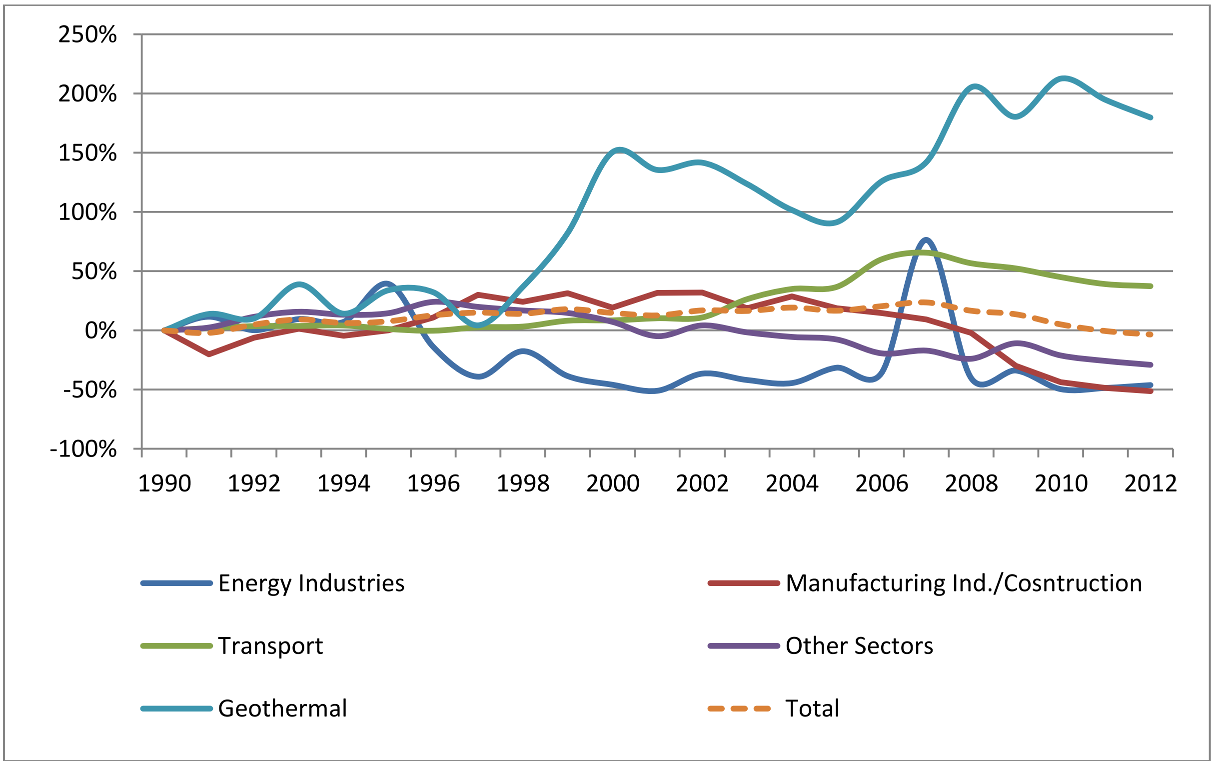

Figure 2.17. Percentage changes in emissions in various source categories in the Energy sector during the period 1990-2012, compared to 1990.

Table 2.8 and Figure 2.17 show that emissions from transport have increased by 37% since 1990 as emissions from other sectors (dominated by fishing) have decreased by 29%. Emissions from energy industries are 46% below 1990 levels and emissions from manufacturing industries and construction are 51% below 1990 levels.

Energy industries 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 0.4% of the sector's total and 0.2% of the total GHG emissions in Iceland in 2012. 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 unfavourable water conditions for the hydropower plants. This created a shortage of electricity which was met by burning oil for electricity and heat production. In 2007 a new aluminium plant was established. 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. Since 2007 emissions from fuel combustion at the cement plant have decreased by 69% as a result of the collapse of the construction sector. 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 37% from 1990 to 2012. Emissions from road transport have increased by 50% 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 76%. Also, the Icelandic population has grown by 26% from 1990 to 2012. Emissions from road vehicles peaked in 2007 and have decreased by 13% 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 2010-2012. 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 2012 emissions were 29% below the 1990 level and 5% below the 2011 level. Annual changes are inherent to the nature of fisheries.

Geothermal Energy

Emissions from geothermal energy utilization accounts for 4% of the total greenhouse gas emissions in Iceland in 2012. 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 2012. Electricity production using geothermal power increased more than 16-fold during this period from 283 to 5,210 GWh. Emissions during the same time increased by 180%. Emissions from geothermal utilization are site and time-specific, and can vary greatly between areas and the wells within an area as well as by the time of extraction.

Table 2.9. Emissions from geothermal energy from 1990-2012 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Geothermal energy	62	83	154	118	188	173	193	182	173

Distribution of oil products

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

2.3.2 Industrial Processes

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 42% of the national greenhouse gas emissions. As can be seen in Table 2.10 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 aluminium industry has increased. By 2012, emissions from the industrial processes sector were 117% above the 1990 level.

Table 2.10. Emissions from industrial processes 1990-2012in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Mineral products	52	38	66	56	63	30	11	21	2
Chemical industry	49	43	19	NO	NO	NO	NO	NO	NO
Metal production	767	456	855	818	1,883	1,732	1,752	1,653	1,732
- Ferroalloys	208	243	374	375	347	348	369	375	408
- Aluminium	559	213	480	443	1,536	1,384	1,383	1,278	1,324
o Aluminium CO_2	139	154	353	417	1,187	1,231	1,238	1,214	1,244
o Aluminium PFC	420	59	127	26	349	153	146	63	80
Consumption of HFCs and SF_6	1	9	37	61	74	98	127	125	150
Total	869	546	976	935	2,020	1,861	1,890	1,798	1,883
Emissions fulfilling 14/CP.7*					1,161	1,205	1,225	1,209	1,279

**Decision 14/CP.7 allows Iceland to exclude certain industrial process carbon dioxide emissions from national totals.*

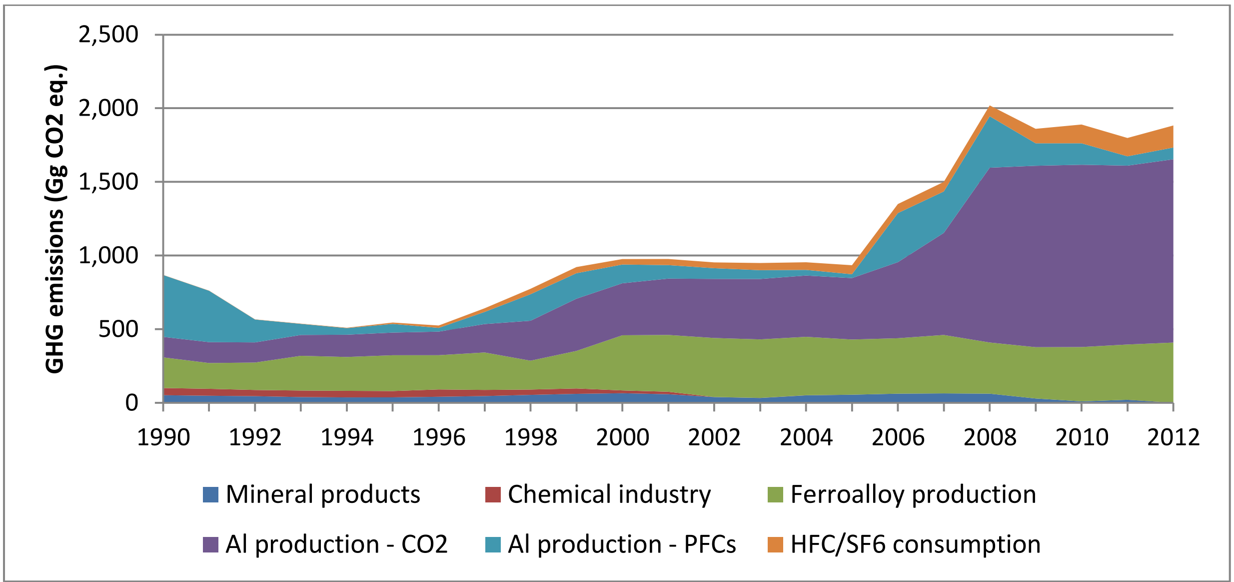

Figure 2.18. Total greenhouse gas emissions in the Industrial Process sector during the period from 1990-2012 in Gg CO_2-equivlalents.

The most significant category within the Industrial Processes sector is metal production, which accounted for 88% of the sector's emissions in 1990 and 92% in 2012. Aluminium production is the main source within the metal production category, accounting for 70% of the total Industrial Processes emissions. 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 the 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. The extent of the increase can be explained by technical difficulties experienced during the expansion. 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 0.1 tonnes CO_2-equivalents per tonne aluminium in 2012.

Production of ferroalloys is another major source of emissions, accounting for 22% of Industrial Processes emissions in 2012. CO_2 is emitted due to the use of coal and coke as reducing agents and from the consumption of electrodes. In 1998 a power shortage caused a temporary closure of the ferrosilican 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 80% since 1990. Emissions in 2012 were 9% higher than in 2011.

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 CO2 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 2.11).

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 2.11). 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 2.11. HFC and SF_6 emissions from consumption of HFC and SF_6 in Gg CO_2 equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
HFCs (refrigeration)	0.0	7.9	35.7	57.7	69.9	94.3	121.8	120.5	143.3
HFCs (metered dose inhalers)	0.0	0.0	0.0	0.7	0.7	0.7	0.8	0.8	0.8
SF6 (electrical equipment)	1.1	1.3	1.4	2.6	3.2	3.2	4.9	3.1	5.6

2.3.3 Solvent and other Product Use

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. The NMVOC compounds are oxidized to CO_2 in the atmosphere over time. Also included in this sector are emissions of N_2O from product uses. N_2O is used mainly for medical purposes. To a smaller extent it is also used in car racing and fire extinguishing.

Total NMVOC emissions from solvent and other product use amounted to 2.7 Gg CO_2-equivalents in 2012 (less than 0.1% of total GHG emissions), which was 8% below the 1990 level and 1% above the 2010 level. This development was mainly due to a decrease in paint application. Emissions from N_2O use decreased by 44% between 1990 and 2012 due to decreasing imports for medical purposes (anaesthesia).

2.3.4 Agriculture

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 2.12 and Figure 2.20).

Since 2005 emissions from agriculture have increased by 8% due to an increase in livestock population size but still remain 9% below 1990 levels.

This general trend is modified by the amount of synthetic nitrogen applied annually to agricultural soils. The amount was highest in 2008, when it amounted to more than 15,300 tonnes, but has decreased to less than 11,800 tonnes in 2012. This development was due to the economic crisis in Iceland which was accompanied by a weakening of the Icelandic króna thus increasing the price of imported fertilizer.

The largest sources of agricultural greenhouse gas emissions in 2012 were nitrous oxide emissions from agricultural soils: direct soil N_2O emissions, indirect soils N_2O emissions, and N_2O emissions from pasture and range manure accounted for 54% of total agriculture emissions (Figure 2.19). The remaining 46% were made up of methane emissions from enteric fermentation and methane and nitrous oxide emissions from manure management (i.e. before the manure is applied to soils).

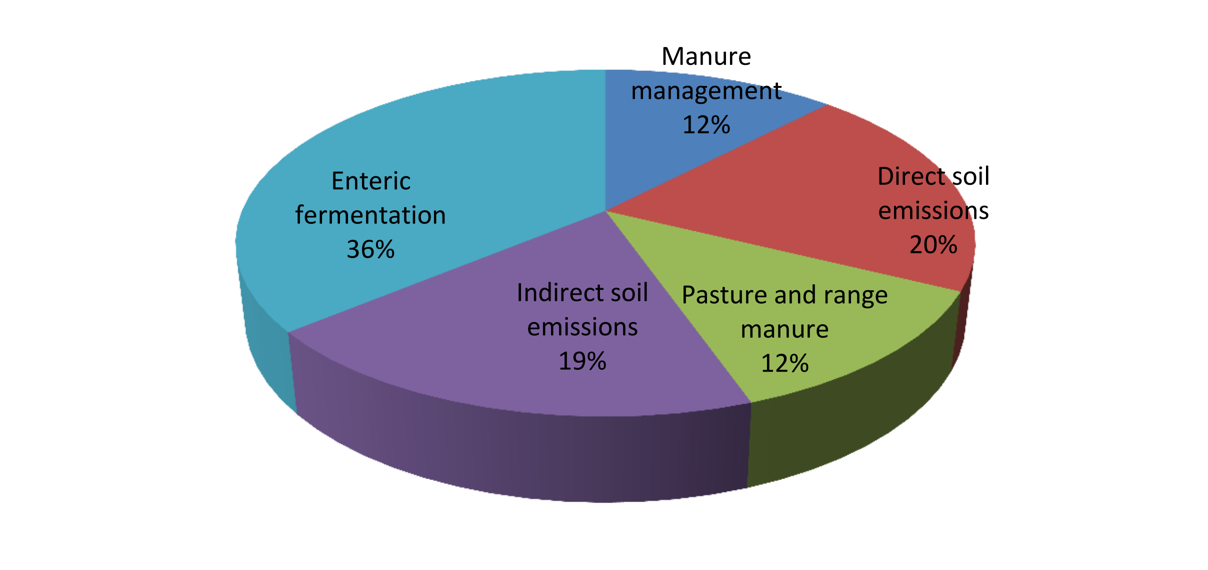

Figure 2.19. Greenhouse gas emissions in the agriculture sector 2012, distributed by source categories.

Table 2.12. Total greenhouse gas emissions from agriculture in 1990-2012 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Manure management	93	80	81	79	81	83	82	83	83
Direct soil emissions	149	135	143	124	156	138	131	129	136
Pasture and range manure	90	82	82	81	82	83	84	84	84
Indirect soil emissions	141	127	134	119	144	132	127	126	131
Enteric fermentation	264	244	239	232	242	244	246	246	244
Total emissions	737	667	680	635	704	680	671	669	678

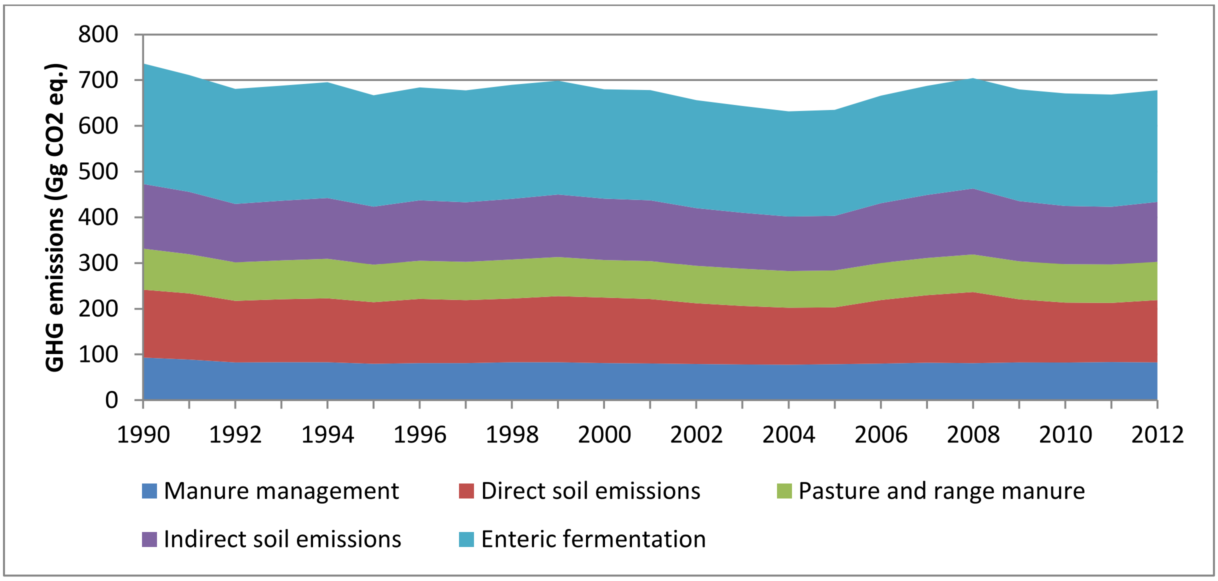

Figure 2.20. Total greenhouse gas emissions from agriculture 1990-2012 in Gg CO2-equivalents.

2.3.5 *Land Use, Land-Use Change and Forestry (LULUCF)*

Net emissions from the LULUCF sector in Iceland are high; the sector had the third highest net emissions in 2012 but the second most in 1990. A large part of the absolute value of emissions from the sector in 2012 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 2.13. 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 2.13. Emissions from the LULUCF sector from 1990-2012 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Forest Land remaining Forest Land	-15	-16	-19	-25	-22	-23	-29	-34	-36
Land converted to Forest Land	-26	-50	-86	-133	-153	-166	-184	-205	-232
Cropland remaining Cropland	764	872	963	1,018	1,026	1,022	1,015	1,008	1,00 3
Land converted to Cropland	434	297	177	95	69	65	64	64	64
Grassland remaining Grassland	168	220	243	274	275	275	274	274	274
Other land converted to grassland (revegetation)	-349	-380	-425	-473	-502	-509	-521	-534	-543
Other conversion to Grassland	127	84	75	59	71	75	77	76	78
Land converted to wetlands (reservoirs)	3	14	17	17	18	18	18	18	18
Settlements	NO	NO	NO	0	0	0	0	0	0
Wildfires (all landuse categories)	NO	NO	NO	NO	0	0	0	NO	0
Grassland non CO2 emissions	69	69	72	74	77	77	78	78	79
Net emissions LULUCF	1,175	1,110	1,016	906	859	834	791	746	706

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.

Iceland has elected revegetation as an activity under Article 3.4 of the Kyoto Protocol. Removals from revegetation amounted to 194 Gg (Net – Net accounting) in 2012. Removals from activities under Articles 3.3 (Afforestation, Reforestation, and Deforestation) amounted to 173 Gg in 2011. Afforestation falling under Convention reporting amounted to 233 Gg. The difference (60 Gg) is explained by a C-stock increase in afforestation before 1990 but younger than the 50 year conversion period.

2.3.6 Waste

Emissions from the Waste sector accounted for 4% of total GHG emissions in 2012. About 89% of these emissions were methane emissions from solid waste disposal on land. 6% were CH_4 and N_2O emissions from wastewater treatment and 4% were CO_2, CH_4 and N_2O emissions from waste incineration. The remaining 1% 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 2.14 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 2012 amounted to 36%.

Table 2.14. Total emissions from the Waste sector from 1990-2012 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Solid waste disposal	119	158	180	189	196	190	189	176	162
Wastewater	8	9	9	12	11	11	11	12	12
Incineration	18	12	7	5	7	8	7	9	7
Composting	NO	0.4	0.4	0.9	1.9	2.3	2.7	2.5	2.0
Total emissions	145	179	196	207	216	211	210	198	183

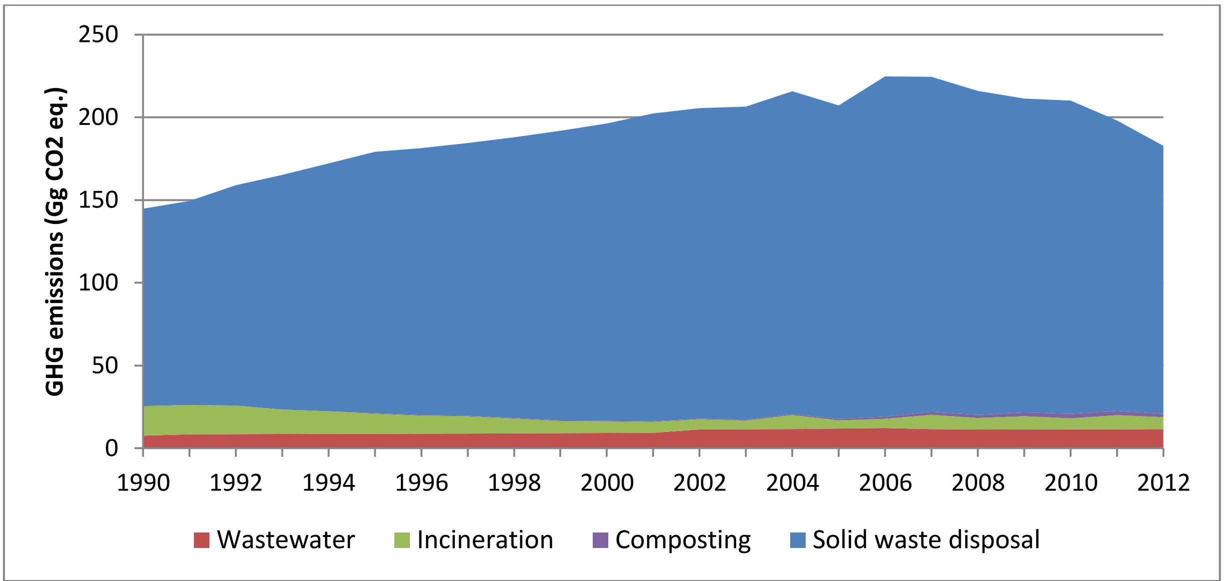

Figure 2.21. Aggregated GHG emissions of the Waste sector 1990-2012 in Gg CO_2-equivalents.

Total wastewater handling emissions increased by 52% 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 59% between 1990 and 2012 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.

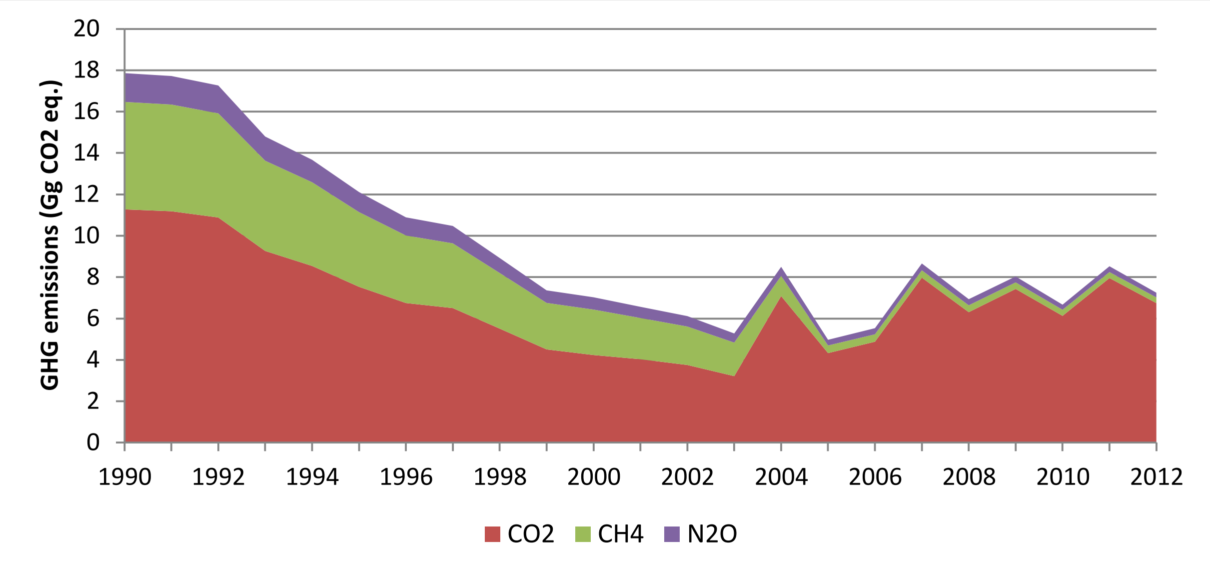

Figure 2.22. Emissions from waste incineration.

Emissions from composting have been steadily increasing between 1995 when composting started and 2010. Between 2010 and 2012 composting emissions decreased by 27% due to decreasing amounts of waste composted.

2.3.7 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 2.15.

In 2012, greenhouse gas emissions from ships and aircrafts in international traffic bunkered in Iceland amounted to a total of 630 Gg CO_2-equivalents, which corresponds to about 14% of the total Icelandic greenhouse gas emissions. Greenhouse gas emissions from marine and aviation bunkers increased by around 96% from 1990 to 2012; with a 1% increase between 2011 and 2012.

Looking at these two categories separately, it can be seen that greenhouse gas emissions from international marine bunkers increased by 84% from 1990 to 2012, while emissions from aircrafts increased by 101% during the same period. Between 2011 and 2012 emissions from marine bunkers decreased by 8% while emissions from aviation bunkers increased by 5%. Emissions from international bunkers are rising again after decline since 2007. Foreign commercial fishing vessels dominate the fuel consumption from marine bunkers.

Table 2.15. Greenhouse gas emissions from international aviation and marine bunkers 1990-2012 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Aviation	222	238	411	425	432	337	381	426	446
Marine	100	146	221	112	231	167	184	201	184
Total	322	384	632	538	663	503	565	626	630

2.4 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.

2.4.1 Nitrogen Oxides (NOx)

The main sources of nitrogen oxides in Iceland are commercial fishing, transport, and the manufacturing industry and construction, as can be seen in Figure 2.22). The NO_x emissions from commercial fishing rose from 1990 to 1996 when a substantial portion of the commercial fishing fleet was operating in distant fishing grounds. From 1996 emissions decreased, reaching the 1990 levels in 2001. Emissions rose again in 2002 but have declined since with exception of 2009 due to less fuel consumption. Emissions in 2012 were 26% below the 1990 level. Annual changes are inherent to the nature of fisheries. Emissions from transport are dominated by road transport. These emissions have decreased rapidly (by 33%) after the use of catalytic converters in all new vehicles became obligatory in 1995, despite the fact that fuel consumption has increased by 40%. The rise in emissions from the manufacturing industries and construction until 2007 are dominated by increased activity in the construction sector during the period. In 2008 the construction sector collapsed leading to much lower emissions from the sector. In 2012 emissions from manufacturing industry and construction were 39% lower than in 1990. This is due to the collapse of the construction sector (including lower emissions from the cement plant) and to less fuel consumption at fishmeal plants where fuel has been replaced with electricity and production has decreased. Total NO_x emissions, like the emissions from fishing, increased until 1996 and decreased thereafter until 2001. Emission rose again between 2001 and 2004 and then decreased again. Total NO_x emissions in 2012 were 24% below the 1990 level.

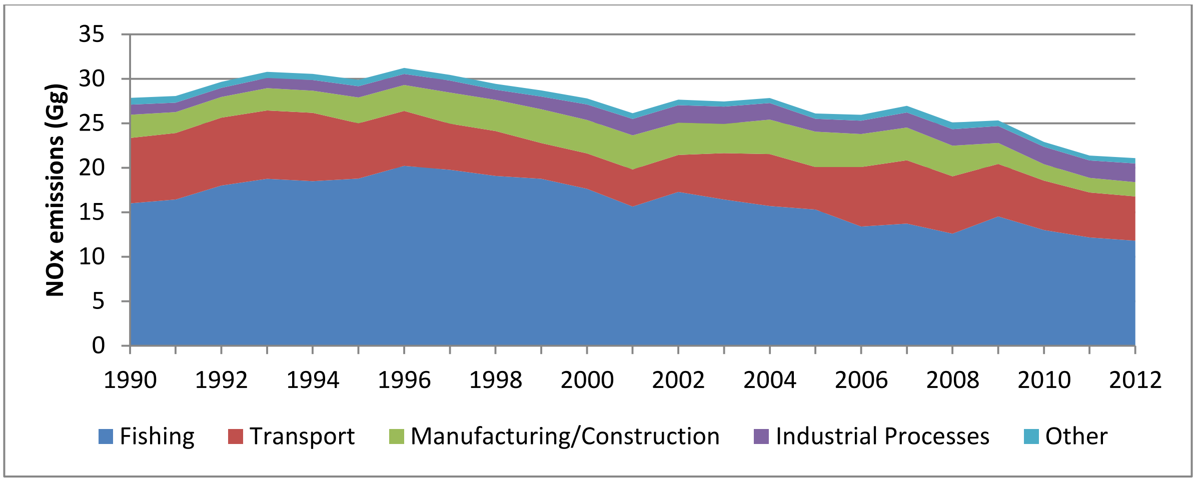

Figure 2.23. Emissions of NO_x by sector 1990-2012 in Gg.

2.4.2 *Non-Methane Volatile Organic Compounds (NMVOC)*

The main sources of non-methane volatile organic compounds are transport and solvent use, as can be seen in Figure 2.24. Emissions from transport are dominated by road transport. These emissions decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995. Emissions from solvent use have been around 1 Gg and show a downward trend in recent years. Other emissions include emissions from industrial processes, where food and drink production is the most prominent contributor. The total emissions showed a downward trend from 1994 to 2012. The emissions in 2012 were 56% below the 1990 level.

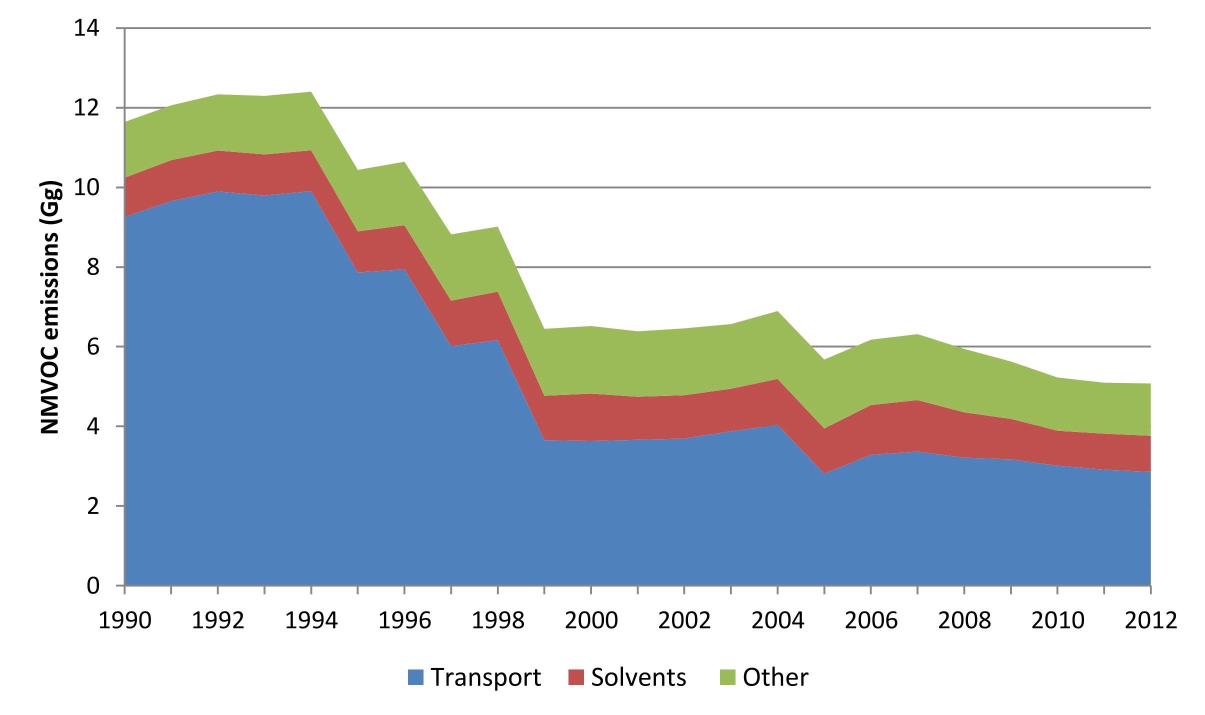

Figure 2.24. Emissions of NMVOC by sector 1990-2012 in Gg.

2.4.3 Carbon Monoxide (CO)

Transport is the most prominent contributor to CO emissions in Iceland, as can be seen in Figure 2.25. Emissions from transport are dominated by road transport. These emissions have decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995. Total CO emissions show, like the emissions from transport, a rapid decrease after 1990. The emissions in 2012 were 61% below the 1990 level.

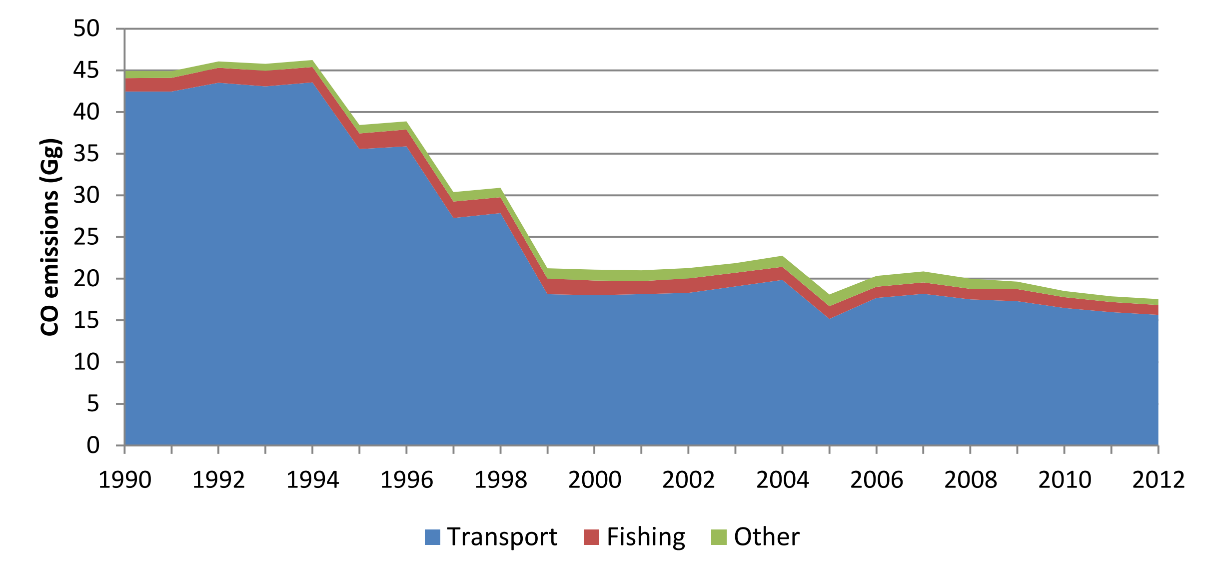

Figure 2.25. Emissions of CO by sector 1990-2012 in Gg.

2.4.4 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 384% since 1990 due to increased activity in this field, as electricity production at geothermal power plants has increased more than 17-fold since 1990. Other significant sources of sulphur dioxide in Iceland are industrial processes, manufacturing industry and construction, 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, 88,839 tonnes of aluminium were produced at one plant and 62,792 tonnes of ferroalloys at one plant. In 2012 821,021 tonnes of aluminium were produced at three plants and 118,359 tonnes of ferroalloys were produced at one plant. This led to increased emissions of sulphur dioxide (329% 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; the emissions were 64% below the 1990 level in 2012.

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 2012 were 3% below the 1990 level although fuel consumption was 26% less.

In 2012 total sulphur emissions in Iceland, calculated as SO_2, were in 295% above the 1990 level, but 107% when excluding emissions from geothermal power plants.

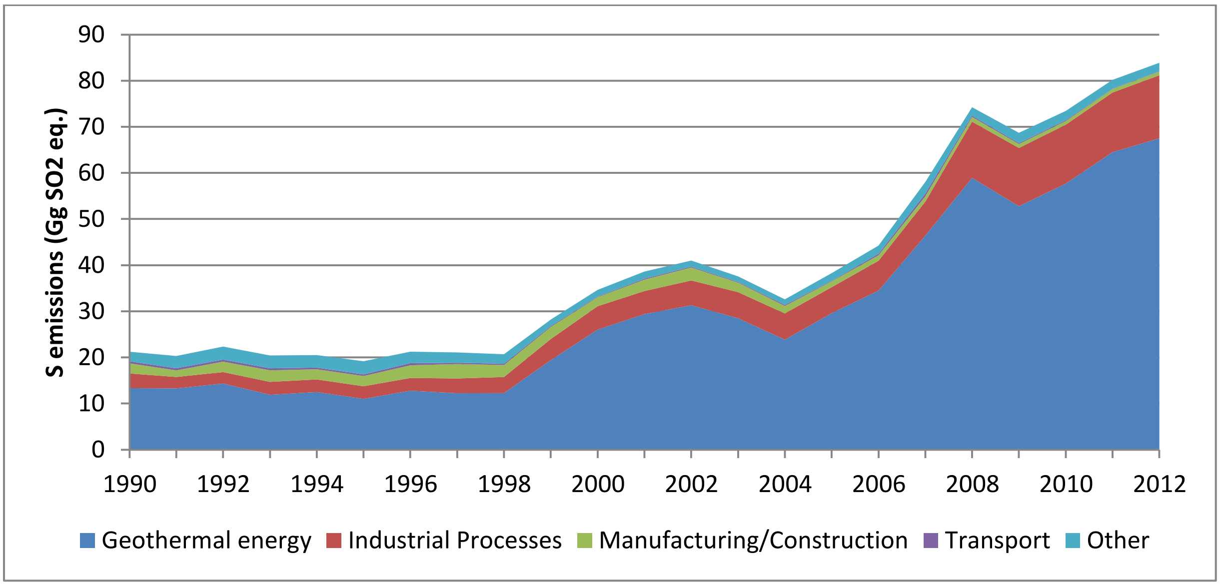

Figure 2.26. Emissions of S (sulphur) by sector 1990-2012 in Gg SO_2-equivalents.

In 2010 the volcano Eyjafjallajökull started eruption. The eruption lasted from 14th of April until 23rd of May. During that time 127 Gg of SO_2 were emitted or 71% more than total man made emissions in 2010. In 2011 the volcano Grímsvötn started erupting. The eruption lasted from 21st until 28th of May. During that time around 1000 Gg 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

3.1 Overview

The Energy sector in Iceland is unique in many ways. Iceland ranks 1st among OECD countries in the per capita consumption of primary energy. The per capita consumption in 2012 was around 786 GJ. However, the proportion of domestic renewable energy in the total energy budget is about 85%, 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 production industry used around 75% of the total electricity produced in Iceland in 2012. 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). Only 0.016% of the electricity in 2012 was produced with fossil fuels.

The Energy sector accounts for 38.5% (fuel combustion 34.6%, geothermal energy 3.9%, fugitive emissions from fuels 0%) of the GHG emissions in Iceland. Energy related emissions decreased by 3.4% from 1990 to 2012. Emissions from fuel combustion decreased by 10.0% from 1990 to 2012 while emissions from geothermal energy increased by 179.8%. From 2011 to 2012 the emissions from fuel combustion decreased by 2.7%, while emissions from geothermal energy decreased by 5.0%. Total emissions related to energy decreased by 2.9% from 2011 to 2012. Fisheries and road traffic are the sector’s largest single contributors. Combustion in manufacturing industries and construction is also an important source. No recalculations have been made in the Energy sector since last submission.

3.1.1 Methodology

Emissions from fuel combustion activities are estimated at the sectoral level based on the methodologies suggested by the IPCC Guidelines and the Good Practice Guidance. 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 IPCC sectors perfectly so EA has made adjustments to the data where needed to better reflect the IPCC categories. This applies for the sectors 1A1a 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 (955 tonnes in 2012), as would be needed for the electricity production (714 tonnes in 2012), 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 2012 there was a surplus in the energy industries category, so 241 tonnes were added to the category 10X40 House heating and swimming pools. So now the category 10X40 has 1987 tonnes in 2012 (1746+241).
- NEA has estimated that 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 2012. These values are subtracted from the adjusted 10X40 category, leaving 1687 tonnes in the category in 2012 (1987-300). This rest is then 1A4c – Residential.
- For years where there is still fuel in the category 10X90 Other (260 tonnes were left in that category in 2012), this is added to the 10X5X Industry (originally with 5151 tonnes in 2012). This is the fuel use in 1A2 – Industry (5151+260=5411 tonnes in 2012).

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 Source Analysis

The key source analysis performed for 2012 has revealed, as indicated in Table 1.1, that in terms of total level and/or trend uncertainty the key sources in the Energy sector are the following:

- Manufacturing Industries and Construction – CO_2 (1A2)
  - » This is a key source in level (1990, 2012) and trend
- Road Transport – CO_2 (1A3b)
  - » This is a key source in level (1990, 2012) and trend
- Road Transport – N_2O (1A3b)
  - » This is a key source in trend
- Non-Road Transport – CO_2 (1A3a/d)
  - » This is a key source in level (1990) and trend
- Residential/institutional/commercial – CO2 (1A4a/b)
  - » This is a key source in level (1990) and trend
- Fishing – CO_2 (1A4c)
  - » This is a key source in level (1990, 2012) and trend
- Fugitive emissions from fuels – CO_2 (1B)
  - » This is a key source in level (1990, 2012) and trend

3.1.3 Completeness

Table 3.1 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 3.1. 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
Energy industries										
- Public electricity and heat production	E	E	E	NA	NA	NA	E	E	E	E
- Petroleum refining	NOT OCCURRING									
- Manufacture of Solid Fuels	NOT OCCURRING									
Manufacturing Industries and Construction										
- Iron and Steel	E	E	E	NA	NA	NA	E	E	E	E
- Non-ferrous metals	E	E	E	NA	NA	NA	E	E	E	E
- Chemicals	E	E	E	NA	NA	NA	E	E	E	E
- Pulp, paper and print	NOT OCCURRING									
- Food Processing, Beverages and Tobacco	E	E	E	NA	NA	NA	E	E	E	E
- Other	E	E	E	NA	NA	NA	E	E	E	E
Transport										
- Civil Aviation	E	E	E	NA	NA	NA	E	E	E	E
- Road Transportation	E	E	E	NA	NA	NA	E	E	E	E
- Railways	NOT OCCURRING									
- Navigation	E	E	E	NA	NA	NA	E	E	E	E
- Other Transportation	NOT OCCURRING									
Other Sector										
- Commercial/Institutional	E	E	E	NA	NA	NA	E	E	E	E
- Residential	E	E	E	NA	NA	NA	E	E	E	E
- Agriculture/Forestry/Fisheries	E	E	E	NA	NA	NA	E	E	E	E
Other	NOT OCCURRING									
Fugitive Emissions from Fuels										
- Solid Fuels	NOT OCCURRING									
- Oil and Natural Gas	E	E	NA	NA	NA	NA	NA	NA	E	NA
- Geothermal Energy	E	NA	NA	NA	NA	NA	NA	NA	NA	E
International Transport										
- Aviation	E	E	E	NA	NA	NA	E	E	E	E
- Marine	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 Energy Industries (1A1)

Energy Industries include emissions from electricity and heat production. Iceland has extensively utilised renewable energy sources for electricity and heat production, thus emissions from this sector are low. Emissions from Energy Industries accounted for 0.4% of the sectors total and 0.2% of the total GHG emissions in Iceland in 2012.

Activity data for the energy industries 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 revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and presented in Table 3.4 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 1-15 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. The EF for CH_4 is the one for large diesel fuel engines (4 kg/TJ) Default emission factors (EFs) from Tables 1.7 to 1.11 in the Reference Manual were used where EFs are missing. As there is no EF for N2O in Table 1-15, the default EF from Table 1-8, for oil used in energy industries (0.6 kg/TJ), is used in the inventory. It has to be noted that only 0.016% 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 GL. 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.

3.2.1 Electricity Production

Electricity was produced from hydropower, geothermal energy and fuel combustion in 2012 (Table 3.2) with hydropower as the main source of electricity (Orkustofnun, 2013). Electricity was produced with fuel combustion at a two locations that are located far from the distribution system (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.

Table 3.2. Electricity production in Iceland (GWh).

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Hydropower	4,159	4,678	6,352	7,014	12,427	12,279	12,592	12,507	12,337
Geothermal	283	288	1,323	1,658	4,037	4,553	4,465	4,701	5,210
Fuel combustion	5.6	8.4	4.4	7.8	2.7	2.9	1.7	2.1	2.8
Total	**4,447**	**4,977**	**7,679**	**8,680**	**16,467**	**16,835**	**17,059**	**17,210**	**17,549**

Activity data

Activity data for electricity production is calculated from the information on electricity production, from the energy content of the gasoil (43.33 TJ/kt) assuming 34% efficiency. Only 0.016% of the electricity in Iceland is produced with fuel combustion. Activity data for fuel combustion and the resulting emissions are given in Table 3.3.

Table 3.3. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from electricity production.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gas/Diesel oil (kt)	1.4	2.1	1.1	1.9	0.7	0.7	0.4	0.5	0.7
Emissions (Gg)	**4.4**	**6.7**	**3.6**	**6.3**	**2.2**	**2.3**	**1.4**	**1.7**	**2.3**

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 3.4 along with sulphur content of the fuels.

Table 3.4. 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	43.33	20.20	0.99	3.18	0.2

The resulting emissions of GHG from electricity produced from fuels in GHG per kWh amount to 800 g of CO_2 per kWh.

Emissions from hydropower reservoirs are included in the LULUCF sector and emissions from geothermal power plants are reported in sector 1B2. Emissions from hydropower reservoirs amounted to 18 Gg of CO_2-equivalents and emissions from geothermal power plants to 172 Gg of CO_2-equivalents, in 2012. The resulting emissions of GHG per kWh amount to 1.4 g CO_2-equivalents/kWh for hydropower plants and to 33 g CO_2-equivalents/kWh for geothermal energy. The weighted average GHG emissions from electricity production in Iceland in 2012 were thus 11 g/kWh.

Uncertainties

The estimate 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 Heat Production

Geothermal energy was the main source of heat production in 2012. 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 in case of electricity shortages or problems in the distribution system. Three district heating stations burn waste to produce heat and are connected to the local distribution system. Emissions from these waste incineration plants are reported under Energy Industries.

Activity Data

Activity data for heat production with fuel combustion and waste incineration and the resulting emissions are given in Table 3.5. No fuel consumption for heat production was reported by the NEA for 2010 and 2011.

Table 3.5. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equvalents) from heat production.

	1990	1995	2000	2005	2007	2008	2009	2010	2011	2012
Residual fuel oil	3.0	3.1	0.1	0.2	4.5	0.1	0.1	-	-	0.1
Gas/Diesel oil	-	-	-	-	-	-	-	-	-	-
Solid waste	-	4.7	6.1	5.4	12.0	10.3	9.5	8.2	7.5	5.8
Emissions (GHG)	**9.2**	**12.3**	**3.8**	**3.1**	**21.3**	**6.0**	**6.7**	**5.5**	**5.3**	**5.1**

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 1996 IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance. They are presented in Table 3.6 along with the sulphur content of the fuels. The CO_2 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 the 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 0.78 t CO_2 per tonne waste (cf. chapter 8.4.3).

Table 3.6: 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	40.19	21.10	0.99	3.08	1.8
Gas/Diesel oil	43.33	20.20	0.99	3.18	0.2
Solid waste	10.70	14.53	1	0.60[1]	0.17

[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 estimate 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.

3.3 Manufacturing Industries and Construction (1A2)

Emissions from the Manufacturing Industries and Construction account for 10.7% of the Energy sector's total and 4.1% of total GHG emissions in Iceland in 2012. Mobile Combustion in the Construction sector accounts for 56.6% of the total emissions from Manufacturing Industries and the Construction sector.

3.3.1 Manufacturing Industries, Stationary Combustion

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 law no. 65/2007 (metal production, cement) and from green accounts submitted by the industry in accordance with regulation 851/2002 for industry not falling under law no. 65/2007. All major industries, falling under law no. 65/2007 (metal and cement industries) 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 2012 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). 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 3.7 and Table 3.8). Emissions from fuel use in the ferroalloys production is reported under 1A2a.

Table 3.7. Fuel use (kt) and emissions (GHG total in Gg CO_2-equivalents) from stationary combustion in the manufacturing industry.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gas/Diesel oil	5.1	1.1	10.3	22.2	8.6	9.8	9.4	4.9	5.4
Residual fuel oil	55.9	56.2	46.2	25.0	20.5	17.6	16.5	17.3	17.8
LPG	0.5	0.4	0.9	0.9	1.9	1.2	1.0	1.0	1.8
Electrodes (residue)	0.8	0.3	1.5	-	0.5	0.4	0.4	-	-
Steam Coal	18.6	8.6	13.3	9.9	21.5	10.2	3.6	7.8	-
Petroleum coke	-	-	-	8.1	-	-	-	-	-
Waste oil	-	5.0	6.0	1.8	2.2	0.9	1.4	1.2	1.2
Total Emissions	**241**	**210**	**228**	**205**	**157**	**118**	**97**	**94**	**80**

Emission Factors

The CO_2 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 revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance. They are presented in Table 3.8 along with sulphur content of the fuels.

Table 3.8. Emission factors for CO_2 from fuel combustion and S-content of fuel (IE: Included Elsewhere).

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t fuel]	S-content [%]
Kerosene (heating and aviation)	44.59	19.50	0.99	3.16	0.2
Gasoline	44.80	18.90	0.99	3.07	0.005
Gas/Diesel oil	43.33	20.20	0.99	3.18	0.2
Residual fuel oil	40.19	21.10	0.99	3.08	1.8
Petroleum coke	31.00	27.50	0.99	3.09	IE*
LPG	47.31	17.20	0.99	2.95	0.05
Waste oil	20.06	23.92	0.99	1.74	NE
Electrodes (residue)	31.35	31.42	0.98	3.54	1.55
Steam coal	27.59	25.80	0.98	2.56	0.9

**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 other pollutants are taken from Table 1.16 and 1.17 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Where EFs were not available the default EF from Tables 1.7 to 1.11 in the Reference Manual was used. Table 3.9 gives an overview of the used EFs.

Table 3.9. Emission factors CH4 and N2O in the manufacturing industry

	CH_4 [kg/TJ]	N_2O [kg/TJ]
Gasoil: cement and silicium production	1.0	0.6
Gasoil: other use	2.0	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	2.0	0.6
Waste oil: fishmeal production	3.0	0.3
Waste oil: cement production	1.0	0.6
LPG	1.1	NA
Petroleum coke, coal, electrodes residues: cement production	1.0	1.4

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.

3.3.2 Manufacturing Industries, Mobile Combustion

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, (thereby reported as road transport), as well as it happens that fuel sold to contractors, for use on machinery, is used for road transport (but reported under construction). This is, however, very minimal and the deviations is believed to level each other 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 3.10.

Table 3.10. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from mobile combustion in the construction industry.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gas/Diesel oil	38	47	62	68	59	41	32	28	29
Emissions	**136**	**167**	**222**	**243**	**212**	**146**	**115**	**99**	**104**

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 3.11.

Table 3.11. 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	43.33	20.20	0.99	3.18	0.7	1.3

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 (1A3)

Emissions from Transport accounted for 49.7% of the Energy sector's total and 19.1% of the total GHG emissions in Iceland in 2012. Road Transport accounts for 95.9% of the emissions in the transport sector.

3.4.1 Civil Aviation

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

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 3.12.

Table 3.12. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from domestic aviation.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Jet kerosene	8.409	8.253	7.728	7.390	7.601	6.271	6.066	6.027	6.133
Gasoline	1.681	1.131	1.102	0.872	0.731	0.649	0.648	0.411	0.492
Emissions	**32**	**30**	**28**	**26**	**26**	**22**	**21**	**20**	**21**

Emission Factors

The emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 3.13. Emissions of SO_2 are calculated from S-content in the fuels.

Table 3.13. Emission factors for CO_2 and other pollutants for aviation.

	NCV [TJ/kt]	C EF [t C/TJ]	Fraction oxidised	EF CO_2 [t CO_2/t]	NO_x [kg/TJ]	CH_4 [kg/TJ]	NMVOC [kg/TJ]	CO [kg/TJ]	N_2O [kg/TJ]
Jet kerosene	44.59	19.50	0.99	3.16	300	0.5	50	100	2
Gasoline	44.80	18.90	0.99	3.07	300	0.5	50	100	2

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.

Planned Improvements

Planned improvements involve moving emission estimates from aviation to the Tier 2 methodology by next submission.

3.4.2 Road Vehicles

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.

Activity Data

Total use of diesel oil and gasoline are based on the NEA's annual sales statistics for fossil fuels (Table 3.14).

Table 3.14. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from road transport.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasoline	127.812	135.601	142.599	156.730	155.115	154.932	148.214	142.688	136.841
Diesel oil	36.567	36.862	47.463	83.478	113.964	114.491	106.433	106.293	110.540
Emissions	**529**	**561**	**633**	**800**	**891**	**892**	**844**	**824**	**818**

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 2012 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 2012 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.

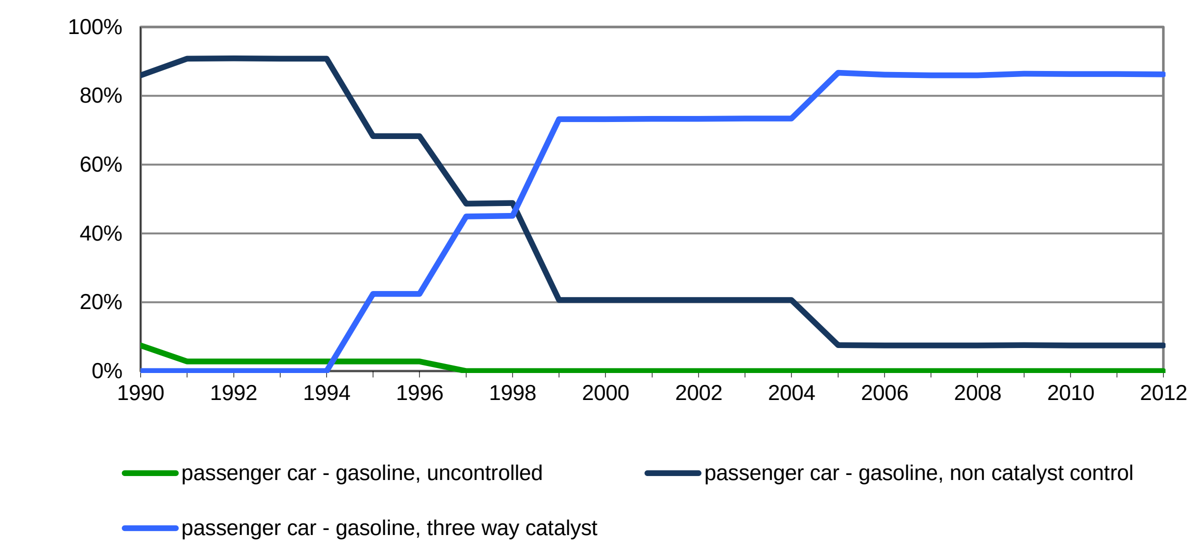

Figure 3.1. Passenger cars by emission control technology.

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 3.15.

Table 3.15. Emission factors for GHG from European vehicles, g/kg fuel.

	CH_4	N_2O	CO_2
Passenger car – gasoline, uncontrolled	0.8	0.06	3,180
Passenger car – gasoline, non catalyst control	1.1	0.08	3,180
Passenger car – gasoline, three way catalyst	0.3	0.8	3,180
Light duty vehicle – gasoline	0.8	0.06	3,180
Heavy duty vehicle – gasoline	0.7	0.04	3,180
Motorcycles - gasoline	5.0	0.07	3,180
Passenger car – diesel	0.08	0.2	3,140
Light duty vehicle – diesel	0.06	0.2	3,140
Heavy duty vehicle – diesel	0.2	0.1	3,140

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.

Planned Improvements

It is planned to implement COPERT, a software tool used worldwide to calculate air pollutant and greenhouse gas emissions from road transport, in the 2015 submission.

3.4.3 National Navigation

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

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 3.16.

Table 3.16. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from national navigation.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gas/Diesel oil	11.749	7.043	3.425	6.199	13.179	6.270	8.464	5.526	4.142
Residual fuel oil	7.170	4.755	0.542	0.881	4.192	3.709	2.612	0.330	0.181
Emissions	**60**	**37**	**13**	**23**	**55**	**32**	**35**	**19**	**19**

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 3.17.

Table 3.17. 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	43.33	20.20	0.99	3.18	2	0.086	7	0.30
Residual fuel oil	40.19	21.10	0.99	3.08	2	0.084	7	0.28

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.

3.4.4 International Bunker Fuels

Emissions from international aviation and marine bunker fuels are excluded from national totals as is outlined in the IPCC Guidelines.

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 Guidelines and presented in Table 3.13 above.

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 3.17 above.

3.5 Other Sectors (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. Residential heating with electricity is subsidized and occurs in areas far from public heat plants. Commercial fuel combustion includes the heating of swimming pools, but only a few swimming pools in the country are heated with oil. 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 accounted for 29.1% of the Energy sector's total and for 11.2% of total GHG emissions in Iceland 2012. Fishing accounted for 98% 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.

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 3.18.

Table 3.18. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from the commercial/institutional sector.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gas/Diesel oil	1.8	1.6	1.6	1.0	0.3	0.3	0.3	0.3	0.3
Waste oil	3.3	-	-	-	-	-	-	-	-
LPG	0.3	0.3	0.5	0.5	0.1	0.1	0.2	0.2	0.5
Solid waste	-	0.5	0.6	0.5	0.4	0.4	0.4	0.2	0.2
Emissions	**12.3**	**6.3**	**6.8**	**4.9**	**1.5**	**1.4**	**1.7**	**1.6**	**2.5**

Activity data for fuel combustion in the Residential sector and the resulting emissions are given in Table 3.19. 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 utilisation 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.

Table 3.19. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from the residential sector.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gas/Diesel oil	8.8	6.4	6.0	3.2	2.0	2.1	1.9	1.4	1.7
LPG	0.4	0.5	0.7	0.9	1.1	1.6	1.4	0.7	0.6
Kerosene	0.5	0.2	0.1	0.2	0.8	4.0	1.2	3.2	0.1
Emissions	**30.6**	**22.1**	**21.8**	**13.6**	**12.0**	**24.0**	**14.2**	**16.6**	**7.5**

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 3.8 along with sulphur content of the fuels. Emissions of SO2 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 3.20 gives an overview of the used EFs.

Table 3.20. Emission factors for CH_4 and N_2O in the residential, commercial and institutional sector

	CH_4 [kg/TJ]	N_2O [kg/TJ]
Gasoil	0.7	0.6
LPG	1.1	NA
Kerosene	0.7	0.6
Waste oil	10.0	0.6

The CO_2 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 8.4.3). The IEF for the sector shows fluctuations over the time series. From 1993 onwards waste has been incinerated to produce heat at two locations (swimming pools, school building). The IEF for waste is considerably higher than for liquid fuel. Further waste oil was used in the sector from 1990 to 1993. This combined explains the rise in IEF for the whole sector.

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

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.

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 3.21.

Table 3.21. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from the fishing sector.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gas/Diesel oil	174.9	191.3	211.1	171.7	127.7	144.7	128.2	120.1	116.2
Residual fuel oil	32.4	53.4	16.0	26.3	36.3	44.6	41.4	38.5	37.7
Emissions	**662.3**	**779.8**	**727.5**	**632.9**	**522.7**	**603.4**	**540.2**	**505.3**	**490.3**

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 3.17 above.

Uncertainties

The estimate 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. In that work these issues will be tackled.

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 1(A)d.

3.7 Fugitive Emissions (1B)

3.7.1 Distribution of oil products (1B2 av)

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 Gg per 1000 m^3 and the CH_4 EF is 2.5E-05 Gg 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 in Table 3.22.

Table 3.22. Fuel use (kt) and resulting emissions from distribution of oil products.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasoline	129,353	132,191	153,421	164,167	152,382	157,242	144,530	144,999	138,443
Jet Kerosene	78,697	72,284	146,546	139,366	152,567	116,593	120,359	141,797	148,581
Other Kerosene	34	24	2	9	6	5	2	6	27
Gas/Diesel oil	335,776	309,349	427,921	418,229	356,251	358,606	292,308	300,322	278,511
Residual Fuel Oil	105,958	151,920	64,077	62,897	94,174	96,485	93,051	88,710	105,921
LPG	1,286	1,322	1,676	2,460	3,943	3,037	2,620	2,511	792
Emissions	**0.41**	**0.42**	**0.51**	**0.50**	**0.48**	**0.46**	**0.43**	**0.41**	**0.43**

3.7.2 Geothermal Energy (1B2 d other)

Overview

Iceland relies heavily on geothermal energy for space heating (90%) and to a significant extent for electricity production (30% of the total electricity production in 2012). 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 et al., 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.

Key Source Analysis

The key source analysis performed for 2012 has revealed that geothermal energy is a key source in terms of both level and trend, as indicated in Table 1.1.

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 3.23 shows the electricity production with geothermal energy and the total CO_2, CH_4 and sulphur emissions (calculated as SO_2).

Table 3.23. Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Electricity production (GWh)	283	288	1323	1658	4037	4553	4465	4701	5210
Carbon dioxide emissions (Gg)	61	82	153	116	184	168	189	179	170
Methane emissions (Gg CO_2 eq)	0.3	0.3	1.3	1.6	3.9	4.4	3.7	2.9	2.3
Sulphur emissions (as SO_2, Gg)	13	11	26	30	59	53	58	64	68

Uncertainties

The estimate 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

4.1 Overview

The production of raw materials is the main source of Industrial Process related emissions for CO_2, N_2O and PFCs. 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 42% of the GHG emissions in Iceland in 2012. By 2012, emissions from the industrial processes sector were 117% above the 1990 level. This is mainly due to the expansion of energy intensive industry. The dominant category within the Industrial Process sector is metal production, which accounted for 92% of the sector's emissions in 2012. Figure 4.1 shows the location of major industrial plants in Iceland.

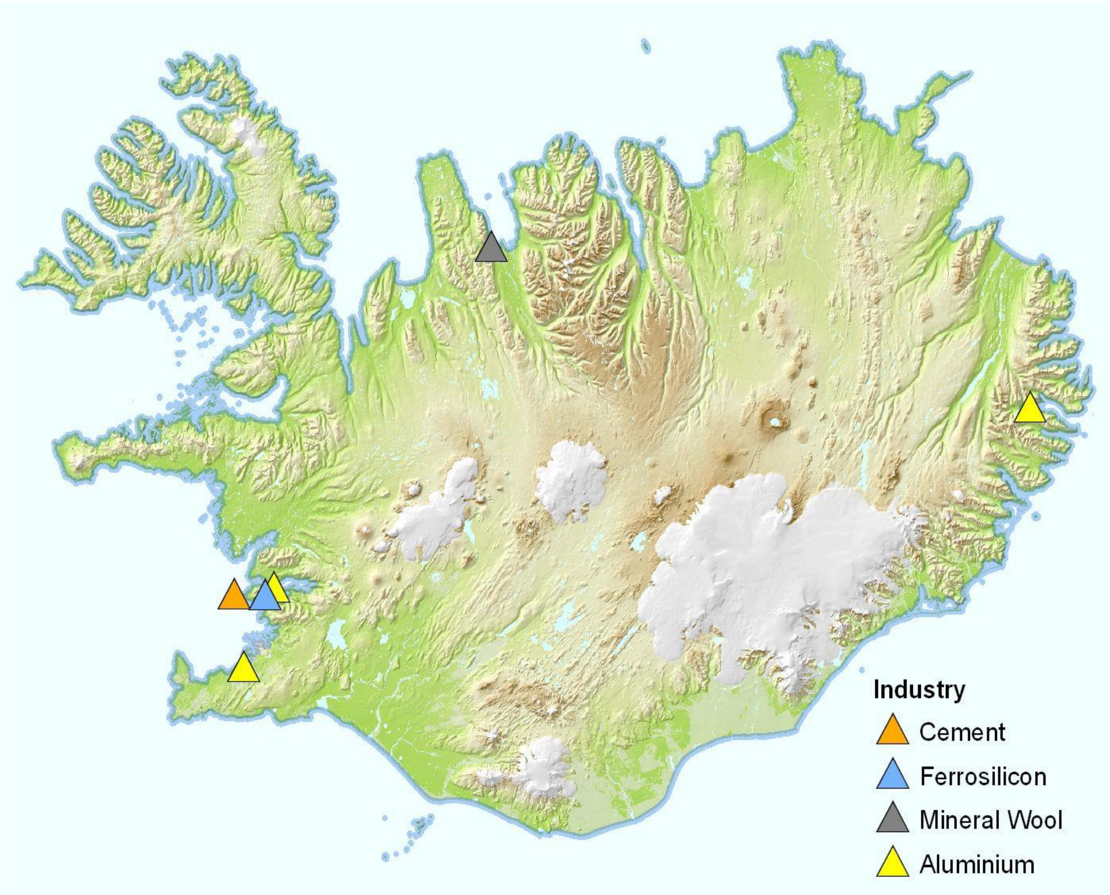

Figure 4.1. Location of major industrial sites in Iceland.

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. Four projects fulfilled the provisions of Decision 14/CP.7 in the first commitment period (CP1) of the Kyoto Protocol (2008 – 2012). Total CO_2 emissions from these projects that fall under the provisions of Decision 14/CP.7 amounted to 1,279 Gg in 2012 and to 6,079 Gg in total in CP1. Total emissions savings from these projects are 3,972 Gg in 2012 and 19,108 Gg in total in CP1.

4.1.1 Methodology

Greenhouse gas emissions from industrial processes are calculated according to methodologies suggested by the Revised 1996 IPCC Guidelines and the IPCC Good Practice Guidance.

4.1.2 Key Source Analysis

The key source analysis performed for 2012 has revealed the following greenhouse gas sources from the Industrial Processes Sector as key sources in terms of total level and/or trend (Table 1.1).

- Emissions from Mineral industry – CO_2 (2A)
  - This is a key source in level (1990) and trend.
- Emissions from Chemical industry – N_2O (2B)
  - This is a key source in level (1990).
- Emissions from Ferroalloys – CO_2 (2C2)
  - This is a key source in level (1990, 2012) and trend.
- Emissions from Aluminium Production – CO_2 (2C3)
  - This is a key source in level (1990, 2012) and trend.
- Emissions from Aluminium Production – PFCs (2C3)
  - This is a key source in level (1990, 2012) and trend
- Emissions from Consumption of halocarbons and SF_6 – HFCs (2F)
  - This is a key source in level (2012) and trend

4.1.3 Completeness

Table 4.1 gives an overview of the IPCC source categories included in this chapter and presents the status of emission estimates from all subcategories in the Industrial Process sector.

Table 4.1. Industrial Processes – Completeness (E: estimated, NE: not estimated, NA: not applicable, IE: included elsewhere).

	Greenhouse gases						Other gases			
Sector	**CO_2**	**CH_4**	**N_2O**	**HFC**	**PFC**	**SF_6**	**NO_x**	**CO**	**NMVOC**	**SO_2**
Mineral Products:										
Cement Production	E	NE	NE	NA	NA	NA	NE	NE	NE	IE[1]
Lime Production	NOT OCCURRING									
Limestone and Dolomite Use	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soda Ash Production and Use (IE)[2]	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
Asphalt Roofing	NOT OCCURRING									
Road Paving with Asphalt	NE	NE	NE	NA	NA	NA	NA	NA	E	NA
Other (Mineral Wool Production)	E	NE	NE	NA	NA	NA	NE	E	NE	E
Chemical Industry										
Ammonia Production (IE)[3]	NA	NA	E	NA	NA	NA	E	NA	NA	NA
Nitric Acid Production	NOT OCCURRING									
Adipic Acid Production	NOT OCCURRING									
Carbide Production	NOT OCCURRING									
Other (Silicium Production – until 2004)	E	NE	NE	NA	NA	NA	E	NE	NE	NE
Other (Fertilizer Production – until 2001)	NA	NE	E	NA	NA	NA	E	NE	NE	NE
Metal Production										
Iron and Steel Production	NOT OCCURRING									
Ferroalloys Production	E	E	NA	NA	NA	NA	E	E	E	E
Aluminium Production	E	NE	NE	NA	E	NA	NE	NE	NE	E
SF_6 used in aluminium/magnesium foundries	NOT OCCURRING									
Other	NOT OCCURRING									
Other Production										
Pulp and Paper	NOT OCCURRING									
Food and Drink	NE	NA	NA	NA	NA	NA	NA	NA	E	NA
Production of HFCs and SF_6	NOT OCCURRING									
Consumption of HFCs and SF_6	NA	NA	NA	E	NO	E	NA	NA	NA	NA
Other	NOT OCCURRING									

1 SO_2 emissions from cement production are reported under the Energy sector, based on measurements.
2 Soda Ash was used at the Silicon plant which closed down in 2004, resulting CO_2 emissions from soda ash use are reported under silicon 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 fertilizer production.

4.1.4 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. 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

4.2.1 Cement Production (2A1)

The single operating cement plant in Iceland produced (the plant was closed down in 2011) 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 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.

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

Where,

M_{cl} = Clinker production

EF_{cl} = Clinker emission factor; $EF_{cl} = 0.785 \times$ CaO content

CF_{ckd} = Correction factor for non-recycled cement kiln dust.

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 single operating cement plant in Iceland had been slowly decreasing since 2000. 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 4.2. Clinker production and CO_2 emissions from cement production from 1990-2012.

Year	Cement production [t]	Clinker production [t]	CaO content of clinker	EF	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	-	-	-	-	-	-

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 4.2. The corrected emission factor for CO_2 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 (CKD) was 107.5% for all years from 1990 to 2004, 110% from 2005 – 2008 and 108% in 2009 and 2010. In 2011 the CKD correction factor was 110%.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from Cement Production is 8% (with an activity data uncertainty of 5% and emission factor uncertainty of 6.5%). This can be seen in the quantitative uncertainty table in Annex II.

4.2.2 Limestone and Dolomite Use (2A3)

Limestone has been used at the Elkem Iceland Ferrosilicon plant since 1999. Emissions are calculated based on the consumption of limestone and emission factors from the IPCC Guidelines. The consumption of limestone is collected from Elkem Iceland by EA through an electronic reporting form. The emission factor is 440 kg CO_2 per tonne limestone, assuming the fractional purity of the limestone is 1.

