Emissions of greenhouse gases in Iceland from 1990 to 2010

National Inventory Report 2012

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 2012. The NIR together with the associated Common Reporting Format tables (CRF) 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 – 2010. The Standard Electronic Format (SEF) is not reported as Iceland has not transferred or acquired any Kyoto Protocol Units.

The NIR is written by the Environment Agency of Iceland (EA), with a major contribution by the Agricultural University of Iceland (AUI).

Environment Agency, Reykjavík, April 2012

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DEFINITION OF PREFIXES AND SYMPOLS 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.

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 Oxigen Demand
C_2F_6	Hexafluoroethane
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 Oxigen 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
IFS	Iceland Forest Service
IFVA	Icelandic Food and Veterinary Association
IPCC	Intergovernmental Panel on Climate Change
ITL	International Transaction Log

Table continued	
IW	Industrial Waste
Kha	Kilohectare
KP	Kyoto Protocol
LULUCF	Land Use, Land-Use Change and Forestry
MAC	Mobile Air Conditioning
MAC	Mobile Air-Conditioning Systems
MCF	Methane Correction Factor
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	Perfluorinated Compounds
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
SO2	Sulfur Dioxide
SO2-eq	Sulfur Dioxide Equivalents
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

ES 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 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 resulting from 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.

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 in Iceland were 3,501 Gg of CO_2-equivalents. In 2010, total emissions were 4,542 Gg CO_2-equivalents. This is an increase of 30% over the time period.

A summary of the Icelandic national emissions for 1990, 2008, 2009, and 2010 is presented in Table ES 1 (without LULUCF). Empty cells indicate emissions not occurring.

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

	1990	2008	2009	2010	Changes 1990-2010	Changes 2009-2010
CO_2	2,154	3,579	3,546	3,405	58%	-4%
CH_4	409	469	468	460	12%	-2%
N_2O	518	507	472	457	-12%	-3%
HFC		49	55	69		25%
PFC	420	349	153	146	-65%	-5%
SF_6	1	6	6	5	340%	-17%
Total	3,501	4,959	4,700	4,542	30%	-3%
CO_2 emissions fulfilling 14/CP.7*		1,163	1,187	1,216		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		3,796	3,513	3,326		

**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 2010 was the Energy sector, followed by Industrial Processes, then Agriculture, Waste, and Solvent and other Product Use (Table ES 2). From 1990 to 2010, the contribution of the Energy sector to the total emissions decreased from 51% to 41%. The contribution of industrial processes decreased from 25% in 1990 to less than 20% from 1992 to 1997. The contribution of industrial processes increased again after 1997 and was 40% in 2010.

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

	1990	2008	2009	2010	Changes 1990-2010	Changes 2009-2010
Energy	1,778	2,072	2,018	1,866	5%	-8%
Industrial processes	863	1,974	1,798	1,810	110%	1%
Emissions fulfilling 14/CP.7		1,163	1,187	1,216		2%
Solvent use	9	7	6	6	-32%	-3%
Agriculture	703	679	654	646	-8%	-1%
LULUCF	1,188	794	759	734	-38%	-3%
Waste	148	226	224	214	45%	-4%
Total without LULUCF	3,501	4,959	4,700	4,542	30%	-3%
Total emissions excluding CO_2 emissions fulfilling 14/CP.7		3,796	3,513	3,326		
Removals from KP 3.3 and 3.4		300	318	339		

The distribution of the total greenhouse gas emissions over the UNFCCC sectors (including geothermal energy and excluding LULUCF) in 2010 is shown in Fig ES 1. Emissions from the Energy sector account for 41% (fuel combustion 37% and geothermal energy 4%) of the national total emissions, industrial processes account for 40% and agriculture for 14%. The Waste sector accounts for 5%, and Solvent and other Product Use for 0.1%.

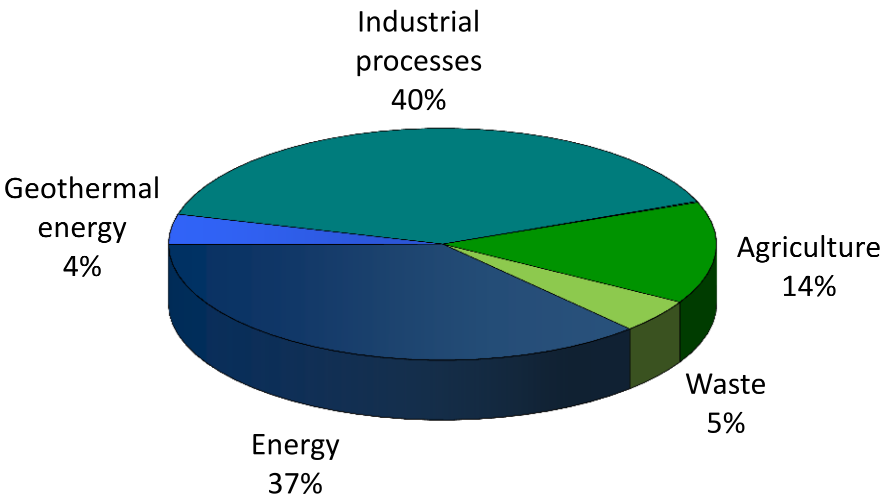

Fig. ES 1. Emissions of greenhouse gases by UNFCCC sector in 2010.

Kyoto Accounting

Iceland's 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. Iceland's total Annex A greenhouse gas emissions were estimated at 4,959 Gg CO_2-equivalents for 2008, 2,700 CO_2-equivalents in 2009 and 4,542 Gg CO_2-equivalents in 2010. Iceland's total emissions in 2010 were 31% above 1990 levels. Emissions that fall under the provision of Decision 14/CP.7 amounted to 1,163 Gg CO_2 in 2008, 1,187 Gg CO_2 in 2009 and 1,216 Gg CO_2 in 2010. Emissions falling under Decision 14/CP.7 are to be reported separately and shall not be included in national totals to the extent they would cause Iceland to exceed its assigned amount. In this submission all emissions are reported, as Iceland will undertake the accounting with respect to Decision 14/CP.7 at the end of the commitment period. Activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol amounted to 300 Gg in 2008, 318 Gg in 2009 and 339 Gg CO_2-equivalents in 2010. Iceland did not submit the Standard Electronic Format (SEF) as Iceland has not transferred or acquired any Kyoto Protocol Units.

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

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 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 one 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 1.6 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 III.

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 1990-2010. The methodology 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. The Standard Electronic Format (SEF) is not reported as Iceland has not transferred or acquired any Kyoto Protocol Units.

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, 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. Fig. 1.1 illustrates the flow of information and allocation of responsibilities.

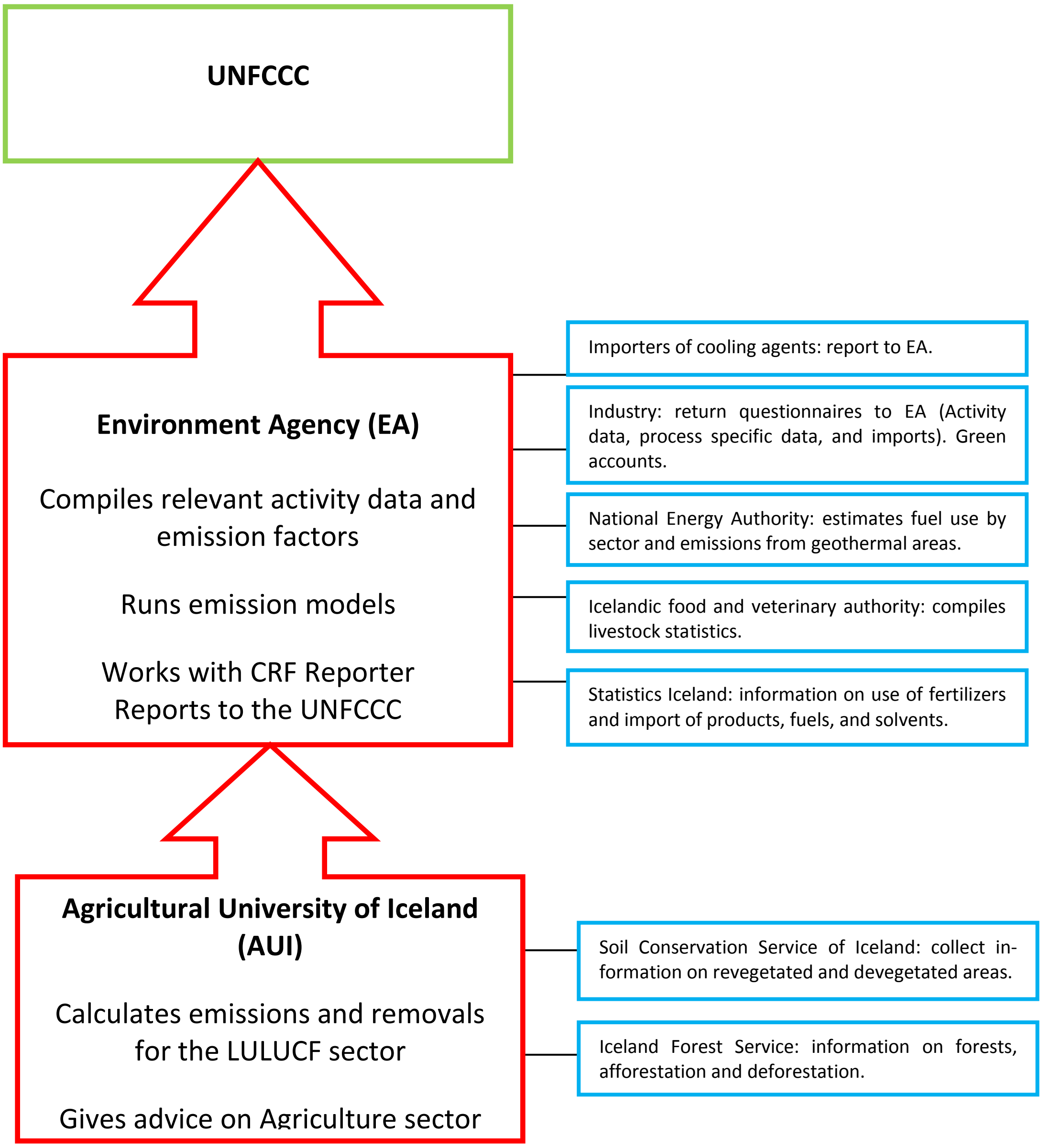

Fig. 1.1. Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the UNFCCC.

A Coordinating Team was established in 2008 as a part of the national system. The team has representatives from the Ministry for the Environment, the EA and the AUI not directly involved in preparing the inventory. Its official roles are 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 this inventory cycle the Coordinating Team held 7 meetings, thereof there were 3 meetings only with Coordinating Team members and 4 with the team members as well as major data providers. The work of the team has already 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 are incorporated into this and last year's submissions.

1.2.2 *Act No. 65 from 2007*

An act on the emission of greenhouse gases was passed by the Icelandic legislature, Althingi, in March 2007. The stated purpose of the act is to create conditions for Icelandic authorities to comply with international obligations in limiting emissions of greenhouse gases. The act establishes the national system for the estimation of greenhouse gas emissions by sources and removals by sinks, a national registry, emission permits and the duty of companies to report relevant information to the authorities.

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. The EA shall, in accordance with the legislation, produce instructions on the preparation of data and other information for the national inventory. Formal agreements have been made between the EA and the necessary collaborating agencies involved in the preparation of the inventory to cover responsibilities such as data collection and methodologies, data delivery timelines and uncertainty estimates. These involve the National Energy Authority and the Agricultural University of Iceland. The Agricultural University has also made formal agreements with its major data providers, the Soil Conservation Service of Iceland and the Iceland Forest Service. Regulation 244/2009 further elaborates on the reporting of information from the industrial plants falling under the act.

According to the act 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, allocates emissions allowance for operators falling within the scope of the Act during the period 1 January 2008 to 31 December 2012.

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 the 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 recommendation 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. 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 (Fig. 1.2) describes individual activities performed each year in preparation for next submission of the emission estimates.

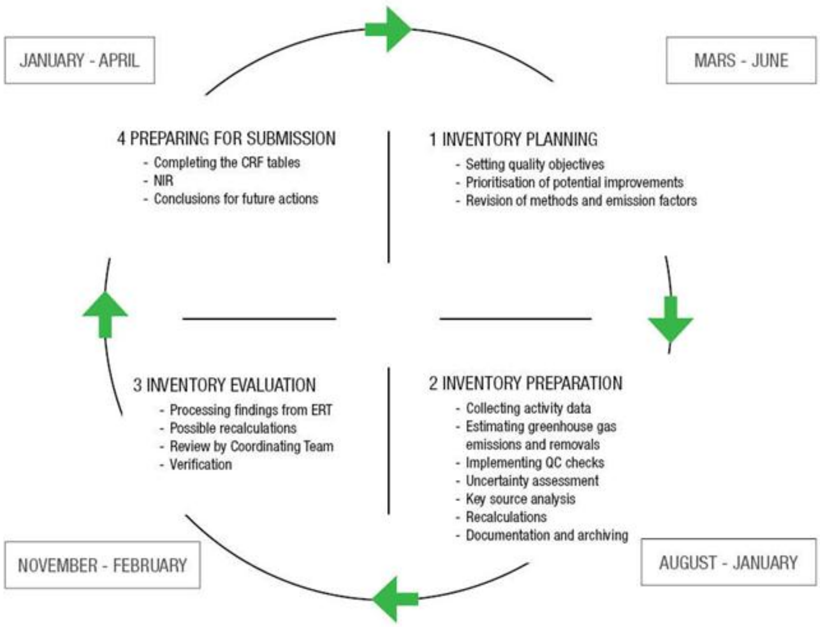

Fig. 1.2. The annual inventory cycle.

A new annual cycle begins with an initial planning of activities for the inventory cycle by the Coordinating Team, taking into account the outcome of the review by the team and 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 final review of the greenhouse gas inventory by the Coordinating Team, the inventory is submitted to the UNFCCC by 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 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 2012 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 included LULUCF greenhouse gas sources and sinks.

Table 1. 1. Icelandic emission inventory 2010 key source categories.

IPCC source categories		Direct greenhouse gas	Level 1990	Level 2010	Trend
Energy sector					
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]		✓
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.2	Geothermal energy	CH_4			
1.B.2	Geothermal energy	CO_2	✓	✓	✓
Industrial processes					
2.A	Mineral production	CO_2	✓		✓
2.B	Chemical industry	CO_2			
2.B	Chemical industry	N_2O	✓		
2.C.2	Ferroalloys	CO_2	✓	✓	✓
2.C.3	Aluminium	CO_2	✓	✓	✓
2.C.3	Aluminium	PFC	✓	✓	✓
2.F	Consumption of halocarbons and SF6	HFC		✓	✓
2.F	Consumption of halocarbons and SF6	SF_6			
Solvents and other product use					
3	Solvent and other product use	CO_2			
3	Solvent and other product use	N_2O			
Agriculture					
4.A.1	Enteric fermentation, cattle	CH_4	✓	✓	
4.A.3	Enteric fermentation, sheep	CH_4	✓	✓	✓
4.A.4-10	Enteric fermentation, rest	CH_4			
4.B	Manure management	CH_4			
4.B	Manure management	N_2O	✓	✓[1]	
4.D.1	Direct soil emissions	N_2O	✓	✓	
4.D.2	Animal production	N_2O	✓	✓	

Table 1.1 continued					
IPCC source categories		Direct green-house gas	Level 1990	Level 2010	Trend
4.D.3	Indirect soil emissions	N_2O	✓	✓	✓
LULUCF					
5.A	Forest land- Afforestation	CO_2		✓	✓
5.A	Forest land- Natural birch forest	CO_2		✓	✓
Energy sector					
5.A	Forest land - Afforestation	N_2O			
5.B.1	Cropland remaining cropland	CO_2	✓	✓	✓
5.B.2	Land converted to cropland	CO_2	✓	✓	✓
5.C.1	Wetland drained for more than 20 years	CO_2	✓	✓	✓
5.C.1	Other remaining grassland	CO_2			
5.C.2.1-4	Other conversion to grassland	CO_2	✓	✓	✓
5.C.2.5	Other land converted to grass-land, revegetation	CO_2	✓	✓	✓
5.D.2	Land converted to wetland (res-ervoirs)	CH_4			
5.D.2	Land converted to wetland (res-ervoirs)	CO_2			
5.E.2.1	Forest land converted to settle-ments	CO_2			
5.G	Grassland non CO2-emissions	N_2O	✓	✓	
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: Key source excluding LULUCF.

1.6 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.

1.7 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 gasses are reviewed separately as CO_2-equivalents. The total base year´s and current year's emissions within a sector are used in the calculations as well as an uncertainty estimate value of activity data and emission factors.

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. Combination of all source category uncertainties yielded a total uncertainty of 19.1% (percentage uncertainty of national emissions of 2010). The total uncertainty in the trend was estimated to be 12.1%. By excluding the LULUCF sector, total uncertainty was reduced to 5.1% and trend uncertainty to 6.9%. The drastic reduction was mainly caused by the removal of the two source categories Cropland remaining cropland (5B1) and Wetland drained for more than 20 years (5C1), which combined high emission estimates (a total of 1300 Gg CO_2 in 2010) with high uncertainty estimates (combined uncertainty of 92% for both categories). The results of the uncertainty estimate can be found in Annex II.

1.8 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 2010.

With regard to sectoral coverage few sources are not estimated.

The main sources not estimated are:

- Emissions of CO_2 and CH_4 from distribution of oil products (1B2a v)
- Emissions of CO_2 and CH_4 from road paving with asphalt (2A6).

- The number of LULUCF components for which emissions/removals are not estimated has decreased considerably (see Chapter 7). The most important estimates remaining are probably the estimates of emissions/removals of mineral soil in few categories and emissions due to biomass burning.

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.

1.9 Planned and Implemented Improvements

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

- Adjustment of the fuel data provided by the National Energy Authority in sectors 1A1a, 1A2 and 1A4.
- Reallocation of fuel consumption for different vehicle types for the years 2006 to 2010, including motorcycles.
- Estimate of methane emissions from geothermal power plants.
- Estimate of NMVOC emissions from food and drink production.
- Realignment of methodology for NMVOC emissions from solvents and other product use along the EMEP/EEA air pollutant emission inventory guidebook (EEA, 2009).
- Change of methodology in calculating CH_4 emissions from manure management: application of Tier 2 for cattle and sheep.
- Time series have been prepared and defined conversion periods adapted for many land use categories thus improving the areal estimate of relevant categories. Estimates of many LULUCF components previously not estimated are provided in this submission.
- Efforts in improving the area estimate for drained organic soils of grassland and its subdivisions to soil classes started last summer.
- More thorough estimation of waste composition to estimate DOC content for emissions from SWDS and fossil carbon content for emissions from waste incineration.

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, in accordance with the formal agreement between EA and NEA.
- 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 emissions from HFCs.
- Move emission estimates of SF_6 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 ongoing task of the AUI.
- Ongoing national forest inventory (NFI) will further improve both estimates of Forest land area and Carbon stock changes.
- Similar effort as the NFI regarding Revegetation began in 2007. The Revegetation inventory is expected to provide improved data on carbon stock changes and area of revegetated land in the next two years.
- Further improvement of the time series already presented for different land use categories and the estimate on past and present land use changes and preparation of time series for remaining land use categories.

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.

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 1990-2010 are presented in the following tables, expressed in terms of contribution by gas and source.

Table 2.1 presents emission figures for greenhouse gases by sector in 1990, 2008, 2009 and 2010 expressed in CO_2-equivalents along with the percentage change indicated for both time periods 1990-2010 and 2009-2010. Table 2.2 presents emission figures for all greenhouse gases by gas in 1990, 2008, 2009 and 2010, expressed in CO_2-equivalents along with the percentage change indicated for both time periods 1990-2010 and 2009-2010. Empty cells indicate emissions not occurring.

Table 2.1. Emissions of greenhouse gases by sector in Iceland during the period 1990-2010 in Gg CO_2-equivalents.

	1990	2008	2009	2010	Chang es ´90-	Chang es ´09-
Energy	1,778	2,072	2,018	1,866	4.9%	-7.5%
- Fuel combustion	1,717	1,884	1,845	1,674	-2.5%	-9.3%
- Geothermal en-	62	188	173	193	212.7	11.5%
Industrial processes	863	1,974	1,798	1,810	109.7	0.7%
Solvent and other prod-	9	7	6	6	-32.2%	-2.6%
Agriculture	703	679	654	646	-8.1%	-1.3%
LULUCF	1,188	794	759	734	-38.2%	-3.3%
Waste	148	226	224	214	44.6%	-4.4%
Total without LULUCF	**3,501**	**4,959**	**4,700**	**4,542**	**29.7%**	**-3.4%**
CO_2 emissions fulfilling 14/CP.7*		1,163	1,187	1,216		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		**3,796**	**3,513**	**3,326**		

**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 1990-2010 (without LULUCF) in Gg CO_2-equivalents.

	1990	2008	2009	2010	Changes ´90-´10	Changes ´09-´10
CO_2	2,154	3,579	3,546	3,405	58.1%	-4.0%
CH_4	409	469	468	460	12.5%	-1.6%
N_2O	518	507	472	457	-11.7%	-3.2%
HFC's	-	49	55	69	-	24.9%
PFC's	420	349	153	146	-65.3%	-4.7%
SF_6	1	6	6	5	339.6%	-16.7%
Total	**3,501**	**4,959**	**4,700**	**4,542**	**29.7%**	**-3.4%**
CO_2 emissions fulfilling 14/CP.7*		1,163	1,187	1,216		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*				**3,796**	**3,513**	**3,326**

**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, the total emissions of greenhouse gases (excluding LULUCF) in Iceland were 3,501 Gg of CO_2-equivalents. In 2010 total emissions were 4,542 Gg CO_2-equivalents. This implies an increase of 30% over the time period. Total emissions show a decrease between 1990 and 1994, with an exception in 1993, and an increase from 1995 to 1999. Emissions remained relatively stable from 2000 to 2005 (± 1% per year). A sudden increase of 14% was seen between 2005 and 2006 followed by an increase of 5% in 2007 and 8% increase in 2008. Since 2008 emissions have decreased; by 5% in 2009 and 3% in 2010.

By the middle of the 1990s economic growth started to gain momentum in Iceland. Iceland experienced until 2007 one of the highest growth rates of GDP among OECD countries. Late year 2008, Iceland was severely hit by an economic crisis when its three largest banks collapsed. The blow was particularly hard owing to the large size of the banking sector in relation to the overall economy as it had grown to be ten times the annual GDP. The crisis has resulted in serious contraction of the economy followed by increase in unemployment, a depreciation of the Icelandic króna (ISK), and a drastic increase in external debt. Private consumption has contracted by a quarter since 2007. Emissions of greenhouse gases decreased from most sectors between 2008 and 2010.

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 2010, 818,859 tonnes of aluminium were produced in three aluminium plants. Parallel investments in increased power capacity were needed to accommodate for an nine fold increase in aluminium production. The size of these investments is large relative to the Icelandic economy.

The increase in GDP since 1990 explains further the general growth in emissions as well as the fact that the Icelandic population has grown by 24% from 1990 to 2010. This has resulted in higher emissions from most sources, but in particular from transport and the construction sector. Since 1990 emission from the transport sector have risen considerably, owing to the fact that 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 the years before. The knock-off effect of the increased levels of economic growth until 2007 was an increase in construction, especially house 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 autumn 2008. Emissions from fuel combustion in the transport and construction sector decreased in 2008 by 5% compared to 2007, in 2009 by 2% compared to 2008 and in 2010 by 7% compared to 2009, because of the economic crises. Emissions from Cement production have decreased by 84% since 2007 (process emissions and emissions from fuel consumption) also as a result of the economic crises and the collapse of the construction sector.

The overall increasing trend of greenhouse gas emissions was until 2005 to some extent counteracted by decreased emissions of PFCs, caused by improved technology and process control in the aluminium industry. Increased emissions due to increased production capacity in the aluminium industry, since 2006, has led to a trend of overall increase in greenhouse gas emissions. Emissions from the Aluminium sector peaked in 2008. In 2010 the total emissions from the aluminium sector was 10% lower than in 2008 due to less PFC emissions from the sector.

2.2 Emission Trends by Gas

As shown in Fig. 2.1, the largest contributor by far to the total GHG emissions is CO_2 (75%), followed by CH_4 (10%), N_2O (10%) and fluorinated gases (PFCs, HFCs, and SF_6, 5%). In the year 2010, the changes in gas emissions compared to 1990 levels for CO_2, CH_4, N_2O, and fluorinated gasses were 58%, 12%, -12%, and -48%, respectively (Fig. 2.2, Fig. 2.2 and

Table 2.3).

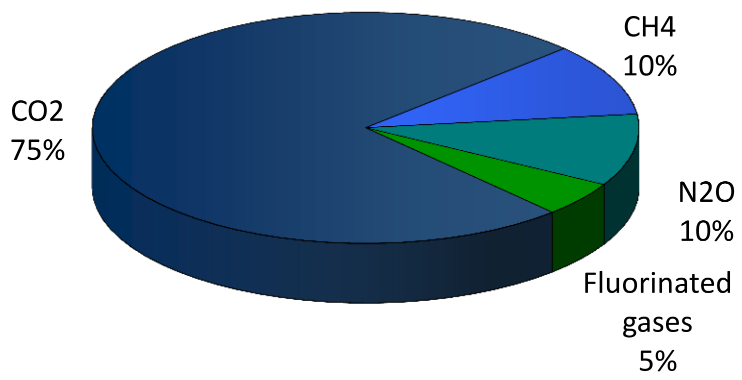

Fig. 2.1. Distribution of emissions of greenhouse gases by gas in 2010.

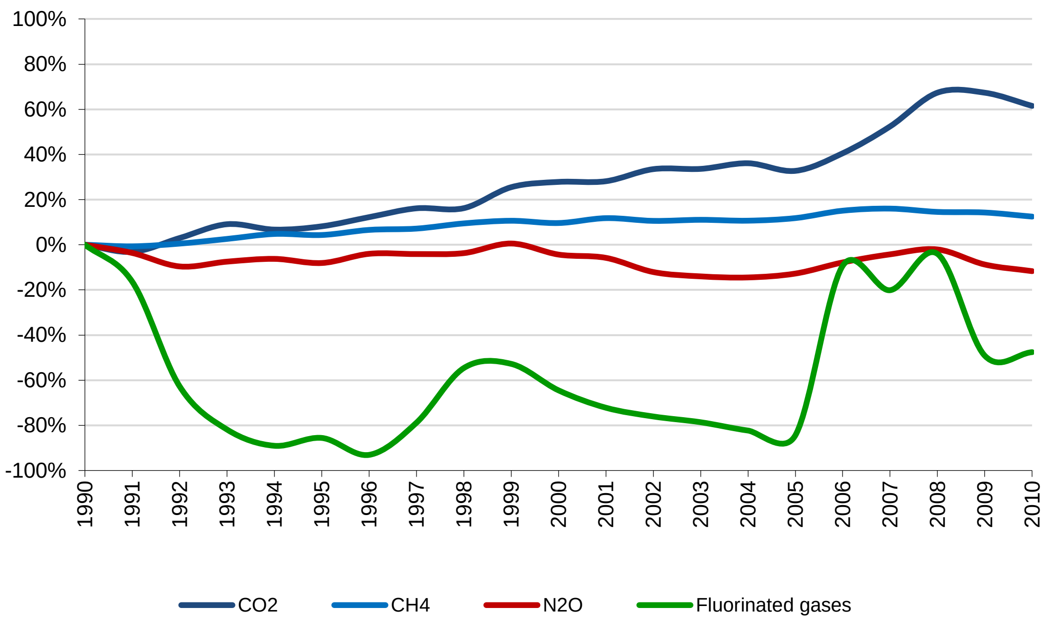

Fig. 2.2. Percentage changes in emissions of GHG by gas 1990-2010, compared to 1990 levels.