4.2.3 Road Paving with Asphalt (2A6)

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. The emission factors for NMVOC are taken from Table 3.1, in chapter 2.A.6 in the EMEP/EEA emission inventory guidebook (2009). 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.

4.2.4 Mineral Wool Production (2A7)

Emissions of CO_2 and SO_2 are calculated from the amount of shell sand and electrodes used in the production process. Emissions of CO are based on measurements that were made in year 2000 at the single plant in operation. Activity data is provided by the industry (application for free allowances under the EU ETS for the years 2005 to 2010 and information from the plant for other years).

4.3 Chemical Industry (2B5)

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. Emissions of CO_2 and NO_x were estimated on the basis of the C-content and N-content of the sludge. Emissions also occur from the use of soda ash in the production process and those emissions are reported here. 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.

4.4 Metal Production

4.4.1 Ferroalloys (2C2)

Ferrosilicon (FeSi, 75% Si) is produced at one plant, Elkem Iceland at Grundartangi. The raw material used is quartz (SiO_2). The quartz is reduced to Si and CO using reducing agents. The waste gas CO and some SiO are oxidized as part of the process to form CO_2 and silica dust. In the production raw ore, carbon material, and slag forming materials are mixed and heated to high temperatures for reduction and smelting. 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. Electric (submerged) arc furnaces with Soederberg electrodes are used. The furnaces are semi-covered. Emissions of CO_2 originate from the use of coal and coke as reducing agents, as well as from the consumption of electrodes. Emissions are calculated according to the Tier 3 method from the 2006 IPCC Guidelines, based on the consumption of reducing agents and electrodes and plant specific carbon content. The amount of carbon in the ferrosilicon and coarse and fine microsilica is subtracted. The carbon content of electrodes and reducing agents is calculated by using equation 4.19 of the 2006 IPCC Guidelines, based on measurements at the plant. The IEF fluctuates over the time series depending on the consumption of different reducing agents and electrodes (3.13 – 3.6 t CO_2/t FeSi). 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.

Activity Data

The consumption of reducing agents and electrodes are collected from Elkem Iceland by EA through an electronic reporting form. Activity data for raw materials, products and the resulting emissions are given in Table 4.3.

Table 4.3. Raw materials (kt), production (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from Elkem.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Electrodes	3.8	3.9	6.0	6.0	4.9	5.1	4.8	4.9	5.1
Coking coal	45.1	52.4	88.0	86.9	86.7	87.8	96.1	96.8	105.1
Coke oven coke	24.9	30.1	35.8	42.6	31.8	31.3	30.3	31.9	35.4
Char coal	-	-	-	2.1	0.2	0.2	-	-	-
Waste wood	16.7	7.7	16.2	15.6	14.2	16.4	11.3	7.4	23.3
Limestone	-	-	0.5	1.6	2.3	3.1	0.5	2.2	2.4
Production (FeSi)	62.8	71.4	108.4	111.0	96.4	98.0	102.2	105.2	118.4
Coarse Microsilica	0.9	1.0	1.4	1.6	1.3	1.3	1.1	1.2	1.2
Fine Microsilica	13.2	15.0	21.4	24.3	19.8	19.4	17.0	20.1	20.9
Emissions	**207**	**242**	**374**	**374**	**346**	**347**	**368**	**374**	**408**

Emission Factors

Plant and year specific emission factors for CO_2 are based on the carbon content of the reducing agents, electrodes, the ferrosilicon and microsilica. 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 also provided this information for the years 2000 to 2004 and 2011 and 2012. Carbon content of coking coal, coke and charcoal are based on routine measurements of each lot at the plant. These measurements are available for the years 2000 to 2012. 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).* Carbon content of products (ferrosilicon, coarse and fine microsilica) is based on measurements at the plant. The carbon content is presented in Table 4.4. The emission factor 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 3.60 tonne CO_2 per tonne Ferrosilicon in 2010.

Emission factors for CH_4, NO_x, and NMVOC are taken from Tables 1.7, 1.9, and 1.11 in the IPCC Guidelines Reference Manual. Values for NCV are from the Good Practice Guidance.

Emissions of SO_2 are calculated from the sulphur content of the reducing agents and electrodes. The emission factor for CO comes from Table 2.16 in the Reference Manual of the 1996 IPCC Guidelines.

Table 4.4.Carbon content of raw material and products at Elkem.

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Electrodes	94%	94%	94%	94%	94%	94%	94%	94%	94%
Coking coal	74.8%	74.8%	79.0%	75.5%	74.6%	74.6%	74.8%	75.2%	75.2%
Coke oven coke	78.8%	78.8%	76.6%	73.8%	80.9%	80.3%	80.8%	79.7%	78.7%
Char coal	-	-	-	80.9%	84.3%	82.0%	-	-	-
Waste wood	48.7%	48.7%	48.7%	48.7%	48.7%	48.7%	48.7%	48.7%	48.7%
Production (FeSi)	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Coarse Microsilica	18%	18%	18%	18%	18%	18%	18%	18%	18%
Fine Microsilica	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%

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.

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 Aluminium Production (2C3)

Aluminium is produced in 3 smelters in Iceland, Rio Tinto Alcan at Straumsvík, Century Aluminium at Grundartangi, and Alcoa Fjarðaál at Reyðarfjörður (Figure 4.1). They all use the Centre Worked Prebaked Technology. Primary aluminium production results in emissions of CO_2 and PFCs. 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 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. Emission factors are calculated according to the Tier 2 Slope Method. Default coefficients are taken from the IPCC Good Practice Guidance for Centre Worked Prebaked Technology. Emission factors are calculated using the following formula:

$$\textbf{EF (kg } CF_4 \textbf{ or } C_2F_6 \textbf{ per tonne of Al)} = \textbf{Slope} \times \textbf{AE min/cell day}$$

Emissions are then calculated by multiplying the emission factors with the amount of aluminium produced.

Activity Data

The EA collects annual process specific data from the aluminium plants, through electronic reporting forms. Activity data and the resulting emissions can be found in Table 4.5.

Table 4.5. Aluminium production, AE, CO_2, and PFC emissions from 1990-2012.

Year	Aluminium production [kt]	CO_2 emissions [Gg]	PFC emissions [Gg CO_2-eq]	CO_2 [t/t Al]	PFC [t CO_2-eq/t Al]
1990	87.839	139.2	419.6	1.58	4.78
1991	89.217	142.0	348.3	1.59	3.90
1992	90.045	136.8	155.3	1.52	1.72
1993	94.152	141.6	74.9	1.50	0.80
1994	98.595	151.0	44.6	1.53	0.45
1995	100.198	154.0	58.84	1.54	0.59
1996	103.362	160.3	25.2	1.55	0.24
1997	123.562	192.8	82.4	1.56	0.67
1998	173.869	271.1	180.1	1.56	1.04
1999	222.014	354.3	173.2	1.60	0.78
2000	226.362	353.0	127.2	1.57	0.56
2001	244.148	382.4	91.7	1.57	0.38
2002	264.107	401.2	72.5	1.52	0.27
2003	266.611	410.2	59.8	1.54	0.22
2004	271.384	415.9	38.6	1.53	0.14
2005	272.488	417.1	26.1	1.53	0.10
2006	326.270	516.4	333.2	1.58	1.02
2007	455.761	693.0	281.3	1.52	0.62
2008	781.151	1186.8	349.0	1.52	0.45
2009	817.281	1231.5	152.7	1.51	0.19
2010	818.859	1237.6	145.6	1.51	0.18
2011	806.319	1214.3	63.2	1.51	0.08
2012	821.021	1244.2	79.7	1.52	0.10

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. The weighted average carbon content of the electrodes ranges from 98.0% to 98.8%.

The default coefficients for the calculation of PFC emissions come from the IPCC Good Practice Guidance for Centre Worked Prebaked Technology (0.14 for CF_4 and 0.018 for C_2F_6). For high performing facilities that emit very small amounts of PFCs, the Tier 3 method will likely 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.

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 7% for CF_4 and 22% for C_2F_6 (combining to an uncertainty of 9.3% for all PFC emissions from aluminium production).

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 Information on Decision 14/CP.7

4.5.1 Introduction

Decision 14/CP.7 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. The total amount that can be reported separately under this decision is set at 8 million tonnes or on average at 1.6 million tonnes of carbon dioxide per year. Only parties where the total carbon dioxide emissions were less than 0.05% of the total carbon dioxide emissions of Annex I Parties in 1990 calculated in accordance with the table contained in the annex to document FCCC/CP/1997/7/Add.1 can avail themselves of this Decision. The total carbon dioxide emissions in Iceland in 1990 amounted to 2158.6 Gg and the total 1990 CO_2 emissions from all Annex I Parties amounted to 13,728,306 Gg (FCCC/CP/1997/7/Add.1). Iceland's CO_2 emissions were thus less than 0.016% of the total carbon dioxide emissions of Annex I Parties in 1990, which is less than 0.05%. Iceland availed itself of the provisions of Decision 14/CP.7 with a letter to COP, dated October 17th, 2002.

In the decision a single project is defined as an industrial process facility at a single site that has come into operation since 1990 or an expansion of an industrial process facility at a single site in operation in 1990.

For the first commitment period, industrial process carbon dioxide emissions from a single project which adds in any one year of that period more than 5% to the total carbon dioxide emissions in 1990 shall be reported separately and shall not be included in national totals to the extent that it would cause Iceland to exceed its assigned amount, provided that:

- Renewable energy is used, resulting in a reduction in greenhouse gas emissions per unit of production (Article 2(b));
- Best environmental practice (BEP) is followed and best available technology (BAT) is used to minimize process emissions (Article 2(c));

Compliance with BAT is i.a. demonstrated by comparing CO_2, PFC, fluoride, dust and SO_2 to benchmark values given in the IPPC Reference Document on Best Available Techniques (BREF) in the Non Ferrous Metals Industries from December 2001 (http://eippcb.jrc.ec.europa.eu/reference/BREF/nfm_bref_1201.pdf).

For projects that meet the requirements specified above, emission factors, total process emissions from these projects, and an estimate of the emission savings resulting from the use of renewable energy in these projects are to be reported in the annual inventory submissions.

Four projects fulfilled the provisions of Decision 14/CP.7 in 2012, all three Icelandic aluminium plants and the single ferrosilicon plant:

- The expanded part of the Rio Tinto Alcan Aluminium plant at Straumsvík
- The Alcoa Fjarðaál Aluminium plant at Reyðarfjörður
- The Century Aluminium plant at Grundartangi
- The expanded part of the Elkem Iceland Ferrosilicon plant at Grundartangi

As mentioned above the total carbon dioxide emissions in Iceland in 1990 amounted to 2,158.6 Gg. Industrial process carbon dioxide emissions from a single project which adds in any one year of the first commitment period more than 5% to the total carbon dioxide emissions in 1990, i.e. 107.9 Gg, shall be reported separately and shall not be included in national totals to the extent that it would cause Iceland to exceed its assigned amount. Table 4.6 shows that CO_2 emissions from all four projects exceeded the threshold of 107.9 Gg CO_2 during all years of the first commitment period. The sum of all emissions is the sum of all emissions theoretically availing to decision 14/CP.7.

Table 4.6. CO_2 emissions of the four projects falling under Decision 14/CP.7 along with respective fractions of Iceland´s CO_2 emissions in 1990.

		2008	2009	2010	2011	2012
Rio Tinto Alcan (expansion)[1]	Gg CO_2 (% of total 1990 CO_2)	133.8 (6.2%)	135.3 (6.3%)	138.5 (6.4%)	131.3 (6.1%)	142.2 (6.6%)
Alcoa Fjarðaál	Gg CO_2 (% of total 1990 CO_2)	497.0 (23%)	530.1 (24.6%)	539.8 (25%)	514.3 (23.8%)	521.9 (24.2%)
Century Aluminium	Gg CO_2 (% of total 1990 CO_2)	408.9 (18.9%)	417.7 (19.3%)	411.3 (19.1%)	421.9 (19.5%)	431.8 (20%)
Elkem (expansion)[2]	Gg CO_2 (% of total 1990 CO_2)	121.2 (5.6)	122.3 (5.7%)	135.6 (6.3%)	141.6 (6.6%)	182.9 (8.5%)
Sum	Gg CO_2 (% of total 1990 CO_2)	1,160.9 (53.8%)	1,205.4 (55.8%)	1,225.1 (56.8%)	1,209.1 (56%)	1,278.9 (59.2%)

[1] Values for the expansion of Rio Tinto Alcan relate to the share of production that exceeds the production amount in 1995, i.e. the year before the expansion took place. [2] Values for the expansion of the ferrosilicaon plant relate to the share of production in excess of the production in 1990.

Practically all electricity in Iceland is produced with renewable energy sources, hydropower, and geothermal (See Chapter 3 – Energy). Electricity, produced with fuel combustion is only 0.010% of the electricity production. All electricity used in heavy industry is produced from renewable energy sources. Weighted average GHG emissions from electricity production in Iceland were 11 g/kWh in 2012.

For calculation of the resulting emission savings by using renewable energy, a comparison is made with a gas fired power plant with 55% efficiency. According to the International Aluminium Institute[1] the major part of the electrical power used in primary aluminium production in 2009, excluding hydropower and nuclear energy, is coal followed by gas. It can be assumed that if the aluminium would not be produced in Iceland using renewable energy, it would be produced with coal or gas energy. A conservative approach is to estimate emission savings in comparison with gas based electricity production.

The Icelandic legislature, Althingi, passed in 2007 an act on emission of greenhouse gases (No. 65/2007). According to the Act, a three-member Emissions Allowance Allocation Committee was established with representatives of the Ministry of Industry, Ministry for the Environment, and the Ministry of Finance. The role of the committee is to publish a plan on how Icelandic Emission Allowances are to be allocated and distributed to the industry in the first Commitment Period, and how they are divided between general allowances according to the Kyoto Protocol (AAUs) and the special emission allowances according to Decision 14/CP.7.

The Allowance Allocation Committee has allocated emissions allowances to the four projects mentioned above, based on Decision 14/CP.7.

4.5.2 Detailed information on projects under Decision 14/CP.7

In this next section the following information for each of the projects, fulfilling the provisions of the decision will be listed:

1. Definition of the single project, according to the Allowance Allocation Committee.
2. How the projects adds more than 5% to the total carbon dioxide emission in 1990, i.e. more than 107.9 Gg.
3. How renewable energy is used, resulting in reduction in greenhouse gas emissions per unit of production and the resulting emission savings.
4. How the best environmental practice (BEP) and best available technology (BAT) is used to minimize process emissions.
5. Total process emissions and emission factors and summary of information on the project in CP1.

[1] http://www.world-aluminium.org/publications/

Expansion of the Rio Tinto Alcan Aluminium plant at Straumsvík

1. Aluminium production started at the Aluminium plant in Straumsvík in 1969. The plant consisted in the beginning of one potline with 120 pots which was expanded to 160 pots in 1970. In 1972 a second potline, with 120 pots, was taken into operation. The second potline was expanded in 1980 to 160 pots. In 1996 a further expansion of the plant took place. The 1996 expansion project involves an expansion in the plant capacity by building a new potline with increased current in the electrolytic pots. At the same time current was also increased in potlines one and two. This has led to increased production in potlines one and two. The process used in all potlines is point feed prebake (PFPB) with automatic multiple point feed. The 1996 expansion is a single project as defined in Decision 14/CP.7.

2. In 2012 189,932 tonnes of aluminium were produced compared to 100,198 tonnes in 1995. In 2012 the production increase resulting from this project amounted to 89,734 tonnes of aluminium (72,747 tonnes in potline 3 and 16,987 tonnes in potlines 1 and 2). The resulting emissions from the production of 89,734 tonnes of aluminium are 142 Gg of CO_2. This amount adds more than 5% to the total carbon dioxide emissions in 1990. An overview of project emissions in CP1 is given in Table 4.7

3. In 2012 the plant used 2,939 GWh of electricity, thereof 1,389 GWh were used for producing the 89,734 tonnes that fall under the definition of a single project. As stated before, all the electricity used is produced from renewable sources. Average emissions from this electricity production in 2012 is 11 g CO_2/kWh. Total CO_2 emissions from the electricity used for the project amounts to 15.3 Gg. Typical emissions from a gas fired power plant with 55% efficiency amount to 371 g CO_2/kWh. The emissions from electricity use in the project would therefore have equalled 515 Gg had the energy been from natural gas and not from renewable sources. The resulting emissions savings are 500 Gg CO_2. An overview of project electricity and emission savings in CP1 is also given in Table 4.7.

4. The use of centre worked prebaked cells with automatic multiple point feeding of alumina is considered to be BAT for the production of primary aluminium (see p. 325 of the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001). Best available techniques (BAT), are applied in the production of aluminium to minimize process emissions:

    a. All pots are closed and the pot gases are collected and cleaned via a dry absorption unit; the technique is defined as BAT.
    b. Prebake anodes are used and automatic multiple point feed.
    c. Computer control is used in the potlines to minimize energy use and formation of PFC.

Total process emissions from production of 189,932 tonnes of aluminium at Rio Tinto Alcan were 298.3 Gg CO_2-equivalents in 2012, 290.5 Gg of CO_2 from electrodes consumption and 7.8 Gg CO_2-equivalents of PFCs due to anode effects. The resulting IEF are 1.53 tonnes CO_2 per tonne of aluminium and 0.04 tonnes of PFC in CO_2-equivalents per tonne of aluminium. For comparison, the median value of PFC emissions in 2009 for prebake plants worldwide was 0.34 CO_2-equivalents per tonne of aluminium[2]. According to the IPPC Reference Document on Best Available Techniques in the Non Ferrous Metals Industries from December 2001 (http://eippcb.jrc.ec.europa.eu/reference/BREF/nfm_bref_1201.pdf), the range of 0.02 to 0.1 kg PFCs per tonne aluminium is given. PFC emissions from the Rio Tinto aluminium plant oscillate between 0.003 and 0.006 kg PFC per t aluminium from 2008-2012 and are therefore well under the lower threshold of the range given by the BREF.

According to the same IPPC document, an efficient prebake plant consumes about 0.4 tonnes of carbon anodes per tonne aluminium, corresponding to 1.4 to 1.7 tonnes of CO_2 per tonne aluminium. The CO_2 IEF per tonne of aluminium ranges between 1.51 and 1.59 t/t and is therefore in the middle of the range. These values are also reported in Table 4.7. Besides that 6 Gg were emitted from fuel combustion. The IEF for fuel use is 0.03 t CO_2-equivalents per tonne of aluminium.

The BREF also contains emission ranges for total fluoride, dust and SO2. These ranges are as follows:

- Total fluoride: 0.3-4 kg per tonne aluminium produced
- Dust: 0.6-7 kg per tonne aluminium produced
- SO_2: 10-30 kg per tonne aluminium produced

Alcan reports emission values for the above mentioned pollutants in their annual green accounts. The values are reported in Table 4.7. It is evident that the fluoride, dust and SO2 emissions of the aluminiumplant oscillate closer to the lower thresholds of the BREF.

Best environmental practice (BEP) is used in the process and the facility has a certified environmental management system according to ISO 14001. The environmental management system was certified in 1997. Besides the environmental management system, the facility also has a certified ISO 9001 quality management system and an OHSAS 18001 occupational health and safety management system.

5. Summary of information on how the expansion of Rio Tinto Alcan fulfils the provisions of Decision 14/CP.7 along with process specific information is given in Table 4.7.

[2] International Aluminium Institute: http://world-aluminium.org/cache/fl0000342.pdf

Table 4.7. Information on the expansion of the Rio Tinto Alcan aluminium plant.

Parameter	unit	2008	2009	2010	2011	2012
Al production, plant	kt	187.4	189.5	190.0	185.3	189.9
Al production, expansion	kt	87.2	89.3	89.8	85.1	89.7
Process CO2 emissions, plant	Gg	281.0	283.7	286.4	278.1	290.5
Process CO2 emissions, expansion	Gg	133.8	135.3	138.5	131.3	142.2
Process CO2 IEF, plant	t CO_2/t Al	1.499	1.497	1.508	1.501	1.530
Process CO2 IEF, expansion	t CO_2/t Al	1.535	1.514	1.543	1.544	1.585
CO2 IEF (Fuel combustion)	T CO2/t Al	0.07	0.06	0.06	0.05	0.03
Total PFC emissions	Gg CO_2 eq.	4.41	3.37	3.69	7.36	7.77
PFC IEF	t CO_2 eq./t Al	0.024	0.018	0.019	0.040	0.041
PFC IEF	kg PFC/t Al	0.003	0.003	0.003	0.006	0.006
Total flouride emissions	kg/t Al	0.67	0.55	0.50	0.55	0.53
Dust emissions	kg/t Al	0.88	0.73	0.63	0.59	0.51
SO_2 emissions	kg/t Al	14.1	14.1	13.6	14.2	14.6
Project electricity	GWh	1,360	1,382	1,377	1,315	1,389
Project electricity emissions	Gg CO_2	17.9	15.5	17.1	15.4	15.3
Project electricity emissions gas-fired	Gg CO_2	504	513	511	488	515
Emission savings	Gg CO_2	487	497	494	473	500

Expansion of the Ferrosilicon plant at Grundartangi

1. The Elkem Iceland Ferrosilicon plant at Grundartangi was established in 1977, when the construction of two furnaces started. The first furnace came on stream in 1979 and the second furnace a year later. The production capacity of the two furnaces was in the beginning 60,000 tonnes of ferrosilicon, but was later increased to 72,000 tonnes. In 1993 a project was started that enabled overloading of the furnaces in comparison to design, resulting in increased production. The production was further increased in 1999 by the addition of a third furnace. The production increase since 1990 is a single project as defined in Decision 14/CP.7. In the production raw ore, carbon material and slag forming materials are mixed and heated to high temperatures for reduction and smelting. The carbon materials used are coal, coke, and wood. The iron comes from imported ready-to-use iron pellets. Electric (submerged) arc furnaces with Soederberg electrodes are used. All furnaces are semi-covered. From 2008-2012 it was not possible to use wood in Furnace 3.

2. In 1990 62,792 tonnes were produced leading to emissions of 207 Gg of CO_2. In 2012 118,359 tonnes were produced (36,138 tonnes in furnace 1; 36,751 tonnes in furnace 2; and 45,470 tonnes in furnace 3) leading to emissions of 407 Gg of CO_2 (130, 130 and 147 Gg in furnace 1, 2 and 3 respectively). The production falling under Decision 14/CP.7 is thus 55,567 tonnes of ferrosilicon (all production in furnace 3; and 10,097 tonnes in furnace 1 and 2). This production leads to emissions of 183 Gg of CO_2. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2012 the plant used 1,032 GWh of electricity, thereof 485 GWh were used for the production increase since 1990 (45,470 tonnes of ferrosilicon). All the electricity used

for the production comes from renewable sources. The average CO_2 emissions from producing this electricity are 11 g/kWh. The total CO_2 emissions from the electricity use for the project amounts to 5 Gg. Had the energy been from a gas fired power plant with 55% efficiencythe emissions would amount to 371 g/kWh. The resulting emissions from electricity use in the project would in this case have amounted to 180 Gg CO_2. Emissions savings from using renewable energy for the project are 174 Gg CO_2.

4. The plant uses BAT according to the IPPC Reference Document on Best Available Technology in non-ferrous metals industries (December 2001) and the plant has an environmental management plan as a part of a certified ISO 9001 quality management system, meeting the requirement of BEP.

   Total process carbon dioxide emissions from production of 118,359 tonnes of ferrosilicon at Elkem Iceland in 2012 were 407 Gg CO_2-equivalents (449 Gg if including biological CO_2). The resulting IEF are 3.44 tonnes CO_2 per tonne of ferrosilicon (3.79 tonnes CO_2 including organic CO_2). According to Table 9.12 of the IPPC Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001 (http://eippcb.jrc.ec.europa.eu/reference/BREF/nfm_bref_1201.pdf), CO_2 emissions from FeSi production are 4,24 tonnes per tonne of product[3] (this number includes both fossil and biological CO_2). IEF for CO_2 at Elkem Iceland are therefore lower than the values given in the report. This is valid for all years during CP1 (See Table 4.8). Besides that 0.9 Gg CO_2 were emitted from fuel combustion. The IEF for fuel use is 0.007 t CO_2-equivalents per tonne of ferrosilicon.

5. Summary of information on how the expansion of Elkem fulfils the provisions of Decision 14/CP.7 along with process specific information is given in Table 4.8.

[3] The cell in the table says: 4240 – (N4). The „-„ indicates there should be a range given.

Table 4.8. Information on the expansion of Elkem ferrosilicon plant.

Parameter	unit	2008	2009	2010	2011	2012
FeSi production, plant	kt	96.4	98.0	102.2	105.2	118.4
FeSI production, expansion	kt	33.6	35.2	39.4	42.4	55.6
Fossil CO2 emissions, plant	Gg	346.2	347.2	367.6	374.4	406.9
Fossil CO2 emissions, expansion	Gg	121.2	122.3	135.6	141.6	182.9
Fossil CO2 IEF, plant	t CO2/t Al	3.59	3.54	3.60	3.56	3.44
Fossil CO2 IEF, expansion	t CO2/t Al	3.61	3.47	3.44	3.34	3.29
Fossil and organic CO2 emissions, plant	Gg	372.1	377.1	387.8	387.6	448.5
Fossil and organic CO2 emissions, expansion	Gg	121.2	122.3	135.6	141.6	200.8
Fossil and organic CO2 IEF, plant	t CO2/t Al	3.86	3.85	3.79	3.68	3.79
Fossil and organic CO2 IEF, expansion	t CO_2/t Al	3.61	3.47	3.44	3.34	3.61
CO2 IEF (Fuel combustion)	t CO2/t Al	0.01	0.01	0.01	0.01	0.01
Project electricity	GWh	284	321	359	381	485
Project electricity emissions	Gg CO_2	4	4	4	4	5
Project electricity emissions gas-fired	Gg CO_2	105	119	133	141	180
Emission savings	Gg CO_2	102	116	129	137	174

Establishment of the Century Aluminium plant at Grundartangi

1. The Century Aluminium plant at Grundartangi was established in 1998. The plant consisted in the beginning of one potline. In 2001 a second potline was taken into operation. In 2006 a further expansion of the plant took place. The Century Aluminium plant is a single project as defined in Decision 14/CP.7.

2. In 2012 the Century Aluminium plant produced 286,457 tonnes of aluminium. The resulting industrial process carbon dioxide emission amounted to 432 Gg. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2012 the plant used 4,270 GWh of electricity, all from renewable sources. Average emissions from producing this electricity are equivalent to 11 g/kWh. The resulting total CO_2 emissions from the electricity use are 47 Gg. Had the energy been from a gas fired power plant with 55% efficiency the emissions would have amounted to approximately 371 g/kWh, resulting in emissions from electricity use in the project equivalent to 1,584 Gg. Emissions savings from using renewable energy equal 1,537 Gg.

4. Best available techniques (BAT), as defined by the IPPC, are applied at the Century Aluminium plant as stipulated in the operating permit. Century Aluminium is implementing an environmental management system according to ISO 14001. The environmental management system was certified in late 2013.

Total process emissions from production of 286,457 tonnes of aluminium at Century Aluminium in 2012 were 458 Gg CO_2-equivalents, 432 Gg of CO_2 from electrodes consumption and 26 Gg CO_2-equivalents of PFCs due to anode effect. The resulting IEF are 1.507 tonnes CO_2 per tonne of aluminium and 0.09 tonnes of PFC in CO_2-

equivalents per tonne of aluminium. Besides that 1.9 Gg were emitted from fuel combustion. The IEF for fuel use is 0.007 t CO_2-equivalents per tonne of aluminium.

According to the IPPC Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001 (http://eippcb.jrc.ec.europa.eu/reference/BREF/nfm_bref_1201.pdf), the range of 0.02 to 0.1 kg PFCs per tonne aluminium is given. PFC emissions from the Century Aluminium plant decreased from 0.077 kg PFC/t Al to 0.014 kg PFC/t Al and are therefore within the BREF range.

According to the same IPPC document, an efficient prebake plant consumes about 0.4 tonnes of carbon anodes per tonne aluminium, corresponding to 1.4 to 1.7 tonnes of CO_2 per tonne aluminium. The CO2 IEF per tonne of aluminium ranges between 1.49 and 1.51 t/t and is therefore in the middle of the range. These values are also reported in Table 4.9.

The BREF also contains emission ranges for total fluoride, dust and SO2. These ranges are as follows:

- Total fluoride: 0.3-4 kg per tonne aluminium produced
- Dust: 0.6-7 kg per tonne aluminium produced
- SO_2: 10-30 kg per tonne aluminium produced

Century Aluminium reports emission values for the above mentioned pollutants in their annual green accounts. The values are reported in Table 4.9. It is evident that the fluoride, dust and SO_2 emissions of the aluminiumplant oscillate close to the lower thresholds of the BREF.

5. Summary of information on how the Century Aluminium plant fulfils the provisions of Decision 14/CP.7 along with process specific information is given in Table 4.9.

Table 4.9. Information on the Century Aluminium plant.

Parameter	unit	2008	2009	2010	2011	2012
Al production, total	kt	273.8	278.2	276.1	280.3	286.5
Process CO2 emissions, total	Gg	408.9	417.7	411.3	421.9	431.8
Process CO2 IEF, total	t CO2/t Al	1.493	1.501	1.490	1.505	1.507
CO2 IEF (Fuel combustion)	t CO2/t Al	0.01	0.01	0.01	0.01	0.01
Total PFC emissions	Gg CO2 eq.	143.9	104.6	54.9	33.3	26.4
PFC IEF	t CO2 eq./t Al	0.526	0.376	0.199	0.119	0.092
PFC IEF	kg PFC/t Al	0.077	0.055	0.029	0.017	0.014
Total flouride emissions	kg/t Al	0.42	0.43	0.41	0.45	0.41
Dust emissions	kg/t Al	0.91	0.87	0.81	0.80	0.84
SO_2 emissions	kg/t Al	12.6	12.5	11.2	11.8	12.1
Project electricity	GWh	4,041	4,176	4,114	4,164	4,270
Project electricity emissions	Gg CO_2	53.1	46.8	51.2	48.7	46.9
Project electricity emissions gas-fired	Gg CO_2	1,499	1,549	1,526	1,545	1,584
Emission savings	Gg CO_2	1,446	1,502	1,475	1,496	1,537

Establishment of the Alcoa Fjarðaál Aluminium plant at Reyðarfjörður

1. The Alcoa Fjarðaál Aluminium plant at Reyðarfjörður was established in 2007. In 2008 the plant reached full production capacity. Since then, a small capacity increase has occurred. In 2012 344,632 tonnes of aluminium were produced at the plant. The Alcoa Aluminium plant is a single project as defined in Decision 14/CP.7.

2. In 2012 the Alcoa Aluminium plant produced 344,632 tonnes of aluminium. The resulting industrial process carbon dioxide emission amounted to 522 Gg. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2012 the plant used 4,891 GWh of electricity, all from renewable sources. Average emissions from producing this electricity are equivalent to 11 g/kWh. The resulting total CO_2 emissions from the electricity use are 54 Gg. Had the energy been from a gas fired power plant with 55% efficiency the emissions would amount to approximately 371 g/kWh, resulting in emissions from electricity use in the project equivalent to 1,815 Gg. Emissions savings from using renewable energy equal 1,761 Gg.

4. Best available techniques (BAT), as defined by the IPPC, are applied at the Alcoa Aluminium plant as stipulated in the operating permit. Alcoa Fjarðaál has implemented an ISO 14001 environmental management system. The environmental management system was certified in 2012.

   Total process emissions from production of 344,632 tonnes of aluminium at Alcoa Fjarðaál in 2012 were 567 Gg CO_2-equivalents, 522 Gg of CO_2 from consumption of electrodes and 46 Gg CO_2-equivalents of PFCs due to anode effect. The resulting IEF are 1.514 tonnes CO_2 per tonne of aluminium and 0.132 tonnes of PFC in CO_2-equivalents per tonne of aluminium. Besides that, 2.3 Gg were emitted from fuel combustion. The IEF for fuel use is 0.007 t CO_2-equivalents per tonne of aluminium.

   According to the IPPC Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001 (http://eippcb.jrc.ec.europa.eu/reference/BREF/nfm_bref_1201.pdf), the range of 0.02 to 0.1 kg PFCs per tonne aluminium is given. PFC emissions from the Century Aluminium plant decreased from 0.092 kg PFC/t Al to 0.019 kg PFC/t Al and are therefore within the BREF range.

   According to the same IPPC document, an efficient prebake plant consumes about 0.4 tonnes of carbon anodes per tonne aluminium, corresponding to 1.4 to 1.7 tonnes of CO_2 per tonne aluminium. The CO_2 IEF per tonne of aluminium ranges between 1.51 and 1.55 t/t and is therefore in the middle of the range. These values are also reported in Table 4.10.

   The BREF also contains emission ranges for total fluoride, dust and SO2. These ranges are as follows:

   - Total fluoride: 0.3-4 kg per tonne aluminium produced
   - Dust: 0.6-7 kg per tonne aluminium produced

- SO_2: 10-30 kg per tonne aluminium produced

Alcoa reports emission values for the above mentioned pollutants in their annual green accounts. The values are reported in Table 4.10. It is evident that the fluoride, dust and SO_2 emissions of the aluminium plant oscillate close to the lower thresholds of the BREF.

5. Summary of information on how the Alcoa plant fulfils the provisions of Decision 14/CP.7 along with process specific information is given in Table 4.10.

Table 4.10. Information on the Alcoa Fjarðaál aluminium plant.

Parameter	unit	2008	2009	2010	2011	2012
Al production, total	kt	319.9	349.5	352.8	340.8	344.6
Process CO2 emissions, total	Gg	497.0	530.1	539.8	514.3	521.9
Process CO2 IEF, total	t CO2/t Al	1.553	1.517	1.530	1.509	1.514
CO2 IEF (Fuel combustion)	t CO2/t Al	0.01	0.01	0.01	0.01	0.01
Total PFC emissions	Gg CO2 eq.	200.7	44.8	87.0	22.6	45.5
PFC IEF	t CO2 eq./t Al	0.627	0.128	0.247	0.066	0.132
PFC IEF	kg PFC/t Al	0.092	0.019	0.036	0.010	0.019
Total flouride emissions	kg/t Al	0.35	0.33	0.31	0.22	0.32
Dust emissions	kg/t Al	0.42	0.32	0.38	0.23	0.46
SO_2 emissions	kg/t Al	11.3	11.5	12.3	14.7	15.4
Project electricity	GWh	4,297	4,838	4,968	4,797	4,891
Project electricity emissions	Gg CO_2	56.5	54.3	61.8	56.1	53.7
Project electricity emissions gas-fired	Gg CO_2	1,594	1,795	1,843	1,780	1,815
Emission savings	Gg CO_2	1,538	1,741	1,781	1,724	1,761

4.5.3 Summary of emissions under Decision 14/CP.7

Table 4.11. Process CO2 emissions, electricity demand and emission savings from the four projects falling under Decisions 14/CP.7.

Project CO2	Unit	2008	2009	2010	2011	2012	Total
Rio Tinto (exp.)	Gg CO_2	134	135	138	131	142	681
Alcoa Fjarðaál	Gg CO_2	497	530	540	514	522	2,603
Century Aluminium	Gg CO_2	409	418	411	422	432	2,092
Elkem (exp.)	Gg CO_2	121	122	136	142	183	704
Total	Gg CO_2	1,161	1,205	1,225	1,209	1,279	6,079
Project electricity	Unit						
Rio Tinto (exp.)	GWh	1,360	1,382	1,377	1,315	1,389	6,822
Alcoa Fjarðaál	GWh	4,297	4,838	4,968	4,797	4,891	23,791
Century Aluminium	GWh	4,041	4,176	4,114	4,164	4,270	20,765
Elkem (exp.)	GWh	284	321	359	381	485	1,829
Total	GWh	9,982	10,717	10,817	10,657	11,034	53,207
Emission savings	Unit						
Rio Tinto (exp.)	Gg CO_2	487	497	494	473	500	2,450
Alcoa Fjarðaál	Gg CO_2	1,538	1,741	1,781	1,724	1,761	8,544
Century Aluminium	Gg CO_2	1,446	1,502	1,475	1,496	1,537	7,457
Elkem (exp.)	Gg CO_2	102	116	129	137	174	657
Total	Gg CO_2	3,572	3,856	3,879	3,829	3,972	19,108

4.6 Other Production (2D)

Other production in Iceland is the Food and Drink Industry. NMVOC emissions from this sector are estimated. Production statistics were obtained from Statistics Iceland for beer, fish, meat and poultry for the whole time series (Figure 4.2) Production statistics were extrapolated for the years 1990 to 2004. Further production of bread, cakes and biscuits was estimated from consumption figures (Þorgeirsdóttir et al., 2012). Emission factor for NMVOC were taken from Tables 2-24 and 2-25 in the 1996 IPCC Guidelines.

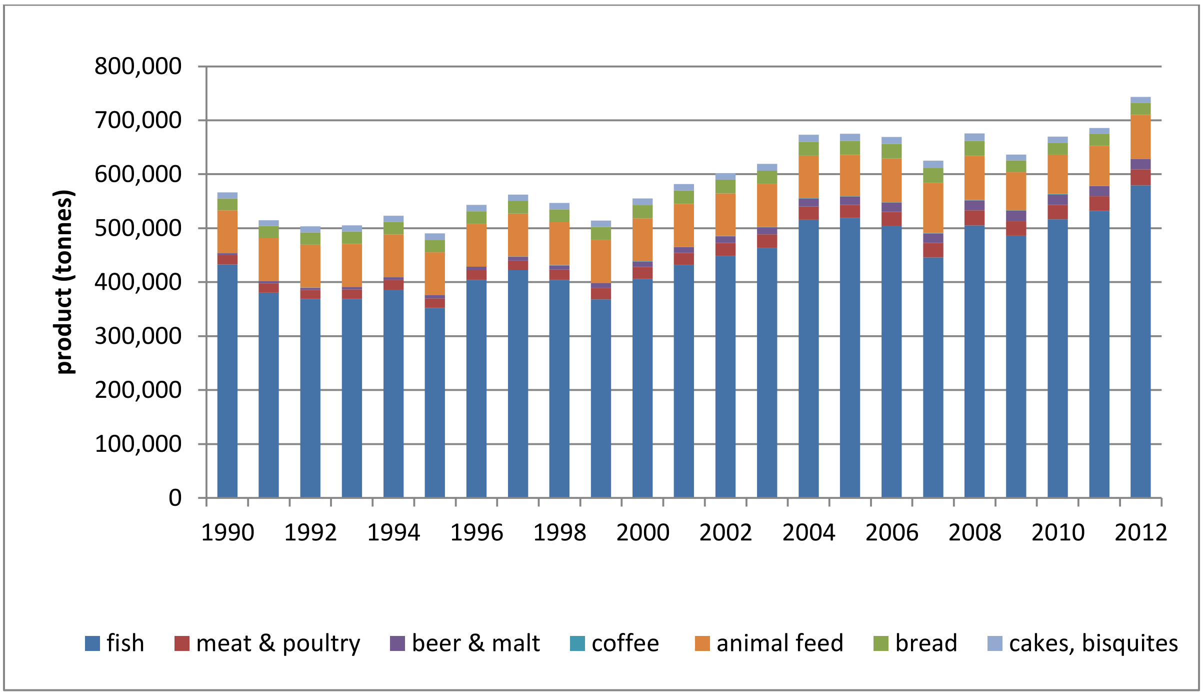

Figure 4.2. Food and drink production in Iceland.

4.7 Production of Halocarbons and SF_6 (2E)

There is no production of halocarbons or sulphur hexafluoride (SF_6) in Iceland.

4.8 Consumption of Halocarbons and SF_6 (2F)

4.8.1 Consumption of Halocarbons

Overview

In Iceland hydrofluorocarbons (HFCs) are used first and foremost as refrigerants. 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. HFCs were first introduced to Iceland in 1993. Fluorinated gases have been regulated since 1998. Regulation 230/1998 bans production, import, and sale of HFCs (and CFCs) or products containing HFCs with the exception of HFCs used in refrigeration and air conditioning equipment and in metered dose inhalers. This diction thus implies 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 (MDIs), and as solvents (2F5).

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

- domestic refrigeration,
- commercial refrigeration,
- transport refrigeration,

- industrial refrigeration,
- residential and commercial A/C, including heat pumps
- mobile air conditioning (MAC).

HFCs are also used in metered dose inhalers (2F4). Use of HFCs in other sub-source categories is not occurring. The structure of the source category consumption of Halocarbons is shown in Table 4.12.

Table 4.12. Source category structure of HFC consumption

GHG source category	GHG sub-source category	Further specification
2F1 Refrigeration	Domestic refrigeration	
	Commercial refrigeration	Combination of stand-alone and medium & large commercial refrigeration
	Transport refrigeration	Reefers
		Fishing vessels
	Industrial refrigeration	
	Stationary Air-conditioning	
	Mobile air conditioning (MAC)	Passenger cars
		Trucks
		Coaches
2F4 Aerosols	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 by 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. The ban on importing new R-22, which became effective in 2010 and the impending ban on importing recovered R-22 mean a price increase for R-22 and adds urgency to the process.

Refrigeration systems onboard 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.

The HFCs most commonly used in Iceland are HFC-125, HFC-134a, and HFC-143a. They are imported in bulk and in equipment such as domestic refrigerators, vehicle air conditionings, reefers, and MDIs. All other HFCs are imported in bulk only.

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 notations are used later on when the R-blends have been disaggregated by calculations into the HFCs contained in them.

Methodology

Emissions for the refrigeration and air conditioning sector are estimated using the GPG Tier 2a – Bottom-up 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 will be explained in more detail in the chapter on activity data. Emissions from MDIs are calculated using equation 3.35 in the GPG.

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 2012 and the sum of all sub-source emissions until 2012 and the amount allocated to the sub-sources 2013 stock. This difference had to be zero.

Activity data

Refrigeration and air conditioning

All HFCs 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.

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.

Information on registered vehicles was obtained from the Road Traffic Directorate. 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: GPG default of 0.8 kg for passenger cars
- EU classes N2 and N3 (trucks): GPG default 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 GPG: 0.05-0.5 kg (Table 3.22 on page 3.106).

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 is the EA aware that this method simplifies the sector. Figure 4.3 shows the quantity of HFCs introduced to Iceland in bulk between 1993 and 2012.

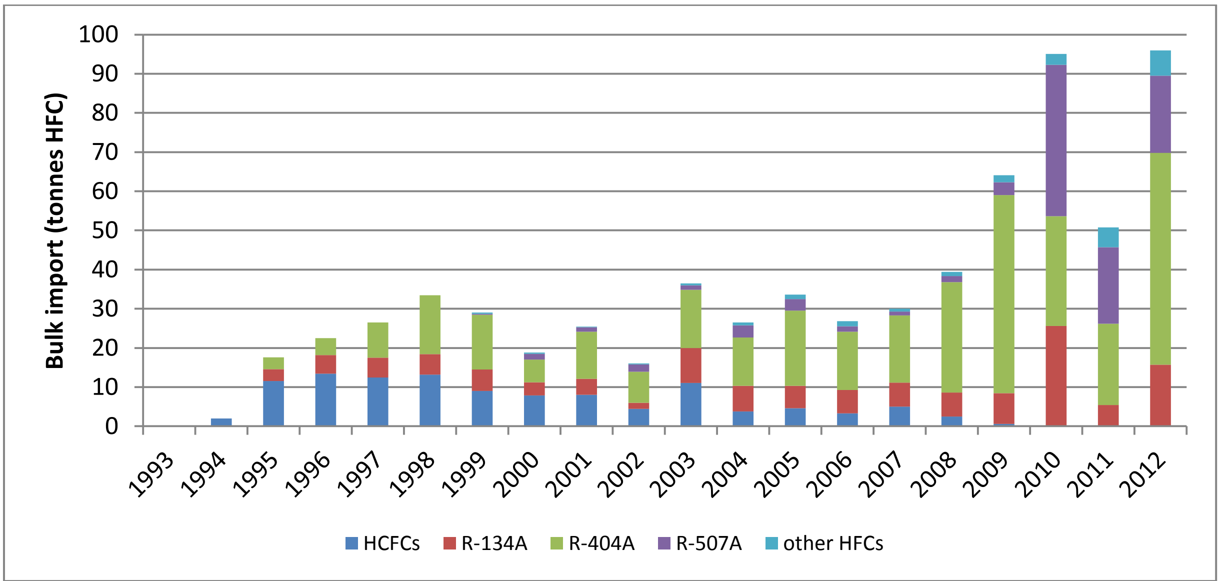

Figure 4.3. Quantity of HFCs introduced in bulk to Iceland between 1993 and 2012.

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

Emission factors

Total emissions from refrigeration and air conditioning equipment are calculated using equation 3.39 from the GPG (p. 3.100).

EQUATION 3.39

Total Emissions = Assembly Emissions + Operation Emissions + Disposal Emissions

Assembly emissions include the emissions associated with product manufacturing, even if the products are eventually exported.

Operation emissions include annual leakage from equipment stock in use as well as servicing emissions. This calculation should include all equipment units in the country, regardless of where they were manufactured.

Disposal emissions include the amount of refrigerant released from scrapped systems. As with operation emissions, they should include all equipment units in the country where they were scrapped, regardless of where they were manufactured.

Assembly emissions are calculated by multiplying the amount of HFC and PFC in the initial charge with an emission factor k that represents the percentage of initial charge that is released during assembly of the e.g. refrigeration system (equation 3.41 in the GPG). Sub-source values used as k are presented in Table 4.13.

Operation emissions are calculated by multiplying the amount of HFC and PFC in stock with an annual leak rate x (equation 3.42 in the GPG).Sub-source values used for x are shown in Table 4.13.

The calculation of disposal emissions requires information on the average lifetime n of equipment. 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. Recovery efficiency factors used are also shown in Table 4.13.

The equation for disposal emissions is shown below:

EQUATION 3.43

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

Table 4.13. Values used for charge, lifetime and emission factors for stationary refrigeration equipment and mobile air conditioning. Sources for the majority of values are GPG Tables 3.22 and 3.23 on pages 3.106 and 3.110.

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	9	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	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 GPG. The lifetime EF and the efficiency of recovery at end of life are GPG default values. Initial emissions are not occurring since domestic refrigeration equipment is assembled prior to import. The same applies as well to reefers and MACs. Transport refrigeration equipment on fishing vessels, commercial and industrial refrigeration equipment as well as residential ACs - on the other hand - 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 GPG. 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 GPG (both commercial applications together have a lifetime EF range from 1-30%). 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 been decreasing 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. The latter value was determined after evaluation of information from the above mentioned poll.

Values for residential AC are default values given by the GPG 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. Therefore 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 GPG. 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.

According to GPG methodology it is good practice to use an EF of 50% 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.

Emissions

Emitted refrigerants are dissected into constituent HFCs. HFC emissions are aggregated by multiplying individual HFCs with respective GWPs leading to totals in CO_2 eq. All values and fractions below relate to aggregated emissions expressed in CO_2 eq.

Total emissions from all refrigeration and air conditioning equipment amounted to 143.3 Gg in 2012 which is a 19% increase compared to 2011 (Figure 4.4). This increase is due to the combination of a build-up in HFC stock and a pronounced increase in the quantity of imported HFCs between 2011 and 2012.

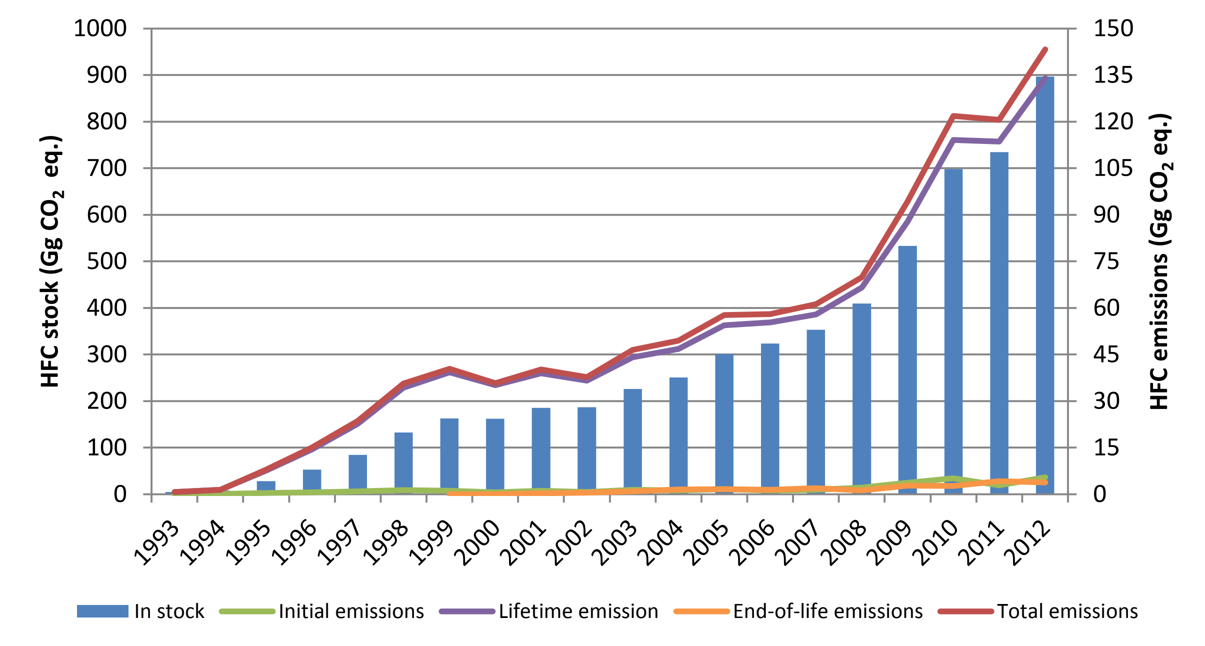

Figure 4.4. HFC stock (primary y-axis) and emissions (secondary y-axis) from refrigeration and air conditioning equipment. Included are domestic refrigeration, commercial refrigeration, industrial refrigeration (fishing vessels and reefers), residential ACs, and MACs.

Lifetime emissions are 93.5% of total emissions, 2.6% are end-of-life emissions and 3.8% are initial emissions. 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 the fact that the amount of imported HFCs 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.

Almost two thirds of emissions stem from refrigeration systems on fishing vessels. Total transport refrigeration emissions, i.e. including reefers, account for 68% of all HFC emissions. Other important sectors are industrial refrigeration (15.5%), commercial refrigeration (11.7%), and MACs (4.2%). Residential AC emission shares are within 1% 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 4.5).

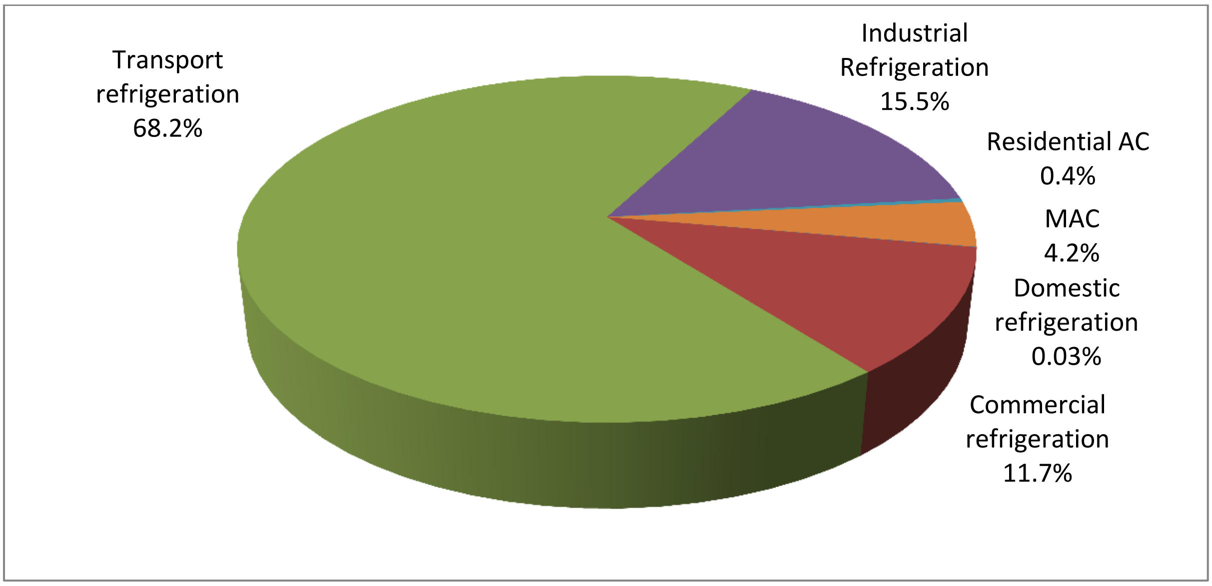

Figure 4.5. 2012 emission distribution of refrigeration and AC sub-source categories.

The relations between imports, stock development and emission trends are shown for fishing vessels and MAC hereafter. The stock of HFCs in refrigeration systems on fishing vessels (Figure 4.6) shows a distinct increase between 2007 and 2010 caused by a stark import increase of especially R-404A and R-507A, two refrigerants with high GWPs. The import decrease between 2010 and 2011 slows the growth of the sub-source´s HFC stock but the record import of bulk HFC in 2012 accelerates stock growth again. Lifetime emissions increase between 2011 and 2012 (although the EF is being decreased from 21.6% to 20%) 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 graphs for commercial and industrial refrigeration show the same trends on different scales and with different onset years for end-of-life emissions.

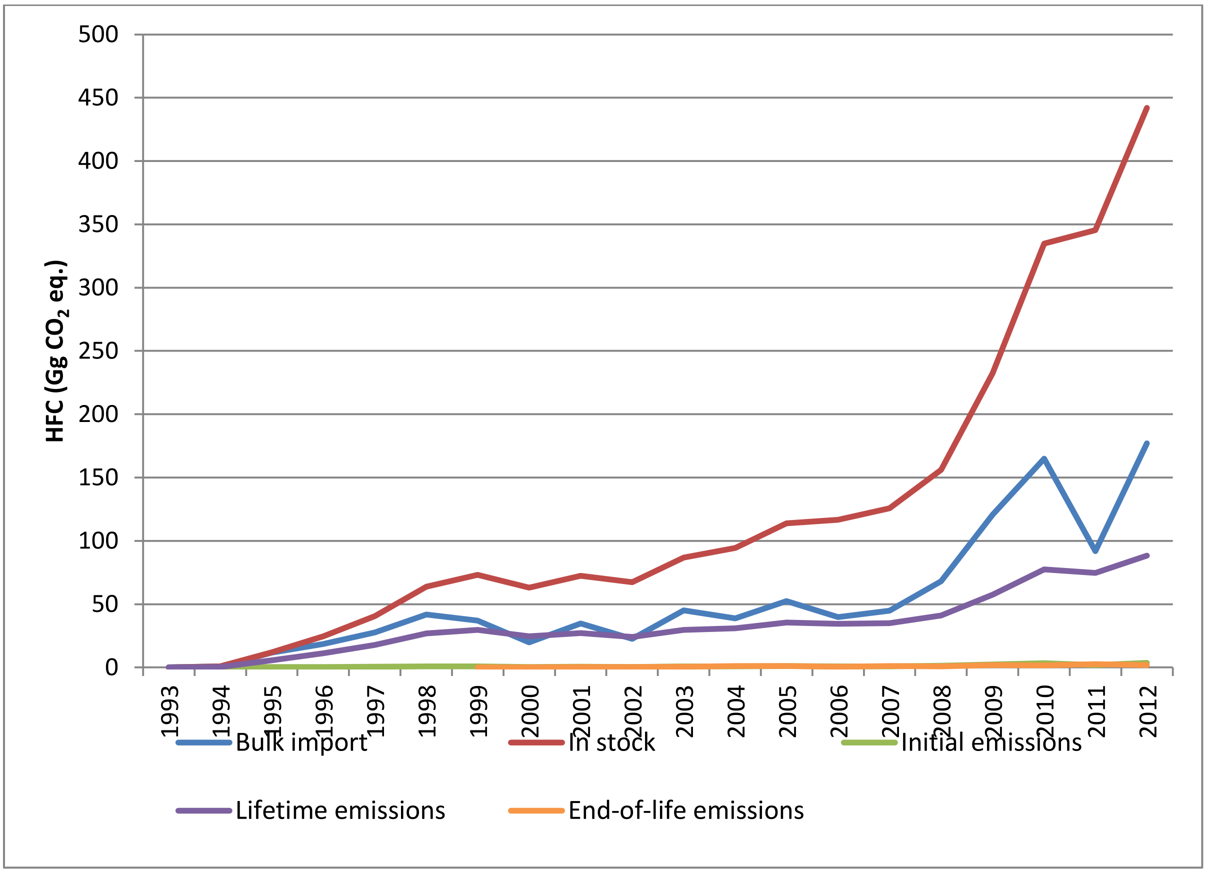

Figure 4.6. Import, stock development and emissions from refrigeration systems on fishing vessels between 1993 and 2012.

The graph for MACs (Figure 4.7) does not show import quantities since 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 2012 leading to a stock increase during the same year.

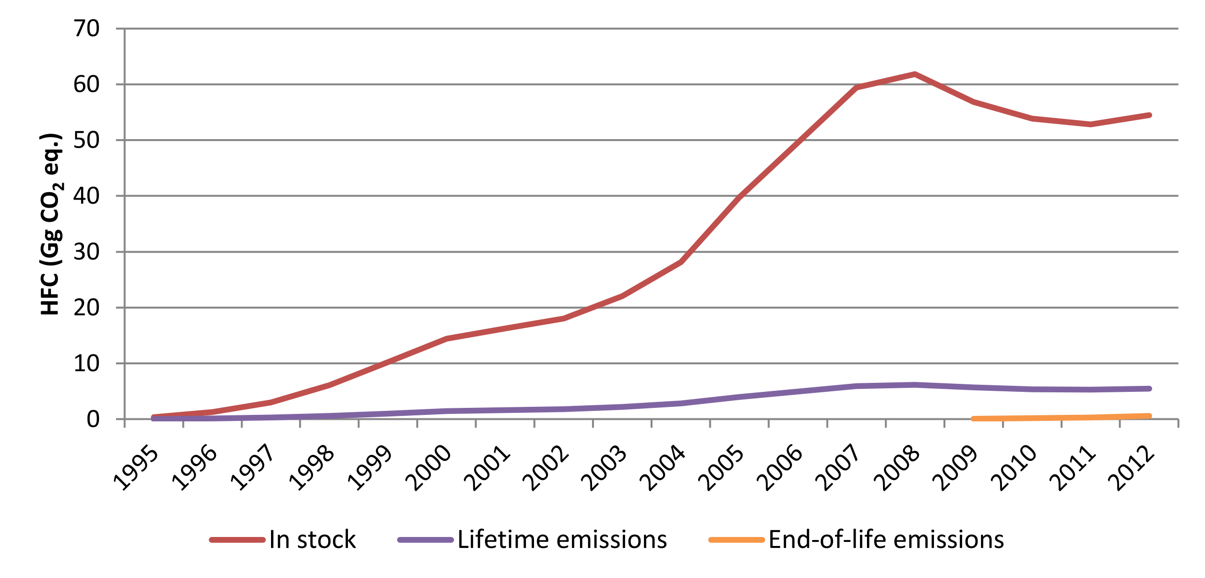

Figure 4.7. Emissions from mobile air conditionings.

Emissions from MDIs increased from 0.82 Gg CO_2 eq. in 2011 to 0.83 Gg CO_2 eq. in 2012 or by 2% due to increasing import in equipment.

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 0.04%.

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 2012 emission quantities. The resulting EF and AD certainties were then combined by multiplication (equation 6.4 on page 6.12 of the GPG). Uncertainty factors are summarized in Table 4.14.

Table 4.14. Lifetime EFs used along with EF ranges given in the GPG; calculated EF uncertainties and estimated AD uncertainties as well as 2012 emission shares used to weight uncertainties.

Value ranges (Lifetime EF)	EF, lower bound	EF, upper bound	Lifetime EF used	EF uncertainty (%)	AD uncertainty (%)	2012 emission share	Combined uncertainty (%)
Domestic ref.	0.1	0.5	0.3	67	500	0.0%	
Commercial ref.	5.5	20	10	100	200	11.7%	
Fishing vessels	15	50	35	57	200	C	
Reefers	5	20	10	100	50	C	
Industrial ref.	7	25	10	150	100	15.5%	
Residential AC	1	5	3	67	200	0.4%	
MAC	10	20	10	100	100	4.2%	
Weighted unc.				80	176		193

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.

Recalculations and improvements

Only minor recalculations took place between 2013 and 2014 submissions. Refilling of HFC amounts leaked from reefers between 1993 and 1995 had not been dealt with in the 2013 submission. In this submission the HFC 134A amount that had leaked from reefers between 1993 and 1995 was subtracted from the bulk amount imported in 1995. This reduced HFC 134A import allocated to fishing vessels, commercial and industrial refrigeration and subsequent HFC emissions from these subsectors. The difference is greatest in the year of the reallocation (1995: 0.57 Gg CO2 eq.) but decreases with time due to the decreasing influence of stock changes in 1995 on more recent lifetime emissions. In 2012 the difference was less than 0.01 Gg CO2 eq.

4.8.2 Consumption of SF6

Overview

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 SF6 used in Iceland is used by Landsnet LLC which operates Iceland´s electricity transmission system. A number of energy intensive plants, like aluminium smelters and the aluminium foil producer have their own high voltage gear using SF_6.

Methodology

SF_6 nameplate capacity development data as well as SF_6 quantities lost due to leakage were obtained from the above mentioned stakeholders. The data regarding leakage consisted of measured quantities as well as calculated ones. Measurements consisted mainly of weighing amounts used to refill or replace equipment after incidents. Quantities were calculated either by allocating periodical refilling amounts to the number of years since the last refilling or by assuming leakage percentages. This approach can best be described as a hybrid of GPG Tiers 2b and 3C.

Emissions

SF_6 emissions amounted to 233 kg in 2012 which is tantamount to 5.6 Gg CO_2 eq. or less than 0.2% of Iceland´s total GHG emissions in 2012. Emissions increased by 384% since 1990. However, this increase is slightly less than proportional compared to the net increase in SF_6 nameplate capacity since 1990.

Figure 4.8 shows both nameplate capacity development and emissions between 1990 and 2012. 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.

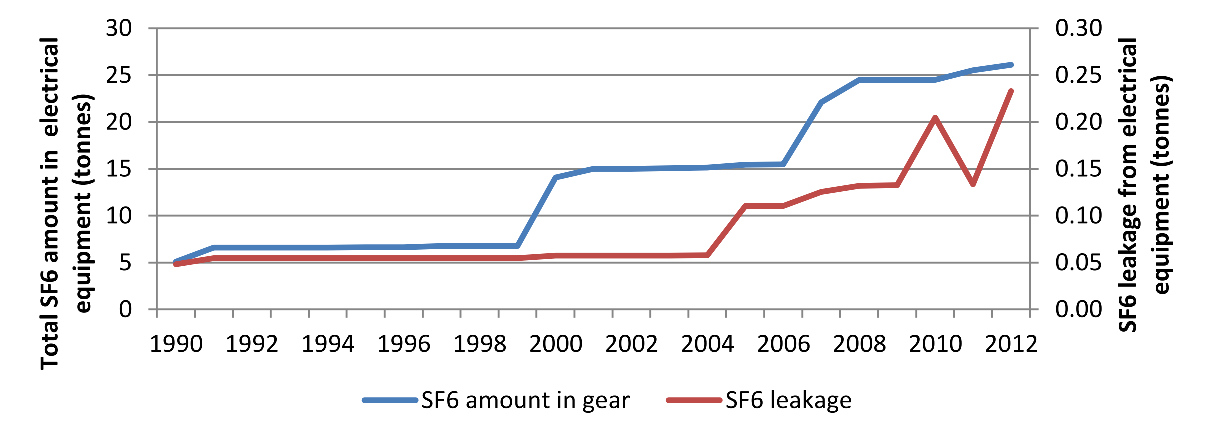

Figure 4.8. Total SF_6 amounts contained in and SF_6 leakage from electrical equipment (tonnes).

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).

Recalculations

No recalculations were performed between 2013 and 2014 submissions.

5 Solvent and Other Product Use

5.1 Overview

This chapter describes non-methane volatile organic compounds (NMVOC) emissions from solvents and N_2O emissions from other product use in Iceland. 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. Also, NMVOCs act as precursors to the formation of ozone. When volatile chemicals are exposed to air, emissions are produced through evaporation of the chemicals. The use of solvents and other organic compounds in industrial processes and households is an important source of NMVOC evaporation.

N_2O in Iceland is almost exclusively used as anaesthetic and analgesic in medical applications. Minor uses of N_2O in Iceland comprise its use in fire extinguishers and as fuel oxidant in auto racing.

In 1990 emissions from Solvent and Other Product had been 9.1 Gg CO_2 equivalents. Emissions decreased by 32% between 1990 and 2012 and were 6.2 Gg CO_2 equivalents in 2012 accounting for roughly 0.1% of the total greenhouse gas emissions of Iceland in 2012.

5.1.1 Methodology

NMVOC emissions are estimated according to the EMEP/EEA air pollutant emission inventory guidebook (EEA, 2009). In this chapter, sources of NMVOC are divided into subcategories using the classification of the EMEP guidebook. The nomenclatures of both EMEP guidebook and Common Reporting Format are shown in Table 5.1 along with the respective “Selected nomenclature for sources of air pollution“ (SNAP). N_2O emissions were estimated using the 2006 GL.

Table 5.1. Subcategories in the sector Solvents and other product use with their respective codes in CRF, EMEP, and SNAP.

Solvent and other product use	CRF	EMEP	SNAP	In this chapter
Paint application	3A	3A	0601	5.2
Degreasing and dry cleaning	3B	3B	0602	5.3
Chemical Products, manufacturing and processing	3C	3C	0603	5.4
Other	3D			
1. Use of N_2O for anaesthesia	3D.1			5.6
2. Fire extinguishers	3D.2			5.6
3. N_2O from aerosol cans	3D.3			5.6
4. Other use of N_2O	3D.4			5.6
5. Other NMVOC emissions from printing, other domestic use, other product use (preservation of wood and tobacco)	3D.5	3D	0604	5.5

5.1.2 Key source analysis

The key source analysis performed for 2012 has revealed that the sector Solvent and other product use is neither a key source category in level nor in trend. This is shown in Table 1.1.

5.1.3 Completeness

Table 5.2 shows the completeness of the sector. All greenhouse gas source categories have been estimated in this submission with the exception of N_2O from aerosol cans, which does not occur in Iceland.

Table 5.2. Solvent and other product use – completeness (E: estimated, NA: not applicable, NO: not occurring)

	CO_2	NMVOC	N_2O
Solvent and other product use			
Paint application	E	E	NA
Degreasing and dry cleaning	E	E	NA
Chemical Products, manufacturing and processing	E	E	NA
Other			
1. Use of N_2O for anaesthesia	NA	NA	E
2. Fire extinguishers	NA	NA	E
3. N_2O from aerosol cans	NA	NA	NO
4. Other use of N_2O	NA	NA	E
5. Other NMVOC emissions from printing, other domestic use, other product use (preservation of wood and tobacco)	E	E	NA

5.1.4 *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.

5.2 Paint application

5.2.1 *Methodology, activity data and emission factors*

The greenhouse gas source categories Paint application, Degreasing, and Other NMVOC emissions from printing and other product use have in common that their activity data consists of data about imported goods and substances. This data was received from Statistics Iceland. Table 5.3 shows all customs codes used in the respective chapters. The customs codes stem from the customs code register published online in January 2012 (http://tollur.is/upload/files/Tollskr%C3%A1%202012%20-%20web.pdf, Icelandic directorate of customs, 2012).

Table 5.3. Customs codes from the Icelandic directorate of customs (Icelandic directorate of customs, 2012)

Activity	Customs chapter	Sub-chapter	Extensions
Paint application	32	5	0
Paint application	32	8	All sub numbers except for 1003 (wood preservatives)
Paint application	32	10	All sub numbers
Paint application	32	11	0
Paint application	32	12	9001, 9009
Paint application	32	13	All sub numbers
Paint application	32	14	1001-1003
Paint application	38	14	10
Degreasing	27	7	3000
Degreasing	29	2	4100, 4200, 4300, 4400
Degreasing	29	3	1200, 1901, 2200, 2300
Degreasing	38	14	0021, 0029, 0090
Printing	32	12	1000
Printing	32	15	All sub numbers
Wood preservation	32	8	1003
Wood preservation	27	7	9100
Tobacco	24	1	All sub numbers
Tobacco	24	2	All sub numbers
Tobacco	24	3	All sub numbers except for 9109 (snuff)

The EMEP guidebook (EEA, 2009) provides emission factors based on amounts of paint applied. Data exists on imported paint since 1990 (Statistics Iceland, 2013) and on domestic production of paint since 1998 (Icelandic recycling fund, 2013). The Tier 1 emission factor refers to all paints applied, e.g. waterborne, powder, high solid and solvent based paints. The existing data on produced and imported paints, however, makes it possible to narrow activity data down to conventional solvent based paints. Therefore 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. The amounts of solvent based paint produced domestically and imported are shown in Figure 5.1.