Table 2.3. Emissions of greenhouse gases in Iceland during the period 1990-2010 (without LULUCF) in Gg CO2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
CO_2	2,154	2,311	2,752	2,844	3,267	3,579	3,546	3,405
CH_4	409	427	449	458	475	469	486	460
N_2O	518	476	495	452	495	507	472	457
HFC's	-	0.4	19	35	45	49	55	69
PFC's	420	59	127	26	281	349	153	145
SF_6	1	2	3	4	10	6	6	5
Total	**3,501**	**3,274**	**3,845**	**3,819**	**4,573**	**4,959**	**4,700**	**4,542**
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*						**3,796**	**3,513**	**3,326**

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

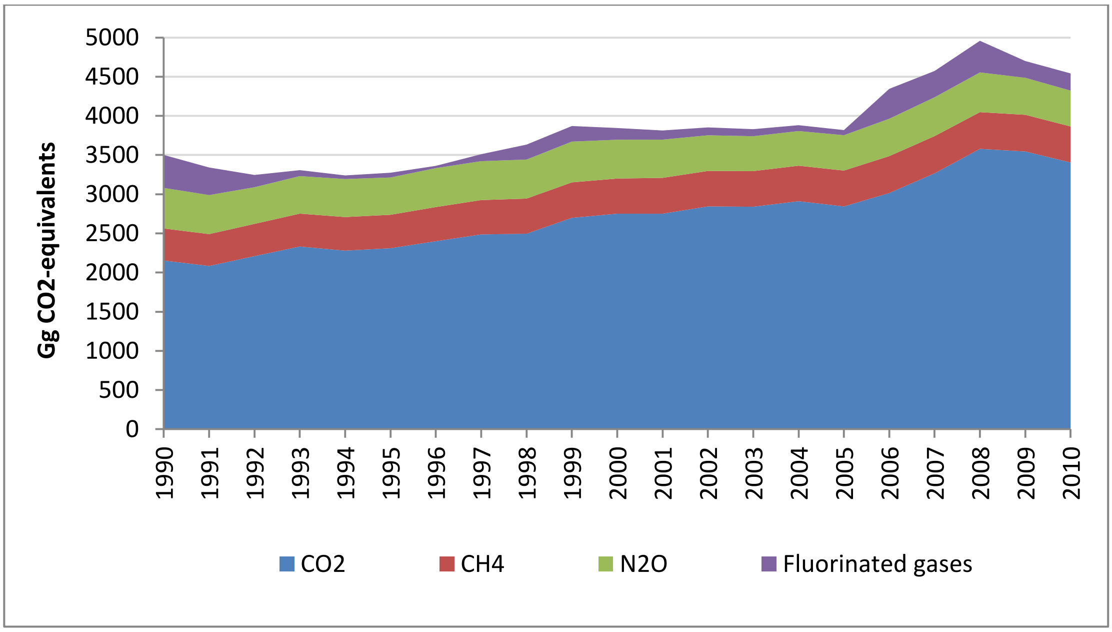

Fig. 2.3. Emissions of greenhouse gases by gas, 1990-2010.

2.2.1 Carbon Dioxide (CO2)

Industrial processes, road transport and fisheries are the three main sources of CO_2 emissions in Iceland. Since emissions from the 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 2.4 lists CO_2 emissions from each source category for the period 1990-2010. Fig. 2.4 illustrates the distribution of CO_2 emissions by main source categories, and Fig. 2.5 shows the percentage change in emissions of CO_2 by source from 1990 to 2010 compared with 1990 levels.

Table 2.4. Emissions of CO2 by sector 1990-2010 in Gg.

	1990	1995	2000	2005	2007	2008	2009	2010
Fishing	656	772	720	626	565	517	597	535
Road vehicles	521	547	602	761	904	851	852	806
Stationary combustion, liquid fuels	243	228	214	172	149	109	112	97
Industrial processes	393	428	769	838	1,134	1,570	1,583	1,589
Construction	121	149	197	215	196	188	129	102
Geothermal	61	82	153	116	146	184	168	189
Other	159	106	96	115	173	160	104	88
Total CO_2 emissions	**2,154**	**2,311**	**2,752**	**2,844**	**3,267**	**3,579**	**3,546**	**3,405**

In 2010 the total CO_2 emissions in Iceland were 3,405 Gg. This implies an increase of 58% from 1990 levels and a decrease of about 4% from the preceding year. Emissions from industrial processes increased by 0.4% from 2009 to 2010 due to higher CO_2 emission from the ferroalloys industry, but partly counteracted by less emissions from the cement industry. Emissions from geothermal energy increased by 12%. Emissions from road vehicles peaked in 2007. Emissions decreased in 2008 and were 5% below the emissions in 2007 but increased by 0.1% between 2008 and 2009. It is likely that the economic crisis has led to fewer air flights abroad and therefore more travel within Iceland during summer vacation. This would explain why emissions from road transport have not decreased more during 2008 and 2009 despite significantly higher fuel prices, owing to the depreciation of the Icelandic króna during the year. This can also be seen in decreased international aviation in 2008 and 2009 (Table 2.18). In 2009 and 2010 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. Emissions from stationary combustion of liquid fuels decreased by 14% from 2009 to 2010. Emissions from construction decreased by 21% and emissions from other sources decreased by 16% during the same time period.

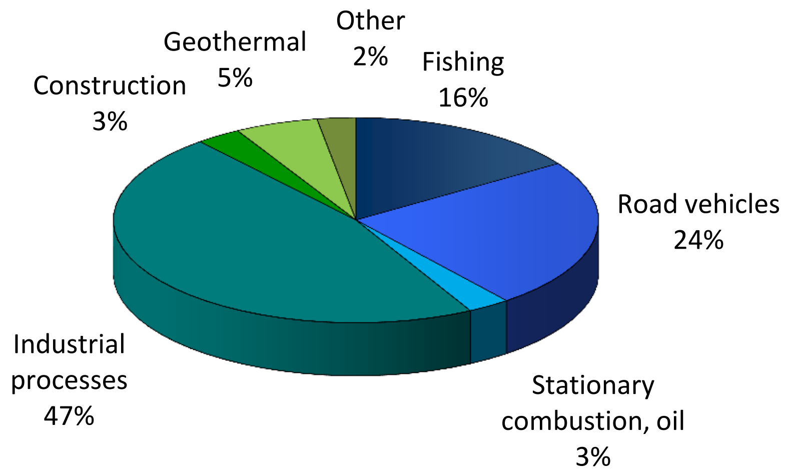

Fig. 2.4. Distribution of CO2 emissions by source in 2010.

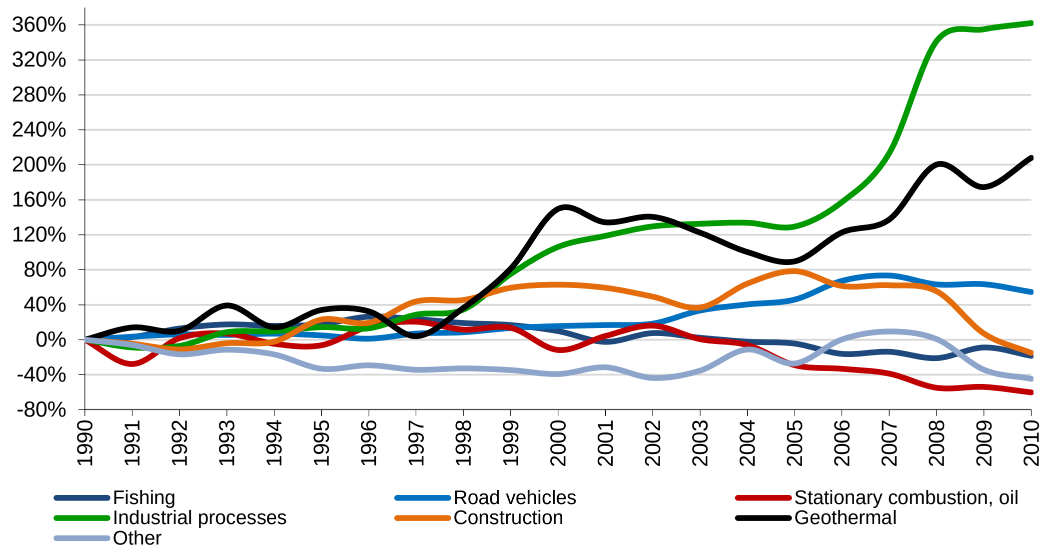

Fig. 2.5. Percentage changes in emissions of CO2 by major sources 1990-2010, compared to 1990 levels.

The increase in CO_2 emissions between 1990 and 2010 can be explained by increased emissions from industrial processes (304%), road transport (55%) and geothermal energy utilisation (208%). Total emissions from the fishing sector declined by 18%, by 15% from the construction sector and by 45% from other sources during the same period.

The main driver behind increased emissions from industrial processes since 1990 has been the expansion of the metal production sector, the aluminium sector in particular. 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 2010, 818,859 tonnes of aluminium were produced in three aluminium plants.

CO_2 emissions from road transport have increased by 55% 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 41%. Also, the Icelandic population has grown by 24% from 1990 to 2010. Emissions from both domestic flights and navigation have declined since 1990.

Emissions from geothermal energy exploitation have increased by 208%. Electricity production using geothermal energy has increased from 283 GWh in 1990 to 4,465 in 2010, or 15-fold.

Emissions from 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 increased again by 10% between 2001 and 2002, but in 2003 they dropped to 1990 levels. In 2010, the emissions were 18% below the 1990 levels and 10% below the 2009 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 increased demand for cement, and the production at the cement plant (building time from 2002 to 2007) increased again between 2004 and 2007, although most of the cement used in this project was imported. In 2010, emissions from cement production were 84% lower than in 2007, due to the collapse of the construction sector.

2.2.2 *Methane (CH_4)*

Agriculture and waste treatment have been the main sources of methane emissions since 1990. In 2010 they comprised 56% and 42% of total methane emissions, respectively (Table 2.5 and Fig. 2.6). The main methane source in the agriculture sector was enteric fermentation, the main source in the waste sector was solid waste disposal on land. Both accounted for roughly 90% of sector methane emissions.

Methane emissions from agriculture decreased by 6% between 1990 and 2010. This development was due to a decrease in livestock population. Emissions from waste on the other hand increased by 51% 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 waste disposal sites which are characterised by higher methane production potential. The decrease in methane emissions from the waste sector since 2007 was due to a decrease in the amount of waste landfilled since 2005 (Fig. 2.7).

Table 2.5. Emissions of CH4 by sector 1990-2010 (Gg CO2-eqivalents).

	1990	1995	2000	2005	2007	2008	2009	2010
Agriculture	274	252	250	242	250	253	255	257
Waste	129	169	193	210	217	208	204	196
Other	6	5	6	6	8	8	8	7
Total	409	427	449	458	475	469	468	460

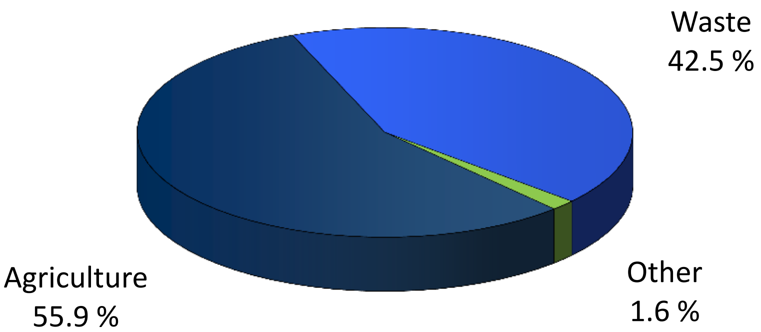

Fig. 2.6. Distribution of CH4 emissions by source in 2010.

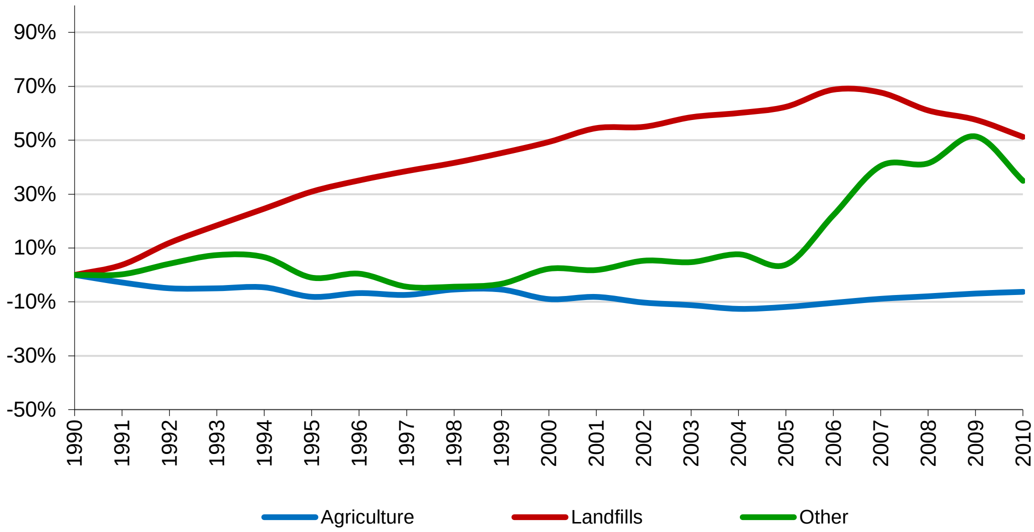

Fig. 2.7. Percentage changes in emissions of CH4 by major sources 1990-2010, compared to 1990 levels.

2.2.3 Nitrous Oxide (N_2O)

Agriculture has been the main source of N_2O emissions in Iceland and accounted for 85% of nitrous oxide emissions in 2010 (Table 2.6 and Fig. 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 of farm animals which was accompanied by a decrease in manure production. The second most important source of N_2O 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. The decrease in agriculture emissions was reinforced by a decrease of N_2O emissions in other sectors. The close down of the only domestic fertilizer plant in 2001 was the main driver behind the decrease in other nitrous oxide emissions (Fig. 2.9).

Table 2.6. Emissions of N2O by sector 1990-2010 (Gg CO2-equivalents).

	1990	1995	2000	2005	2007	2008	2009	2010
Agriculture	429	383	403	368	412	426	399	389
Road traffic	5	12	29	38	40	38	38	37
Other	84	81	63	45	44	42	35	32
Total	518	476	495	452	496	507	472	457

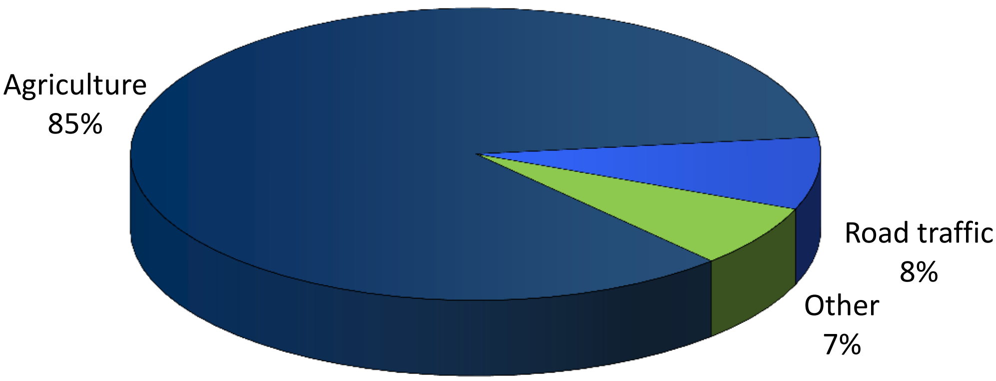

Fig. 2.8. Distribution of N2O emissions by source in 2010.

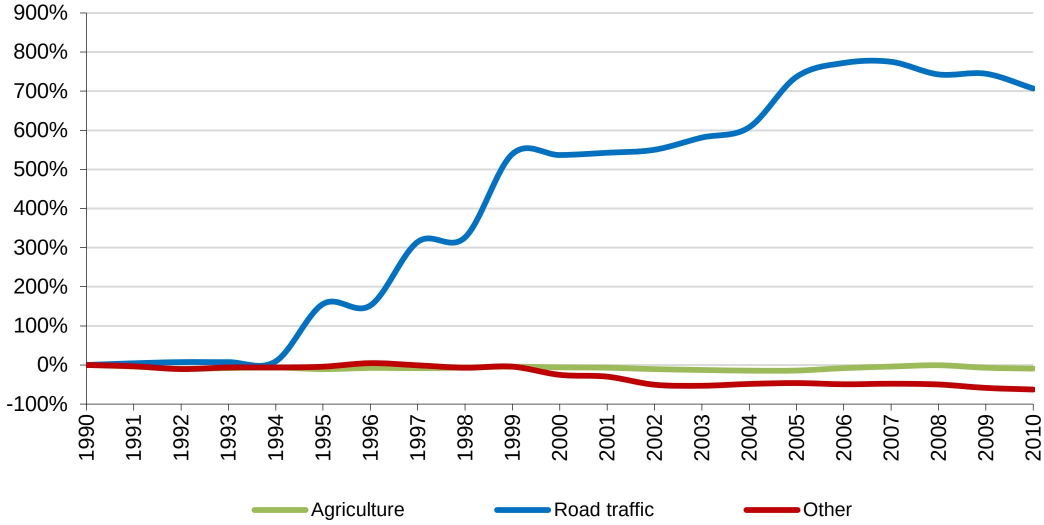

Fig. 2.9. Changes in N2O emission for major sources between 1990 and 2010.

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 123 and 22 Gg CO_2-equivalents respectively in 2010, or 146 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 0.002 Gg CO_2-equivalents in 2010 (Table 2.7).

Total PFC emissions decreased by 65% in the period of 1990-2010. The emissions decreased steadily from 1990 to 1996 with the exception of 1995, as can be seen from Fig. 2.10. 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 and 2010 was achieved through improved process control at both Century Aluminium plant and Alcoa Fjarðarál (until 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.

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 2010.

Table 2.7. Emissions of PFCs 1990-2010 in Gg CO2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
CF_4	355	50	108	22	238	295	129	129
C_2F_6	65	9	20	4	43	54	24	24
C_3F_8	-	-	-	-	-	-	-	0.0003
Total	**420**	**59**	**127**	**26**	**281**	**349**	**153**	**153**

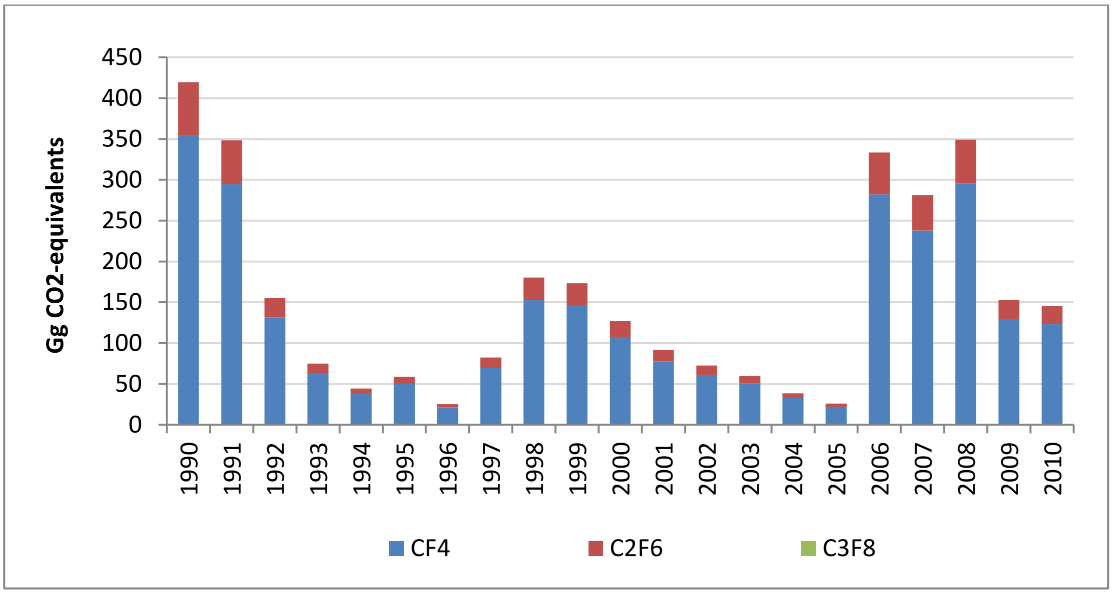

Fig. 2.10. Emissions of PFCs from 1990 to 2010, Gg CO2-equivalents.

2.2.5 *Hydrofluorocarbons (HFCs)*

Total actual emissions of HFCs, used as substitutes for ozone depleting substances, amounted to 69 Gg CO_2-equivalents in 2010 (Table 2.8). The imports of HFCs started in 1993 and have increased since then in response to the phase-out of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). Refrigeration and air-conditioning were the largest sources of HFC emissions.

Over the years the use of ozone depleting substances (ODS) in the fishing industry has been decreasing due to a restriction of ODS import. Therefore the use of substitutes (HFCs) has been increasing. Also, HFCs are used in the aluminium industry whose production capacity has increased rapidly since 1990. The openings of two large shopping centres in Iceland have led to a further increase in HFC usage (Fig. 2.11). Since 2008 the import of HFCs has increased more than twofold.

Table 2.8. Emissions of HFCs 1990-2010 in Gg CO2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
HFC 23	NO	NO	NO	0.01	0.01	0.01	0.01	0.01
HFC 32	NO	NO	0.01	0.03	0.07	0.08	0.09	0.10
HFC 125	NO	0.12	8.04	13.40	16.14	17.30	19.58	24.68
HFC 134a	NO	0.21	3.30	6.77	9.32	10.33	10.91	11.42
HFC 143a	NO	NO	7.73	14.82	19.13	20.79	24.57	32.74
HFC 152a	NO	0.00	0.05	0.05	0.05	0.05	0.05	0.04
HFC 227	NO	NO	NO	0.04	0.03	0.03	0.03	0.03
Total	NO	0.34	19.13	35.13	44.75	48.60	55.24	69.00

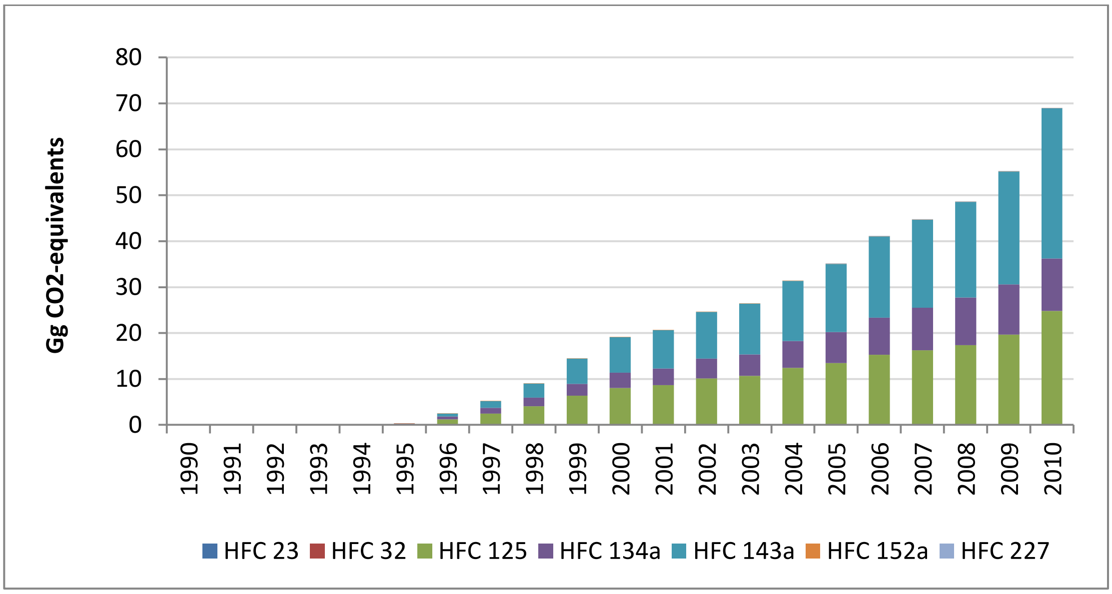

Fig. 2.11. Actual emissions of HFCs 1990-2010, Gg CO2-equivalents (HFC-23, HFC-32, HFC-152 and HFC-227 cannot be seen in figure due to proportionally low levels compared to other levels).

2.2.6 Sulphur Hexafluoride (SF_6)

The largest source of SF_6 emissions is leakage from electrical equipment. Total emissions in 2010 were 4.9 Gg CO_2-equivalents. Emissions have oscillated between 1 and 11 Gg CO_2-equivalents between 1990 and 2010 (Fig. 2.12). One explanation for the fluctuations seen in SF_6 emission is leakage that occurs during the installation of new distribution systems and expansion of older systems. Emission peaks occurred during power plant construction. Emissions were highest in 1999, when two large power stations were built or enlarged (Sultartangi and Búrfell). On average SF_6 emissions amounted to 4 Gg CO_2-equivalents between 1990 and 2010.

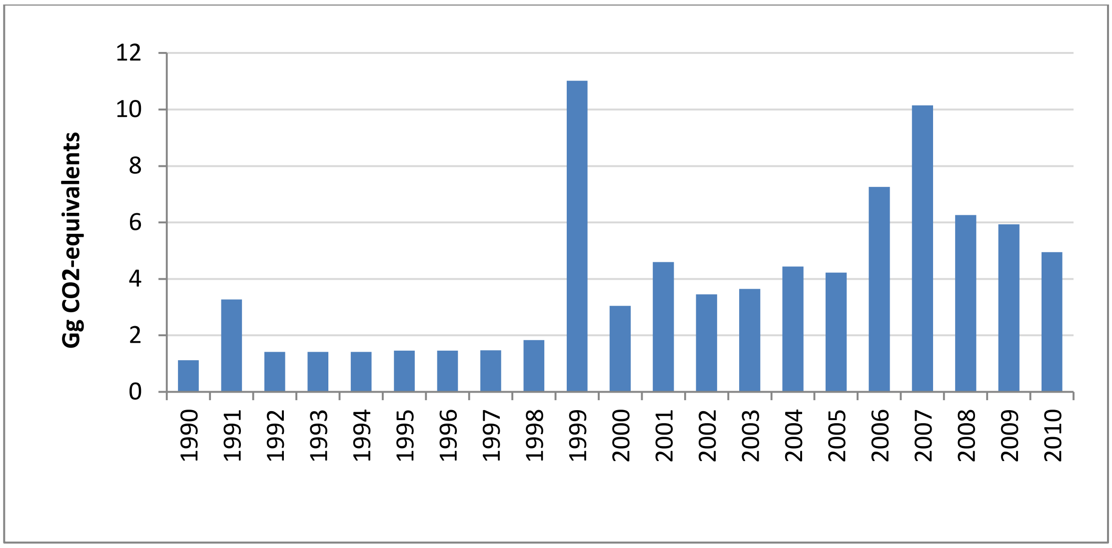

Fig. 2.12. Emissions of SF6 from 1990 to 2010 in Gg CO2-equivalents.

The development of the Blanda power project began in 1984 and the first generating unit went online in the autumn of 1991. This can be seen as a peak in Fig. 2.12. In the years after 1996 expansion took place in the metal production sector, which called for increased electricity production. The power plants at Blanda and Búrfell were expanded and new plants were constructed at Sultartangi and Vatnsfell in southern Iceland. In 2002 construction began on Kárahnjúkar hydropower project which was put into operation in 2007.

2.3 Emission Trends by Source

The Energy sector is the largest contributor of greenhouse gas emissions (without LULUCF) in Iceland, followed by Industrial Processes, Agriculture, Waste, and Solvent and other Product Use. The contribution of the Energy sector to the total net emissions decreased from 51% in 1990 to 41% in 2010. The contribution of Industrial Processes was 25% in 1990 and 40% in 2010 (Table 2.9, Fig. 2.13, and Fig. 2.15).

Table 2.9. Total emissions of GHG by sources in 1990 - 2010 in CO2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
Energy	1,778	1,916	2,041	2,075	2,196	2,072	2,018	1,866
- Fuel combustion	1,717	1,833	1,887	1,957	2,047	1,884	1,845	1,674
- Geothermal energy	62	83	154	118	149	188	173	193
Industrial processes	863	531	938	904	1,471	1,974	1,798	1,810
Solvent and other product use	9	8	8	7	8	7	6	6
Agriculture	703	636	653	610	662	679	654	646
LULUCF	1,188	1,131	1,003	877	822	794	759	734
Waste	148	184	205	223	236	226	224	214
Total without LULUCF	**3,501**	**3,274**	**3,845**	**3,819**	**4,574**	**4,959**	**4,700**	**4,542**
Total with LULUCF	**4,690**	**4,406**	**4,848**	**4,696**	**5,396**	**5,753**	**5,459**	**5,276**

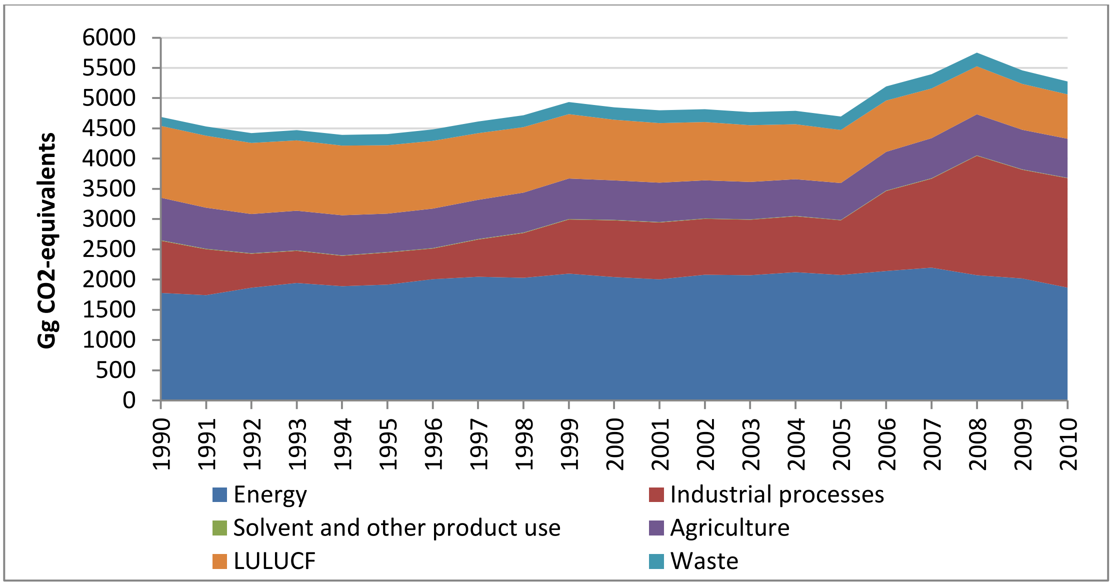

Fig. 2.13. Emissions of GHG by sector from 1990 to 2010 in CO2-equivalents.

The distribution of the total greenhouse gas emissions over the UNFCCC sectors (excluding LULUCF) in 2010 is shown in Fig. 2.14.

Emissions from the Energy sector accounted for 41% (fuel combustion 37% and geothermal energy 4%) of the national total emissions without LULUCF, Industrial Processes accounted for 40%, and Agriculture for 14%. The Waste sector accounted for 5% and Solvent and other Product Use for 0.1%.

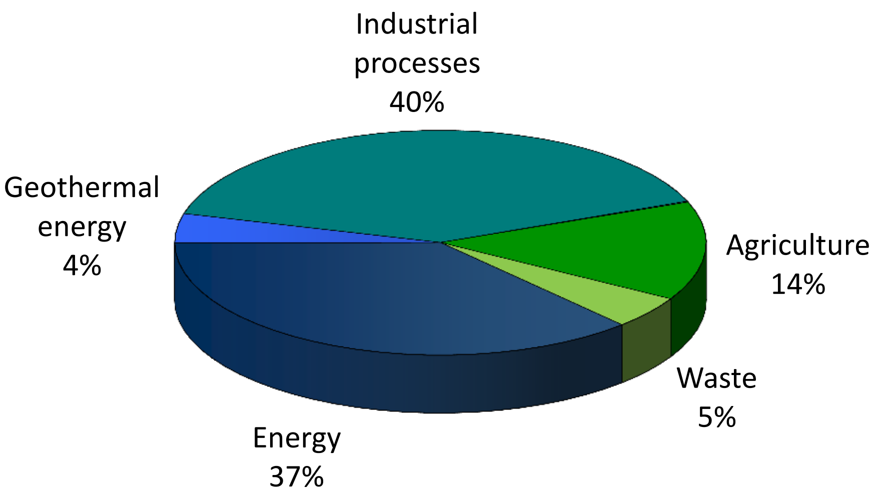

Fig. 2.14. Emissions of greenhouse gases by UNFCCC sector in 2010.

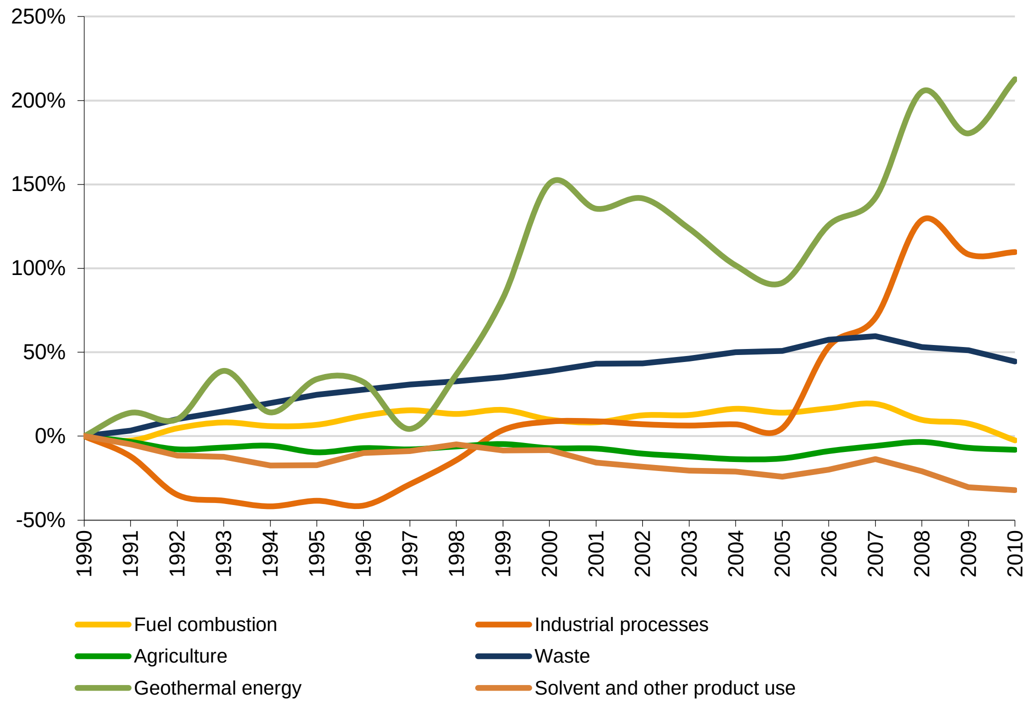

Fig. 2.15. Percentage changes in emissions of total greenhouse gas emissions by UNFCCC source categories during the period 1990-2010, compared to 1990 levels.

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. In 2010 the consumption per capita was about 735 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 79% of the total electricity produced in Iceland in 2010. Iceland relies heavily on its geothermal energy sources for space heating (over 90% of all homes) and electricity production (26% of the electricity) and on hydropower for electricity production (74% 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 the signing of 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 2010 are listed in Table 2.10. Emissions from fuel combustion in the Energy sector accounted for 37% of the total greenhouse gas emissions in Iceland in 2010. Fig. 2.16 shows the distribution of emissions in 2010 by different source categories. The percentage change in the various source categories in the Energy sector between 1990 and 2010, compared with 1990, are illustrated in Fig. 2.17.

Table 2.10. Total emissions of GHG from the fuel combustion in the Energy sector in 1990-2010, CO2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
Energy industries	14	19	7	9	22	6	6	5
Manufacturing industry and construction	377	378	450	447	412	369	264	213
Transport	621	628	674	849	1,028	973	946	900
- Road	529	561	633	800	945	891	892	844
- Other	92	67	41	49	83	82	54	56
Other sectors	705	808	756	651	585	536	629	556
- Fishing	662	780	728	633	571	523	603	540
- Residential/ commercial	43	28	29	18	14	14	26	16
Total	**1,717**	**1,833**	**1,807**	**1,957**	**2,047**	**1,884**	**1,845**	**1,674**

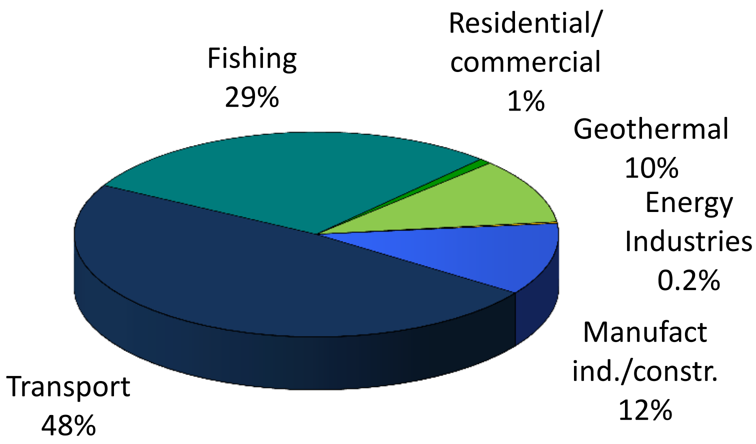

Fig. 2.16. Greenhouse gas emissions in the Energy sector 2010, distributed by source categories.

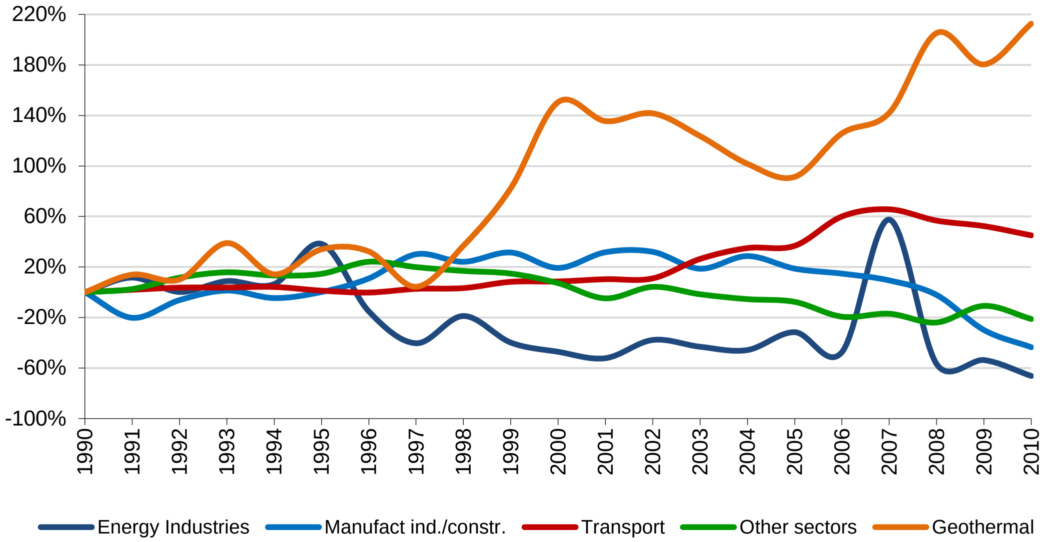

Fig. 2.17. Percentage changes in emissions in various source categories in the Energy sector during the period 1990-2010, compared to 1990.

Table 2.10 and Fig. 2.17 show that emissions from transport have increased (by 45%) as emissions from other sector (dominated by fishing) have decreased (by 21%). Emissions from energy industries are 66% below 1990 levels and emissions from manufacturing industries and construction are 44% 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. Emissions from energy industries accounted for 0.2% of the sector's total and 0.1% of the total GHG emissions in Iceland in 2010. 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 back up 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 48% between 2007 and 2010. Further, since 2007 emissions from fuel combustion at the cement plant have decreased by 83% 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 less production.

Emissions from the Transport sector increased by 45% from 1990 to 2010. Emissions from road transport have increased by 60% since 1990, owing to an increase in the number of cars per capita, more mileage driven and until 2007 an increase in larger vehicles. Since 1990 the vehicle fleet in Iceland has increased by 141%. Also, the Icelandic population has grown by 24% from 1990 to 2010. Emissions from road vehicles peaked in 2007. Emissions decreased in 2008 and were 5% below the emissions in 2007 but increased by 0.1% between 2008 and 2009. It is likely that the economic crisis has led to fewer air flights abroad and therefore more travel within Iceland during summer vacation. This would explain why emissions from road transport have not decreased more during 2008 and 2009 despite significantly higher fuel prices, owing to the depreciation of the Icelandic króna during the year. In 2009 and 2010 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 the same. 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 2010 emissions were 18% below the 1990 level and 10% below the 2009 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 2010. Iceland relies heavily on geothermal energy for space heating (over 90% of the homes) and electricity production (26% of the total electricity production). The emissions from geothermal power plants are considerably less than from fossil fuel power plants, or 19 times. Table 2.11 shows the emissions from geothermal energy from 1990 to 2010. Electricity production using geothermal power increased 15-fold during this period from 283 to 4,465 GWh. 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 2.11. Emissions from geothermal energy from 1990-2010 in CO2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
Geothermal energy	62	83	154	118	149	188	173	193

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 use of HFCs as substitutes for ozone depleting substances and SF_6 from electrical equipment. The Industrial Process sector accounts for 40 % of the national greenhouse gas emissions as can be seen in Table 2.12 and Fig. 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 2010, emissions from the industrial processes sector were 110% above the 1990 level.

Table 2.12. Emissions from industrial processes 1990-2010 in CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
Mineral products	52	38	66	56	65	63	30	11
Chemical industry	49	43	19	-	-	-	-	-
Metal production	761	449	831	809	1,352	1,857	1,707	1,725
- **Ferroalloys**	205	239	358	374	391	340	342	360
- **Aluminium**	557	210	473	435	961	1,517	1,365	1,365
○ Aluminium CO_2	137	151	346	409	680	1,168	1,212	1,219
○ Aluminium PFC	420	59	127	26	281	349	153	146
Consumption of HFCs and SF_6	1	2	22	39	55	55	61	74
Total	**863**	**631**	**938**	**904**	**1471**	**1,974**	**1,798**	**1,810**
Emissions fulfilling 14/CP.7*						**1,163**	**1,187**	**1,216**

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

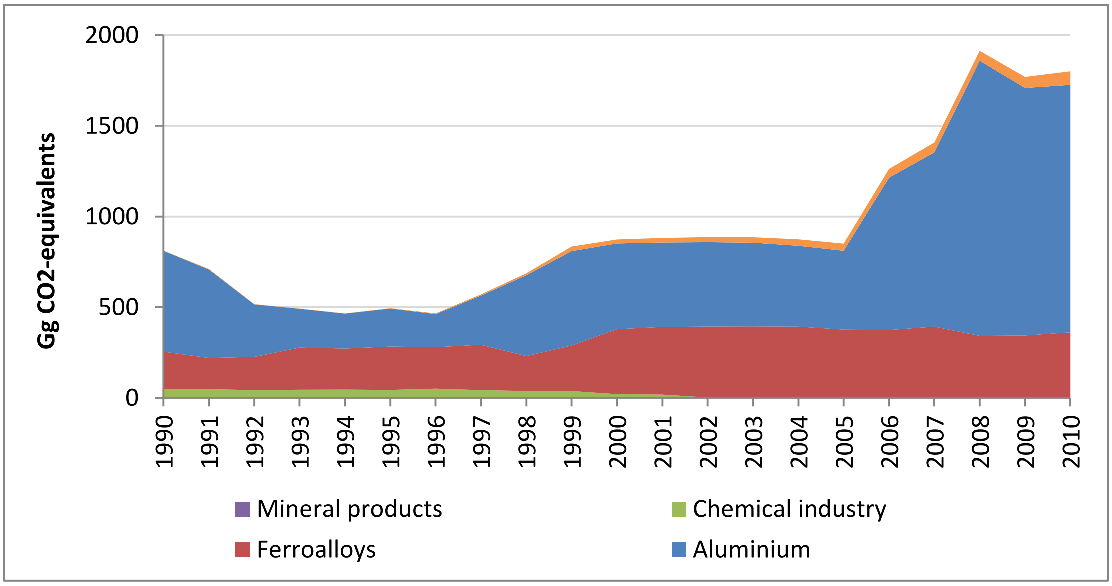

Fig. 2.18. Total greenhouse gas emissions in the Industrial Process sector during the period from 1990-2010 in Gg CO_2-equivlalents.

The most significant category within the industrial processes sector is metal production, which accounted for 88% of the sector's emissions in 1990 and 95% in 2010. Aluminium production is the main source within the metal production category, accounting for 75% 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 2010 reaching 2005 levels in 2010. 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 at both Century Aluminium plant and Alcoa Fjarðarál (until December at Alcoa). 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. The amount of total PFC emitted per tonne of aluminium was 0.18 tonnes of CO_2-equivalents in 2010. More discussion on PFC emissions from the three aluminium plants can be found in chapter 4.5.

Production of ferroalloys is another major source of emissions, accounting for 20% of industrial processes emissions in 2010. 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 67% since 1990. Emissions in 2010 were 5% higher than in 2009.

Production of minerals accounted for 0.6% of the emissions in 2010. Cement production is the dominant contributor. Cement is produced in one plant in Iceland, emitting CO_2 derived from carbon in the shell sand used as the raw material in the process. 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. Since 2007 emissions from the plant have decreased by 84%.

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 silicon production facility in 2004.

Imports of HFCs started in 1993 and have increased steadily since then. They are used as substitutes for ozone depleting substances that are being phased out in accordance with the Montreal Protocol. On shore as well as on sea refrigeration in the fishing sector were the largest importers and emitters of HFCs. The HFCs stored in refrigeration units constitute banks of refrigerants which emit HFCs over time due to normal operation and leakage. The amount of HFCs emitted by mobile air conditioning units in vehicles has also been increasing steadily (Table 2.13).

The largest source of SF_6 emissions was leakages from electrical equipment. Emissions have varied between 1 to 11 Gg from 1990 to 2010, peaking in years when new power plants were built (Table 2.13).

Table 2.13. HFC and SF_6 emissions from consumption of HFC and SF_6 in Gg CO_2 equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
HFC	NO	0.34	19.13	35.13	44.75	48.60	55.24	69.00
SF_6	1.13	1.46	3.05	4.23	10.15	6.26	5.94	4.95

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 2010 (less than 0.1% of total GHG emissions), which was 11% below the 1990 level and 13% below the 2009 level. This development was mainly due to a decrease in paint application (Table 2.14). Emissions from N_2O use decreased by 43% between 1990 and 2010 due to decreasing imports for medical purposes (anaesthesia).

Table 2.14. Total greenhouse gas emissions from solvents and other product use in 1990-2009 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
Paint Application	1.71	1.75	1.82	1.17	1.47	1.24	1.12	0.93
Degreasing and Dry Cleaning	0.24	0.18	0.27	0.19	0.20	0.18	0.16	0.12
Chemical products, manufacture and processing	0.05	0.05	0.04	0.02	0.02	0.01	0.02	0.01
Other (NMVOC emissions from other product use)	1.07	1.23	1.58	2.16	2.34	2.12	1.87	1.67
Use of N_2O from product uses	6.00	4.29	4.60	3.35	3.80	3.63	3.15	3.41
Total emissions from solvents and other product use	9.07	7.51	8.31	6.88	7.83	7.18	6.31	6.15

2.3.4 Agriculture

Emissions from agriculture are closely coupled with livestock population size. Since emission factors were assumed to be stable during the last two decades (with the exception of gross energy intake of dairy cows, which increased due to 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 2.15 and Fig. 2.20). Since 2005 emissions from agriculture have increased by 6% due to an increase in livestock population size but still remain 8% 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 15,000 tonnes, but has decreased to less than 11,000 tonnes in 2010. 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 2010 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 (Fig. 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).

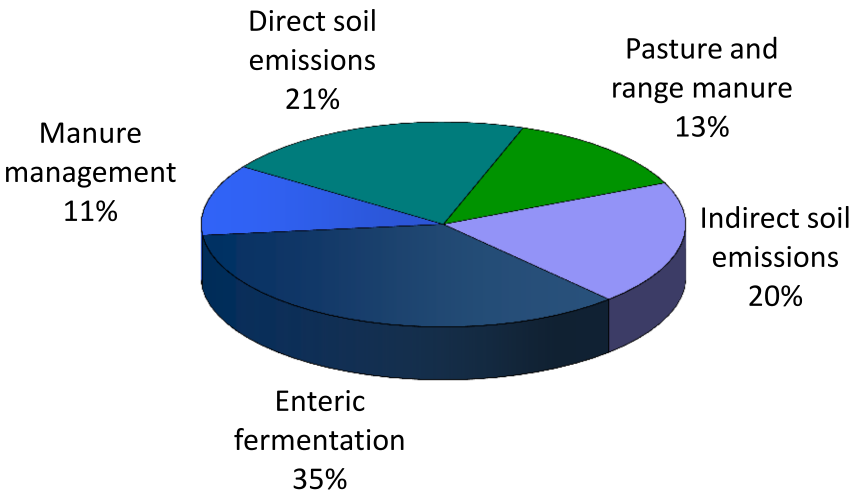

Fig. 2.19. Greenhouse gas emissions in the agriculture sector 2010, distributed by source categories.

Table 2.15. Total greenhouse gas emissions from agriculture in 1990-2010 in Gg CO2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
CH_4, enteric fermentation	244	224	221	214	220	223	226	228
CH_4 and N_2O, manure management	83	69	72	69	72	71	73	73
Direct soil emissions (N_2O)	146	133	144	126	150	158	141	135
Pasture and range manure (N_2O)	90	82	82	81	81	82	83	84
Indirect soil emissions (N_2O)	141	127	134	119	138	144	132	127
Total emissions	703	636	653	610	662	679	654	646

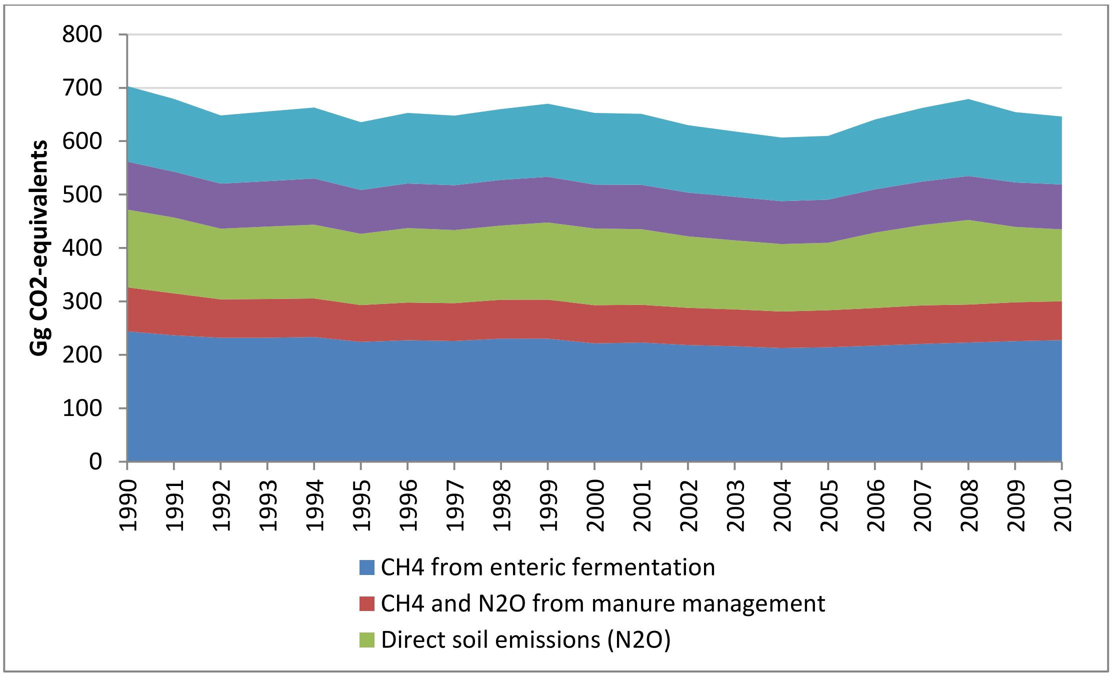

Fig. 2.20. Total greenhouse gas emissions from agriculture 1990-2010 in Gg CO2-equivalents.

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

Emissions from the LULUCF sector in Iceland are high; the sector is the third largest in 2010 but was the second largest in 1990. A large part (62%) of the absolute value of emissions from the sector in 2010 was from cropland and grassland due to drainage of 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 2.16. Emissions from the LULUCF sector from 1990-

2010 in Gg CO2-equivalents. 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 2.16. Emissions from the LULUCF sector from 1990-2010 in Gg CO2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
Forest land - Natural birch forest	0	0	-34	-58	-72	-79	-88	-89
Forest land - Afforestation	-32	-53	-86	-127	-148	-159	-170	-182
Cropland remaining cropland	764	872	963	1018	1025	1026	1022	1015
Land converted to cropland	434	297	177	95	75	69	65	64
Grassland remaining grass-land	172	228	249	279	278	279	275	275
Other land converted to grassland, revegetation	-349	-378	-424	-474	-493	-502	-509	-516
Other conversion to grass-land	126	81	70	53	62	65	69	70
Land converted to wetland (reservoirs)	3	14	17	17	18	18	18	18
Forest land converted to settlements	NE, NO	NE, NO	NE, NO	0	0	NE, NO	NE, NO	0
Grassland non CO2-emissions	69	70	72	74	76	77	78	78
Net LULUCF	1188	1131	1003	877	822	794	759	734

Analyses of trends in emissions of the LULUCF sector must be interpreted with care as time series are missing for many factors and potential sinks or 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 167 Gg (Net – Net accounting) in 2010. Removals from activities under Articles 3.3 (Afforestation and Reforestation) amounted to 172 Gg in 2010. Afforestation falling under Convention reporting amounted to 182 Gg. The difference, 10 Gg, was due to C-stock increase in older forests.

2.3.6 Waste

Emissions from the Waste sector accounted for less than 5% of total GHG emissions in 2010. About 89% of these emissions were methane emissions from solid waste disposal on land. 5.5% were CH_4 and N_2O emissions from wastewater treatment and 4% were CO_2, CH_4 and N_2Oemissions 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 2.17 and Fig. 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 also caused by a decrease in SWD emissions which is due to a rapidly decreasing share of waste landfilled since 2005. The total increase of SWD emissions between 1990 and 2010 amounted to 55%.

Table 2.17. Total emissions from the Waste sector from 1990-2010 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
SWD	122.8	163.5	188.6	204.9	212.0	203.7	199.1	190.6
Wastewater treatment	7.8	8.9	9.4	12.3	11.7	11.5	11.5	11.6
Incineration (without ER)	17.3	11.7	6.8	4.9	10.5	9.2	10.7	8.9
Composting	0.0	0.4	0.4	0.9	1.8	1.9	2.3	2.7
Total	**147.9**	**184.5**	**205.2**	**222.9**	**236.0**	**226.3**	**223.6**	**213.8**

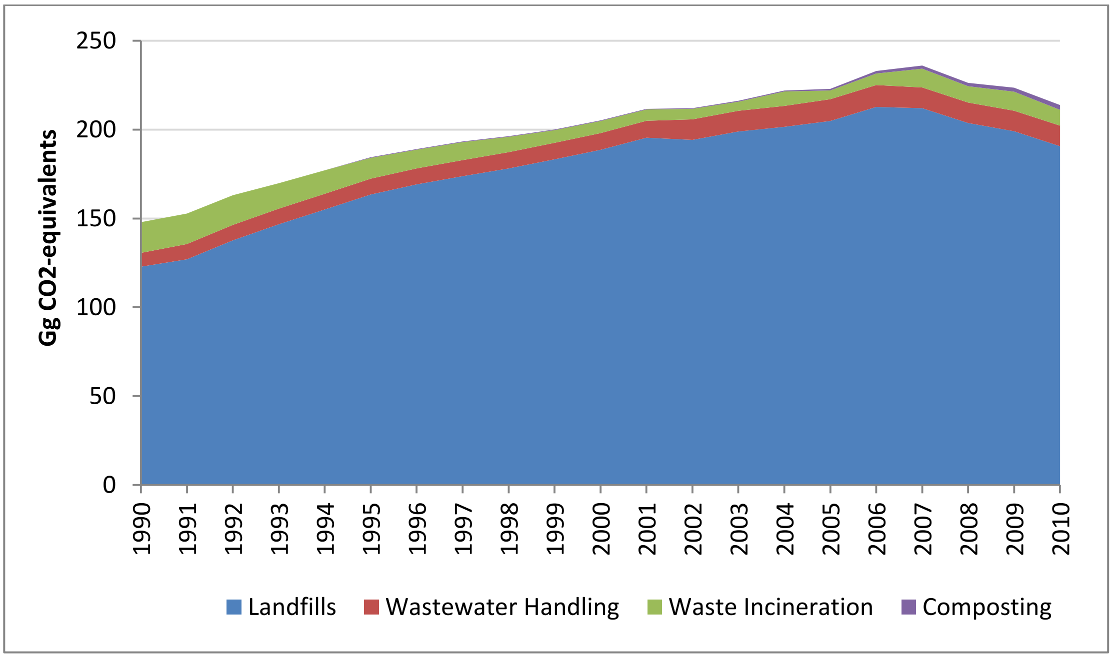

Fig. 2.21. Emissions of greenhouse gases in the Waste sector 1990-2009 in Gg CO_2-equivalents.

Total wastewater handling emissions increased by 49% 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 of in fast running rivers or straight into the sea.

Emissions from waste incineration decreased by 49% between 1990 and 2010 due to a decrease in the amount of waste incinerated. The amount of waste burned in open pits decreased by 95% since 1990 (this includes the amount burned in bonfires every New Year Eve – otherwise the decrease would amount to 99.9%). The amount of waste incinerated (without energy recovery), however, increased from zero in 1990 to 12.7 tonnes in 2010. This change in waste incineration methods explains the different scales of emission decrease between greenhouse gases: since 1990 CO_2 emissions from waste incineration decreased by only 23% whereas methane and N_2O emissions decreased by 94% and 78%, respectively (Fig. 2.22). The CO_2 emission factor for waste incineration is slightly higher than the one for open burning of waste (oxidisation factor of 1 vs. 0.58), the CH_4 emission factor for open burning of waste however is 27 times higher and the N_2O emission factor 2.5 times higher than the one for waste incineration.