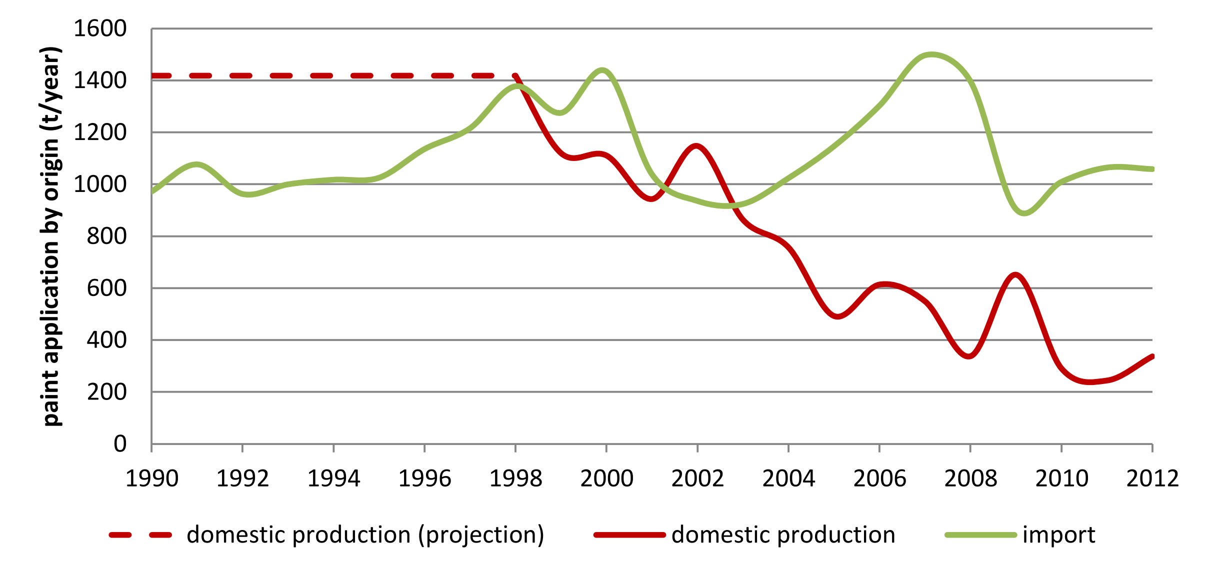

Figure 5.1. Amounts of solvent based paints imported and produced domestically from 1990-2012.

5.3 Degreasing and dry cleaning

5.3.1 Methodology, activity data and emissions

The EMEP guidebook provides a Tier 1 emission factor for degreasing based on amounts of cleaning products used. Data on the amount of cleaning products imported is provided by Statistics Iceland. Activity data consisted of the chemicals listed by the EMEP guidebook: methylene chloride (MC), tetrachloroethylene (PER), trichloroethylene (TRI) and xylenes (XYL). In Iceland, though, PER is mainly used for dry cleaning (expert judgement). In order to estimate emissions from degreasing more correctly without underestimating them, only half of the imported PER was allocated to degreasing. Emissions from dry cleaning are estimated without using data on solvents used (see below). The use of PER in dry cleaning, though, is implicitly contained in the method. In Iceland, Xylenes are mainly used in paint production (expert judgement). In order to estimate emissions from degreasing more correctly without underestimating them, only half of the imported xylenes were allocated to degreasing. Emissions from paint production are estimated without using data on solvents used (see chapter 5.4.1) 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. 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 guidebook. Activity data for calculation of NMVOC emissions is the amount of textile treated annually, which is assumed to be 0.3 kg/head (EMEP guidebook default) 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 guidebook reduction default value of 0.89. NMVOC emissions from dry cleaning were calculated thus:

$$E_{NMVOC}(t) = population(t) \bullet 0.3 \bullet (177/1000) \bullet (1-0.89)$$

Where:

E_{NMVOC} (t) = emissions of NMVOC in year t, kg

Population (t) = population in year t

0.3 = amount of textiles treated inhabitant/year, kg

177 = g NMVOC emissions/kg textile treated

0.89 = abatement efficiency of closed circuit PER machines

5.4 Chemical products, manufacturing and processing

5.4.1 *Methodology, activity data and emissions*

The only activity identified for the subcategory chemical products, manufacture and processing is manufacture of paints. NMVOC emissions from asphalt blowing, included in the EMEP guidebook under chemical products, are covered in the industry sector (NO in Iceland). NMVOC emissions from the manufacture of paints were calculated using the EMEP guidebook Tier 2 emission factor of 11 g/kg product. The activity data consists of the amount of paint produced domestically as discussed above in chapter 5.2.1.

5.5 Other NMVOC emissions

5.5.1 *Methodology, activity data and emissions*

Printing

NMVOC emissions for printing were calculated using the EMEP guidebook Tier 1 emission factor of 500g/kg ink used. Import data on ink was received from Statistics Iceland (Statistics Iceland, 2013).

Other domestic use

NMVOC emissions from other domestic use were calculated using the EMEP guidebook emission factor of 1 kg/inhabitant/year.

Other product use

Emissions from wood preservation were calculated using the EMEP guidebook Tier 2 emission factors for creosote preservative type (110 g/kg creosote) and organic solvent borne preservative (900 g/kg preservative). Import data on both wood preservatives was received from Statistics Iceland (Statistics Iceland, 2013).

NMVOC emissions from tobacco combustion were calculated using the EMEP guidebook Tier 2 emission factors for tobacco combustion of 3.5 g/tonne tobacco. Activity data consisted of all smoking tobacco imported and was provided by Statistics Iceland (Statistics Iceland, 2012).

5.6 N_2O from product uses

5.6.1 Methodology, activity data and emissions

N_2O emissions from product uses 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 IPPU chapter of the 2006 guidelines, 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.

Equation 8.24

EN2O (t) = Σi { [0.5 • Ai(t) + 0.5 • Ai(t-1)] • 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

The 2006 GL recommend an emission factor of 1 for medical use of N_2O. This emission factor is also used for other N_2O uses. Around 95% of all N_2O imported is used for medical purposes.

Total emissions from N_2O use decreased from 19 tonnes N_2O in 1990 to 11 tonnes N_2O in 2012.

5.7 Emissions

Figure 5.2 shows NMVOC emissions from solvents and other product use from 1990-2012. NMVOC emissions were around one Gg from 1990 to 1995. Between 1996 and 2008 emissions oscillated between 1.1 and 1.3 Gg. The decrease of emissions during the last three years is mainly due to decreasing emissions from paint application, printing and organic wood preservatives.

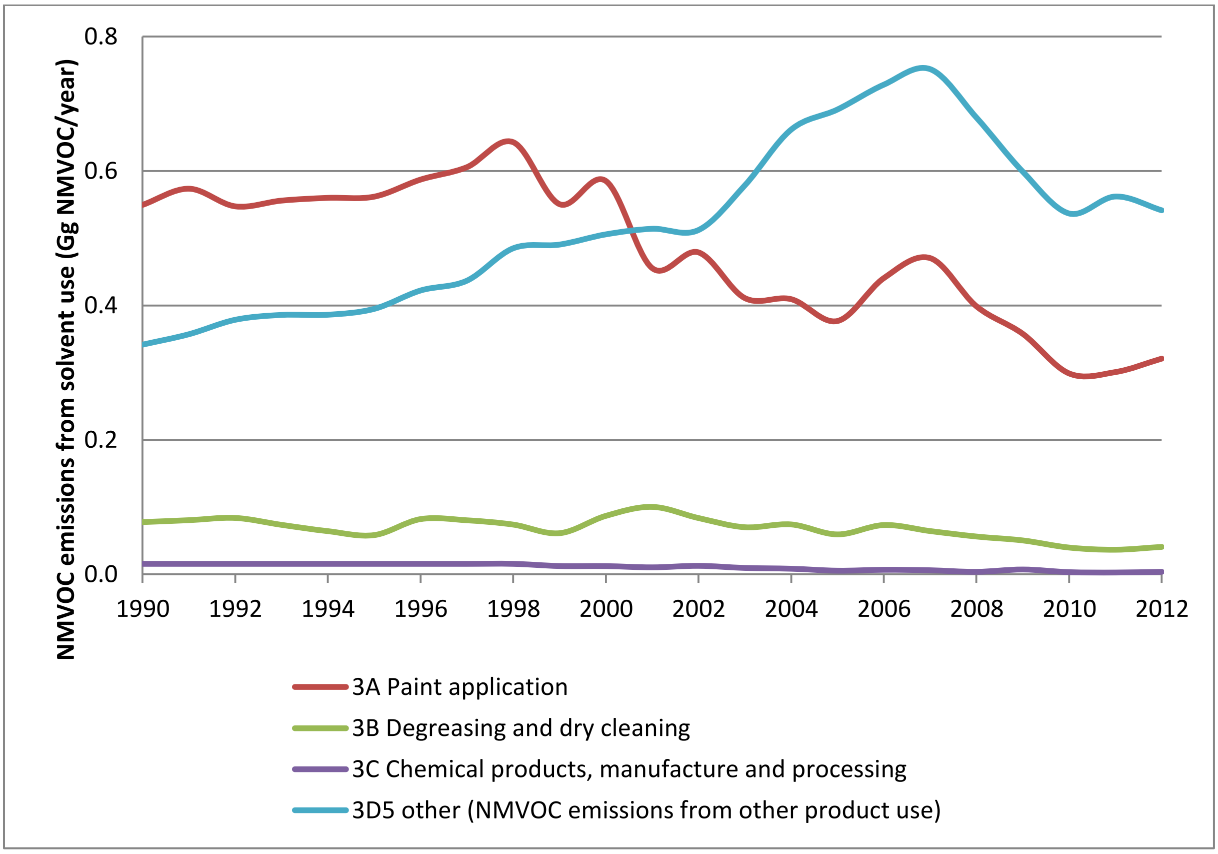

Figure 5.2. NMVOC emissions from solvent and other product use (Gg/year) from 1990-2012.

NMVOC emissions will oxidize to CO_2 in the atmosphere over a period of time. This conversion has been estimated with the following equation:

Emissions from NMVOCs in CO_2-equivalents

$$CO_2 \text{ equivalents} = 0.85 \bullet NMVOC_t \bullet 44/12$$

Where:

0.85 = Carbon content fraction of NMVOC

$NMVOC_t$ = Total NMVOC emissions in the year t

44/12 = Conversion factor

The addition of thus transformed NMVOC emissions and N_2O emissions from product use result in total emissions for solvent and other product use reported in chapter 5.1.

5.8 Uncertainties

Uncertainty estimates for emissions from Solvent and Other Product 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 6.4 from page 6.12 of the GPG. 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 6.3 from the GPG (page 6.12) using 2012 emissions as uncertain quantities. Combined AD uncertainty for the sector was 61%, combined EF uncertainty 168%. This resulted in 178% total uncertainty for CO_2 emission from the sector. Table 5.4 shows the uncertainties for the subsectors and the respective references.

Table 5.4. Subsector AD and EF uncertainties for CO_2 emissions from solvent use.

Subsector	AD uncertainty	EF uncertainty
Paint application	100[a]	57[b]
Degreasing	200[a]	96[b]
Dry cleaning	1000[b]	105[b]
Chemical products	20[a]	500[b]
Printing	50[a]	320[b]
Other domestic use	5[a]	200[b]
Other product use: wood preservation, creosote	100[a]	36[b]
Other product use: wood preservation, organic solvent borne preservative	100[a]	44[b]
Other product use: tobacco	50[a]	108[b]

A = expert judgement; B = EMEP GB

The applied 2006 GL 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. Therefore 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%.

6 AGRICULTURE

6.1 Overview

Icelanders are 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.

Total methane emissions from agriculture amounted to 13.51 Gg in 2012; total nitrous oxide emissions to 1.27 Gg. Thus combined CH_4 and N_2O emissions amounted to 678 Gg CO_2-eq. in 2012. Aggregated agriculture emissions were 737 Gg CO_2-eq. in 1990. The 8% decrease 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. 89% of N_2O emissions were caused by agricultural soils, the rest by manure management, i.e. storage of manure.

6.1.1 *Methodology*

The calculation of greenhouse gas emissions from agriculture is based on the methodologies suggested by the IPCC Good Practice Guidance (IPCC, 2000). In three cases default values were taken from the 2006 IPCC Guidelines (IPCC, 2006). These exceptions concern the manure management methane emission factor for fur-bearing animals, the methane correction factor (MCF) for manure management systems, and default values for nitrogen excretion rate for animal species. The default for fur-bearing animals is non-existent in the GPG and the 1996 IPCC Guidelines and was taken from the 2006 guidelines for completeness. MCF and nitrogen excretion defaults from the 2006 Guidelines better suit Icelandic circumstances and were therefore used. This will be discussed further in the respective chapters, 6.4.1 and 6.5.1.

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 GPG. 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.

6.1.2 *Key source analysis*

The key source analysis performed for 2012 (Table 1.1) revealed the following greenhouse gas source categories from the agriculture sector to be key sources in terms of total level and/or trend:

Emissions from Enteric Fermentation, Cattle – CH_4 (4A1)
- This is a key source in level (1990 and 2012)

Emissions from Enteric Fermentation, Sheep – CH_4 (4A3)
- This is a key source in level (1990 and 2012) and trend

Emissions from Manure Management – CH_4 (4B)
- This is a key source in level (2012); only when LULUCF is excluded

Emissions from Manure Management – N_2O (4B)
- This is a key source in level (1990 and 2012)

Direct Emissions from Agricultural Soils – N_2O (4D1)
- This is a key source in level (1990 and 2012)

Pasture, Range, and Paddock Manure – N_2O (4D2)
- This is a key source in level (1990 and 2012)

Indirect Emissions from Agricultural Soils – N_2O (4D3)
- This is a key source in level (1990 and 2012)

6.1.3 *Completeness*

Table 6.1 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 6.1. Agriculture – completeness (E: estimated, NE: not estimated, NA: not applicable, NO: not occurring).

Sources	CO_2	CH_4	N_2O
Enteric Fermentation (4A)	NA	E	NA
Manure Management (4B)	NA	E	E
Rice Cultivation (4C)	Not Occurring		
Agricultural Soils (4D)			
1. Direct Emissions	NA	NA	E
2. Animal Production	NA	NA	E
3. Indirect Emissions	NA	NA	E
4. Other	Not Occurring		
Prescribed burning of Savannas (4E)	Not Occurring		
Field burning of Agricultural Residues (4F)	Not Occurring		
Other (4G)	Not Occurring		

6.2 Activity data

6.2.1 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. The IFVA reports the census to Statistics Iceland which publishes them.

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 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). Number of piglets was calculated with data on piglets per sow and year (Farmers Association of Iceland, written information, 2012). Number of kids was calculated with information on birth rates received from Iceland´s biggest goat farmer (Þorvaldsdóttir, oral information, 2012). Numbers 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 horses (3% in 2012), they are considerably higher for sheep and poultry (56 and 117%, respectively). Number of swine, however, is eleven times higher in the NIR than in the national census. Table 6.2 shows animal populations for 1990, 2000 and 2012 for the census and NIR as well as percentage differences between both.

Table 6.2. Livestock population data from original national census and after adding data on animals with a life span of less than one year unaccounted for in census to it (NIR). All numbers in animal years, i.e. number of animals with a life span of less than one year were weighted with their age at slaughter.

	1990	1990	2000	2000	2012	2012
Livestock category	census	NIR	census	NIR	census	NIR
dairy cattle	32,249	32,249	27,066	27,066	24,761	24,761
other mature cattle	22,536	22,536	27,157	27,157	26,984	26,984
young cattle	20,118	20,118	17,912	17,912	19,768	19,768
cattle (total)	74,903	74,903	72,135	72,135	71,513	71,513
mature ewes	445,635	445,635	373,194	373,194	375,232	375,232
other mature sheep	13,277	13,277	12,091	12,091	11,352	11,352
animals for replacement	89,795	89,795	80,289	80,289	89,678	89,678
lambs (weighted)		313,108		263,716		267,803
sheep (total)	548,707	861,815	465,574	729,290	476,262	744,065
increase ((NIR-census)/census)		57%		57%		56%
sows	3,135	3,135	3,862	3,862	3,643	3,643
piglets (weighted)		26,510		28,405		40,335
total swine	3,135	29,645	3,862	32,267	3,643	43,978
% increase ((NIR-census)/census)		846%		735%		1107%
adult horses	49,464	49,464	51,728	51,728	53,503	53,503
young horses	15,803	15,803	17,113	17,113	16,331	16,331
foals (weighted for NIR)	6,763	8,600	4,828	6,789	6,114	8,226
total horses	72,030	73,867	73,669	75,630	75,948	78,060
% increase ((NIR-census)/census)		3%		3%		3%
goats	345	345	416	416	857	857
kids (weighted)		159		192		395
total goats	345	504	416	608	857	1,252
% increase ((NIR-census)/census)		46%		46%		46%
minks	42,804	42,804	36,593	36,593	40,178	40,178
foxes	4,974	4,974	4,132	4,132	3	3
rabbits	1,814	1,814	706	706	258	258
hens	214,975	214,975	193,097	193,097	200,169	200,169
broilers	291,190	291,190	91,515	91,515	50,820	50,820
pullets	24,020	24,020	63,039	63,039	68,432	68,432
chickens		139,095		184,202		452,838
total chickens	530,185	669,280	347,651	531,853	319,421	772,259
% increase ((NIR-census)/census)		26%		53%		142%
ducks/geese/turkeys	3,618	3,618	5,762	5,762	2,600	2,600
ducks/geese/turkeys: chickens (weighted)		1,659		7,645		9,428
total ducks/geese/turkeys	3,618	5,277	5,762	13,407	2,600	12,028
% increase ((NIR-census)/census)		46%		133%		363%

6.2.2 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” and “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 6.3 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 from the GPG to calculate gross energy intake for cattle and sheep subcategories.

Table 6.3. Overview of equations used to calculate gross energy intake in enhanced livestock population characterisation for cattle and sheep (NA: not applicable)

Subcategory	**Equations from the GPG, Net energy for maintenance, activity, growth, lactation, wool, and pregnancy**					
	maintenance	activity	growth	lactation	wool	preg-nancy
mature dairy cows	4.1	4.2	NA	4.5a	NA	4.8
cows used for producing	4.1	4.2	NA	4.5a	NA	4.8
heifers	4.1	4.2	4.3a	NA	NA	4.8
steers used principally for producing meat	4.1	4.2	4.3a	NA	NA	NA
young cattle	4.1	4.2	4.3a	NA	NA	NA
mature ewes	4.1	4.3	NA	4.5c	4.7	4.8
other mature sheep	4.1	4.3	NA	NA	4.7	NA
animals for replacement[1]	4.1	4.3	4.3b	NA	4.7	4.8
Lambs	4.1	4.3	4.3b	NA	4.7	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 6.4 shows national parameters that were used to calculate gross energy intake for cattle in 2012. Not all parameters have been constant over the last two decades. The ones that have changed during that time period are listed with the range for the respective parameter (see: chapter 6.2.4).

Table 6.4. Animal performance data used in calculation of gross energy intake for cattle in 2012. Where time dependent data is used, the range of data is shown in brackets below the 2010 value (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	8.7 (9 - 8.7)	1	8.1	10.9[1]	12
Months on pasture	3.3 (3 – 3.3)	11	3.9	1.1	0
Mature body weight (kg)	430	500	430	515[2]	515[2]
Daily weight gain (kg)	NO	NO	0.5	0.53	0.5
Kg milk per day	14.9 (11.3 – 15)	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 6.5 shows national parameters that were used to calculate gross energy intake for sheep in 2012.

Table 6.5. Animal performance data used in calculation of gross energy intake for sheep from 1990-2010 (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	6.6	6.6	6.6	0
Months on flat pasture	2	2	2	1.1
Months on hilly pasture	3.4	3.4	3.4	3.4
Body weight at weaning (kg)	22	22	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	0.185[1]	NA	0.55[1]	NA
Double birth fraction	0.72[1]	NA	0.14[1]	NA
Triple birth fraction	0.06[1]	NA	NO	NA
Annual wool production (kg)	3	2.5	1.5	1.5
Digestible energy (in % of gross energy)	69	69	69	69

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.

6.2.3 *Feed characteristics and gross energy intake*

The 2013 ERT review of Iceland´s GHG inventory investigated the origin of the values used for digestible energy (DE) content of cattle and sheep feed. The respective values were 79% for all cattle except for steers, 66% for steers and 69% for sheep. Iceland had to admit that the values were based on expert judgment and that sufficient references could not be provided. The relatively high values for cattle led to a relatively low gross energy intake estimate and subsequently to low CH_4 emission estimates for enteric fermentation and manure management (the latter via volatile solid excretions). Since Iceland could not provide sufficient references, these possible underestimations of methane emissions from cattle led to a resubmission of Iceland´s GHG estimates from agriculture. This revision used default values for DE from the 1996 GL that were considerably lower (65% for calves, 60% for all other cattle) and was reported as part of a resubmission of CRF tables in October 2013.

In preparation of the 2014 submission characteristics of cattle and sheep feed were revised. They now built on information on feed composition, daily feed amounts, their dry matter digestibility and feed ash content. This information was collected by the 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 6.6 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 Annexd VII.

Table 6.6. Dry matter digestibility, digestible energy and ash content of cattle and sheep feed.

	DMD (%)	DE (%)	Ash in feed (%)
mature dairy cows	74.4	68.2	6.9
cows used for producing meat	74.4	68.1	7.0
heifers	74.4	68.2	7.1
steers used principally for producing meat	72.5	66.3	7.2
young cattle	79.7	73.4	7.6
mature ewes	70.5	64.3	7.0
other mature sheep	70.5	64.3	7.0
animals for replacement	70.5	64.3	7.0
lambs	83.5	77.2	7.4

Figure 6.1 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 6.2.4). The GE of mature dairy cattle has increased from 200 MJ/day in 1990 to 236 MJ/day in 2012. 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 5.6 t in 2012.

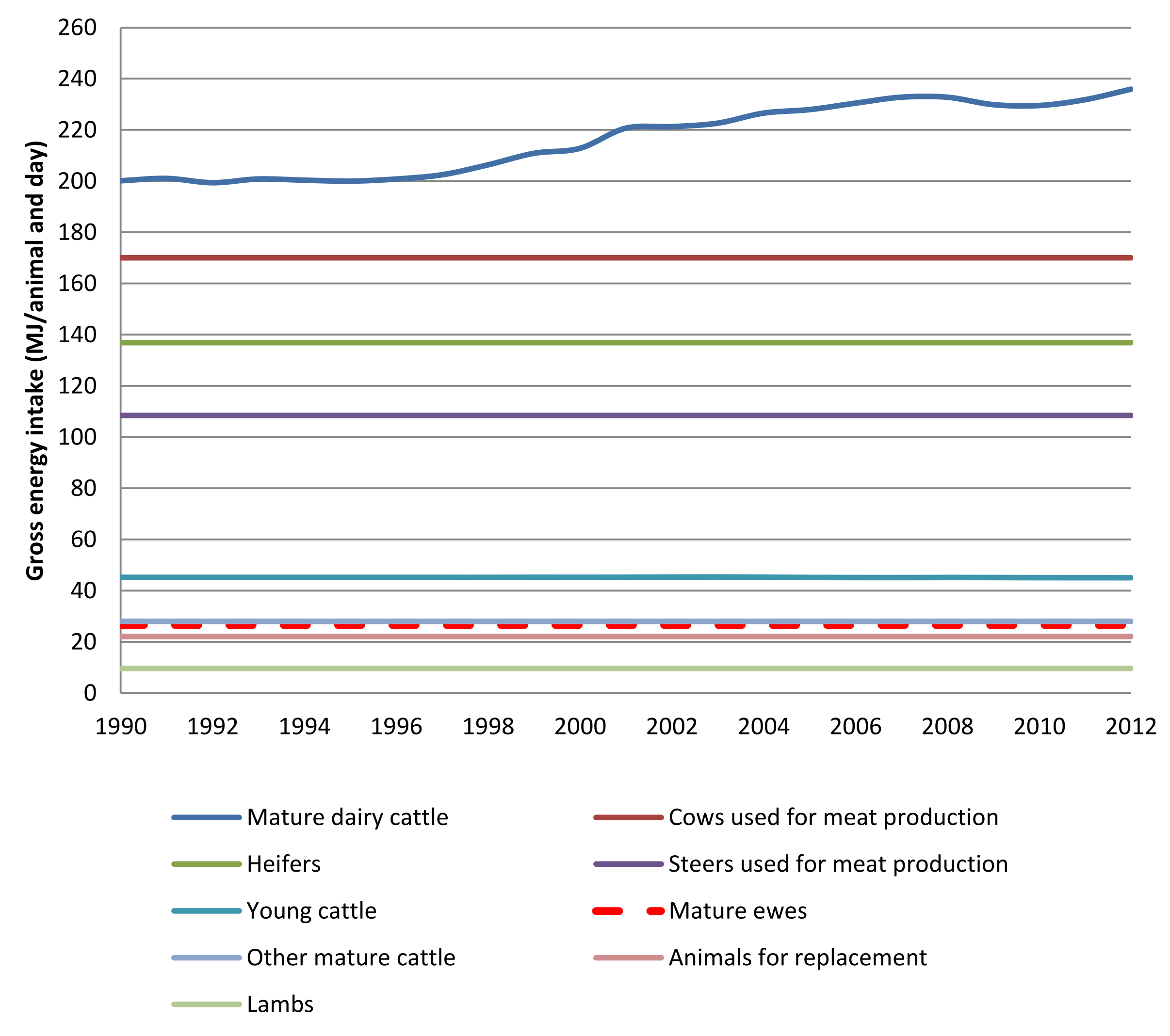

Figure 6.1. Gross energy intake (MJ/day) for cattle and sheep subcategories from 1990-2010.

6.2.4 *Planned improvements*

For the next submission 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.

6.3 CH_4 emissions from enteric fermentation in domestic livestock (4A)

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, 2000).

6.3.1 *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 4.14 from the GPG was applied:

Equation 4.14

Emission factor development

$$EF = (GE * Y_m * 365\ days/yr) / (55.65\ MJ/kg\ CH_4)$$

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 6.7).

Table 6.7. Methane conversion rates for cattle and sheep (IPCC, 2000)

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 1996 Guidelines. The 1996 GL do not contain default emission factors for poultry and fur animals. Therefore default values from the Norwegian NIR (2011) were used for poultry and fur animals.

6.3.2 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 6.8 are solely based on fluctuations in population size. The population size of mature dairy cattle has decreased by 23% between 1990 and 2012. Methane emissions, however, have only decreased by 9% from 2.5 Gg to 2.3 Gg 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 14% between 1990 and 2012 (from 5.4 to 4.6 Gg). Similar decreases can be seen for other sheep subcategories.

The only non-ruminant livestock category with substantial methane emissions is horses. Emissions from horses increased from 1.33 Gg methane in 1990 to 1.41 Gg methane in 2012 due to an equal increase in population size.

The decrease in methane emissions from cattle and sheep caused total methane emissions from enteric fermentation in agricultural livestock to drop from 12.6 Gg in 1990 to 11.6 Gg in 2011, or by 7.3% (Table 6.8).

Table 6.8. Methane emissions from enteric fermentation from agricultural animals for years 1990, 1995, 2000, 2005 and 2008-2012 in t methane.

	1990	1995	2000	2005	2010	2011	2012
livestock category	2,540	2,395	2,267	2,201	2,323	2,341	2,299
cows used for producing meat	0	49	64	91	112	110	115
heifers	247	689	343	362	369	352	365
steers used for producing meat	766	656	847	650	810	801	789
young cattle	358	247	319	322	365	358	351
mature ewes	5,437	4,541	4,553	4,397	4,567	4,558	4,578
other mature sheep	171	159	156	144	150	150	146
animals for replacement	651	535	582	604	679	649	650
lambs	987	823	831	808	846	841	844
swine	44	47	48	57	61	65	66
horses	1,332	1,447	1,364	1,382	1,422	1,442	1,408
goats	2	2	3	3	5	5	6
fur animals	5	4	4	4	4	4	4
poultry	13	7	11	15	14	16	16
total methane emissions	12,553	11,601	11,390	11,041	11,725	11,691	11,635
emission reduction (year-base year)/base year		-7.6%	-9.3%	-12.0%	-6.6%	-6.9%	-7.3%

6.3.3 Recalculations

The revision of digestible energy led to a general decrease of DE values for cattle compared to the 2013 NIR but a general increase compared to the resubmission of CRF tables in October 2013. These changes along with respective impact on gross energy intake are presented in Table 6.9.

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Table 6.9 Digestible energy content estimates of cattle and sheep feed and resulting daily gross energy intake as reported in 2013 NIR, the 2013 resubmission and this submission. All values refer to 2011.

	2013 NIR		2013 CRF resubmission		2014 submission	
	DE	GE	DE	GE	DE	GE
mature dairy cows	78.7	192	60.0	279	68.2	232
cows used for producing meat	78.7	141	60.0	204	68.1	170
heifers	78.7	111	60.0	171	68.2	137
steers used principally for producing meat	65.8	110	60.0	129	66.3	108
young cattle	78.7	41	65.0	54	73.4	45
mature ewes	69.0	24	69.0	24	64.3	27
other mature sheep	69.0	25	69.0	25	64.3	28
animals for replacement1	69.0	20	69.0	20	64.3	22
lambs	69.0	11	69.0	11	77.2	10

The changes in GE translate proportionally into methane emission estimates. Thus CH_4 emissions from enteric fermentation in cattle increased by 0.25 Gg methane or 6.6%. At the same time emissions decreased by 0.81 Gg methane or 17 % between the resubmission and this submission. Methane emissions from enteric fermentation in sheep increased by or 0.37 Gg methane or 6.4% % between 2013 and 2014 submissions due to the decrease in DE and increase in GE (the estimate had not been revised for the resubmission). Taken together these changes decreased enteric fermentation emissions by 0.44 Gg methane or 3.6% since the resubmission.

6.3.4 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 2012 emissions = 17.8%) and 16 and 22 % for sheep (weighted mean = 17.2%). According to the GPG (page 4.28), emission factor estimates for enteric fermentation using Tier 2 are likely to be in the order of +-20%. 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%.

6.4 CH_4 emissions from manure management (4B)

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, 2000).

6.4.1 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 were used. They originate from the 1996 Guidelines except for rabbits and fur-bearing animals, for which the 1996 Guidelines do not contain default values. For completeness these defaults were taken from the 2006 Guidelines. In order to calculate emission factors from manure management, daily volatile secretion (VS) rates have to be calculated first. VS are calculated using gross energy intake per day in the livestock population characterisation and national values for digestible energy and ash content of feed (cf. chapter 6.2.3). Equation 4.16 from the GPG was used.

Equation 4.16

Volatile solid excretion rates

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

Where:

VS = volatile solid excretion per day on a dry-matter weight basis, kg-dm/day

GE = Estimated daily average feed intake in MJ/day

DE = Digestible energy of the feed in percent

ASH = Ash content of the manure in percent

Volatile solid excretion per day is then used in equation 4.17 from the GPG to calculate emission factors for manure management.

Equation 4.17

Emission factor from manure management

$$EF_i = VS_i * 365\ days/year * B_{oi} * 0.67\ kg/m^3 * \Sigma(j)\ MCF_j * MS_{ij}$$

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 CH4 producing capacity for manure produced by an animal within defined population *i*, m^3/kg of VS

MCF_j = CH4 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 1996 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. The reasoning behind the use of the 2006 GL defaults is that the GPG default of 0.39 is judged to be too high for Icelandic circumstances with an average annual temperature of 4°C (expert judgement). The application of the 2006 GL defaults was made after consultation with the IPCC Technical Support Unit (Srivastava, written communication). The high MCF for liquid/slurry is also incompatible with its counterparts from the 1996 and 2006 guidelines. This is shown in Table 6.10.

Table 6.10. Methane correction factors (fractions) included in Good practice guidance, 1996 and 2006 Guidelines for different manure management systems.

		cattle	cattle	cattle	sheep
	Conditions	pasture/range	solid storage	liquid/ slurry	all manure manag. systems
1996 GL	cool climate	1%	1%	10%	1%
GPG	cool climate	1%	1%	39%	same as for cattle
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

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, as a consequence, N_2O emissions from agricultural soils. The fractions used are based on expert judgement (Sveinsson, oral communication; Sveinbjörnsson, oral communication; Dýrmundsson, oral communication) and are assumed to be constant since 1990 except for mature dairy cattle. The average amount of time mature dairy cattle spend on pasture has increased from 90 to 100 days over the last 20 years. Heifers spend 120 days per year on pasture whereas cows used for meat production spend 11 months on grazing pastures. Young cattle and steers are housed all year round. All cattle manure, i.e. not spread on site by the animals themselves, is managed as liquid/slurry without natural crust cover. Sheep spend 5.5 months on pasture and range; this includes the whole live span of lambs. 65% of the manure managed is managed as solid storage, the remaining 35% as liquid/slurry (Table 6.11).

Table 6.11. Manure management system fractions for all livestock categories

	liquid/slurry	solid storage	pasture/ range/ paddock
mature dairy cattle	73%		27%
cows used for producing meat	8%		92%
heifers	67%		33%
steers used for producing meat	91%		9%
young cattle	100%		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 6.12.

Mature dairy cows and steers have the highest emission factors for methane from manure management. Although mature dairy cows have a roughly 60% higher gross energy intake (average from 1990-2010), their emission factors are very similar. This is caused by two things: all steer manure is managed and therefore multiplied with a higher MCF than the share of manure accumulated by mature dairy cattle during grazing on pasture. More importantly, their feed has a lower digestible energy content, which in turn increases volatile solid excretion.

Table 6.12. Emission factors values, range and origin used to calculate methane emissions from manure management.

livestock category	emission factor 2012	emission factor range 1990-2012	source
	(kg CH_4/head year)	(kg CH_4/head year)	
mature dairy cattle	28.00	24.4-28.0	LPS
cows used for producing meat	2.65		LPS
heifers	10.70		LPS
steers used for producing meat	11.84		LPS
young cattle	4.24	4.24-4.27	LPS
mature ewes	0.99		LPS
other mature sheep	1.04		LPS
animals for replacement	0.82		LPS
lambs	0.05		LPS
swine	3.00		1996 GL
horses	1.40		1996 GL
goats	0.12		1996 GL
minks	0.68		2006 GL
foxes	0.68		2006 GL
rabbits	0.08		2006 GL
poultry	0.08		1996 GL

1: Livestock population characterisation

6.4.2 Emissions

As can be seen in Table 6.12 above, there are no emission factor fluctuations for most livestock categories and only minor fluctuations for the remaining cattle subcategories. This implies that fluctuations in methane emission estimates for all livestock subcategories except mature dairy cattle can be 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 emissions from manure management have been stable for the last five years and were 1.87 Gg methane in 2012, i.e. 5% lower than they were in 1990 (Table 6.13).

Table 6.13. Methane emissions from manure management in tons.

livestock category	1990	1995	2000	2005	2010	2011	2012
mature dairy cattle	793	742	696	671	701	706	693
cows used for producing meat	0.0	2.0	2.5	3.6	4.4	4.3	4.6
heifers	49	137	68	72	73	70	72
steers used for producing meat	213	182	235	180	225	222	219
young cattle	86	59	76	77	87	86	84
mature ewes	439	367	368	355	369	368	370
other mature sheep	14	13	13	12	12	12	12
animals for replacement	74	60	66	68	77	73	73
lambs	16	13	14	13	14	14	14
swine	89	93	97	115	122	131	132
horses	103	112	106	107	110	112	109
goats	0.1	0.1	0.1	0.1	0.1	0.1	0.2
fur animals (minks and foxes)	32	26	28	25	25	28	27
rabbits	0.1	0.0	0.1	0.0	0.0	0.0	0.0
poultry	53	28	43	60	56	63	61
total methane from manure management	1960	1836	1810	1760	1876	1890	1872
emission reduction (year-base year)/base year		-6.4%	-7.7%	-10.2%	-4.3%	-3.6%	-4.5%

6.4.3 Recalculations

The revision of feed DE values and (to a lesser extent) feed ash content reported in chapter 6.2.3 led to changes in the amount of volatile solid excretions for all cattle and sheep categories. Table 6.14 summarizes the impact of the different DE values on volatile excretions. The changes in VS translate proportionally into methane emission estimates. Thus CH_4 emissions from manure management in cattle increased by 0.37 Gg methane or 51.7% between the 2013 and 2014 NIR. At the same time emissions decreased by 0.53 Gg methane or 33 % between the resubmission and this submission. Methane emissions from sheep manure management increased by or 0.09 Gg methane or 25.2% between 2013 and 2014 submissions due to the decrease in DE and increase in GE (the estimate had not been revised for the resubmission). Taken together these changes decreased manure management emissions by 0.44 Gg methane or 18.8% since the resubmission.

Table 6.14 Digestible energy content estimates of cattle and sheep feed and resulting volatile solid excretions as reported in 2013 NIR, the 2013 resubmission and this submission. All values refer to 2011.

	2013 submission		2013 reubmission		2014 submission	
	DE (%)	VS (kg dm)	DE (%)	VS (kg dm)	DE (%)	VS (kg dm)
mature dairy cows	78.7	2.04	60	5.57	68.2	3.72
cows used for producing meat	78.7	1.49	60	4.08	68.1	2.73
heifers	78.7	1.17	60	3.41	68.2	2.19
steers used principally for producing meat	65.8	1.88	60	2.57	66.3	1.84
young cattle	78.7	0.43	65	0.95	73.4	0.60
mature ewes	69	0.37	69	0.37	64.3	0.99
other mature sheep	69	0.39	69	0.39	64.3	1.04
animals for replacement	69	0.30	69	0.30	64.3	0.82
lambs	69	0.17	69	0.17	77.2	0.05

6.4.4 *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 2012 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 2012 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.

6.5 N_2O emissions from manure management

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 6.6 and 6.7

6.5.1 Activity data

Equation 4.18 in the GPG lists the input variables (printed in bold and discussed below) necessary to estimate N_2O emissions from manure management. Note that all remaining formulae in this chapter report N_2O emissions in units of nitrogen. N_2O emissions are subsequently calculated by multiplying units of nitrogen with 44/28 (molar mass of N_2O divided by molar mass of N_2).

EQUATION 4.18

N_2O EMISSIONS FROM MANURE MANAGEMENT

$$(N_2O\text{-}N) = \Sigma_{(S)} \{[\Sigma_{(T)} (N_{(T)} \bullet Nex_{(T)} \bullet MS_{(T,S)})] \bullet EF_{(S)}\}$$

Where:

$(N_2O\text{-}N)$ = N_2O-N emissions from manure management in the country (kg N_2O-N/yr)

$N_{(T)}$ = Number of head of livestock species/category T in the country

$Nex_{(T)}$ = Annual average N excretion per head of species/category T in the country (kg N/animal/yr)

$MS_{(T,S)}$ = Fraction of total annual excretion for each livestock species/category T that is managed in manure management system S in the country

$EF_{(S)}$ = N_2O emission factor for manure management system S in the country (kg N_2O-N/kg N in manure management system S)

S = Manure management system

T = Species/category of livestock

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 6.4.1. 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 6.11.

Average annual nitrogen excretion rates were calculated using 2006 GL default values (Table 6.15). 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 2000-2012. 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 6.15. Nitrogen excretion rates (N_{ex})

livestock category	N_{ex} 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	75.3[1]
cows used for producing meat	0.33	500	60.2
heifers	0.33	370	44.5
steers used for producing meat	0.33	328	39.5
young cattle	0.33	126	15.2
mature ewes	0.85	65	20.2
other mature sheep	0.85	95	29.5
animals for replacement	0.85	36	11.1
lambs	0.85	21	6.5
sows	0.42	150	23.0
piglets	0.51	41	7.6
horses	0.26	375	35.6
young horses	0.26	175	16.6
foals	0.26	60	5.7
goats	1.28	44	20.3
minks			4.6
foxes			12.1
rabbits			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.

6.5.2 Emission factors

Emission factors are taken from the GPG, table 4.12: 0.001 kg N_2O-N is emitted per kg nitrogen excreted when manure is managed as liquid slurry. 0.02 kg N_2O-N is emitted per kg nitrogen excreted when manure is managed in solid storage as well as when it is unmanaged, i.e. deposited directly on soils by livestock.

6.5.3 Emissions

N_2O emissions from the manure management systems liquid/slurry and solid storage amounted to 140 tonnes N_2O in 2012 and 168 tonnes in 1990 (-17%).

Emissions from liquid systems make up only a small part of total emissions from managed systems or only 6% of total emissions from manure management systems in 2012. 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 2012, followed by solid storage of poultry manure (11.5%), horse manure (6.8%), and fur animal manure (4.2%).

Figure 6.2 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 2012 N_2O emissions from manure spread on pasture by livestock amounted to 270 tonnes or almost twice as much as aggregated emissions from liquid systems and solid storage. Emissions from sheep manure were 181 tonnes, emissions from horse manure were 60 tonnes, and emissions from cattle manure amounted to 28.5 tonnes N_2O.

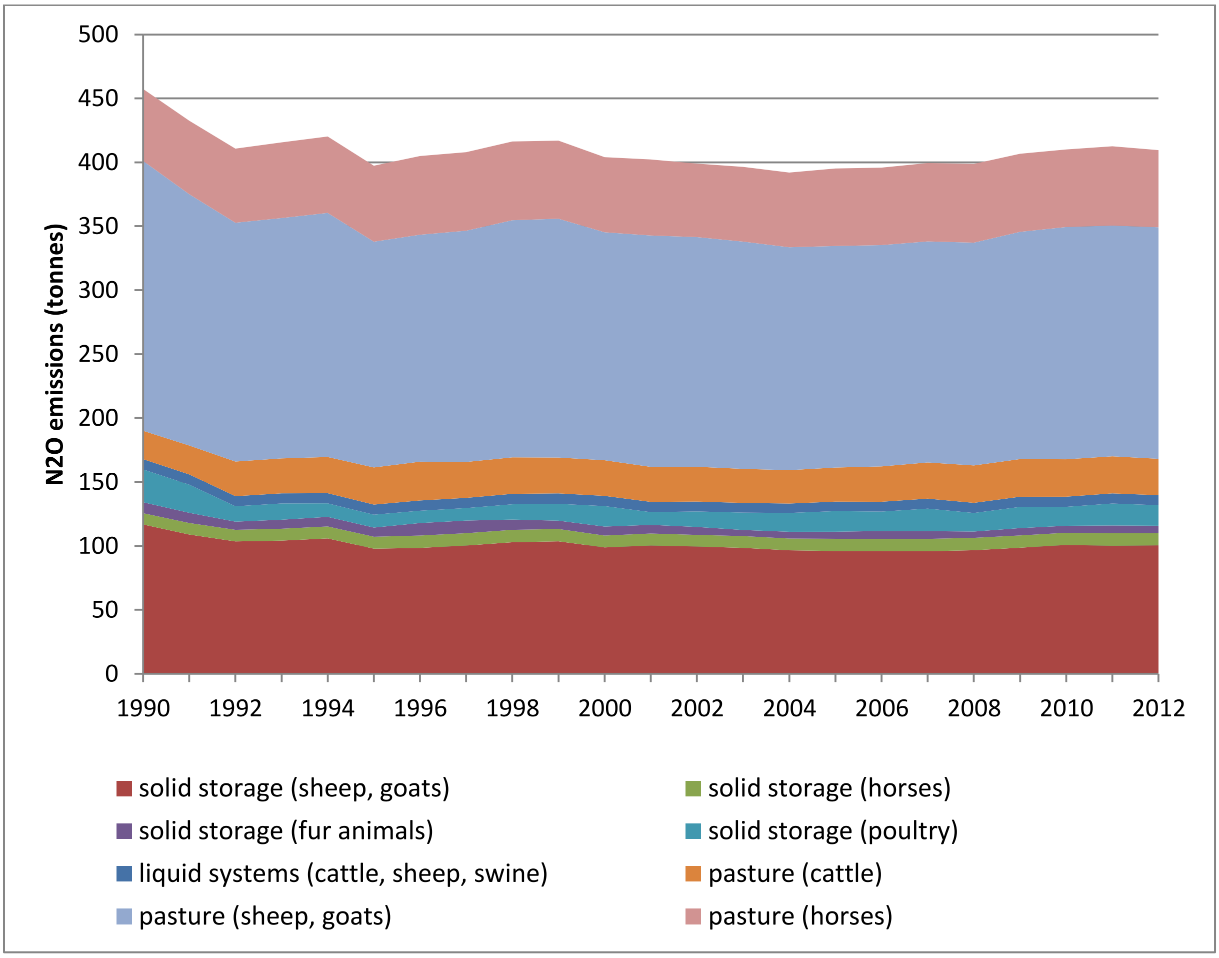

Figure 6.2. N_2O emissions from manure management in Gg N_2O.

6.5.4 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%.

6.5.5 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.

6.6 Direct N_2O emissions from agricultural soils

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, i.e. through volatilisation as NH_3 and NO_x and subsequent redeposition and through leaching and runoff (IPCC, 2000). Direct N_2O emissions from agricultural soils are described here, indirect emissions in chapter 6.7.

6.6.1 Activity data and emission factors

Direct N_2O emissions from agricultural soils are calculated with equation 4.20 from the GPG. Of the five possible sources of input into soils four are applicable for Iceland:

- Synthetic fertilizer nitrogen
- Animal manure nitrogen used as fertilizer
- Nitrogen in crop residues returned to soils
- Cultivation of organic soils

EQUATION 4.20

DIRECT N_2O EMISSIONS FROM AGRICULTURAL SOILS (TIER 1a)

$$N_2O_{Direct}\text{-}N = [(F_{SN} + F_{AM} + F_{BN} + F_{CR}) \bullet EF_1] + (F_{OS} \bullet EF_2)$$

Where:

N_2O_{Direct} -N = Emission of N_2O in units of Nitrogen

F_{SN} = Annual amount of synthetic fertiliser nitrogen applied to soils adjusted to account for the amount that volatilises as NH_3 and NO_x

F_{AM} = Annual amount of animal manure nitrogen intentionally applied to soils adjusted to account for the amount that volatilises as NH_3 and NO_x

F_{BN} = Amount of nitrogen fixed by N-fixing crops cultivated annually

F_{CR} = Amount of nitrogen in crop residues returned to soils annually

F_{OS} = Area of organic soils cultivated annually

EF_1 = Emission factor for emissions from N inputs (kg N_2O-N/kg N input) EF_2 = Emission factor for emissions from organic soil cultivation (kg N_2O-N/ha-yr)

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 6.3). The amount has to be adjusted for the amount that volatilizes as NH_3 and NO_x. The IPCC default for volatilization of synthetic fertilizer N is 0.1.

Animal manure nitrogen (F_{AM})

Animal manure nitrogen is calculated by multiplying Nitrogen excretion rates per head and year for livestock species/categories with the respective population sizes (see chapter: 6.5.2). The amounts have to be adjusted for N that volatilizes as NH_3 and NO_x. The IPCC default for volatilization of animal manure N is 0.2. The nitrogen amount from manure has to be further reduced by the amount deposited onto soils by grazing livestock, which is accounted for separately. Activity data development can be seen in Figure 6.3.

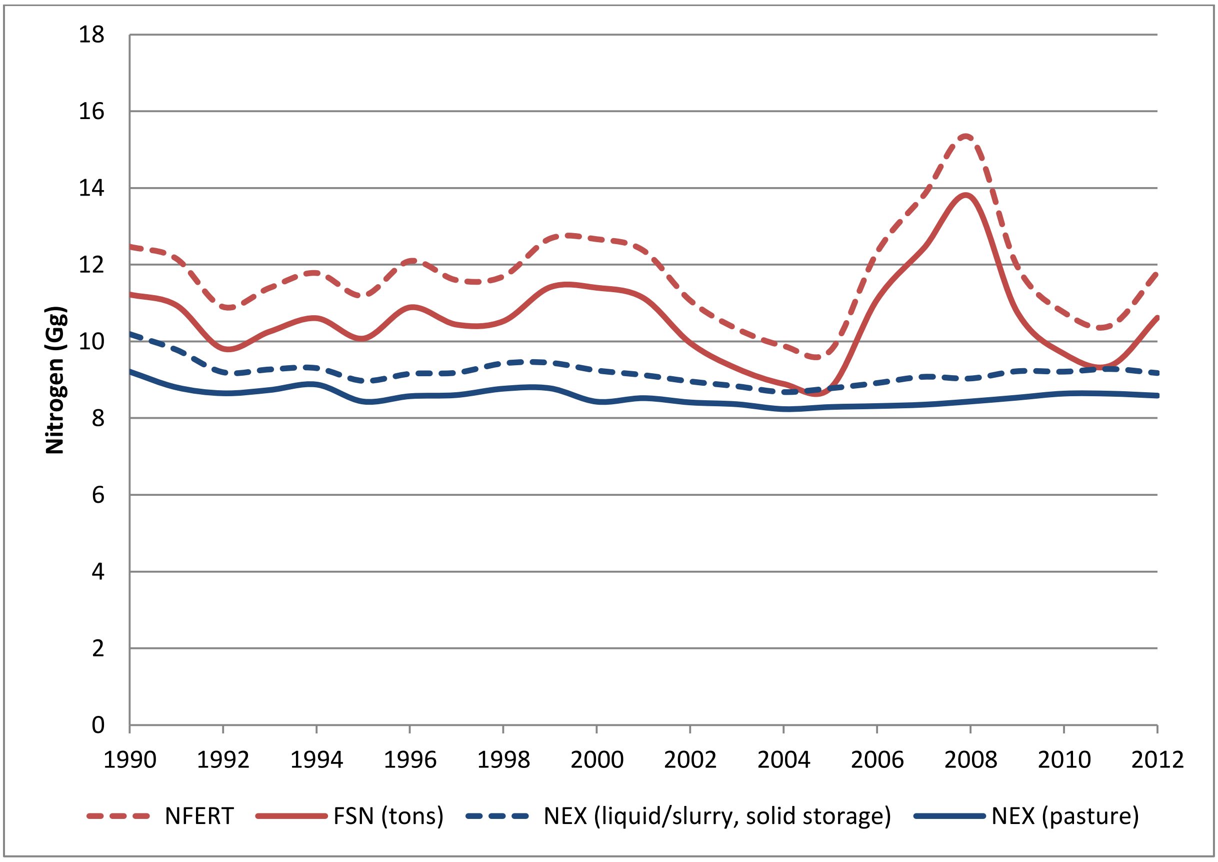

Figure 6.3. Amounts of nitrogen from synthetic fertilizer and animal manure application. Solid lines show nitrogen amounts adjusted for volatilization. Total N amounts are shown in dashed lines of same colour.

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 the Tier 1b method of the GPG:

Amount of produce * residue/crop product ratio * dry matter fraction * nitrogen fraction * (1 – fraction of residue used as fodder)

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 in Figure 6.4).

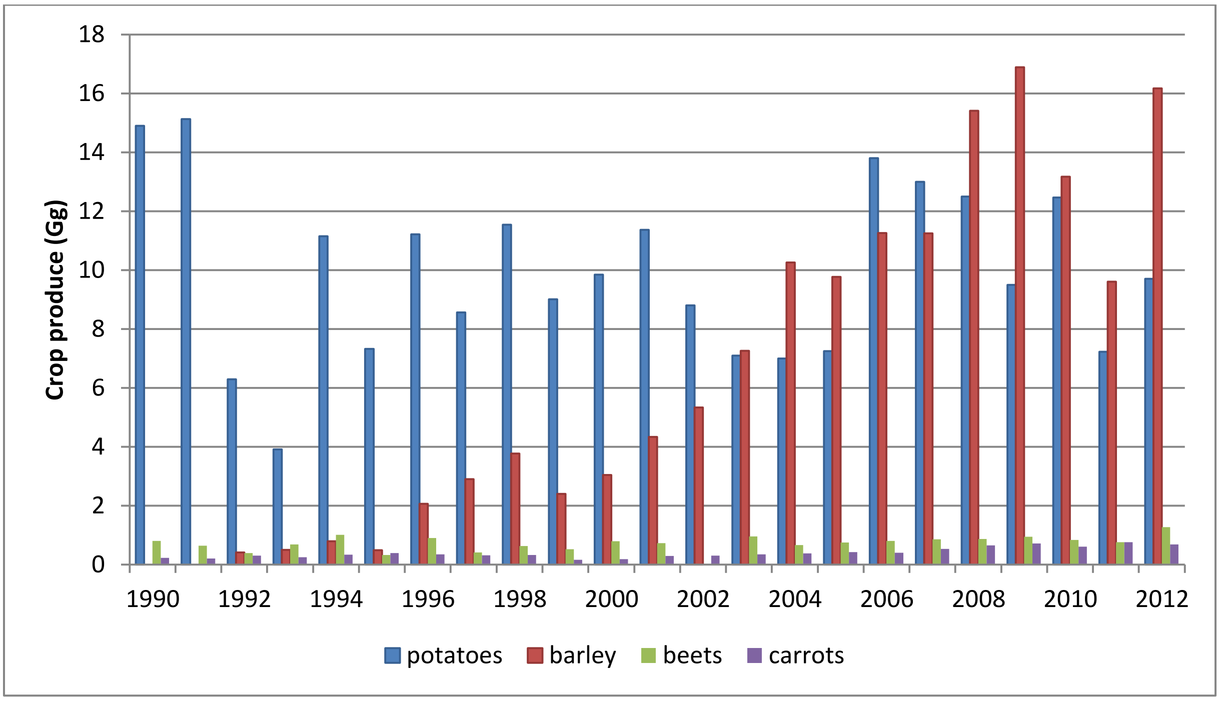

Figure 6.4. Crop produce in kilotonnes for 1990-2012.

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 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. Whereas the first amount ranges between 10 and 20 tonnes, the latter range from 5,000 – 15,000 tonnes annually.

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 57.4 kha in 2012.

6.6.2 Emission factors

The common emission factor for F_{SN}, F_{AM}, and F_{CR} was the IPCC default value of 1.25% kg N_2O-N/kg N.

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. The results have not been published in peer reviewed papers, yet, but publication is in preparation. Results are available in a project report to the Icelandic Research Council (Guðmundsson, 2009).

6.6.3 Emissions

The product of nitrogen amounts and respective emission factors was subsequently transformed into N2O emissions by multiplying units of nitrogen with 44/28 (molar mass of N2O divided by molar mass of N2). Direct emission from agricultural soils amounted to 440 tonnes N2O in 2010, which meant a decrease of 8% in comparison to 1990 emissions. Drivers behind the decrease were decreasing amounts of synthetic fertilizer and animal manure applied to soils as well as the decrease in the total area of cultivated soils. 47% of 2012 emissions originated from synthetic fertilizer application, 33% from animal manure application and 20% from organic soils. The contribution of N in crop residues returned to soils is extremely low (0.1%). Annual fluctuations in emissions are mainly caused by the amount of fertilizer applied to soils (Figure 6.5).

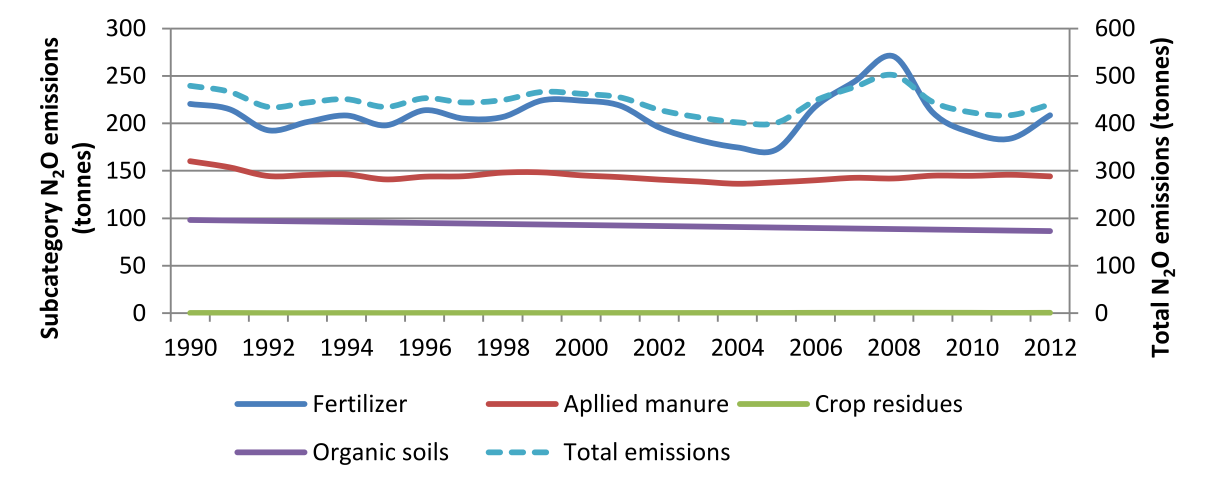

Figure 6.5. Direct N_2O emissions from soils (Gg).

6.6.4 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 2012 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%.

6.7 Indirect N_2O emissions from nitrogen used in agriculture

6.7.1 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 8.3. The first two sources are covered here.

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 format According to the 1996 guidelines, the amount of applied agricultural N that volatilizes and subsequently deposits on nearby soils is equal to the total amount of synthetic fertiliser nitrogen applied to soils plus the total amount of animal manure nitrogen excreted in the country multiplied by appropriate volatilisation factors (IPCC, 1996). That means that this emission source shares activity data with direct emissions from agricultural soils. Here, this includes manure deposited on pasture by grazing livestock. The amounts of nitrogen that were subtracted from total N in order to adjust for volatilization from fertilizer and animal manure application in chapter 6.6 “Direct emissions from agricultural soils” constitute activity data for N_2O from atmospheric deposition. That means that N amounts in fertilizer are multiplied with 0.1 and amounts in animal manure with 0.2 in order to calculate N_2O from atmospheric deposition. This is summarized in equation 4.31 of the GPG. The IPCC emission factor for estimating indirect emissions due to atmospheric deposition of N_2O is 0.01 kg N_2O-N/kg NH_4-N & NO_x-N deposited.

EQUATION 4.31

N_2O FROM ATMOSPHERIC DEPOSITION OF N (TIER 1a)

$$N_2O(G)\text{-}N = [(N_{FERT} \bullet Frac_{GASF}) + (\Sigma T(N_{(T)} \bullet Nex_{(T)}) \bullet Frac_{GASM})] \bullet 0.01$$

Where:

$N_2O(G)$ = N_2O produced from atmospheric deposition of N, kg N/yr

N_{FERT} = total amount of synthetic nitrogen fertiliser applied to soils, kg N/yr 20

$\Sigma T(N_{(T)} \bullet Nex_{(T)})$ = total amount of animal manure nitrogen excreted in a country, kg N/yr

$Frac_{GASF}$ = fraction of synthetic N fertiliser that volatilises as NH_3 and NO_x, kg NH_3-N and NO_x-N/kg of N input

$Frac_{GASM}$ = fraction of animal manure N that volatilises as NH_3 and NO_x, kg NH_3-N and NO_x-N/kg of N excreted

N_2O from leaching and runoff

A large proportion of nitrogen is lost from agricultural soils through leaching and runoff. This nitrogen enters groundwater, wetlands, rivers, and eventually the ocean, where it enhances biogenic production of N_2O (IPCC; 2000). To estimate the amount of applied N that leaches or runs off, amount of synthetic fertilizer and animal manure applied to soils (including manure deposited on pasture by grazing livestock) is multiplied by the fraction that is lost through leaching and runoff (GPG: 0.3). Indirect N_2O emissions from leaching and runoff are calculated by multiplying the resulting nitrogen amount with the GPG emission factor for estimating indirect emissions due to leaching and runoff of N_2O: 0.025 kg N_2O-N/kg N leached & runoff.

6.7.2 Emissions

The development of indirect N_2O emissions from 1990-2012 - after conversion from nitrogen to nitrous oxide - is shown in

Figure 6.6. N_2O emissions amounted to 423 tonnes N_2O in 2012, which meant a 7% decrease from the 1990 value of 456 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.

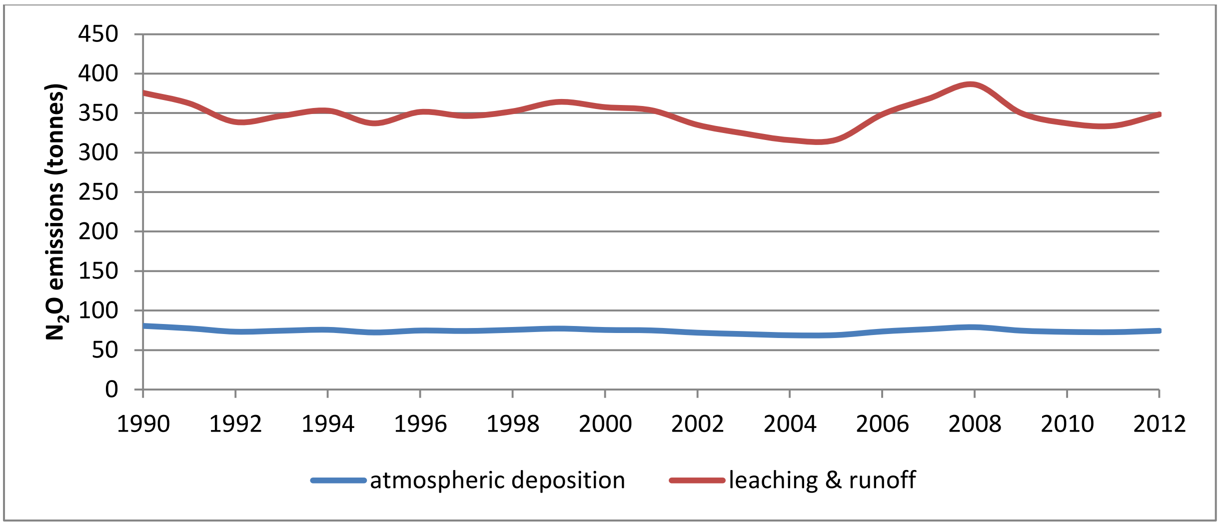

Figure 6.6. Indirect N_2O emissions from agricultural soils.

6.7.3 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%.

7 LULUCF

7.1 Overview

This chapter provides estimates of emissions and removals from Land Use, Land-Use Change and Forestry (LULUCF) and documentation of the implementation of guidelines given in “2006 Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and Other Land Use” (IPCC 2006) hereafter named AFOLU Guidelines. The LULUCF reporting is according to the CRF LULUCF tables. This section was written by the Agricultural University of Iceland (AUI) in close cooperation with Soil Conservation Service of Iceland (SCSI) on chapters related to revegetation. The Icelandic Forest Research (IFR) wrote the chapter on Forest land (7.5) and cooperated on other sections regarding forest and natural birch shrubland.The CRF for LULUCF was prepared through UNFCCC CRF Reporter program (version 3.7.3). The structure of information is the same as in last submission. Time series from previous submissions have been extended to the inventory year.

As in previous year’s submissions the area estimate for the all land use categories is based on the Icelandic Geographical Land Use Database (IGLUD) (Gudmundsson et al 2010) except where more precise estimates are available.

The Non-CO_2 emissions of Grassland are still reported under 5.G- Other, as present version of CRF Reporter does not allow this category reported under Grassland.

The QC/QA plan presented in the 2008 NIR is followed for LULUCF as for other sectors with the exception that no coordination team is presently operating in Iceland and thus ERT reviews are included as substitute. Documentation of all the QC results is not included in preparation of the inventory as QC findings are corrected prior to submission, if possible. The remaining QC findings are reported in this report.

All map layers except those descending from fullscale classification of Icelandic Farmland Database (IFD) (see ch. 7.3.2) were resampled to 15x15 m pixels size instead of 14x14 m in previous submissions. The outer boundaries of the map layers were in prevous submissions taken from the IFD classification. In this year’s submission, a new costline prepared by AUI (see ch. 7.3.2) is included. This new outer boundaries result in some adjustments of other map layers and also introduction of small areas of land not included in previous land cover classifications. This land is in this submission categorizied as unclassified land and included as Other land. The previous map layers of lakes and rivers, i.e. IFD layer lands and rivers and synonymous IS 50 v 3.2 layer, were replaced by a new map layer of lakes and rivers from IS 50 V2013. Where the new layer was not overlapping the IFD layer, small areas of unclassified land appear. That land is likewise categorized as unclassified and included in Other land. Updated map layes of cultivated forest and revegetation activities are also included. With all these modifications the compilation process of the land use map as described in chapter 7.3.6 and in (Gudmundsson et al. 2013) was repeated. The new compilation resulted in revised area estimate for many categories. The processing of land use data is further described below .

The emissions reported for the LULUCF sector in 2012 equals 706.14 Gg CO_2-equivalents compared to 746.23 Gg CO_2-equivalents in 2011 reported in last year's submission. In this year's submission the estimated LULUCF emission for 2011 is 745.67 Gg CO_2-equivalents reflecting recalculation effects. The revision of emission and removal involves several previous reported categories and also estimates are provided for new categories hereto not estimated.

7.2 Land use practices and consequences

The dominant land use through the ages in Iceland has been that of livestock grazing. The natural birch woodland, widespread in the lowland at the time of settlement (AD 875), was exhausted for most part by the end of the 19th century as a result of land clearance, intensive grazing, collection of firewood and charcoal making (Þórarinsson 1974). Following vegetation degradation, soil erosion became prevalent leading to the present day situation of highland areas having almost completely lost their soil mantle and large areas in the lowland regions being impacted by erosion as well (Arnalds et al. 2001).

Cultivation of arable land in Iceland has through the ages been very limited. Cereals (barley) were cultivated to some extent in the first centuries after settlement but cultivation ceased during the Little Ice-age. Due to better cultivars and warmer climate, grain cultivation has resurfaced in the last few decades (Hermannsson 1993). Livestock fodder, was traditionally obtained from uncultivated grasslands and wetlands. With the mechanization of agriculture early in the 20th century, farmers increasingly converted natural grasslands and wetlands into hayfields (Jónsson 1968).

In the period 1940-1990 massive excavation of ditches to drain wetlands took place, aided by governmental subsidies. Part of the drained areas was converted to hayfields or cultivated. The larger part of the lowland wetlands in Iceland was converted to Grassland through this drainage effort.

At the same time cultivation of mineral soils also increased and the area of both the mineral and the organic cropland increased. This increased cultivation along with other factors was reflected in increased livestock. The number of sheep reached a maximum in 1977 leading to over-production of lambmeat and high grazing pressure on many grazing areas. This maximum in sheep number was followed by rapid decline in until 1990 when present winterfead stock size leves was reached (Figure 7.1). 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 also the time spent on highland grazing area is better managed than before affecting the overall grazing pressure.

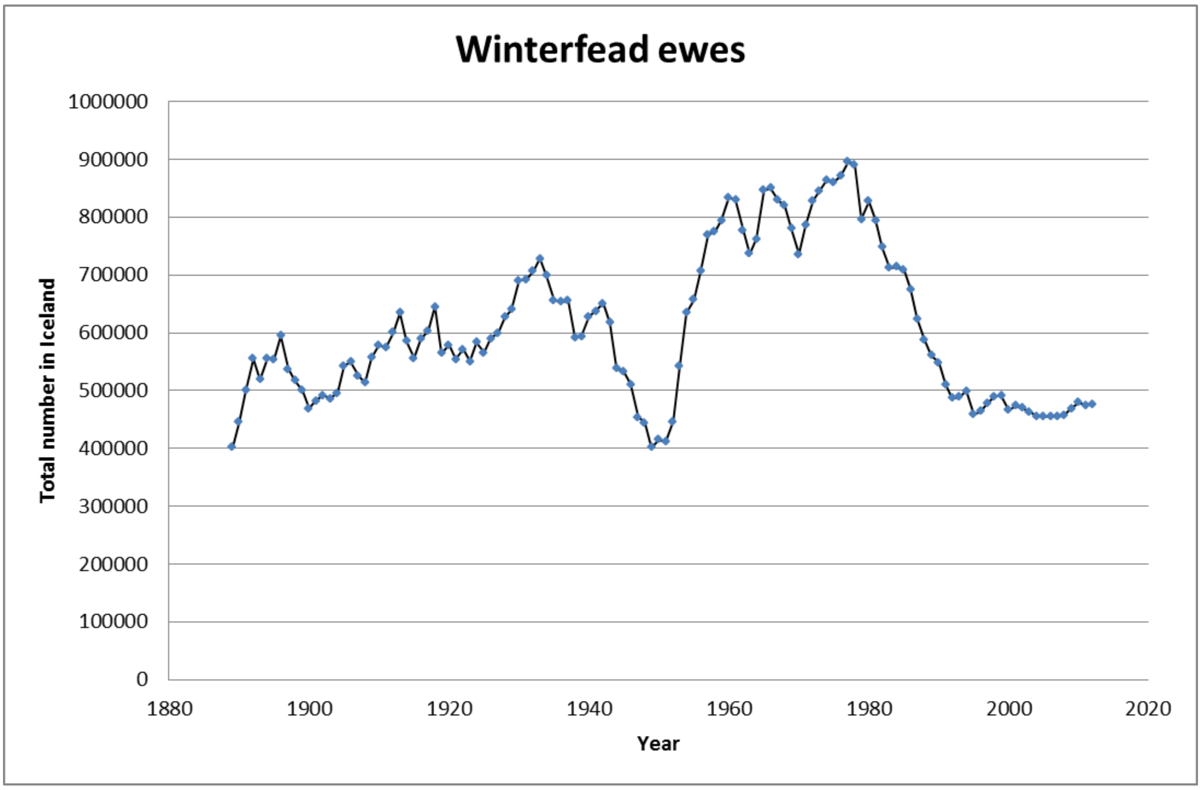

Figure 7.1. Changes in number of winterfead sheep as officially recorded (Statistic Iceland website 2014)

Afforestation has been increasing since the middle of last century. Through afforestation mostly Grassland and, to some extent, other land use categories have been converted to forest land. This afforestation is now documented by the IFR both present activites and older afforestations.

The Soil Conservation Services of Iceland (SCSI) was established in the beginning of last century as response to ongoing soil erosion and sand drift, threatening vegetated areas. Since then SCSI has been combatting soil erosinon and drifting sand as well as revegetating areas of lost vegetation and therby converted unvegetated land to Grassland. The present revegetation is documented by SCSI and previous activites are also being recorded.

The present state of the land and the land use is marked by this land use history. Most of these land use factors are also reflected in this inventory. The areas of wetlands drained were therby converted mostly to cropland or grassland both reported as sources of greenhouse gasses. Afforestation and revegetation are to the contrary reported as sinks. The soil and vegetation degradation of grassland and their recover following less grazing and warmer climate still remains to be tackled properly in the inventory. According to the AFOLU guidelines (IPCC 2006) degradation is equated with decreased C input to soil relative to native conditions. Classification of Grassland according to these criteria has not been carried out so far.

Comprehensive recording of on-going land use changes in Iceland is presently not available. Beside the few exceptions of countrywise recording of land use conversion the direction or trend in land use changes is generally unknown. Certain land use changes are though apparent. Among these are decreased grazing, enlargement of agricultural units and abandonment of others, urban spreading and introduction of new branches in farming. The major challenge of the IGLUD project is to detect and quantify these changes.

7.2.1 Existing land use information

Geographical mapping of land use in Iceland is limited. Municipial planning, as a rule, categorise all land outside developed areas as one unit defined as farming land. Historically, the land allocated to individual farms is relatively large but generally only a small percentage of that land is cultivated. Use of commons, such as for summer grazing in the highlands, was connected to municipalites rather than individual farms. Boundaries of commons and farms was based on orally inherited rules or written accounts. When written descriptions existed it was generally based on references to names of identities in the landscape rather than maps. Land use within each farm was based on the decisions of the farmer and mapping not practised.

It is not until the 20th century that detailed countrywide mapping begins. A complete mapping of Iceland which included major landscape features and vegetation types was finished in 1943 (Landmælingar Íslands 1943). Since then there have been ongoing efforts to map e.g. topography, vegetation, erosion and geology. Land use has currently only partially been mapped. Mapping of cultivated areas was attempted few times in last century but never completed. Settlements have been recorded on topographical maps and updated regularly. The first soil map of Iceland was produced in 1959 (Jóhannesson 1988). A new map was produced in the year 2000 and revised in 2001 (Arnalds and Gretarsson 2001) and again 2009 (Arnalds et al. 2009). Total vegetation mapping started in 1955. The main objective was to estimate the grazing capacity of the land. The project was led by the Icelandic Agricultural Research Institute and its precursors. The project was taken over by the Icelandic Institute of Natural History in 1995. Today, 2/3 of the country has been mapped for vegetation at scales ranging from 1:10,000 to 1:40,000.

The natural birch woodland has been mapped in two surveys, first in 1972-1975 and again in 1987-1991. These maps have been digitised and rectified along with new maps of cultivated forest build on forest management maps and reports (Traustason and Snorrason 2008). IFR started a remapping of the natural birch woodland in 2010 which is estimated to finish in 2014. These new maps were used for the first time in last years submission to estimate the change in areas of birch woodlands since 1987-91.

In the last two decades of the 20th century satellite images became available and opened up new opportunities in mapping. Several mapping projects were initiated in Iceland using this data. In the years 1991-1997 soil erosion was assessed and mapped and all farmland was mapped in 1998-2008 both vegetation types and grazing land conditions as derivated from land cover classification through remote sensing. This last mapping project is compiled in a digital geographical database (NYTJALAND) and forms the main data source for the IGLUD. The NYTLALAND full-scale 12 class (Table 7.1) classification is not with complete coverage of Iceland. For the remaining areas a coarser classification of seven classes (Table 7.1), was carried out in relation with the CORINE project. IGLUD is based on this coarser classification where the full-scale NYTJALAND coverage is lacking.

In connection with the UNFCCC and KP reporting of the LULUCF sector, several existing maps have been developed further or initiated for the preparation of IGLUD. These maps include, map of woodland (forest and birch shrubland), map of revegetated land, map of ditches, maps of drained land and map of cultivated land. Short description of these maps is provided below.

7.3 Data Sources

The present CRF reporting is based on land use as recorded from IGLUD (Icelandic Geographical Land Use Database), activity data and mapping on afforestation and deforestation and natural birch forest and birch shrubland from Icelandic Forest Research (IFR) and on revegetation from the Soil Conservation Service of Iceland (SCSI), time series of Afforestation and reforestation, Cropland and Grassland categories, including revegetation, drainage and cropland abandonment, and of reservoirs. Data on liming is based on sold $CaCO_3$ and imported synthetic fertilizers containing chalk or dolomite. Data on biomass burning is based on area mapping of the Icelandic Institute of Natural History and Westfjords Natural History Institute and biomass estimation for relevant land categories obtained through IGLUD field sampling as described in (Gudmundsson et al 2010).

7.3.1 The Icelandic Geographic Land Use Database (IGLUD)

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 AFULU Guidelines (IPCC 2006). 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. As first goal of this objective all the six main land use classes defined in AFOLU gudelines (IPCC 2006) should be geographically identified. Important criteria regarding subdivision of land use categories is to recognise the land use practices most affecting the emission or removal of greenhouse gasses. This subdivision can only be relative and not geographically identifiable or it can be geographically identifiable at various resolutions. The relative division can thus be known within a region or the whole country. Relative division can be based on 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.

From the available map layers the land use map is extracted in such way that consistency is ensured and overlapping avoided 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.

The sources of the map layers in IGLUD are described below. 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. Description of field work for collecting land information for the database and some preliminary results can be found in (Gudmundsson et al 2010).

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

7.3.2 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 institutes, constructed a geographical database (IFD) on the condition of vegetation on all farms in Iceland.

The full scale mapping was completed for 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. This work is presently summarised and ground truthing work analysed revealing 70% overall accuracy (proportion of correctly classified- %PCC) (Brink & Gísladóttir personal communication 2014). The categorization used in the full scale mapping divides the land into twelve classes, ten for vegetation and two for lakes, rivers and glaciers . The classes used in IFD are listed in Table 7.1.

Table 7.1. 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 area not covered by full-scale classification of IFD was classified by applying coarser classification (seven classes) modified according to CORINE requirements (Bossard et al. 2000). Adding these two levels of classification one with seven classes and other with 12 classes covering 60% of the country a whole country map layer of this classification is available.

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 therby creating 18 map layers.

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

IS 50 V2013

The IS 50V2013 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” all of which are unchanged from the previous version of IS50 v 3.2. Additionally in this submission a revised layer of lakes and rivers from IS50V2013 is included replacing the previous layers of IFD lakes and rivers and IS50v 3.2 lakes and rivers. The roads in the IS 50V2013 database are linear features representing the centerline of the road. To allocate area to roads a buffer zone, defined according to road type, was added. This buffer zone was compared with the map layer of Cropland and overlaping area removed from the buffer to avoid unnessecary reduction of cropland next to roads. These map layers are in vectoral format and before entering the IGLUD they are conveted 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 category Forest Land in IGLUD map is based on this map. The map is in vectoral format including classification attributes connected to each mapping unit. Before entering the IGLUD database they are converted to raster format and resampled to 15x15m pixels and then divided to seven separate map layers according to their feature attributes. In this submission, only the updated version of the IFR map layers on cultivated forest are applied. The map layers on birch forest and shrubland from last years submission are kept unchanged as their extensive revision, based on field mapping, is expected to be completed this year.

Maps of Land being revegetated

The SCSI collects information on revegetation activities. The majority of revegetation activities since 1990 are already mapped and available in vectoral format. Mapping of the activity “Farmers revegetate the land” (FRL) has now been completed and is also available in vectoral 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 activites” (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 7.3.9). 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 currently being made to locate and delineate currently unlocated activities prior to 1990 based on available information and data. The activities before 1990 already mapped are available in vectoral format. The category Revegetated land in IGLUD is based on these maps.

Maps of ditches and 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) have recently been digitized in a cooperative effort of the AUI and the NLSI (Figure 7.2).

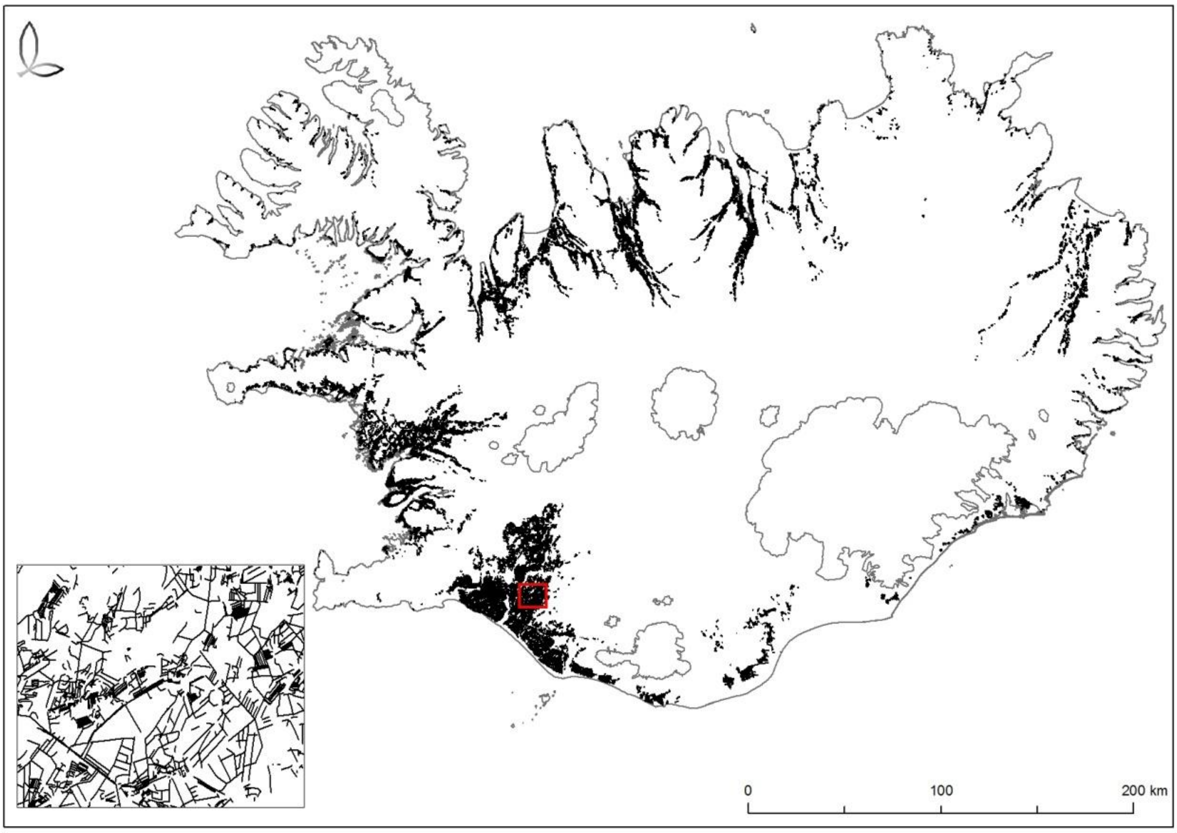

Figure 7.2. Map of Iceland showing all digitized ditches. (AUI 2008).

The map layer "Drained land" was prepared by AUI from 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 ectracted form IFD was excluded; "Sparsely vegetated land" (ID: 603 and 604), "Partly vegetated land" (ID: 506 and 509), "Lakes and Rivers" (Map layers from last years submission), "Shrubs and forest" (ID: 507) and the IFR map layer Natural birch woodland <2 m (ID: 515). 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 "Grassland organic soil" is identified in IGLUD on basis of this map.

This map layer was then compiled into the IGLUD map according to the order of compilation listed in Table 7.2 thereby excluding all higher ranking map layers. Due to the order of compilation; all Settlement, Forest Land, Cropland areas were excluded as well as Reservoirs, Glaciers and perpetual snows and the new layer of lakes and rivers. The map layers of “Wetland”, “Semi-wetland” and “Semi-wetland/wetland complex” from the IFD are not excluded from the map layer of drained land, neither in the process of preparing the map of drained land nor in the compilation process in to IGLUD. The identification of these land cover classes in the IFD is based on the signature on satellite images of areas classified according to vegetation and wetness. The wetland vegetation can dominate in these areas for long time after drainage if no other disturbances occur. The land classified as Wetland converted to grassland has not been ploughed or harrowed and wetland vegetation is still prevailing in many areas. The separation of semi-wetland and wetland in the Semi-wetland/wetland complex is not available in the present dataset. There is therefore large uncertainty regarding these areas and the exclusion of that land as whole from the map layer drained land is not considered justifiable. Because the map layer of drained land was, modified according to the map layers of Lakes and rivers used in last years compilation not the present IS50V2013 map layer for Lakes and rivers, some area not maped as lakes and rivers in this year´s land use map but were in last year’s map might be excluded from the map. The area identified as lakes and rivers in previous land use map but not in present landuse map is 34 kha.

Maps of cultivated Land

The map layer Cropland was also produced in cooperation with NLSI. The digitization was completed in 2009 by AUI. This map layer is the only source of identification of Cropland in IGLUD. The IFD map layers identifying Cropland are not included in IGLUD, as considered far less accurate. The map layers of Cropland organic soils on the land use map are based on density analysis of the ditch network (Gísladóttir et al 2010). The estimate of total area of Cropland organic soils is presently not based on these density classes (see below ch 7.3.7 and 7.3.8). These map layers are available in raster format 1x1m pixels. Geographical identification of organic soils within Cropland is ongoing project of AUI with field work expected to finish summer 2014.

Maps of reservoirs

Two map layers on reservoirs are available one with the reservoirs of Landsvirkjun which is the main hydropower company in Iceland, and a second layer prepared by AUI on basis of available information (Sigurðsson 2002) and local knowledge. Included in this second layer are many smaller reservoirs and reservoirs managed by others than Landsvirkjun. This map layer still needs to be verified. These layers are available in vector format and are converted to rasters 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 IS 50v 3.2 reveals less area included in the IS 50 v3.2 and 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 two map layers were representing lakes and rivers, i.e. one from IFD an the other from IS 50 v3.2. In the land use map prepared for this years submission both these map layers are replaced by a new layer from IS 50V2013. Small areas of land, which in the IFD was classified as lakes and rivers but is not included in the new IS 50V2013 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 previous submissions the outer boundaries of Iceland were represented by the total area classified in the IFD. In this submission the outer boundaries lines are extracted form IS 50V2013. This revision results in an addition of many small islands and islets and the costal outline changes. Through this revision some areas are removed from the IFD classes and new areas not previously classified are added. These new areas are added as a separate map layer. This map layer is not entered into the hierarchy of map layers, but is compared to the land use map, produced in the compilation process, as described below (ch. 7.3.6). That comparison is in two stages, first the land not included in any other map layer are identified and scecondly the area of all other map layers not included in this boundary layer are excluded from the land use map.

Map of historical lava fields covered with mosses

To separate land with almost full vegetation cover but very little or 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.

The map layers used in compiling the IGLUD map are listed in Table 7.2. Layers in vector format were converted to rasters. All layers were finally resampled to 15x15 m pixels before entering IGLUD. The compilation process is done by overlay analyses using ERDAS imaging 9.3 software. In that process the hierarchy of the map layers plays an important 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”, with hierarchy order 1, and the map layers “Reservoirs 2”,”Lakes and rivers ”with hierarchy order 13 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).

Table 7.2. 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 mostly after 1990 but some older	202	9
		Forest cultivations most probably planted before 1990	204	10
		Forest cultivations uncertain age	205	11
	Natural birch forest	Natural birch forest 2- 10m	206	12
3.**Cropland**	Cropland mineral soil	Cropland	301	17
	Cropland organic soil	Cropland with ditch density 10-15 km km^{-2}	302	14
		Cropland with ditch density 15-20 km km^{-2}	303	15
		Cropland with ditch density > 20 km km^{-2}	304	16
4.**Wetland**	Other wetlands	Semi-wetland (wetland upland eco-tone)	401	35
		Wetland	402	36
		Semi-wetland/wetland complex	403	37
	Rivers and lakes	Lakes and rivers	404	13
	Reservoirs	Reservoirs 1	405	1
		Reservoirs 2	406	2
5.Grassland	Other grassland	Grassland (true grassland)	501	24
		Richly vegetated heath land	502	25
		Cultivated land	503	33
		Poorly vegetated heath land	504	26
		Mosses	505	28
		Partly vegetated land (1)	506	27
		Shrubs and forest	507	23
		Grassland, heath-land shrubs and forest complex	508	31
		Partly vegetated land (2)	509	32
		Cropland and pasture	510	34
	Revegetated land	Farmers revegetation	511	19
		Revegetation before 1990	513	20
		Revegetation activity 1990-2012	514	18
	Drained grasland	Drained land	512	21
	Natural birch shrubland	Natural birch Woodland <2m	515	22
6.Other land	Other land	Historical lava fields with mosses (1)	601	29
		Historical lava fields with mosses (2)	602	30
		Sparely vegetated land (1)	603	39
		Sparely vegetated land (2)	604	40
		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

7.3.3 Definitions of IGLUD Land use categories

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

7.3.4 Broad Land Use Categories

Settlements: All areas included within map layers "Towns and villages" and "Airports" as defined in the IS 50 v3.2 geographical database. Also included as Settlement are roads classified with at least 15 m wide road zone, including primary and secondary roads.

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[4]: 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 reservoirs as managed subdivision 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.

Revegetation is not defined as subject to one specific land use category according to the FCCC/CP/2001/13/Add.1, but as an activity. Revegetation as practiced in Iceland converts eroded or desertified land from "Other land" or less vegetated subcategories of Grassland to Grasslands or Grasslands with more vegetation cover. The revegetation activity can also result in such land being converted to Cropland, Wetland or Settlement. Forest land is excluded by definition.

Revegetation: 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 and reforestation.

[4] Definition according is to AFOLU guidelines (2006) with addition of 20 m minimum width and clarification on harvested hayfields.

7.3.5 Subcategories applied in land use map

In the land use map prepared for this year's submission, land is divided to 18 land use classes.

Forest land is represented by four classes prepared through combination of available forest map layers from IFR. The classes are "Natural birch forest", "Forest planted before 1990", "Forest planted since 1990" and "Planted forest of unknown age".

Cropland is presented as two classes i.e. "Cropland on mineral soil" and "Cropland on organic soil". The separation of these classes is based on analyses of the digitized ditches (Gísladóttir et al. 2010), where all cropland with the density of ditches network higher than 10 km/km^2 is defined as organic soil. The remaining Cropland is accordingly defined as mineral soil.

Grassland is represented as five classes in the land use map; The "Natural birch shrubland" as mapped by IFR. The classes "Revegetation before 1990" and "Revegetation since 1990" as mapped by SCSI. The class "Grassland organic" soil as identified on basis of the map layer drained land. The class "Grassland other" as all other land defined as Grassland.

Wetland is in the land use map represented as three classes; "Lakes and rivers", "Reservoirs and "Other Wetland".

Settlement is in the land use map represented as one class.

Other land is represented as three classes; "Glaciers and perpetual snow", "Other land" and "Unclassified land".

7.3.6 Land Use Map

Applying the definitions of land use categories the available maps were categorized to the relevant land use category. Considering the hierarchy of main land use categories (Table 7.2), overlaps of individual map layers, the logical dominance of map layers and the map accuracy, as estimated from information on map preparation, the order of compilation of the map layers was decided as listed in Table 7.2. The criteria applied to rank map layers in to the hierarchical order are described elsewhere (Gudmundsson et al 2013). The map layers were then compiled according to this order using ERDAS imaging 9.3, software. Considering the remaining area of each map layer the layers were grouped to estimate the total area of mapped land use categories.

The resulting land use map is shown in Figure 7.3, Figure 7.4, and Figure 7.5. The IGLUD and the maps produced have been developing since it was initiated. Refinement of the maps for three important land use categories is ongoing and expected to be completed in next few years. These categories are; Natural birch woodland (both forest and shrubland), Drained wetlands included as Grassland organic soil, and land revegetated before 1990. When these refinements are completed it is expected that the resulting land use map can be used as baseline for detecting future land use changes. In this submission the area of each land use category in IGLUD resulting from the compilation process is used as first estimates for the CRF. Because of the difference in IGLUD mapping area and direct area estimate of three land use categories it is not possible to use the IGLUD mapping area directly in the CRF for all categories.

The land use categories and their area resulting from the IGLUD map are listed in Table 7.3. Also listed in the same table is the comparative area as applied in the CRF after modifications described below (see Chapter 7.3.9). The differences in these two area estimates, pinpoint the categories where either mapping or area estimate used for CRF needs to be revaluated. Solving these differences may include revised compilation of land use map-layers, improved mapping, adopting the mapping results in CRF, revision of method used for CRF area estimate or reallocation or subdivision of category area. In preparation of this year's submission these methods were used to improve the coherence between the IGLUD maps and area reported in CRF.

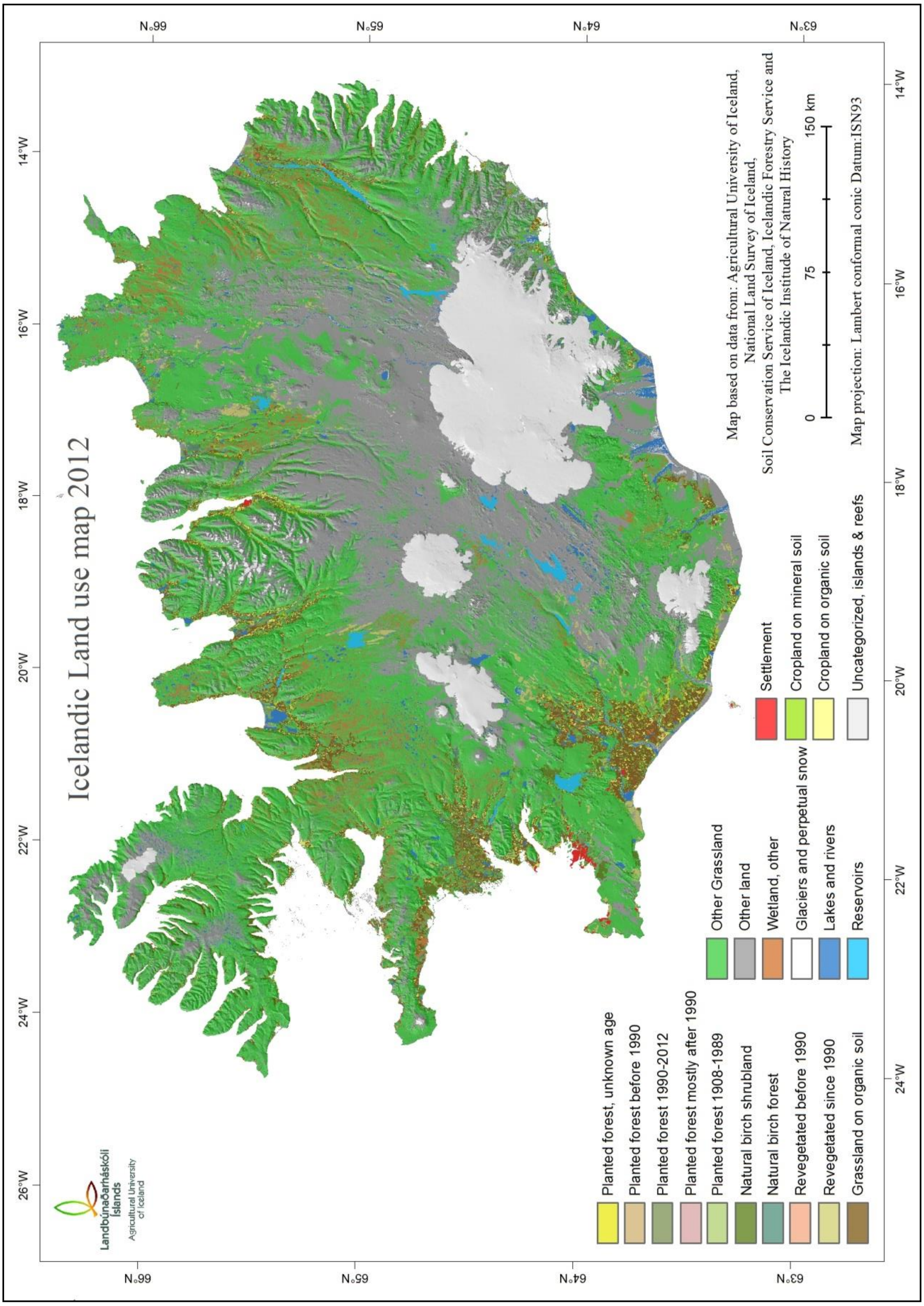

Figure 7.3. Map of Iceland showing the present status of land use classification in IGLUD.

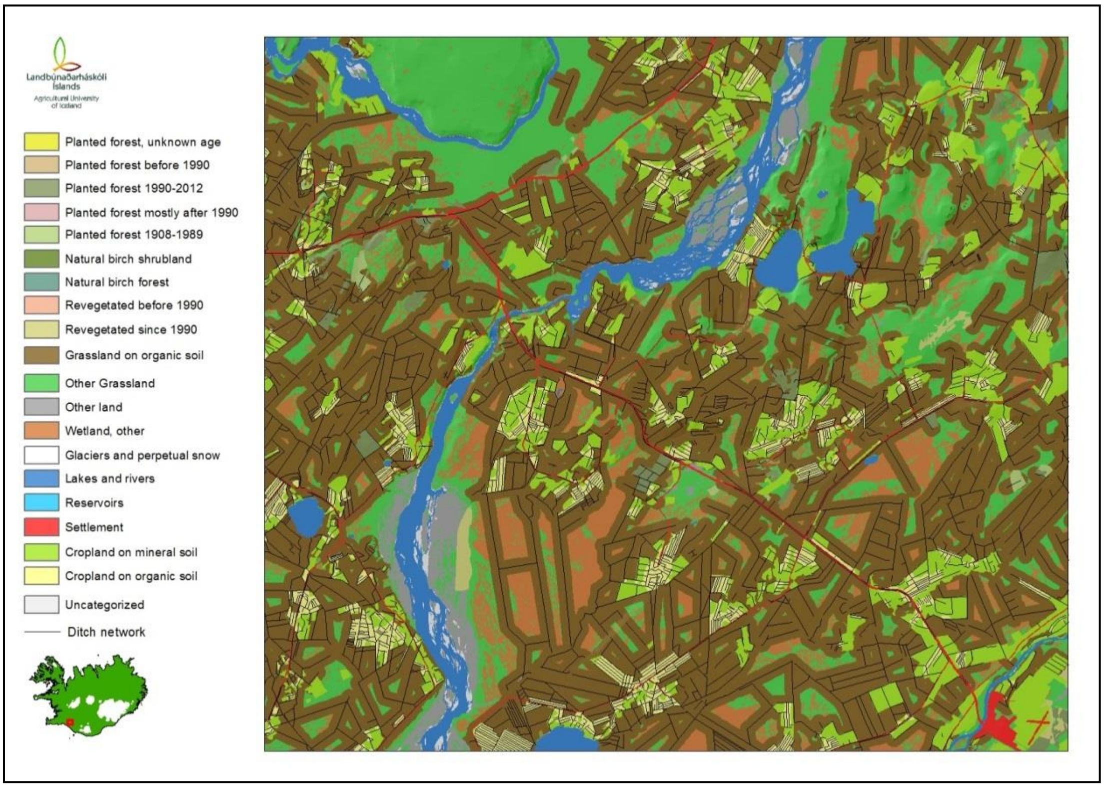

Figure 7.4. Enlarged map (I) showing details in IGLUD land use classification.

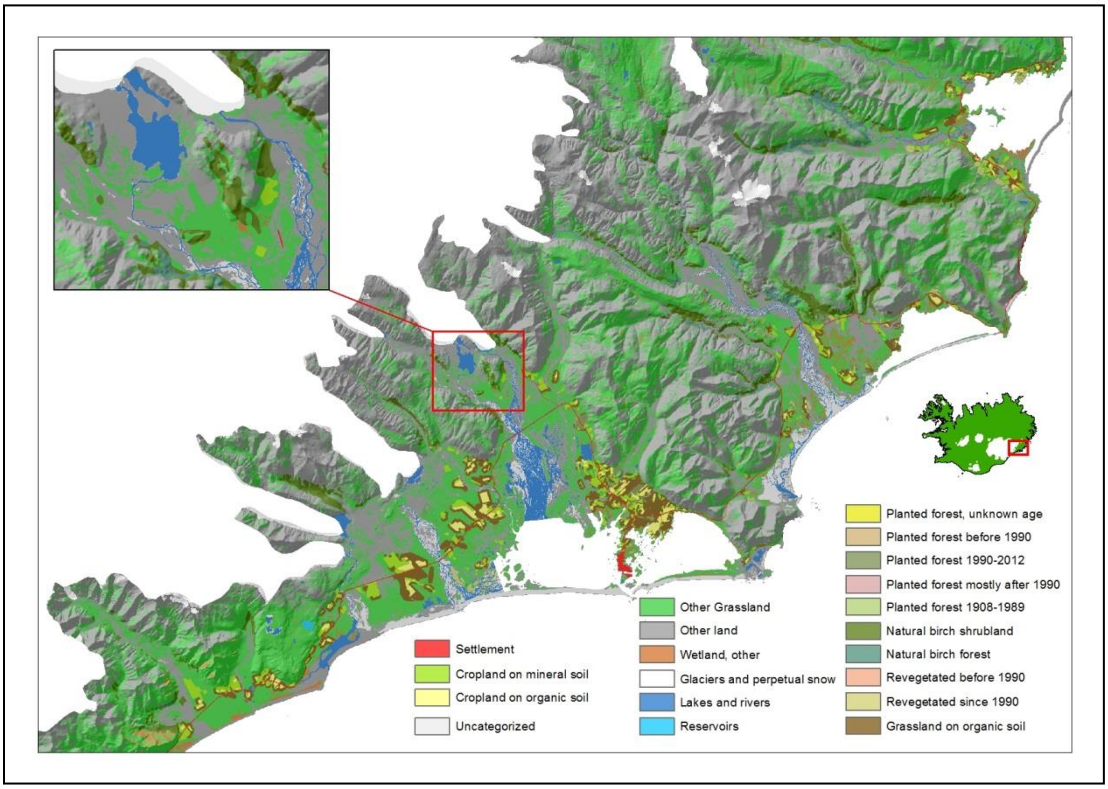

Figure 7.5. Enlarged map (II) showing details in IGLUD land use classification

7.3.7 Time Series

Time series of last submission were extended to the present inventory year. All land use categories for which emission or removal is reported are now represented by time series. Independent time series are available for; afforestation, deforestation, expansions of natural birch forest and shrubland, cropland converted to forest land, other land converted to forest land, wetland drainage, land converted to cropland, cropland abandonment, revegetation and establishment of new reservoirs. All other reported time series on land use are derivates of these 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 were converted to Grassland or Cropland. Only a minor part 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 organic soils from wetland 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 other wetland. 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. This time series is then corrected according to an independent time series of “Cropland converted to Forestland”. The construction of time series will be further described elsewhere (Gudmundsson in prep).

7.3.8 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.

Forest land

Two subcategories are defined, natural birch forest and cultivated forest. Both categories are further divided according to age of afforestation to forest land remaining forest land and land converted to forest land. Afforested land is forest where planted or directly seeded trees or trees naturally generated from cultivated forests or natural birch forest.

Afforestation is considered one year old in the autumn of the year the seedlings were planted[5]. For directly seeded or naturally regenerated forest, assessed age is used to determine the year of initiation. In general the CRF subcategories are not directly represented by the categories of the land use map. In CRF, Forest land is reported in following subcategories:

Afforestation older than 50 years: The area reported for this category as all Forest land categories is according to IFR activity data. Within the land use map this category is to be found in the categories Forests planted before 1990 and Planted forests of unknown age.

Natural birch forest: Forest where the dominant species is *Betula pubescens* that has regenerated naturally from sources of natural origin. All land mapped as Natural birch forest is included in this category. Considerable part of the area reported as Natural birch forest is located in areas mapped as grassland category Natural birch shrubland.

Plantations in natural birch forest: Within the land use map this category is to be found mostly in the categories Forest planted before 1990 and Planted forest of unknown age.

Afforestation 1-50 years old: This category is reported under both, Grassland converted to Forest land – Cultivated forest, Grassland converted to forest land - Natural birch forest expansion, Cropland converted to Forest land and Other land converted to Forest land. In the land use map there is no separation of these categories except between the Natural birch forest expansion and the cultivated forest. The area reported as the cultivated part of this category is to be located in areas mapped as Forest planted since 1990, Forest planted before 1990 and Planted forest of unknown age. The Natural birch forest expansion is either located on the maps of natural birch forest or on Other Grassland.

Cropland

In CRF, Cropland is reported in the subcategories; Cropland remaining Cropland, Grassland converted to Cropland and Wetland converted to Cropland. Cropland remaining Cropland includes both area of organic and mineral soil and related to both map units. Grassland converted to Cropland is only reported on mineral soil and therefore only relates to that mapping unit. Likewise Wetland converted to Cropland contains only organic soil and relates to the mapping unit Cropland on organic soil.

Grassland

In CRF Grassland is reported as ten subcategories. 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

[5] For the inventory year 2007 plantations planted the years 1988-2007 are included.

Wetland converted to Grassland are together represented by the mapping unit Grassland on organic soil. The area of the CRF categories Natural birch shrubland old and Natural birch shrubland recently expanded into Other Grassland is all assumed to be included within the mapping unit Natural birch shrubland. The land use mapping unit Revegetated since 1990 is all included in CRF subcategory Other land converted to Grassland- Revegetation since 1990. Some area of that CRF subcategory is related to the mapping units Other Grassland and Other land. The land use mapping unit Revegetated before 1990 is related to the CRF categories, Revegetated land older than 60 years, and Other land converted to Grassland-Revegetation before 1990. The CRF subcategory Other Grassland is represented by the land use mapping unit Other Grassland taken into account the claims of other CRF categories to that mapping unit as described above.

Wetland

In CRF Wetland is reported as six first and second order subcategories. The CRF category “Lakes and rivers” is represented by the land use mapping unit with same name. Similarly the CRF category Other Wetland is represented by synonymous mapping unit. The land use mapping unit Reservoirs represent collectively the remaining CRF Wetland subcategories; Reservoirs, High SOC, Medium SOC and Low SOC, respectively under Wetland remaining wetland, and Other land converted to Wetland subcategories.

Settlement

In CRF Settlement is reported as two subcategories, i.e. Settlement remaining Settlement, and Forest land converted to Settlement. Only one mapping unit for Settlement is presented in the land use map.

Other land

IN CRF “Other land” is reported as undivided. There are three land use mapping units representing “Other land” i.e.; Glaciers and perpetual snows, “Other land”and “Unclassified land”. The last maping unit is of three different origin as explained above (ch. 7.3.2 page 147). Part of the mapping unit “Other land” is represented in CRF as Revegetation since 1990.

7.3.9 Estimation of Area of Land Use Categories used in the CRF LULUCF Tables

The area reported in CRF is based on, direct activity data, time series prepared or estimated from the land use map. The mapped area in many cases does not match completely the activity data or area estimated through time series. To be able to estimate the area of land use categories from the land use map the difference between activity data or time series, and the relevant mapping unit needs to be accounted for and area needs to be transferred between categories. In Table 7.3 the mapping units in the land use map are listed and their area compared to area reported for relevant CRF category. The adjustments made are described below.

The adjustments are based on the area of categories according to reported area from activity data or as estimated from time series for the inventory year 2012.

Forest land: The total area of cultivated forest as reported by IFR is for the year 2012 38.02 kha but mapped area of all forest cultivations is 52.01 kha. The difference, 13.99 kha, is added to the area of Other Grassland. The area of Natural birch forest as reported by IFR for the CRF is 95.58 kha, including forests at least 2m high expecting to reach that height *in situ* at maturity. The mapping unit including all mapped birch forest areas not considering height at maturity is 34.53 kha. The difference 61.35 kha is added to the category from the mapped area of Natural birch shrubland and mapping unit Other Grassland 40.81 kha and 20.54 kha respectively.

Cropland: The total area of Cropland as estimated from AUI cropland time series is 128.13 kha but area mapped as Cropland is 169.89 kha. The difference 41.77 kha is added to the area of Grassland.

Grassland: The area of Grassland organic soil mapping unit is 337.65 kha. The total area of organic soils reported in the Grassland category is 361.04 kha. Thereof 0.24 kha and 14.56 kha are included as Natural birch shrubland and Cropland organic soils respectively. The remaining 346.24 kha reported is 8.59 kha larger than the mapping unit “Grassland organic soil”. That area is accordingly included in the area of “Grassland organic soils” and consequently subtracted from the area of “Other wetland” mapping unit. This correction represents the estimated drained areas since 2008. The area of Natural birch shrubland as estimated by IFR and reported in CRF is 51.14 kha but the area included in the mapping unit is 91.94 kha. The difference is 40.81 kha and was added to the area of Natural birch forest, as explained above. The area of land revegetated before 1990 is in CRF represented in two categories i.e. “Grassland remaining Grassland-Revegetated land older than 60 years”, and “Other land converted to Grassland-Revegetation before 1990” with total area 165.36 kha. The area of “Revegetated land before 1990” mapping unit is 1.45 kha the difference 163.90 kha is added to the area of the mapping unit from the Grassland mapping unit. The total area of Revegetation since 1990 reported in CRF is 96.80 kha but the mapping unit Revegetated land since 1990 is 109.76 kha. The difference is 12.95 kha and half of it was added to the area of the mapping unit Grassland and the other half to the mapping unit “Other land”. The area of mapping unit Other Grassland is then balanced against the difference of total area of the Grassland mapping unit and all other mapping units included as Grassland as resulting from the above described corrections.

Wetland: The area reported in CRF and the area of the mapping units of, Lakes and rivers, and Reservoirs are the same. The area reported in CRF for Other wetland is 417.37 kha while the area of the mapping unit is 425.97 kha. The difference, 8.59 kha, is added to the mapping unit Grassland organic soil.

Settlement: The area of Settlement reported in CRF is the same as the area of the mapping unit.

Other land: The area of “Other land” as reported in CRF is 4,083.09 kha but the area included in the mapping unit “Other land” is 4,076.61 kha the difference is 6.48 kha which was added to the Revegetation since 1990 mapping unit.

Table 7.3. Area of land use categories as mapped in IGLUD and as applied in CRF-tables.

Mapped area	Area kha	Comparable area as reported in CRF	Area kha
Settlement	51.46	Settlement	51.46
Forest Land	86.54	Forest Land	133.90
Natural birch forest	34.53	Natural birch forest	95.88
Cultivated forest	52.01	Cultivated forest total	38.02
Cropland	169.89	Cropland	128.13
Cropland on organic soil	55.21	Cropland organic soil	57.37
Cropland on mineral soil	114.69	Cropland mineral soil	70.78
Wetland	690.81	Wetland	682.21
Lakes and rivers	206.94	Lakes and rivers	206.94
Reservoirs	57.90	Reservoirs	57.90
Other wetlands	425.97	Other wetlands	417.37
Grassland	5,193.02	Grassland	5,189.54
Natural birch shrubland	91.94	Natural birch shrubland	51.14
Other grassland	4,652.21	Other grasslands	4,538.60
Grassland organic soil	337.65	Grassland organic soil	361.04
Revegetated land (RL)	111.21	OL converted to GL + RL older than 60 years	262.16
RL before 1990	1.45	RL before 1990	165.36
RL since 1990	109.76	RL since 1990	96.80
Other Land	4,076.61	Other Land	4,083.09
Glaciers and perpetual snow	1,086.62	Glaciers and perpetual snow	Not rep

7.3.10 Land Use Change

Emission/removal of GHG due to land use changes is reported for eleven types of land conversions (Table 7.4). Time series of land use changes have been extended to the present inventory year.

Table 7.4. Land use classification used in GHG inventory 2012 submitted 2014 and the total area and the area of organic soil of each category.

Land-Use Category	Sub-division	Area (kha)	Area of organic soil (kha)
Total Forest Land		133.90	3.62
Forest Land remaining Forest Land		87.41	0.50
	Afforestation older than 50 years	0.77	0.05
	Natural birch forest	85.58	0.45
	Plantation in natural birch forest	1.07	
Land converted to Forest Land		46.49	3.12
Cropland converted to Forest Land	Afforestation 1-50 years old	0.94	0.30
Grassland converted to Forest Land		38.86	2.82
	Afforestation 1-50 years old	28.55	2.82
	Natural birch forest expansion	10.30	
Other Land converted to Forest Land	Afforestation 1-50 years old	6.69	
Total Cropland		128.13	57.37
Cropland remaining Cropland		122.73	54.51
Land converted to Cropland		5.40	2.87
Grassland converted to Cropland		2.53	
Wetlands converted to Cropland		2.87	2.87
Total Grassland		5,189.54	361.04
Grassland remaining Grassland		4,873.47	319.99
	Natural birch shrubland-old	45.53	0.24
	Revegetated land older 60 years	2.29	
	Wetland drained for more than 20 years	314.67	314.67
	Cropland abandoned for more than 20 years	20.06	5.09
	Other Grassland	4,485.32	
	Natural birch shrubland – recently expanded into “Other Grassland”	5.61	
Land converted to Grassland		316.07	41.05
Cropland converted to Grassland		24.63	9.47
Wetlands converted to Grassland		31.58	31.58
Other Land converted to Grassland		259.87	
	Revegetation before 1990	163.07	
	Revegetation since 1990	96.80	
Total Wetlands		682.21	
Wetlands remaining Wetlands		655.79	
	Lakes and rivers	206.94	
	Other wetlands	417.37	
	Reservoirs	31.47	
Land converted to Wetlands		26.42	
Grassland converted to Wetlands		7.95	
	High SOC	0.99	
	Medium SOC	6.96	
Other Land converted to Wetlands	Low SOC	18.48	

Table 7.4 continued			
Land-Use Category	**Sub-division**	**Area (kha)**	**Area of organic soil (kha)**
Total Settlements		51.46	
Settlements remaining Settlements		51.41	
Land converted to settlements		0.05	
Forest land converted to Settlement		0.05	
Total Other Land		4,083.09	
Other Land remaining Other Land		4,083.09	

The conversion period varies between categories as explained in relevant chapters below. Real time countrywide recording of land use changes is still limited in Iceland and only available for few of the land use categories requested in CRF. For some land use categories like Settlements, changes are recorded at municipal level, but have not been assembled. Regular land use surveys have not been practiced in Iceland. In preparing this submission, 42 map layers were prepared (Table 7.2). The accuracy of many map layers still needs to be ascertained. Many of these map layers e.g. those originating from the full scale IFD classification were tested in extensive ground truth project. The IFD project is presently being reviewed and in that context the results of ground truth has been calculated revealing 68.9% overall accuracy as PCC (Points Correctly Classified) (Gísladóttir F., Ó. Arnalds and S.H. Brink in prep). The user accuracy and area differences of individual categories range from 62.5% to 91.6% and -15.6% to 15.5% respectively. Gradual updating of the maps and comparison with older maps and land use data is expected to provide better estimate for land use changes than is currently available.

Land use change matrix*:* In Table 7.5 the on-going land use changes are summarized. As land use changes are reported with different conversion periods extending from 20-60 years, the initial stage of all categories cannot be assigned to a certain year. The area summed in the last row of the table can be seen as the area of the category prior to all ongoing conversions and the last column as the area of each category when all ongoing conversion are completed.

Table 7.5. Land use change matrix 2012 showing ongoing changes in land use and the area prior to and at the end of defined conversion period. The numbers in each cell show the area converted from „column“ to „row“.

To\From [Kha]	Forest land	Cropland	Grassland	Wetland	Settlement	Other land	Total at end of conversion period
Forest land	87.41	0.94	38.86	IE	NO	6.69	133.90
Cropland	NE	122.73	2.53	2.87	NO	NE	128.13
Grassland	NO	24.63	4873.47	31.58	NO	259.87	5189.54
Wetland	NO	IE	7.95	655.79	NO	18.48	682.21
Settlement	0.05	NE	NE	NE	51.41	NE	51.46
Other land	NE	NE	NE	NE	NE	4083.09	4083.09
Total the year before conversion period	87.46	148.30	4922.81	690.24	51.41	4368.13	10268.35

7.3.11 Uncertainties QA/QC

Inclusion of new data and revision of other map layers in IGLUD is considered to have improved the quality of the land use data compared with previous submissions. The new time series applied are also considered to have substantially improved the quality of the data. All map layers that are used have been visually controlled by the AUI GIS laboratory staff during the preparation process and compared with local knowledge. This internal quality control has led to an exclusion of many faults arising during the process, establishing good confidence in the maps. This control is still only qualitative.

Uncertainty estimates for following map estimates are provided; Cropland total area (including abandoned Cropland), Forest land and revegetation activity area. The reliability of the map of ditches has also been evaluated (see relevant chapters).

All map layers originating from the full scale IFD classification have been controlled through extensive ground truthing process. In ongoing review of the IFD project the area differences between mapping and ground truth is estimated as ranging from ± 15%. The map layers of Settlement are based on NLSI IS 50 maps and the maps of forest and revegetation are prepared through mixture of, on *in situ* mapping, remote sensing and on screen mapping. Quantitative estimate of mapping uncertainty is though still not available for few map layers.

The uncertainty of area of reported categories is set at 15% for all categories except revegetation and Forest land, where more precise evaluations are available see 10.1.3 below.

7.3.12 Planned Improvements regarding Land Use Identification and Area Estimates

The IGLUD database compiles land use data obtained through remote sensing, GIS mapping and field surveys on land use. Repeated land classification based on new satellite images through remote sensing, updating and improving GIS-maps and continuing field surveys is included in the IGLUD project. Presently, new RapidEye satellite images from the year 2011 and 2012 of most of Iceland´s lowlands have become available and their analysis is pending. The IGLUD land use map has since the project was initiated been developing form submission to submission. Both increase in accuracy of individual map layers and new data available have constantly improved IGLUD. This development has resulted in improved land use map and better management of the available data. At the same time the changes in the resulting land use maps can’t be interpreted as entirely reflecting ongoing land use changes as canges originating from real changes in land use can´t be separated easely from those appearing through improved mapping and data management. Accordingly it is important to define a baseline land use map valid for certain point in time. This land use map can then be used to geographically detect land use change to ceratin level of accuracy.

The IGLUD project is presently assumed to have reached the stability in data neccessary for make the defination of baseline land use map realistic. Therefore baseline land use map is expected to be available within next few years.

7.4 Completeness and Method

Based on the above described accumulation of land use data and emission factors or C-stock changes the emission by source and removal by sinks were calculated.

Summary of method and emission factors used is provided in Tables 7.6 to 7.8.

Table 7.6. Summary of method and emission factors applied on CO_2 emission calculation.

Source/sink	Area (kha)	Method	EF	Gg Emission/Removal (-)
Forest Land remaining Forest Land	87.41			-35.64
Afforestation older than 50 years	0.77			-9.10
Living biomass		T3		-9.13
Dead organic matter		NE		
Mineral soil		NE		
Organic soil	0.05	T1	D	0.03
Natural Birch forest	85.58			-12.32
Living biomass		T3		-12.58
Dead organic matter		NE		
Mineral soil		NE		
Organic soil	0.45	T1	D	0.26
Plantations in natural birch forest	1.01			-14.22
Living biomass		T3		-14.22
Dead organic matter		NE		
Mineral soil		NE		
Organic soil		NO		
Land converted to Forest Land	46.49			-232.79
Cropland converted to Forest Land	0.94			-3.05
Living biomass		T3		-1.88
Dead organic matter		T2	CS	-0.49
Mineral soil	0.64	T2	CS	-0.86
Organic soil	0.30	T1	D	0.18
Grassland converted to Forest Land	38.86			-198.98
Afforestation 1-50 years old - Cultivated forest	28.55			-169.60
Living biomass		T3	CS	-122.01
Dead organic matter		T3,T2	CS	-14,76
Mineral soil	25.73	T2	CS	-34,48
Organic soil	2.82	T1	D	1,65
Afforestation Natural birch forest 1 - 50 years old	10.30			-29.38
Living biomass		T2	CS	-10.24
Dead organic matter		T2	CS	-5.32
Mineral soil		T2	CS	-13.80
Organic soil	NE			
Other Land converted to Forest Land	6.69			-30.76
Afforestation 1-50 years old	6.69			-30.76
Living biomass		T3		-14.72
Dead organic matter		T2	CS	-3.46
Mineral soil		T2	CS	-12.58
Organic soil	NO			
Cropland remaining Cropland	122.73			999.26
Living biomass		T1		NO
Dead organic matter		T1		NO
Mineral soil		NE		NE
Organic soil	54.51	T1		999.26
Agricultural liming	NA			4.03
Limestone $CaCO_3$		T1	D	1.29
Dolomite $CaMg(CO_3)_2$		T1	D	1.02
Shellsand (90% $CaCO_3$)		T2	CS	1.72

Table 7.6 continued				
Source/sink	Area (kha)	Method	EF	Gg Emission/Removal (-)
Land converted to Cropland	5.40			64.43
Grassland converted to Cropland	2.53			3.95
Living biomass		T1	CS	4.91
Dead organic matter		IE		
Mineral soil		T1	CS	-0.97
Organic soil	NO			
Wetlands converted to Cropland	2.87			60.48
Living biomass		NE		7.94
Dead organic matter		IE		
Mineral soil	NO			
Organic soil	2.87	T1	D	52.54
Grassland remaining Grassland	4,873.47			273.82
Natural birch shrubland-old	45.53			-3.29
Living biomass		T3	CS	-3.51
Dead organic matter	NE			
Mineral soil	NE			
Organic soil	0.24	T1	D	0.22
Revegetated land older than 60 years	2.29	NO		
Wetland drained for > 20 years	314.67			288.44
Living biomass		NE		
Dead organic matter		NO		
Mineral soil		NO		
Organic soil	314.67	T1	D	288.44
Cropland abandoned for > 20 years	20.06			4.66
Living biomass		NO		
Dead organic matter		NO		
Mineral soil		NO		
Organic soil	5.08	T1	D	4.66
Other Grassland	4,585.32	NE		
Natural birch shrubland -recently expanded into Other Grassland	5.61			-15.99
Living biomass		T2	CS	-5.58
Dead organic matter		T2	CS	-2.90
Mineral soil		T2	CS	-7.52
Organic soil		NE		
Land converted to Grassland	316.07			-465.00
Cropland converted to Grassland	24.63			49.18
Living biomass		T1	CS	-47.78
Dead organic matter		IE		
Mineral soil	15.15	T2	CS	5.78
Organic soil	9.47	T1	D	91.18
Wetlands converted to Grassland	31.58			28.95
Living biomass		NO		
Dead organic matter		NO		
Mineral soil	NO	NA		
Organic soil	31.58	T1	D	28.95
Other Land converted to Grassland	259.87			-543.12
Revegetation before 1990	163.07			-340.81
Living biomass		T2	CS	-34.08
Dead organic matter		IE		
Mineral soil	163.07	T2	CS	6.73

Table 7.6 continued				
Source/sink	**Area (kha)**	**Method**	**EF**	**Gg Emission/Removal (-)**
Organic soil	NO			
Revegetation since 1990	96.80			-202.31
Living biomass		T2	CS	-20.23
Dead organic matter		IE		
Mineral soil	96.80	T2	CS	-182.08
Organic soil	NO			
Wetlands remaining Wetlands	655.79			
Lakes and rivers	206.94	NA		
Other wetlands	417.37	NA		
Reservoirs	31.47	NA		
Land converted to Wetlands	26.42			9.72
Grassland converted to Wetlands	7.95			8.83
High SOC CO_2	0.99	RA/T2	CS	2.75
Medium SOC CO_2	6.96	RA/T2	CS	6.09
Other Land converted to Wetlands	18.48			0.89
Low SOC CO_2	18.48	RA/T2	CS	0.89
Settlements remaining Settlements	51.41	NA		
Land converted to Settlement	0.05			0.11
Forest land converted to Settlement	0.05			0.11
Living biomass		NO		
Dead organic matter		NO		
Soil		T2	CS	0.11
Other Land remaining Other Land	4,083.09	NA		

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 7.7. Summary of method and emission factors applied on CH_4 emission calculations.

Source/sink	Area kha	Method	EF	Gg Emission/ Removal (-)	Gg CO_2 -eq
Land converted to Forest land					
- **Biomass burning-wildfire**	0.00	T2	CS,D	0.00	0.00
Grassland remaining Grasland					
- **Biomass burning-wildfire**	0.00	T2	CS,D	0.00	0.00
Other land					
Biomass burning-wildfire	0.00	T2	CS,D	0.00	0.00
Wetlands remaining Wetlands	688.08				
- **Lakes and rivers**	259.99	NA			
- **Other wetlands**	396.62	NA			
- **Reservoirs**	31.47	NA			
Land converted to Wetlands	26.42			0.40	8.33
Grassland converted to Wetlands	7.95			0.36	7.57
- **High SOC CH_4**	0.99	RA/T2	CS	0.11	2.38
- **Medium SOC CH_4**	6.96	RA/T2	CS	0.25	5.19
Other Land converted to Wetlands	18.48			0.04	0.75
- **Low SOC CH_4**		RA/T2	CS	0.04	0.75

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 7.8. Summary of method and emission factors applied on N_2O emission calculations.

Source/sink	Area kha	Method	EF	Gg Emission / Removal (-)	Gg CO_2 eq
Forest Land remaining Forest Land	87.41				
- **Mineral Soil**		NE			
- **Organic Soils N_2O**	0.50	T1	D	0.00	0.14
Land converted to Forest Land	46.49				
- **N_2O fertilizers**		T3	D	0.00	0.13
- **Mineral Soil**		NE			
- **Organic Soils N_2O**	3.12	T1	D	0.00	0.88
- **Biomass burning- wildfire**	0.00	T2	CS,D	0.00	0.00
Cropland remaining cropland	122.73				
- **Mineral Soil**		NE			
- **Organic Soils N_2O**	54.51	IE			
Wetland converted to cropland	2.87				
- **Mineral Soil**	NO	NA			
- **Organic Soils N_2O**	2.87	IE			
Grassland remaining Grassland	4,873.47				
Cropland abandoned for more than 20 years	20.06				
- **Organic Soils N_2O**	5.09	T2	CS	0.00	1.06
Wetland drained for more than 20 years	314.67				
- **Organic Soils N_2O**	314.67	T2	CS	0.22	65.49
Natural birch shrubland-old	45.53				
Organic Soils N_2O	0.24	T2	CS	0.00	0.05
Biomass burning wildfire	0.02	T2	CS,D	0.00	0.01
Land converted to Grassland	316.07				
Cropland converted to Grassland	24.63				
- **Organic Soils N_2O**	9.47	T2	CS	0.01	3.20
Wetlands converted to Grassland	31.57				
- **Organic Soils N_2O**	31.57	T2	CS	0.02	6.57
Other land	4,083.09				
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.

7.5 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.

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 m^2 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 four data sources; data obtained through plot measurement in 2005-2011, on tree biomass data sample from 1987, survey from 1987-1991 and on-going remapping of natural birch woodlands 2010-2014.

By analysing the age structure in the natural birch woodland, already remapped in the on-going remapping project, 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 131.10 kha at the time of the initial survey in 1987-1991. 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 146.32 kha. The difference of 15.22 kha is an estimate of a natural expansion of the woodland over the time period of 1987 to 2011 (24 years). In the plot measurements 2005-2011 the ratio of the natural birch woodland that can reach 2 m height in mature state and is defined a forest was 65% of the total area. Natural birch forest is accordingly estimated 85.58 kha in 1987 and 95.88 kha in 2012, the former figure categorising the natural birch forest classified as Forest remaining Forest and the differences between the two figures (10.30 kha) as natural birch forest classified as Grassland converted to forest land with mean annual increase in of 0.45 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 2012 is estimated in NFI as 38.02 kha (±1.63 kha 95% CL) whereof; 28.56 kha (±1.69 kha 95% CL) are Afforestation 1-50 years old on “Grassland converted to Forest land”, 0.95 kha (±0.43 kha 95% CL) are Afforestation 1-50 years old on “Cropland converted to Forest land”, 6.69 kha (±1.07 kha 95% CL) are Afforestation 1-50 years old on “Other Land converted to Forest land”, 1.07 kha (±0.45kha 95% CL) are

Plantations in natural birch forests and 0.72 (±0.38 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 2013. In 2013 submission this area was estimated 37.92 kha (±1.65 kha 95% CL) in 2011 but in this year's submission the estimate for 2011 is 37.35 kha (±1.64 kha 95% CL) reflecting the effect of the recalculation.

The area of Forest land 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 2011 reported 3.28 kha (±0.78 kha 95% CL) in 2013 submission but is estimated 3.17 kha (±0.76 kha 95% CL) for 2011 in this year's submission reflecting the recalculation.

Land converted to Forest land is recognized as key sources/sinks in level 2012 and in trend.

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.

The smaller area of Natural birch forest on maps is explained by the inclusion of young woodland which currently falls below 2 m height, but *in situ* is estimated to reach the 2 m threshold in mature state. The correction of mapped area of other categories due to these inconsistencies is explained in chapter 7.3.9.

7.5.1 Carbon Stock Changes (5A)

Changes in C-stock of natural birch forest are reported for the forth time in this year's submission. Same method as was in last year submission is used again. 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. Total biomass of birch trees and shrubs in natural birch woodlands was according to the new estimates 976 kt C (±586 kt 95% CL) with average of 7.44 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 1064 kt C (±298 kt 95% CL) with average of 8.11 t C ha^{-1}. The C-stock in the forest and the shrub part of the natural birch woodland is estimated to 832 kt C with an average of 9.72 t C ha^{-1} and 232 kt C with average of 5.10 t C ha^{-1}.

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). Most of the cultivated forests in Iceland are relatively young, only 17% 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 Iceland 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.

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 analysed.

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 analysed.

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 and reported for the second time in this year submission. 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.

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", "Cropland converted to Forest Land-Afforestation 1-50 years old", "Forest Land remaining Forest Land" – subcategory "Afforestation older than 50 years" and subcategory "Natural birch forest". Drained organic soil has not been estimated on "Grassland converted to Forest Land - Natural birch forest expansion. 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 a recent study of the ICEWOODS data a significant increase in SOC was found in the uppermost 10 cm layer of the soil (Bjarnadóttir 2009). The average increase in soil carbon detected was 134 g CO_2 m^{-2} yr^{-1} for the three most used tree species. This rate of C-sequestration to soil was applied to estimate changes in soil carbon stock in mineral soils 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.

7.5.2 Other Emissions (5(I), 5 (II), 5(III))

Direct N_2O emission from use of N fertilisers is reported for Land converted to Forest Land since fertilisation 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. N_2O emissions from drainage of organic soils are also reported separately for forest land. Due to the structure of the CRF-Reporter the N_2O emission associated with drained soils in forest is reported under the category “Forest land remaining Forest land-5(II)-Organic soil-Afforestation 1-50 years old” although the subcategory “Afforestation 1-50 years old” is categorized under Land converted to Forest Land in the inventory.

7.5.3 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”, “Cropland” 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 categorise is unavailable.

7.5.4 Methodological Issues

One of the main data sources of the NFI is a systematic sampling consisting of a total of nearly 1000 permanent plots for field measurement and data sampling. One fifth of the plots 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 in Chapter 7.5.1 (Snorrason and Kjartansson 2004; 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 figures provided by IFR are based on the inventory data of the first forest inventory and the four first years of the second inventory. 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 16 m in cultivated forest but 24 m in natural birch forest.

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 7.9). The most accurate estimates are for 2007-2011 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 2012 the estimated is forwarded one year compared to the midvalue for 2011. As relative growth rate decreases with age the 2012 estimate is an overestimate and was calibrated by 0.91, which is the relative difference between the midvalue and a forwarded value of one year for the year of 2011. 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 7.9. Measurement years used to estimate different annual estimates of biomass stock change.

Mid value estimates	For-warded estimates	Back-warded estimates	Built on measure-ment years
	2011		2008-2012
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 on-going 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 after 1990. They are built on interpolation between 1990 and the mid year of the remapping 2010-2012 and extrapolations from 2011 with even annual increase in area.

A mean annual change in the area of the natural birch forest was estimated to 0.448 kha increase between 1990 and 2011.

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 2008-2012. The method used only gives a mean net annual C-stock change in the period 1990-2012, not gains and losses.

7.5.5 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 2013).

Carbon stock change in living biomass in other vegetation than trees is not estimated currently. 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 on devegetated soil, 0.51 t C ha^{-1} yr^{-1}. Revegetation and afforestation on devegetated soil are very similar processes, except that the latter includes tree-planting. A removal factor of 0,141 Mg C ha^{-1} yr^{-1} which is an 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 initation year are also assessed. Dead wood is then reported in the dead wood stock at the initation year. The changes in litter and dead wood stock are reported together as changes in dead organic matter stock.

Tier 1 and default EF = 0.16 [t C ha^{-1} yr^{-1}] (AFOLU Guidelines Table 4.6.) is used to estimate net carbon stock change in forest organic soils. For direct N_2O emission from N fertilization and N_2O emissions from drained organic soils, Tier 1 and default EF=1.25% [kg N_2O-N/kg N input] (GPG2000) and EF=0.6 [kg N_2O-N $ha^{-1}yr^{-1}$] (AFOLU Guidelines Table 11.1.) were used respectively.

In accordance to the Forest Law in Iceland, the Iceland Forest Service holds a register on planned activity that can lead to deforestation (Skógrækt ríkisins 2008). Deforestation activities have to be announced to the Iceland 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 the lost biomass. Deforestation is reported for the inventory years 2004-2007 and for 2011. Two rather different types of deforestation have occurred in these years. The first and most common type is road building, house building and construction of snow avalanche defences. 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 initation) 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 tonnes C ha^{-1} as weighted C-stock of 10 year old afforestations. 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 tonnes C ha^{-1}, for fully vegetated areas with thick developed andisol layers it was 72.9 tonnes 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 tonnes ha^{-1} on poor and fully vegetated sites, respectively. Weighted C-stock of treeless land is then 66.9 tonnes 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.

7.5.6 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 cultivated forest, and the biomass C-stock of 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.

7.5.7 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 build on the same methodology as in last year´s submission. As a result of these recalculations the total reported removal has decreased from -250.53 Gg CO_2-equivalents for the year 2011 as reported in 2013 submission to -240.59 Gg CO_2-equivalents in this year's submission or a 4.0% decrease in removal. These changes in reported emission removal of the category reflect the improvement in data and estimation of factors previously not estimated as well as development in the methodology applied for estimating this category.

7.5.8 Planned Improvements regarding Forest Land

Data from NFI are used for the sixth 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 material and other vegetation than trees is expected in future reporting when data from re-measurement of the permanent sample plot will be available.

New mapping of the natural birch woodland which started the summer 2010 will be finished this summer. It will increase the accuracy of the new area estimate of the natural birch woodland and the changes in area with time.

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.

7.6 Cropland

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

Carbon dioxide emissions from "Cropland remaining Cropland" and "Land converted to Cropland" are both recognized as key source/sink in level 1990 and 2012 and in trend.

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 169.89 kha. The mapped area includes both Cropland in use and abandoned Cropland reported as Grassland. The area reported in CRF as Cropland is 128.13 kha, whereof 57.37 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 Figure 7.6.

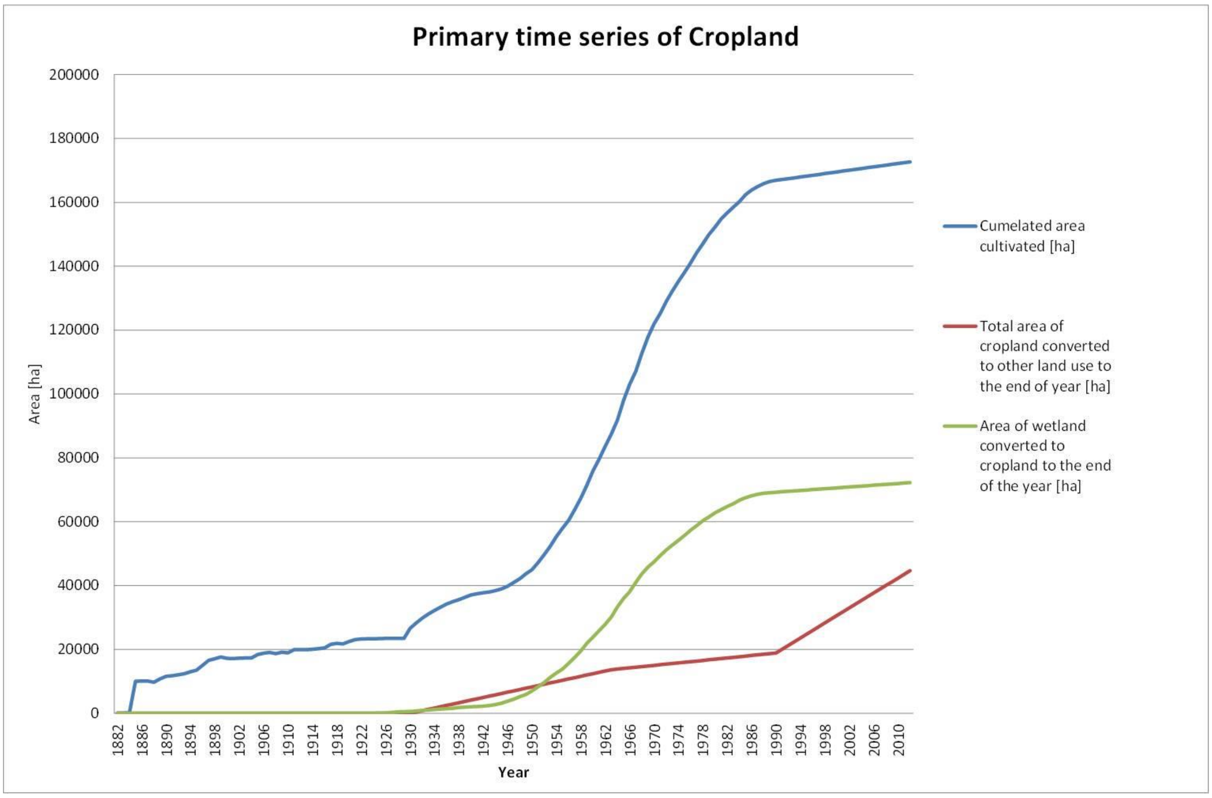

Figure 7.6. Primary time series of Cropland area: Cumulated area represents all land that has been cultivated to that time. Area of wetland converted to cropland represents the part of that area on organic soil. Total area converted to other land use represents the estimated area of abandoned Cropland.

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 (Figure 7.7).

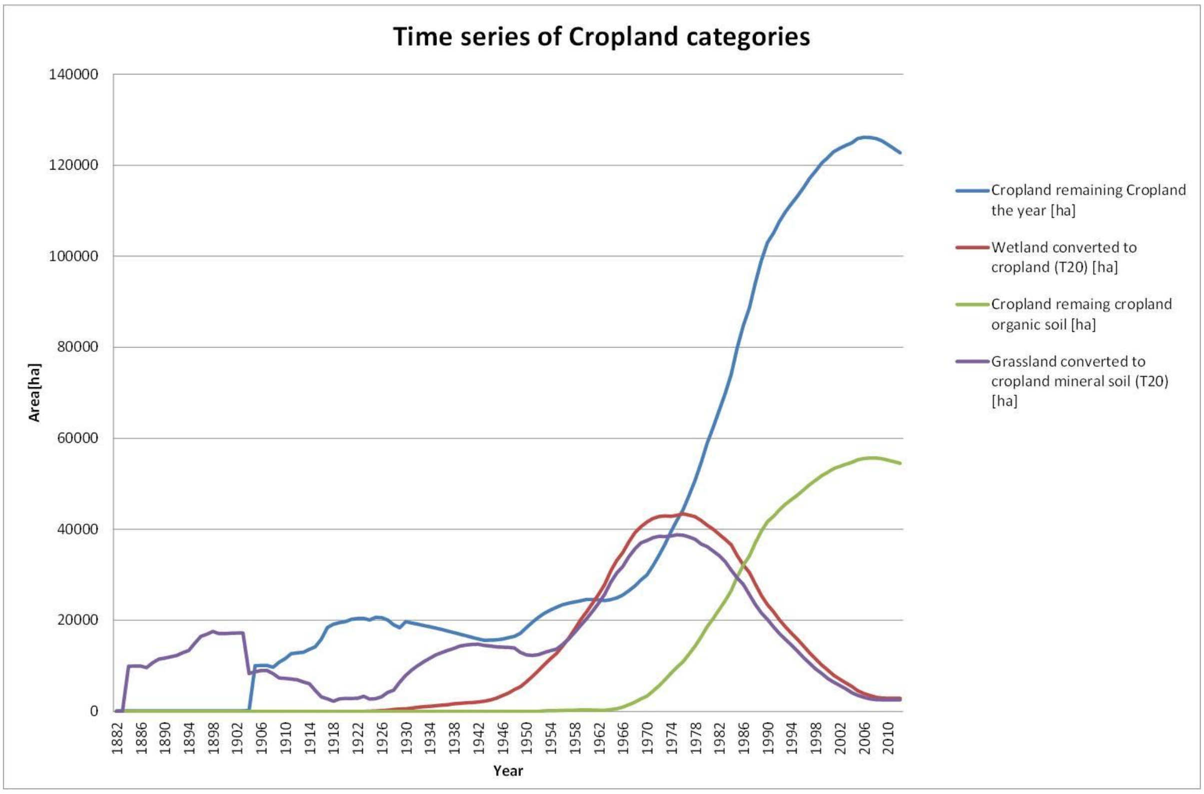

Figure 7.7. Time series of Cropland as reported. Area in hectares as estimated at the end of the year.