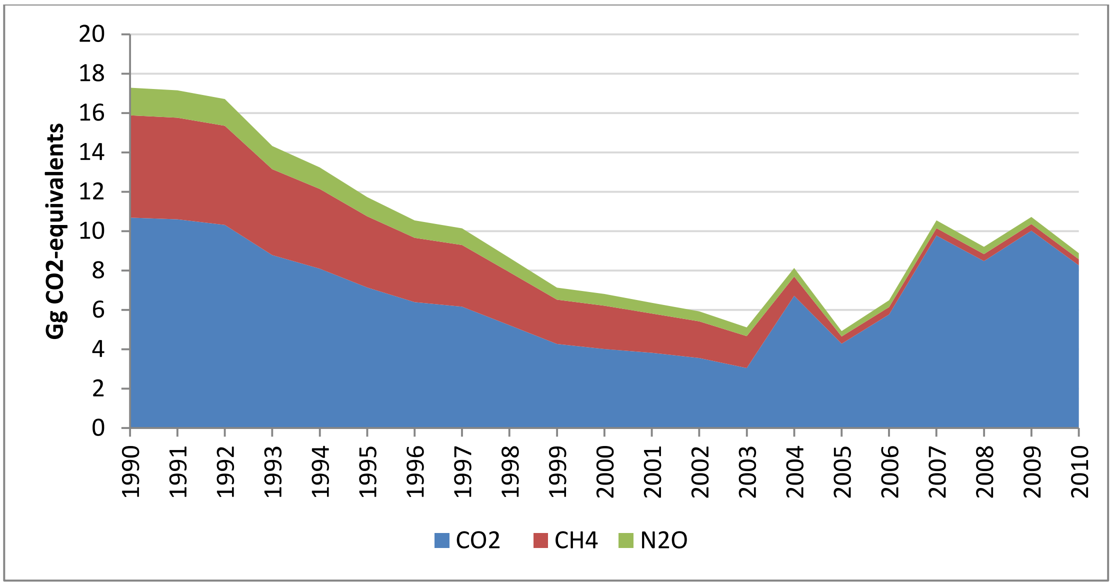

Fig. 2.22. Emissions from waste incineration.

Emissions from composting have been steadily increasing since composting started in Iceland the year 1995 and accounted for roughly 1% of total waste sector emissions in 2010. Between 2009 and 2010 composting emissions increased by 20%.

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 2.18.

In 2010, greenhouse gas emissions from ships and aircrafts in international traffic bunkered in Iceland amounted to a total of 565 Gg CO_2-equivalents, which corresponds to about 12% of the total Icelandic greenhouse gas emissions. Greenhouse gas emissions from marine and aviation bunkers increased by around 76% from 1990 to 2010; with a 12% increase between 2009 and 2010.

Looking at these two categories separately, it can be seen that greenhouse gas emissions from international marine bunkers increased by 84% from 1990 to 2010, while emissions from aircrafts increased by 72% during the same period. Between 2009 and 2010 emissions from marine bunkers increased by 11% while emissions from aviation bunkers increased by 13%. Emissions from international bunkers are rising again after decline since 2007. Foreign fishing vessels dominate the fuel consumption from marine bunkers.

Table 2.18. Greenhouse gas emissions from international aviation and marine bunkers 1990-2010 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009	2010
Aviation	222	238	411	425	516	432	337	381
Marine	100	146	221	112	209	231	167	184
Total	**322**	**384**	**632**	**538**	**725**	**663**	**503**	**565**

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 fishing, transport, and the manufacturing industry and construction, as can be seen in Fig. 2.23. The NO_x emissions from fishing rose from 1990 to 1996 when a substantial portion of the 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 2010 were 19% 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 20%) after the use of catalytic converters in all new vehicles became obligatory in 1995, despite the fact that fuel consumption has increased by 54%. 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 2010 emissions from manufacturing industry and construction were 29% lower than in 1990. This is due to the collapse of the construction sector (including less emissions from the cement plant) and to less fuel consumption at fishmeal plants as 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 2010 were 21% below the 1990 level.

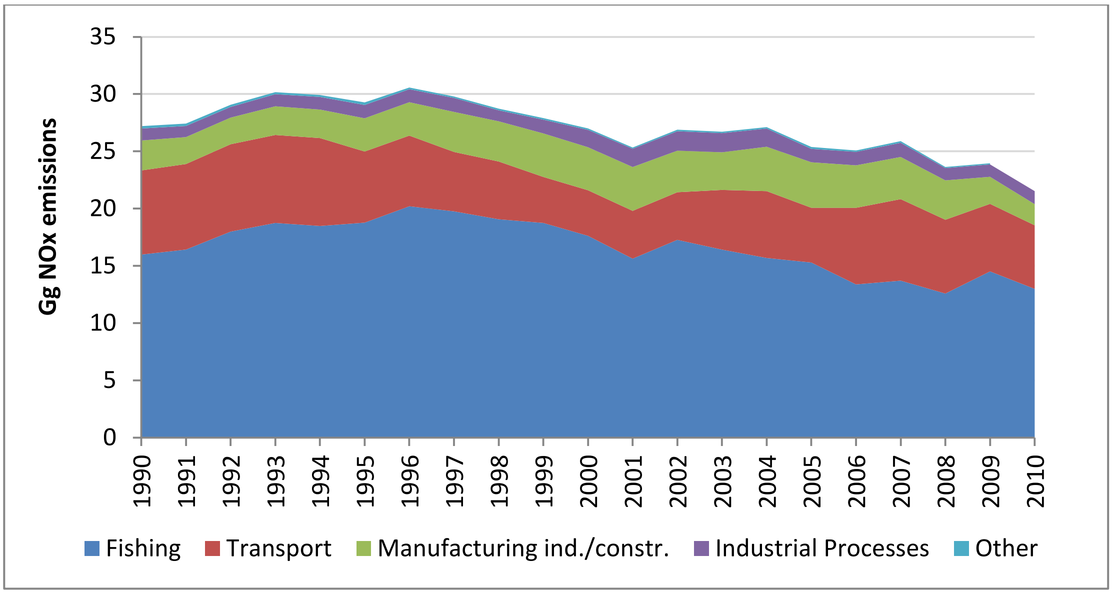

Fig. 2.23. Emissions of NO_x by sector 1990-2010 in Gg.

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 Fig. 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. The total emissions showed a downward trend from 1994 to 2010. The emissions in 2010 were 57% below the 1990 level.

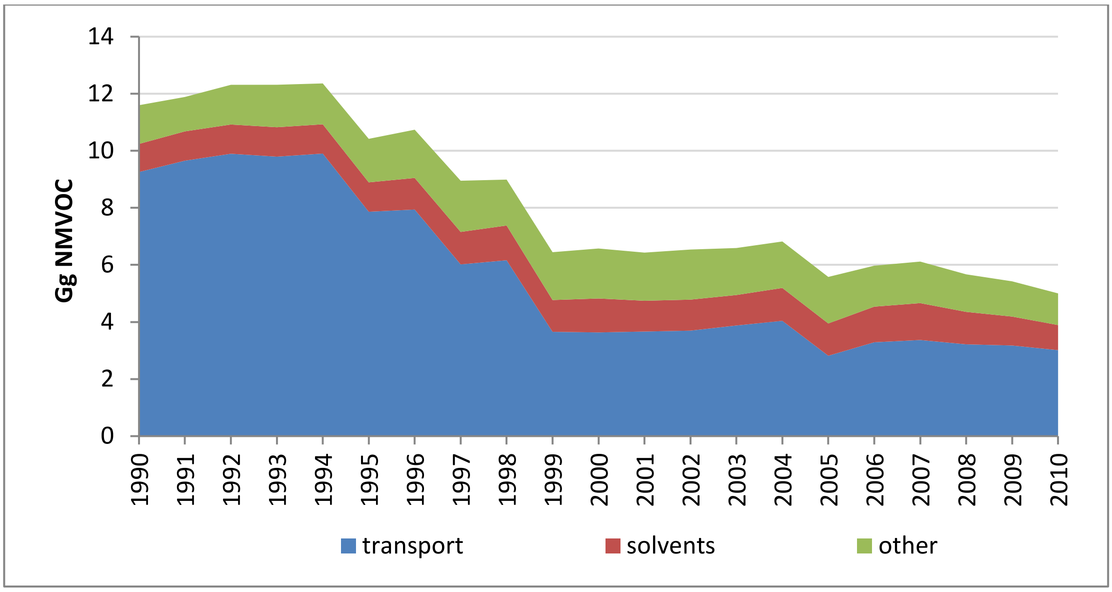

Fig. 2.24. Emissions of NMVOC by sector 1990-2010 in Gg.

2.4.3 Carbon Monoxide (CO)

Transport is the most prominent contributor to CO emissions in Iceland, as can be seen in Fig. 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 2010 were 59% below the 1990 level.

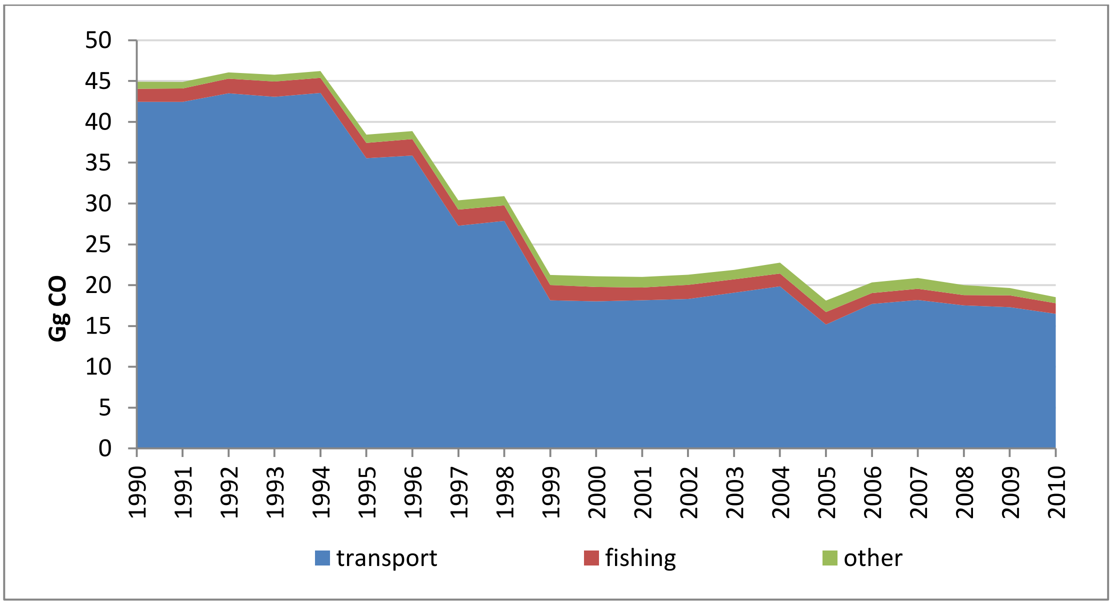

Fig. 2.25. Emissions of CO by sector 1990-2010 in Gg.

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 333% since 1990 due to increased activity in this field, as electricity production at geothermal power plants has increased 15-fold since 1990. Other significant sources of sulphur dioxide in Iceland are industrial processes and manufacturing industry and construction, as can be seen in Fig 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 2010 818,859 tonnes of aluminium were produced at three plants and 102,214 tonnes of ferroalloys were produced at one plant. This led to increased emissions of sulphur dioxide (238% 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 69% below the 1990 level in 2010.

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 lead to higher sulphur emissions from the fishing fleet in recent years. Emissions from the fishing fleet in 2010 were 7% above the 1990 level although fuel consumption was 19% less.

In 2010 total sulphur emissions in Iceland, calculated as SO_2, were in 241% above the 1990 level, but 87% when excluding emissions from geothermal power plants.

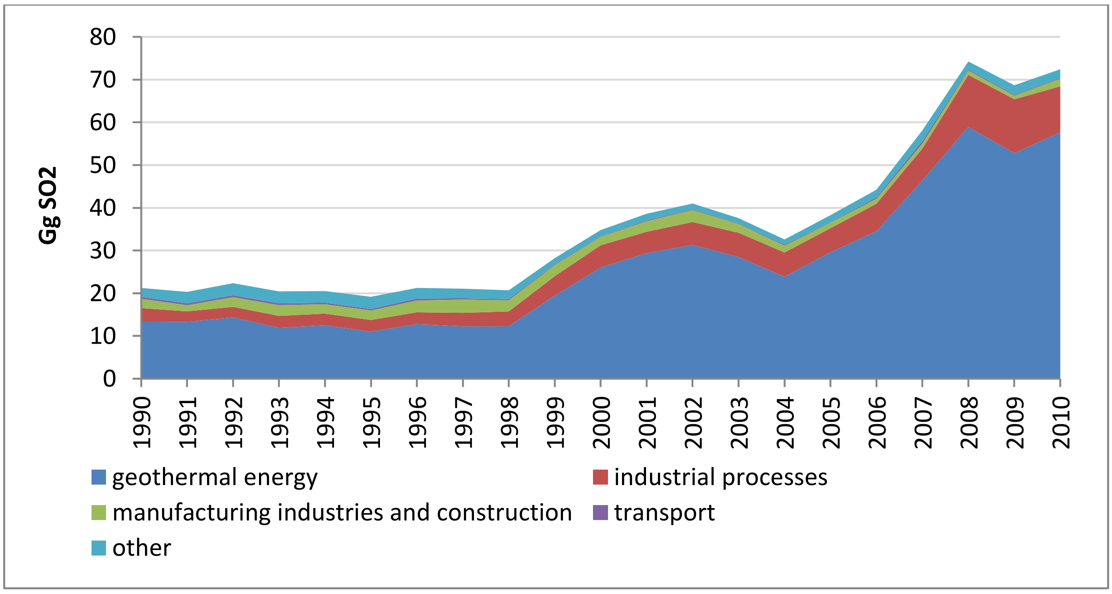

Fig. 2.26. Emissions of S (sulphur) by sector 1990-2010 in Gg SO_2-equivalents.

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 75% more than total man made emissions in 2010. 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 2010 was about 753 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 79% of the total electricity produced in Iceland in 2010. Iceland relies heavily on its geothermal energy sources for space heating (over 90% of all homes) and electricity production (26% of the electricity) and on hydropower for electricity production (74% of the electricity).

The Energy sector accounts for 41% (fuel combustion 37%, geothermal energy 4%) of the GHG emissions in Iceland. Energy related emissions increased by 5% from 1990 to 2010. Emissions from fuel combustion decreased by 2.5% from 1990 to 2010 while emissions from geothermal energy increased by 213%. From 2009 to 2010 the emissions from fuel combustion decreased by 9%, while emissions from geothermal energy increased by 11.5%. Total emissions related to energy decreased by 7.5% from 2009 to 2010. Fisheries and road traffic are the sector’s largest single contributors. Combustion in manufacturing industries and construction is also an important source. Recalculations have been made in the Energy sector since last submission by reason of fuel allocation in the sectors 1A1a Energy industries, 1A2 Manufacturing industry (stationary) and 1A4 Residential. Further two waste incineration facilities which were covered by the Energy sector in earlier submissions are now covered by the Waste sector.

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. Further explanation of this adjustment is given in Annex III. This applies for the sectors 1A1a Energy industries, 1A2 Manufacturing industry (stationary combustion) and 1A4 Residential.

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 2010 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, 2010) and trend
- Non-Road Transport – CO_2 (1A3a/d)
  » This is a key source in level (1990, 2010) and trend
- Road Transport – CO_2 (1A3b)
  » This is a key source in level (1990, 2010) and trend
- Commercial/institutional/residential – CO_2 (1A4a/b)
  » This is a key source in level (1990) and trend
- Fishing – CO_2 (1A4c)
  » This is a key source in level (1990, 2010) and trend
- Geothermal Energy – CO_2 (1B2d)
  » This is a key source in level (1990, 2010) 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	NE	NE	NE	NA	NA	NA	NE	NE	NE	NE
- 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 been developed yet 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 0.2% of the sectors total and 0.1% of the total GHG emissions in Iceland in 2010.

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. Default emission factors (EFs) from Tables 1.7 to 1.11 in the Reference Manual were used where EFs are missing.

3.2.1 Electricity Production

Electricity was produced from hydropower, geothermal energy and fuel combustion in 2010 (Table 3.2) with hydropower as the main source of electricity (Orkustofnun, 2011). 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	2007	2008	2009	2010
Hydropower	4,159	4,678	6,352	7,014	8,394	12,427	12,279	12,592
Geothermal	283	288	1,323	1,658	3,579	4,037	4,553	4,465
Fuel combustion	5.6	8.4	4.4	7.8	3.5	2.7	2.9	1.7
Total	**4,447**	**4,977**	**7,679**	**8,680**	**11,976**	**16,467**	**16,835**	**17,059**

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. 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	2007	2008	2009	2010
Gas/Diesel oil (kt)	1.4	2.1	1.1	1.9	0.8	0.7	0.7	0.4
Emissions (Gg)	**4.4**	**6.7**	**3.6**	**6.3**	**2.8**	**2.2**	**2.3**	**1.4**

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 193 Gg of CO_2-equivalents, in 2010. The resulting emissions of GHG per kWh amount to 1.4 g CO_2-equivalents/kWh for hydropower plants and to 43 g CO_2-equivalents/kWh for geothermal energy. The weighted average GHG emissions from electricity production in Iceland in 2010 was thus 12.4 g/kWh.

Recalculations

Since last submission changes have been made regarding fuel allocation in the sectors 1A1a Energy industries, 1A2 Manufacturing industry (stationary) and 1A4 Residential, as further explained in Annex III. This has led to some minor changes in emissions (Table 3.5).

Table 3.5. Changes in greenhouse gas emissions between 2011 and 2012 submissions. All emissions in Gg CO_2 eq.

Greenhouse gas	Year	2011 Submission	2012 Submission	Change between submissions	Main reason for change
CO_2, CH_4, N_2O	1990	4.1	4.3	5%	Fuel reallocation
CO_2, CH_4, N_2O	2009	2.4	2.3	- 3%	Fuel reallocation

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 2010. 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. Two 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. A description of the method to estimate greenhouse gas emissions from waste incineration plants is given in Chapter 8.4.

Activity Data

Activity data for heat production with fuel combustion and waste incineration and the resulting emissions are given in Table 3.6. No fuel consumption for heat production was reported by the NEA for 2010.

Table 3.6. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equvalents) from heat production (NO: Not occurring).

	1990	1995	2000	2005	2007	2008	2009	2010
Residual fuel oil	3.0	3.1	0.1	0.2	4.5	0.1	0.1	-
Gas/Diesel oil	-	-	-	-	-	-	-	-
Solid waste	NO	4.7	6.0	6.0	8.2	6.3	4.7	4.8
Emissions (GHG)	**9.2**	**12.1**	**3.7**	**3.1**	18.8	**3.7**	**4.0**	**3.3**

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 3.7along with sulphur content of the fuels.

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

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t fuel]	S-content [%]
Residual fuel oil	40.19	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	24.95	0.98	0.96	0.17

Recalculations

Since last submission changes have been made regarding fuel allocation in the sectors 1A1a Energy industries, 1A2 Manufacturing industry (stationary) and 1A4 Residential, as further explained in Annex III. Further emissions from one waste incineration facility (Húsavík) which was covered by the sector 1A1a in earlier submissions are now covered by the Waste sector as the plant does not recover energy. This has led to some changes in emissions (Table 3.8).

Table 3.8. Changes in greenhouse gas emissions between 2011 and 2012 submissions. All emissions in Gg CO_2 equivalents.

Greenhouse gas	Year	2011 Submission	2012 Submission	Change between submissions	Main reason for change
CO_2, CH_4, N_2O	1990	9.2	9.2	No change	
CO_2, CH_4, N_2O	2009	12.4	4.0	- 68%	Fuel and incineration plant reallocation

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 11% of the Energy sector's total and 5% of total GHG emissions in Iceland in 2010. Mobile Combustion in the Construction sector accounts for 54% 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. They 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. There is thus a given total, which the usage in the different sectors must sum up to. All major industries, falling under law no. 65/2007 (metal and cement industries) report their fuel use to 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 2010 are based on data provided by the industry (Green Accounts submitted under regulation 851/2007). 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 3.9). Emissions from fuel use in the ferroalloys production is reported under 1A2a.

Table 3.9. Fuel use (kt) and emissions (GHG total in Gg CO_2-equivalents) from stationary combustion in the manufacturing industry.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	5.1	1.1	10.3	22.2	14.9	8.6	9.8	9.4
Residual fuel oil	55.9	56.2	46.2	25.0	22.8	20.5	17.6	16.5
LPG	0.5	0.4	0.9	0.9	1.5	1.9	1.2	1.0
Electrodes (residue)	0.8	0.3	1.5	-	0.5	0.5	0.4	0.4
Steam Coal	18.6	8.6	13.3	9.9	24.4	21.5	10.2	3.6
Petroleum coke	-	-	-	8.1	0.2	-	-	-
Waste oil	-	5.0	6.0	1.8	2.3	2.2	0.9	1.4
Total Emissions	**241**	**210**	**228**	**205**	**191**	**157**	**118**	**97**

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 3.10 along with sulphur content of the fuels.

Table 3.10. 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.

Recalculations

Since last submission changes have been made regarding fuel allocation in the sectors 1A1a Energy industries, 1A2 Manufacturing industry (stationary) and 1A4 Residential, as further explained in Annex III. This has led to some changes in emissions (Table 3.11).

Table 3.11. Changes in greenhouse gas emissions between 2011 and 2012 submissions. All emissions in Gg CO_2 equivalents.

Greenhouse gas	Year	2011 Submission	2012 Submission	Change between submissions	Main reason for change
CO_2, CH_4, N_2O	1990	241	241	No change	
CO_2, CH_4, N_2O	2009	116	118	+ 2%	Fuel reallocation

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 it happens that machinery tanks its fuel at a tank station, (thereby reported as road transport), as well as it happens that fuel that is sold to contractors, to be used on machinery, is used for road transport (but reported under construction). This is, however, very minimal and the deviation is believed to level 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 3.12.

Table 3.12. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from mobile combustion in the construction industry.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	38	47	62	68	62	59	41	32
Emissions	**136**	**167**	**222**	**243**	**221**	**212**	**146**	**115**

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 and N_2O are presented in Table 3.13.

Table 3.13. 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 48% of the Energy sector's total and 20% of the total GHG emissions in Iceland in 2010. Road Transport accounts for 94% 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 3.14.

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

	1990	1995	2000	2005	2007	2008	2009	2010
Jet kerosene	8.409	8.253	7.728	7.390	6.159	7.601	6.271	6.066
Gasoline	1.681	1.131	1.102	0.872	0.848	0.731	0.649	0.648
Emissions	**32**	**30**	**28**	**26**	**22**	**26**	**22**	**21**

Emission Factors

The emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 3.15. Emissions of SO_2 are calculated from S-content in the fuels.

Table 3.15. Emission factors for CO_2 and other pollutants for aviation.

	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 3.16).

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

	1990	1995	2000	2005	2007	2008	2009	2010
Gasoline	127.812	135.601	142.599	156.730	159.922	155.115	154.932	148.214
Diesel oil	36.567	36.862	47.463	83.478	125.863	113.964	114.491	106.433
Emissions	**529**	**561**	**633**	**800**	**945**	**891**	**892**	**844**

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 2010 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 2010 also contains information on motorcycles. The Road Traffic Directorate is working on providing similar data for previous years along with average fuel consumption per group. This work was not finished in time for this submission, but will be included in next submission. 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 Fig 3.1.

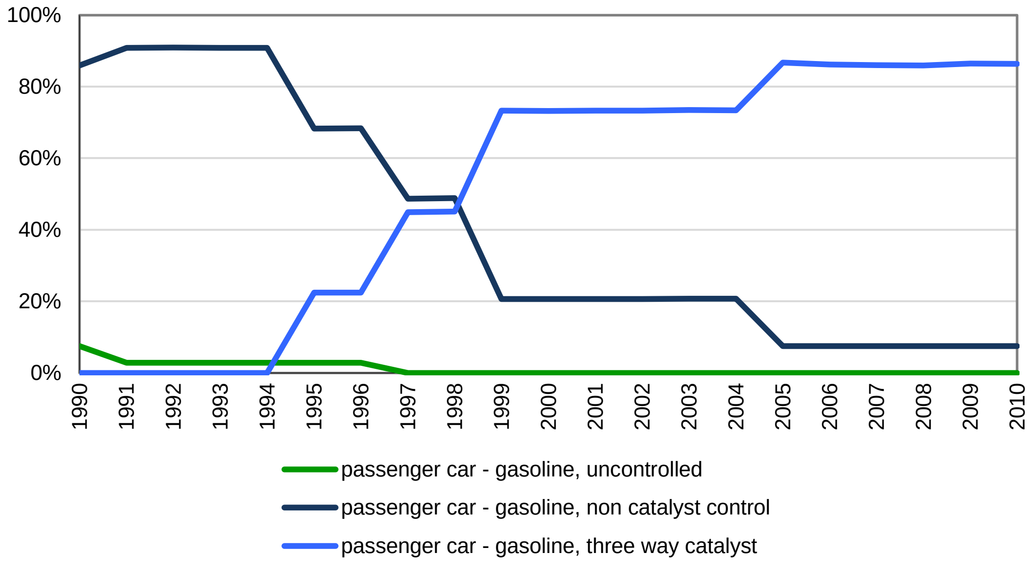

Fig 3.1. Passenger cars by emission control technology.

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 3.17.

Table 3.17. 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

Recalculations

Since last submission changes have been made regarding how fuel is divided between different vehicles groups for the years 2006 to 2010. The data for 2006 to 2010 also contains information on motorcycles. This has led to minor changes in emissions of CH_4 and N_2O (Table 3.18).

Table 3.18. Changes in greenhouse gas emissions between 2011 and 2012 submissions. All emissions in Gg CO_2 eq.

Greenhouse gas	Year	2011 Submission	2012 Submission	Change between submissions	Main reason for change
CH_4	1990	3.0	3.0	No change	
CH_4	2009	1.6	1.6	+ 3%	Fuel division
N_2O	1990	4.5	4.5	No change	
N_2O	2009	39.2	38.4	- 2%	Fuel division

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

Planned improvements involve getting more comprehensive data regarding the fleet composition, mileage driven and fuel consumption from the Road Traffic Directorate for all years and in the near future estimating emissions from road transport with the COPERT model.

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 3.19.

Table 3.19. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from national navigation.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	11.749	7.043	3.425	6.199	5.023	13.179	6.270	8.464
Residual fuel oil	7.170	4.755	0.542	0.881	14.374	4.192	3.709	2.612
Emissions	**60**	**37**	**13**	**23**	**61**	**55**	**32**	**35**

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 3.20.

Table 3.20. 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.

3.5 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. Emissions 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 3.15 above.

The retail supplier divides fuel use 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 3.20 above. 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 30% of the Energy sector's total and for 12% of total GHG emissions in Iceland 2010. Fishing accounted for 97% 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 3.21.

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

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	1.8	1.6	1.6	1.0	0.3	0.3	0.3	0.3
Waste oil	3.3	-	-	-	-	-	-	-
LPG	0.3	0.3	0.5	0.5	0.5	0.1	0.1	0.2
Solid waste	-	0.5	0.6	0.6	0.7	0.4	0.3	0.3
Emissions	**12.3**	**6.3**	**6.8**	**4.9**	**2.9**	**1.5**	**1.4**	**1.7**

Activity data for fuel combustion in the Residential sector and the resulting emissions are given in Table 3.22. As can be seen in the table the use of kerosene has increased substantially the last two years. 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 2010 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 does not have CO_2 tax, despite the fact that it is not good for the engine.

Table 3.22. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from the residential sector.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	8.8	6.4	6.0	3.2	2.4	2.0	2.1	1.9
LPG	0.4	0.5	0.7	0.9	1.1	1.1	1.6	1.4
Kerosene	0.5	0.2	0.1	0.2	0.2	0.8	4.0	1.2
Emissions	**30.6**	**22.1**	**21.8**	**13.6**	**11.2**	**12.0**	**24.0**	**14.0**

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 3.10 along with sulphur content of the fuels. Emissions of SO_2 are calculated from the S-content of the fuels. Emission factors for other pollutants are taken from Table 1.18 and 1.19 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Default EFs from Tables 1.7 to 1.11 in the Reference Manual were used in cases where EFs were not available. Emissions from waste incineration with recovery, where the energy is used for swimming pools/school buildings are reported here. A description of the method for calculating GHG is provided in Chapter 8. The IEF for the sector shows fluctuations over the time series. From 1994 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.

Recalculations

Since last submission changes have been made regarding fuel allocation in the sectors 1A1a Energy industries, 1A2 Manufacturing industry (stationary) and 1A4 Residential, as further explained in Annex III. Further one waste incineration facility (Kalka) which was covered by the sector 1A4 in earlier submissions is now covered by the Waste sector as the plant generates electricity and heat for its own use and is therefore an auto producer. This has led to some changes in emissions (Table 3.23).

Table 3.23. Changes in greenhouse gas emissions between 2011 and 2012 submissions. All emissions in Gg CO_2 eq.

Greenhouse gas	Year	2011 Submis-sion	2012 Submis mis-sion	Change between submissions	Main reason for change
1A4a GHG	1990	12.3	12.3	-	No change
1A4a GHG	2009	7.0	1.4	- 80%	Fuel and incineration plant reallocation
1A4b GHG	1990	31.0	30.6	- 0.6%	Fuel allocation
1A4b GHG	2009	23.9	24.0	+ 1.1%	Fuel allocation

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 3.24.

Table 3.24. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from the fishing sector.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	174.9	191.3	211.1	171.7	129.1	127.7	144.7	128.2
Residual fuel oil	32.4	53.4	16.0	26.3	50.3	36.3	44.6	41.4
Emissions	**662.3**	**779.8**	**727.5**	**632.9**	**570.9**	**522.7**	**603.4**	**540.2**

Emission Factors

The emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships and are presented in Table 3.19 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

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. EA is in the process to make a new agreement with the NEA to further clarify the cooperation between the two agencies as well as to clarify the role of NEA in the inventory process and to obtain better data to use for the reference approach as well as better data for the fuel split for the sectoral approach. This process could not be finished before this submission.

Iceland is not a member of the International Energy Agency (IEA). The NEA still provides 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. 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.

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 Geothermal Energy (1B2)

3.7.1 Overview

Iceland relies heavily on geothermal energy for space heating (90%) and to a significant extent for electricity production (26% of the total electricity production in 2010). Geothermal energy is generally considered to have 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 extensive 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.

3.7.2 Key Source Analysis

The key source analysis performed for 2010 has revealed that geothermal energy is a key source in terms of both level and trend, as indicated in Table 1. 1.

3.7.3 Methodology

Geothermal systems can be considered as geochemical reservoirs of CO_2. Degassing of mantle-derived magma is the sole source of CO_2 in these systems in Iceland. CO_2 sinks include calcite precipitation, CO_2 discharge to the atmosphere and release of CO_2 to enveloping groundwater systems. The CO_2 concentration in the geothermal steam is site and time-specific, and can vary greatly between areas and the wells within an area as well as by the time of extraction.

The total emissions estimate of CO_2 is based on direct measurements. The enthalpy and flow of each well are measured and the CO_2 concentration of the steam fraction determined at the wellhead pressure. The steam fraction of the fluid and its CO_2 concentration at the wellhead pressure and the geothermal plant inlet pressure are calculated for each well. Information about the period each well discharged in each year is then used to calculate the annual CO_2 discharge from each well and finally the total CO_2 is determined by adding up the CO_2 discharge from individual wells.

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

Table 3.25 shows the electricity production with geothermal energy and the total CO_2, CH_4 and sulphur emissions (calculated as SO_2).

Table 3.25. Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2007	2008	2009	2010
Electricity production (GWh)	283	288	1323	1658	3579	4037	4553	4465
Carbon dioxide emissions (Gg)	61	82	153	116	146	184	168	189
Methane emissions (Gg CO_2 eq)	0.3	0.3	1.3	1.6	3.4	3.9	4.4	3.7
Sulphur emissions (as SO_2, Gg)	13	11	26	30	46	59	53	58

Recalculations

In 2011 the National Energy Authority published a report (Baldvinsson et al., 2011)) on emissions from geothermal power plants from 1970 to 2009. Some emissions estimates for CO_2 and H_2S were revised for the period. This has led to minor changes in reported emissions (Table 3.26)

During an in country review in 2011 Iceland was encouraged to report CH_4 emissions from geothermal activity. Emission estimates for CH_4 are provided in this report.

Table 3.26. Changes in greenhouse gas emissions between 2011 and 2012 submissions. All emissions in Gg CO_2 equivalents.

Greenhouse gas	Year	2011 Submission	2012 Submission	Change between submissions	Main reason for change
CO_2	1990	67	61	- 8%	Revision of data
CO_2	2009	175	168	- 4%	Revision of data
CH_4	1990	NE	0.3	-	New estimate
CH_4	2009	NE	4.4	-	New estimate

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 Process sector accounted for 40% of the GHG emissions in Iceland in 2010. By 2010, emissions from the industrial processes sector were 110% 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 95% of the sector's emissions in 2010. Fig. 4.1 shows the location of major industrial plants in Iceland.

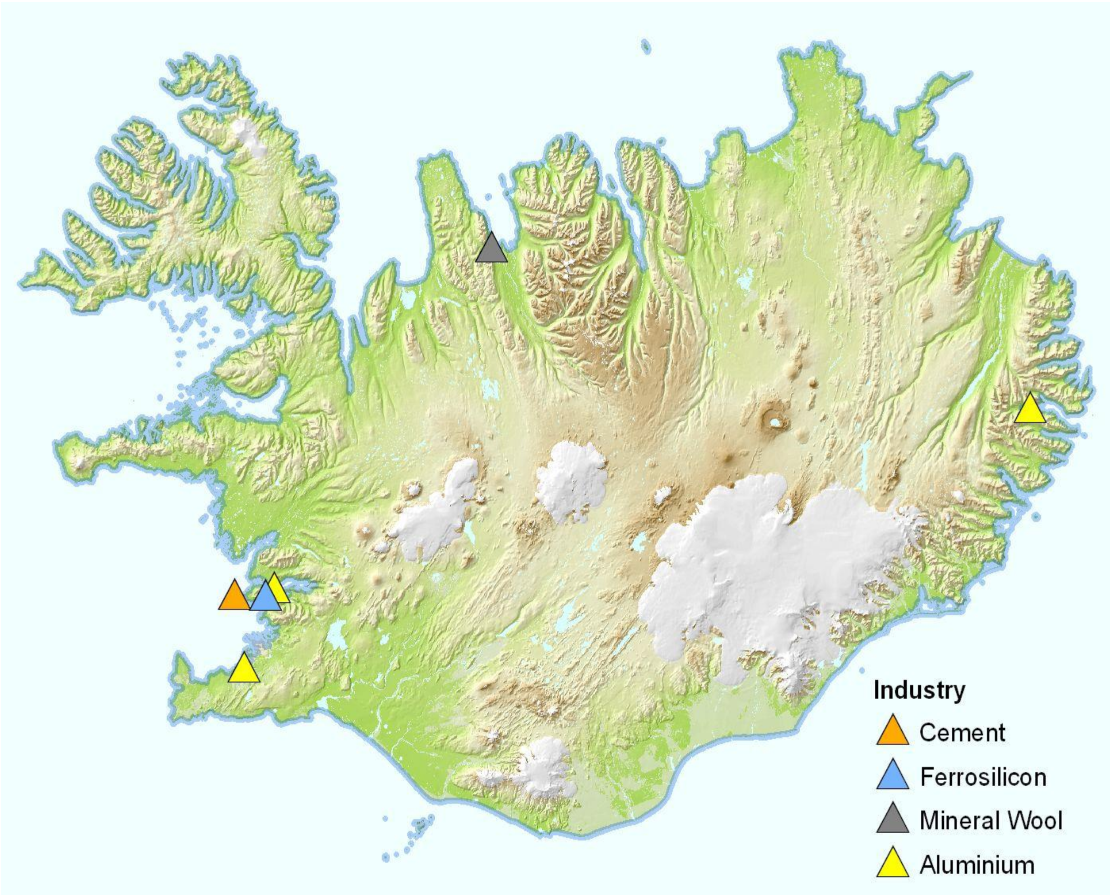

Fig. 4.1. Location of major industrial sites in Iceland.

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 2010. Total CO_2 emissions from these projects amounted to 1,216 Gg and total emissions savings from the projects are 6,367 Gg. In this submission all emissions are reported, as Iceland will undertake the accounting with respect to Decision 14/CP.7 at the end of the commitment period.

Some minor recalculations were done for the Industrial Processes sector for this submission. Activity data for the year 2008 for limestone use were corrected, leading to minor reduction in emissions. Activity data and emission estimates for HFC were revised leading to changes in emissions.

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 2010 has revealed the following greenhouse gas sources from the Incustrial 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, 2010) and trend.
- Emissions from Aluminium Production – CO_2 (2C3)
  » This is a key source in level (1990, 2010) and trend.
- Emissions from Aluminium Production – PFCs (2C3)
  » This is a key source in level (1990, 2010) and trend
- Emissions from Consumption of halocarbons and SF_6 – HFCs (2F)
  » This is a key source in level (2010) 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 produces 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.

Table 4.2. Clinker production and CO_2 emissions from cement production from 1990-2010.

Year	Cement produc-tion [t]	Clinker produc-tion [t]	CaO con-tent 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

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 and 0.497 in 2010. 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.

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. The amount of limestone used in 2008 has been corrected leading to minor changes in emissions for that year (1.02 Gg instead of 0.44).

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, from 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.

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, silicium containing sludge 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 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 1 method based on the consumption of reducing agents and electrodes and emission factors from the IPCC Guidelines. The IEF fluctuates over the time series depending on the consumption of different reducing agents and electrodes (3.08 – 3.52 t CO_2/t FeSi).

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 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	2007	2008	2009	2010
Electrodes	3.8	3.9	6.0	6.0	5.3	4.9	5.1	4.8
Coking coal	45	52	88	87	97	87	88	96
Coke oven coke	25	30	36	43	40	32	31	30
Char coal	-	-	-	2.1	0.8	0.2	0.2	-
Waste wood	17	8	16	16	18	14	16	11
Limestone	-	-	0.5	1.6	0.4	2.3	3.1	0.5
Production	63	71	108	111	114	96	98	102
Emissions	205	239	358	374	391	340	342	360

Emission Factors

Standard emission factors are used for CO_2, based on the carbon content of the reducing agents and electrodes. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 4.4. Values for NCV are from the Good Practice Guidance. 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. 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. Emission factors for CO_2 from production of ferroalloys.

Carbon input	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxi-dised	CO_2 EF [t CO_2/ t input]
Coking coal	29.01	25.80	0.98	2.69
Coke oven coke	26.65	29.50	0.98	2.82
Electrodes	28.00	32.14	0.98	3.23

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from ferroalloys production is 11% (with an activity data uncertainty of 5% and emission factor uncertainty of 10%). 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.

Planned Improvements

Iceland will join the EU ETS for industry from 2013 onwards. This will likely provide opportunity to collect more comprehensive data and develop plant specific emission factors.

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 (Fig. 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 1 method based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines.

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:

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

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 (production and information on anode effect) and the resulting emissions can be found in Table 4.5.

Table 4.5. Aluminium production, AE, CO_2, and PFC emissions from 1990-2010.

Year	Aluminium production [kt]	CO_2 emissions [Gg]	AE Anode Effect [min/cell day]	PFC emissions [Gg CO_2-eq]	CO_2 [t/t Al]	PFC [t CO_2-eq/ t Al]
1990	87.839	136.5	4.44	419.6	1.55	4.78
1991	89.217	139.3	3.63	348.3	1.56	3.90
1992	90.045	134.2	1.60	155.3	1.49	1.72
1993	94.152	139.0	0.74	74.9	1.48	0.80
1994	98.595	148.0	0.42	44.6	1.50	0.45
1995	100.198	150.7	0.55	58.84	1.50	0.59
1996	103.362	157.0	0.23	25.2	1.52	0.24
1997	123.562	188.9	0.62	82.4	1.53	0.67
1998	173.869	265.5	1.18	180.1	1.53	1.04
1999	222.014	347.2	0.63	173.2	1.56	0.78
2000	226.362	345.5	0.51	127.2	1.53	0.56
2001	244.148	373.9	0.35	91.7	1.53	0.38
2002	264.107	392.6	0.25	72.5	1.49	0.27
2003	266.611	401.6	0.21	59.8	1.51	0.22
2004	271.384	407.3	0.14	38.6	1.50	0.14
2005	272.488	408.7	0.08	26.1	1.50	0.10
2006	326.270	506.9	0.86	333.2	1.55	1.02
2007	455.761	679.8	0.46	281.3	1.49	0.62
2008	781.151	1167.9	0.33	349.0	1.50	0.45
2009	817.281	1212.1	0.17	152.7	1.48	0.19
2010	818.859	1219.1	0.14	145.6	1.49	0.18

Emission Factors

The standard emission factors used for CO_2 are based on the carbon content of the electrodes. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 4.6. 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.

Table 4.6. Emission factors CO_2 from aluminium production.

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t input]
Electrodes	31.35	31.42	0.98	3.54

Planned Improvements

Iceland will join the EU ETS for industry from 2013 onwards. This will likely provide opportunity to collect more comprehensive data and develop plant specific CO_2 emission factors.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from aluminium production is 11% (with an activity data uncertainty of 5% and emission factor uncertainty of 10%). 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 9% for CF_4 (with an activity data uncertainty of 5% and emission factor uncertainty of 7%) and 23% for C_2F_6 (with an activity data uncertainty of 5% and emission factor uncertainty of 22%).

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

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 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 is followed and best available technology is used to minimize process emissions (Article 2(c));

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.

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.

Four projects fulfilled the provisions of Decision 14/CP.7 in 2010, production in all three aluminium plants (Rio Tinto Alcan –the expanded part, Alcoa, and Century Aluminium) and in the ferrosilicon plant (Elkem, the expanded part). The total CO_2 emissions from these projects amounted to 1,216 Gg and total emissions savings from the projects are 6,376 Gg. Table 4.7 provides summary information for these projects.

Table 4.7. Information on project falling under decision 14/CP.7.

	Project CO_2 [Gg]	Project CO_2 % CO_2'90	Project IEF [CO_2 t/t]	Total PFC [Gg CO_2-eq]	Total IEF PFC [t CO_2-eq/t]	Total IEF CO_2 [CO_2 t/t]	Project Electricity [GWh]	Emission savings [Gg CO_2-eq]
Rio Tinto Alcan	135.7	6.3	1.512	3.7	0.02	1.478	1,377	808
Alcoa	534.1	24.7	1.514	87.0	0.25	1.514	4,968	2,917
Century Alumini-	404.2	18.7	1.464	54.9	0.20	1.464	4,114	2,416
Elkem	142.0	6.6	3.601	NA*	NA*	3.516	385	226
Total	**1,216**	-	-	**145.6**	-	-	**10,843**	**6,367**

**NA: Not Applicable.*

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 12.4 g/kWh in 2010.

For calculation of the resulting emission savings by using renewable energy, a comparison is made with a gas fired power plant. 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.

As explained in Chapter 1.2.2, the Icelandic legislature, Althingi, passed a new 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 four production plants, operating in 2010, based on Decision 14/CP.7. Those are:

A. expansion of the Rio Tinto Alcan Aluminium plant at Straumsvík,
B. expansion of the Elkem Iceland Ferrosilicon plant at Grundartangi,
C. establishment of the Century Aluminium plant at Grundartangi, and
D. establishment of the Alcoa Fjarðaál Aluminium plant at Reyðarfjörður.

[1] http://stats.world-aluminium.org/iai/stats_new/formServer.asp?form=7

In the 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.

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 2010 189,965 tonnes of aluminium were produced compared to 100,198 tonnes in 1995. In 2010 the production increase resulting from this project amounted to 89,767 tonnes of aluminium (70,982 tonnes in potline 3 and 18,785 tonnes in potlines 1 and 2). The resulting emissions from the production of 89,767 tonnes of aluminium are 136 Gg of CO_2. This amount adds more than 5% to the total carbon dioxide emissions in 1990. In 2010 118,983 tonnes of aluminium were produced in potlines 1 and 2 leading to emissions of 172 Gg of CO_2. In potline 3 70,982 tonnes of aluminium were produced, leading to emissions of 109 Gg of CO_2. Total CO_2 emissions from the plant were thus 281 Gg.

3. In 2010 the plant used 2,913 GWh of electricity, thereof 1,377 GWh were used for producing the 89,767 tonnes that fall under the definition of a single project. As stated before all the electricity used is produced from renewable sources. Average emission from producing this electricity is 12.4 g CO_2/kWh. Total CO_2 emissions from the electricity used for the project amounts to 17 Gg. Typical emissions from a gas fired power plant amount to 600 g CO_2/kWh[2]. The emissions from electricity use in the project would therefore

[2] http://tonto.eia.doe.gov/ftproot/environment/co2emiss00.pdf

have equalled 825 Gg had the energy been from natural gas and not from renewable sources. The resulting emissions savings are 808 Gg.

4. Best available techniques (BAT), as defined in the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, 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.

    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. Total process emissions from production of 189,965 tonnes of aluminium at Rio Tinto Alcan were 284.5 Gg CO_2-equivalents in 2010, 280.8 Gg of CO_2 from electrodes consumption and 3.7 Gg CO_2-equivalents of PFCs due to anode effects. The resulting IEF are 1.478 tonnes CO_2 per tonne of aluminium and 0.02 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[3]. Besides that 11.8 Gg were emitted from fuel combustion. The IEF for fuel use is 0.06 t CO_2-equivalents per tonne of aluminium.

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. It is not possible to use wood in Furnace 3.

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

2. In 1990 62,792 tonnes were produced leading to emissions of 204 Gg of CO_2. In 2010 102,214 tonnes were produced (26,193 tonnes in furnace 1; 33,746 tonnes in furnace 2; and 42,275 tonnes in furnace 3) leading to emissions of 359 Gg of CO_2 (94, 123 and 142 Gg in furnace 1, 2 and 3 respectively). The production falling under Decision 14/CP.7 is thus 42,275 tonnes of ferrosilicon (all production in furnace 3; the production increase since 1990 is less than the production in furnace 3). This production leads to emissions of 142 Gg of CO_2. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2010 the plant used 930 GWh of electricity, thereof 385 GWh were used for the production increase since 1990 (42,275 tonnes of ferrosilicon). All the electricity used for the production comes from renewable sources. The average CO_2 emissions from producing this electricity are 12.4 g/kWh. The total CO_2 emissions from the electricity use for the project amounts to 4.8 Gg. Had the energy been from a gas fired power plant the emissions would amount to 600 g/kWh. The resulting emissions from electricity use in the project would in this case have amounted to 231 Gg CO_2. Emissions savings from using renewable energy for the project are 226 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 further the plant has an environmental management plan as a part of a certified ISO 9001 quality management system, meeting the requirement of BEP.

5. Total process emissions from production of 102,214 tonnes of ferrosilicon at Elkem Iceland in 2010 were 359 Gg CO_2-equivalents. The resulting IEF are 3.516 tonnes CO_2 per tonne of ferrosilicon. Besides that 1.5 Gg CO_2 were emitted from fuel combustion. The IEF for fuel use is 0.014 t CO_2-equivalents per tonne of ferrosilicon.

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 2010 the Century Aluminium plant produced 276,113 tonnes of aluminium. The resulting industrial process carbon dioxide emission amounted to 404 Gg. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2010 the plant used 4,114 GWh of electricity, all from renewable sources. Average emissions from producing this electricity are equivalent to 12.4 g/kWh. The resulting total CO_2 emissions from the electricity use are 51 Gg. Had the energy been from a gas fired power plant the emissions would have amounted to approximately 600 g/kWh, resulting in emissions from electricity use in the project equivalent to 2,467 Gg. Emissions savings from using renewable energy equal 2,416 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 has reported that they are preparing implementation of an environmental management system according to ISO 14001.

5. Total process emissions from production of 276,113 tonnes of aluminium at Century Aluminium in 2010 were 459 Gg CO_2-equivalents, 404 Gg of CO_2 from electrodes consumption and 55 Gg CO_2-equivalents of PFCs due to anode effect. The resulting IEF are 1.464 tonnes CO_2 per tonne of aluminium and 0.20 tonnes of PFC in CO_2-equivalents per tonne of aluminium. Besides that 2.1 Gg were emitted from fuel combustion. The IEF for fuel use is 0.008 t CO_2-equivalents per tonne of aluminium.

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, 346,000 tonnes of aluminium per year. Since then, small capacity increase has occurred. In 2010 352,781 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 2010 the Alcoa Aluminium plant produced 352,781 tonnes of aluminium. The resulting industrial process carbon dioxide emission amounted to 534 Gg. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2010 the plant used 4,968 GWh of electricity, all from renewable sources. Average emissions from producing this electricity are equivalent to 12.4 g/kWh. The resulting total CO_2 emissions from the electricity use are 62 Gg. Had the energy been from gas fired power plant the emissions would amount to approximately 600 g/kWh, resulting in emissions from electricity use in the project equivalent to 2,979 Gg. Emissions savings from using renewable energy equal 2,917 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.

5. Total process emissions from production of 352,781 tonnes of aluminium at Alcoa Fjarðaál in 2010 were 621 Gg CO_2-equivalents, 534 Gg of CO_2 from consumption of electrodes and 87 Gg CO_2-equivalents of PFCs due to anode effect. The resulting IEF are 1.514 tonnes CO_2 per tonne of aluminium and 0.25 tonnes of PFC in CO_2-equivalents per tonne of aluminium (as described in section 2.4.4 an rectifier was damaged in fire at Alcoa in 2010 causing unusually high emissions of PFCs). Besides that, 2.1 Gg were emitted from fuel combustion. The IEF for fuel use is 0.006 t CO_2-equivalents per tonne of aluminium.

4.6 Other Production (2D)

Other production in Iceland is the Food and Drink Industry. NMVOC emissions from this sector have now been estimated for the first time. Production statistics were obtained by Statistics Iceland for beer, fish, meat and poultry for the whole time series (Fig. 4.2). Statistics for coffee roasting and animal feed were available for the years 2005 to 2010. Production statistics were extrapolated for the years 1990 to 2004. No information was available for production of bread, cakes and biscuits. Emission factor for NMVOC were taken from Tables 2-24 and 2-25 in the 1996 IPCC Guidelines.

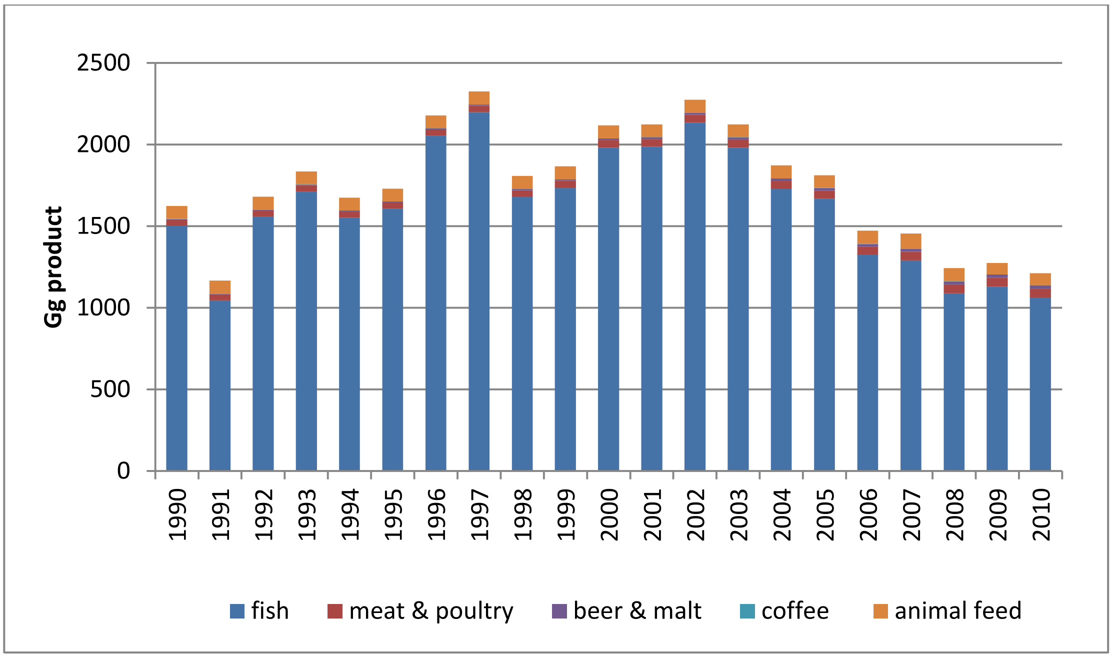

Fig. 4.2. Fish, meat & poultry, beer & malt, coffee, and animal feed production in Iceland.

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)

In the following section a brief description is provided for the activities for which emissions of hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6) are estimated.

4.8.1 Emission of HFCs

Overview

HFCs are used as substitutes for the ozone depleting substances chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and halons, which are being phased out by the Montreal Protocol. In Iceland fluorinated gases have been regulated since 1998. HFCs are banned for certain uses in Iceland. These uses include

A. Use in fire protection (2F3)
B. Use as aerosols (2F4) with the exception of metered dose inhalers (MDIs)
C. Use as solvents (2F5)

HFCs are used in refrigeration and air conditioning equipment (2F1), i.e. domestic refrigeration, mobile air conditioning systems (MACs), and chillers used in fisheries and fish processing. They are also contained in metered dose inhalers (2F4). No HFCs are used in foam blowing (2F2). A more detailed explanation is provided in the paragraph Foam blowing.

The HFCs most commonly used in Iceland are HFC-32, HFC-125, HFC-134a, HFC-143a, and HFC-152a. All HFCs with the exception of HFC-134 are solely used in chillers. These HFCs are imported either in pure form or in blends containing different HFCs. As minor components HFCs are also contained in HCFCs.

In this chapter the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 34 is used to label HCFCs and HFCs. It consists of the letter R and additional numbers and letters. HFC-numbers are used later on when the R-blends have been disaggregated by calculations into the HFCs contained in them.

Methodology

Emissions from Refrigeration and air conditioning equipment were calculated using the Tier 2a method of the 2006 IPCC guidelines (emission factor approach). Emissions from aerosols were calculated with the default method of the 2006 GL.

Refrigeration and air conditioning equipment (2F1)

This category consists of 3 sub-categories: domestic refrigeration, industrial processes including chillers, and mobile air conditioning.

Activity data

For the greenhouse gas source category refrigeration and air conditioning equipment, HFCs are imported in equipment such as refrigerators and cars, as well as in bulk. Data on imported cars is gathered from the Road Traffic Directorate. Data on HFCs in refrigeration equipment is estimated from import statistics, based on land of origin and type of refrigerator. Importers are required to report the type and amount of HFC they import in order to release the chemicals from the Icelandic directorate of customs. This data is reported to the EA. Import of HFCs in bulk started in 1993 (Fig. 4.3). The amount of imported HFCs and HFC-containing HCFC-blends stayed between 15 and 40 tonnes between 1995 and 2008, but has increased since then to 95 tons in 2010. During the beginning of the period HCFC blends and the HFC blend R-404A were the main refrigerants imported. The amount of HCFC blends has decreased during the last few years and was banned from 2010 onwards. No HCFC blends imports were reported by the Icelandic customs directorate in 2010. As a result of the ban of import of HCFC-blends the share of R-404A and R-134A in refrigerants imported to Iceland increased. Other HFC blends play minor roles with the exception of R-507A for which an unprecedentedly high import of 38.6 tonnes was recorded by the Icelandic directorate of customs in 2010.

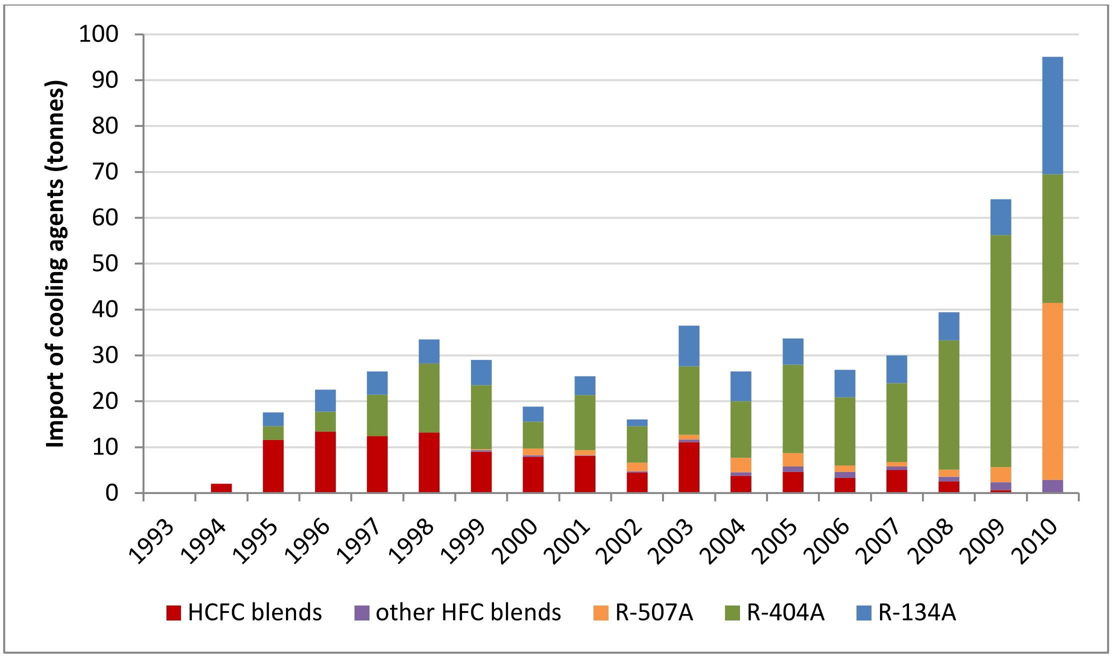

Fig. 4.3. Bulk import of HFCs and HCFCs since 1993. Included in HCFC blends are the following HFC containing blends: R-401A/B, R-402A/B, R-408A, R-409A, R-411B, and R-412A. Included in other HFC blends are the following chemicals: R-23, R-227ea, R-407A/C, R-410A, R-422A/D, R-437A, and R-508.

It is assumed that 95% of all R-134A imported as well as 100% of the other HFCs (including HFC contained in HCFC blends) is used for replacing refrigerants in the fishing industry. The remaining 5% of R-134A import are assumed to be used to refill MACs.

It is assumed that the import of cars with MACs started in 1995. Since then, there has been a rapid increase in private cars with MAC. From the year 2005 onwards around 50% of all new passenger cars, all coaches, and about 60% of larger trucks are considered to have MAC.