The area of Cropland organic soils is estimated through the time series available as described above (chapter 7.3.7). 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 expected to be finished in summer 2014. This project is expected to improve geographical idendification 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.

7.6.1 Carbon Stock Change (5B)

Carbon Stock Changes in Living Biomass

As no perennial woody crops are cultivated in Iceland, no biomass changes need 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 Gg C, whereof 1.61 Gg C is from Grassland converted and 2.45 Gg C from Wetland converted. The CO_2 emission is thus 14.89, 5.90 and 8.98 Gg 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 Gg C, with 0.27 Gg C from Grassland converted and 0.29 Gg C from Wetland converted. The CO_2 removal of the gain is 2.01, 0.99, and 1.06 Gg CO_2 respectively. The net loss is 3.51 Gg C for all land converted or emission of 12.87 Gg CO_2.

Net 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 recognised 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.

Net Carbon Stock Change 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, which are harvested once or twice during the growing season. Ploughing or harrowing is only done occasionally (10 years interval). Many hayfields are also used for livestock grazing for part of the growing season (spring and autumn in case of sheep farming). Most hayfields are fertilized with both synthetic fertilizers and manure. Changes in SOC for mineral soil 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” F_{LU} = 0.93 was selected based on the descriptions in Table 5.5 as best describing the hayfields in Iceland. For management and input, F_{MG} =1.10 no tillage-temperate boreal -dry and F_I =1.00 medium input, were selected. The SOC_{REF}, 90.5 tC 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 t C 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 beeing 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 Gg C in the inventory year. Consequently these soils are estimated as removing 0.95 Gg 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 2.26 in 2006 IPCC guidelines (IPCC 2006). Organic soils of Cropland are reported in two categories i.e.

Cropland remaining Cropland and Wetland converted to Cropland 54.51 kha and 2.87 kha respectively. These organic soils are estimated to annually loose 272.52 Gg C and 14.33 Gg C in the same order. The consequent emission is estimated as 999.26 Gg CO_2 for organic soils of Cropland remaining Cropland and 52.54 Gg CO_2 for soils of Wetland converted to Cropland. All soils of Wetland converted to Cropland are assumed to be organic.

7.6.2 Other Emissions (5(I), 5 (II), 5(III), 5(IV))

Direct N_2O emissions from use of N fertilisers are included under emissions from agricultural soils and reported under 4.D.1.

All N_2O emissions from drainage of organic soils are reported under the Agriculture sector 4.D.1.5- Cultivation of Histosols. N_2O emissions from disturbance associated with conversion of land to cropland (5.(III)) are included there as indicated by use of the notation key IE.

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

7.6.3 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.

7.6.4 Emission Factors

The CO_2 emissions from Cropland organic soil calculated according to a Tier 1 methodology using the EF= 5.0 t C $ha^{-1}yr^{-1}$ (AFOLU Guidelines Table 5.6).

The emissions 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 year conversion period, the annual change is in $\Delta C_{Mineral}$ = 0.10 t C ha^{-1} for Grassland converted to Cropland.

The CO_2 emissions due to liming of cropland are calculated by conversion of carbonated carbon to CO_2.

7.6.1 Biomass burning

Biomass burning of Cropland is reported for the inventory year is reported as not occuring. Method for estimating area of biomass burned is described in chapter 7.12.

7.6.2 Uncertainty and QA/QC

According to the time series for Cropland the cumulated area of cultivated land is in reasonable good agreement with the area mapped as Cropland 172 kha versus 169 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 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 initated 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 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 organic Cropland are based on default EF from AFOLU Guidelines Table 5.6 the uncertainty of that EF is 90%. Emissions due to liming calculated on basis of amounts of liming agents, independent of area.

No quality control or quality assurance has been undertaken regarding the submitted amounts of liming agents. The amount of shellsand from distributors only covers shellsand obtained ofshore through offshore pumping of sand by one company. Shellsand is also available locally at several places and has traditionally been the source of liming agent for farmers in these regions. No recording of the amount of shellsand from these sources is available.

7.6.3 Recalculations

The emissions from biomass burning due to wildfires on cropland of the years 2006-2012 are recalculated according to revised methods as described in chapter 7.12.

7.6.4 Planned Improvements regarding Cropland

In this submission as in last year's submission 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 soil 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 emissions 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. Establishing country specific emission factors, including variability in soil classes, is already included in on-going research projects at the AUI. These studies are assumed to result in new emission factors. 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.

7.7 Grassland

Grassland is the largest land use category identified by present land use mapping as described above. Grassland is a very diverse category with regard to vegetation, soil type, erosion and management.

The Grassland category is, as in last year's submission, divided into ten subcategories.

The Grassland time series reported are prepared from three primary time series (Figure 7.8), 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 and Reservoirs (Figure 7.9, Figure 7.10, and Figure 7.11).

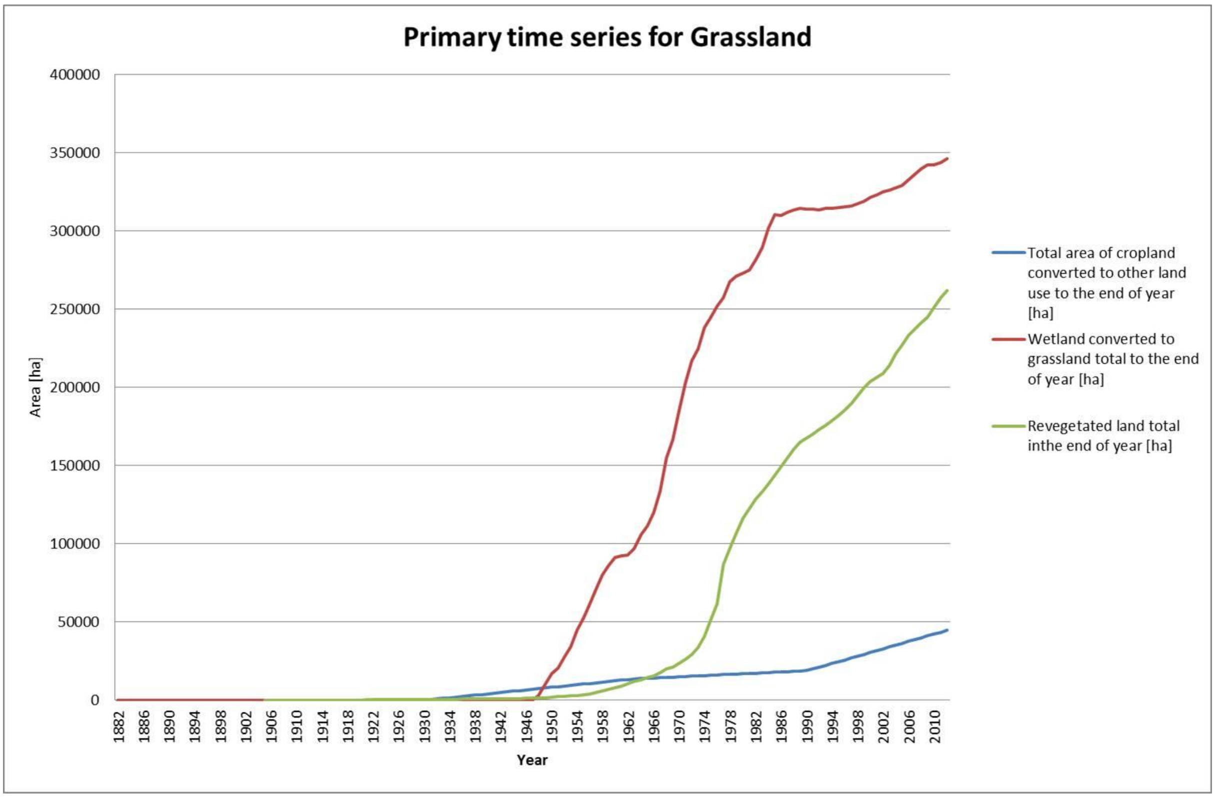

Figure 7.8. Primary time series for Grassland: Total area of Cropland converted to other land uses at the end of the year, Wetland converted to Grassland at the end of the year, Revegetated land at the end of the year. All graphs showing cumulative area at the end of the year from the beginning of time series.

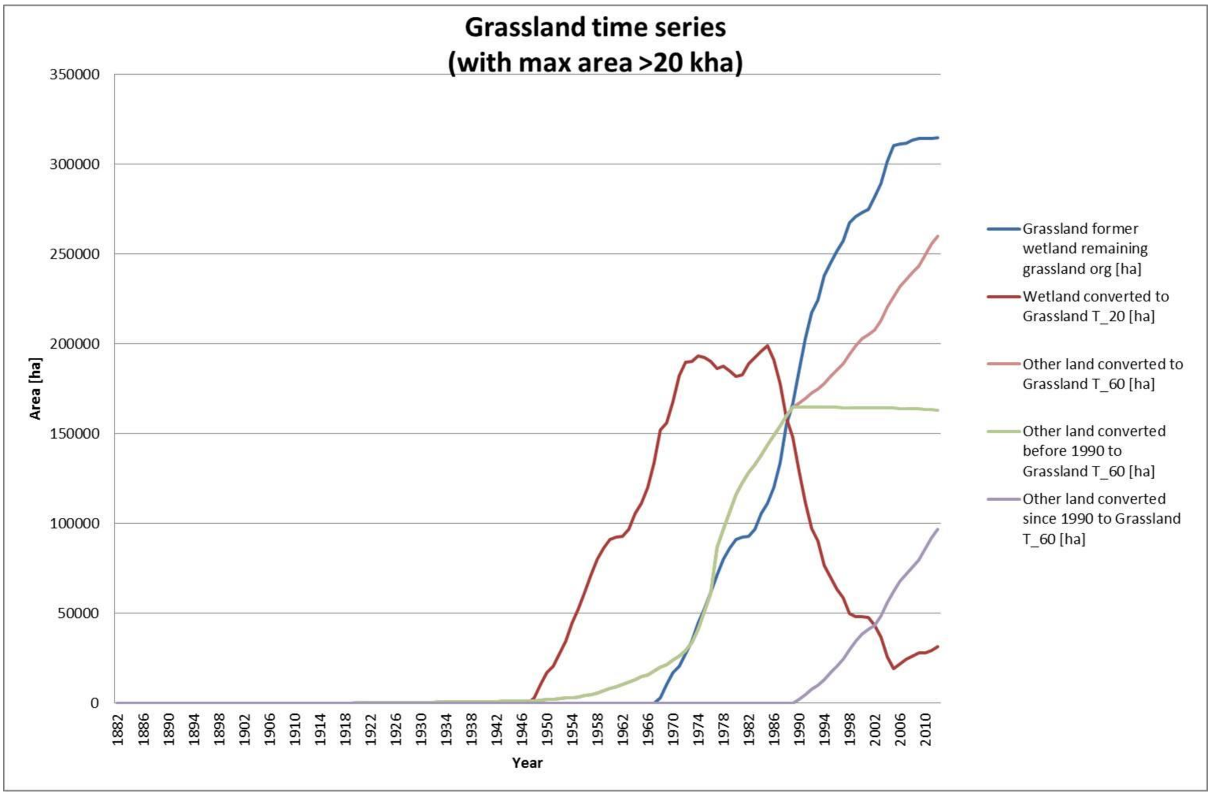

Figure 7.9. Time series of reported Grassland categories with max area >20 kha: Grassland former Wetland remaining Grassland organic soil, Wetland converted to Grassland T_20, Other land converted to Grassland T_60, Other land converted to Grassland before 1990 T_60, Other land converted to Grassland since 1990 T_60. All graphs showing the area in hectares at the end of the year.

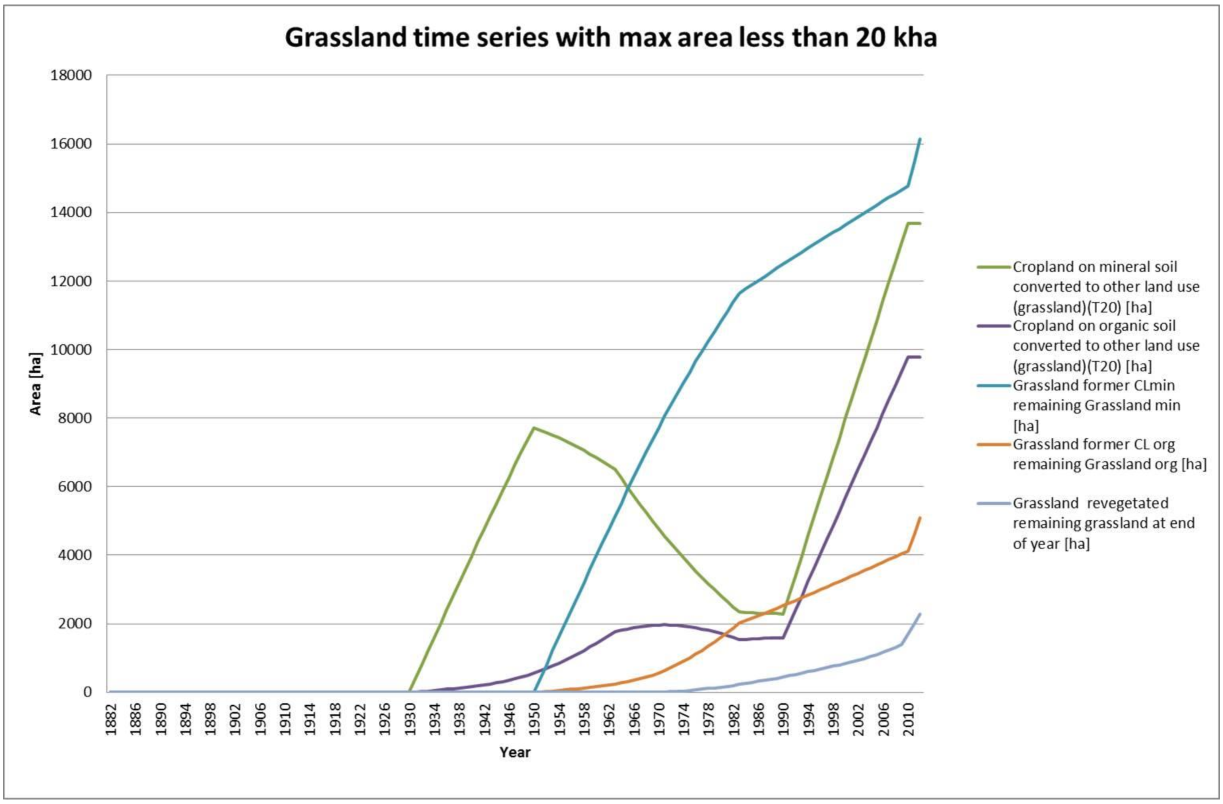

Figure 7.10. Time series of reported Grassland categories with max area <20 kha: Cropland on mineral soil converted to Grassland T_20, Cropland on organic soil converted to Grassland T_20, Grassland former Cropland remaining Grassland mineral soil, Grassland former Cropland remaining Grassland organic soil, Grassland former revegetated Other land remaining Grassland. All graphs showing the area in hectares at the end of the year.

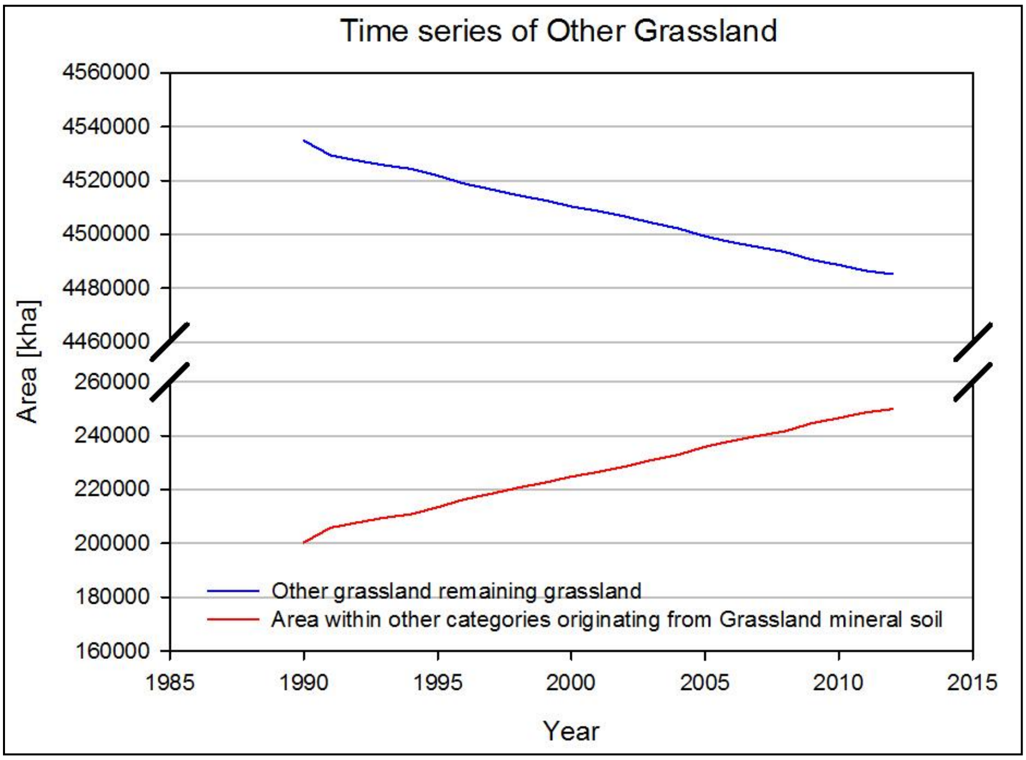

Figure 7.11. Time series for Other Grassland as prepared from changes in area of former Grassland within other land use categories.

7.7.1 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.

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 20.06 kha whereof 5.09 kha is organic soil.

Natural Birch Shrubland

Natural birch shrubland is the part of the natural birch woodland not meeting the thresholds to be accounted for as forest and 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 its area and stock changes are 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.

Similar to natural birch woodland, two subcategories of natural birch shrubland are reported. One i.e. “Natural birch shrubland –old” is for shrubland remaining shrubland including shrubland surveyed in the 1987 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 (0.021 Mg C ha^{-1} yr^{-1}). The second subcategory i.e. "Natural birch shrubland – recently expanded into Other Grassland" is for other grassland converted to shrubland. 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 IPCC default emission factor for organic soil. As no historical data before 1987 exists, a time series for changes in area and C-stock of natural birch shrubland only exist after 1987. They are built on interpolation between 1987 and 2007 and extrapolations from 2007 with even annual increase in area and C-stock.

Other Grassland

The mapping unit Other grassland includes all land 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 7.2), are excluded as 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 7.3.9) and the time series prepared as described above.

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 60-250×10^3 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 Gg CO_2 if all of this lost SOC is decomposed or 92-183 Gg 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 (194 Gg 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 present increasing both in vigour and continuity (Magnússon et al. 2006). In these areas, the annual carbon budget might be positive at present 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.

Revegetated land older than 60 years

By defining a conversion period of 60 years, for Other land converted to Grassland (Revegetation) which is shorter than the time revegetation of other land 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 2.29 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 Maps of Land being revegetated).

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 area 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 314.67 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 organic soil. The preparation of that mapping unit is described in (chapter 7.3.9). This category is recognized as key category in CO_2 emission in level 1990 and 2012 and in trend. The N_2O emission from all Grassland organic soils, where the major part is in this category, is recognized as key category in level 1990 and 2012.

7.7.2 Land converted to Grassland

Land converted to Grassland is reported in three categories i.e.; "Cropland converted to Grassland", "Wetland converted to Grassland" and "Other land converted to Grassland". Conversions of Forest land and Settlement to Grassland are reported as not occurring.

Cropland converted to Grassland

The area reported is as emerging from the time series available for Cropland using the default conversion period of 20 years. The category is at present not identified as a specific mapping unit but is included in both the mineral and organic soil part of the Cropland mapping unit. The total area reported for this category is 24.63 kha with 9.48 kha on organic soil. The area of this category is estimated the same as in last submission, because the area of new conversions is estimated the same for more than 20 years therefore size of the area added and removed from the categoru is the same.

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 31.58 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.

Other Land converted to Grassland

Revegetation

The land reported as "Other land converted to Grassland" is the result of revegetation activity. The original vegetation cover is less than 20% for the vast majority of land where revegetation is started, 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 category "Revegetation since 1990" 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 area of Revegetation since 1990 reported for the year 2012 is 96.80 kha compared to 87.09 kha reported for the year 2011 in last year´submission. The area revegetatated each year since 1990 is in this submission revised and area for the year 2011 reported in this submission is 92.10 kha.

The CO_2 removal of “Other land converted to Grassland-(Revegetation)” and aggregated emission for “all other conversions to Grassland” are both recognised as key source/sink in level for bothe 1990 and 2012 and for trend in 2012.

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)

7.7.3 Carbon Stock Change (5C)

Carbon stock changes are estimated for all subcategories included both under Grassland remaining Grassland and Land converted to Grassland.

Carbon Stock Change 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 0.96 Gg C and 1.52 Gg C respectively removing 3.52 Gg CO_2 and 5.58 Gg 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 7.6.4). The living biomass of this category is estimated to have increased by 13.03 Gg C in 2012, consequently removing 47.78 Gg CO_2.. The stock changes in living biomass of the category “Other land converted to Grassland (Revegetation)” reflect the increase in vegetation coverage and biomass achieved through revegetation 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. The carbon stock in living biomass is estimated to have increased by 9.29 Gg

C and 5.52 Gg C respectively for the categories Revegetation before 1990 and Revegetation since 1990 removing 34.08 Gg CO_2 and 20.23 Gg CO_2 from the atmosphere, respectively.

Net 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” by the IFR in the NFI.

This carbon stock is estimated to have increased by 0.79 Gg C in the year 2012 and accordingly removing 2.90 Gg CO_2 from the atmosphere.

The changes in dead organic matter are included in C-stock changes in living biomass for the category “Cropland converted to Grassland” see above (chapter 7.6.4). The changes in dead organic matter are also included in living biomass of “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.

Net carbon Stock Change in Soils

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 2.05 Gg C in the year 2012 and thereby removing a total of 7.52 Gg 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 7.6.4). The loss from mineral soils of Cropland converted to Grassland is reported as 1.58 Gg C and consequently emitting 5.79 Gg CO_2. No mineral soil is included as “Wetland converted to Grassland”.

For the category “Other land converted to Grassland (Revegetation)” the changes in carbon stock in mineral soils are estimated applying Tier 2 and CS emission (removal) factor. The carbon stock in mineral soils is estimated to have increased by 83.65 Gg C and 49.66 Gg C respectively for the categories Revegetation before 1990 and Revegetation since 1990 removing 306.73 Gg CO_2 and 182.08 Gg CO_2 from the atmosphere.

Organic soils are reported for the Grassland subcategories “Natural birch shrubland- old” “Wetland drained for more than 20 years”, “Cropland abandoned for more than 20 years”, “Wetland converted to Grassland” and “Cropland 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 112.76 Gg C in the inventory year emitting 413.45 Gg CO_2.

7.7.4 Other Emissions (5(IV))

Liming of Grassland soil is not practiced and therefore reported as not occurring. Due to the structure of the CFR- Reporter software version 3.7.3, used in preparing the CRF tables, non-CO_2 emission resulting from drainage i.e. N_2O still needs to be reported under "5.G. Other", where it is included as subdivision "*Grassland Non-CO_2 emission-5(II)- Non- CO_2 emission from drainage of soils and wetlands-Organic soils*" (chapter 7.11.2).

7.7.5 Biomass burning (5(V))

The area of biomass burning within Grassland is all reported under Grassland remaining Grassland. Only wildfires are included in the present estimate. The methodology for estimating the biomass burned and the consequent emissions is explained in chapter 7.12. The area of Grassland burned in the inventory year in wildfires is estimated as 16.7 ha emitting 0.46 Mg CH_4 and 0.04 Mg N_2O equivalent to 9.6 Mg CO_2 and 12.9 Mg CO_2 respectively.

7.7.6 Emission Factors

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.

Emissions of CO_2 from organic soil in all categories of Grassland except Cropland converted to Grassland are calculated according to Tier 1 methodology EF= 0.25 [t C ha^{-1} yr^{-1}]. The emission factor applied for organic soil of Cropland converted to Grassland is 2.63 considering both default emission factors for Cropland organic soil and Grassland organic soil.

In recent review paper on GHG emission from organic soils in Nordic countries Maljanen et al (Maljanen et al. 2010) report average emission of 1320 g CO_2 m^{-2} yr^{-1} or 3.6 tC ha^{-1} yr^{-1} for abandoned croplands on organic soils in Scandinavia. Recent measurements in Iceland also show comparable emission factor (Gudmundsson and Óskarsson 2014). Considering the category being a key source it is urgent to move up to higher tier in estimating the emission from the category. EF for N_2O is discussed in chapter 7.18.2.2.

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.

Carbon stock changes in mineral soils of the subcategory “Natural birch shrubland–recently expanded into Other Grassland” are estimated applying same EF 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 7.6.4) EF= -0.10 t C ha^{-1}.

7.7.7 Conversion Periods for Land converted to Grassland.

The conversion period for all categories of “Land converted to Grassland” except “Other land converted to Grassland-Revegetation”, is set as default 20 years. The conversion period of Revegetation is set 60 years, based on NIRA sampling (Thorsson et al. in prep.).

7.7.8 Uncertainty 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. Uncertainities of Other land converted to grassland have been estimated using data from the KP LULUCF sampling program (see 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.

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.

Carbon stock changes of living biomass for Natural birch shrubland are estimated by IFR through NFI. That estimate 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 cause 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).

Uncertainty in reported emissions from drained soil is also substantial. That uncertainty is both due to uncertainty in the estimate of the size of the drained area and in the uncertainty of applied EF’s ± 90%. 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 validity of this number needs to be confirmed. 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.

Applying one EF for all drained land also involves many uncertainties. The emission can be supposed to 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.

Regarding the category "Land converted to Grassland" changes for three categories are reported. The aggregated uncertainty of emission factors other than for revegetation is estimated as 90%. The uncertainty of both areas is currently estimated 30%, but it decreases as real-time GPS methodology is increasingly used (Thorsson et al, in prep). EF in Revegetation is estimated 10%.

7.7.9 Planned Improvements regarding Grassland

Emissions of CO_2 from, "Wetland drained for more than 20 years", aggregated CO_2 emission from "All other conversions to Grasslands", "Other land converted to Grassland" are identified as key sources both as level 1990 and 2012 and in trend, and N_2O emission of "Grassland non CO2-emissions" as level 1990 and 2012. The emissions from organic soil within these categories are accordingly an important source.

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. Improvements in ascertaining the extent of drained organic soils in total and within different land use categories and soil types is also a priority. 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. This project was continued in summers 2012 and 2013 and it is expected that data sampling will be completed in this year. The results of this project are expected to improve the area estimate of drained land and of effectiveness of drainage.

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. Such information can also be used to evaluate the time series of drainage.

The emission factor for drained organic soils of Grassland is expected to be revised in next submission, both as revised guidelines are available and new data from in country studies are expected. This revision might lead to a considerable rise in the estimated emissions from drained organic soils.

In this submission a new subcategory is added i.e. “Natural birch shrubland –recently expanded into Other Grassland” Otherwise the subdivision remains unchanged. 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 are a 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 and Óskarsson 2009) Subdivision of that category according to management, vegetation condition 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.

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 this year if manpower allows. 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.

7.7.10 Recalculation

The following recalculations for Grassland subcategories are reported in this year's submission. The area of Wetland drained for more than 20 years is revised according to revision of other map layers. This revision is insignificant and does not affect the emissions reported. The area of the subcategory "Other Grasslands" is revised in accordance with changes in other map layers and the hierarchical order of the category. The area of the subcategory "Natural birch shrubland recently expanded into other grassland" is revised from last submission and consequently the removals reported. The area of Cropland converted to Grassland are revised in balance with the changes in the category "Cropland converted to Forest land" and an unchanged estimate of total area of Cropland converted to other use from the time series. Some insignificant changes in the area of "Wetland converted to Grassland" were made but not affecting the emissions reported. The area of "Revegetation since 1990" is revised based on new activities since the last submission.

Emission caused by biomass burning in wildfires from the year 2006 is revised as improvements have been made in recording the area burned.

7.8 Wetland

The map layers of previous submission representing lakes and riveres i.e. "Lakes and rivers" from the IFD and IS50v 3.2 are replaced by a new map layer IS50V2013. This revision of maps results in a decrease in the estimate of the total area of lakes and rivers from 259.99 kha reported in last submission to 206.94 kha in this submission. Most of the difference is transferred to other map layers through the compilation process as most of the land involved also had other classification. Small areas, never the less, were not included in other map layers and where transferred to new map layer of unclassified land included under the category "Other land", as explained in chapter 7.3.2. The area of the category "Other wetland" reported in this submission is 417.37 kha compared to 396.62 kha reported in last submission. The change is mostly explanded by revised mapping of lakes and rivers.

Emissions are only estimated for the categories Grassland and Other land converted to wetland resulting from flooding of land due to the establishment of hydropower reservoirs. The emission estimates for this category has not changed from last year's submission.

7.8.1 Carbon Stock Changes (5D)

Areas of Wetland remaining wetlands are divided into three subcategories, "Lakes and Rivers", "Reservoirs" and "Other wetlands". Two categories are considered unmanaged, and noted in the CRF as not applicable. Reservoirs, which are classified as wetland remaining wetland, include only lakes and rivers turned into reservoirs. In cases where the water surface area of the lake has increased only, the lake area before the increase is defined as wetland remaining wetland. No emissions are assumed from natural lakes converted to reservoirs. Peat mining for fuel does not occur. The only peat excavation currently occurring is related to land converted to settlement (chapter 7.9.1).

Some of the land included under other wetlands could fall under managed land due to livestock grazing and should be reported as such; no information is at present available on the area of grazed peatlands. Drained peatlands are reported as wetlands converted to grassland and regarding "Non CO_2 emission" under subcategory "Other- Grassland organic soil". All lakes and rivers are considered unmanaged.

Flooded Land

CO_2 emission from reservoirs is presented for three subcategories:

- Grassland with high soil organic carbon content (High SOC). SOC higher than 50 kg C m^{-2}. This category includes land with organic soil or complexes of peatland and upland soils. This land is classified as land converted to Wetland or as changes between wetland subcategories. The high SOC soils are in most cases organic soils of peat lands or peat land previously converted to Grassland or Cropland through drainage.

- 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.

- 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 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 emissions are calculated from the emission factors available, reservoir area and estimated length of the ice-free period. Limited data is available on ice-free periods of lakes or reservoirs but 215 days are assumed as an average number of ice-free days, like in previous submissions. The estimated CO_2 emissions from reservoirs in the inventory year 2012 equals 9.72 Gg and is the same as reported in last year's submission for the year 2011.

7.8.2 Other Emissions (5II)

Emission of N_2O from drained wetlands are reported under subcategory "5.G Other-Grassland Non CO_2 emission 5(II) Non CO_2 emissions from drainage of soils and wetlands-organic soils".

Flooded Land

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. Emissions of N_2O are considered as not occurring. The Tier 1 method of the AFOLU Guidelines includes no default emission factors for N_2O. Zero emissions were measured in a recent Icelandic study on which the emission estimate is based (Óskarsson and Guðmundsson, 2008).

Estimated CH_4 emission from reservoirs is 0.40 Gg CH_4 and the same as in last year's submission.

7.8.3 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 7.10).

Table 7.10. Emission factors applied to estimate emissions from flooded land based on (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

Emission factors include diffusion from surface and degassing through spillway for both CO_2 and CH_4 and also bubble emission for the latter.

7.8.4 Land converted to Wetland

Two sources of land converted to wetland are recognized: flooding due to construction of new hydropower reservoirs and reclamation of wetland to counteract damaged wetlands due to road building or as recreational area connected to tourism. Land flooded is reported as Grassland converted to Wetland, (high or medium SOC) or as "Other land converted to Wetland" (low SOC) depending on vegetation cover. All flooded land is kept in a conversion stage, although most of the land has been flooded for more than ten years.

7.8.5 Uncertainty and QA/QC

The main uncertainty is associated with the emission factors used and how well they apply to reservoirs of different age. 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 for. 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%.

7.8.6 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. Recording and compiling information on the ice-free period for individual reservoirs or regions is planned. 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.

7.8.7 Recalculations

No recalculations were made for the category Wetland affecting the reported emissions. The area estimate for both the categories “Lakes and rivers” and “Other wetland”.

7.9 Settlement

The area of Settlement reported is the area estimate of IGLUD. The map layers representing Settlements are the same as in last years submission (Table 7.2). The area reported is 51.46 kha compared to 51.85 kha in last year’s submission. The difference is explaned by revision of outer boundaries (chapter 7.3.2).

7.9.1 Carbon Stock Changes (5E)

Carbon stock changes are only estimated for Forest land converted to Settlement and is further described above in chapter 7.5.5. The emissions reported are based on carbon stock estimates of the living biomass of the trees on the deforested land (T3 approach) and in country estimates of C-stock in dead organic matter and soil (T2 approach). The area reported in the inventory year as “Forest land converted to Settlement” is 0.05 kha and the attached estimated emission is 0.11 Gg CO_2.

Conversion of other land use categories to Settlement are presently not estimated. No systematic recording of the previous land use of the land converted is presently available. Conversion of land to Settlement often involves removal of vegetation and soil and changes in C-stocks accordingly expected. The estimate of these removal and potential vegetation recover depend on area of each category converted presently unavaialbe.

7.9.2 Other Emissions (5)

Removal of organic soils or their drainage within the Settlement area can be potential source of N_2O emission The area of drained wetlands inside Settlement area, has not been estimated.

7.9.1 Biomass burning (5V)

Small areas where biomass was burned in the inventory year is in the IGLUD land use map Identified as Settlement. The emissions connected to the burning if the biomass in this area are included within Grassland remaining Grassland biomass burned. The area involved is small country roads and adjacent sites. These sites are either included as a buffer zone on roads or through the pixelsize applied.

7.9.2 Land converted to Settlement

At present no official country-wise periodic compilation of land converted to settlement has been made. Previous land use categories are generally not recorded in municipal area planning. The only conversion of land to Settlement reported is Forest land converted to Settlement.

7.9.3 Planned Improvements regarding Settlement

The present estimate of Settlement area is based on IS50V2013. Mapping of Settlement have changed through the period involved. As pointed out earlier (chapter 7.3.12) changes in the mapped area can reflect both improved mapping or actual changes in land use. The changes reported in area of Settlement are only those counteracting conversion of Forest land converted to Settlement. Revision of relative changes in Settlement area using available supplementary data as total basal area of buildings as proxy is planned. To obtain information on area converted to Settlement recording of past changes in the area of selected towns and villages and previous land use is planned in next years.

7.10 Other Land (5F)

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 (see Table 7.2). The map layers included in the category “Other land” are areas with vegetation cover < 20% or covered with mosses.

The total area reported as other land is 4,083.09 kha for the inventory year compared to 3,999.96 kha in last year's submission. The difference is mostly explained by the revision of the map layer "Lakes and rivers", and the outer boundaries. Additional to the increase in area conversion of other land to both Grassland and Forest land occurred in the inventory year as reported above for therelevant categories.

7.10.1 Biomass burning(5V)

The category "Other land " includes land with less then 20% cover of vascular plants. Some of the land included in this category is covered with mosses and can have considerable stock of above ground biomass both as living biomass and dead organic matter. In the inventory year a small area of other land was burned or total of 0.18 ha and resulting emission reported is 3.88 kg CH_4 and 0.35 kg N_2O or equivalent to 0.191 Mg CO_2.

7.10.2 Recalculations

The area of the category is revised from last submission both as consequence of revision of the map layer for "Lakes and rivers" and of outer boundaries. Biomass burning for the years 2006-2011 is revised from last years submission according to new data available and methodology described in chapter 7.12.

7.10.3 Planned Improvements regarding other Other Land

The development of IGLUD in coming years is expected to improve area estimates for the category. Especially, improvements regarding mapping of revegetation activities before 1990, are expected to improve the quality of mapping of the "Other land" category.

7.11 Other (5)

One emission/removal category is reported under other i.e. Grassland Non-CO_2 emission Harvested Wood Products are not reported.

7.11.1 Harvested Wood Products

No data is available on stock changes in harvested wood products and they have therefore not been estimated. Currently there are no planned improvements regarding recording of this stock.

7.11.2 Wetland converted to Grassland Non CO_2 Emissions

Non-CO_2 emissions from Grassland are reported here. The present structure of the CRF Reporter software (version 3.7.3) does not allow reporting of these emissions under the Grassland land use category, as the category "5(II) Non-CO_2 emissions from drainage of soils and wetlands- Organic soils" is not included under Grassland tables. The emission estimate for this category has changed from last submission mostly due to changes in reported area. The estimated emissions in this year's submission are 0.25 Gg N_2O or 77.9 Gg CO_2-equivalents compared to last year's estimate, 0.25 Gg N_2O or 77.93 Gg CO_2-equivalents.

Other Emissions (5(I), 5(II), 5(III)

Grasslands in Iceland are generally not fertilized. The main exception is fertilization as a part of revegetation activity. Use of fertilizers in revegetation is reported separately (see below). Direct N_2O emissions from eventual use of N fertilisers on grassland are included under emissions from agricultural soils.

Emissions of N_2O due to drainage of organic soils of Grassland are reported here under "5(II) Non-CO_2 emissions from drainage of soils and wetlands- Organic soils".

Emission Factors

Emissions of N_2O from drained organic soil under Grassland are calculated according to a Tier 2 using a new CS emission factor EF=0.44 [kg N_2O-N ha^{-1} yr^{-1}] (Gudmundsson 2009). The emission factor is based on direct measurements of N_2O emissions from drained grassland soils. The drained grassland soils in Iceland have not been ploughed seeded or fertilized and are not agricultural or cultivated soils.

7.12 Biomass Burning (5V)

Accounting for biomass burning in all land use categories is addressed commonly in this section. The only emissions reported in previous submissions are for the year 2006 due to single large wild-fire event in western Iceland. The Icelandic Institute of Natural History has in cooperation with regional Natural History Institutes started recently to record incidences of biomass burning categorised 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 since 2006 is now reported for the land use categories; Land converted to Forest land, Cropland, Grassland, Wetland and Other Land. For the categories Cropland, Grassland and Wetland the burned area is aggregated in land remaining in relevant category. For Other land all burned area is reported under land converted to Other land as category "(5V)-Biomass burning" is not available for Other land remaining other land in the CRF reporter, but the area burned belonges there. 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 7.1: Equation 2.27 from AFULU guidelines (IPCC 2006): L_{fire}=tonnes of GHG emitted, A= area burned [ha], M_B=mass of fuel available [tonnes/ha], C_f =combustion factor, G_{ef}= emission factor [gGHG/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 angainst 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 preburning values within few years from the burning. Available biomass range from 18.7

±3.8 to 29.9 ±1.9 tonnes orgainc matter Dw ha^{-1} the standard error for individual categories from 6-29%

Controlled burning of forest land is considered as not occurring. Controled 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 occuring.

7.12.1 Planned Improvements regarding Biomass Burning

Recording of the area where controlled biomass burning is licenced 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 municipial fire departments regarding this matter. Prohibitation or stricter licences on controlled burning can be expected in near future. This development might involve better recordkeeping on biomass burning.

7.13 Planned Improvements of Emission/Removal Data for LULUCF

Improvements which apply specifically to one of the land use categories and activities, or one of their pools are listed above in their relevant chapters.

As part of the IGLUD project extensive field data has been obtained on carbon stocks, vegetation cover, land use and state of the land in around 1800 sampling points. The analysis of of this data is expected to give a baseline for the present carbon stocks of the relevant land category and the landuse and the state of the land which can be referred to at later visits at these points. This tata is also expected to enable further division of the land according to management and how that land is responding to that management.

8 WASTE

8.1 Overview

This sector includes emissions from solid waste disposal on land (6A), wastewater treatment (6B), waste incineration (6C), and biological treatment of solid waste (6D).

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 so that the waste did not have to be transported far 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 of the capital´s population 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 communities outside the capital area opened municipal SWDS in the 1970s and 1980s.

Before 1990 three waste incinerators were opened in Keflavík, Husavík and Isafjörður. In total they burned around 15,000 tonnes of waste annually. They operated at low or varying temperatures and the energy produced was not utilised. Proper waste incineration in Iceland started in 1993 with the commissioning of the incineration plant on 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 recover the burning energy and use it for either public or commercial heat production. 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 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 about waste composition of landfilled waste since 1999. For the last few years the waste sector has had to report data about amounts and kinds of waste landfilled, incinerated, and recycled.

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 points. 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 2012, 85 tonnes of hazardous waste were landfilled, 604 tonnes were incinerated, 6,091 tonnes were recycled, and 122 tonnes of acid were neutralized.

Clinical waste has been incinerated in incinerators either at hospitals or at waste incineration plants. 124 tonnes of clinical waste were incinerated in incineration plants in 2012.

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 2012, more than 90% 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 increased since then. Over recent years, composting has become a publically known option in waste treatment and a number of composting facilities have been commissioned.

In 2012, about 36% of all waste generated was landfilled, 57% recycled or recovered, 4% incinerated, and 3% composted.

Wastewater treatment in Iceland consists mainly in basic treatment with subsequent discharge into the sea. The majority of the Icelandic population, approximately 90%, lives by the coast, a non-problem area with regard to eutrophication, as Iceland is surrounded by an open sea with strong currents and frequent storms which lead to effective mixing. About 63% of the population lives in the capital 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 amounted to 183 Gg CO_2 equivalents in 2012, which is tantamount to a 26% increase since 1990. Between 2011 and 2012, however, emissions from the waste sector have decreased by 7.7% due to a decrease of SWD emissions. Around 89% of all emissions from the waste sector (2012) are caused by solid waste disposal, 6% by wastewater treatment, 4% by waste incineration without energy recovery and 1% by composting. The development of greenhouse gas emissions from the waste sector is shown in Figure 8.1.

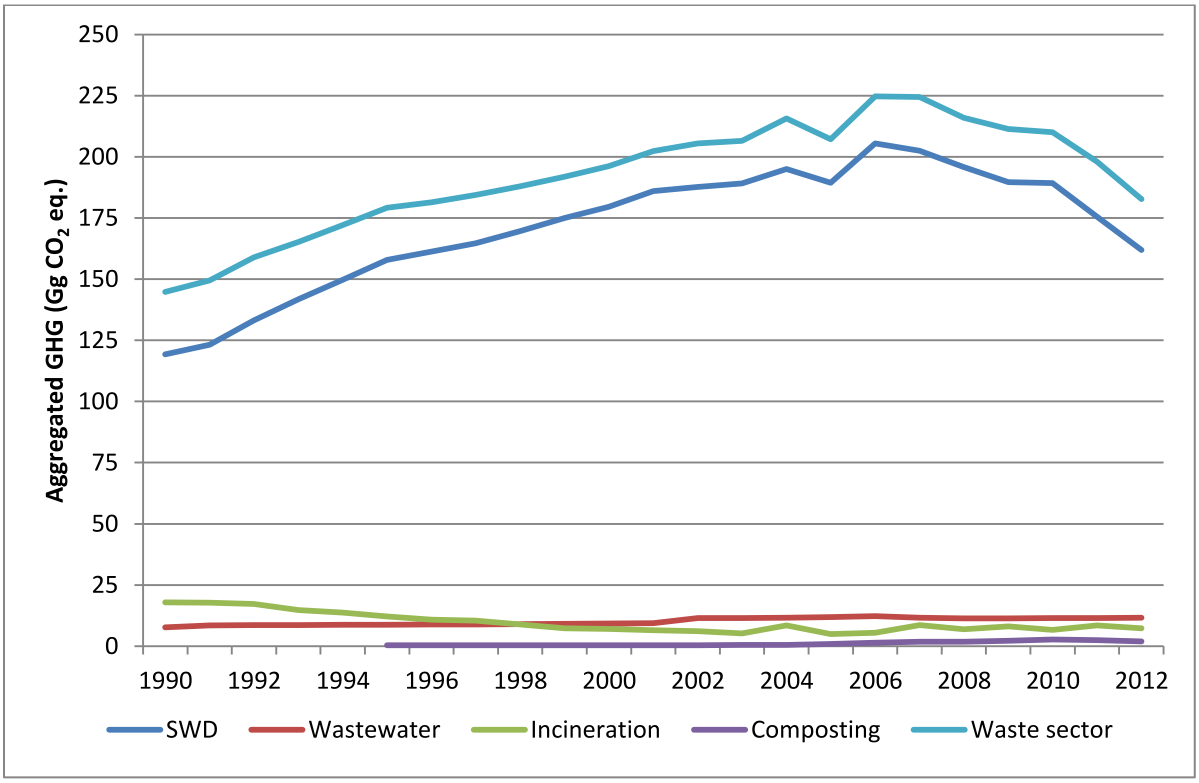

Figure 8.1. Greenhouse gas emissions from the waste sector in Iceland. CO_2, CH_4 and N_2O emissions were aggregated by calculating CO_2 equivalents for CH_4 and N_2O (factors 21 and 310, respectively). The top line is the sum of the four lines below.

8.1.1 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) and the Good Practice Guidance (GPG). Methodology for each greenhouse gas source category within the waste sector is described separately below.

8.1.2 Key source analysis

The key source analysis performed for the 2014 submission revealed that in terms of total level and/or trend uncertainty the key sources in the waste sector are as follows:

- Managed waste disposal on land – CH_4 (6A)
    - This is a key source in level (2012) and trend
- Unmanaged waste disposal on land – CH_4 (6A)
    - This is a key source in level (1990) and trend

8.1.3 Completeness

Table 8.1 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 8.1. Waste sector – completeness (E: estimated, NE: not estimated, IE: included elsewhere).

	Direct GHG			Indirect GHG		
Waste Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Solid waste disposal on land (6A)						
- **Managed (6A1)**	NE	E	NE	NE	NE	E
- **Unmanaged (6A2)**	NE	E	NE	NE	NE	E
Wastewater treatment (6B)						
- **Industrial (6B1)**	NE	E	IE[2]	NE	NE	NE
- **Domestic and commercial (6B2)**	NE	E	E	NE	NE	NE
Waste incineration (6C)	E	E	E	E[1]	E[1]	E[1]
Other – Composting (6D)	NE	E	E	NE	NE	NE

1: Data also submitted under CLRTAP; 2: included in 6B2

8.1.4 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.

8.2 Solid waste disposal on land (6A)

8.2.1 Methodology

The methodology for calculating methane from solid waste disposal on land is according to the Tier 2 method of the 2006 GL and uses the 2006 IPCC 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 model was expanded to include additional waste categories. Therefore the Technical Support Unit of the IPCC NGGIP was contacted and provided the author with the password to unprotect the spread sheet.

8.2.2 Activity data

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, 2013). 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. 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 last year the amount of material burned annually in bonfires had been estimated to amount to up to 6 Gg. Beginning with last 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 2012. The result was projected back in time using expert judgement. Until last year 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 since 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.

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

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

The waste amount generated was calculated for total waste and not separately for municipal and industrial waste as was done in Iceland´s 2011 submission 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 8.2.2).

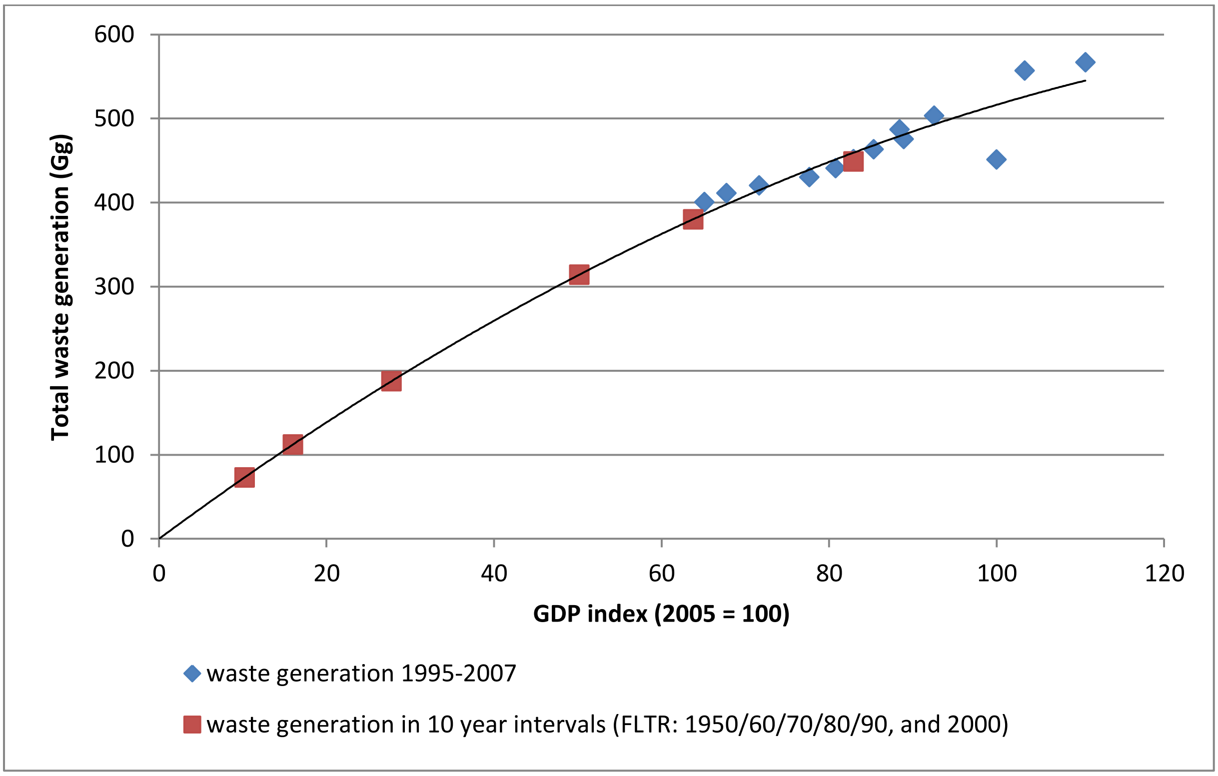

Figure 8.2. Waste generation from 1950-2007. Blue rhombuses denote waste generation between 1995 and 2007 and were used to calculate waste amounts before 1995, which are shown as red squares in 10 year intervals along the trend line.

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 1950-2012 are shown in Figure 8.3.

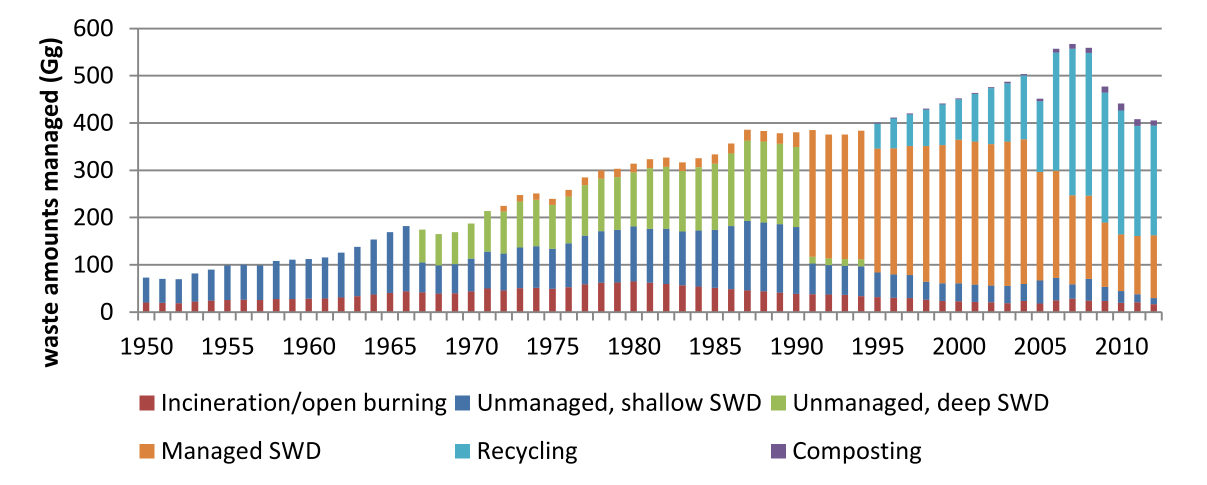

Figure 8.3. Waste amount and allocation to incineration/open burning, solid waste disposal, recycling and composting.

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")

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 site 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 2005 (Figure 8.4), i.e. shallow landfill sites receive a disproportionate amount of waste compared to the share of population they are serving.

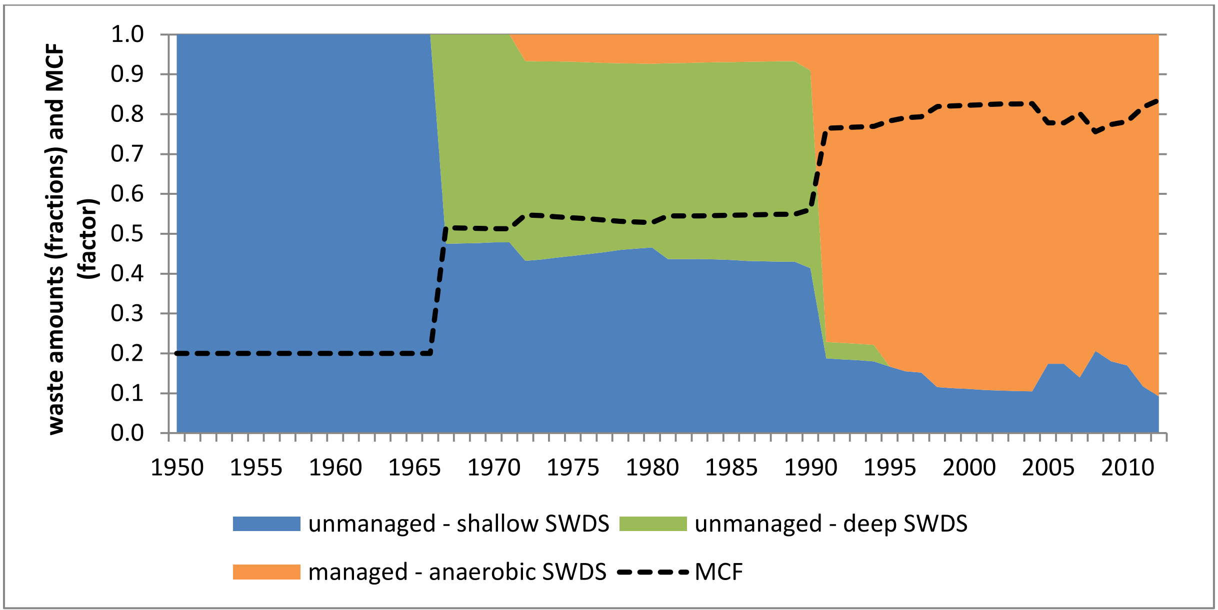

Figure 8.4. Fractions of total waste disposed of in unmanaged and managed SWDS and corresponding methane correction factor (see also: chapter 8.2.4)

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 8.2.

Table 8.2. 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 8.3. 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 8.3. Waste category fractions for selected years since 1950.

	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	30.4%	8.7%	16.6%	2.1%	2.4%	3.2%	5.2%	2.0%	1.4%	28.1%

8.2.3 Emission factors

Methane emissions from solid waste disposal sites are calculated with equation 3.1 of the 2006 GL:

Equation 3.1

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

Where:

CH_4 Emissions = CH_4 emitted in year T, Gg

T = inventory year

x = waste category or type/material

R_T = recovered CH_4 in year T, Gg

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 8.2.4. In order to calculate methane generated, the FOD method uses the emission factors and parameters shown in Table 8.4.

Table 8.4. Emission factors and parameters used to calculate methane generated.

Emission factors/parameters	values
Degradable organic carbon in the year of deposition (DOC)	Table 8.5
Fraction of DOC that can decompose (DOC_f)	0.5
Methane correction factor for aerobic decomposition (MCF)	Table 8.6

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 8.5
Half-life time of waste in years (y)	Table 8.5
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 8.5).

Table 8.5. Degradable organic carbon (fraction), methane generation rate and half-life time (years) of ten different waste categories.

category	food	food industry[1]	paper	Textiles	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 8.3) 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 8.6. 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 (cf. Figure 8.4).

Table 8.6. IPCC methane correction factors and MCFs used in NIR 2012.

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

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

Equation 3.5

DDOC decomposed at the end of year T

$$DDOCm\ decomp_T = DDOCma_{T\text{-}1} * (1\text{-}e^{-k})$$

Where:

T = inventory year

$DDOCma_T$ = DDOCm accumulated in the SWDS at the end of year T, Gg

$DDOCma_{T-1}$ = DDOCm accumulated in the SWDS at the end of year (T-1), Gg

$DDOCmd_T$ = DDOCm deposited into the SWDS in year T, Gg

DDOCm $decomp_T$ = DDOCm decomposed in the SWDS in year T, Gg

k = reaction constant, k = $\ln(2)/t_{1/2}$ (y^{-1})

$t_{1/2}$ = half-life time (y)

Finally, generated CH_4 is calculated by multiplying decomposed DDOC with the volume fraction of CH_4 in landfill gas (= 0.5) and the molecular weight ratio of methane and carbon (16/12=1.33)

8.2.4 Emissions

Methane recovery

The only SWDS recovering landfill gas is Álfsnes which serves the capital area It started doing so in 1996. Data on the amount of landfill gas recovered stems from the operator Sorpa ltd. (Einarsson, written communication). Data for the years 1996-2004 is based on estimations whereas data since 2005 is 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 8.5 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 (data not shown) the recovered amounts surpassed the 2005 level. The amount incinerated dropped in 2003, 2006, and 2010 because of damage to the burner. From 2011 onwards all methane is utilized, i.e. no methane is incinerated.

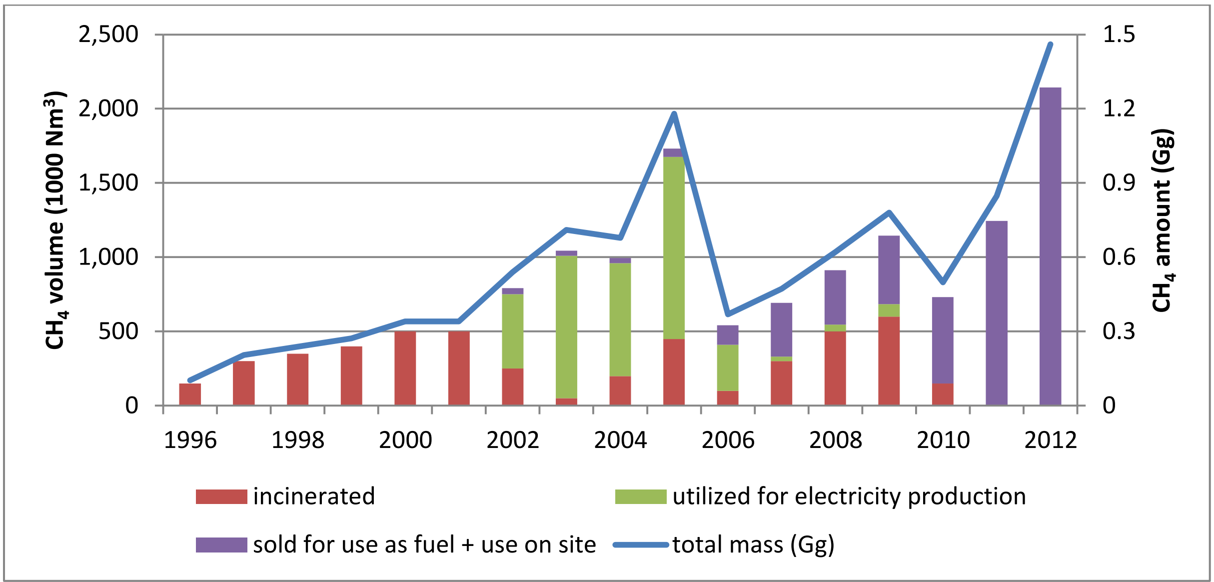

Figure 8.5. Methane recovery at solid waste disposal site Álfsnes (1000 Nm3).

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 7.7 Gg in 2012. This equals an increase of 36% between 1990 and 2012.

The main reason behind the increase until 2006 is a rather stable, high amount of waste disposed of in SWDS in connection with an increase of the methane correction factor caused by the close down of unmanaged SWDS in favour of managed SWDS. The shift in emissions from unmanaged to managed SWDS can be seen in Figure 8.6. 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 2012 79% 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.

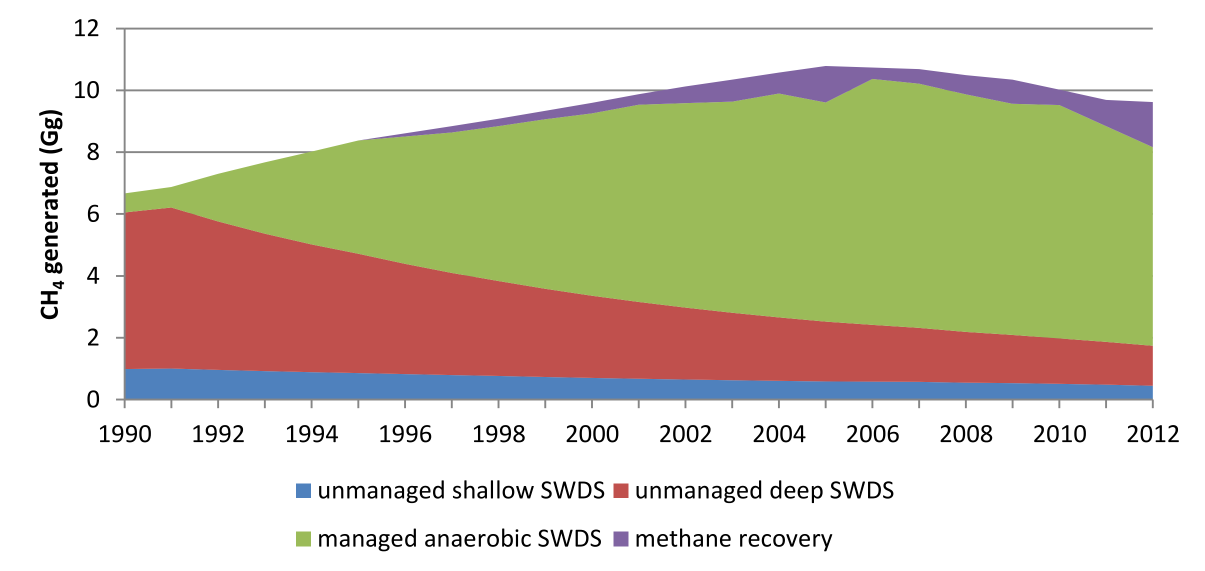

Figure 8.6. Methane emissions from SWDS, separated into SWDS types. The amount of methane recovered at the managed SWDS Álfsnes is shown as purple area (reducing the size of the green area for emissions from managed SWDS)

8.2.5 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 an uncertainty of +-10% was assumed. 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 SWD 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 2012 emissions leading to a total EF uncertainties of unmanaged SWDS of 57%.

AD und EF uncertainties combined were 56% for managed SWDS and 67% for unmanaged SWDS.

8.3 Emissions from Wastewater Handling (6B)

8.3.1 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 the turn of the century the share of direct discharge of wastewater has been reduced mainly in favour of collection in closed underground sewers with basic treatment. Basic or primary treatment includes e.g. removal of suspended solids by settlement and subsequent pumping of wastewater up to 4 km away from the coastline (capital area). Since 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 in order to let it 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 Icelandic site factors reduce methane emissions from wastewater, 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 wastewater.

Total CH_4 and N_2O emissions from wastewater amounted to 11.6 Gg CO_2 equivalents in 2012. Compared to 1990 emissions of 7.6 Gg CO_2 equivalents this means an increase of 52%.

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.

8.3.2 Methane emissions from wastewater

Domestic wastewater

Activity data

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 GL. 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 originate from domestic sewage. The 2006 GL default for Canada, Europe, Russia, and Oceania of 60 g BOD per person and day was used.

Between 1990 and 2012 annual TOW increased proportionally to population from 5.6 Gg to 7 Gg.

Emission factors

Emission factors are a product of maximum CH_4 producing capacity for domestic wastewater (B_o) and discharge pathway specific methane correction factors (MCF). The default B_o of 0.6 kg CH_4/kg BOD suggested by the 2006 GL was applied. Four wastewater discharge pathways exist in Iceland. They are shown in Table 8.7 along with respective shares of total wastewater discharge and MCFs.

Table 8.7. Wastewater discharge pathways fractions and population of Iceland.

	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	0.00	0.04	255,708
1995	0.04	0.90	0.00	0.06	267,806
2000	0.33	0.61	0.00	0.06	282,849
2005	0.54	0.33	0.02	0.11	299,404
2010	0.57	0.33	0.02	0.08	318,452
2011	0.57	0.33	0.02	0.08	319,575
2012	0.57	0.33	0.02	0.08	321,857
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 its 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 GL.

Equation 6.1

$$CH_4 \text{ emissions} = (\Sigma (T_j * EF_j)) * (TOW - S) - R$$

Where:

CH_4 emissions = CH_4 emissions in inventory year, kg CH_4/yr

TOW = total organics in wastewater in inventory year, kg BOD/yr

S = organic component removed as sludge in inventory year, kg BOD/yr

T_j = degree of utilisation of treatment/discharge pathway or system, j, in inventory year

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/yr

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.

Emissions

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. This can be seen in Figure 8.7. The slight increase of TOW caused a slight increase of methane emissions during years when the share of septic tanks stayed unchanged. The sudden increase of emissions between 2001 and 2002 is due to an increase of septic system fraction from 6 to 11%. CH_4 emissions were highest in 2006, when they reached 0.22 Gg. In recent years the share of septic systems has decreased to 8%, which caused a decrease of emissions to 0.17 Gg in 2012. This is tantamount to an increase of wastewater treatment emissions of 150% since 1990. The decrease of septic systems in Iceland after 2008 was caused by the completion of the Kárahnjúkar hydropower plant where the wastewater of the workforce had been collected in septic tanks.

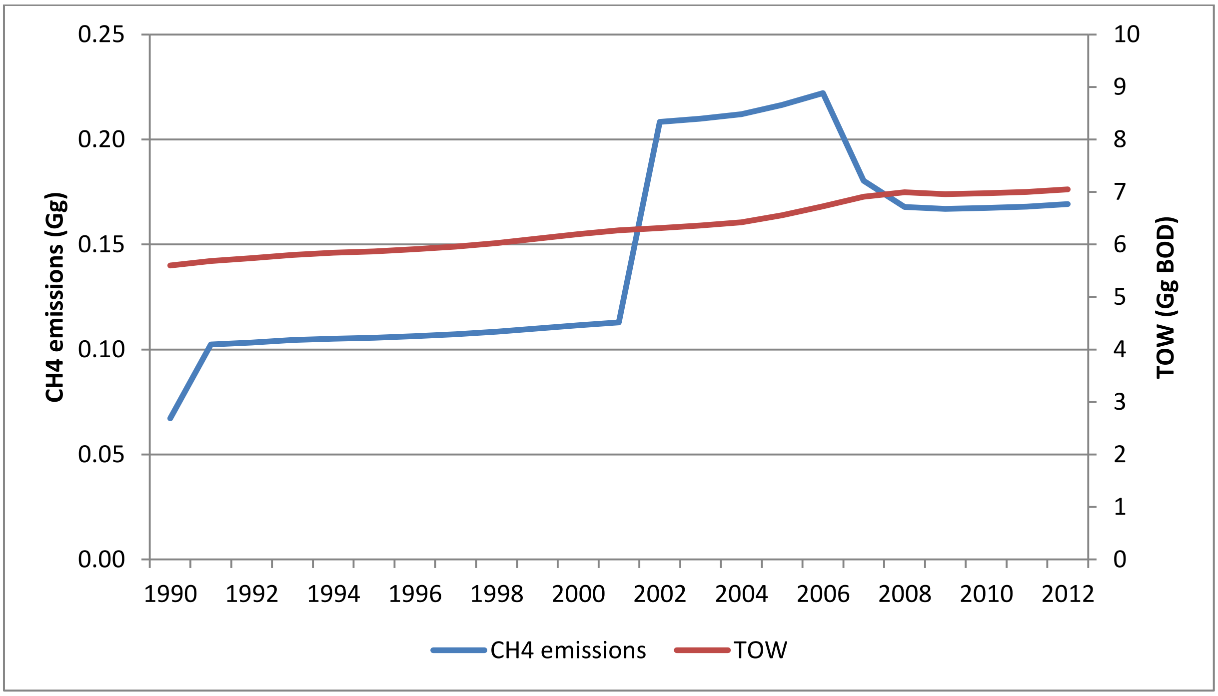

Figure 8.7. Methane emissions and total organics in wastewater.

Industrial wastewater

Industrial wastewater in Iceland is untreated and either discharged directly into rivers or to the sea or by means of closed sewers. For industrial wastewater, the same MCFs as for domestic wastewater were used, i.e. zero. Therefore methane emissions from industrial wastewater are reported as not occurring.

8.3.3 Nitrous oxide emissions from wastewater

Activity data

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 8.8.

Table 8.8. 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 1990-2011).

Emission factor and emissions

The 2006 GL emission factor for N_2O emissions from domestic wastewater is 0.005 kg N_2O-N/kg N. 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 8.8. Emissions rose from 0.021 Gg in 1990 to 0.026 in 2012. This is tantamount to an increase of 29%. The main driver behind this development was a 26% increase of population during the same time.