Furthermore it is assumed that each domestic refrigerator imported since 2001 from the United States contains 110 g of R-134A and that refrigerators from other countries contain no HFCs.

The HFC contained in all R-blends imported in either bulk or appliances was calculated by multiplying the amounts of R-blends imported with the respective HFC fractions.

Emission factors

The Tier 2a or emission-factor approach for refrigeration and air-conditioning accounts for emissions during four different stages, i.e. during

A. refrigerant container management,
B. charging of equipment,
C. lifetime, i.e. operation and servicing, and
D. at end-of-life.

In this submission only lifetime emissions, i.e. emissions due to operation, leakage, and servicing are accounted for. Refrigeration container management, as it is defined in the 2006 GL, does not occur since the refrigerants are imported in smaller amounts. Charging of equipment takes place only in the country of equipment manufacture, i.e. not in Iceland. End-of-life emissions are not accounted for in the fishing industry since it is assumed that all HFC left in old equipment is reused in new equipment. The approach is slightly adjusted for available activity data in Iceland thus that refrigerant charges are used for domestic refrigerators only (Table 4.8), but HFC bulk import data for the fishing industry (all bulk import minus 5% of imported HFC 134) and both refrigerant charges and import data (5% of bulk HFC 134A) for MACs.

Emissions from the three sub-applications domestic refrigeration, industrial processes including chillers, and MACs are calculated using equation 7.12 from the 2006 GL:

Equation 7.12

$$E_{lifetime,t} = B_t \bullet (x/100)$$

Where:

$E_{lifetime,t}$ = amount of HFC emitted during system operation in year *t*, kg

B_t = amount of HFC banked in existing systems in year *t* (per sub-application), kg

x = annual emission rate (i.e., emission factor) of HFC of each sub-application bank during operation, accounting for average annual leakage and average annual emissions during servicing, percent

Annual emission rates are shown in Table 4.8.

Table 4.8. Estimates for charge and emission factors for refrigeration and air-conditioning systems.

Sub-application	Domestic refrigera-	Industrial refrigeration, chillers	Mobile air conditioning units (MACs)
Charge (kg)	0.11[1]	NA	0.5 (passenger cars) 1 (coaches and lorries)
annual emission rate x (% of initial charge/year)	0.3	10[1]	10[2]
2006 GL range for x	0.1 – 0.5	2 - 15	10 – 20

1: expert judgement. 2: cold climate results in little MACs usage

The amount of HFCs banked in existing systems in year 1 is calculated by allocating to them all HFC contained in equipment and bulk import. Next year´s bank consists of the sum of year one´s bank and HFC imports multiplied with the ratio not emitted (1 minus annual emission rate). Thus the amounts of HFC emissions and banks are interconnected. This is shown for industrial refrigeration in Fig. 4.4.

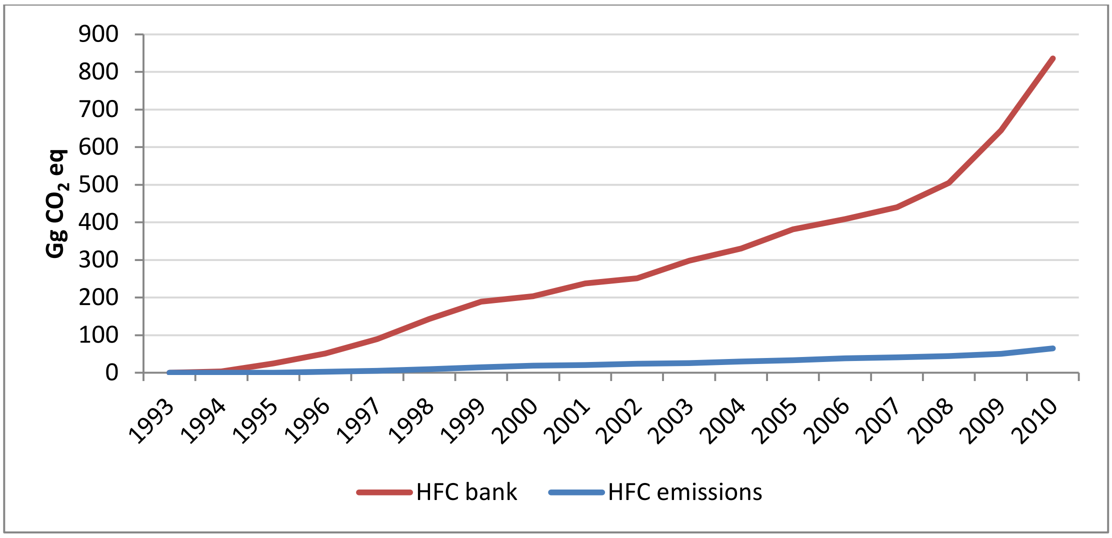

Fig. 4.4. HFC emissions and banks for the fishing industry since 1993. All HFCs are summarized by means of their GWP.

Emissions

Table 4.9 shows the HFC amounts emitted and contained in banks for the three sub-applications for several years since 1995. Industrial refrigeration (fisheries) is the most important sub-application, accounting for more than 90% of total emissions. The remaining emissions stem mainly from MACs. The fraction of emissions from domestic refrigeration is vanishingly low. Total emissions from refrigeration and air conditioning have increased by 14% between 2008 and 2009 and by 25% between 2009 and 2010. A similar increase can be expected for the next year because of the large amount of refrigerants imported to Iceland in 2010. The increase in imports can be explained by the fact that the Icelandic fishing industry is still in the process of retrofitting its fleet, i.e. switching from HCFC refrigerants to HFC refrigerants.

Table 4.9. HFC emissions and banks for refrigeration sub-applications in Gg CO_2-equivalents (NO: Not Occurring).

		1995	2000	2005	2008	2009	2010
industrial refrigeration	emis-sions	0.3	18.9	33.0	44.0	50.5	64.4
	bank	24.8	203.0	381.6	504.7	643.9	835.6
domestic refrigeration	emis-sions	NO	0.0	0.0	0.0	0.0	0.0
	bank	NO	0.0	0.2	0.3	0.3	0.4
mobile air conditioning	emis-sions	0.0	0.3	1.3	3.8	4.1	3.8
	bank	0.3	4.0	22.4	40.6	38.5	38.4
total	emis-sions	0.3	19.1	34.4	47.9	54.5	68.2
	bank	25.1	207.0	404.2	545.5	682.7	874.4

Foam blowing (2F2)

During the in-country review of the 2011 submission the expert review team remarked that emissions from foam blowing were declared as not occurring although Iceland reported the import of hard foams in containers for fish export since 2001. In response to the remark, emissions were estimated based on weight of annually imported fish containers, as well as assumptions about their HFC content and their dwell time between import and export as product container.

During the preparation of the 2012 submission information on the nature of imported fish containers were gathered in order to estimate emissions more exactly. The Icelandic Directorate of Customs supplied the EA with a list of all companies importing goods under the customs number denoting fish boxes to Iceland. The five biggest importers, which comprise more than 99% of fish container imports, were contacted. The biggest importer buys foam boxes from a manufacturer in the UK. The manufacturer produces the boxes from HFC free polypropylene. Another company buys its boxes from a manufacturer in Slovakia. The manufacturer was contacted and explained that it does not use HFC in the production of foam boxes. One company buys HFC free containers in Spain. The same company also imports polyurethane boards from The Netherlands to insulate fish tanks they manufacture. The manufacturer of the polyurethane boards was contacted and declared that it did not use HFC in the production of its boards. The remaining two companies importing fish containers import exclusively cardboard containers.

As a result of this enquiry, emissions from foam blowing in Iceland are reported again as not occurring.

Aerosols/metered dose inhalers (2F4)

As mentioned above, the import of HFC as propellants in aerosols is banned in Iceland with the exception of metered dose inhalers (MDIs). Data on imported dose inhalers is gathered from the Icelandic Medicines Control Agency. The only HFC contained in MDIs is HFC 134A. The import of HFC containing MDIs started in 2002 and the amount of imported HFC 134A has been constantly between 0.5 and roughly 0.6 tonnes. According to equation 7.6 of the 2006 GL it is assumed that emissions from MDIs occur within two years of import. Therefore they are considered as prompt emissions. Taking this into account, emissions are calculated by allocating 50% of current import to emissions and 50% to next year´s emissions. This resulted in annual emissions between 0.5 and 0.6 tonnes of HFC 134A, which is congruent with annual emissions between 0.7 and 0.8 Gg CO_2 equivalents. The connection between imports, emissions and (short lived) bank are shown in Fig. 4.5.

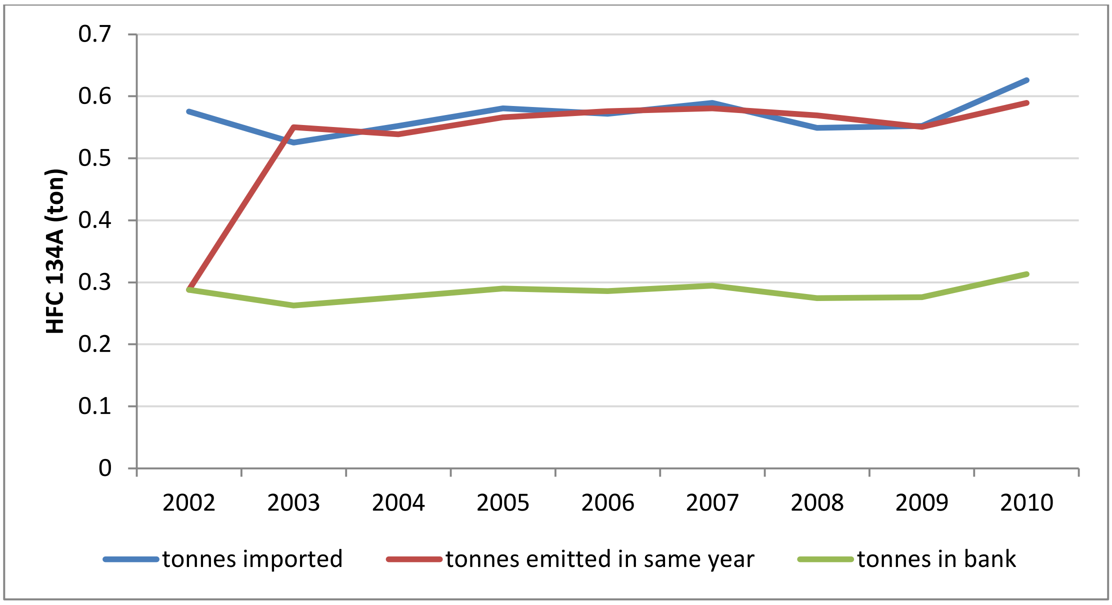

Fig. 4.5. Import of HFC 134A in metered dose inhalers along with respective emissions and bank.

HFC collection and destruction

The Icelandic recycling fund charges a fee for imported refrigerators and freezers which is returned when the theys are delivered to collection points for destruction by incineration. The amount of returned refrigerants has been 1.5 tonnes on average for the last ten years, thus constituting only a small fraction of imports. This is mainly due to the fact that the biggest user of refrigerants, the fishing industry, is reusing its refrigerants. Which HFCs are returned is not recorded. Because of the differences in GWP scale it is not possible to offset the amounts recovered against the amounts in the banks.

Uncertainty

Activity data regarding import of MDIs is deemed reliable. The data about imported cars and domestic refrigerators is also considered reliable. Uncertainty arises from the estimation of the share of cars with MACs and the share of domestic refrigerators containing HFCs as refrigerants. Also there is considerable uncertainty regarding the import of refrigerants in bulk. This uncertainty does not regard the amount of refrigerants imported but their correct declaration. This fact has considerable impact on uncertainty estimations because of the scale difference in GWP between HFCs. Therefore activity data uncertainty is estimated to be 100%. Combined uncertainty of HFC emissions (with an emission factor uncertainty of 100%) was estimated to be 141.4%.

Recalculations

The import of HFCs was revised. Older data was checked more closely which lead to the inclusion of two additional HFCs: HFC 23 and HFC 227ea and two PFCs: PFC 116 (C_2F_6) and PFC 218 (C_3F_8). The result is that activity data for industrial refrigeration deviated between last submission and this year´s submission. The deviations are bidirectional, i.e. the amounts of imported refrigerants of this year's submission were up to 16% above as well as up to 11% below the ones of last year´s submission. For most years though, the difference was only few%. For 2009 it was only 0.1%.

More importantly, though, the annual emission rate was updated. In last year´s submission an annual emission rate of 15% was allocated to all three refrigeration and air conditioning sub-applications. The ranges for annual emission rates suggested by the 2006 GL are shown above in Table 4.8. Related to the 2006 GL, 15% is the mean value of the range for MACs, the highest value of the range for chillers and 30 times the highest value of the range for domestic refrigeration. In this year´s submission all values for annual emission rates were inside the ranges suggested by the 2006 GL. The value for MACs was lowered to 10% due to the cold climate in Iceland involving little MAC usage. This emission factor reduction, accompanied by slight changes in activity data, resulted in reduced emission estimates: between submissions emissions for 2009 were lowered from 5.8 to 4.1 Gg CO_2 equivalents (-30.7%).

The emission factor for chillers was reduced from 15 to 10% as well. This reduction was based on the expert judgement and is in line with the range from 2 – 15% suggested by the 2006 GL. This emission factor reduction, accompanied by aforementioned changes in activity data, resulted in similarly reduced emission estimates (although on a bigger scale): between submissions emissions for 2009 were lowered from 79.8 to 50.5 Gg CO_2 equivalents (-36.7%).

The annual emission factor for domestic refrigeration was lowered from an erroneously high 15% to 0.3% (mean of 2006 GL range). This emission factor reduction by 98% led to a reduction of emission estimates by 96.7% or from 0.0258 to 0.0008 Gg CO_2 equivalents.

In summary, the adjustment of annual emission rates led to a 31.1 Gg CO_2 equivalents or 36.3% reduction of emission estimates (2009) between submissions.

Planned Improvements

In order of importance:

- For the next submission efforts will be made to find out how much of the HFC used in the fishing industry is used on vessels and how much in fish processing plants on land. It is assumed that the operation emissions of vessels are higher than those of fish processing plants. If that were to be the case and if amounts can be allocated to the two sub-applications, two different annual emission rates will be used in the next submission. This year´s value of 10% will be scrutinised and adjusted if interviews with stakeholders from the fishing industry make it plausible.

- Efforts will be made to approximate the kind of refrigerants that are collected for destruction in order to be able to adjust the respective bank accordingly.

- It is planned to revaluate the fraction of passenger cars, coaches and lorries with MAC and adjust the amount of HFC banked in MACs for MACs in cars that are exported.

4.8.2 Emissions of SF_6 from Electrical Equipment

Sulphur hexafluoride (SF_6) is mainly used for insulation and current interruptions in equipment used in the transmission and distribution of electricity. To a minor extent, SF_6 is used in research particle accelerators in the University of Iceland. There is no SF_6 production in Iceland and consumption of SF_6 is mainly through insulation in electrical distribution systems. Actual emissions of SF_6 have been estimated through questionnaires addressed to power companies asking for the installed amounts of SF_6 in operating equipment, and the replaced amounts of SF_6 during service. Data on SF_6 use dates back to 1974.

Methodology

Emissions of SF_6 are calculated using the Tier 1 methodology which takes into account manufacturing emissions (none in Iceland), equipment installation emissions as well as use and disposal emissions. The equation is as follows:

SF_6 Emission from Insulation in the Electrical Distribution System
Total emissions of SF_6 = Installation Emissions + Use Emission + Disposal Emissions

The IPCC default emission factor of 6% is used for installation emissions (Table 8.2, 2006 IPCC Guidelines). The results showed an installed accumulated amount of approximately 20,300 kg SF_6. This is probably a slight underestimate as there might be some data missing. One of the larger power stations (Blanda) has been registering leakage since 2006. Leakage is usually negligible, but taking into account exceptional leakage, an annual leakage rate of 0.8% was used, as input data in this inventory. There are no data on retired equipment.

According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, SF_6 emission from university particle accelerators was estimated by use of import data dating back to 1993.

University and Research Particle Accelerator SF_6 Emissions
Total emissions of SF_6 = Use Emissions

On average, 49 kg of SF_6 have been imported each year for these purposes. The IPCC default emission factor of 7% is used for use emissions (Table 8.2, 2006 IPCC Guidelines).

Activity data

Information on the import of SF_6 chemicals used for the electricity transmission system is obtained from the Icelandic transmission system operator (TSO) named Icegrid (Landsnet hf.). The data on SF_6 import for universities are obtained from Statistics Iceland.

Uncertainty

The activity data on SF_6 import for universities are considered reliable. The electricity transmission system agency Icegrid, updates their data every year but due to less reliable registering of SF_6 in earlier times, there are some uncertainties regarding old transmission systems. Also, one large power station (Blanda) has been registering leakage since the year 2006 but it is not known for how long the leakage had been before being detected. Therefore activity data uncertainty is estimated to be 20%, emission factor uncertainty 100% and combined uncertainty 102%.

Planned Improvements

It is planned to use the 2006 GL Tier 2 method in order to estimate the SF_6 emissions for the next submission.

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 gasses. 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 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 use had been 9.1 Gg CO_2 equivalents. Emissions decreased by 30% between 1990 and 2010 and were 6.3 Gg CO_2 equivalents in 2010. That means that they accounted for roughly 0.1% of the total greenhouse gas emissions in Iceland in 2010.

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 pro-	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 2010 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	NMVO	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 (car racing here or be-	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. 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 newest customs code register, published online in January 2012 (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, 2012) and on domestic production of paint since 1998 (Icelandic recycling fund, 2012). 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, permits 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 Fig. 5.1.

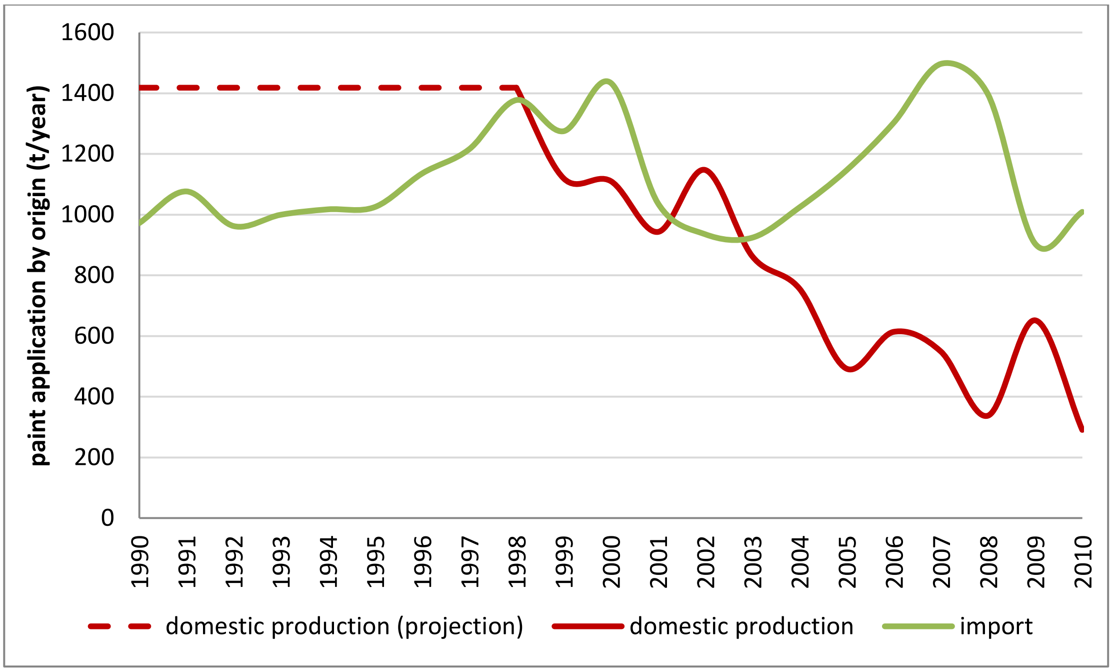

Fig. 5.1. Amounts of solvent based paints imported and produced domestically

5.2.2 Recalculations, improvements and planned improvements

There have been slight changes to the use of data on imported paints. Solvent based wood preservatives that were included before are now allocated to 3D, other NMVOC emissions, preservation of wood. There are a number of product types not included in the last submission, which are included in this submission. Examples are colour lakes, paints for artistic and educational purposes and sealing varnish. Paint thinners that were allocated to degreasing are now included under paint application. Until now domestic production of solvent based paints had been estimated. This year it is based on production data provided by the Icelandic recycling fund from 1998-2010 (Icelandic recycling fund, 2012).

Until last year NMVOC emissions were calculated by multiplying the activity data with 0.5. Now the Tier 2 emission factor for conventional solid based paints of 0.23 is applied.

Because of the changes in activity data and emission factors NMVOC emissions decreased between submissions by 52% in 1990 and by 67% in 2009.

For next year´s submission it is planned to make an effort to determine domestic paint production from 1990-1997.

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. There is data on the amount of cleaning products imported 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,- trichloroethylene (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

5.3.2 *Recalculations, improvements and planned improvements*

Until this submission degreasing and dry cleaning were not itemized as emission sources of NMVOC, but shared activity data and emission factors. The emission factors for solvent use in degreasing and dry cleaning differ from each other. Therefore both technologies are treated separately in this submission. The activity data used before for both degreasing and dry cleaning is now allocated to degreasing with the following exceptions. Half of the PER imported is not allocated to degreasing since it is mainly used in dry cleaning. Emissions from PER use in dry cleaning are implied by the method reported for conventional closed circuit PER machines. Paint thinners that were allocated to degreasing/dry cleaning are now allocated to paint application. Xylenes that were allocated to other NMVOC emissions are now partly allocated to degreasing and partly implicated in paint production.

In the last submission an emission factor of 1 was assumed for both technologies. In this submission the emission factors supplied by the EMEP guidebook, i.e. 460 g/kg cleaning product for degreasing and 177 g/kg treated textile for dry cleaning (reduced with an abatement efficiency of 89%) were applied.

Because of the changes in activity data and emission factors NMVOC emissions decreased between submissions by 64% in 1990 and 59% in 2009.

For next year´s submission it is planned to determine the amount of imported PER and xylenes not allocated to degreasing more accurately and to review the customs codes applied in the source category.

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.

5.4.2 Recalculations, improvements and planned improvements

NMVOC emissions from manufacture of paint had not been estimated in preceding submissions.

For next year´s submission it is planned to determine domestic paint production from 1990-1997.

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, 2012).

Other domestic use

NMVOC emissions from other domestic use were calculated using the EMEP guide-book 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 sol-vent borne preservative (900 g/kg preservative). Import data on both wood preserv-atives was received from Statistics Iceland (Statistics Iceland, 2012).

NMVOC emissions from tobacco combustion were calculated using the EMEP guide-book 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 Ice-land (Statistics Iceland, 2012).

5.5.2 Recalculations, improvements and planned improvements

In preceding submissions other NMVOC emissions from product use were calculated adding the following substances imported: toluene, xylenes, naphthalene, low vis-cosity oils and part of the white spirit import. It was assumed that 80% of the white spirit was used for domestic paint production and the amount imported was reduced accordingly. This submission was calculated along the 2009 EMEP guidelines and therefore used other approaches calculating emissions from other product use.

Because of the changes in activity data and methodology used, NMVOC emissions decreased between submissions by 71% for 1990 but increased by 40% for 2009.

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 2010 or by 43%.

5.6.2 *Recalculations, improvements and planned improvements*

Until this submission only one importer of N_2O was included in the activity data. Since the beginning of 2009 there are two companies importing N_2O to Iceland. Data was collected from both of them. Preceding submissions did not implement the time delay between N_2O distribution and use suggested by the 2006 GL. Other use than medical use of N_2O was estimated for the whole time period from 1990-2010 based on the 2004 fractions of N_2O imported for medical and other use. During that year N_2O was also imported for usage as fuel oxidant in auto racing. It was possible to determine the N_2O sold for other uses than medical uses from 2005 to 2010. Thus the use of N_2O for fire extinguishers was added. Other uses of N_2O before 2004 were calculated using average fractions from 2004 to 2010.

Due to changes in activity data and methodology, 2009 N_2O emissions from product use increased between submissions by 251% (this is tantamount to an increase of 8 tonnes N_2O or 2.5 Gg CO_2 eq). Since no activity data could be determined for base year-1 (1989), emissions did not change for 1990.

5.7 Emissions

Fig. 5.2 shows NMVOC emissions from solvents and other product use from 1990-2010. 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 two years is mainly due to decreasing emissions from paint application, printing and organic wood preservatives. Fig. 5.3 shows NMVOC emissions from 1990 to 2010 for each emission source subcategory. The scale of the y-axis is logarithmic, providing insight into the different scale of NMVOC emissions.

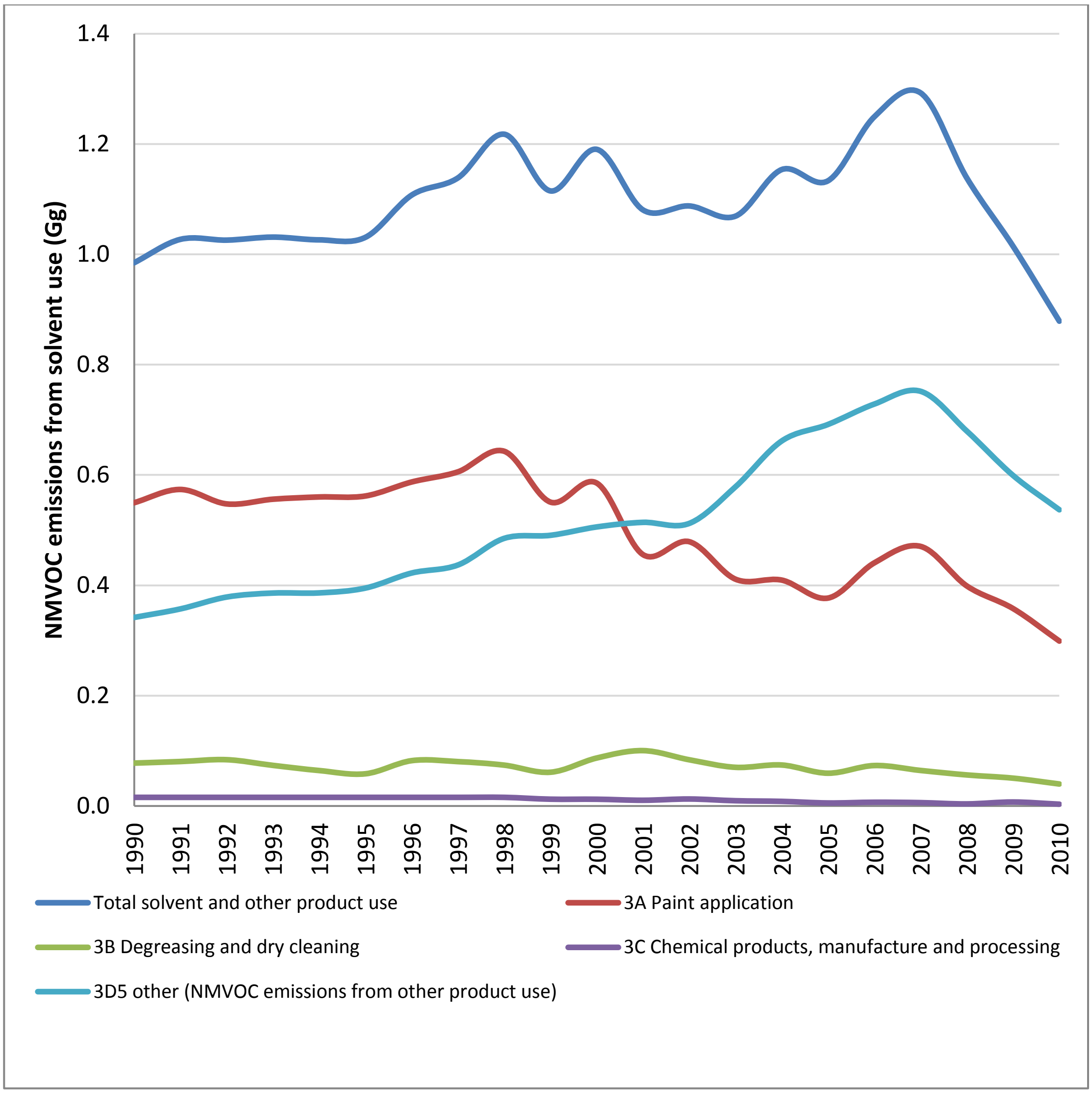

Fig. 5.2. NMVOC emissions from solvent and other product use (Gg/year) from 1990-2010.

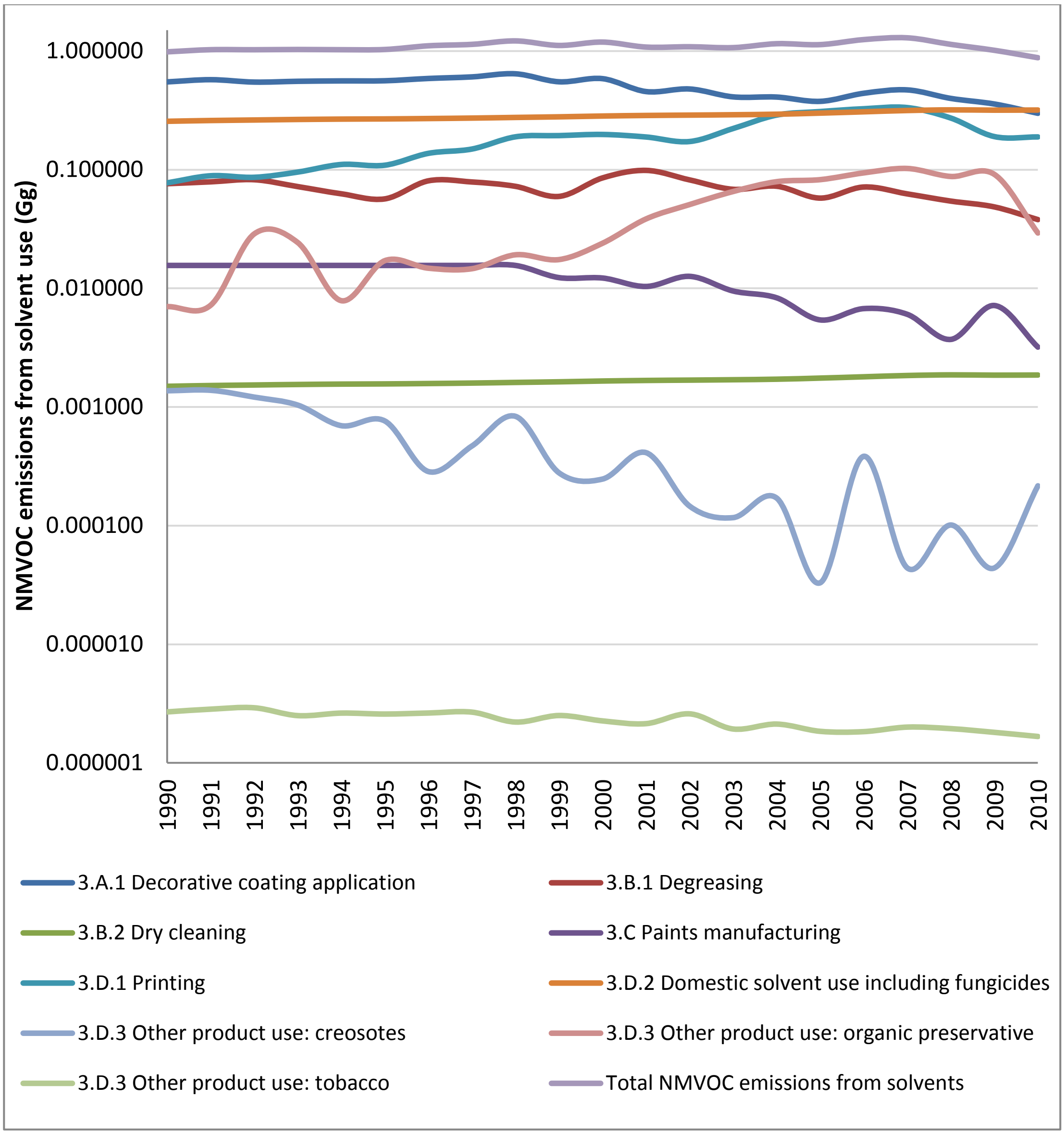

Fig. 5.3. NMVOC emissions from solvent use (kg/year) for all emission source subcategories (logarithmic y-axis scale).

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. Changes in activity data, emission factors and methodology resulted in differences of emission estimates between the 2011 and 2012 submissions. Emissions for the year 1990 decreased by 35% between 2011 and 2012 submissions. Since N_2O emissions are identical for that year the decrease is due to the changes in NMVOC emissions as they were described earlier. Although NMVOC emissions for 2009 are lower in the 2012 submission, total sector emissions are 7.5% higher than in the 2011 submission due to the inclusion of additional N_2O import.

5.8 Uncertainties

Activity data uncertainty for NMVOC emissions from solvents and other product use was estimated to be 50%. Emission factor uncertainty was assumed to be 50%. Thus the combined uncertainty for NMVOC emissions from solvents use was 70.7%. Activity data for N_2O emissions from product use were deemed more reliable. Therefore activity data uncertainty was assessed to be 5%. An estimated emission factor uncertainty of 50% resulted in a combined uncertainty of 50.25%.

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 and nitrous oxide emissions from agriculture amounted to 646 Gg CO_2 equivalents in 2010. Agriculture emissions were 703 Gg CO_2 equivalents in 1990. The 8% decrease is mainly due to a decrease in sheep livestock population. 40% of total emissions were methane emissions, the rest nitrous oxide emissions. 88% 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. during storage of manure. The majority of N_2O emissions from agricultural soils, however, are caused by animal manure deposited onto soils. Synthetic fertilizer application and cultivation of organic soils are lesser N_2O emission sources.

6.1.1 Methodology

The calculation of greenhouse gas emissions from the agriculture sector is based on the methodologies suggested by the Good Practice Guidance (GPG; IPCC, 2000). In three cases default values were taken from the 2006 Guidelines. 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 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 further discusses 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 the Tier 2 method. The Tier 1 method 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 subsource 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 2010 (Table 1. 1) has 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 2010)
- Emissions from Enteric Fermentation, Sheep – CH_4 (4A3)
- This is a key source in level (1990 and 2010) and trend
- Emissions from Manure Management – N_2O (4B)
- This is a key source in level (1990)
- Direct Emissions from Agricultural Soils – N_2O (4D1)
- This is a key source in level (1990, 2010)
- Pasture, Range, and Paddock Manure – N_2O (4D2)
- This is a key source in level (1990, 2010)
- Indirect Emissions from Agricultural Soils – N_2O (4D3)
- This is a key source in level (1990, 2010) and trend

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	NE	E
2. Animal Production	NA	NE	E
3. Indirect Emissions	NA	NE	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 annual livestock censuses. 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 they are wrong. 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 (2.1% in 2010), they are considerably higher for sheep and poultry (56 and 124%, respectively). Number of swine, however, is many times higher in the NIR than in the national census (1024% in 2010). Table 6.2 shows animal populations for 1990, 2000 and 2010 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	2010	2010
category	census	NIR	census	NIR	census	NIR
dairy cattle	32,249	32,249	27,066	27,066	25,711	25,711
other mature cattle	22,536	22,536	27,157	27,157	27,508	27,508
young cattle	20,118	20,118	17,912	17,912	20,562	20,562
cattle (total)	74,903	74,903	72,135	72,135	73,781	73,781
mature ewes	445,635	445,635	373,194	373,194	374,332	374,332
other mature sheep	13,277	13,277	12,091	12,091	11,627	11,627
animals for replacement	89,795	89,795	80,289	80,289	93,646	93,646
lambs (weighed)		313,108		263,716		268,397
sheep (total)	548,707	861,815	465,574	729,290	479,605	748,002
increase (difference/census)		57.1%		56.6%		56.0%
sows	3,135	3,135	3,862	3,862	3,615	3,615
piglets (weighed)		26,510		28,405		36,900
total swine	3,135	29,645	3,862	32,267	3,615	40,515
% increase (difference/census)		845.6%		735.5%		1020.7%
adult horses	49,464	49,464	51,728	51,728	53,631	53,631
young horses	15,803	15,803	17,113	17,113	16,659	16,659
foals (weighed for NIR)	6,763	8,600	4,828	6,789	6,906	8,559
total horses	72,030	73,867	73,669	75,630	77,196	78,849
% increase (difference/census)		2.6%		2.7%		2.1%
goats	345	345	416	416	729	729
kids (weighed)		159		192		336
total goats	345	504	416	608	729	1,065
% increase (difference)/census)		46.0%		46.0%		46.0%
minks	42,804	42,804	36,593	36,593	37,409	37,409
foxes	4,974	4,974	4,132	4,132	5	5
rabbits	1,814	1,814	706	706	213	213
hens	214,975	214,975	193,097	193,097	174,519	174,519
broilers	291,190	291,190	91,515	91,515	44,493	44,493
pullets	24,020	24,020	63,039	63,039	100,751	100,751
chickens		139,095		184,202		392,689
total chickens	530,185	669,280	347,651	531,853	319,763	712,452
% increase (difference/census)		26.2%		53.0%		122.8%
ducks/geese/turkeys	3,618	3,618	5,762	5,762	3,651	3,651
ducks/turkeys chickens (weighted)		1,659		7,645		8,191
total ducks/geese/turkeys	3,618	5,277	5,762	13,407	3,651	11,842
% increase (difference/census)		45.9%		132.7%		224.3%

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, heifers, 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. Equations 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**					
	mainte-nance	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 2010. 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. Not all parameters that are time dependent have time dependent parameters (see: chapter 6.2.4).

Table 6.4. Animal performance data used in calculation of gross energy intake for cattle in 2010. 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
Digestible energy (% of gross energy)	78.72	78.72	78.72	65.77	78.72

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 2010. Not all parameters that are time dependent have time dependent parameters (see: chapter 6.2.4).

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.

Fig. 6.1 shows the gross energy intake (GE) in MJ per day for all cattle and sheep subcategories. As of the 2012 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 166 MJ/day in 1990 to 190 MJ/day in 2010. 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 milk production from 4.1 t in 1990 to 5.4 t in 2010.

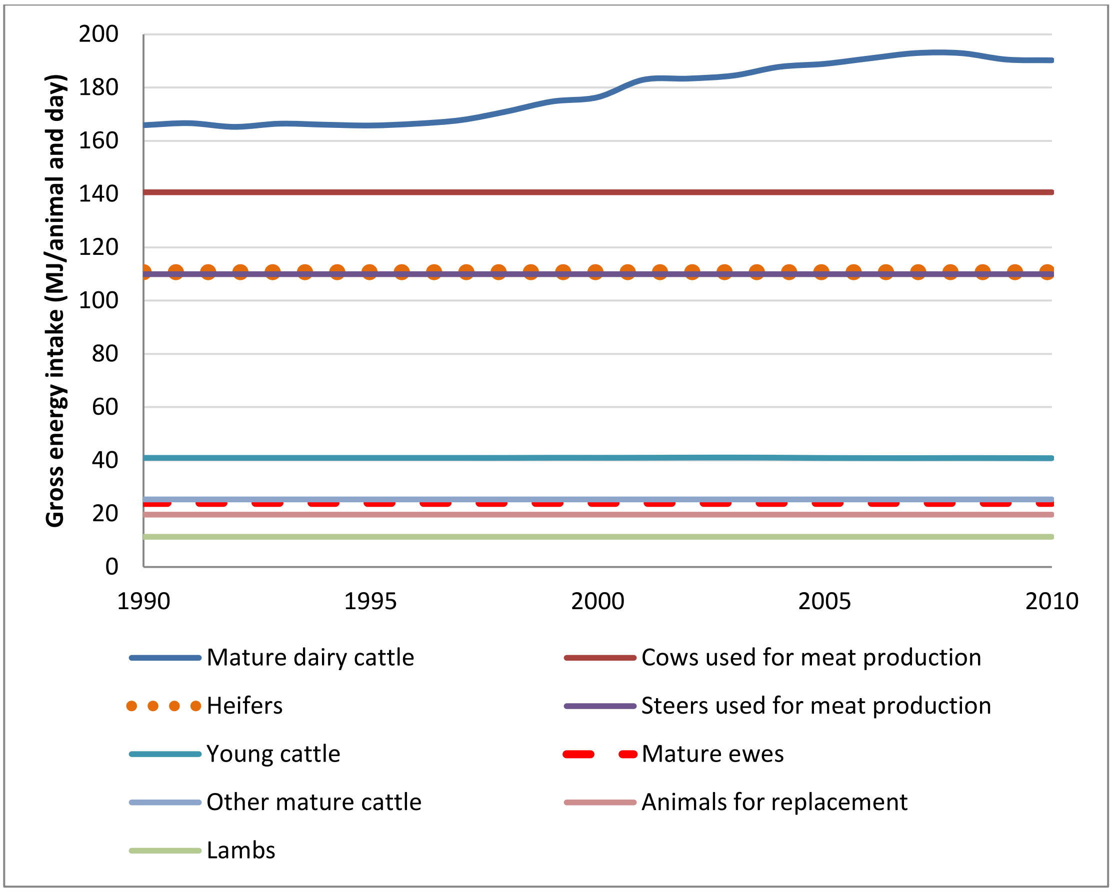

Fig. 6.1. Gross energy intake (MJ/day) for cattle and sheep subcategories from 1990-2010.

6.2.3 *Recalculations and improvements*

In response to the UNFCCC in-country review of the 2011 submission, there have been numerous changes to animal population data between 2011 and 2012 submissions. Their nature and impact on animal populations are discussed in the list below.

Cattle the subcategory low producing dairy cattle (Icelandic: holdakýr) has been relocated from the category dairy cattle to category other mature cattle since they are not used for milk but meat production. The relocation had no net impact on cattle population size. The number of cattle in the 2012 submission, however, increased because the number of calves was not reduced by weighting it with an average lifetime of 6 months as was done in the 2011 submission. The majority of calves are not slaughtered during their first year of age.

Sheep the population increased by 9.9% between submissions. This was due to a number of factors

- The average lifetime of lambs was increased from 4 to 4.5 months
- Number of animals for replacement had been reduced by weighting it with a lifetime of eight months in the 2011 submission. In the 2012 submission their number is not reduced since they are not slaughtered at eight months of age but continue to live and become mature ewes the following year. Thus a negligible methodological error is introduced: animals for replace-

ment recorded in the census of year x are taken into account in the emission estimates of year x although the last four months of their first year of existence happen in year x+1. The error is accepted since it is offset by animals for replacement recorded in year x-1 and because the number of animals for replacement changes only slightly between years.

- The calculation of lambs born annually had been calculated thus in the 2011 submission: assumed number of lambs in 2002 divided by recorded number of ewes in 2002 times recorded number of ewes in year x. This assumption based calculation was replaced by a calculation based on data on fertility rates, single, double, and triple birth fractions. This increased number of lambs born annually slightly.

Horses the population data provided by the IFVA contains data on number of adult horses, young horses, and foals. In the 2011 submission the total horse population data was assumed to not contain information on young horses which was subsequently added based on assumptions. The omission of this addition reduced horse population data by 4% between emissions.

Swine number of piglets per sow increased from 17 to 25 based on new information. This increased weighted swine population by 31% between submissions.

Poultry chickens for all poultry species had been calculated using an assumed number of chickens per hen of 3.6. This assumption was replaced by species specific data on number of chickens per hen supplied by the IFVA or gathered from poultry producers. This increased weighted poultry population by 7.8%.

There have also been numerous changes to the data used in the livestock population characterization. They are summarized in Table 6.6. Another improvement between 2011 and 2012 submissions consisted of the calculation of gross energy for lambs. In the 2011 submission gross energy calculated for animals for replacement was applied to both animals for replacement and lambs.

Table 6.6. Percental changes in gross energy (GE) for cattle and sheep subcategories between 2011 and 2012 submissions.

subcategory	GE change (2011-2012)	main reasons behind change
mature dairy cattle	-10.6%	- Reduction of live weight from 450 to 430 kg[1] - Division of annual milk production by 365 instead of 305 days[2]
cows used for producing meat	3.8%	- Increase of live weight from 450 to 500 kg[1] - Increase of time spent on pasture from 6 to 11 months[3]
heifers		- Was **part** of subcategory other mature cattle, therefore no comparability between submissions
steers used for producing meat		- Was **part** of subcategory other mature cattle, therefore no comparability between submissions
young cattle	79.1%	- Increase of live weight from 50 to 126 kg[2]
mature ewes	-16.2%	- Reduction of net energy for lactation by reducing weight gain of lambs between birth and weaning from 35 to 18 kg[2]
other mature sheep	19.2%	- Increase of weight from 85 to 95 kg[3]
animals for replacement	14.3%	- Increase of weight gain between weaning and one year of age from 15 to 33 kg[2]
lambs		- Was not calculated in 2011 submission

1: Sveinbjörnsson and Ólafsson, 1999. 2. Correction of methodological errors. 3. Expert judgement

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)
Ym	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 guidelines 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 summation of emissions for all categories.

There is only one livestock subcategory that has time dependent 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 20% between 1990 and 2010. Methane emissions, however, have only decreased by 8.5% from 2.1 Gg to 1.9 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. Emissions from mature ewes decreased by 16% between 1990 and 2010 (from 4.9 to 4.1 Gg) due to an equal decrease of population size. 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 1.42 Gg methane in 2010 due to an equal increase in population size.

The decrease in methane emissions from cattle and sheep, though, caused total methane emissions from enteric fermentation in agricultural livestock to drop from 11.6 Gg in 1990 to 10.9 Gg in 2010, or by 6.7%.

Table 6.8. Methane emissions from enteric fermentation from agricultural animals for years 1990, 1995, 2000, 2005 and 2008-2010 in t methane.

livestock category	1990	1995	2000	2005	2008	2009	2010
mature dairy cattle	2105	1985	1878	1824	1990	1986	1925
cows used for producing meat	0	41	53	75	89	87	93
heifers	199	557	277	293	301	298	299
steers used for producing meat	777	665	859	659	777	803	821
young cattle	324	224	289	292	311	322	330
mature ewes	4919	4109	4119	3978	3990	4042	4132
other mature sheep	154	144	141	131	135	134	135
animals for replacement	578	475	517	537	546	591	603
lambs	1160	968	977	950	954	973	995
swine	44	47	48	57	70	63	61
horses	1332	1447	1364	1382	1436	1424	1422
goats	2	2	3	3	4	4	5
fur animals	5	4	4	4	3	4	4
poultry	13	7	11	15	15	15	14
total methane emissions	11614	10674	10540	10200	10621	10747	10838
emission reduction (year-base year)/base year		-8.1%	-9.3%	-12.2%	-8.6%	-7.5%	-6.7%

6.3.3 *Recalculations and improvements*

Methane emission estimates from enteric fermentation for the year 2009 were lowered from 11.92 Gg CH_4 to 10.84 Gg CH_4 or by 9.1% between submissions. The main driver behind this reduction is the reduction of methane emissions from mature ewes. Methane emission estimates from enteric fermentation of mature ewes were lowered by 1.5 Gg CH_4 or 26.6%. As discussed above this reduction is mainly due to decreased net energy for lactation which in turn is caused by the correction of weight of lambs at weaning.

6.3.4 *Uncertainties*

Some emission factors used for calculating methane emissions from livestock enteric fermentation are not country specific. The emission factor for horses are default values in the 1996 IPCC Guidelines and may therefore be a slight overestimate due to the fact that the domestic livestock of horses are generally smaller than in other European countries. Other default emission factors may perhaps not accurately represent Iceland livestock characteristics. The estimate of quantitative uncertainty has revealed that the uncertainty of CH_4 emissions from Enteric Fermentation for cattle, sheep, and other livestock animals is 28% (with an activity data uncertainty of 20% and emission factor uncertainty of 20%). This can be seen in the quantitative uncertainty table in Annex II.

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 (CH_4). These conditions often occur when large numbers of animals are managed in confined areas, e.g. dairy, swine and poultry farms, where manure is typically stored 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 the ones 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 calculated in the livestock population characterisation, national values for digestible energy of feed and IPCC default values for ash content of manure. The calculation uses equation 4.16 from the GPG.

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:

EFi = annual emission factor for defined livestock population *i*, in kg

VSi = daily VS excreted for an animal within defined population *i*, in kg

Boi = maximum CH4 producing capacity for manure produced by an animal within defined

population *i*, m^3/kg of VS

MCFj = CH4 conversion factors for each manure management system *j*

MSij = 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 6.9.

Table 6.9. 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 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 grazing pastures. Young cattle and steers are housed all year round. All cattle manure managed, i.e. not spread on pasture 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 6.10).

Table 6.10. Manure management system fractions for all livestock categories

	liquid/slurry	solid storage	pasture/ range/ paddock
mature dairy cattle	73%		27%
cows used for producing meat	8%		92%
heifers	67%		33%
steers used for producing meat	91%		9%
young cattle	100%		0%
mature ewes	19%	36%	45%
other mature sheep	19%	36%	45%
animals for replacement	19%	36%	45%
lambs			100%
goats		55%	45%
horses		14%	86%
young horses		14%	86%
foals			100%
sows	100%		
piglets	100%		
poultry, fur animals		100%	

Emission factors both calculated with volatile solid excretion rates, methane conversion factors, and manure management fractions as well as IPCC default values for other livestock categories than cattle and sheep were used to calculate methane emissions from manure management in 2010 and are shown in Table 6.11.

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

livestock category	emission factor 2010	emission factor range 1990-2010	source
	(kg CH_4/head year)	(kg CH_4/head year)	
mature dairy cattle	14.95	13.38-15.26	LPS[1]
cows used for producing meat	1.33		LPS[1]
heifers	5.73		LPS[1]
steers used for producing meat	12.09		LPS[1]
young cattle	3.06	3.06-3.08	LPS[1]
mature ewes	0.77		LPS[1]
other mature sheep	0.81		LPS[1]
animals for replacement	0.63		LPS[1]
lambs	0.08		LPS[1]
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 6.11 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 solely 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 a 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 1.41 Gg in 2010, i.e. 3% lower than they were in 1990 (Table 6.12).

Table 6.12. Methane emissions from manure management in tons.

livestock category	1990	1995	2000	2005	2008	2009	2010
mature dairy cattle	435	407	382	368	399	398	384
cows used for producing meat	0.0	1.1	1.4	2.0	2.3	2.3	2.4
heifers	26	73	36	39	40	39	39
steers used for producing meat	217	186	240	184	217	224	229
young cattle	62	43	55	56	59	61	63
mature ewes	341	285	286	276	277	281	287
other mature sheep	11	10	10	9	9	9	9
animals for replacement	56	46	50	52	53	57	59
lambs	25	21	21	21	21	21	22
swine	89	93	97	115	140	125	122
horses	103	112	106	107	111	111	110
goats	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fur animals (minks and foxes)	32	26	28	25	23	27	25
rabbits	0.1	0.0	0.1	0.0	0.0	0.0	0.0
poultry	53	28	43	60	58	60	56
total methane from manure management	1451	1332	1355	1314	1409	1417	1409
emission reduction (year-base year)/base year		-8.2%	-6.7%	-9.4%	-2.9%	-2.4%	-2.9%

6.4.3 Recalculations and improvements

In the 2011 submission all manure management EF with the exception of the EF for fur animals were taken from the 1996 GL. In this submission swine, horse, poultry, and goats EFs were taken from the 1996 GL and are therefore identical with the ones from the 2011 submissions. The EFs for cattle and sheep, however, were based on the enhanced livestock population characterization, which takes national manure management system fractions into account. This led to a slight increase in the EF for dairy cattle but had a bigger impact on the EF for non-dairy cattle. The 2012 submission for heifers is close to the 1996 GL default of 6 kg CH_4 per head and year (5.73 kg), which was applied to the subcategories heifers, steers used for producing meat, and young cattle. The lower EF for young cattle (3.06 kg) is offset by the doubling in activity data (see chapter 6.2.1). The increase of the EF for steers used for meat production from 6 kg to 12.09 kg CH_4, however, increased methane emission estimates from manure management of non-dairy cattle from 0.21 Gg to 0.33 Gg CH_4. Methane emission estimates from sheep manure management increased even more between submissions: from 0.13 to 0.37 Gg methane. This tripling of emission estimates is due to the fact that EFs for all sheep subcategories with the exception of lambs increased by a factor of four between emissions. The EF proposed in the 1996 GL and used in the 2011 submission was based on the assumption that all sheep manure was managed in dry systems (NGGIP-TSU, written information). The default was therefore too low for Iceland. The increases for non-dairy cattle and sheep, along with an activity data driven increase of 0.03 Gg CH_4 for swine manure, explain the increase of emission estimates from 1.01 to 1.42 Gg CH_4 between submissions (for 2009).

In the 2011 submission the EFs for fur animals were taken from the Norwegian NIR since they were not contained in the 1996 GL. In this submission they were taken from the 2006 GL. This increased emission estimates slightly.

6.4.4 Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of methane emissions from manure management is 36.1% (with an activity data uncertainty of 20% and emission factor uncertainty of 30%). This can be seen in the quantitative uncertainty table 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 6.10.

Average annual nitrogen excretion rates were calculated using 2006 GL default values (Table 6.13). The defaults relate to 1000 kg animal mass. This means that they account for two cows weighing 500 kg each or roughly 15 ewes weighing 65 kg each. The calculated default for dairy cattle was not used since national, time dependent values existed: Ketilsdóttir and Sveinsson (2010) measured the Annual N excretion rates for dairy cows. The resulting value of 94.8 kg N was applied to dairy cows from 2000-2010. Since the value is based on new measurements and therefore 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 6.13. 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 138.5 tonnes N_2O in 2010 and 167.9 tonnes in 1990. This was tantamount to a decrease in emissions of 17.5%. Emissions from liquid systems make up only a small part of total emissions from management systems. They accounted for only 5.7% of total emissions from manure management systems in 2010. This was due to the emission factor for liquid systems which is twenty times lower than the one for solid storage. The majority of emissions originated from the solid storage of sheep manure (72.7% in 2010, followed by solid storage of poultry manure (10.7%), of horse manure (6.9%), and fur animal manure (3.9%). Fig. 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. They are included here in order to show their magnitude, although they are reported under emissions from agricultural soils in national totals. In 2010 N_2O emissions from manure spread on pasture by livestock amounted to 271.5 tonnes or almost twice as much as emissions from liquid systems and solid storage. Emissions from sheep manure were 181.6 tonnes, emissions from horse manure were 60.7 tonnes, and emissions from cattle manure amounted to 29.3 tonnes N_2O.

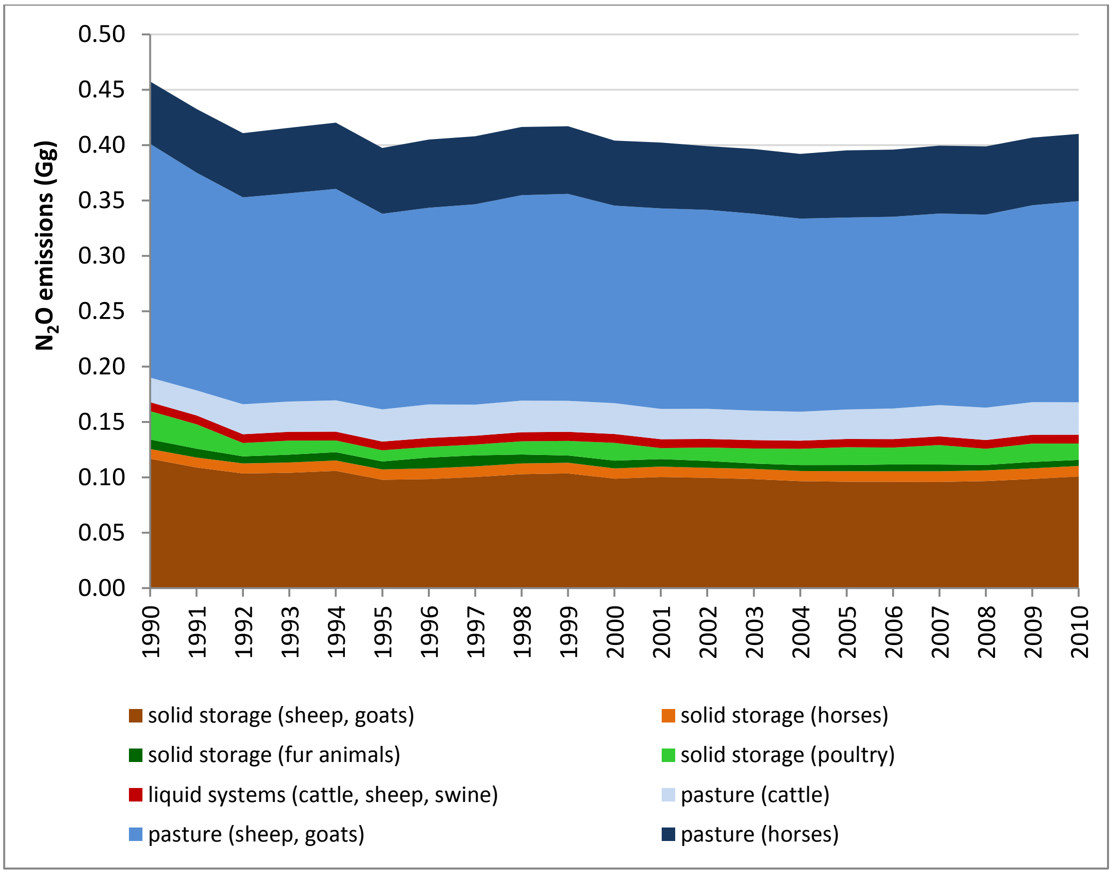

Fig. 6.2. N_2O emissions from manure management in Gg N_2O.

6.5.4 Recalculations and improvements

There have been slight changes to manure management system fractions for a number of livestock categories. The 42% increase in N_2O emissions from manure management for the year 2009 from 0.1 Gg N_2O to 0.14 Gg N_2O between 2011 and 2012 submissions, however, is first and foremost due to changes in nitrogen excretion rates for sheep. The reported nitrogen excretion rate for sheep was 5.76 kg N per head and year. This value was changed in line with the 2006 GL for the 2012 submission and increased consequently to 14.28 kg N per head and year (weighted average for adult ewes, other adult sheep, animals for replacement, and lambs).