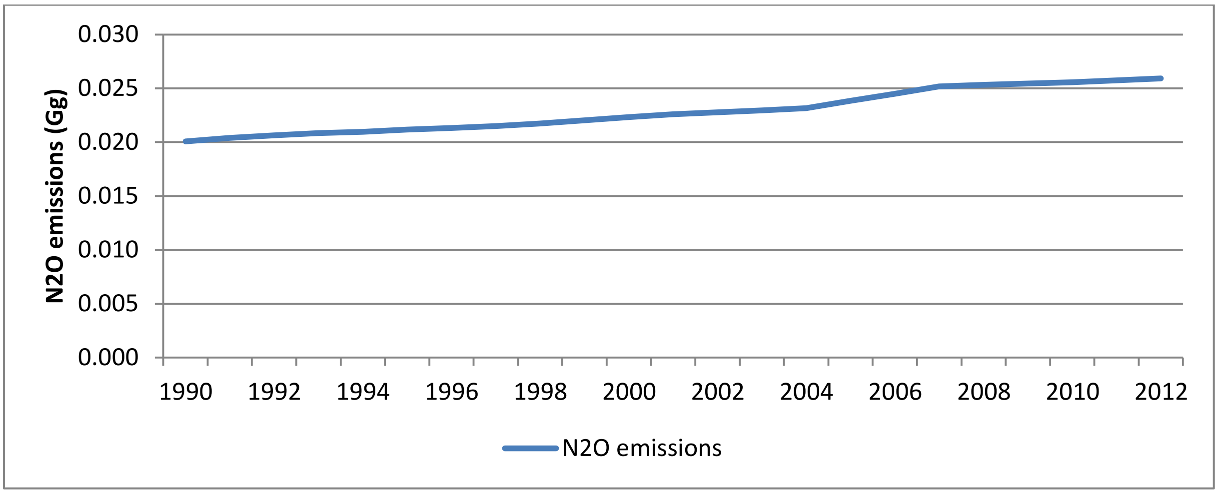

Figure 8.8. N_2O emissions from wastewater effluent between 1990 and 2010 in Gg.

8.3.4 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 dissected 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.

8.4 Waste incineration (6C)

8.4.1 Overview

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 (6C).

The amount of waste burned in open pits decreased rapidly since the early 1990s, when more than 30 kilotonnes 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 kt in 1990 to 1.7 kt in 2012. 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 17.9 Gg CO_2 eq. in 1990 to 7.2 Gg CO_2 eq. in 2012.

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.

CH_4, N_2O, NO_x, CO, NMVOC, and SO_2 emissions are estimated as well.

8.4.2 Activity data

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 8.9.

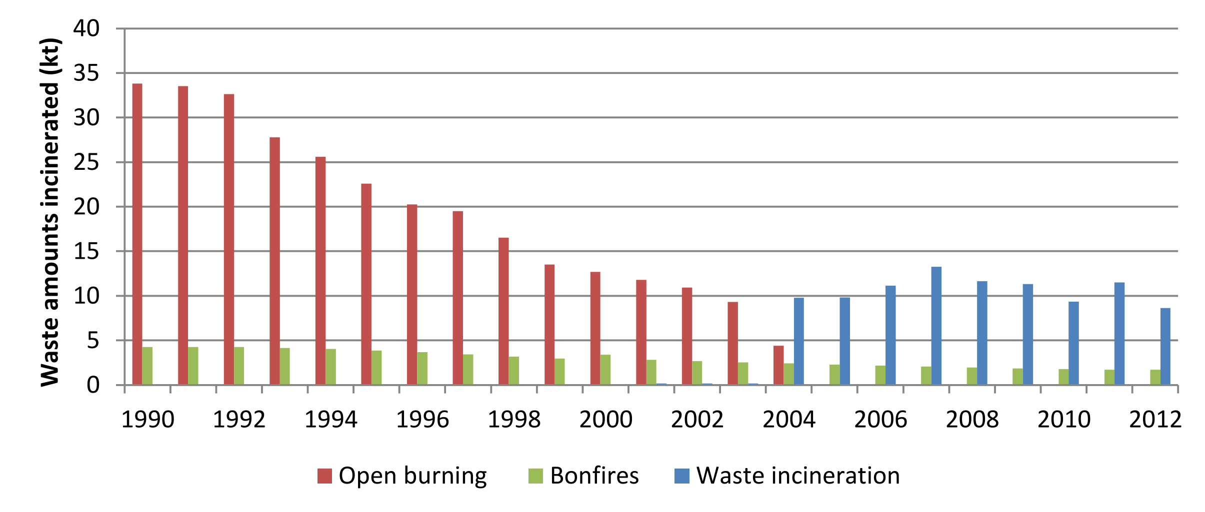

Figure 8.9. Amounts of waste incinerated without energy recovery, burned openly and amount of woodburned in bonfires.

Fig. 8.9 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 biggest of its kind in Iceland. It produces energy and electricity for its own requirements and therefore rates as auto producer. Thus it is categorized as incineration plant without energy recovery.

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 11 categories shown in Figure 8.10 along with their weight fractions from 2005 to 2012. 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.

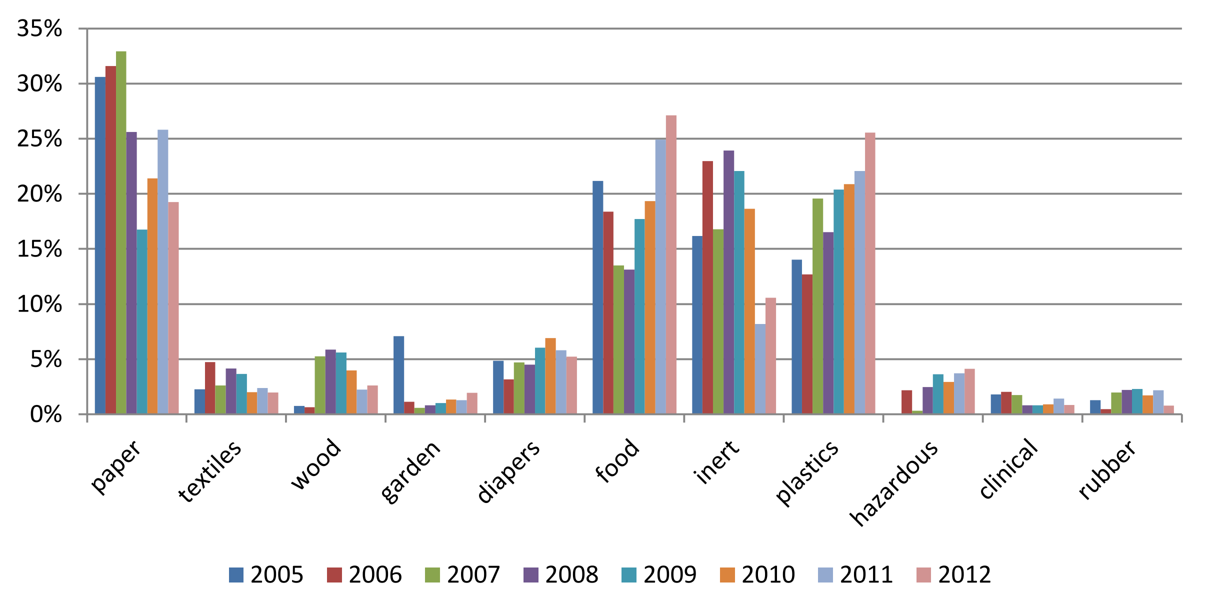

Figure 8.10. Waste categories for incineration along with weight fractions for 2005-2010 and the average weight fraction of whole period.

This data exists only for waste incineration and for the years from 2005 to 2012. 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).

8.4.3 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, Gg/yr

MSW = total amount of municipal solid waste as wet weight incinerated or open-burned, Gg/yr

WF_j = fraction of waste type/material of component j in the MSW (as wet weight incinerated or openburned)

dm_j = dry matter content in the component j of the MSW incinerated or open-burned, (fraction)

CF_j = fraction of carbon in the dry matter (i.e., carbon content) of component j

FCF_j = fraction of fossil carbon in the total carbon of component j

OF_j = oxidation factor, (fraction)

44/12 = conversion factor from C to CO_2

with: $\Sigma_j WF_j = 1$

j = component of the MSW incinerated/open-burned such as paper/cardboard, textiles, food waste, wood, garden (yard) and park waste, disposable nappies, rubber and leather, plastics, metal, glass, other inert waste.

As oxidation factors 2006 GL defaults of 1 for waste incineration (= complete 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 2012 in Table 8.9.

Table 8.9. Calculation of fossil carbon amount incinerated in 2012. The column "fossil carbon (wet weight basis), fraction" is the product of the three columns preceding it.

	waste category	waste category	dry matter	carbon content (dry weight basis)	fossil carbon (total carbon basis)	fossil carbon (wet weight basis)	fossil carbon
tonnes/fractions	weight	fraction	fraction	fraction	fraction	fraction	weight
paper	1664	0.19	0.90	0.46	0.01	0.004	7
textiles	172	0.02	0.80	0.50	0.20	0.080	14
wood	225	0.03	0.85	0.50	0.00	0.000	0
garden	169	0.02	0.40	0.49	0.00	0.000	0
diapers	453	0.05	0.40	0.70	0.10	0.028	13
food	2345	0.27	0.40	0.38	0.00	0.000	0
inert	913	0.11	0.90	0.03	1.00	0.027	25
plastics	2210	0.26	1.00	0.75	1.00	0.750	1658
hazardous	356	0.04	0.50	0.55	1.00	0.275	98
clinical	73	0.01	0.65	0.62	0.63	0.250	18
rubber	67	0.01	0.84	0.67	0.20	0.113	8
sum	8648						1839

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 8.10 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.

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 8.10.

Table 8.10. 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 EF	237	60	1800	700	20	400
Open burning EF	6500	150[1]	1800	700	20	400

1: g/tonne dry waste

8.4.4 Emissions

GHG emissions from incineration and open burning of waste are shown in Figure 8.11. CO_2 Emissions from open burning of waste decreased from 11.3 Gg in 1990 Gg to 6.7 Gg in 2012 thereby following the generally decreasing trend in incinerated waste amounts. CH_4 emissions from waste incineration decreased more rapidly or from 5.2 Gg CO_2 eq. in 1990 to 0.3 Gg in 2012. The reason more this more pronounced decrease is the switch from open burning of waste to waste incineration which goes along with reduced methane EF (cf. Table 8.10). N_2O emissions decreased from 1.4 Gg CO_2 eq. in 1990 to 0.2 Gg in 2012. This decrease is caused by both decreasing waste amounts and a lower EF for waste incineration as opposed to open burning of waste. Aggregated GHG emissions from waste incineration and open burning of waste decreased by 59% during this period.

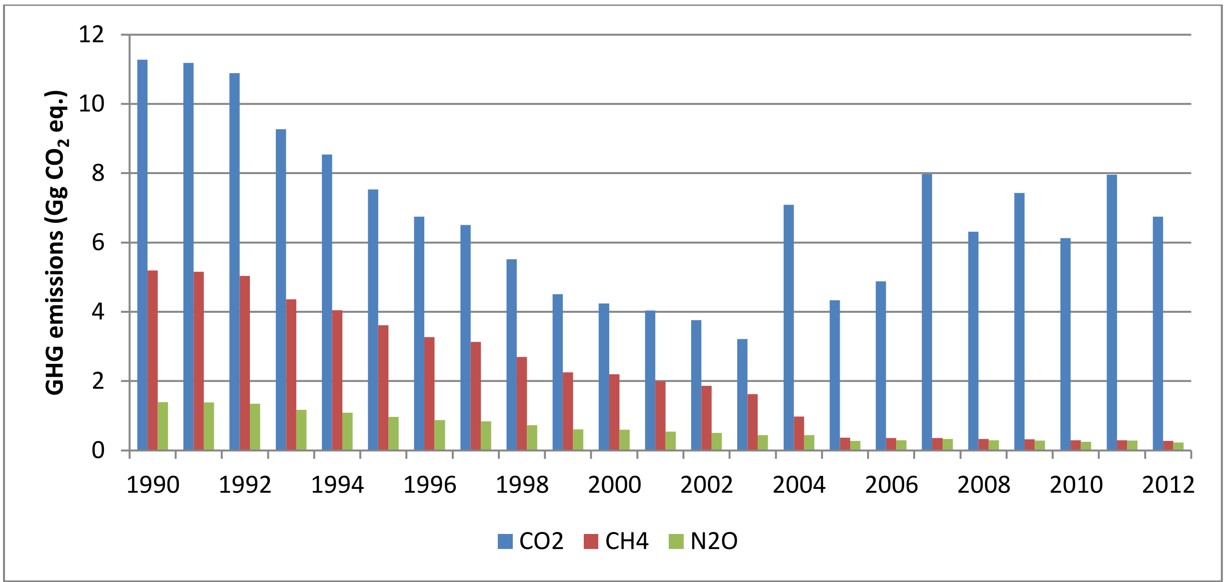

Figure 8.11. CO_2 emissions from incineration and open burning of waste in Gg.

8.4.5 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 1990-2012 by weighting them with the sum of all years´ CO_2 emissions resulting in an EF uncertainty of 14% and a total uncertainty of CO2 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%) supplied by the 2006 GL (page 5.23). This resulted in combined uncertainties of 102% for both GHGs.

8.5 Biological treatment of solid waste: composting (6D)

8.5.1 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 roughly 15 kt in 2011 but has decreased again to 11 kt in 2012.

Methodology

Estimation of CH_4 and N_2O emissions from composting are calculated using the Tier 1 method of the 2006 GL.

8.5.2 *Activity data*

There exists data about the amount of waste composted since 1995. The amount composted is estimated to be between 2000 and 3000 tonnes annually until 2004. Since 2005 this amount has increased by roughly 2000 tonnes per year and was around 15,000 tonnes in 2010 (Figure 8.12). There exists data on the composition of waste composted since 2007. In 2010 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.

8.5.3 *Emission factors*

Both CH_4 and N_2O emissions from composting are calculated by multiplying the mass of organic waste composted with the respective emission factors. The 2006 GL default emission factors are (on a wet weight basis):

- 4 g CH_4/kg waste treated
- 0.3 g N_2O/kg waste treated

8.5.4 *Emissions*

CH_4 emissions from composting amounted to 0.045 Gg CH_4 or 0.9 Gg CO_2 equivalents in 2012. N_2O emissions amounted to 0.003 Gg N_2O or 1 Gg CO_2 equivalents in 2012. This is shown in Figure 8.12.

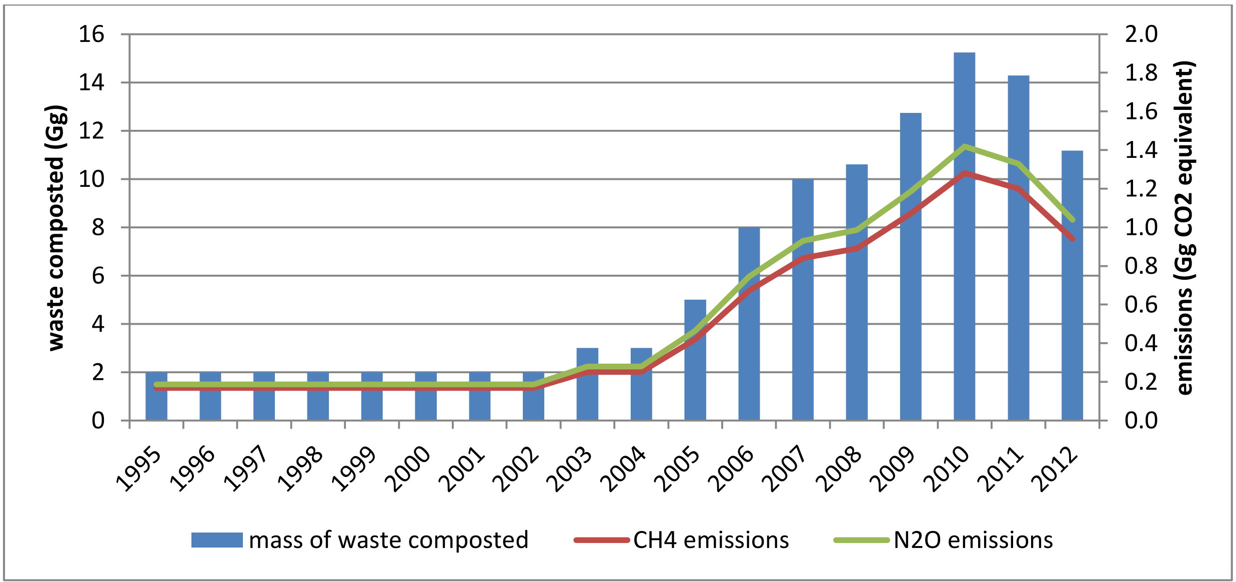

Figure 8.12. Mass of waste composted and resulting CH_4 and N_2O emissions (in Gg CO_2 eq).

8.5.5 *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%.

9 Other

10 Recalculations

10.1 Overall Description of Recalculations

The Icelandic 2014 greenhouse gas emission inventory has been recalculated to a small extent (Table 10.1). All recalculations made are calculated for the entire time series 1990-2011 and are compared to Iceland´s resubmission of CRF tables on October 22nd of 2013 (Submission 2013 v2.1). Recalculations for some components and sources have been made to account for new knowledge and/or more accurate approximation of activity data and emission factors. Detected calculation errors have been removed. The figures reported in this submission are therefore consistent throughout the whole time series.

The biggest differences in emission estimates between submissions were recorded for the agriculture sector where a revision of digestible energy estimates for cattle and sheep feed impacted methane emissions from both enteric fermentation and manure management.

All recalculations and improvements taken together (without LULUCF) led to slightly decreased emission estimates for the whole time period.

Table 10.1. Total recalculations in 2013 submission compared to 2013 submission (without LULUCF) in Gg CO_2-equivalents.

Inventory year	2013 submission	2014 submission	Decrease (Gg)	Decrease (%)
1990	3,555	3,538	-17	-0.49%
1995	3,336	3,315	-21	-0.62%
2000	3,921	3,903	-18	-0.47%
2005	3,876	3,859	-17	-0.44%
2008	5,041	5,022	-19	-0.38%
2009	4,799	4,779	-19	-0.40%
2010	4,665	4,646	-19	-0.40%
2011	4,460	4,441	-19	-0.42%

10.2 Specific description of recalculations

10.2.1 Energy

No recalculations were made for the energy sector between the 2013 and 2014 submissions Industry

10.2.2 Industrial Processes

There have only been minor recalculations in the Industrial Processes sector. The changes were confined to emissions from HFC and SF_6 consumption. Refilling of HFC 134A amounts leaked from reefers between 1993 and 1995 had not been dealt with in the 2013 submission. In this submission the HFC 134A amount that had leaked from reefers between

1993 and 1995 was subtracted from the bulk amount imported in 1995. This reduced HFC 134A import allocated to fishing vessels, commercial and industrial refrigeration and subsequent HFC emissions from these subsectors. The difference is greatest in the year of the reallocation (1995: 0.57 Gg CO2 eq.) but decreases with time due to the decreasing influence of stock changes in 1995 on more recent lifetime emissions. In 2011 the difference was less than 0.01 Gg CO2 eq.

One aluminium factory that had reported no SF_6 leakage from its high voltage electrical equipment reported 2.6 kg for 2011 since last submission. This increased the SF_6 emission estimate for 2011 by 0.062 Gg CO_2 eq.

10.2.3 Solvent and other Product Use

No recalculations were made in this sector between the 2012 and 2013 submissions.

10.2.4 Agriculture

Iceland had to submit a revised set of CRF tables in October of 2013 because it could not provide sufficient documentation for the country specific values for digestible energy content of cattle feed. In the revised set of CRF tables Iceland used IPCC default values from the 1996 GL for the DE of cattle feed. These relatively low DE values increased cattle methane emissions from enteric fermentation and manure management. Country specific DE values for the feed of cattle and sheep were created enlisting the help of an expert from the Agricultural University of Iceland (Sveinbjörnsson, written communication). Sheep feed was included because the documentation for the CS value was deemed insufficient as well. For further information regarding methodology and documentation refer to chapter 6.2.3 and Annex VI.

DE values increased for all cattle subcategories from the default values of 60% and 65% for cattle and young cattle, respectively. New CS DE values ranged from 66% (steers) to 73% (young cattle). The value for sheep decreased between submissions from 69% to 64% but increased for lambs from 69% to 77%. Digestible energy content of feed in related inversely related to methane emissions from enteric fermentation and (via volatile solid excretions) from manure management. The increased DE for cattle thus led to decreasing methane emissions from cattle whereas the decreased DE for sheep led to increasing methane emissions from sheep. The impact of the increased value for lambs is secondary because of their lower per head methane emissions related to lower gross enery intake and excretions. The combined effect of these changes were overall emission decreases for all years of the period, ranging from 0.77 to 0.97 Gg CH4 or 16 to 20 Gg CO2 eq. Recalculation effects are presented in Figure 10.1.

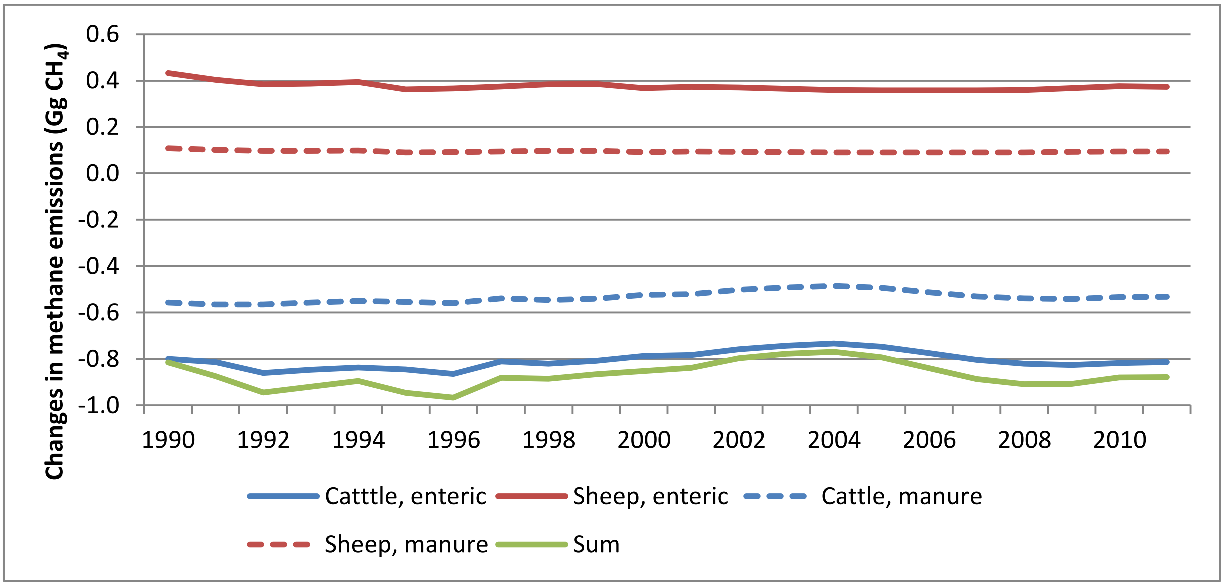

Figure 10.1. Changes in methane emission estimates from enteric fermentation in and manure management of cattle and sheep.

The CS EF for for N_2O emissions from cultivation of histosols was lowered from 0.97 kg N_2O-N/ha to 0.96. The previous value was based on a transcription error. This lowered estimates for direct N_2O emissions from soils by 0.001 Gg N_2O in 1990 and 0.0009 Gg N_2O in 2011 or 0.32 and 0.28 Gg CO_2 eq., respectively.

The livestock polulation census reports 1,639 foxes for the year 2011 although there has been no fox fur farm in operation since 2007. The actual number of foxes is only 5 (residents of the Reykjavík zoo). The surplus of 1634 are actually minks and this value has been subtracted from the fox and added to the mink population. This impacted all methane and nitrous oxide emissions related to livestock populations to a small extent. The net impact is an overall emission decrease of 0.24 Gg CO_2 eq. for 2011.

10.2.5 LULUCF

The emissions of several LULUCF categories were revised resulting in changes of CO_2, CH_4 and N_2O emission estimates. Net emission changes however are small and never exceed one percent in either direction (Table 10.2).

Table 10.2. Emission estimates for the LULUCF sector (Gg CO_2 eq.).

Inventory year	2013 submission (Gg)	2014 submission (Gg)	Difference (Gg)	Difference (%)
1990	1171.4	1175.1	-3.7	-0.3%
1995	1108.8	1110.0	-1.2	-0.1%
2000	1015.0	1016.5	-1.5	-0.1%
2005	904.9	906.0	-1.1	-0.1%
2008	858.9	858.7	0.2	0.0%
2009	834.6	834.2	0.3	0.0%
2010	795.8	791.2	4.6	0.6%
2011	746.3	745.7	0.6	0.1%

Forest Land

CO2 and N2O emission estimates from Forest Land were revised for the whole time period from 1990-2011. Revision of estimates from 1990-2010 is caused solely by a revision of activity data or Forest Land area. Differences between 2013 and 2014 submissions account for a slight decrease in removal estimates or 0.3-3 Gg CO2 eq. The removal estimate for Forest Land for 2011 decreased by 10 Gg or 4%. This is caused by the fact that direct stock measurements for cultivated forests were reviewed based data accumulated in the field work of the NFI during the summer of 2013. These changes in reported emission removal reflect an improvement in data and estimation of factors previously not estimated as well as development in the methodology applied for estimating this category.

Cropland

The emissions from biomass burning due to wildfires on Cropland of the years 2006-2011 are recalculated according to revised method as described in chapter 7.12. This has only a very minor effect on emission estimates (less than 0.05 Gg CO_2 eq. for all years).

Grassland

The following recalculations for Grassland subcategories are reported in this year's submission. The area of Wetland drained for more than 20 years is revised according to revision of other map layers. This revision is insignificant and does not affect the emissions reported. The area of the subcategory "Other Grasslands" is revised in accordance with changes in other map layers and the hierarchical order of the category. The area of the subcategory "Natural birch shrubland recently expanded into other grassland" is revised from last submission and consequently the removals reported. The area of Cropland converted to Grassland are revised in balancing the changes in the category "Cropland converted to Forest land" and unchanged estimate of total area of Cropland converted to other use from the time series. Some insignificant changes in the area of "Wetland converted to Grassland" were made but not affecting the emissions reported. The area of "Revegetation since 1990" is revised based on new activities since the last submission. The revision of "Revegetation since 1990" leads to a net increase in emission removals from Grassland of 11 Gg CO2 in 2011 (Table 10.3).

Emission caused by biomass burning in wildfires from the year 2006 is revised as improvements have been made in recording the area burned. Table 10.3 summarizes the net effect of all changes reported above.

Table 10.3. Recalculation results for emissions from Grassland in Gg CO_2-equivalents.

Inventory year	2013 submission (Gg)	2014 submission (Gg)	Difference (Gg)	Difference (%)
1990	-55.1	-54.2	0.8	-1.5%
1995	-75.1	-76.1	-1.0	1.4%
2000	-106.9	-106.7	0.2	-0.2%
2005	-140.7	-140.2	0.5	-0.3%
2008	-155.1	-155.8	-0.7	0.5%
2009	-158.4	-159.3	-0.9	0.6%
2010	-164.9	-170.4	-5.4	3.3%
2011	-173.2	-184.0	-10.8	6.2%

Other Land

The area of the category is revised from last submission both as consequence of revision of the map layer for “Lakes and rivers” and of outer boundaries. Biomass burning for the years 2006 -2011 is revised from last years submission according to new data available and methodology described in chapter 7.12.

10.2.6 Waste

There have been no recalculations between the 2013 and 2014 submissions.

10.3 Planned improvements

In the near future the following improvements for the inventory are planned:

- Preparation of a national energy balance. The NEA should prepare a national energy balance annually and submit to the EA. Work has already been initiated by the NEA, with the aim of producing the national energy balance within two years. The obligation of the NEA to provide national energy balance will be further elaborated in a regulation, to be set on basis of Act no 70/2012.
- Improvement of methodologies to estimate emissions from road transportation (use of COPERT).
- Move estimates of emissions from aviation to the Tier 2 methodology.
- Improvement of methodologies to estimate N_2O emissions from manure management.
- Developing a time series for the enhanced livestock population characterisation
- The division of land use into subcategories and improved time and spatial resolution of the land use information is an on-going task of the AUI.
- Repeated land classification based on new satellite images through remote sensing, updating and improving GIS-maps and continuing field surveys is included in the IGLUD project.
- Definition of baseline map that helps separating actual land use changes from seeming land use changes brought on by improved mapping and data management
- Improving the area estimate of drained land and of the effectiveness of drainage
- Revision of EF for drained organic soils

- Improving identification of former cropland categories and destination of abandoned cropland.
- Higher tier estimates of changes regarding the carbon stock in soil, dead organic material and other vegetation than trees on forest Land is expected in future reporting when data from re-measurement of the permanent sample plot will be available.
- Increase the accuracy of the new area estimate of the natural birch woodland and the changes in area with time
- 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. When implemented, these improvements will provide more accurate area and removal factor estimates for revegetation, subdivided according to management regime, regions and age.
- Improve area estimate of Settlement area and Other land
- Further improvement of the time series already presented.
- The provision of missing Annexes.

The following improvements are under consideration:

- Develop CS emission factors for fuels.
- Develop verification procedures for various data.
- Improvement of QA/QC for LULUCF.
- Revision of LULUCF emission/removal factors, in order to emphasize key sources and aim toward higher Tier levels.
- Evaluation of LULUCF factors, not estimated in present submission and disaggregation of components presently reported as aggregated emissions.
- Establishing country specific emission factors, including variability in soil classes, for Cropland categories
- Improvements regarding information on reservoir area and type of land Introduction of reservoir specific emission factors for more reservoirs is to be expected as information on land flooded is improved.
- 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 are a 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 C content (Arnalds and Óskarsson 2009) Subdivision of that category according to management, vegetation condition 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 next years.

Part II: Supplementary information required under Article 7, Paragraph 1

11 Kyoto Protocol – LULUCF

11.1 General Information

The Icelandic greenhouse gas emission inventory for the KP LULUCF is prepared by the AUI on basis of information provided by the IFR on ARD and the SCSI on Revegetation. The general methods applied to estimate the sinks and sources reported are described in Chapter 7 of this report.

11.1.1 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 (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 11.1.

Table 11.1. Criteria in forest definitions of the Marrakech Accord (MA), the UNEP Convention on Biological Diversity (CBD) and the Forest Resource Assessment (FAO/FRA).

Parameters	MA	CBD	FAO/FRA
Minimum area (ha)	0.05-1.0	0.5	0.5
Minimum height (m)	2-5	5	5
Crown cover (%)	10-30	10	10
Strip width (m)			20

Iceland uses the suggested FAO definition, but instead of the suggested 5 m height minimum, Icelandic forests are defined as being at least 2 m in height (which is the lower limit of the MA definition). That is in agreement with the general perception in Iceland and current legitimate 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 activity under the Kyoto Protocol, hence promoting the use of native species in afforestation and prevent deforestation of the natural birch woodlands.

The functional definition of Forest land as it is applied under the KP – LULUCF is: All forested land, not belonging to Settlement, that is presently covered with trees or woody vegetation more than 2 m high, crown cover of a minimum 10% and at least 0.5 ha in continuous area with a minimum width of 20 m. Land which currently falls below these thresholds, but *in situ* will reach these thresholds at mature state, is included.

11.1.2 Elected Activities under Article 3, Paragraph 4

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.

Interpretation of elected activities under Article 3.4

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.

Hierarchy among the elected activities under Article 3.4

Revegetation is the only activity elected by Iceland under Article 3.4, hierarchy among activities is therefore not applicable.

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 strata, Region 1 is defined covering all land areas in Iceland.

Article 3.3

Afforestation since 1990 is estimated in the NFI for Region 1 by systematic sampling of permanent plots (SSPP). The plots of the cultivated forest and in the natural birch forest will be re-measured at five and ten year intervals, respectively. Re-measurement of the cultivated forest started in 2010 and will start in 2015 for the natural birch forest. 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 11.4).

Within Region 1 all cultivated forests and natural birch woodland are already mapped. The mapping of the natural birch woodland is old and remapping is ongoing and will finish 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 7.12). New land being afforested is recorded annually by the IFR and consequently added to the mapped area of forest land. The SSPP falling on these new area are then included in the NFI. New areas of natural birch forest following changes in land use are considered as afforestation. Annual increase in area is found by the difference between the old and the new mapping survey.

Article 3.4

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. This delays final data submission based on the first sampling phase. 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 2014.

11.1.3 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

Revegetation is the only Article 3.4 activity elected. Hierarchy among activities is thus irrelevant. 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 Forestry 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).

11.2 Land-Related Information

11.2.1 Spatial Assessment Unit used for Determining the Area of the Units of Land under Article 3.3

Maps of cultivated forest and natural birch woodland do exist. Although they can be used to locate forests, they are not precise and overestimate areas of cultivated forest. They are used, on the other hand, 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 natural birch woodlands remapped portion (3/5) is used to estimate the total area. The area of afforestation of cultivated forest 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 ongoing mapping (Snorrason et al. in prep).

11.2.2 Methodology Used to Develop the Land Transition Matrix

Land transition matrix was prepared based on data for activity area in the years 1990, 2008, 2009, 2010 and 2011. 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.

11.2.3 Maps and/or Database to Identify the Geographical Locations, and the System of Identification codes for the Geographical Locations

Maps of cultivated forest and natural birch woodland 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.

11.3 Activity-Specific Information

11.3.1 Methods for Carbon Stock Change and GHG Emission and Removal Estimates

Description of the methodologies and the underlying assumptions used

Article 3.3

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.

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 descripted in chapter 7.5.1, carbon stock changes of afforestation of the natural birch forest 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.

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 NNFI 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.

Article 3.4

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.

Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

Article 3.3

Carbon stock samples of above ground biomass of other vegetation than trees are collected on field plots under the field measurement in NFI. Estimate of carbon stock changes in aboveground biomass of other vegetation than trees will be available from NFI data when sampling plots will be revisited in the period 2010-2014. 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).

Article 3.4

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.

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 and Revegetation. Both AR and Revegetation have 1990 as base year. This short time window makes factoring out irrelevant.

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 also been revised. Inclusion of components not estimated in last submission and additional data on C-stock changes in the pools estimated in last submission contribute to these recalculations. See Chapter 7 for a complete list of changes.

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.

Information on Other Methodological Issues

The Year of the Onset of an Activity, if after 2008:

Not applicable.

11.4 Article 3.3

11.4.1 Information that Demonstrates that Activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are Direct Human induced

The age of afforestation is estimated in field on the sample plots of the NFI. Cultivated forests are mostly plantations. A minority are direct seeded or self seedlings originating from cultivated forests. Natural birch forest 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.

11.4.2 Information on how Harvesting or Forest Disturbance that is followed by the Re-Establishment of Forest is Distinguished from Deforestation

Deforestation is estimated by special inventory where the change in the area of forest where deforestation has been reported is estimated by GPS delineation of a new border between forest and the new land use which is dominantly settlements (new power lines, roads or buildings). Major forest disturbances will be detected in the NFI but local forest disturbances (wildfires etc) will be handled with special inventory as done for deforestation.

11.4.3 Information on the Size and Geographical Location of Forest Areas that have lost Forest Cover but which are not yet classified as Deforested

The only human induced forest degradation occurring is when trees have to give way for summer houses and roads to summer houses. There the forest removed is below the minimum area of 0.5 ha or 20 m with, no direct estimate of the effect of decrease of the C-stock is made. The permanent sample plot system of the NFI will, however, detect significant forest degradation.

11.5 Article 3.4

11.5.1 Information that Demonstrates that Activities under Article 3.4 have occurred since 1 January 1990 and are Human induced

All the revegetation activity included under Article 3.4 is included on the bases of SCSI activity records. No area not recorded by SCSI as revegetation activity is included.

11.5.2 Information Relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the Base Year

The removal recorded due to Revegetation in base year is estimated from SCSI archives on revegetation prior to 1990. All land revegetated before 1990 is included in the estimate. The estimate of changes in C-pools is according to Tier 2 methods as described in chapter 7.7.

11.5.3 Information Relating to Forest Management

Forest management is not elected.

11.6 Other Information

11.6.1 Key Category Analysis for Article 3.3 Activities and any Elected 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 Gg CO_2 equivalents the smallest key category of level including LULUCF in the year 2012.

12 Information on accounting of Kyoto Units

12.1 Background Information

The national registry is maintained by the Environment Agency of Iceland. The registry holds as of 7th of April 2014: 46 EU ETS accounts, thereof 5 Operator holding accounts, 32 Aircraft operator holding accounts, 7 Verifier accounts, 1 National holding account and 1 Party holding account.

Iceland's AAUs, 18,523,847 tonnes of CO_2-equivalents, for the first commitment period were issued in the Icelandic Registry in September 2013. In addition, 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 an other 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.

12.2 Summary of Information reported in the SEF Tables

Article 3 in part I "General reporting instruction", to Annex "Standard electronic format for reporting of information on Kyoto Protocol units", of decision 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 submits SEF tables for the Kyoto Protocol units issued in 2013. Annual external transactions consisted of additional 182 AAUs from Sweden 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. No problems were found in Iceland's SEF table when performing completeness check and consistency check.

12.3 Discrepancies and Notifications

No discrepancies or notifications have occurred in relation to Iceland's accounting of Kyoto units in 2013.

12.4 Publicly Accessible Information

A set of information regarding the registry and guidance on accessing registry accounts has been updated on the homepage of the Environment Agency, both in Icelandic (http://www.ust.is/atvinnulif/vidskiptakerfi-esb/skraningarkerfi/) and in English (aimed at foreign account holders in the EU-ETS - http://www.ust.is/the-environment-agency-of-iceland/eu-ets/registry/).

The website of the 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

12.5 Calculation of the Commitment Period Reserve (CPR)

The Annex to Decision 11/CMP.1 specifies that: "each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90% of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8 of the Kyoto Protocol, or 100% of five 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 × 18,523,847 tonnes CO_2 equivalent

= 16,671,462 tonnes CO_2 equivalent.

or,

100% of 5 × (the national total in the most recently reviewed inventory)

= 5 × 4,413,247 tonnes CO_2 equivalent

= 22,066,234 tonnes CO_2 equivalent

This means Iceland's Commitment Period Reserve is 16,671,462 tonnes CO_2 equivalent, calculated as 90% of Iceland's assigned amount.

12.6 KP-LULUCF Accounting

Iceland intends to account for Article 3.3 and 3.4 LULUCF activities for the entire commitment period. Iceland has 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 would allow issuance of 1,541,960 RMUs (Table 12.1).

Table 12.1. Removals from activities under Article 3.3 and 3.4 and resulting RMUs.

	2008	2009	2010	2011	2012	Total
Article 3.3 (t CO_2)	103,268	115,465	135,426	153,265	172,805	680,229
Article 3.4 (t CO_2)	152,293	159,608	171,719	184,453	193,658	861,730
RMUs	**255,561**	**275,073**	**307,145**	**337,718**	**366,463**	**1,541,960**

12.7 Decision 14/CP.7 Accounting

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 will undertake the accounting with respect to Decision 14/CP.7 at the end of the commitment period.

Four projects fulfilled the provisions of Decision 14/CP.7 in 2008, 2009, 2010, 2011, and 2012. Further description of these projects can be found in Chapter 4.5. Total CO_2 emissions fulfilling the provisions of Decision 14/CP.7 amounted to 1,161 Gg in 2008, to 1,205 Gg in 2009, to 1,225 in 2010, to 1,209 Gg in 2011 and to 1,279 Gg in 2012. Total CO_2 emissions fulfilling the provisions of Decision 14/CP.7 for the first commitment period under the Kyoto Protocol therefore are 6,079 Gg.

12.8 Summary of Kyoto accounting for the 1. Commitment Period

Iceland´s initial assigned amount for CP1 were 18,523,847 AAUs. Added to that are a total of 1,541,960 RMUs from Art. 3.3 and Art. 3.4 activities resulting in an available assigned amount of 20,065,807 AAUs.

Emissions from Annex A sources during CP1 were 23,356,066 tonnes CO_2-eq. This means that Annex A emissions were 3,290,264 tonnes CO_2 in excess of Iceland´s available assigned amount.

Total CO_2 emissions falling under Decision 14CP.7 during CP1 were 6,079,323 tonnes CO_2. Therefore, in order to comply with its goal for CP1, would Iceland report 3,290,264 tonnes of the CO_2 emissions falling under decision 14/CP.7 separately and not included them in national totals.

The CRF tables accompanying the 2014 NIR, however, stll contain Iceland´s Annex A emissions in their entirety.

Table 12.2 and Figure 12.1 demonstrate this.

Table 12.2. 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
KP-LULUCF Art. 3.3	RMUs	103,268	115,465	135,426	153,265	172,805	680,229
KP-LULUCF Art. 3.4	RMUs	152,293	159,608	171,719	184,453	193,658	861,730
Available assigned amount	AAUs	3,960,330	3,979,843	4,011,914	4,042,487	4,071,233	20,065,807
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.	1,061,456	799,424	634,247	398,639	396,497	3,290,264
Emissions falling under Decision 14/CP.7	t CO_2 eq.	1,160,862	1,205,354	1,225,141	1,209,095	1,278,871	6,079,323
Emissions falling under Decision 14/CP.7 reported under national totals	t CO_2 eq.	99,406	405,930	590,894	810,456	882,373	2,789,059
Emissions falling under Decision 14/CP.7 not reported under national totals	t CO_2 eq.	1,061,456	799,424	634,247	398,639	396,497	3,290,264

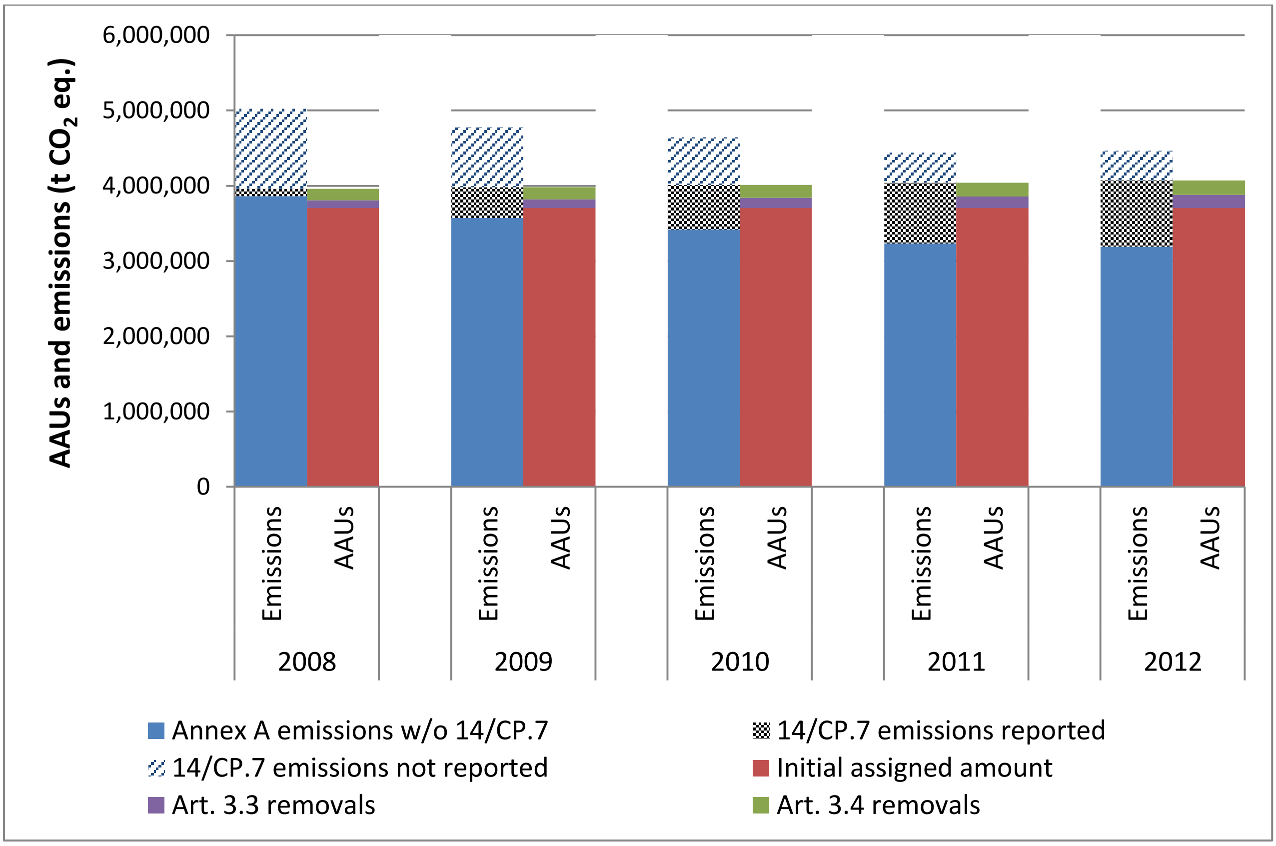

Figure 12.1. Summary of Kyoto accounting for CP1.

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 changes in national registry

The national registry is maintained by the Environment Agency of Iceland as before.

The diagram of the database structure was updated (attached as Annex VII) in relations to 15/CMP.1 annex II.E paragraph 32.(c).

The changes introduced in versions 5 (January 2013) and 6 (June 2013) of the CSEUR primarily concerned EU ETS functionality and accounting. More detailed descriptions of the changes can be found in Annex VIII.

In summary these changes include:

- Enabling ETS phase 3 allocation
- Enabling ETS end of Phase 2 banking and clearing processes
- Disabling of ETS phase 2 functionality
- Functionality for operators to surrender allowances valid for the third trading period
- Functionality to allow account holders to distinguish international credits that are eligible in the EU ETS from those not eligible and limit the holding of non-eligible units to Kyoto Protocol accounts only.
- Blocking of transfer of ineligible units from KP accounts to EU ETS accounts
- Multiple bug fixes
- Improvements in the user interface

However, 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 VIII). 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 VIII.

The Environment Agency of Iceland updated it's publicly available information. The information available is in accordance with Decision 13/CMP.1 of the Kyoto Protocol paragraphs no. 45, 46, 47 & 48 and contains Iceland's greenhouse gas inventory including National Inventory Reports and numerical data contained in the Common Reporting Format.

The following changes to the national registry of Iceland have therefore occurred in 2013.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	Registry System Administrators: Kristján Andrésson - (kristjan@registry.ust.is) Vanda Hellsing - (vanda@registry.ust.is)

Reporting Item	Description
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	An updated diagram of the database structure is attached as Annex VII. Iteration 5 of the national registry released in January 2013 and Iteration 6 of the national registry released in June 2013 introduces changes in the structure of the database. Changes introduced in release 5 and 6 of the national registry 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. 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 in release 5 and 6 of the national registry were limited and only affected EU ETS functionality. However, 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 VIII). Annex H testing was carried out in February 2014 and the successful test report has been attached as Annex IX. No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No change of security measures occurred during the reporting period
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	The Environment Agency of Iceland updated it's publicly available information on the following webpage: http://www.ust.is/the-environment-agency-of-iceland/eu-ets/registry/#Tab3 The information available is in accordance with Decision 13/CMP.1 of the Kyoto Protocol paragraphs no. 45, 46, 47 & 48. A link to information regarding Iceland's greenhouse gas inventory including National Inventory Reports and numerical data contained in the Common Reporting Format can be found on the same webpage.

Reporting Item	Description
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 in release 5 and 6 of the national registry were limited and only affected EU ETS functionality. 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 VIII. Annex H testing was carried out in February 2014 and the successful test report has been attached as Annex IX.

15 Information on minimization of adverse impacts in accordance with Article 3, Paragraph 14

No changes have been made regarding the information of adverse impact since last submission.

Figure 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

16 Other information

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Annex I. KEY SOURCES

According to the IPCC definition, key sources are those that add up to 95% of the total uncertainty in level and/or in trend. In the Icelandic Emission Inventory key source categories are identified by means of Tier 1 method.

A key source analysis was prepared for this round of reporting. Table 1.1 lists identified key sources. Table A1 shows the level assessment of the key source analysis for 2012, Table A2 the level assessment of the key source analysis for 1990 and Table A3 the trend assessment of the key source analysis.

Table A1: Key source analysis – 2012 level assessment.

IPCC Source category	IPCC Source category	GHG	Current Year Estimate Non-LULUCF	Current Year Estimate LULUCF	Current Year Estimate Absolute Value	Level Assess-ment without LULUCF	Cumula-tive Total of Column to left	Level Assessment with LULUCF	Cumula-tive Total of Column to left
2.C.3	Aluminium	CO2	1,244.21		1,244.21	0.278	0.278	0.182	0.182
5.B.1	Cropland remaining Cropland	CO2		1,003.29	1,003.29	0.000	0.278	0.147	0.329
1.AA.3b	Road transport	CO2	782.25		782.25	0.175	0.454	0.115	0.444
5.C.2.5	Other land converted to Grassland, revegetation	CO2		-543.12	543.12	0.000	0.454	0.080	0.523
1.AA.4c	Fishing	CO2	485.29		485.29	0.109	0.562	0.071	0.594
2.C.2	Ferroalloys	CO2	406.88		406.88	0.091	0.653	0.060	0.654
5.C.1	Wetland drained for more than 20 years	CO2		288.44	288.44	0.000	0.653	0.042	0.696
5.A.2	Land converted to forest land	CO2		-232.79	232.79	0.000	0.653	0.034	0.730
1.AA.2	Manufacturing industry and construction	CO2	172.05		172.05	0.039	0.692	0.025	0.756
1.B	Fugitive emissions from fuels	CO2	170.18		170.18	0.038	0.730	0.025	0.781
2.F	Consumption of halocarbons and SF6, refrigeration	HFC	144.12		144.12	0.032	0.762	0.021	0.802
4.D.1	Direct soil emissions	N2O	136.33		136.33	0.031	0.793	0.020	0.822
6.A.1	Managed waste disposal on land	CH4	134.80		134.80	0.030	0.823	0.020	0.841
4.D.3	Indirect soil emissions	N2O	131.05		131.05	0.029	0.852	0.019	0.861
4.A.3	Enteric fermentation, sheep	CH4	130.57		130.57	0.029	0.881	0.019	0.880
4.D.2	Animal production	N2O	83.66		83.66	0.019	0.900	0.012	0.892
4.A.1	Enteric fermentation, cattle	CH4	82.29		82.29	0.018	0.919	0.012	0.904
2.C.3	Aluminium	PFC	79.74		79.74	0.018	0.936	0.012	0.916
5.G	Grassland non CO2-emissions	N2O		78.66	78.66	0.000	0.936	0.012	0.927
5.C.2.1/2/3/4	All other conversion to Grassland	CO2		78.13	78.13	0.000	0.936	0.011	0.939
5.B.2	Land converted to Cropland	CO2		64.43	64.43	0.000	0.936	0.009	0.948
4.B	Manure management	N2O	43.29		43.29	0.010	0.946	0.006	0.954
4.B	Manure management	CH4	39.31		39.31	0.009	0.955	0.006	0.960
5.A.1	Forest land remaining forest land	CO2		-35.64	35.64	0.000	0.955	0.005	0.965
1.AA.3a/d	Transport	CO2	34.59		34.59	0.008	0.963	0.005	0.971
1.AA.3b	Road transport	N2O	34.36		34.36	0.008	0.970	0.005	0.976
4.A.4-10	Enteric fermentation, rest	CH4	31.48		31.48	0.007	0.977	0.005	0.980
6.A2	Unmanaged waste disposal sites	CH4	27.15		27.15	0.006	0.983	0.004	0.984
5.C.1	All other remaining Grassland	CO2		-14.62	14.62	0.000	0.983	0.002	0.986
1.AA.2	Manufacturing industry and construction	N2O	11.86		11.86	0.003	0.986	0.002	0.988
1.AA.4a/b	Residential/institutional/commercial	CO2	9.96		9.96	0.002	0.988	0.001	0.990
5.D	Wetlands	CO2		9.72	9.72	0.000	0.988	0.001	0.991
5.D	Wetlands	CH4		8.33	8.33	0.000	0.988	0.001	0.992
6.B	Wastewater handling	N2O	8.04		8.04	0.002	0.990	0.001	0.993
1.AA.1	Public electricity and heat production	CO2	7.21		7.21	0.002	0.992	0.001	0.994
6.C	Waste incineration	CO2	6.74		6.74	0.002	0.993	0.001	0.995
2.F	Consumption of halocarbons and SF6, electrical equipment	SF6	5.57		5.57	0.001	0.994	0.001	0.996

Table A1 continued

IPCC Source category	IPCC Source category	GHG	Current Year Estimate Non-LULUCF	Current Year Esti-mate LULUCF	Current Year Esti-mate Absolute Value	Level Assess-ment without LULUCF	Cumula-tive Total of Column to left	Level Assessment with LULUCF	Cumula-tive Total of Column to left
1.AA.4c	Fishing	N2O	4.06		4.06	0.001	0.995	0.001	0.997
6.B	Wastewater handling	CH4	3.55		3.55	0.001	0.996	0.001	0.997
3	Solvent and other product use	N2O	3.34		3.34	0.001	0.997	0.000	0.998
3	Solvent and other product use	CO2	2.83		2.83	0.001	0.998	0.000	0.998
1.B	Fugitive emissions from fuels	CH4	2.69		2.69	0.001	0.998	0.000	0.999
2.A	Mineral production	CO2	1.59		1.59	0.000	0.999	0.000	0.999
1.AA.3b	Road transport	CH4	1.46		1.46	0.000	0.999	0.000	0.999
5.A	Forest land	N2O		1.19	1.19	0.000	0.999	0.000	0.999
2.C	Metal production	CH4	1.11		1.11	0.000	0.999	0.000	0.999
6.D	Other (composting)	N2O	1.04		1.04	0.000	0.999	0.000	1.000
1.AA.4c	Fishing	CH4	0.96		0.96	0.000	1.000	0.000	1.000
6.D	Other (composting)	CH4	0.94		0.94	0.000	1.000	0.000	1.000
1.AA.3a/d	Transport	N2O	0.30		0.30	0.000	1.000	0.000	1.000
6.C	Waste incineration	CH4	0.28		0.28	0.000	1.000	0.000	1.000
6.C	Waste incineration	N2O	0.23		0.23	0.000	1.000	0.000	1.000
1.AA.2	Manufacturing industry and construction	CH4	0.15		0.15	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat production	N2O	0.11		0.11	0.000	1.000	0.000	1.000
5.E.2.1	Settlements	CO2		0.11	0.11	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat production	CH4	0.03		0.03	0.000	1.000	0.000	1.000
1.AA.3a/d	Transport	CH4	0.03		0.03	0.000	1.000	0.000	1.000
1.AA.4a/b	Residential/institutional/commerci al	N2O	0.02		0.02	0.000	1.000	0.000	1.000
5	LULUCF, wildfires	N2O		0.01	0.01	0.000	1.000	0.000	1.000
5	LULUCF, wildfires	CH4		0.01	0.01	0.000	1.000	0.000	1.000
1.AA.4a/b	Residential/institutional/commerci al	CH4	0.00		0.00	0.000	1.000	0.000	1.000
2.F	Consumption of halocarbons and SF6, refrigeration	PFC	0.00		0.00	0.000	1.000	0.000	1.000
2.B	Chemical industry	CO2	0.00		0.00	0.000	1.000	0.000	1.000
2.B	Chemical industry	N2O	0.00		0.00	0.000	1.000	0.000	1.000
	Total		**4,468**	**706**	**6,826**				

Table A2: Key source analysis – 1990 level assessment.

IPCC Source category	IPCC Source category	GHG	Current Year Estimate Non-LULUCF	Current Year Estimate LULUCF	Current Year Estimate Absolute Value	Level Assess-ment without LULUCF	Cumula-tive Total of Column to left	Level Assess-ment with LULUCF	Cumula-tive Total of Column to left
5.B.1	Cropland remaining Cropland	CO2		764.03	764.03	0.000	0.000	0.139	0.139
1.AA.4c	Fishing	CO2	655.49		655.49	0.185	0.185	0.119	0.258
1.AA.3b	Road transport	CO2	521.26		521.26	0.147	0.333	0.095	0.353
5.B.2	Land converted to Cropland	CO2		434.33	434.33	0.000	0.333	0.079	0.432
2.C.3	Aluminium	PFC	419.63		419.63	0.119	0.451	0.076	0.508
1.AA.2	Manufacturing industry and construction	CO2	360.79		360.79	0.102	0.553	0.066	0.574
5.C.2.5	Other land converted to Grassland, revegetation	CO2		-349.47	349.47	0.000	0.553	0.064	0.637
2.C.2	Ferroalloys	CO2	207.42		207.42	0.059	0.612	0.038	0.675
5.C.1	Wetland drained for more than 20 years	CO2		169.65	169.65	0.000	0.612	0.031	0.706
4.A.3	Enteric fermentation, sheep	CH4	152.14		152.14	0.043	0.655	0.028	0.734
4.D.1	Direct soil emissions	N2O	148.54		148.54	0.042	0.697	0.027	0.761
4.D.3	Indirect soil emissions	N2O	141.43		141.43	0.040	0.737	0.026	0.786
2.C.3	Aluminium	CO2	139.21		139.21	0.039	0.776	0.025	0.812
5.C.2.1/2/3/4	All other conversion to Grassland	CO2		127.27	127.27	0.000	0.776	0.023	0.835
6.A2	Unmanaged waste disposal sites	CH4	106.30		106.30	0.030	0.806	0.019	0.854
1.AA.3a/d	Transport	CO2	91.11		91.11	0.026	0.832	0.017	0.871
4.D.2	Animal production	N2O	89.75		89.75	0.025	0.857	0.016	0.887
4.A.1	Enteric fermentation, cattle	CH4	82.13		82.13	0.023	0.880	0.015	0.902
5.G	Grassland non CO2-emissions	N2O		68.58	68.58	0.000	0.880	0.012	0.915
1.B	Fugitive emissions from fuels	CO2	61.36		61.36	0.017	0.898	0.011	0.926
2.A	Mineral production	CO2	52.28		52.28	0.015	0.913	0.010	0.935
4.B	Manure management	N2O	52.04		52.04	0.015	0.927	0.009	0.945
2.B	Chemical industry	N2O	48.36		48.36	0.014	0.941	0.009	0.953
1.AA.4a/b	Residential/institutional/commercial	CO2	42.84		42.84	0.012	0.953	0.008	0.961
4.B	Manure management	CH4	41.17		41.17	0.012	0.965	0.007	0.969
4.A.4-10	Enteric fermentation, rest	CH4	29.35		29.35	0.008	0.973	0.005	0.974
5.A.2	Land converted to forest land	CO2		-26.60	26.60	0.000	0.973	0.005	0.979
1.AA.2	Manufacturing industry and construction	N2O	15.91		15.91	0.004	0.978	0.003	0.982
5.A.1	Forest land remaining forest land	CO2		-14.83	14.83	0.000	0.978	0.003	0.985
1.AA.1	Public electricity and heat production	CO2	13.64		13.64	0.004	0.981	0.002	0.987
6.A.1	Managed waste disposal on land	CH4	12.96		12.96	0.004	0.985	0.002	0.989
6.C	Waste incineration	CO2	11.27		11.27	0.003	0.988	0.002	0.991
6.B	Wastewater handling	N2O	6.23		6.23	0.002	0.990	0.001	0.993
3	Solvent and other product use	N2O	6.00		6.00	0.002	0.992	0.001	0.994
1.AA.4c	Fishing	N2O	5.51		5.51	0.002	0.993	0.001	0.995
6.C	Waste incineration	CH4	5.19		5.19	0.001	0.995	0.001	0.996
1.AA.3b	Road transport	N2O	4.54		4.54	0.001	0.996	0.001	0.996
3	Solvent and other product use	CO2	3.07		3.07	0.001	0.997	0.001	0.997
1.AA.3b	Road transport	CH4	2.96		2.96	0.001	0.998	0.001	0.998

Table A2 continued									
IPCC Source category	**IPCC Source category**	**GHG**	**Current Year Estimate Non-LULUCF**	**Current Year Estimate LULUCF**	**Current Year Estimate Absolute Value**	**Level Assess-ment without LULUCF**	**Cumula-tive Total of Column to left**	**Level Assess-ment with LULUCF**	**Cumula-tive Total of Column to left**
5.D	Wetlands	CO2		1.86	1.86	0.000	0.998	0.000	0.998
5.C.1	All other remaining Grassland	CO2		-1.67	1.67	0.000	0.998	0.000	0.998
5.D	Wetlands	CH4		1.60	1.60	0.000	0.998	0.000	0.998
6.B	Wastewater handling	CH4	1.41		1.41	0.000	0.998	0.000	0.999
6.C	Waste incineration	N2O	1.39		1.39	0.000	0.998	0.000	0.999
1.AA.4c	Fishing	CH4	1.31		1.31	0.000	0.999	0.000	0.999
2.F	Consumption of halocarbons and SF6, electrical equipment	SF6	1.15		1.15	0.000	0.999	0.000	0.999
1.AA.3a/d	Transport	N2O	0.77		0.77	0.000	0.999	0.000	1.000
1.B	Fugitive emissions from fuels	CH4	0.68		0.68	0.000	1.000	0.000	1.000
2.C	Metal production	CH4	0.61		0.61	0.000	1.000	0.000	1.000
2.B	Chemical industry	CO2	0.36		0.36	0.000	1.000	0.000	1.000
5.A	Forest land	N2O		0.32	0.32	0.000	1.000	0.000	1.000
1.AA.2	Manufacturing industry and construction	CH4	0.25		0.25	0.000	1.000	0.000	1.000
1.AA.3a/d	Transport	CH4	0.12		0.12	0.000	1.000	0.000	1.000
1.AA.4a/b	Residential/institutional/commercia l	N2O	0.10		0.10	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat production	N2O	0.02		0.02	0.000	1.000	0.000	1.000
1.AA.4a/b	Residential/institutional/commercia l	CH4	0.02		0.02	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat production	CH4	0.01		0.01	0.000	1.000	0.000	1.000
2.F	Consumption of halocarbons and SF6, refrigeration	HFC			0.00	0.000	1.000	0.000	1.000
2.F	Consumption of halocarbons and SF6, refrigeration	PFC			0.00	0.000	1.000	0.000	1.000
5.E.2.1	Settlements	CO2			0.00	0.000	1.000	0.000	1.000
5	LULUCF, wildfires	CH4			0.00	0.000	1.000	0.000	1.000
5	LULUCF, wildfires	N2O			0.00	0.000	1.000	0.000	1.000
6.D	Other (composting)	CH4			0.00	0.000	1.000	0.000	1.000
6.D	Other (composting)	N2O			0.00	0.000	1.000	0.000	1.000
	Total		**3,538**	**1,175**	**5,498**				

Table A3: Key source analysis – trend assessment.

IPCC Source category	IPCC Source category	GHG	Base Year Estimate	Current Year Estimate	Absolute Estimate	Level Assessment	Trend Assessment	Contribution to Trend	Cumulative Total
2.C.3	Aluminium	CO2	139.21	1,244.21	1,244.21	0.182	0.146	0.254	0.254
5.B.2	Land converted to Cropland	CO2	434.33	64.43	64.43	0.009	0.055	0.096	0.350
2.C.3	Aluminium	PFC	419.63	79.74	79.74	0.012	0.051	0.089	0.439
1.AA.4c	Fishing	CO2	655.49	485.29	485.29	0.071	0.031	0.055	0.493
1.AA.2	Manufacturing industry and construction	CO2	360.79	172.05	172.05	0.025	0.030	0.052	0.545
1.AA.3b	Road transport	CO2	521.26	782.25	782.25	0.115	0.028	0.049	0.594
5.A.2	Land converted to forest land	CO2	-26.60	-232.79	232.79	0.034	0.027	0.047	0.642
2.C.2	Ferroalloys	CO2	207.42	406.88	406.88	0.060	0.024	0.042	0.683
5.B.1	Cropland remaining Cropland	CO2	764.03	1,003.29	1,003.29	0.147	0.022	0.038	0.722
5.C.2.5	Other land converted to Grassland, revegetation	CO2	-349.47	-543.12	543.12	0.080	0.021	0.037	0.759
2.F	Consumption of halocarbons and SF6, refrigeration	HFC		144.12	144.12	0.021	0.019	0.034	0.792
6.A.1	Managed waste disposal on land	CH4	12.96	134.80	134.80	0.020	0.016	0.028	0.820
1.B	Fugitive emissions from fuels	CO2	61.36	170.18	170.18	0.025	0.014	0.024	0.844
5.C.1	Wetland drained for more than 20 years	CO2	169.65	288.44	288.44	0.042	0.014	0.024	0.868
6.A2	Unmanaged waste disposal sites	CH4	106.30	27.15	27.15	0.004	0.012	0.021	0.889
1.AA.3a/d	Transport	CO2	91.11	34.59	34.59	0.005	0.009	0.015	0.904
5.C.2.1/2/3/4	All other conversion to Grassland	CO2	127.27	78.13	78.13	0.011	0.008	0.014	0.918
2.A	Mineral production	CO2	52.28	1.59	1.59	0.000	0.007	0.013	0.931
1.AA.4a/b	Residential/institutional/commercial	CO2	42.84	9.96	9.96	0.001	0.005	0.009	0.940
4.A.3	Enteric fermentation, sheep	CH4	152.14	130.57	130.57	0.019	0.005	0.008	0.949
1.AA.3b	Road transport	N2O	4.54	34.36	34.36	0.005	0.004	0.007	0.955
4.D.1	Direct soil emissions	N2O	148.54	136.33	136.33	0.020	0.004	0.006	0.962
4.D.3	Indirect soil emissions	N2O	141.43	131.05	131.05	0.019	0.003	0.006	0.967
5.A.1	Forest land remaining forest land	CO2	-14.83	-35.64	35.64	0.005	0.003	0.005	0.972
4.D.2	Animal production	N2O	89.75	83.66	83.66	0.012	0.002	0.003	0.975
4.B	Manure management	N2O	52.04	43.29	43.29	0.006	0.002	0.003	0.978
5.C.1	All other remaining Grassland	CO2	-1.67	-14.62	14.62	0.002	0.002	0.003	0.981
4.A.1	Enteric fermentation, cattle	CH4	82.13	82.29	82.29	0.012	0.001	0.002	0.983
1.AA.1	Public electricity and heat production	CO2	13.64	7.21	7.21	0.001	0.001	0.002	0.985
5.D	Wetlands	CO2	1.86	9.72	9.72	0.001	0.001	0.002	0.987
5.D	Wetlands	CH4	1.60	8.33	8.33	0.001	0.001	0.002	0.988
4.B	Manure management	CH4	41.17	39.31	39.31	0.006	0.001	0.001	0.990
6.C	Waste incineration	CO2	11.27	6.74	6.74	0.001	0.001	0.001	0.991
1.AA.2	Manufacturing industry and construction	N2O	15.91	11.86	11.86	0.002	0.001	0.001	0.992
6.C	Waste incineration	CH4	5.19	0.28	0.28	0.000	0.001	0.001	0.994
2.F	Consumption of halocarbons and SF6, electrical equipment	SF6	1.15	5.57	5.57	0.001	0.001	0.001	0.995
5.G	Grassland non CO2-emissions	N2O	68.58	78.66	78.66	0.012	0.000	0.001	0.995

Table A3 continued									
IPCC Source category	**IPCC Source category**	**GHG**	**Base Year Estimate**	**Current Year Estimate**	**Absolute Estimate**	**Level Assessment**	**Trend Assess-ment**	**Contri-bution to Trend**	**Cumula-tive Total**
3	Solvent and other product use	N2O	6.00	3.34	3.34	0.000	0.000	0.001	0.996
6.B	Wastewater handling	CH4	1.41	3.55	3.55	0.001	0.000	0.000	0.997
1.AA.4c	Fishing	N2O	5.51	4.06	4.06	0.001	0.000	0.000	0.997
1.B	Fugitive emissions from fuels	CH4	0.68	2.69	2.69	0.000	0.000	0.000	0.998
1.AA.3b	Road transport	CH4	2.96	1.46	1.46	0.000	0.000	0.000	0.998
6.C	Waste incineration	N2O	1.39	0.23	0.23	0.000	0.000	0.000	0.998
6.B	Wastewater handling	N2O	6.23	8.04	8.04	0.001	0.000	0.000	0.999
6.D	Other (composting)	N2O		1.04	1.04	0.000	0.000	0.000	0.999
6.D	Other (composting)	CH4		0.94	0.94	0.000	0.000	0.000	0.999
5.A	Forest land	N2O	0.32	1.19	1.19	0.000	0.000	0.000	0.999
4.A.4-10	Enteric fermentation, rest	CH4	29.35	31.48	31.48	0.005	0.000	0.000	0.999
1.AA.3a/d	Transport	N2O	0.77	0.30	0.30	0.000	0.000	0.000	1.000
3	Solvent and other product use	CO2	3.07	2.83	2.83	0.000	0.000	0.000	1.000
1.AA.4c	Fishing	CH4	1.31	0.96	0.96	0.000	0.000	0.000	1.000
2.C	Metal production	CH4	0.61	1.11	1.11	0.000	0.000	0.000	1.000
1.AA.2	Manufacturing industry and construction	CH4	0.25	0.15	0.15	0.000	0.000	0.000	1.000
5.E.2.1	Settlements	CO2		0.11	0.11	0.000	0.000	0.000	1.000
1.AA.3a/d	Transport	CH4	0.12	0.03	0.03	0.000	0.000	0.000	1.000
1.AA.4a/b	Residential/institutional/commercial	N2O	0.10	0.02	0.02	0.000	0.000	0.000	1.000
1.AA.1	Public electricity and heat production	N2O	0.02	0.11	0.11	0.000	0.000	0.000	1.000
1.AA.1	Public electricity and heat production	CH4	0.01	0.03	0.03	0.000	0.000	0.000	1.000
1.AA.4a/b	Residential/institutional/commercial	CH4	0.02	0.00	0.00	0.000	0.000	0.000	1.000
5	LULUCF, wildfires	N2O		0.01	0.01	0.000	0.000	0.000	1.000
5	LULUCF, wildfires	CH4		0.01	0.01	0.000	0.000	0.000	1.000
2.F	Consumption of halocarbons and SF6, refrigeration	PFC		0.00	0.00	0.000	0.000	0.000	1.000
2.B	Chemical industry	CO2	0.36	0.00	0.00	0.000		0.000	1.000
2.B	Chemical industry	N2O	48.36	0.00	0.00	0.000		0.000	1.000
	Totals		**4,713**	**5,174**	**6,826**		**0.573**	**1.000**	

ANNEX II. QUANTITATIVE UNCERTAINTY (including LULUCF)

IPCC Source category	IPCC Source category	Gas	Base year emis-sions (1990)	Year t emissions (2012)	Activity data uncer-tainty	Emission factor uncer-tainty	Combined uncer-tainty	Combined 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
1.AA.1	Public electricity and heat production	CO2	13.6	7.2	5.0	5.0	7.1	0.010	-0.002	0.002	-0.008	0.011	0.014
1.AA.1	Public electricity and heat production	CH4	0.0	0.0	5.0	100.0	100.1	0.001	0.000	0.000	0.000	0.000	0.001
1.AA.1	Public electricity and heat production	N2O	0.0	0.1	5.0	150.0	150.1	0.003	0.000	0.000	0.003	0.000	0.003
1.AA.2	Manufacturing industry and construction	CO2	360.8	172.0	5.0	5.0	7.1	0.235	-0.047	0.037	-0.237	0.258	0.351
1.AA.2	Manufacturing industry and construction	CH4	0.3	0.1	5.0	100.0	100.1	0.003	0.000	0.000	-0.003	0.000	0.003
1.AA.2	Manufacturing industry and construction	N2O	15.9	11.9	5.0	150.0	150.1	0.344	-0.001	0.003	-0.178	0.018	0.179
1.AA.3a/d	Transport	CO2	91.1	34.6	5.0	5.0	7.1	0.047	-0.014	0.007	-0.069	0.052	0.087
1.AA.3a/d	Transport	CH4	0.1	0.0	5.0	100.0	100.1	0.001	0.000	0.000	-0.002	0.000	0.002
1.AA.3a/d	Transport	N2O	0.8	0.3	5.0	200.0	200.1	0.012	0.000	0.000	-0.023	0.000	0.023
1.AA.3b	Road transport	CO2	521.3	782.2	5.0	5.0	7.1	1.070	0.045	0.166	0.223	1.174	1.195
1.AA.3b	Road transport	CH4	3.0	1.5	5.0	40.0	40.3	0.011	0.000	0.000	-0.015	0.002	0.015
1.AA.3b	Road transport	N2O	4.5	34.4	5.0	50.0	50.2	0.334	0.006	0.007	0.312	0.052	0.316
1.AA.4a/b	Residential/institutional/commercial	CO2	42.8	10.0	5.0	5.0	7.1	0.014	-0.008	0.002	-0.039	0.015	0.042

1.AA.4a/b	Residential/institutional/commercial	CH4	0.0	0.0	5.0	100.0	100.1	0.000	0.000	0.000	0.000	0.000	0.000
1.AA.4a/b	Residential/institutional/commercial	N2O	0.1	0.0	5.0	150.0	150.1	0.001	0.000	0.000	-0.003	0.000	0.003
1.AA.4c	Fishing	CO2	655.5	485.3	3.0	5.0	5.8	0.547	-0.050	0.103	-0.248	0.437	0.502
1.AA.4c	Fishing	CH4	1.3	1.0	3.0	100.0	100.0	0.019	0.000	0.000	-0.010	0.001	0.010
1.AA.4c	Fishing	N2O	5.5	4.1	3.0	150.0	150.0	0.118	0.000	0.001	-0.063	0.004	0.063
1.B	Fugitive emissions from fuels	CO2	61.4	170.2	10.0	1.0	10.0	0.331	0.022	0.036	0.022	0.511	0.511
1.B	Fugitive emissions from fuels	CH4	0.7	2.7	6.0	8.0	10.0	0.005	0.000	0.001	0.003	0.005	0.006
2.A	Mineral production	CO2	52.3	1.6	5.0	6.5	8.2	0.003	-0.012	0.000	-0.077	0.002	0.077
2.B	Chemical industry	CO2	0.4	0.0	3.0	1.0	3.2	0.000	0.000	0.000	0.000	0.000	0.000
2.B	Chemical industry	N2O	48.4	0.0	30.0	40.0	50.0	0.000	-0.011	0.000	-0.450	0.000	0.450
2.C	Metal production	CH4	0.6	1.1	1.5	100.00	100.0	0.022	0.000	0.000	0.009	0.001	0.009
2.C.2	Ferroalloys	CO2	207.4	406.9	1.5	1.0	1.8	0.142	0.038	0.086	0.038	0.183	0.187
2.C.3	Aluminium	CO2	139.2	1,244.2	1.5	1.0	1.8	0.434	0.232	0.264	0.232	0.560	0.606
2.C.3	Aluminium	PFC	419.6	79.7	5.0	9.3	10.6	0.163	-0.081	0.017	-0.751	0.120	0.761
2.F	Consumption of halocarbons and SF6, refrigeration	HFC		144.1	176.0	79.6	193.2	5.383	0.031	0.031	2.432	7.611	7.991
2.F	Consumption of halocarbons and SF6, refrigeration	PFC		0.0	176.0	79.6	193.2	0.000	0.000	0.000	0.000	0.000	0.000
2.F	Consumption of halocarbons and SF6, electrical equipment	SF6	1.1	5.6	20.0	50.0	53.9	0.058	0.001	0.001	0.046	0.033	0.057
3	Solvent and other product use	N2O	6.0	3.3	20.0	5.0	20.6	0.013	-0.001	0.001	-0.003	0.020	0.020
3	Solvent and other product use	CO2	3.1	2.8	61.3	167.5	178.4	0.098	0.000	0.001	-0.019	0.052	0.055
4.A.1	Enteric fermentation, cattle	CH4	82.1	82.3	17.8	20.0	26.8	0.426	-0.002	0.017	-0.033	0.441	0.442
4.A.3	Enteric fermentation, sheep	CH4	152.1	130.6	17.2	20.0	26.4	0.666	-0.008	0.028	-0.154	0.674	0.691
4.A.4-10	Enteric fermentation, rest	CH4	29.3	31.5	20.0	40.0	44.7	0.272	0.000	0.007	-0.006	0.189	0.189
4.B	Manure management	N2O	52.0	43.3	55.7	100.0	114.4	0.958	-0.003	0.009	-0.293	0.723	0.780
4.B	Manure management	CH4	41.2	39.3	50.9	126.9	136.7	1.039	-0.001	0.008	-0.158	0.601	0.621

4.D.1	Direct soil emissions	N2O	148.5	136.3	31.1	326.1	327.6	8.636	-0.006	0.029	-1.843	1.273	2.240
4.D.2	Animal production	N2O	89.7	83.7	55.8	100.0	114.5	1.853	-0.003	0.018	-0.314	1.401	1.436
4.D.3	Indirect soil emissions	N2O	141.4	131.0	66.9	1,000.0	1,002.2	25.397	-0.005	0.028	-5.121	2.632	5.758
5.A.1	Forest land remaining forest land	CO2	-14.8	-35.6	14.0	10.0	17.2	-0.119	-0.004	-0.008	-0.041	-0.150	0.155
5.A.2	Land converted to forest land	CO2	-26.6	-232.8	5.0	10.0	11.2	-0.503	-0.043	-0.049	-0.432	-0.349	0.556
5.A	Forest land	N2O	0.3	1.2	5.0	400.0	400.0	0.092	0.000	0.000	0.071	0.002	0.071
5.B.1	Cropland remaining Cropland	CO2	764.0	1,003.3	20.0	90.0	92.2	17.886	0.035	0.213	3.144	6.021	6.793
5.B.2	Land converted to Cropland	CO2	434.3	64.4	20.0	90.0	92.2	1.149	-0.087	0.014	-7.863	0.387	7.872
5.C.1	Wetland drained for more than 20 years	CO2	169.6	288.4	20.0	90.0	92.2	5.142	0.022	0.061	1.953	1.731	2.609
5.C.1	All other remaining Grassland	CO2	-1.7	-14.6	20.0	20.0	28.3	-0.080	-0.003	-0.003	-0.054	-0.088	0.103
5.C.2.1/2/3/4	All other conversion to Grassland	CO2	127.3	78.1	20.0	90.0	92.2	1.393	-0.013	0.017	-1.175	0.469	1.265
5.C.2.5	Other land converted to Grassland, revegetation	CO2	-349.5	-543.1	30.0	25.0	39.1	-4.101	-0.034	-0.115	-0.848	-4.889	4.962
5.D	Wetlands	CO2	1.9	9.7	20.0	50.0	53.9	0.101	0.002	0.002	0.082	0.058	0.100
5.D	Wetlands	CH4	1.6	8.3	20.0	50.0	53.9	0.087	0.001	0.002	0.070	0.050	0.086
5.E.2.1	Settlements	CO2		0.1	5.0	10.0	11.2	0.000	0.000	0.000	0.000	0.000	0.000
5	LULUCF, wildfires	CH4		0.0	10.0	70.0	70.7	0.000	0.000	0.000	0.000	0.000	0.000
5	LULUCF, wildfires	N2O		0.0	10.0	70.0	70.7	0.000	0.000	0.000	0.000	0.000	0.000
5.G	Grassland non CO2-emissions	N2O	68.6	78.7	20.0	25.0	32.0	0.487	0.001	0.017	0.018	0.472	0.472
6.A.1	Managed waste disposal on land	CH4	13.0	134.8	42.4	35.9	55.6	1.448	0.026	0.029	0.918	1.716	1.946
6.A2	Unmanaged waste disposal sites	CH4	106.3	27.1	42.4	51.4	66.7	0.350	-0.019	0.006	-0.976	0.346	1.035
6.B	Wastewater handling	CH4	1.4	3.6	36.4	58.3	68.7	0.047	0.000	0.001	0.025	0.039	0.046
6.B	Wastewater handling	N2O	6.2	8.0	45.7	1,000.0	1,001.0	1.556	0.000	0.002	0.256	0.110	0.279
6.C	Waste incineration	CO2	11.3	6.7	33.9	13.8	36.6	0.048	-0.001	0.001	-0.016	0.069	0.070
6.C	Waste incineration	N2O	1.4	0.2	20.0	100.0	102.0	0.004	0.000	0.000	-0.028	0.001	0.028

6.C	Waste incineration	CH4	5.2	0.3	20.0	100.0	102.0	0.005	-0.001	0.000	-0.115	0.002	0.115
6.D	Other (composting)	CH4		0.9	20.0	100.0	102.0	0.019	0.000	0.000	0.020	0.006	0.021
6.D	Other (composting)	N2O		1.0	20.0	100.0	102.0	0.021	0.000	0.000	0.022	0.006	0.023
	Totals		**4,713.1**	**5,171.6**				**33.6**					**16.0**

ANNEX III. Explanation of EA'S adjustment of date on fuel sales by sector

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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
		Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	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	6,349	5,756	3,665	4,428	4,240	2,417	2,420	1,546	1,626	1,637	1,595	1,746
10X5X	industry	5,072	1,129	8,920	9,443	10,233	22,762	24,995	15,196	15,455	12,819	7,217	9,100	6,663	3,783	5,151
10X60	energy industries	1,300	1,091	1,065	897	1,112	631	112	21	1,349	1,109	1,436	760	1,012	683	955
10X90	other	0	458	1,386	1,323	756	1,832	8,124	8,928	8,296	2,033	1,336	1,499	2,728	1,136	260
Residual Fuel Oil																
10840	house heating and swimming pools	2,989	3,079	122	162	203	118	37	195	76	86	63	78	0	0	0
1085X	industry	55,895	56,172	46,146	55,782	64,026	48,547	28,230	25,005	23,635	22,708	19,562	17,646	14,917	16,514	17,839
10860	energy industries	0	0	-53	0	23	0	0	0	5	4,498	0	0	0	0	0
10890	other	39	52	67	4,978	6,465	319	6,139	0	0	131	913	0	1,629	780	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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Swimming pools	1,800	1,600	1,600	1,400	1,400	1,200	1,100	1,000	300	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 1990-2012

1990

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**3,264.68**	**438.20**	**589.48**	**NA,NE,NO**	**419.63**	**1.15**	**4,713.14**
1. Energy	**1,746.49**	**5.35**	**26.86**				**1,778.70**
A. Fuel Combustion (Sectoral Approach)	1,685.13	4.67	26.86				1,716.66
1. Energy Industries	13.64	0.01	0.02				13.67
2. Manufacturing Industries and Construction	360.79	0.25	15.91				376.96
3. Transport	612.37	3.08	5.32				620.77
4. Other Sectors	698.33	1.33	5.61				705.27
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	61.36	0.68	NA,NO				62.04
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	61.36	0.68	NA,NO				62.04
2. Industrial Processes	**399.28**	**0.61**	**48.36**	**NA,NE,NO**	**419.63**	**1.15**	**869.03**
A. Mineral Products	52.28	NE,NO	NE,NO				52.28
B. Chemical Industry	0.36	NE,NO	48.36	NA	NA	NA	48.72
C. Metal Production	346.63	0.61	NA	NA,NE,NO	419.63	NA,NO	766.88
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				NA,NO	NA,NO	1.15	1.15
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.07**		**6.00**				**9.07**
4. Agriculture		**304.78**	**431.75**				**736.54**
A. Enteric Fermentation		263.62					263.62
B. Manure Management		41.17	52.04				93.20
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE,NO	379.72				379.72
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**1,104.57**	**1.60**	**68.90**				**1,175.07**
A. Forest Land	-41.43	NE,NO	0.32				-41.11
B. Cropland	1,198.36	NE,NO	IE,NA,NE,NO				1,198.36
C. Grassland	-54.22	NE,NO	NE,NO				-54.22
D. Wetlands	1.86	1.60	NA,NO				3.46
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	68.58				68.58
6. Waste	**11.27**	**125.86**	**7.61**				**144.75**
A. Solid Waste Disposal on Land	NA,NE	119.25					119.25
B. Waste-water Handling		1.41	6.23				7.64
C. Waste Incineration	11.27	5.19	1.39				17.86
D. Other	NA	NO	NO				NA,NO
7. Other (*as specified in Summary 1.A*)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	318.65	0.23	2.76				321.64
Aviation	219.65	0.03	1.92				221.61
Marine	99.00	0.20	0.84				100.03
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,538.08
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,713.14

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

1991

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1991
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**3,190.24**	**438.83**	**570.49**	**NA,NE,NO**	**348.34**	**1.30**	**4,549.20**
1. Energy	**1,710.48**	**5.40**	**26.31**				**1,742.20**
A. Fuel Combustion (Sectoral Approach)	1,640.53	4.80	26.31				1,671.65
1. Energy Industries	15.22	0.01	0.02				15.25
2. Manufacturing Industries and Construction	285.34	0.21	15.07				300.62
3. Transport	624.15	3.22	5.47				632.83
4. Other Sectors	715.83	1.36	5.75				722.95
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	69.95	0.60	NA,NO				70.55
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	69.95	0.60	NA,NO				70.55
2. Industrial Processes	**365.29**	**0.51**	**46.81**	**NA,NE,NO**	**348.34**	**1.30**	**762.25**
A. Mineral Products	48.65	NE,NO	NE,NO				48.65
B. Chemical Industry	0.31	NE,NO	46.81	NA	NA	NA	47.12
C. Metal Production	316.32	0.51	NA	NA,NE,NO	348.34	NA,NO	665.17
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				NA,NO	NA,NO	1.30	1.30
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.20**		**5.43**				**8.63**
4. Agriculture		**296.05**	**415.12**				**711.17**
A. Enteric Fermentation		255.50					255.50
B. Manure Management		40.54	48.33				88.87
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	366.80				366.80
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [(1)]	**1,100.08**	**6.31**	**69.11**				**1,175.51**
A. Forest Land	-43.16	NE,NO	0.37				-42.79
B. Cropland	1,193.22	NE,NO	IE,NA,NE,NO				1,193.22
C. Grassland	-57.34	NE,NO	NE,NO				-57.34
D. Wetlands	7.36	6.31	NA,NO				13.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	68.74				68.74
6. Waste	**11.18**	**130.56**	**7.70**				**149.44**
A. Solid Waste Disposal on Land	NA,NE	123.25					123.25
B. Waste-water Handling		2.15	6.32				8.47
C. Waste Incineration	11.18	5.16	1.38				17.72
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	259.64	0.11	2.26				262.01
Aviation	221.99	0.03	1.94				223.96
Marine	37.65	0.08	0.32				38.05
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,373.69
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,549.20

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

1992

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1992
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**3,300.21**	**443.99**	**539.55**	**NA,NE,NO**	**155.28**	**1.30**	**4,440.33**
1. Energy	**1,833.72**	**5.67**	**26.03**				**1,865.42**
A. Fuel Combustion (Sectoral Approach)	1,766.11	5.03	26.03				1,797.17
1. Energy Industries	13.67	0.01	0.02				13.70
2. Manufacturing Industries and Construction	339.15	0.24	14.15				353.54
3. Transport	634.57	3.30	5.57				643.44
4. Other Sectors	778.72	1.49	6.29				786.49
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	67.62	0.63	NA,NO				68.25
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	67.62	0.63	NA,NO				68.25
2. Industrial Processes	**368.30**	**0.53**	**41.85**	**NA,NE,NO**	**155.28**	**1.30**	**567.26**
A. Mineral Products	45.69	NE,NO	NE,NO				45.69
B. Chemical Industry	0.25	NE,NO	41.85	NA	NA	NA	42.10
C. Metal Production	322.36	0.53	NA	NA,NE,NO	155.28	NA,NO	478.16
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				NA,NO	NA,NO	1.30	1.30
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.20**		**4.82**				**8.02**
4. Agriculture		**291.15**	**389.75**				**680.90**
A. Enteric Fermentation		251.65					251.65
B. Manure Management		39.50	43.06				82.56
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE,NO	346.69				346.69
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**1,084.11**	**6.31**	**69.36**				**1,159.78**
A. Forest Land	-48.35	NE,NO	0.45				-47.91
B. Cropland	1,187.35	NE,NO	IE,NA,NE,NO				1,187.35
C. Grassland	-62.25	NE,NO	NE,NO				-62.25
D. Wetlands	7.36	6.31	NA,NO				13.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	68.91				68.91
6. Waste	**10.88**	**140.33**	**7.74**				**158.95**
A. Solid Waste Disposal on Land	NA,NE	133.12					133.12
B. Waste-water Handling		2.17	6.39				8.56
C. Waste Incineration	10.88	5.03	1.35				17.26
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	263.56	0.15	2.29				266.00
Aviation	203.62	0.03	1.78				205.43
Marine	59.95	0.12	0.51				60.57
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,280.55
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,440.33

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

1993

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1993
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**3,409.01**	**451.95**	**550.39**	**0.67**	**74.86**	**1.30**	**4,488.18**
1. Energy	**1,910.14**	**5.76**	**27.52**				**1,943.42**
A. Fuel Combustion (Sectoral Approach)	1,824.76	5.11	27.52				1,857.40
1. Energy Industries	14.87	0.02	0.09				14.98
2. Manufacturing Industries and Construction	366.43	0.26	15.28				381.96
3. Transport	635.04	3.28	5.60				643.91
4. Other Sectors	808.43	1.56	6.55				816.54
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	85.38	0.65	NA,NO				86.02
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	85.38	0.65	NA,NO				86.02
2. Industrial Processes	**416.72**	**0.60**	**44.02**	**0.67**	**74.86**	**1.30**	**538.18**
A. Mineral Products	39.68	NE,NO	NE,NO				39.68
B. Chemical Industry	0.24	NE,NO	44.02	NA	NA	NA	44.26
C. Metal Production	376.80	0.60	NA	NA,NE,NO	74.86	NA,NO	452.26
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				0.67	NA,NO	1.30	1.98
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.21**		**4.74**				**7.96**
4. Agriculture		**290.99**	**396.94**				**687.93**
A. Enteric Fermentation		251.66					251.66
B. Manure Management		39.34	43.74				83.08
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE,NO	353.19				353.19
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry (1)	**1,069.68**	**6.31**	**69.54**				**1,145.53**
A. Forest Land	-53.68	NE,NO	0.46				-53.22
B. Cropland	1,181.43	NE,NO	IE,NA,NE,NO				1,181.43
C. Grassland	-65.43	NE,NO	NE,NO				-65.43
D. Wetlands	7.36	6.31	NA,NO				13.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	69.08				69.08
6. Waste	**9.27**	**148.27**	**7.63**				**165.17**
A. Solid Waste Disposal on Land	NA,NE	141.72					141.72
B. Waste-water Handling		2.19	6.46				8.66
C. Waste Incineration	9.27	4.36	1.17				14.80
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	293.02	0.22	2.54				295.78
Aviation	195.64	0.03	1.71				197.38
Marine	97.38	0.19	0.82				98.40
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,342.65
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,488.18

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

1994

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1994
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**3,343.12**	**461.19**	**556.57**	**1.41**	**44.57**	**1.30**	**4,408.16**
1. Energy	**1,857.28**	**5.75**	**27.69**				**1,890.72**
A. Fuel Combustion (Sectoral Approach)	1,787.16	5.10	27.69				1,819.94
1. Energy Industries	14.54	0.02	0.09				14.65
2. Manufacturing Industries and Construction	343.79	0.25	15.50				359.54
3. Transport	637.79	3.31	5.65				646.75
4. Other Sectors	791.04	1.52	6.45				799.00
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	70.12	0.66	NA,NO				70.78
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	70.12	0.66	NA,NO				70.78
2. Industrial Processes	**417.92**	**0.57**	**44.33**	**1.41**	**44.57**	**1.30**	**510.10**
A. Mineral Products	37.37	NE,NO	NE,NO				37.37
B. Chemical Industry	0.35	NE,NO	44.33	NA	NA	NA	44.68
C. Metal Production	380.20	0.57	NA	NA,NE,NO	44.57	NA,NO	425.34
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				1.41	NA,NO	1.30	2.71
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.20**		**4.29**				**7.49**
4. Agriculture		**292.56**	**402.96**				**695.52**
A. Enteric Fermentation		253.34					253.34
B. Manure Management		39.22	43.78				83.00
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE,NO	359.18				359.18
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry (1)	**1,056.18**	**6.31**	**69.72**				**1,132.21**
A. Forest Land	-56.67	NE,NO	0.47				-56.20
B. Cropland	1,175.47	NE,NO	IE,NA,NE,NO				1,175.47
C. Grassland	-69.98	NE,NO	NE,NO				-69.98
D. Wetlands	7.36	6.31	NA,NO				13.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	69.24				69.24
6. Waste	**8.54**	**155.99**	**7.59**				**172.11**
A. Solid Waste Disposal on Land	NA,NE	149.73					149.73
B. Waste-water Handling		2.21	6.50				8.71
C. Waste Incineration	8.54	4.05	1.08				13.67
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	307.10	0.22	2.66				309.98
Aviation	213.62	0.03	1.87				215.52
Marine	93.49	0.19	0.79				94.46
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,275.95
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,408.16

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

1995

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1995
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**3,351.88**	**458.28**	**547.12**	**7.95**	**58.84**	**1.30**	**4,425.38**
1. Energy	**1,872.78**	**5.32**	**38.15**				**1,916.25**
A. Fuel Combustion (Sectoral Approach)	1,790.55	4.58	38.15				1,833.28
1. Energy Industries	18.89	0.03	0.12				19.04
2. Manufacturing Industries and Construction	358.10	0.27	19.29				377.67
3. Transport	613.50	2.73	12.20				628.43
4. Other Sectors	800.06	1.54	6.54				808.14
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	82.23	0.74	NA,NO				82.97
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	82.23	0.74	NA,NO				82.97
2. Industrial Processes	**434.70**	**0.59**	**42.16**	**7.95**	**58.84**	**1.30**	**545.54**
A. Mineral Products	37.87	NE,NO	NE,NO				37.87
B. Chemical Industry	0.46	NE,NO	42.16	NA	NA	NA	42.62
C. Metal Production	396.37	0.59	NA	NA,NE,NO	58.84	NA,NO	455.81
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				7.95	NA,NO	1.30	9.25
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.21**		**4.29**				**7.51**
4. Agriculture		**282.17**	**384.80**				**666.97**
A. Enteric Fermentation		243.63					243.63
B. Manure Management		38.55	41.02				79.56
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [3]		NA,NE,NO	343.78				343.78
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [1]	**1,033.66**	**6.31**	**70.01**				**1,109.98**
A. Forest Land	-67.09	NE,NO	0.52				-66.57
B. Cropland	1,169.54	NE,NO	IE,NA,NE,NO				1,169.54
C. Grassland	-76.15	NE,NO	NE,NO				-76.15
D. Wetlands	7.36	6.31	NA,NO				13.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	69.49				69.49
6. Waste	**7.53**	**163.88**	**7.71**				**179.12**
A. Solid Waste Disposal on Land	NA,NE	157.88					157.88
B. Waste-water Handling		2.22	6.56				8.77
C. Waste Incineration	7.53	3.61	0.97				12.11
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	380.15	0.32	3.28				383.76
Aviation	236.15	0.04	2.07				238.25
Marine	144.00	0.29	1.21				145.50
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,315.39
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,425.38

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

1996

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1996
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**3,426.77**	**466.77**	**568.08**	**15.01**	**25.15**	**1.30**	**4,503.09**
1. Energy	**1,963.14**	**5.46**	**38.08**				**2,006.67**
A. Fuel Combustion (Sectoral Approach)	1,881.87	4.75	38.08				1,924.70
1. Energy Industries	11.62	0.03	0.13				11.78
2. Manufacturing Industries and Construction	399.02	0.30	18.78				418.10
3. Transport	604.42	2.76	12.11				619.29
4. Other Sectors	866.82	1.66	7.06				875.54
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	81.27	0.70	NA,NO				81.97
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	81.27	0.70	NA,NO				81.97
2. Industrial Processes	**434.07**	**0.57**	**49.29**	**15.01**	**25.15**	**1.30**	**525.40**
A. Mineral Products	41.78	NE,NO	NE,NO				41.78
B. Chemical Industry	0.40	NE,NO	49.29	NA	NA	NA	49.69
C. Metal Production	391.89	0.57	NA	NA,NE,NO	25.15	NA,NO	417.61
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				15.01	NA,NO	1.30	16.32
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.45**		**4.71**				**8.16**
4. Agriculture		**286.08**	**398.09**				**684.17**
A. Enteric Fermentation		247.01					247.01
B. Manure Management		39.07	42.01				81.08
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	356.07				356.07
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [(1)]	**1,019.36**	**7.70**	**70.25**				**1,097.30**
A. Forest Land	-71.95	NE,NO	0.53				-71.42
B. Cropland	1,163.64	NE,NO	IE,NA,NE,NO				1,163.64
C. Grassland	-81.30	NE,NO	NE,NO				-81.30
D. Wetlands	8.98	7.70	NA,NO				16.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	69.71				69.71
6. Waste	**6.75**	**166.97**	**7.67**				**181.39**
A. Solid Waste Disposal on Land	NA,NE	161.30					161.30
B. Waste-water Handling		2.23	6.61				8.84
C. Waste Incineration	6.75	3.27	0.88				10.89
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	395.45	0.29	3.42				399.17
Aviation	271.51	0.04	2.38				273.93
Marine	123.95	0.25	1.04				125.24
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,405.79
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,503.09

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

1997

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1997
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**3,495.94**	**466.94**	**567.56**	**23.55**	**82.36**	**1.30**	**4,637.65**
1. Energy	**1,992.27**	**5.16**	**48.99**				**2,046.42**
A. Fuel Combustion (Sectoral Approach)	1,928.42	4.27	48.99				1,981.67
1. Energy Industries	8.17	0.03	0.12				8.33
2. Manufacturing Industries and Construction	467.37	0.35	22.64				490.36
3. Transport	615.75	2.26	19.35				637.36
4. Other Sectors	837.12	1.62	6.88				845.62
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	63.85	0.89	NA,NO				64.74
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	63.85	0.89	NA,NO				64.74
2. Industrial Processes	**493.42**	**0.60**	**41.11**	**23.55**	**82.36**	**1.30**	**642.34**
A. Mineral Products	46.55	NE,NO	NE,NO				46.55
B. Chemical Industry	0.44	NE,NO	41.11	NA	NA	NA	41.54
C. Metal Production	446.44	0.60	NA	NA,NE,NO	82.36	NA,NO	529.40
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				23.55	NA,NO	1.30	24.85
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.55**		**4.71**				**8.26**
4. Agriculture		**283.22**	**394.46**				**677.68**
A. Enteric Fermentation		244.78					244.78
B. Manure Management		38.45	42.64				81.09
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	351.81				351.81
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [(1)]	**1,000.20**	**7.70**	**70.62**				**1,078.51**
A. Forest Land	-79.41	NE,NO	0.56				-78.85
B. Cropland	1,157.66	NE,NO	IE,NA,NE,NO				1,157.66
C. Grassland	-87.03	NE,NO	NE,NO				-87.03
D. Wetlands	8.98	7.70	NA,NO				16.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	70.05				70.05
6. Waste	**6.50**	**170.25**	**7.69**				**184.44**
A. Solid Waste Disposal on Land	NA,NE	164.70					164.70
B. Waste-water Handling		2.25	6.66				8.91
C. Waste Incineration	6.50	3.13	0.84				10.47
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	440.80	0.34	3.81				444.95
Aviation	292.12	0.04	2.56				294.72
Marine	148.68	0.30	1.25				150.23
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,559.14
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,637.65

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

1998

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1998
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**3,482.78**	**477.17**	**569.92**	**35.61**	**180.13**	**1.30**	**4,746.92**
1. Energy	**1,974.38**	**5.34**	**49.50**				**2,029.21**
A. Fuel Combustion (Sectoral Approach)	1,890.68	4.24	49.50				1,944.41
1. Energy Industries	11.11	0.03	0.13				11.27
2. Manufacturing Industries and Construction	444.57	0.33	22.88				467.79
3. Transport	619.00	2.30	19.83				641.13
4. Other Sectors	815.99	1.57	6.66				824.22
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	83.70	1.10	NA,NO				84.80
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	83.70	1.10	NA,NO				84.80
2. Industrial Processes	**521.32**	**0.44**	**35.84**	**35.61**	**180.13**	**1.30**	**774.64**
A. Mineral Products	54.39	NE,NO	NE,NO				54.39
B. Chemical Industry	0.40	NE,NO	35.84	NA	NA	NA	36.23
C. Metal Production	466.53	0.44	NA	NA,NE,NO	180.13	NA,NO	647.11
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				35.61	NA,NO	1.30	36.92
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.80**		**4.84**				**8.63**
4. Agriculture		**288.84**	**400.95**				**689.79**
A. Enteric Fermentation		249.45					249.45
B. Manure Management		39.40	43.63				83.02
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	357.32				357.32
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [(1)]	**977.78**	**7.80**	**71.15**				**1,056.74**
A. Forest Land	-88.40	NE,NO	0.64				-87.76
B. Cropland	1,151.70	NE,NO	IE,NA,NE,NO				1,151.70
C. Grassland	-94.62	NE,NO	NE,NO				-94.62
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	70.51				70.51
6. Waste	**5.51**	**174.74**	**7.65**				**187.90**
A. Solid Waste Disposal on Land	NA,NE	169.61					169.61
B. Waste-water Handling		2.28	6.74				9.02
C. Waste Incineration	5.51	2.69	0.72				8.93
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	514.67	0.40	4.44				519.51
Aviation	338.13	0.05	2.96				341.14
Marine	176.54	0.35	1.48				178.37
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,690.18
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,746.92

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

1999

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1999
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**3,668.68**	**481.52**	**592.12**	**40.37**	**173.21**	**1.30**	**4,957.21**
1. Energy	**2,031.73**	**5.18**	**61.20**				**2,098.11**
A. Fuel Combustion (Sectoral Approach)	1,920.46	3.60	61.20				1,985.26
1. Energy Industries	8.24	0.03	0.12				8.40
2. Manufacturing Industries and Construction	470.11	0.36	25.04				495.50
3. Transport	640.69	1.67	29.49				671.84
4. Other Sectors	801.42	1.54	6.55				809.51
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	111.27	1.58	NA,NO				112.86
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	111.27	1.58	NA,NO				112.86
2. Industrial Processes	**670.41**	**0.68**	**36.18**	**40.37**	**173.21**	**1.30**	**922.15**
A. Mineral Products	61.46	NE,NO	NE,NO				61.46
B. Chemical Industry	0.43	NE,NO	36.18	NA	NA	NA	36.61
C. Metal Production	608.52	0.68	NA	NA,NE,NO	173.21	NA,NO	782.41
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				40.37	NA,NO	1.30	41.68
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.47**		**4.82**				**8.29**
4. Agriculture		**288.14**	**410.62**				**698.76**
A. Enteric Fermentation		248.90					248.90
B. Manure Management		39.24	43.74				82.98
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE,NO	366.88				366.88
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**958.56**	**7.80**	**71.68**				**1,038.05**
A. Forest Land	-94.36	NE,NO	0.67				-93.69
B. Cropland	1,145.63	NE,NO	IE,NA,NE,NO				1,145.63
C. Grassland	-101.82	NE,NO	NE,NO				-101.82
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	71.01				71.01
6. Waste	**4.51**	**179.72**	**7.62**				**191.85**
A. Solid Waste Disposal on Land	NA,NE	174.99					174.99
B. Waste-water Handling		2.31	6.83				9.14
C. Waste Incineration	4.51	2.25	0.61				7.36
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	527.25	0.38	4.57				532.20
Aviation	363.37	0.05	3.18				366.61
Marine	163.88	0.33	1.38				165.59
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,919.16
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,957.21

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2000

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2000
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**3,712.00**	**475.50**	**567.37**	**35.73**	**127.16**	**1.37**	**4,919.13**
1. Energy	**1,975.42**	**5.24**	**61.05**				**2,041.71**
A. Fuel Combustion (Sectoral Approach)	1,822.28	3.47	61.05				1,886.79
1. Energy Industries	7.24	0.03	0.12				7.40
2. Manufacturing Industries and Construction	423.71	0.33	25.49				449.53
3. Transport	642.83	1.65	29.29				673.77
4. Other Sectors	748.50	1.45	6.14				756.09
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	153.15	1.77	NA,NO				154.92
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	153.15	1.77	NA,NO				154.92
2. Industrial Processes	**792.55**	**0.94**	**18.63**	**35.73**	**127.16**	**1.37**	**976.39**
A. Mineral Products	65.68	NE,NO	NE,NO				65.68
B. Chemical Industry	0.41	NE,NO	18.63	NA	NA	NA	19.04
C. Metal Production	726.46	0.94	NA	NA,NE,NO	127.16	NA,NO	854.57
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				35.73	NA,NO	1.37	37.10
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.71**		**4.60**				**8.31**
4. Agriculture		**277.21**	**402.79**				**680.00**
A. Enteric Fermentation		239.20					239.20
B. Manure Management		38.01	43.13				81.14
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE,NO	359.66				359.66
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry (1)	**936.08**	**7.80**	**72.60**				**1,016.49**
A. Forest Land	-105.88	NE,NO	0.95				-104.93
B. Cropland	1,139.59	NE,NO	IE,NA,NE,NO				1,139.59
C. Grassland	-106.75	NE,NO	NE,NO				-106.75
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	71.65				71.65
6. Waste	**4.24**	**184.30**	**7.70**				**196.23**
A. Solid Waste Disposal on Land	NA,NE	179.59					179.59
B. Waste-water Handling		2.34	6.92				9.26
C. Waste Incineration	4.24	2.20	0.59				7.03
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	626.29	0.50	5.41				632.20
Aviation	407.74	0.06	3.57				411.37
Marine	218.55	0.44	1.84				220.82
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,902.65
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,919.13

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2001

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2001
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**3,695.18**	**484.20**	**559.96**	**40.21**	**91.66**	**1.37**	**4,872.60**
1. Energy	**1,939.14**	**5.19**	**60.23**				**2,004.55**
A. Fuel Combustion (Sectoral Approach)	1,795.37	3.35	60.23				1,858.95
1. Energy Industries	6.55	0.03	0.12				6.71
2. Manufacturing Industries and Construction	470.93	0.35	25.08				496.36
3. Transport	653.53	1.68	29.58				684.79
4. Other Sectors	664.36	1.28	5.45				671.09
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	143.77	1.84	NA,NO				145.61
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	143.77	1.84	NA,NO				145.61
2. Industrial Processes	**826.74**	**0.91**	**16.15**	**40.21**	**91.66**	**1.37**	**977.05**
A. Mineral Products	58.99	NE,NO	NE,NO				58.99
B. Chemical Industry	0.49	NE,NO	16.15	NA	NA	NA	16.64
C. Metal Production	767.26	0.91	NA	NA,NE,NO	91.66	NA,NO	859.82
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				40.21	0.01	1.37	41.59
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.37**		**4.28**				**7.65**
4. Agriculture		**279.75**	**398.52**				**678.27**
A. Enteric Fermentation		241.15					241.15
B. Manure Management		38.60	41.67				80.28
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE,NO	356.84				356.84
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**921.90**	**7.80**	**73.06**				**1,002.76**
A. Forest Land	-111.76	NE,NO	0.95				-110.81
B. Cropland	1,133.44	NE,NO	IE,NA,NE,NO				1,133.44
C. Grassland	-108.88	NE,NO	NE,NO				-108.88
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	72.10				72.10
6. Waste	**4.03**	**190.55**	**7.73**				**202.32**
A. Solid Waste Disposal on Land	NA,NE	186.02					186.02
B. Waste-water Handling		2.37	7.01				9.38
C. Waste Incineration	4.03	1.99	0.54				6.57
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	498.17	0.35	4.32				502.83
Aviation	349.13	0.05	3.06				352.24
Marine	149.04	0.30	1.26				150.60
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,869.83
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,872.60

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2002

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2002
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**3,768.92**	**481.66**	**527.82**	**38.07**	**72.54**	**1.37**	**4,890.38**
1. Energy	**2,014.81**	**5.34**	**59.54**				**2,079.69**
A. Fuel Combustion (Sectoral Approach)	1,867.25	3.50	59.54				1,930.29
1. Energy Industries	8.52	0.04	0.12				8.68
2. Manufacturing Industries and Construction	473.73	0.35	23.52				497.60
3. Transport	657.22	1.69	29.89				688.80
4. Other Sectors	727.78	1.42	6.01				735.20
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	147.57	1.84	NA,NO				149.41
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	147.57	1.84	NA,NO				149.41
2. Industrial Processes	**840.90**	**0.97**	**NA,NE,NO**	**38.07**	**72.54**	**1.37**	**953.86**
A. Mineral Products	39.76	NE,NO	NE,NO				39.76
B. Chemical Industry	0.45	NE,NO	NE,NO	NA	NA	NA	0.45
C. Metal Production	800.68	0.97	NA	NA,NE,NO	72.54	NA,NO	874.19
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				38.07	0.01	1.37	39.45
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.39**		**4.03**				**7.42**
4. Agriculture		**273.52**	**382.72**				**656.24**
A. Enteric Fermentation		236.17					236.17
B. Manure Management		37.35	41.75				79.10
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	340.97				340.97
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [(1)]	**906.06**	**7.80**	**73.77**				**987.63**
A. Forest Land	-119.87	NE,NO	1.04				-118.83
B. Cropland	1,127.26	NE,NO	IE,NA,NE,NO				1,127.26
C. Grassland	-110.44	NE,NO	NE,NO				-110.44
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	72.73				72.73
6. Waste	**3.75**	**194.03**	**7.75**				**205.53**
A. Solid Waste Disposal on Land	NA,NE	187.62					187.62
B. Waste-water Handling		4.37	7.06				11.43
C. Waste Incineration	3.75	1.86	0.50				6.12
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	517.17	0.46	4.46				522.10
Aviation	309.85	0.05	2.71				312.61
Marine	207.32	0.41	1.75				209.49
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,902.75
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,890.38

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2003

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2003
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**3,738.04**	**479.74**	**517.93**	**47.14**	**59.79**	**1.37**	**4,844.02**
1. Energy	**2,007.69**	**5.31**	**58.78**				**2,071.78**
A. Fuel Combustion (Sectoral Approach)	1,871.18	3.52	58.78				1,933.48
1. Energy Industries	7.79	0.03	0.12				7.95
2. Manufacturing Industries and Construction	425.39	0.33	21.51				447.23
3. Transport	751.18	1.81	31.44				784.43
4. Other Sectors	686.82	1.35	5.70				693.88
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	136.51	1.79	NA,NO				138.30
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	136.51	1.79	NA,NO				138.30
2. Industrial Processes	**840.36**	**0.94**	**NA,NE,NO**	**47.14**	**59.79**	**1.37**	**949.61**
A. Mineral Products	33.48	NE,NO	NE,NO				33.48
B. Chemical Industry	0.48	NE,NO	NE,NO	NA	NA	NA	0.48
C. Metal Production	806.41	0.94	NA	NA,NE,NO	59.78	NA,NO	867.13
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				47.14	0.00	1.37	48.52
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.33**		**3.88**				**7.21**
4. Agriculture		**270.28**	**373.25**				**643.52**
A. Enteric Fermentation		233.58					233.58
B. Manure Management		36.69	41.42				78.12
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	331.82				331.82
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [(1)]	**883.44**	**7.80**	**74.20**				**965.44**
A. Forest Land	-130.77	NE,NO	1.05				-129.71
B. Cropland	1,123.44	NE,NO	IE,NA,NE,NO				1,123.44
C. Grassland	-118.35	NE,NO	NE,NO				-118.35
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	73.15				73.15
6. Waste	**3.22**	**195.41**	**7.83**				**206.46**
A. Solid Waste Disposal on Land	NA,NE	189.13					189.13
B. Waste-water Handling		4.41	7.11				11.52
C. Waste Incineration	3.22	1.62	0.44				5.28
D. Other	NA	0.25	0.28				0.53
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	476.72	0.34	4.13				481.19
Aviation	333.00	0.05	2.92				335.97
Marine	143.72	0.29	1.21				145.22
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,878.58
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,844.02

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2004

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**3,783.73**	**481.43**	**515.67**	**50.17**	**38.58**	**1.38**	**4,870.96**
1. Energy	**2,052.17**	**5.52**	**64.13**				**2,121.82**
A. Fuel Combustion (Sectoral Approach)	1,929.27	3.59	64.13				1,996.99
1. Energy Industries	7.43	0.04	0.12				7.59
2. Manufacturing Industries and Construction	458.70	0.36	25.78				484.84
3. Transport	803.26	1.91	32.77				837.93
4. Other Sectors	659.88	1.29	5.46				666.62
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	122.90	1.93	NA,NO				124.83
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	122.90	1.93	NA,NO				124.83
2. Industrial Processes	**863.60**	**0.96**	**NA,NE,NO**	**50.17**	**38.58**	**1.38**	**954.69**
A. Mineral Products	51.45	NE,NO	NE,NO				51.45
B. Chemical Industry	0.39	NE,NO	NE,NO	NA	NA	NA	0.39
C. Metal Production	811.76	0.96	NA	NA,NE,NO	38.58	NA,NO	851.30
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				50.17	0.00	1.38	51.55
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.60**		**3.57**				**7.16**
4. Agriculture		**266.40**	**365.39**				**631.79**
A. Enteric Fermentation		230.15					230.15
B. Manure Management		36.25	41.27				77.52
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE,NO	324.11				324.11
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry (1)	**857.28**	**7.80**	**74.69**				**939.78**
A. Forest Land	-137.99	NE,NO	1.12				-136.87
B. Cropland	1,117.47	NE,NO	IE,NA,NE,NO				1,117.47
C. Grassland	-131.46	NE,NO	NE,NO				-131.46
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	0.16	NE	NE				0.16
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	73.58				73.58
6. Waste	**7.09**	**200.74**	**7.90**				**215.72**
A. Solid Waste Disposal on Land	NA,NE	195.06					195.06
B. Waste-water Handling		4.45	7.18				11.63
C. Waste Incineration	7.09	0.98	0.44				8.50
D. Other	NA	0.25	0.28				0.53
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	576.21	0.45	4.98				581.64
Aviation	380.00	0.06	3.33				383.39
Marine	196.21	0.39	1.65				198.25
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,931.18
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,870.96

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2005

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2005
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**3,675.81**	**477.60**	**524.68**	**58.40**	**26.10**	**2.64**	**4,765.22**
1. Energy	**1,998.59**	**5.30**	**71.70**				**2,075.58**
A. Fuel Combustion (Sectoral Approach)	1,882.24	3.21	71.70				1,957.14
1. Energy Industries	9.22	0.03	0.12				9.37
2. Manufacturing Industries and Construction	419.21	0.35	27.84				447.40
3. Transport	808.94	1.57	38.43				848.93
4. Other Sectors	644.87	1.26	5.31				651.44
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	116.36	2.09	NA,NO				118.45
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	116.36	2.09	NA,NO				118.45
2. Industrial Processes	**846.48**	**0.97**	**NA,NE,NO**	**58.40**	**26.10**	**2.64**	**934.58**
A. Mineral Products	55.72	NE,NO	NE,NO				55.72
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	790.76	0.97	NA	NA,NE,NO	26.09	NA,NO	817.82
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				58.40	0.00	2.64	61.04
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.53**		**3.35**				**6.88**
4. Agriculture		**268.82**	**366.21**				**635.04**
A. Enteric Fermentation		231.86					231.86
B. Manure Management		36.96	41.74				78.69
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	324.48				324.48
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [(1)]	**822.87**	**7.80**	**75.29**				**905.96**
A. Forest Land	-158.37	NE,NO	1.14				-157.23
B. Cropland	1,112.15	NE,NO	IE,NA,NE,NO				1,112.15
C. Grassland	-140.19	NE,NO	NE,NO				-140.19
D. Wetlands	9.11	7.80	NA,NE,NO				16.91
E. Settlements	0.18	NE	NE				0.18
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NA,NE,NO	74.15				74.15
6. Waste	**4.33**	**194.71**	**8.13**				**207.17**
A. Solid Waste Disposal on Land	NA,NE	189.38					189.38
B. Waste-water Handling		4.54	7.39				11.94
C. Waste Incineration	4.33	0.37	0.27				4.97
D. Other	NA	0.42	0.47				0.89
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	532.59	0.28	4.62				537.50
Aviation	421.63	0.06	3.69				425.39
Marine	110.96	0.22	0.93				112.11
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3,859.26
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,765.22

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2006

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2006
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**3,831.86**	**504.18**	**556.76**	**58.74**	**333.22**	**2.64**	**5,287.40**
1. Energy	**2,066.21**	**6.31**	**70.45**				**2,142.97**
A. Fuel Combustion (Sectoral Approach)	1,929.57	3.28	70.45				2,003.30
1. Energy Industries	8.49	0.06	0.21				8.75
2. Manufacturing Industries and Construction	406.89	0.32	25.31				432.52
3. Transport	951.27	1.80	40.30				993.37
4. Other Sectors	562.92	1.10	4.64				568.66
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	136.65	3.03	NA,NO				139.67
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	136.65	3.03	NA,NO				139.67
2. Industrial Processes	**954.33**	**0.99**	**NA,NE,NO**	**58.74**	**333.22**	**2.64**	**1,349.93**
A. Mineral Products	62.72	NE,NO	NE,NO				62.72
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	891.62	0.99	NA	NA,NE,NO	333.22	NA,NO	1,225.83
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				58.74	0.00	2.64	61.38
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.89**		**3.36**				**7.25**
4. Agriculture		**273.66**	**392.41**				**666.07**
A. Enteric Fermentation		235.29					235.29
B. Manure Management		38.37	41.70				80.07
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[3]		NA,NE,NO	350.71				350.71
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[1]	**802.54**	**12.02**	**81.90**				**896.46**
A. Forest Land	-165.09	NE,NO	1.21				-163.88
B. Cropland	1,105.92	0.01	0.02				1,105.95
C. Grassland	-148.50	3.20	4.31				-140.99
D. Wetlands	9.11	8.81	1.35				19.27
E. Settlements	1.09	IE,NE	IE,NE				1.09
F. Other Land	NE	0.00	0.00				0.01
G. Other	NE,NO	NA,NE,NO	75.00				75.00
6. Waste	**4.88**	**211.19**	**8.64**				**224.71**
A. Solid Waste Disposal on Land	NA,NE	205.50					205.50
B. Waste-water Handling		4.66	7.60				12.26
C. Waste Incineration	4.88	0.36	0.30				5.53
D. Other	NA	0.67	0.74				1.42
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	637.13	0.35	5.53				643.00
Aviation	499.89	0.07	4.38				504.35
Marine	137.23	0.27	1.15				138.66
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4,390.94
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,287.40

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2007

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2007
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**4,072.44**	**502.13**	**570.27**	**61.97**	**281.13**	**3.00**	**5,490.94**
1. Energy	**2,121.33**	**7.30**	**70.84**				**2,199.46**
A. Fuel Combustion (Sectoral Approach)	1,975.57	3.34	70.84				2,049.75
1. Energy Industries	23.81	0.07	0.25				24.12
2. Manufacturing Industries and Construction	386.54	0.31	25.38				412.24
3. Transport	986.01	1.84	40.45				1,028.30
4. Other Sectors	579.20	1.13	4.76				585.09
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	145.76	3.96	NA,NO				149.71
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	145.76	3.96	NA,NO				149.71
2. Industrial Processes	**1,153.08**	**1.04**	**NA,NE,NO**	**61.97**	**281.13**	**3.00**	**1,500.21**
A. Mineral Products	64.52	NE,NO	NE,NO				64.52
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1,088.56	1.04	NA	NA,NE,NO	281.13	NA,NO	1,370.72
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				61.97	0.00	3.00	64.97
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**4.03**		**3.80**				**7.83**
4. Agriculture		**278.17**	**409.36**				**687.53**
A. Enteric Fermentation		238.67					238.67
B. Manure Management		39.50	42.46				81.96
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE,NO	366.90				366.90
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry (1)	**786.03**	**8.23**	**77.21**				**871.47**
A. Forest Land	-172.83	NE,NO	1.27				-171.56
B. Cropland	1,100.83	NE,NO	IE,NA,NE,NO				1,100.83
C. Grassland	-151.78	0.01	0.01				-151.77
D. Wetlands	9.60	8.22	NA,NE,NO				17.82
E. Settlements	0.22	NE,NO	NE,NO				0.22
F. Other Land	NE,NO	NE,NO	NE,NO				NE,NO
G. Other	NE,NO	NA,NE,NO	75.93				75.93
6. Waste	**7.98**	**207.40**	**9.06**				**224.44**
A. Solid Waste Disposal on Land	NA,NE	202.42					202.42
B. Waste-water Handling		3.79	7.80				11.59
C. Waste Incineration	7.98	0.35	0.33				8.66
D. Other	NA	0.84	0.93				1.77
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	718.45	0.49	6.21				725.15
Aviation	511.53	0.08	4.48				516.09
Marine	206.92	0.41	1.73				209.06
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4,619.47
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,490.94

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2008

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2008
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**4,377.38**	**498.27**	**582.01**	**70.63**	**349.00**	**3.15**	**5,880.44**
1. Energy	**1,999.42**	**7.47**	**67.78**				**2,074.66**
A. Fuel Combustion (Sectoral Approach)	1,815.15	3.11	67.78				1,886.04
1. Energy Industries	7.92	0.05	0.20				8.17
2. Manufacturing Industries and Construction	344.25	0.28	24.23				368.76
3. Transport	932.13	1.74	38.99				972.86
4. Other Sectors	530.86	1.03	4.37				536.25
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	184.27	4.35	NA,NO				188.62
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	184.27	4.35	NA,NO				188.62
2. Industrial Processes	**1,595.86**	**0.88**	**NA,NE,NO**	**70.63**	**349.00**	**3.15**	**2,019.52**
A. Mineral Products	62.86	NE,NO	NE,NO				62.86
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1,533.00	0.88	NA	NA,NE,NO	349.00	NA,NO	1,882.88
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				70.63	0.00	3.15	73.78
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.55**		**3.63**				**7.18**
4. Agriculture		**281.13**	**423.36**				**704.50**
A. Enteric Fermentation		241.59					241.59
B. Manure Management		39.54	41.44				80.98
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE,NO	381.92				381.92
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry (1)	**772.25**	**8.29**	**78.11**				**858.65**
A. Forest Land	-176.69	0.01	1.23				-175.45
B. Cropland	1,095.15	NE,NO	IE,NA,NE,NO				1,095.15
C. Grassland	-155.88	0.04	0.06				-155.78
D. Wetlands	9.60	8.24	0.03				17.87
E. Settlements	0.08	NE,NO	NE,NO				0.08
F. Other Land	NE	0.00	0.00				0.01
G. Other	NE,NO	NA,NE,NO	76.78				76.78
6. Waste	**6.31**	**200.49**	**9.13**				**215.93**
A. Solid Waste Disposal on Land	NA,NE	195.74					195.74
B. Waste-water Handling		3.53	7.85				11.38
C. Waste Incineration	6.31	0.33	0.30				6.93
D. Other	NA	0.89	0.99				1.88
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	656.36	0.51	5.64				662.52
Aviation	427.83	0.06	3.75				431.64
Marine	228.53	0.45	1.90				230.88
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	5,021.79
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,880.44

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2009

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2009
Submission 2014 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4,318.97**	**495.86**	**547.76**	**94.99**	**152.75**	**3.17**	**5,613.50**
1. Energy	**1,952.48**	**7.97**	**60.77**				**2,021.22**
A. Fuel Combustion (Sectoral Approach)	1,784.02	3.14	60.77				1,847.93
1. Energy Industries	8.81	0.05	0.18				9.04
2. Manufacturing Industries and Construction	247.27	0.20	16.69				264.17
3. Transport	905.31	1.69	38.83				945.84
4. Other Sectors	622.64	1.19	5.06				628.89
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	168.45	4.83	NA,NO				173.29
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	168.45	4.83	NA,NO				173.29
2. Industrial Processes	**1,608.77**	**0.91**	**NA,NE,NO**	**94.99**	**152.75**	**3.17**	**1,860.59**
A. Mineral Products	30.05	NE,NO	NE,NO				30.05
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1,578.72	0.91	NA	NA,NE,NO	152.75	NA,NO	1,732.38
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				94.99	0.00	3.17	98.16
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.16**		**3.15**				**6.31**
4. Agriculture		**284.11**	**395.72**				**679.83**
A. Enteric Fermentation		244.37					244.37
B. Manure Management		39.74	42.92				82.66
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	352.79				352.79
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [(1)]	**747.13**	**8.33**	**78.77**				**834.23**
A. Forest Land	-190.55	0.00	1.27				-189.27
B. Cropland	1,087.18	NE,NO	IE,NA,NE,NO				1,087.18
C. Grassland	-159.30	0.00	0.00				-159.30
D. Wetlands	9.72	8.33	NA,NE,NO				18.05
E. Settlements	0.08	NE,NO	NE,NO				0.08
F. Other Land	NE	0.00	0.00				0.00
G. Other	NE,NO	NA,NE,NO	77.50				77.50
6. Waste	**7.43**	**194.53**	**9.35**				**211.32**
A. Solid Waste Disposal on Land	NA,NE	189.64					189.64
B. Waste-water Handling		3.51	7.88				11.39
C. Waste Incineration	7.43	0.32	0.29				8.03
D. Other	NA	1.07	1.18				2.25
7. Other ***(as specified in Summary 1.A)***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	498.71	0.37	4.29				503.38
Aviation	333.88	0.05	2.92				336.85
Marine	164.84	0.32	1.37				166.53
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4,779.27
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,613.50

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2010

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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**4,135.67**	**496.24**	**532.35**	**122.53**	**145.63**	**4.89**	**5,437.31**
1. Energy	**1,807.12**	**7.02**	**55.02**				**1,869.15**
A. Fuel Combustion (Sectoral Approach)	1,618.13	2.89	55.02				1,676.04
1. Energy Industries	6.69	0.04	0.16				6.89
2. Manufacturing Industries and Construction	199.36	0.17	13.21				212.74
3. Transport	861.59	1.61	37.14				900.34
4. Other Sectors	550.49	1.07	4.51				556.07
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	188.99	4.13	NA,NO				193.12
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	188.99	4.13	NA,NO				193.12
2. Industrial Processes	**1,615.82**	**0.90**	**NA,NE,NO**	**122.53**	**145.63**	**4.89**	**1,889.77**
A. Mineral Products	10.64	NE,NO	NE,NO				10.64
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1,605.18	0.90	NA	NA,NE,NO	145.63	NA,NO	1,751.71
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				122.53	0.01	4.89	127.42
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**2.74**		**3.41**				**6.15**
4. Agriculture		**285.63**	**385.37**				**671.00**
A. Enteric Fermentation		246.23					246.23
B. Manure Management		39.39	42.94				82.33
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE,NO	342.44				342.44
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry (1)	**703.86**	**8.34**	**78.95**				**791.15**
A. Forest Land	-214.52	NE,NO	1.29				-213.23
B. Cropland	1,078.95	NE,NO	IE,NA,NE,NO				1,078.95
C. Grassland	-170.37	0.01	0.01				-170.36
D. Wetlands	9.72	8.33	NA,NE,NO				18.05
E. Settlements	0.08	NE,NO	NE,NO				0.08
F. Other Land	NE,NO	NE,NO	NE,NO				NE,NO
G. Other	NE,NO	NA,NE,NO	77.65				77.65
6. Waste	**6.13**	**194.36**	**9.59**				**210.08**
A. Solid Waste Disposal on Land	NA,NE	189.27					189.27
B. Waste-water Handling		3.51	7.93				11.44
C. Waste Incineration	6.13	0.29	0.25				6.67
D. Other	NA	1.28	1.42				2.70
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	559.61	0.41	4.81				564.84
Aviation	377.26	0.06	3.30				380.62
Marine	182.35	0.36	1.51				184.21
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4,646.16
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,437.31

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2011

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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**3,990.75**	**481.01**	**527.28**	**121.35**	**63.22**	**3.19**	**5,186.80**
1. Energy	**1,712.12**	**6.08**	**51.56**				**1,769.76**
A. Fuel Combustion (Sectoral Approach)	1,533.43	2.71	51.56				1,587.70
1. Energy Industries	6.85	0.04	0.14				7.03
2. Manufacturing Industries and Construction	181.94	0.14	11.38				193.47
3. Transport	826.36	1.53	35.80				863.69
4. Other Sectors	518.29	1.00	4.23				523.52
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	178.68	3.37	NA,NO				182.05
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	178.68	3.37	NA,NO				182.05
2. Industrial Processes	**1,609.87**	**0.87**	**NA,NE,NO**	**121.35**	**63.22**	**3.19**	**1,798.50**
A. Mineral Products	21.15	NE,NO	NE,NO				21.15
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1,588.72	0.87	NA	NA,NE,NO	63.22	NA,NO	1,652.81
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				121.35	0.00	3.19	124.54
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**2.81**		**3.49**				**6.30**
4. Agriculture		**285.20**	**383.30**				**668.50**
A. Enteric Fermentation		245.52					245.52
B. Manure Management		39.68	43.74				83.42
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE,NO	339.56				339.56
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry (1)	**658.00**	**8.33**	**79.35**				**745.67**
A. Forest Land	-240.59	NE,NO	1.32				-239.27
B. Cropland	1,072.41	NE,NO	IE,NA,NE,NO				1,072.41
C. Grassland	-184.00	NE,NO	NE,NO				-184.00
D. Wetlands	9.72	8.33	NA,NE,NO				18.05
E. Settlements	0.46	NE,NO	NE,NO				0.46
F. Other Land	NE,NO	NE,NO	NE,NO				NE,NO
G. Other	NE,NO	NA,NE,NO	78.03				78.03
6. Waste	**7.96**	**180.53**	**9.59**				**198.07**
A. Solid Waste Disposal on Land	NA,NE	175.51					175.51
B. Waste-water Handling		3.53	7.98				11.51
C. Waste Incineration	7.96	0.29	0.28				8.53
D. Other	NA	1.20	1.33				2.53
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	620.60	0.45	5.34				626.39
Aviation	421.93	0.06	3.70				425.69
Marine	198.66	0.39	1.64				200.70
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4,441.13
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,186.80

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

2012

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**3,941.73**	**465.15**	**537.56**	**144.12**	**79.74**	**5.57**	**5,173.87**
1. Energy	**1,661.53**	**5.32**	**50.71**				**1,717.57**
A. Fuel Combustion (Sectoral Approach)	1,491.35	2.63	50.71				1,544.70
1. Energy Industries	7.21	0.03	0.11				7.36
2. Manufacturing Industries and Construction	172.05	0.15	11.86				184.06
3. Transport	816.84	1.49	34.66				852.98
4. Other Sectors	495.25	0.97	4.08				500.30
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	170.18	2.69	NA,NO				172.87
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	170.18	2.69	NA,NO				172.87
2. Industrial Processes	**1,652.68**	**1.11**	**NA,NE,NO**	**144.12**	**79.74**	**5.57**	**1,883.22**
A. Mineral Products	1.59	NE,NO	NE,NO				1.59
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1,651.09	1.11	NA	NA,NE,NO	79.74	NA,NO	1,731.95
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				144.12	0.00	5.57	149.69
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**2.83**		**3.34**				**6.17**
4. Agriculture		**283.66**	**394.34**				**678.00**
A. Enteric Fermentation		244.35					244.35
B. Manure Management		39.31	43.29				82.61
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE,NO	351.04				351.04
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**617.94**	**8.34**	**79.86**				**706.14**
A. Forest Land	-268.43	0.00	1.19				-267.24
B. Cropland	1,067.72	NE,NO	IE,NA,NE,NO				1,067.72
C. Grassland	-191.18	0.01	0.01				-191.15
D. Wetlands	9.72	8.33	NA,NE,NO				18.05
E. Settlements	0.11	IE,NE	IE,NE				0.11
F. Other Land	NE	0.00	0.00				0.00
G. Other	NE,NO	NA,NE,NO	78.66				78.66
6. Waste	**6.74**	**166.72**	**9.30**				**182.77**
A. Solid Waste Disposal on Land	NA,NE	161.95					161.95
B. Waste-water Handling		3.55	8.04				11.59
C. Waste Incineration	6.74	0.28	0.23				7.25
D. Other	NA	0.94	1.04				1.98
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	624.22	0.42	5.38				630.03
Aviation	442.16	0.07	3.87				446.10
Marine	182.07	0.36	1.51				183.93
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4,467.73
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,173.87

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

ANNEX V. Fact sheet for Single Projects

Fact sheet Single Projects under 14/CP.7

Name of the single project	**Rio Tinto Alcan – expansion of aluminium plant**
Name of the company/ production facility	Rio Tinto Alcan
Location of the project	PO 224, 220 Hafnarfjörður, Iceland
NIR category	2.C.3 Aluminium production
Description of the industrial process facility	Aluminium production started at the Aluminium plant in Straumsvík in 1969. The plant consisted in the beginning of one potline. In 1972 a second potline was taken into operation. In 1996 a further expansion of the plant took place. The project involves an expansion in the plant capacity by building a new potline with increased current in the electrolytic pots. At the same time current was also increased in potlines one and two. This has led to increased production in potlines one and two. The process used in all potlines is PFPB with automatic multiple point feed.
Evidence that the projects fulfils paragraph 1[#]	The Environment Agency of Iceland issues Operating licences for the Aluminium production plant in Straumsvík and is responsible for the supervision of the plant. Statistics on production is supplied to the Agency each year.
Evidence that the Party fulfils paragraph 2.(a)	Iceland's total 1990 CO_2 emissions amounted to 2,158.6 Gg. Total 1990 CO_2 emissions from all Annex I Parties amounted to 13,728,306 Gg*. Iceland's CO_2 emissions are thus 0.016% of the Annex I Parties total, calculated in accordance with the table contained in the annex to document FCCC/CP/1997/7/Add.1 This is lower than the 0.05% threshold in paragraph 2(a).
Provide evidence that the selected project fulfils paragraph 2	Iceland's total CO_2 emissions for 1990 were 2,158.6 Gg Total industrial CO_2 emissions from the project in 2012 were 142.2 Gg or 6.6% of the 1990 CO_2 emissions. This is higher than the 5% threshold in paragraph 2.
Reporting of CO_2 emissions from the project, according to paragraph 5	The production increase resulting from this project amounted in 2012 to 89,734 tonnes of aluminium (189,932 tonnes in 2012 compared to 100,198 tonnes in 1995). The resulting CO_2 emissions are 142.2 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the plant and year specific C-content of the electrodes. The implied emission factor in for the expanded part in 2012 is 1.585 t CO_2 per tonne of aluminium. QA/QC procedures include

	collecting activity data through electronic surveys allowing immediate QC-check on IEF. More information is in the QA/QC Manual.
Provide evidence that the project fulfils paragraph 2.(b) and paragraph 5	Rio Tinto Alcan uses LPG for heating of melting pots and residual fuel oil in the foundry. In 2012 the total energy consumption was 1,740 tonnes of residual fuel oil and 209 tonnes of LPG leading to emissions of 6 Gg of GHG. The EF for residual fuel oil is 3.08 t CO_2-equivalents per tonne of fuel. The EF for LPG is 2.95 t CO_2-equivalents per tonne of fuel. The IEF for energy use is 0.05 t CO_2-equivalents per tonne of aluminium. These emissions are reported in the Energy sector. In 2012 the total use of electricity was 2,939 GWh, thereof 1,389 GWh were used for the expansion project. As stated in chapter 3.2., almost all energy in Iceland is produced from renewable energy sources (99.99%). Electricity for all heavy industry in Iceland is produced from renewable energy sources. The average emission per kWh from electricity production in Iceland is 11 CO_2/kWh. The total CO_2 emissions from the electricity use for the project amounts to 15.3 Gg. Had the energy been from a gas fired power plant with 55% effiicency the per kWh emissions would amount to 371 Gg. The resulting emissions from electricity use in the project would thus have amounted to 515 Gg. The resulting emissions savings are therefore 500 Gg.
Provide evidence that the project fulfils paragraph 2.(c)	To minimize process emissions BAT, as defined in the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is used in the production: ○ All pots are closed and the pot gases are collected and cleaned via a dry absorption unit; the technique is defined as BAT. ○ Prebake anodes are used and automatic multiple point feed. ○ Besides that computer control is used in the potlines to minimize energy use and formation of PFC. BEP is used in the process and the facility has a certified environmental management system according to ISO 14001. The environmental management system was certified in 1997. Besides the environmental management system, the facility also has a certified ISO 9001 quality management system and an OHSAS 18001 occupational health and safety management system. Further information is provided in chapter 4.5.2 above.

*http://unfccc.int/resource/docs/2007/sbi/eng/30.pdf

[#] All references to paragraphs are relating to the paragraphs of decision 14/CP.7

Fact sheet Single Projects under 14/CP.7

Name of the single project	**Elkem Iceland – expansion of ferrosilicon plant**
Name of the company/ production facility	Elkem Iceland
Location of the project	Grundartanga, 301 Akranes, Iceland
NIR category	2.C.2 Ferrosilicon production
Description of the industrial process facility	The Elkem Iceland Ferrosilicon plant at Grundartangi was established in 1977, when construction of two furnaces started. The first furnace came on stream in 1979 and the second furnace a year later. The production capacity of the two furnaces was in the beginning 60,000 tonnes of ferrosilicon, but was later increased to 72,000 tonnes. In 1993 a project started enabling over lasting of the furnaces in comparison to design. Thus it has been possible since to increase the production in those furnaces. In 1999 a third furnace was taken into operation. The project involves an expansion in the plant capacity by building a new furnace as well as over lasting the older furnaces. Electric (submerged) arc furnaces with Soederberg electrodes are used. All furnaces are semi-covered. Furnace 3 could not use wood in the process until 2012.
Evidence that the projects fulfils paragraph 1[#]	The Environment Agency of Iceland issues Operating licences for the Ferrosilicon plant in Grundartangi and is responsible for the supervision of the plant. Statistics on production is supplied to the Agency each year.
Evidence that the Party fulfils paragraph 2.(a)	Iceland's total 1990 CO_2 emissions amounted to 2,158.6 Gg. Total 1990 CO_2 emissions from all Annex I Parties amounted to 13,728,306 Gg*. Iceland's CO_2 emissions are thus 0.016% of the Annex I Parties total, calculated in accordance with the table contained in the annex to document FCCC/CP/1997/7/Add.1 This is lower than the 0.05% threshold in paragraph 2(a).
Provide evidence that the selected project fulfils paragraph 2	Iceland's total CO_2 emissions for 1990 were 2,158.6 Gg. Total industrial CO_2 emissions from the project in 2012 were 183 Gg or 8.5% of the 1990 CO_2 emissions. This is higher than the 5% threshold in paragraph 2.
Reporting of CO_2 emissions from the project, according to paragraph 5	The production increase resulting from this project amounted in 2012 to 55,567 tonnes of ferrosilicon (all production in furnace 3 plus increased production in furnaces 1 and 2). The resulting CO_2 emissions are 183 Gg. CO_2 emissions are calculated based on mass balance, using plant and year specific C-content of input (coal and coke as reducing agents) and output (FeSi, microsilica). The implied emission factor for the expanded part in 2012 was 3.292 t CO_2 per tonne of ferrosilicon (excluding

	emiisons from burning of wood) or 3.614 t CO_2 per tonne of ferrosilicon (including emissions from burning of wood). QA/QC procedures include collecting activity data through electronic surveys allowing immediate QC-check on IEF. More information is in the QA/QC Manual.
Provide evidence that the project fulfils paragraph 2.(b) and paragraph 5	Elkem Iceland uses gasoil for heating of melting pots. In 2012 the total energy consumption was 270 tonnes of gasoil leading to emissions of 0.86 Gg of GHG. The EF for gasoil is 3.18 t CO_2-equivalents per tonne of fuel. These emissions are reported in the Energy sector. In 2012 the total use of electricity was 1,032 GWh, thereof 485 GWh were used for the expansion project. As stated in chapter 3.2., almost all energy in Iceland is produced from renewable energy sources (99.99%). Electricity for all heavy industry in Iceland is produced from renewable energy sources. The average emissions per kWh from electricity production in Iceland are 11 g. The total CO_2 emissions from the electricity use for the project amounts to 5.3 Gg. Had the energy been from gas fired power plant with 55% efficiency the per kWh emissions would amount to 371 g. The resulting emissions from the project would thus have amounted to 180 Gg. The resulting emissions savings are 174 Gg.
Provide evidence that the project fulfils paragraph 2.(c)	To minimize process emissions BAT, as defined in the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is used in the production. Further the plant has an environmental management plan as a part of a certified ISO 9001 quality management system, meeting the requirement of BEP. For further information see chapter 4.5.2 above.

[#] All references to paragraphs are relating to the paragraphs of decision 14/CP.7

Fact sheet Single Projects under 14/CP.7

Name of the single project	**Century aluminium – establishment of aluminium plant**
Name of the company/production facility	Century Aluminium
Location of the project	Grundartanga, 301 Akranes, Iceland
NIR category	2.C.3 Aluminium production
Description of the industrial process facility	Aluminium production started at the Century Aluminium plant at Grundartangi in 1998. The plant consisted in the beginning of one potline. In 2001 a second potline was taken into operation. In 2006 a further expansion of the plant took place. The process used in all potlines is PFPB with automatic multiple point feed.
Evidence that the projects fulfils paragraph 1[#]	The Environment Agency of Iceland issues Operating licences for the Aluminium production plant at Grundartangi and is responsible for the supervision of the plant. Statistics on production is supplied to the Agency each year.
Evidence that the Party fulfils paragraph 2.(a)	Iceland's total 1990 CO_2 emissions amounted to 2,158.6 Gg. Total 1990 CO_2 emissions from all Annex I Parties amounted to 13,728,306 Gg*. Iceland's CO_2 emissions are thus 0.016% of the Annex I Parties total, calculated in accordance with the table contained in the annex to document FCCC/CP/1997/7/Add.1 This is lower than the 0.05% threshold in paragraph 2(a).
Provide evidence that the selected project fulfils paragraph 2	Iceland's total CO2 emissions for 1990 were 2,158.6 Gg (according to Iceland's Initial Report under the Kyoto Protocol). Total industrial CO_2 emissions from the project in 2012 were 431.8 Gg or 20% of the 1990 CO_2 emissions. This is higher than the 5% threshold in paragraph 2.
Reporting of CO_2 emissions from the project, according to paragraph 5	The production increase resulting from this project amounted in 2012 to 286,457 tonnes of aluminium. The resulting CO_2 emissions are 432 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the plant and year specific C-content of the electrodes. The implied emission factor in 2012 is thus 1.507 t CO_2 per tonne of aluminium. QA/QC procedures include collecting activity data through electronic surveys allowing immediate QC-check on IEF. More information is in the QA/QC Manual.
Provide evidence that the project fulfils paragraph 2.(b) and	Century Aluminium uses LPG and gasoil for heating of melting pots. In 2012 the total fuel consumption was 448 tonnes of gasoil and 170 tonnes of LPG leading to emissions of 1.9 Gg of GHG. The EF for gasoil is

paragraph 5	3.18 t CO_2-equivalents per tonne of fuel. The EF for LPG is 2.95 t CO_2-equivalents per tonne of fuel. The IEF for energy use is 0.008 t CO_2-equivalents per tonne of aluminium. These emissions are reported in the Energy sector. In 2012 the total use of electricity was 4,270 GWh. As stated before all the electricity used is produced from renewable sources. The average emission from this electricity is 11 g/kWh. The total CO_2 emissions from the electricity used for the project amounts to 47 Gg. Had the energy been from gas fired power plant with 55% efficiency the per kWh emissions would amount to approximately 371 g. The resulting emissions from the project would thus have amounted to 1,584 Gg. The resulting emissions savings are 1,537 Gg.
Provide evidence that the project fulfils paragraph 2.(c)	To minimize process emissions BAT, as defined in the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is used in the production: o All pots are closed and the pot gases are collected and cleaned via a dry absorption unit; the technique is defined as BAT. o Prebake anodes are used and automatic multiple point feed. o Besides that computer control is used in the potlines to minimize energy use and formation of PFC. Century Aluminium implemented an environmental management system according to ISO 14001. The system was certified in 2013. For further information on this see chapter 4.5.2

[#] All references to paragraphs are relating to the paragraphs of decision 14/CP.7

Fact sheet Single Projects under 14/CP.7

Name of the single project	**Alcoa Fjarðaál – establishment of aluminium plant**
Name of the company/production facility	Alcoa Fjarðaál
Location of the project	Reyðarfjörður, Iceland
NIR category	2.C.3 Aluminium production
Description of the industrial process facility	Aluminium production started at the Alcoa Fjarðaál plant at Reyðarfjörður in 2007. In 2008 the plant reached full production capacity of 346,000 tonnes of aluminium. The process used in all potlines is PFPB with automatic multiple point feed.
Evidence that the projects fulfils paragraph 1[#]	The Environment Agency of Iceland issues Operating licences for the Aluminium production plant in Reyðarfjörður and is responsible for the supervision of the plant. Statistics on production is supplied to the Agency each year.
Evidence that the Party fulfils paragraph 2.(a)	Iceland's total 1990 CO_2 emissions amounted to 2,158.6 Gg. Total 1990 CO_2 emissions from all Annex I Parties amounted to 13,728,306 Gg*. Iceland's CO_2 emissions are thus 0.016% of the Annex I Parties total, calculated in accordance with the table contained in the annex to document FCCC/CP/1997/7/Add.1 This is lower than the 0.05% threshold in paragraph 2(a).
Provide evidence that the selected project fulfils paragraph 2	Iceland's total CO_2 emissions for 1990 were 2,158.6 Gg (according to Iceland's Initial Report under the Kyoto Protocol). Total industrial CO_2 emissions from the project in 2012 were 522 Gg or 24.2% the 1990 CO_2 emissions. This is higher than the 5% threshold in paragraph 2.
Reporting of CO2 emissions from the project, according to paragraph 5	The production increase resulting from this project amounted in 2012 to 344,632 tonnes of aluminium. The resulting CO_2 emissions are 522 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the plant and year specific C-content of the electrodes. The implied emission factor in 2012 is 1.514 t CO_2 per tonne of aluminium. QA/QC procedures include collecting activity data through electronic surveys allowing immediate QC-check on IEF. More information is in the QA/QC Manual.
Provide evidence that the project fulfils paragraph 2.(b) and	Alcoa Fjarðaál uses LPG and gasoil for heating of melting pots. In 2012 the total fuel consumption was 446 tonnes of gasoil and 302 tonnes of LPG leading to emissions of 2.3 Gg of GHG. The EF for gasoil is 3.18 t CO_2-equivalents per tonne of fuel. The EF for LPG is 2.95 t CO_2-

paragraph 5	equivalents per tonne of fuel. The IEF for energy use is 0.007 t CO_2-equivalents per tonne of aluminium. These emissions are reported in the Energy sector. In 2012 the total use of electricity was 4,891 GWh. As stated before all the electricity used is produced from renewable sources. The average emission from this electricity is 11 g/kWh. The total CO_2 emissions from the electricity use for the project amounts to 54 Gg. Had the energy been from gas fired power plant with 55% efficiency the per kWh emissions would amount to approximately 371 g. The resulting emissions from the project would thus have amounted to 1,815 Gg. The resulting emissions savings are 1,761 Gg.
Provide evidence that the project fulfils paragraph 2.(c)	To minimize process emissions BAT, as defined in the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is used in the production: ○ All pots are closed and the pot gases are collected and cleaned via a dry absorption unit; the technique is defined as BAT. ○ Prebake anodes are used and automatic multiple point feed. ○ Besides that computer control is used in the potlines to minimize energy use and formation of PFC. Alcoa Fjarðaál has implemented an ISO 14001 environmental management system. The environmental management system was certified in 2012. For further information see chapter 4.5.2 above.

All references to paragraphs are relating to the paragraphs of decision 14/CP.7

ANNEX VI. Values used in calculation of digestible energy of cattle and sheep feed

A) MATURE DAIRY CATTLE

1. Dairy cattle, stallfed, lactation period[1,2]	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

[1] Jóhannes Sveinbjörnsson og Grétar H. Harðarson, 2008. Þungi og átgeta íslenskra mjólkurkúa. Fræðaþing landbúnaðarins: 336-344

[2] 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[3]	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[3,4]	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

[3] Jóhannes Sveinbjörnsson og Bragi L. Ólafsson, 1999. Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi. Ráðunautafundur 1999: 204-217.

[4] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

D) STEERS

1. Steers[5,6]	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[7]	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

[5] Jóhannes Sveinbjörnsson og Bragi L. Ólafsson, 1999. Orkuþarfir sauðfjár og nautgripa í vexti með hliðsjón af mjólkurfóðureiningakerfi. Ráðunautafundur 1999: 204-217.

[6] Harald Volden (ed.), 2011. Norfor- the Nordic feed evaluation system. EAAP publication no. 130. Wageningen Academic Publishers

[7] 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[8]	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[9]	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[10]	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

[8] Jóhannes Sveinbjörnsson, 2013: Fóðrun og fóðurþarfir sauðfjár. Kafli 4 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.

[9] Jóhannes Sveinbjörnsson, 2013: Fóðuröflun og beit á ræktað land. Kafli 5 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.

[10] Ólafur Guðmundsson, 1987: Átgeta búfjár og nýting beitar. Ráðunautafundur 1987: 181-192

G) LAMBS

1. Lambs, pre-weaning[11,12]	amount/day (kg dm)	dry matter digestibility (%)	ash (%)
gras/vegetation	0.4	70.0	7.0
milk	0.3	95.0	5.1
sum	0.7		
average		79.9	6.2
2. Lambs, after-weaning[13,12]	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

[11] Ólafur Guðmundsson, 1987: Átgeta búfjár og nýting beitar. Ráðunautafundur 1987: 181-192

[12] 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)

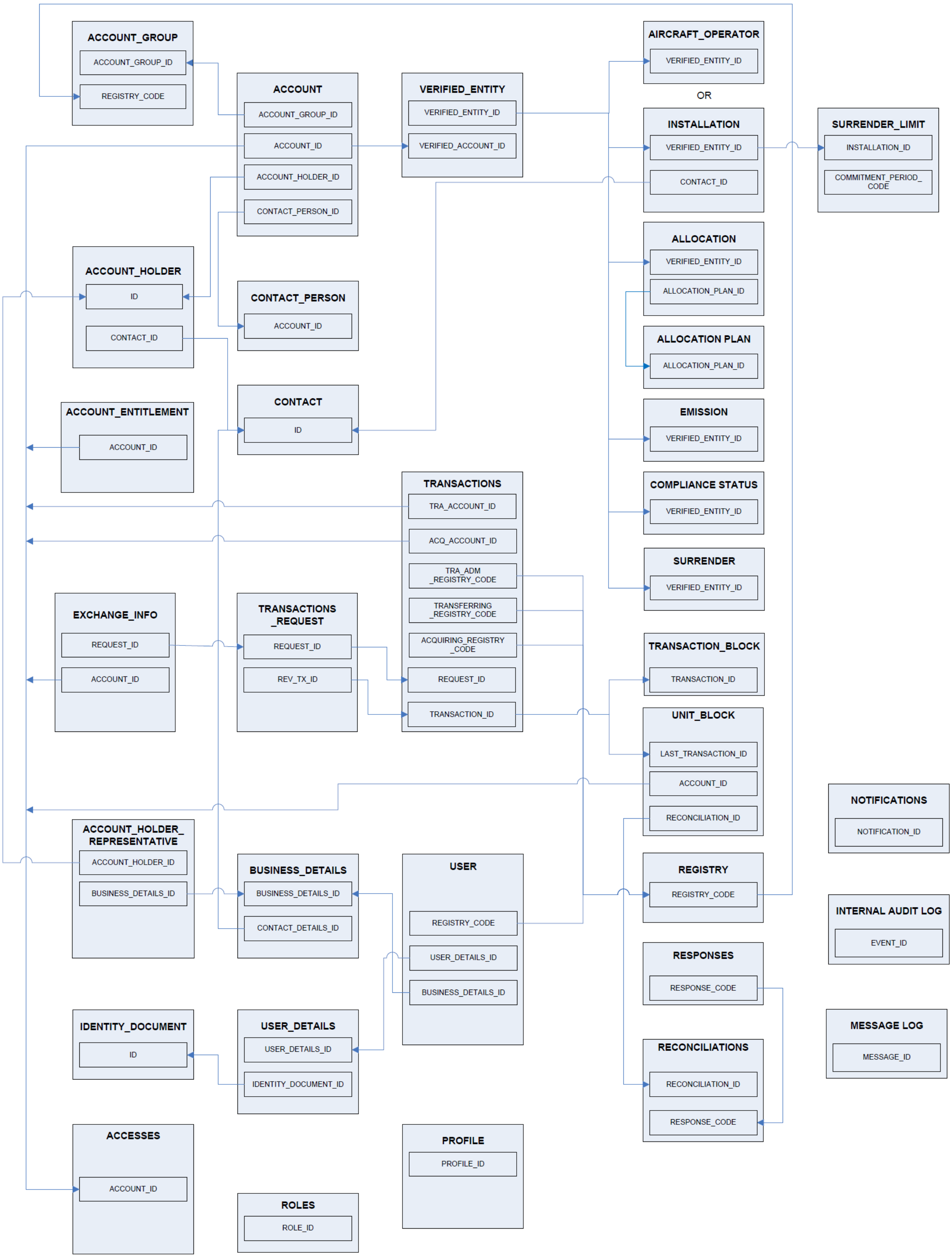
[13] Jóhannes Sveinbjörnsson, 2013: Fóðuröflun og beit á ræktað land. Kafli 5 í: Sauðfjárrækt á Íslandi. Útg. Uppheimar, 2013.

H) CONVERSION OF DMD INTO DE[14]

	dry matter digestibility	organic matter digestibility	metabo-lisable energy	metabo-lizality	Net energy for lactation	Net energy of 1 kg barley	Digestible energy
	DMD	OMD	BO	q	NO_m	FE_m	DE
	%	g/kg	kJ/kg dm		kj/kg		%
calculations	cf. A-G	(0.98*DMD-4.8)*10	15*OMD	BO/18500*100	0.6*(1+0.004*(q-57))*09752*BO	NO_m/6900	OMD*15/0.81/18.5/10
mature dairy cows	74.4	681.6	10,224	55.3	5,941	0.861	68.2
cows used for producing meat	74.4	680.7	10,210	55.2	5,931	0.860	68.1
heifers	74.4	681.3	10,219	55.2	5,937	0.861	68.2
steers used principally for producing meat	72.5	662.5	9,938	53.7	5,738	0.832	66.3
young cattle	79.7	733.4	11,001	59.5	6,500	0.942	73.4
sheep	70.5	642.5	9,637	52.1	5,528	0.801	64.3
lambs	83.5	770.7	11,561	62.5	6,913	1.002	77.2

[14] Guðmundsson, Ó. And Eiríksson, T. (1995) Breyting á orkumatskerfi fyrir jórturdýr (Ráðunautafundur, 1995)

ANNEX VII. CSEUR Database structure



ANNEX VIII. Test results of changes introduced in versions 5 (January 2013) and 6 (June 2013) of the CSEUR

SUMMARY	TEST CASES	PRIORITY	FAT RELEASES 5.2 - 6.1.7.1 EXECUTION STATUS	COMMENTS / ISSUES
Tamper with Browser Request Data	TC_QTM01_03: Verify that it is not possible to modify transaction data after a transaction's confirmation	HIGH	PASSED	
Transaction Units Paging	TC_QTM01_01: Browse Transaction Details of a Transaction with Less Than 10 Lines	MEDIUM	PASSED	
	TC_QTM01_02: Browse Transaction Details of a Transaction with More Than 10 Lines	MEDIUM	PASSED	
National Holidays	TC_QTM01_08: Insert an Add to TAL transaction	HIGH	PASSED	
	TC_QTM01_09: Insert an internal transfer transaction	HIGH	PASSED	
New Activity Codes	TC_QTM01_05: Insert a new Installation	HIGH	PASSED	Translations for the new activity type codes are not included in this v5.2 build. They will be included in the build that will be provided on 18/01/2013 for deployment at the UT environment.
	TC_QTM01_06: Update an Existing Installation	HIGH	PASSED	
	TC_QTM01_07: Browse an Installation	HIGH	PASSED	
Portuguse Translation	TC_QTM01_11: Confirm new menu item for Portuguese exists	MEDIUM	PASSED	
Issuance Limits	TC_QTM01_04: Save Issuance Limits for Phase 3	HIGH	PASSED	
Upload emissions via XML file	TC_QTM01_10: Upload XML files for different periods	MEDIUM	PASSED	
New Activity Type Codes	Request update of business details of Authorised	MEDIUM	PASSED	

	Representative (Medium)			
	Request update of business details of Additional Authorised Representative (Medium)	MEDIUM	PASSED	
	Request update of business details of AR/ AAR that requires approval (Medium)	MEDIUM	PASSED	
	Cancel the update of business details of AR/AAR (Low)	LOW	PASSED	
	Request update of business details of AR/ AAR is approved by EUTL (High)	HIGH	PASSED	
	Request update of business details of AR/ AAR is rejected by EUTL (High)	HIGH	PASSED	
	Request update of business details of AR/ AAR is rejected by Administrator (High)	HIGH	PASSED	
	Request update of business details of AR/ AAR is approved by Administrator and by EUTL (High)	HIGH	PASSED	
	Request update of business details of AR/ AAR is approved by Administrator and rejected by EUTL (High)	HIGH	PASSED	
Upload emissions via XML file	Enter CO2 emissions to OHA (High)	High	PASSED	
	Enter CO2, N2O and PFC emissions to OHA (High)	HIGH	PASSED	
	Enter CO2 emissions to AOHA (High)	HIGH	PASSED	
	Enter emissions to Verified account as National Administrator (Medium)	MEDIUM	PASSED	
	Enter emissions – Data Validation – Negative Testing (Low)	LOW	PASSED	
	Yearly compliance status logging job – 1st May (Medium)	MEDIUM	PASSED	
	Upload emissions with XML file for one installation/ operator (High)	HIGH	PASSED	
	Upload XML file with multiple emissions elements-Data Validation (High)	HIGH	PASSED	
	Upload emission file with invalid format – Negative testing (Low)	LOW	PASSED	
	Upload XML file with invalid size – Negative testing (Low)	LOW	PASSED	
	Upload XML file with invalid emissions elements – Negative testing (Low)	LOW	PASSED	
	Upload XML file when pending emissions exists (Low)	LOW	PASSED	

	Cancel the upload of XML file (Low)	LOW	PASSED	
	Upload XML file when pending emissions exists (Low)	LOW	PASSED	
Translations of activity types	Log in as PT user and verify activity types are in PT	MEDIUM	PASSED	
	Log in as GR user and verify activity types are in GR	MEDIUM	PASSED	
	Insert an Installation with a new activity type in GR	MEDIUM	PASSED	
	Update an Installation with a new activity type in GR	MEDIUM	PASSED	
Add role for account statements tab	Log in with a user with the new permission (PERM_ACC_STATEMENTS_VIEW) and confirm this user can access the "Statements" tab of an OHA	HIGH	PASSED	
	Log in with a user without the new permission (PERM_ACC_STATEMENTS_VIEW) and confirm this user cannot access the "Statements" tab of an OHA	HIGH	PASSED	
	Log in with a user who has the permission (PERM_ACC_STATEMENTS_VIEW) and is a Verifier and confirm this user cannot access the "Statements" tab of an OHA	HIGH	PASSED	
Transferring and acquiring accounts are reversed in account statements	Log in as a user who can access account statements and confirm transferring and acquiring accounts are not reversed.	HIGH	PASSED	
Fixes for the population of SEF reports	Run a SEF report from the interface. Verify data against UN and database figures.	HIGH	PASSED	
Enabling Phase 3 Allocation from 1/1/2013	As CA: Enter Issuance Limits for Phase3; As CA: Enter figures for P3 issueance; As NA: Upload Allocation Table for Phase 3 in EUCR and EUTL; As NA: Check installation(s) to receive units. Confirm allocations to OHA are performed and transaction(s) is/are generated which is/are completed and allocate to OHA(s) the amount(s) checked.	HIGH	PASSED	
Surrender CER for CYP OHA incorrect	Surrender allowances for OHA, CYP Registry. Confirm it is routed to EU Deletion account	MEDIUM	PASSED	

	Surrender CERs for OHA, CYP Registry. Confirm it is routed to EU Cancellation account	MEDIUM	PASSED	
	Surrender allowances for AOHA, CYP Registry. Confirm it is routed to EU Deletion account	MEDIUM	PASSED	
	Surrender allowances for AOHA, CYP Registry.Confirm it is routed to EU Aviation Set-aside account	MEDIUM	PASSED	
	Surrender allowances for OHA, MT Registry. Confirm it is routed to EU Deletion account	HIGH	PASSED	

	Surrender CERs for OHA, MT Registry. Confirm it is routed to EU Cancellation account	HIGH	PASSED	
	Surrender allowances for AOHA, MT Registry. Confirm it is routed to EU Deletion account	HIGH	PASSED	
	Surrender allowances for AOHA, MT Registry. Confirm it is routed to EU Aviation Set-aside account	HIGH	PASSED	
	Surrender allowances for OHA, GR Registry. Confirm it is routed to EU Deletion account	HIGH	PASSED	
	Surrender CERs for OHA, GR Registry. Confirm it is routed to KP Greece Party Holding account	HIGH	PASSED	
	Surrender allowances for AOHA, GR Registry. Confirm it is routed to EU Deletion account	HIGH	PASSED	
	Surrender allowances for AOHA, GR Registry. Confirm it is routed to EU Aviation Set-aside account	HIGH	PASSED	
Account closure requests for AOHA are getting rejected by EUTL	1. Choose an AOHA 2. Select account closure 3. Confirm account is closed. 4. Choose an OHA 5. Select account closure 6. Confirm account is closed.	HIGH	PASSED	Note: The user must NOT have permission PERM_ACC_CLOSE_BYPASS because it is not implemented correctly.
SD Agent cannot close Reconciliation	1. Connect as SD Agent 2. Go to AdminèReconciliation page 3. Choose an open Reconciliation 4. Confirm “Close” is available 5. Close the Reconciliation 6. Confirm the status of the Reconciliation is now closed	HIGH	PASSED	Note: To access the "Administration" menu, the role of the user must have one of the following permissions: * PERM_USERS_SEARCH * PERM_ROLE_PERMISSION_UPDATE * PERM_BLOCKS_VIEW * PERM_GROUPS_LIST

Amendments to NAP/CAAT are rejected by EUTL with the response code 7704	1. Connect as NA2. Go to Phase 2 NAP***Add an entry***3. Add a NAP entry via the screen4. Confirm the add is applied on the NAP 5. Add a NAP entry via the screen6. Confirm the add is applied on the NAP7. Check in EUTL=>NAP/NAAT menu=?Select CP & Registry=>NAP=>installations=>check the corresponding installation that the entry is added***Delete an entry***9. Delete a NAP entry via the screen10. Confirm the deletion is applied on the NAP11. Delete a NAP entry via the screen12. Confirm the deletion is applied on the NAP13. Check in EUTL=>NAP/NAAT menu=>Select CP & Registry=>NAP=>installations=>check the corresponding installation that the entry is deleted	HIGH	PASSED	

	1. Connect as NA 2. Go to Phase 2 NAP =>Aviation Allocation Plans ***Add an entry*** 3. Add a NAAT entry via the screen 4. Confirm the add is applied on the NAAT 5. Add a NAAT entry via the screen 6. Confirm the add is applied on the NAAT 7. Check in EUTL=>NAP/NAAT menu=?Select CP & Registry=>NAAT=>installations=>check the corresponding installation that the entry is added ***Delete an entry*** 9. Delete a NAAT entry via the screen 10. Confirm the deletion is applied on the NAAT 11. Delete a NAAT entry via the screen 12. Confirm the deletion is applied on the NAAT 13. Check in EUTL=>NAP/NAAT menu=>Select CP & Registry=>NAAT=>installations=>check the corresponding installation that the entry is deleted	HIGH	PASSED	
Birth date is only validating on year and not on date of year	TC_V5.4_13: 1. Connect as NA 2. Go to Account Request 3. Submit an OHA open request 4. Declare a new Account Holder 5. Enter the birth date of the account holder as <<today>> +1 day -18 years 6. Ensure the on screen validation states "applicant must be at least 18 years old" 7. Enter the birth date of the account holder as <<today>> -1 day -18 years 8. Ensure the on screen validation does not reject the applicant 9. Enter the birth date of the account holder as <<today>> -18	LOW	PASSED	

	years 10. Ensure the on screen validation does not reject the applicant			
Sort by transaction order is not correct	TC_V5.4_14: 1. Connect as NA 2. Go to Transactions 3. Click Search 4. Sort by Transaction ID 5. Ensure sorting is not string-based but number based (i.e. EU7 comes below EU27)	HIGH	PASSED	
Filtering despite letter size	TC_V5.4_15: 1. Connect as NA 2. Go to Accounts 3. Click Search 4. Sort by Account Holder Name 5. Ensure sorting is not affected by letter capitalization (i.e. "a" comes before "B")	LOW	PASSED	

Names of ARs not visible during the account opening procedure	TC_V5.4_16:1. Connects as NA2. Connect to menu Account Request3. Select to open an Operator Holding Account4. Select a new account holder5. Provide details of the account holder6. Add a new AR via the provision of its URID7. Check that the table at the top of the page contains the full details of the AR corresponding to the provided URID7. Repeat for second AR8. Complete the account request9. Confirm the full details of the entreed users appear on the application form	HIGH	PASSED	
Technical error message whilst un-enrolling user	TC_V5.4_17: 1. Connect as NA 2. Go to menu Administration==>Users==>Click the search button 3. Click on the radio button next to a user 4. Click the un-enroll button 5. From the subsequent confirmation screen click on "submit" without entering a reason 6. The following error message appears: "Please provide a reason for the un-enrolment request (maximum 255 characters)"	LOW	PASSED	

When searching on Account holder in the Claim Account section, error message displayed is not user friendly	TC_V5.4_18: 1. Connect as NA 2. Go to menu Accounts==>Claim Account 3. Enter the Identifier of an account which is in status "Transfer Pending" 4. Click next 5. Enter the Identifier of an account holder already recorded in the Registry and is already linked to the specific account 6. Click Submit 7. The error message appears: "The account holder with identifier ZZZ is already linked to the account YYY" where ZZZ and YYY the identifiers of the account holder and account respectively.	HIGH	PASSED	
Delete NAAT entry: Spelling Error in the confirmation screen	TC_V5.4_19: 1. Connect as NA 2. Go to menu EUETS==>Allocation Tables Phase 3 3. Select the tab National Aviation Allocation Tables 4. Click on an aircraft operator radio button 5. Click the Delete button 6. The alert mentions "Confirm the deletion of 1 aircraft operator"	LOW	PASSED	
Wrong ID in notification e-mail		HIGH	PASSED	
Labels wrong in Pre-Allocation	TC_V5.4_20: 1. Connect as CA, EU Registry 2. Go to menu EUETS==>Pre-allocation 3. Confirm that in section: "Union-wide issuance" the second and third column are titled: "Issuance" and "Issued" respectively.	LOW	PASSED	
Please change "National Allocation Plans" to "National Allocation Tables" everywhere they relate to Phase 3.	TC_V5.4_21: 1. Connect as NA 2. Go to EUETS==>Allocation Tables Phase 3 3. Confirm the term "Plans" does not appear in this screen but only the term "Tables"	HIGH	PASSED	

Make the phase clear on allocation and allocation plans	TC_V5.4_22: 1. Connect as NA 2. Observe EUETS menu 3. Confirm the available selections specify Allocation Plans Phase 2 & Allocation Tables Phase 3.	LOW	PASSED	
Account Statements PDF	1. Log in as NA or AR. 2. Select an account 3. Select the "Account Statements" tab. Ensure the following: a. Commission flag is on the upper left b. Text “Registry admin of country XX” is on the upper right c. On the bottom of the report, a disclaimer appears from system translations; if a Registry provides text, this text appears instead.	HIGH	PASSED	
Names of ARs not visible during the account opening procedure	TC_V5.4.1_1:1. Connects as NA2. Connect to menu Account Request3. Select to open an Operator Holding Account4. Select a new account holder5. Provide details of the account holder6. Add a new AR via the provision of its URID7. Check that the table at the top of the page DOES NOT contain the full details of the AR corresponding to the provided URID7. Repeat for second AR8. Complete the account request9. Confirm the full details of the entreed users DO NOT appear on the application form	MEDIUM	PASSED	

Account statements pending functionality a. Alignment of GUI with PDF b. Extension to show transaction details + statement PDF	TC_V5.4.1_2: 1. Confirm transaction requests and transactions respect statuses presented in sheet "Transaction statuses" of the current sheet in both screen and PDF form. 2. Confirm every transaction request offers "show PDF" button and presents details of the request 3. Confirm every transaction offers "show PDF" button and presents details of the transactions.	HIGH	PASSED	
Account statements - PDF file - logo Replace "Registry Administrator of Country Czech Republic" with the logo of our company at the top of generated PDF Account Statement.	TC_V5.4.1_3: 1. Log in as Czech NA 2. Select PDF generation of an account statement of an account. At the top right corner, the "OTE" logo must appear. 3. Log in an GR NA 4. Select PDF generation of an account statement of an account. At the top right corner, the "OTE" logo must not appear.	LOW	PASSED	-
Unable to access registry if there are no characters in the national welcome page	TC_V5.4.1_4: 1. Ensure a Registry has no front page text via the Administration=>Update Front Page text menu selection 2. Log in as a user of Registry's user 3. Visit the home page and ensure it shows an entry screen, with all usual menus in place	HIGH	PASSED	
(EUTL, change in V_TOTALS_ACCOUNT_IDENTIFIER view, already applied in PROD)	TC_V5.4.1_5: <<This has been tested internally via database queries>>	MEDIUM	PASSED	

It must be possible to add a user as AAR to an account with status EXCLUDED	TC_V5.4.1_6: 1. Log in as NA 2. Exclude an account via the account list screen 3. Go to the "Additional Authorized Representatives" tab 4. Click the "Add AAR" button 5. Fill in the AAR details 6. Confirm the AAR is added on the specific account	MEDIUM	PASSED	
Change in dynamic compliance calculation for AOHA	TC_V5.4.1_7: 1. For a BLOCKED AOHA account 2. Submit & verify 2012 emissions equal to zero for this AOHA 3. Confirm account status turns to INACTIVE of this AOHA TC_V5.4.1_8: 1. For an OPEN AOHA account 2. Submit & verify 2012 emissions equal to zero for this AOHA 3. Confirm account status turns to INACTIVE of this AOHA	HIGH	PASSED	

Validations for remaining ARs when removing un-enrolled user from account	TC_V5.4.2_1: 1. Select an account. Set its status to SUSPENDED2. Confirm the button REMOVE does not appear for any AR of the accountTC_V5.4.2_2: 1. Select an account. 2. Set an AR to "view-only" 3. Confirm the button REMOVE appears next to the ARTC_V5.4.2_3: 1. Set the MIN_REP_ACCOUNT for a registry to 22. Select an account with two ARs. 3. Confirm the button REMOVE does not appearTC_V5.4.2_4: 1. Set the MIN_REP_ACCOUNT for a registry to 22. Select an account with three ARs. 3. Un-enrol two of its ARs4. Confirm the enrolled AR cannot be removedThe respective flowchart appears on the worksheet "Remove AR flowchart"	HIGH	PASSED	

Button "Remove" appears next to ARs if ARs attached to an account are more than MIN_REP_ACCOUNT	TC_V5.4.2_5: 1. Select an account 2. Select "View Details" 3. Select the "Authorized Representatives" tab 4. Confirm a table with the following data appears: Minimum number of ARs allowed for this account Maximum number of ARs allowed for this account Number of view-only ARs of this account Number of un-enrolled ARs of this account Number of enrolled ARs of this account	HIGH	PASSED	
	TC_V5.4.2_6: 1. Define MIN_REP_ACCOUNT for a Registry as 2 2. Set 2 ARs for an account 3. Confirm the "Remove" button does not appear next to any AR 4. Add an AR to the account 5. Confirm the "Remove" button appears next to every AR of the account	HIGH	PASSED	
Transaction details unrecoverable error	TC_V5.4.2_7: 1. Locate a migrated transaction (i.e. without transaction request) 2. Open transaction details tab for this transaction 3. Ensure the screen works and shows empty comments	HIGH	PASSED	-
Unable to remove an AR from 3 accounts	It should be possible to remove an enrolled AR. See EUCR-319 and EUCR-320 above	HIGH	PASSED	-

Users able to see names of Service Desk Agents User sees SD people in the list of claimants of the task	TC_V5.4.2_8: 1. Connext as any user 2. Claim a task 3. Assign it to a user 4. Confirm the list of SD agents of this Registry do not appear in the list	HIGH	PASSED	
Wrong label in the "Units" part of the ITL notification page ref #222	The page KYOTO Protocol=>ITL Notifications contains an extra column which is empty. This column was removed.	MEDIUM	PASSED	
New transaction types for Banking	Banking is implemented by deleting installation and aviation allowances of Phase 2 and issuing equal number of Phase 3 allowances (Reg 920/2010, art.57). To track such transactions, the following new transaction types were introduced: • DeletionChapter2Banking (10,33) • IssuanceChapter2Banking (1,33) • DeletionChapter3Banking (10,34) • IssuanceChapter3Banking (1,34)	HIGH	PASSED	-
Export of a transaction's XML needs to export its number of units	TC_V6.1_1:1. Connect as NA2. Navigate to Accounts=> Transactions Screen3. Enter search criteria and click "Search and Export"4. On the geneated CSV file confirm the field "NB of Units" exists and contains the actual transaction units.	MEDIUM	PASSED	
Management of eligibility lists and	UC_BL_001: Initial list upload	HIGH	PASSED	
	UC_BL_003: Export lists from EUCR	HIGH	PASSED	

blocking of transfer of ineligible units to ETS accounts	UC_BL_008: View Lists	HIGH	PASSED	
	UC_BL_006: View List Change Logs	HIGH	PASSED	
	UC_BL_007: View (in)eligible units of a Registry (Unit Block Management screen)	HIGH	PASSED	
	UC_BL_027: Modify list projects	HIGH	PASSED	
	UC_BL_028: Modify list unit blocks	HIGH	PASSED	
	UC_BL_009: Perform transactions on (in-)eligible units	HIGH	PASSED	
	UC_BL_033: Manage incoming transactions	HIGH	PASSED	
	UC_BL_011: Select (in)eligible units for a transaction	HIGH	PASSED	
	UC_BL_012: Block incoming transactions into EUETS accounts when they contain ineligible units	HIGH	PASSED	
	UC_BL_031: Block in-eligible unit types	HIGH	PASSED	
	UC_BL_013: View eligible and ineligible units of a user's accounts (Account Holdings screen)	HIGH	PASSED	
	UC_BL_014: View entitlement, surrendered and exchanged quantities (Placeholder of future functionality)	HIGH	PASSED	
	UC_BL_016: Account statements show balances of (in-)eligible units	HIGH	PASSED	
Must make it clear to an AR that they can only select destination accounts from their Trusted Account List	TC_V6.1_2: 1. Connect as AR of an account 2. Navigate via Accounts menu to the specific account 3. Propose a "transfer of allowances" transaction for the specific account 4. The transfer screen shows very clearly that the account entry fields are disabled and that the user can only click on the "select from trusted accounts" hyperlink. 5. Confirm that it is not possible to click on the account entry fields, which are clearly disabled.	HIGH	PASSED	Issue was implemented by presenting visually the inability of the account fields to be clicked.

Display Account Identifier in Account Closure Task	TC_V6.1_3: 1. Connect as NA 2. Via the Accounts screen locate an account 3. Click on the "Close" hyperlink of the account 4. Connect as second NA 5. Claim the account closure task and observe its task description screen 6. Confirm the identified of the account to be closed is visible on the task description screen	MEDIUM	PASSED	
Account Holder Details Update needs name of Account Holder, not just the ID	TC_V6.1_4: 1. Connect as NA 2. Select an account and navigate to Account Main => Account Holder section 3. Click on Update and change some details of the account holder 4. Connect as second NA 5. Claim the business details update of the account holder 6. Confirm the task description screen contains sections: Account Holder: Non-updatable details Account Holder: Updated details 7. COnfirm that the account holder name appears in "Account Holder: Non-updatable details" section	MEDIUM	PASSED	

Cannot see who requested and approved a transaction	TC_V6.1_5: 1. Connect as AR 2. Navigate to Accounts=>Transactions screen and locate a transaction 3. Click on "Request Details" tab 4. Confirm this tab contains the following columns: User Act: The action on the transaction (i.e. proposal, approval) Act Date: The respective date of the action User ID: The ID of the user performing the transaction User First Name: the first name of the user performing the update User Last Name: the last name of the user performing the update	MEDIUM	PASSED	Since response codes already appear on another tab, a new tab was introduced named "request details". This tab presents the lifetime of the request of the transaction.
Check digits do not display when looking at Unit Block display	TC_V6.1_6:1. Connect as NA2. Navigate to Administration => Unit Blocks screen3. Enter any search criteria (or none at all) and click on "Search"4. Confirm the generated account list contains the Holding Account5. Confirm the Holding Account column contains the check digit of each account	MEDIUM	PASSED	

Inconsistency of terminology between External Platform and Trading Platform	TC_V6.1_7: Confirm the following sections contain the term "External Trading Platform" and neither "External Platform" nor "Trading Platform" 1. Account Request screen: account type drop-down 2. Email notification with the request; the attachment name 3. Content of the account opening PDF; the account type 4. Account search: the account type filter drop-down 5. Account search results: the account type 6. View account details: the account type	HIGH	PASSED	
Claiming all tasks errors if you already own one	TC_V6.1_8: Confirm the three following scenarios: A 1. Go to Task List screen and click and claim three tasks 2. None of the tasks are claimed 3. All three of the tasks should now belong to the logged-in user B 1. Go to Task List screen and click and claim three tasks 2. One of the tasks is already claimed by the logged-in user; two other tasks are unclaimed 3. All three of the tasks should now belong to the logged-in user C 1. Go to Task List screen and click and claim three tasks 2. One of the tasks is already claimed by another user 3. The message " Claim task item error:One or more task items cannot be claimed, because they are not in unclaimed status." appears and claiming stops	MEDIUM	PASSED	1. It was not requested to alter the exection of tasks unclaiming 2. The error message might need to be altered as well since "Claim task item error:One or more task items cannot be claimed, because they are not in unclaimed status." is not always relevant

Allow "Return to Search" on filter selections	TC_V6.1_9: 1. Connect as NA 2. Navigate to Accounts search screen 3. Enter some criteria (or none at all) and click on "Search" 4. Click on a column to alter sorting 5. Click on an account from the list of returned accounts 6. View the details of the account 7. Click on "Return to Search" 8. Observe that the account search criteria and sorting are preserved	MEDIUM	PASSED	The up or down arrow of the sorted column is not preserved.
Data field 'VAT Registration Number with Country Code' too short	TC_V6.1_10: 1. Connect as AR 2. Request a new account via "Account Request" screen 3. Request the creation of a new Account Holder 4. Select account holder is company 5. Confiorm the VAT field can enter and save 55 characters totally	HIGH	PASSED	
Comments being truncated	TC_V6.1_11: 1. Connect as AR of an account 2. Navigate to the account 3. Propose a transaction 4. Enter comments 5. Confirm entered comments can reach 256 characters 6. Confirm the comments are preseved in the transaction details screen	HIGH	PASSED	

Sorting in Unit Block Search Result	TC_V6.1_12:1. Connect as NA2. Navigate to Administration => Unit Blocks screen3. Enter some criteria (e.g. Holding Account Type=Operator Holding Account)4. On the presented list, alter sorting by clicking on column headers5. Confirm that entered criteria are respected after altering the sorting	MEDIUM	PASSED	
Sorting in JI Projects and conversion to ERUs. Improvement of the UI.	TC_V6.1_13: 1. Connect as NA 2. Navigate to KYOTO protocol => JI projects screen 3. Enter some criteria (e.g. Track=TRACK_1) 4. On the presented list, alter sorting by clicking on column headers 5. Confirm that entered criteria are respected after altering the sorting	MEDIUM	PASSED	
Date range selection in account statements do not allow start date=end date	TC_V6.1_14: 1. Connect as AR of an account 2. Select the account via Account search screen 3. Navigate to "Account Statements" tab 4. Enter Start Date and End Date the same date 5. Confirm the account statement is generated for this specific date in screen and PDF form.	MEDIUM	PASSED	

Account statements do not show all categories of transaction	TC_V6.1_15: 1. Connect as AR of an account 2. Select the account via Account search screen 3. Navigate to "Account Statements" tab 4. Enter a start and an end date 5. Confirm the generated statement contains the following sections: A(Request), B(Pending), C(Completed) and D(Terminated). Default (original) tab is Completed tab.	MEDIUM	PASSED	
NL - Request to change pop up text non domestic emissions	TC_V6.1_16: 1. Connect as NA for NL (or another Registry using the standard EN language translation) 2. Navigate to an AOHAccount 3. Navigate to Compliance tab 4. Hover over the question mark next to non-domestic emissions 5. Confirm the explanatory text is the following: "Relate to all flights which departed from an aerodrome situated in the territory of an EU Member State and arrived at an aerodrome situated in the territory of another EU Member State or a third country and to all flights which departed from an aerodrome situated in the territory of a third country and arrive at an aerodrome situated in the territory of an EU Member State".	MEDIUM	PASSED	
Phase 3 duration in Surrender screen needs to be 2013~2020 (Jira issue revised for clarity)	TC_V6.1_17: 1. Connect as AR of an account 2. Select the account via Account search screen 3. Navigate to Surrender tab 4. Confirm the Phase 3 duration presented on upper left corner is 2013~2020	MEDIUM	PASSED	

SD Agent role _ does not work properly	TC_V6.1_18: 1. Connect as SD_Agent 2. Confirm that under Administration, the menu entries Send Message, Reconciliation, Message Logs are shown and that they lead to respective screens Note: The functionality of those menu entries is defined in respective use case documents.	HIGH	PASSED	
After every insert/deletion of record in EUCR eligibility/ineligibility lists, all four lists must be exported from EUCR and imported in EUTL.This is changed so that only the affected list needs to be exported from EUCR and imported in EUTL.	UC_BL_001_TC_009:1. Connect as CA2. Add a project in CDM Negative list3. Download CDM Negative list from EUCR4. Upload CDM Negative list in EUTL5. Add the same project in General Positive List 6. Download General Positive List from EUCR7. Upload General Positive List in EUTL8. Delete the project from CDM Negative list9. Download CDM Negative list from EUCR10. Upload CDM Negative list in EUTL11. Confirm the specific project in EUCR and in EUTL is eligibleRepeat the above for ERU Negative list and Application Procedure Positive list.	HIGH	PASSED	
"View list log" link should show the screen analysing changes to logs, as described in UC_BL_006.	TC_V6.1.1_01: 1. Login as NA or CA 2. Click the link Administration=>View List Log 3. Confirm the respective screen appears	HIGH	PASSED	-

After the compliance status of all accounts is calculated and published in EUTL Public (on 15 May), emissions may be entered/modified via NA intervention. EUTL Public shows a "*" next to the compliance status of an account, if emissions are entered/modified manually after 15 May.	TC_V6.1.1_02: 1. Login as NA 2. Find an account and enter its Compliance tab 3. Enter/modify emissions for 2012 for this account 4. Login as verifier of this account 5. Approve emissions entered during step [3] 6. Go to EUTL Public => OHA Search => View Details - All Periods=> Navigate to the table Compliance Information for 2012. Next to the Compliance Code, a "*" must appear.	HIGH	PASSED	
An AR can be removed from an account, provided at least 2 ARs remain for this account. The number "2" corresponds to a limit defined per Registry, called MIN_REP_ACCOUNT. AARs can also be removed from accounts.	TC_V6.1.1_03: Confirm AARs can be removed from an account.	HIGH	PASSED	

Transactions in status COMPLETED appear to ARs/AARs of transferring and acquiring accounts. Transactions in status DELAYED_CANCELLED should not appear to to ARs/AARs of acquiring accounts, because the transaction is not completed.	TC_V6.1.1_04: 1. Login as AR of account A 2. Enter a transfer from account A to account B 3. Programmatically set the transaction to status DELAYED-CANCELLED 4. Login as as AR of account B, without access to account A 5. The last logged-in user must NOT see the mentioned transactions	HIGH	PASSED	
The number of ARS of an account is compared to the maximun allowed per Registry. This number used to count only ENROLLED users of this account. This is now changed; this number now also includes VALIDATED users of this account.	TC_V6.1.1_06: 1. Login as NA 2. Assume the limit of minimum ARs for this Registry is 2 3. Find an account with 2 ENROLLED ARs 4. Add a VALIDATED user on this account as AR 5. Remove an ENROLLED AR 6. The AR should be allowed to be removed, because the remaining ARs (1 ENROLLED + 1 VALIDATED) is acceptable for the account	HIGH	PASSED	
After deleting a project from a list, the screen needed an additional refresh to remove the deleted record. This is now fixed and no additional refresh is needed.	TC_V6.1.1_07: 1. Connect as CA 2. Navigate to Administration => View List Details 3. Select a list 4. Delete a record 5. Confirm the deletion 6. The record is deleted without a screen refresh on the underlying "View List Details" screen	HIGH	PASSED	

When entering a record in an (in-)eligibility list, the value in "project identifier" field should be numeric only. A friendly message should appear.	TC_V6.1.1_08:1. Connect as CA2. Navigate to Administration => View List Details3. Select a list4. Click on "Insert" button5. In the "Project Identifier" field enter "abc" and click "Insert"6. The message "Project Identifier: the value provided must be numeric." should appear	HIGH	PASSED	-
In "Request Details" tab of a transaction, clarify the labels of user and action	TC_V6.1.1_09: 1. Connect as any user 2. Open a transaction 3. Navigate to "Transaction Details" 4. Confirm the headers of the table are: User Action, Action Date, URID	HIGH	PASSED	
The name of ERU Negative list appears with correct capitalisation in View List Details screen	TC_V6.1.1_10: 1. Connect as CA 2. Navigate to Administration => View List Details 3. Ensure the name of list ERU Negative list appears with correct capitalisation.	HIGH	PASSED	
The names of exported list filenames should have identifieable names	TC_V6.1.1_15: 1. Connect as CA 2. Navigate to Administration=>View List Details 3. Perform a search 4. Export the retrieved records 5. Ensure the proposed filename is related to the chose list & current date	HIGH	PASSED	

Unit block management screen should show list eligibility information of presented unit blocks.	TC_V6.1.1_16: 1. Connect as NA 2. Navigate to Administration=>Unit Blocks 3. Ensure information on eligibility and flagging reason appears	HIGH	PASSED	
Delayed processes (for example: DELAYED transactions to be processed at 10:00 AM) are spread to be executed over an interval with width equal to a parameter defined per Registry. Name of the parameter: registryConfig.ALL.DELAYED_START_SPREAD_RANGE Default value=0	TC_V6.1.1_17: 1. Set DELAYED_START_SPREAD_RANGE =300 2. Enter a transfer and approve it, so that after 26 hours the time is non-working. 2. Confirm the transaction has execution time 26 hours + a random value between 0 and 300. So, practically, the transaction is entered between 10:00 AM and 10:05 AM.	HIGH	PASSED	
		MEDIUM	PASSED	
An error was generated in LOAD environment when CSRF guard was disabled.		HIGH	PASSED	
Visual fixes for higher screen resolutions	TC_V6.1.1_18: 1. Increase screen resolution to maximum 2. Ensure the top-screen banner in the homepage appears correctly	LOW	PASSED	

Task list headers are correctly displayed if zoom is increased	TC_V6.1.1_19: 1. Increase browser zoom 2. Ensure task list headers are correctly displayed	LOW	PASSED	
Present a friendly error message if user forgets to select relationship type of AR/AAR to account holder	TC_V6.1.1_20: 1. View an account 2. Click on AR or AAR tab and click on add AR or add AAR 3. Click next directly without selecting a radio button (Representative is already related to the Account Holder OR Representative is not yet related to the Account Holder) 4. The presented error message is user-friendly	LOW	PASSED	
Present a friendly error message if delegation is requested without selecting an external platform	TC_V6.1.1_21: 1. Display the list of account 2. Click on Delegate link on the right 3. Click on Next without selecting an external platform	LOW	PASSED	
Set-aside quantity checks the surrenders completed by AOHAs until 30-APRIL 00:00:00. This was corrected to check the surrendered quantity until 30-APRIL 23:59:59	TC_V6.1.1_22: 1. Attempt a set-aside transaction 2. Confirm the allowed quantity can reach up to the surrendered amount by AOHA, including 30-APRIL.	HIGH	PASSED	

The "Request" tab shows the name of the actual users who initiated and approved a transaction. This tab should not be available to AR/AARs of the acquiring account.	TC_V6.1.2_1:1. Enter a transaction from one Registry account to an account of another Registry.2. Approve the transaction request as AAR3. Confirm that the tab "Request" is visible to:* The NA of the transferring Registry* The NA of the acquiring Registry* The AR(s) of the transferring account* The AAR(s) of the transferring accountThe AR(s) and AAR(s) of the acquiring account should not be able to view the "Request" tab.	HIGH	PASSED	
Improvement in UI The term "Ineligible" should be replaced by "Ineligible for ICH". The term "Eligible" should be replaced by "Eligible for ICH".	TC_V6.1.2_2: 1. Login as CA 2. Navigate to all lists management screens (view lists, view list logs, unit block management, account holdings) 3. Confirm the terms "Eligible" and "Ineligible" are now "Eligible for ICH" and "Ineligible for ICH" Repeat for NA. Repeat for AR, AAR for account holdings screen only.	LOW	PASSED	-

Withdrawal of a transaction is only available to transferring Registry administrator.	TC_V6.1.2_3: 1. Login as NA 2. Enter a transfer from an account to another Registry account 3. Approve it as AAR 4. Login as transferring Registry NA 5. Ensure button "withdrawal" is visible for this transaction 6. Login as the acquiring Registry NA 7. Ensure the button "withdrawal" is not visible for this transaction	HIGH	PASSED	-
AR/AAR of the aquiring account of a transaction can only see transactions in status COMPLETED.	TC_V6.1.2_4: 1. Login as NA 2. Enter a transfer from an account to another Registry account 3. Approve it as AAR 4. Login as transferring Registry NA 5. Ensure the transaction appears in the "Transactions" screen as DELAYED. 6. Login as acquiring Registry NA 7. Ensure the transaction does not appear in the "Transactions" screen. Repeat steps 6-7 as acquiring account AR, AAR.	HIGH	PASSED	-
Improvement in UI. In account holdings screen, Eligible/Inelgibile terminology should be constrained only to CER and ERU units.	TC_V6.1.2_5: 1. Login as NA 2. Select an account and navigate to holdings screen 3. Ensure that under columns "Eligible for ICH" and "Ineligible for ICH" values 0 or positive appear only for CER and "ERU from AAU". 4. For AAU, Allowances there are not any values; the cell is empty.	MEDIUM	PASSED	-

	Repeat as AR, AAR			
CSV export functionality is not available for ICH lists.	TC_V6.1.2_6: 1. Login as CA 2. Navigate to "View ICH Lists" 3. Select a list type 4. Click on export to CSV 5. Ensure the geneated CSV file corresponds to the list selected. Note: full list contents are included in the CSV	HIGH	PASSED	-
Change the titles of menu otions to include the ICH acronym	TC_V6.1.2_7: 1. Login as NA 2. Ensure the menu options "View ICH Lists" and "View ICH List Log" exist under menu "Administration" Repeat for CA	LOW	PASSED	-

Show in account statement CSV the eligibility flag of contained unit blocks	TC_V6.1.2_8:1. Login as NA2. Select an account and navigate to account statement3. Enter a date range containing accounts with CER/ERU units contained in lists or in no lists4. Generate account statement CSV5. Ensure the last column of the CSV is "Eligible for ICH" or "not Eligible for ICH" accoridng to the flag of the specific unit blocks.	HIGH	PASSED	-
Correct a message in account statement when selecting a date period which is longer than a month	TC_V6.1.2_9: 1. Login as NA 2. Select an account and navigate to account statement 3. Enter a date range which is longer than a month 4. Ensure the warning message "The selected period should not be longer than a month." appears	MEDIUM	PASSED	-
Improvement in UI. In the ITL notification fulfillment page (page ref #222) remove the last column because it is never used	TC_V6.1.2_10: 1. Login as NA 2. Navigate to ITL Notifications 3. Select a notification and click on "Fulfill" 4. Ensure that in the next screen the rightmost column is titled "Project Number"	MEDIUM	PASSED	-

The following new transaction types are implemented in EUCR and EUTL: • DeletionChapter2Banking (10,33) • IssuanceChapter2Banking (1,33) • DeletionChapter3Banking (10,34) • IssuanceChapter3Banking (1,34)	TC_V6.1.2_11: EUCR: 1. Login as NA 2. Navigate to Transactions 3. Ensure in Transaction Type drop-down the specified new transaction types exist; by selecting each of them, the appropriate transaction records appear. EUTL: 1. Login and navigate to Transaction Mgt. 2. Ensure that in the drop-down box "Supplementary Transaction Type" the records "33-Chapther II Banking" and "34-Chapter III Banking" exist and filter the transactions appropriately.	HIGH	PASSED	-
Wording corrections in request details tab.	TC_V6.1.2_13: 1. Login as NA 2. Locate an outgoing transaction and open its Request Details tab 3. Ensure the first two columns are "User Action" and "Action Date" 4. Ensure the third column is "User URID"	HIGH	PASSED	-
PDF and CSV button in account statement must be translatable	TC_V6.1.2_14: 1. Login as NA 2. Locate an account and navigate to "Account Statements" tab 3. The buttons "Account Statement PDF" and "Account Statement CSV" must follow the defined translation for the specific Registry	LOW	PASSED	-

The button "Transaction PDF" to become translatable.	TC_V6.1.2_15: 1. Login as NA 2. Locate a transaction 3. Ensure the button "Transaction PDF" follows the translation defined for this Registry	LOW	PASSED	-
Rename "CDM negative list" to "General Negative list". Rename "ERU negative list" to "Article 58 (1) negative list"	TC_V6.1.2_16: EUCR 1. Login as NA 2. Navigate to ICH View Lists 3. Ensure the lists contained in the "List Names" drop-down field are General Negative List, Article 58(1)Negative List, General Positive List, Application Procedure Positive List EUTL 1. Login and navigate to "Eligible/Ineligible Lists Upload" 2. Ensure the presented list types are as defined above.	MEDIUM	PASSED	-

The system does not allow to remove AARs and view-only ARs. This functionality has been restored.	TC_V6.1.3_1:TC_1: In an account with AR equal to MIN_REP_ACCOUNT, all ARs are enrolled.Step 1: Remove AR view-only, ENROLLEDStep2: Ensure the AR is removedRepeat step 1 for AR view-only: VALIDATED, UNENROLLEDTC_2: In an account with AR equal to MIN_REP_ACCOUNT, all ARs are validated.Step 1: Remove AR view-only, ENROLLEDStep2: Ensure the AR is removedRepeat step 1 for AR view-only: VALIDATED, UNENROLLEDTC_3: In an account with AR equal to MIN_REP_ACCOUNT, one ARs is enrolled and the other is validated.Step 1: Remove AR view-only, ENROLLEDStep2: Ensure the AR is removedRepeat step 1 for AR view-only: VALIDATED, UNENROLLEDTC_4: In an account with one AAR in status ENROLLED.Step 1: Remove the AARStep2: Ensure the AAR is removedRepeat for AAR view-only: VALIDATED, UNENROLLED	HIGH	PASSED	

In compliance_status table in EUCR, null values cause an error to the account details screen; this is corrected so that zero values are inserted in compliance_status table, whenever a new record is added. An accompanying database script will set current null values to zero, to correct the problem for existing records.	TC_V6.1.3_2: 1. Connect as NA and request a new AOHA with first year of verification 2012 2. Approve the request as second NA 3. Open the account details of the new AOHA 4. Confirm data appear correctly	HIGH	PASSED	
The system does not allow to suspend a view-only AR; this functionality is now corrected.	TC_V6.1.3_4: TC_1: In an account with AR equal to MIN_REP_ACCOUNT, all ARs are enrolled. Step 1: Suspend a view-only AR Step2: Ensure the AR is suspended Repeat step 1 for AR view-only: VALIDATED, UNENROLLED TC_1: In an account with one AAR, the AARs is enrolled. Step 1: Suspend the AAR Step2: Ensure the AAR is suspended Repeat step 1 for AAR : VALIDATED, UNENROLLED	HIGH	PASSED	When an AAR is suspended then the button Restore appears. When an AR view-only is suspended the buttons Remove & Restore appear. When an unenrolled AAR is suspended, he is locked on the account because remove no longer works. When an AR view only is suspended and then removed and the task is rejected, the AR is no longer suspended.

				This last occurs for AR (non-view-only as well.
When exporting an ICH list in CSV form, the generated file has XML extension. This is corrected.	TC_V6.1.3_7: 1. Connect as CA for EU Registry 2. Navigate to Administration => View ICH Lists 3. Select a list type and click Search 4. Click on "Export to CSV" 5. Ensure the file generated has a ".csv" extension	HIGH	PASSED	
When exporting an ICH list in XML form, the generated file has only one line. This is now corrected by adding line breaks after every end of tag.	TC_V6.1.3_8: 1. Connect as CA for EU Registry 2. Navigate to Administration => View ICH Lists 3. Select a list type and click Search 4. Click on "Export to XML" 5. Save the file and open it with Wordpad or Notepad++ 6. Ensure the file contains line breaks on each line	HIGH	PASSED	Due to its treatment of carriage-returns, Notepad cannot show the contents properly; please use Wordpad instead.

The message in EUTL when an invalid XML ICH Lists is uploaded is misleading. There is a bug and it displays "List uploaded successfully" while it should display "Invalid File".	TC_V6.1.3_9: 1.Connect to EUTLTC_V6.1.3_9: 2. Navigate to Eligible/Ineligible List Upload 3. Upload the list attached on issue TST-230 and specify it as "General Positive List" 4. Ensure the message "Invalid XML" appears	HIGH	PASSED	
When adding an account to the trusted list, the digit "0" should be evident that it is locked.	TC_V6.1.4_08:1. Connect as NA 2. Naviagate to an account3. Open the "Trusted Account" tab4. Click on "Add"5. Ensure the digit "0" appears disabled in the next screen	HIGH	PASSED	
The ordering of columns in the holdings screen is changed	TC_V6.1.3_09: 1. Connect as NA 2. Select an account via the Accounts screen 3. Select View Details=>Holdings 4. Ensure the columns Eligible for ICH and Pending/Ineligible for ICH appear before the column Balance	HIGH	PASSED	
The permission with name PERM_BW_LIST_USER_NAMES is created. When this is assigned (to a CA) then the specific user will be able to see which user performed every change in the ICH lists.	TC_V6.1.3_10: 1. Connect as CA for EU Registry 2. Navigate to Administration=>View ICH List Log and select a list type 3. Ensure the rightmost column is "Name" and contains the user who performed last action 4. Connect as NA for any Registry 5. Navigate to Administration=>View ICH List Log and select a list type 6. Ensure the column "Name" is not shown	HIGH	PASSED	The permission PERM_BW_LIST_USER_NAMES needs to be assigned to CA. This is hidden from the permissions management screen and needs to be set via database script.

This permission is hidden and cannot be assigned via the user interface, but only via the database.				
Change the banking transactions from Chapter 2 , Chapter 3 to Aviation allowances and General Allowances	TC_V6.1.3_11: 1. Connect as NA 2. Navigate to Transactions screen 3. Confirm that in transaction type drop-down list the following transaction types appear: 1-33 Issuance Aviation Allowances Banking 1-34 Issuance General Allowances Banking 10-33 Deletion Aviation Allowances Banking 10-34 Deletion General Allowances Banking Selecting each of them retrieves the corresponding type of transactions in the lower part of the screen.	HIGH	PASSED	
By selecting two tasks which are assignable to different sets of users, it is possible to assing a task to a user who cannot normally receive it. This issue is now fixed.	1. Login as any user; go to Task List. Select a task and click "Assign". 2. From the drop-down list at the field "New claimant" notice the names of the assignees. 3. Select another task and notice the names of the assignees via the same process. Make sure that the two tasks have some different assignees. 4. Having clicked the second task, select an assignee that appears only to the second task and not to the first one. 5. Check both tasks and then click "Save". 6. Ensure that the selected assignee is saved only to the second task and that the first task remains unaffected.	HIGH	PASSED	

Allocation cannot happen for years later than the current year.	1. Connect as NA 2. Navigate to EUETS=>Allocation Phase 3 3. Confirm that in "Installations" and "Aircraft Operators" tabs the years from the beginning of Phase 3 up to and including the current year appear as possible selections for "Year" drop-down listbox. No future years appear. 4. User selects allocations for a year 5. User clicks "Submit" 6. User connects as second NA and approves the allocations. 7. Allocations to the specified installations are performed at the next allocation job execution. Repeat for aircraft operators. Note that enough units must have been issued and transferred to EU Allocation account.	HIGH	PASSED	

Users can edit some account details, via the use of a special tool; this issue is now fixed.	A) Test Environment: 1. Firefox Browser 2. Tamper Data Firefox Plugin (TD hereafter) B) Test Case(s): 1. Open the TD Window 2. Login as NA 3. Navigate to the List of Accounts 4. Find an account that does not offer the "Block" action 5. Click "View Details" and from the TD note the "accountId" parameter 6. Return to the List of Accounts 7. Click the "Block" link on any other account from the list 8. Using TD change the "accountId" to the one you've noted in step (5) Expected Results: The system should not permit the action (either with an explicit message, or by returning the user to the previous page without applying the attempted change) Repeat the above test for the rest of the account actions: - Unblock - Suspend - Restore - Close - Delegate - Exclude - Unexclude	HIGH	PASSED	

Users can assign tasks to users with the same role (applicable to AR and AAR users).	1. Log in as AR. 2. Go to Task List. Select a task and click "Assign". 3. From the drop down list at the field "New claimant" check the names of the assignees. 4. Ensure that as an AR you can assign the task only to ARs. 5. Repeat the test with AARs. Ensure that as an AAR you can assign the task only to an other AAR.	HIGH	PASSED	
A users can approve a task he has submitted, via the use of a special tool; this issue is now fixed.	A) Test Environment: a. Firebug installed on your Firefox. b. Your ECAS account to be associated with two mobile phone numbers. B) Test Case(s): 1. Login as AR 2. Propose a transfer of allowance, sign it with Mobile A. 3. Navigate to the Task List. Locate the Approve Transaction task and Claim it. 4. Open its details. You will not see an Approve button. 5. Open your Firebug and inject the following code under the html of the details of the transaction <button id="trustedAccountRequestApproveButtonId" name="trustedAccountRequestApproveButtonId" onclick="confirmDialogApprove.show();" type="button" class="ui-button ui-widget ui-state-default ui-corner-all ui-button-text-only" role="button" aria-disabled="false">Approve</button> 6. The approve button appears. 7. Click it and sign the transaction with Mobile B. C) Expected Result: An application error page is displayed informing the user that his	HIGH	PASSED	

	signature was not valid.			
Proposing a transfer and directly afterwards clicking the "Accounts" link produces an error; this issue is now fixed.	1. Enter a transfer transaction 2. Directly afterwards click the "Accounts" link 3. Confirm an error does not appear and system operates normally	HIGH	PASSED	
Allocations can be performed for all years since they start of Phase 3 up to and including the current year.		HIGH	PASSED	

Users can sign a transaction in ECAS via a different user than the one proposing the transaction; this issue is now fixed.	(A) Test Setup: 1. In order to be able to reproduce this issue, you need to run EUCR on localhost and ECAS Mock on a remote server, otherwise the single sign out prevents you from completing step 1.8 since your http session will have been invalidated already 2. For test case 2 you need an ECAS account with 2 mobiles registered. (B) Test Cases: Test Case 1: 1.1. Log in as NA 1.2. Propose a transaction as NA 1.3. The system redirects to ECAS for signing 1.4. Logout from ECAS 1.5. Login to ECAS as another user. Since it is an ECAS login (and not a EUCR requested login) the user can login using any of the available options: Password, Mobile or Token options. 1.6. Using browser's history, navigate back to the transaction's signing page. 1.7. ECAS allows the second user to sign the transaction and returns to EUCR. Test Case 2: 2.1. Log in as NA using mobile A 2.2. Propose a transaction as NA 2.3. The system redirects to ECAS for signing 2.4 Sign the transaction using mobile B 2.7. ECAS allows the second user to sign the transaction and returns to EUCR. (C) Expected Results: The application should show an error page that the signature is invalid.	HIGH	PASSED	

Annex IX Test results EU (=ANNEX H)

Annex H TEST RESULTS EU

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Prepared by : Prasantha Annamreddy 04th March 2014

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Table of Contents

1 Introduction

The tests were conducted on 24th and 25th February 2014. The environments used were ITL REG, EUTL and CSEUR ACC. The test registries LV and EE were put in sandbox testing for the purpose of the tests

1.1 Overview

This is the Annex H test result document for European Union registry (EU). LV and EE are the registries participated in this test.

This test is customised hence we have executed high important test cases from the original Annex H test plan.

Since we have used our ITL REGISTRY environment for this testing, we have cleared down the data once and uploaded the provided government accounts and manually tweaked in the data base while creating the projects, other required details.

1.2 References

Reference	Identifier	Title
01	DES, Annex H	Technical Specifications for Data Exchange, version 1.1.001 23 February 2007 – Registry Initialization Functional Test Plan

1.3 Abbreviations

Abbreviation	Definition
AAU	Assigned Amount Unit
CDM	Clean Development Mechanism (UNFCCC IT system)
CER	Certified Emission Reduction [Unit]
CITL	Community Independent Transaction Log (EU IT system)
CP	Commitment Period
CSEUR	Consolidated System of EU Registries
DES	Technical Standard for Data Exchange
ERU	Emission Reduction Unit
EU	European Union
FTP	Functional Test Plan
ITL	International Transaction Log
lCER	Long-Term Certified Emission Reduction [Unit]
RMU	Removal Unit
RSA	Registry System Administrators
SSL	Secure Socket Layer (communications encryption)
STL	Supplementary Transaction Log
tCER	Temporary Certified Emission Reduction [Unit]
UNFCCC	United Nations Framework Convention on Climate Change

VPN	Virtual Private Network

2 Test Configuration

2.1 Registries

Following registries are used

ZZ	XX	YY	QQ	RR
LV	EE	CA	--NA--	--NA--

2.2 Additional Results

At the end of each scenario the relevant ITL logs will be captured.

A WebEx session is used for communication during the testing. This will be captured at the end of each day.

3 TEST RESULTS

3.1 Scenario 1 – Issuance and External Transfer of AAUs and RMUs

Ref	Description	Pass/Fail Time	Notes
1.1	Successful AAU issuance	PASS	
1.4	Successful RMU issuance LULUCF activity 1	PASS	
1.17	Reconciliation	PASS	
1.18	Account balance check	PASS	

3.2 Scenario 2 – Conversion of AAUs and RMUs into ERUs

Ref	Description	Pass/Fail Time	Notes
2.6	Successful AAU conversion	PASS	Conversion done for 500,000 AAUs under LV1101 project
2.7	Successful RMU conversion	PASS	Conversion of 500,000 RMU into ERU only done under LV1104 project
2.9	Successful ERU transfer	PASS	
2.10	Reconciliation	PASS	
2.11	Account balance check	PASS	

3.3 Scenario 3 – Cancel units unrelated to CDM projects and ability to receive CPR notification

Ref	Description	Pass/Fail Time	Notes
3.3	Successful voluntary cancellation of AAUs	PASS	
3.4	Cancellation to fulfil net source cancellation notification	PASS	Cancelled for 100 units
3.5	Cancellation to fulfil non-compliance cancellation notification	PASS	For Few Units
3.7	Reconciliation	PASS	
3.8	Account balance check	PASS	

3.4 Scenario 4 – Cancel units in response to ITL notifications related to CDM projects

Ref	Description	Pass/Fail Time	Notes
4.1	Receive CERs, tCERs, lCERs and other units	PASS	
4.7	Reconciliation	PASS	
4.8	Account balance check	PASS	

3.5 Scenario 6 – Events and transactions at the end of CP1 and the start of CP2

Ref	Description	Pass/Fail Time	Notes
6.4	Successful retirement of AAUs, ERUs, CERs and ICERs	PASS	Retirement done for few AAUs , it was not part of the original plan but we have tested this transaction when we had an issue with 3.3 test case (voluntary cancellation of AAUs)