6.5.5 Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of N_2O emissions from manure management is 54% (with an activity data uncertainty of 20% and an emission factor uncertainty of 50%). This can be seen in the quantitative uncertainty table in Annex II.

6.5.6 Planned improvements

The nitrogen excretion rate for cattle and sheep will be recalculated. Recalculation means calculation of nitrogen intake using data on feed and crude protein intake developed in the Livestock population characterisation and default N retention rates.

The AUI is carrying out a study on manure management system fractions for sheep in Iceland. Its results will be included in the next submission.

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 return of crop residue, 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 contained in synthetic fertilizer applied to soils with the exception of the amount of fertilizer applied in forestry (Fig. 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 Fig. 6.3.

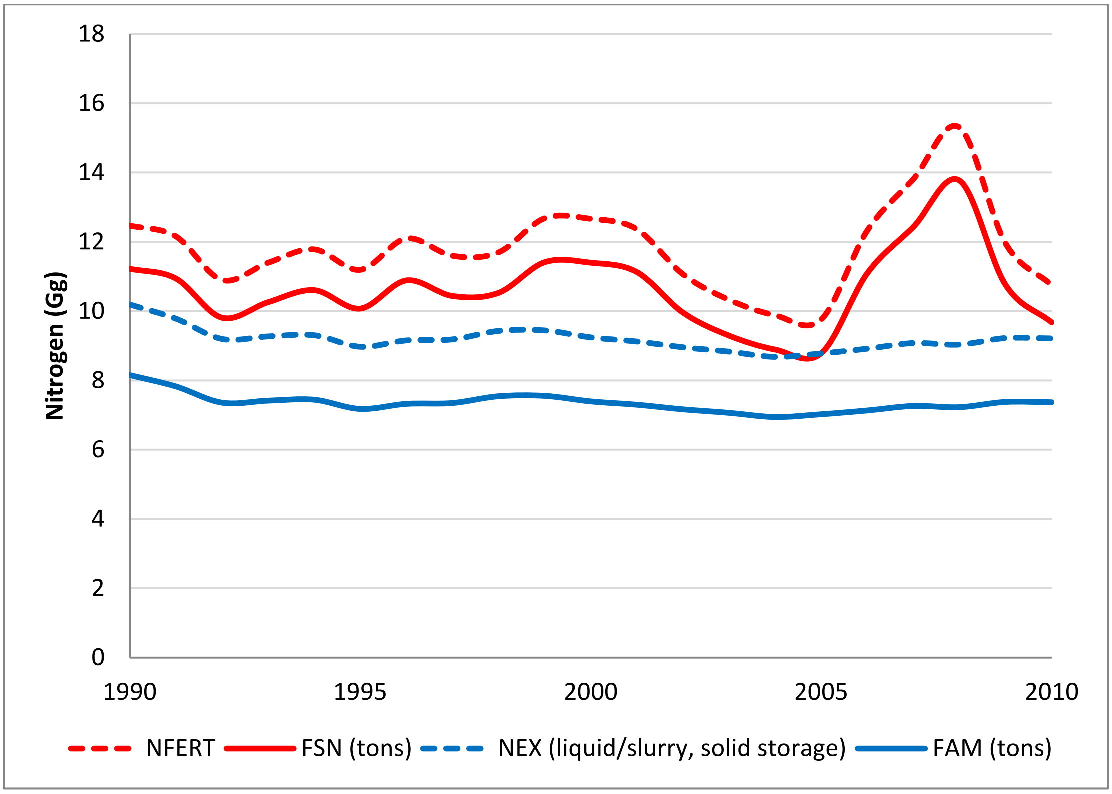

Fig. 6.3. Amounts of nitrogen from synthetic fertilizer and animal manure application. Solid lines show nitrogen amounts adjusted for volatilization. Total N amounts are shown in dashed lines of same colour.

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 amounts of residues returned to 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 Fig. 6.4.

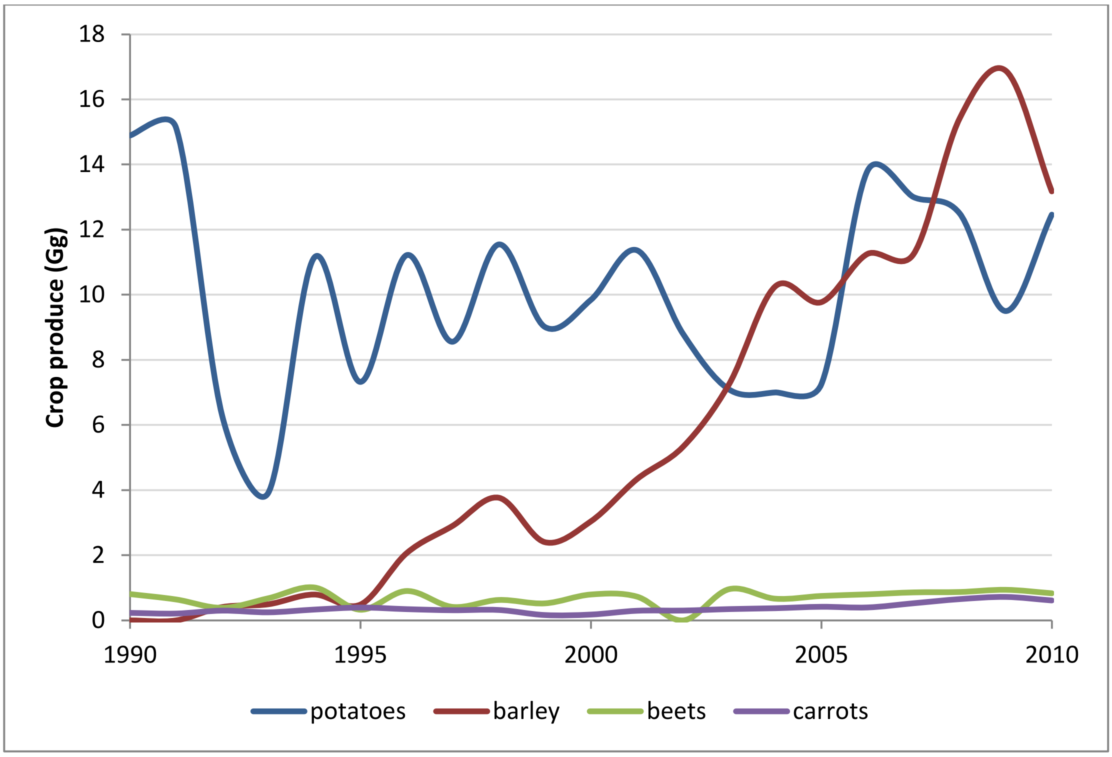

Fig. 6.4. Crop produce in Gg for 1990-2010

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 of cropland (more exactly cropland remaining cropland and grassland converted to cropland) was 580 km^2 in 1990 and has risen steadily to 651.2 km^2 in 2010.

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 viewed 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 N_2O emissions by multiplying units of nitrogen with 44/28 (molar mass of N_2O divided by molar mass of N_2).

Direct emission from agricultural soils amounted to 435 tonnes N_2O in 2010, which meant a decrease of 7.4% in comparison to the respective emissions in 1990. The drivers behind the decrease were the decreasing amounts of synthetic fertilizer and animal manure applied to soils, which counteracted the emission increase from organic soils. 44% of 2010 emissions originated from synthetic fertilizer application, 33% from animal manure applied to soils and 23% from organic soils. The contribution of N in crop residues returned to soils is extremely slight (0.1%). Annual fluctuations in emissions are mainly caused by the amount of fertilizer applied to soils (Fig. 6.5).

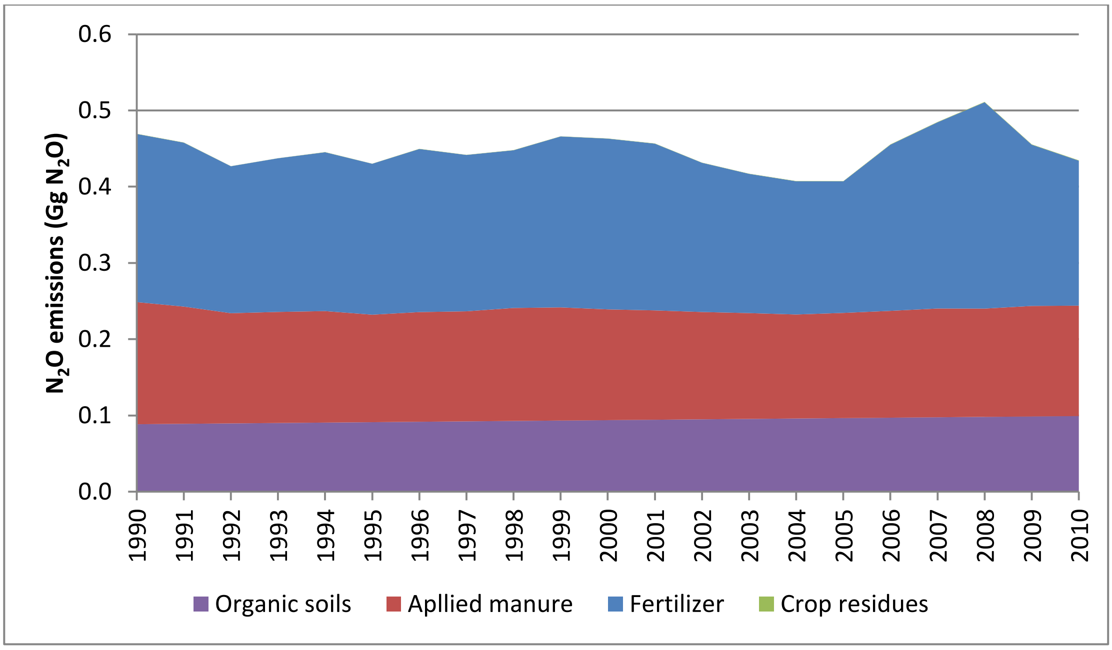

Fig. 6.5. Direct N_2O emissions from soils (Gg)

6.6.4 Recalculations and improvements

The nature of the changes to the N content of livestock excretion has been discussed in chapter 6.5.4. These changes led to an increase of 56% between submissions in N contained in animal manure applied to soils (reference year 2009). The data on area of cultivated organic soils has been revised between submissions. It is now time dependent and was 20% higher in the 2012 submission than it had been in the 2011 submission for 2009. In combination these two changes led to a 17.6% increase of agricultural soil emission estimates between submissions.

6.6.5 Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of direct N_2O emissions from agricultural soils is 32% (with an activity data uncertainty of 20% and emission factor uncertainty of 25%) as well as for indirect emissions from nitrogen used in agriculture and animal production. This can be seen in the quantitative uncertainty table in Annex II.

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 latter 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 1990-2010 - after conversion from nitrogen to nitrous oxide - is shown in Fig. 6.6. N_2O emissions amounted to 410 tonnes N_2O in 2010, which meant a 10% decrease from the 1990 value of 456 tonnes. The general 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.

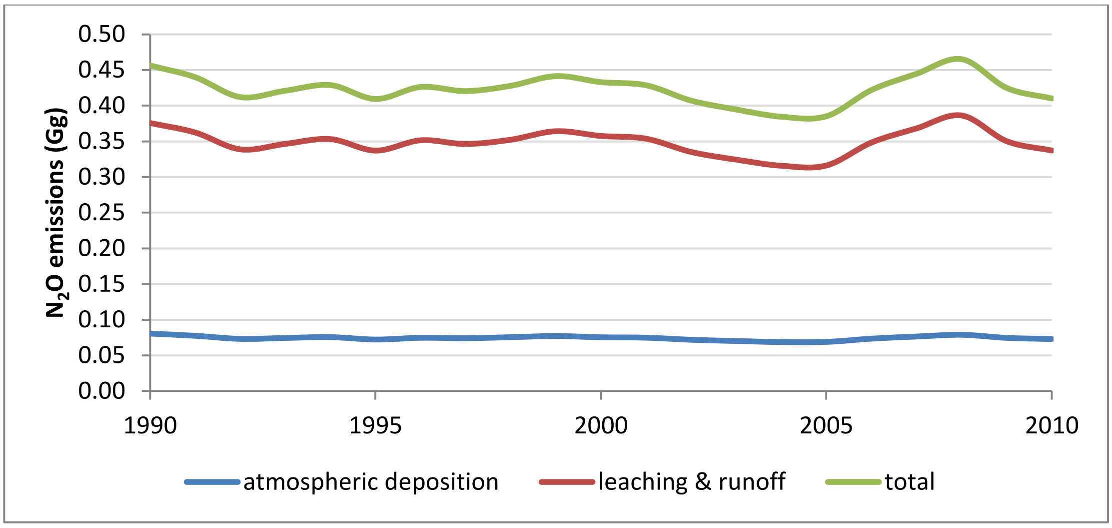

Fig. 6.6. Indirect N_2O emissions from agricultural soils.

6.7.3 Recalculations and improvements

The estimate for indirect N_2O emissions from agricultural soils for 2009 increased by 32% between the 2011 and 2012 submissions due to the aforementioned changes in livestock N excretion rates. The increase between submissions for 1990 emission estimates is 44%.

6.7.4 Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of indirect N_2O emissions from agricultural soils is 54% (with an activity data uncertainty of 20% and emission factor uncertainty of 50%) as well as for indirect emissions from nitrogen used in agriculture and animal production. This can be seen in the quantitative uncertainty table in Annex II.

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 Icelandic Forest Research (IFR) and Soil Conservation Service of Iceland (SCSI) on chapters related to forest and revegetation.

The CRF for LULUCF was prepared through UNFCCC CRF Reporter program (version 3.5.2). Land use categories have been decided and formally defined. The classification of land according to these definitions is implemented for all the main land-use categories. There are considerable changes in the structure of information regarding those categories reported. Time series have been introduced for several categories and subcategories and conversion period revised for most land use conversions. The time series and changes in conversion periods result in substantial reallocation of land between categories and introduction of new subcategories.

In last submission all Cropland was reported in two categories i.e. Cropland remaining cropland involving all cultivated land as mapped in Iceland Geographical Land Use Database (IGLUD), except the area estimated as organic soil which was reported under Wetland converted to Cropland.

In this year's submission Cropland in use is reported as three categories i.e. Cropland remaining cropland, involving cropland in use older than 20 years, Grassland converted to Cropland, and Wetland converted to Cropland, both categories involving 20 years or less old conversions. Abandoned cropland is reported under Grassland.

In last submission Grassland was reported as five subcategories i.e. Natural birch shrubland and Other Grassland, both subcategories of Grassland Remaining Grassland, Land converted to Grassland was reported as Wetland converted to Grassland, involving all drained Grassland, and as Other land converted to Grassland, involving all revegetation divided according to areas initiated before 1990 and area initiated since 1990.

In this year's submission three new categories of Grassland remaining Grassland are reported i.e.; Cropland abandoned for more than 20 years, Revegetated land older than 60 years, and Wetland drained for more than 20 years. The area of Grassland falling under Cropland converted to Grassland is now reported involving conversion 20 years old or less. The land reported as Wetland converted to Grassland is now also restricted to conversion 20 years old or less. The subcategories of Other land converted to Grassland i.e. revegetation before and since 1990 are now restricted to conversion period of 60 years.

The AUI has since 2007 been constructing the Icelandic Geographically Land use Database (IGLUD) to meet the requirements of the LULUCF reporting. In this year's submission the area estimate for the main land use categories is based on this database except where more precise estimates are available.

Time series for land conversion are provided for several new categories, including all Cropland subcategories and all Grassland categories except Natural birch shrubland and Other Grassland. The conversion period used is variable between categories as explained below. Due to limitations of present version of UNFCCC CRF-Reporter the Non-CO_2 emissions of Wetland converted to Grassland are still reported under 5.G-other emissions. Emission caused by use of fertilizers in Revegetation was in last submission reported under 5.G- other emissions is now included in Agricultural sector 4.D.1.1

The QC/QA plan presented in the 2008 national inventory report has not been fully implemented with regard to LULUCF although some components of the plan have been included in the preparation of the inventory (see QC/QA chapters of each category). Formal QC/QA procedures have not been prepared for LULUCF. The methods used for estimating emission/removal for individual sinks and sources are compliant with the AFOLU guidelines as described for relevant components below. In general Tier 1 QC is applied in preparation of the inventory for the LULUCF sector. 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.

Accumulation and processing of land use information is revised adopting new map layers, omitting others instead. Renewed map layer for lakes and rivers is adopted. The map layers for forest and revegetation are updated according to new activities. The previous Settlement map layers of CORINE CLC-2006 were replaced by new map layer of IS 50V (see below). The map layer for reservoirs has been improved including many previously not mapped reservoirs. The land use map is re-compiled adopting these changes. The new compilation resulted in revised area estimate for many categories.

The processing of land use data is described below.

The emissions reported for the LULUCF sector in 2010 equals 733.80 Gg CO_2-equivalents compared to 681.11 Gg CO_2-equivalents in 2009. In this year's submission the estimated LULUCF emission for 2009 is 759,06 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.

1. Emission for the Cropland category is revised thoroughly, including revision of area, reallocation of land to other categories and between subcategories and providing estimates for carbon stock changes not estimated before. The area estimated as Cropland is now 129.94 kha compared to 169.31 kha in last submission. The change in area is explained by abandoned cropland reallocated to the Grassland category. In spite of less area the estimated emission increases from 995.34 Gg CO_2-equivalents to 1078,95 Gg CO_2-equivalents.

Carbon stock changes for living biomass and mineral soils of land converted to Cropland are now provided for the first time causing emission of 14.16 Gg CO_2. The area of organic soil is revised and in spite of reallocation of abandoned cropland it is increased to 58.08 kha compared to 54.07 kha in last submission.

2. Emission for the Grassland category is revised considerably involving; revision of area and reallocation from other categories and between subcategories, new subcategories of Grassland remaining Grassland and emission estimate of subcategories of land converted to Grassland not previously estimated. Emissions/removals are now estimated for first time for Cropland converted to Grassland. Emission from mineral and organic soil is estimated is estimated 90.30 Gg CO_2 removal due to increased biomass and dead organic matter is estimated 45.51 Gg CO_2 resulting in net emission of 44.79 Gg CO_2. The subcategory Cropland abandoned for more than 20 years is introduced and the emission from organic soil in that category is estimated 3.77 Gg CO_2. The two categories Cropland abandoned for more than 20 years and Cropland converted to Grassland represent land reallocated from Cropland as reported in last year submission. The area of the category Other land converted to Grassland is revised. The changes in area are mostly because of revised estimate for revegetation before 1990 increasing by 64.86 kha. The EF's of Revegetation are also revised. The removal reported for this subcategory is 515.98 Gg CO_2 compared to 439.38 Gg CO_2 in last submission. In this year's submission the removal for 2009 is reported 508.71 Gg CO_2 reflecting the recalculation. The Grassland category net removal is in this submission 92.62 Gg CO_2 equivalents including N_2O emission reported under 5.G-others compared to 74.36 Gg CO_2 equivalents in last submission. In this year's submission the removal for 2009 is reported 87.63 Gg CO_2 equivalents reflecting the recalculations effect.

7.2 Land use practices and consequences

The dominant land use in Iceland through the ages 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 completely 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, hay, 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. Only a minor portion of these drained areas was converted to hayfields or cultivated. The larger part of the lowland wetlands in Iceland was turned into grassland through this drainage effort.

This land use history needs to be reflected in the national greenhouse gas inventory to the UNFCCC and also the actions taken to recover some of the lost resources. Definitions of land use categories, thus, need to differentiate between grassland of variable degradation stages and areas which are being restored either by direct activity as in re-vegetation efforts or due to decreased grazing pressure. Grassland and cropland formed by drainage also need to be separated from other land in these categories.

Ongoing land use changes in Iceland are not systematically recorded and consequently its direction or trend is generally unknown. Certain land use changes are although 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 is to detect and quantify these changes.

7.2.1 Existing land use information

Geographical mapping of land use in Iceland has not been practiced to the same extent as in many European countries. Historically the farmlands were relatively large but only a small percentage cultivated. Use of commons, such as for summer grazing in the highlands, was based on orally inherited rules rather than written accounts. When written division existed it was generally based on references to names of identities in the landscape. Land use within each farm was entirely based on the decisions of the owner which in most cases was the residing farmer.

It is not until the 20th century that detailed countrywide mapping begins. First complete mapping of Iceland which included major landscape features and vegetation types was completed in 1943 (Landmælingar_Íslands 1943). Since then there have been ongoing efforts to map topography, vegetation, erosion and geology. Land use has only partially been mapped. Mapping of cultivated areas has been attempted a few times but never really 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 lead 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 that are planned to be finished in 2014.

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. This last mapping project is compiled in a digital geographical database (NYTJALAND) and forms the main data source for the IGLUD. The Nytjaland full-scale 12 class (see Table 7.1) classification is not with complete coverage of Iceland. For the remaining areas a coarser classification (seven classes), has been carried out in relation with the CORINE project. IGLUD is based on this coarser classification where the full-scale NYTJALAND coverage is lacking.

Iceland has become a formal partner of the European land use classification program CORINE. The National Land Survey of Iceland (NLSI) is responsible for Iceland's participation in the CORINE project. The first mapping, CORINE CLC-2006, was delivered in 2008. In 2009 NLSI finished mapping CLC 2000/2006 changes and integrating the changes to give CLC 2000.

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 some 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.

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 2006 IPCC Guidelines for National Greenhouse Gas Inventory (IPCC 2006). The categorization of land use also needs to be, as much as possible, based on existing information and adapted to Icelandic land use practices. Important criteria is that the land use practices most affecting the emission or removal of greenhouse gasses and changes in the extent of these practises are recognised by the database. The defined land use classes need to be as much as possible recognisable both through remote sensing and on ground. This applies especially to those categories not otherwise systematically mapped.

Another important objective of the IGLUD project is that all six main land use classes of IPCC Guidance should be geographically identified. Within the database, subdivisions of main land use categories should either be identified geographically or the relative division within a region or the whole country to be known. Relative division can be based on ground surveys or other additional information.

The data sources and process of compiling the data to IGLUD will be described in details elsewhere (Guðmundsson et al. in prep). 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: Geographical Database on Condition of Farming Land

The Agricultural University of Iceland and its predecessor the Agricultural Research Institute in cooperation with other institutes, has for several years been working on a geographical database on the condition of vegetation on all farms in Iceland.

The full scale mapping is now completed for approximately 60% of the country, thereof is 70% of the lowlands below 400 m above sea level 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. Extensive ground-truthing has resulted in a level of approximately 85% correct categorisation on less than 0.05 ha resolution for most categories. The categorization used divides the land into twelve classes, vegetation covers is ten classes and lakes, rivers and glaciers cover two. The definitions of categories are not the same as required for CRF LULUCF. The classes used in NYTJALAND are listed in Table 7.1.

Table 7.1. The original land cover classes of the NYTJALAND database showing the full scale classes and the coarser class aggregation.

NYTJALAND 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 (Líkt 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 also dwarf shrubs. Soil is generally wet but without standing water. This category includes drained land where vegetation 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.	Sparely 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 NYTJALAND was classified applying coarser classification (seven classes) modified according to CORINE requirements. Accordingly a two levels classification is available for the whole country, i.e. one with seven classes and full coverage of the country and another with 12 classes covering 60% of the country.

The pixel size in this database is 14×14 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 0.196 ha as the minimum mapping unit.

Before compiling the NYTJALAND classes into IGLUD each land cover class is converted to a separate map layer. In last year's submission the map layer "Lakes and rivers", was improved by merging map layer lakes and rivers from IS 50V 3.0 with NYTJALAND's map layer "Lakes and rivers". In this submission the map layer "lakes and rivers" IS 50V 3.2 is used instead of version 3.0. The NYTJALAND map layer of Glaciers and perpetual snows is not used in the compilation of IGLUD.

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

IS 50 v 3.2

The IS 50V 3.2 geographical database of the National Land Survey of Iceland (NLSI) includes eight map layers. From that database four map layers are used in IGLUD i.e. "town and villages", "Airports" and "Roads". These layers with buffer zone on Roads replace the CORINE CLC-2006 Settlement map layer used in last submission. The map layer of IS 50V 3.2 Glaciers and perpetual snows is also used in the IGLUD compilation replacing the previous NYTJALAND map layer of Glaciers.

Maps of Forest

All known woodland 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. These maps form the geographical background for the National Forest Inventory (NFI) carried out by IFR. The control and correction of these maps are part of the NFI work. The category Forest Land in IGLUD map is based on these maps.

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 a Geographical Information System (GIS). Mapping of the "Farmers revegetate the land" (FRL) activity has now been completed and merged with other activities since 1990. FRL is a cooperative revegetation activity between SCSI and voluntary participating farmers. The mapped area forms the geographical data background behind the national inventory of revegetation carried out by SCSI. The recorded activities, which are currently not mapped are not included in the NIRA but will be added as the data become available. 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 mapping of revegetation taking place before 1990 is less reliable with regard to activity, as the documentation often focuses on location rather than the activity. The category Revegetated land in IGLUD is based on these maps.

Maps of ditches and Drained land

Extensive drainage of wetland took place in Iceland mostly in the period 1940-1985. This drainage was aided by governmental subsidies. Only a minor part of these drained areas was turned to hayfields or cultivated, the larger part of the lowland wetlands in Iceland were converted to Grassland or Cropland. 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. All ditches recognizable on satellite images (SPOT 5) have recently been digitized in a cooperative effort of the AUI and the NLSI (Fig. 7.1).

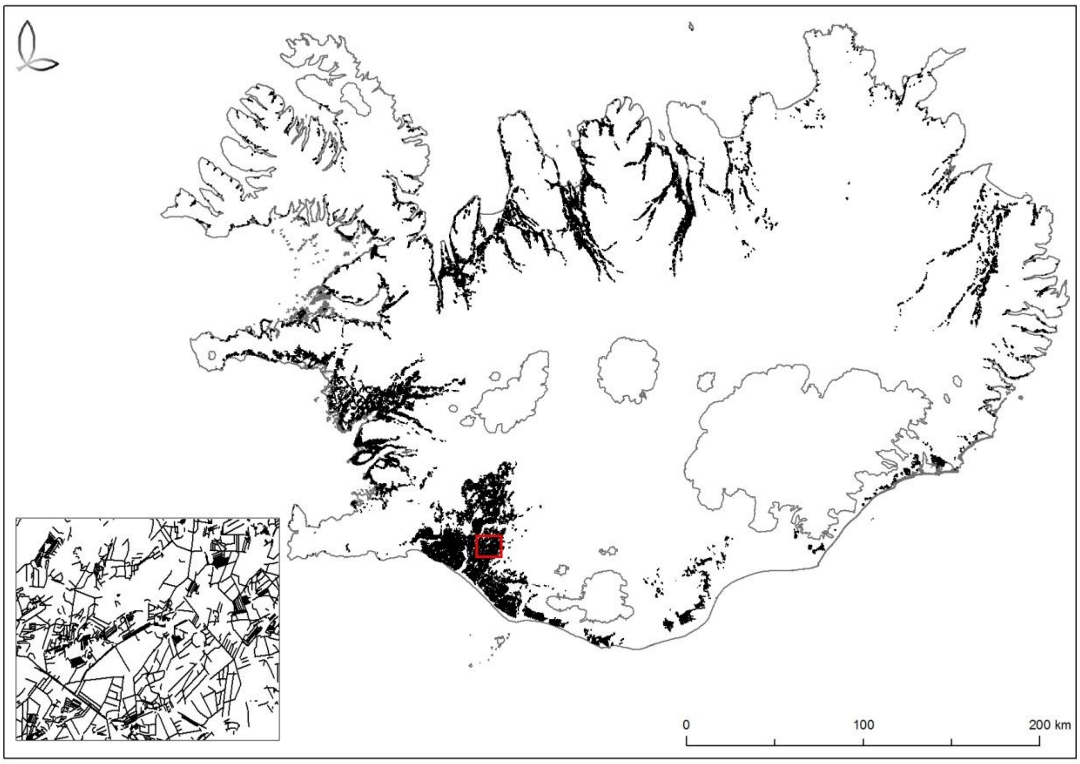

Fig. 7.1. Map of Iceland showing all digitized ditches. (AUI 2008).

The AUI in cooperation with NLSI has, on basis of satellite images (SPOT 5) and support of aerial photographs, digitized all ditches in Iceland. The map layer Drained land was prepared from map of ditches applying a 200 m buffer zone on every ditch. From that area the overlap with following map layers was excluded; Sparsely vegetated land (ID: 603 and 604), Partly vegetated land (ID: 506 and 509), Lakes and Rivers (ID: 404 and 405), Shrubs and forest (ID: 507) and Natural birch woodland <2 m (ID: 515). Additionally all areas where slope exceeded 10° and all areas 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 of drained land so prepared 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 and Glaciers and perpetual snows. The map layers of “Wetland”, “Semi-wetland” and “Semi-wetland/wetland complex” from the Farmland database (NYTJALAND) 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 Farmland database 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.

Maps of cultivated Land

Map layer cultivated land was also produced in cooperation with NLSI. The digitization was completed in 2009 by AUI. The map layers of the NYTJALND database are prepared with remote sensing of satellite images as described above. All Cropland in the NYTJALAND map layers named “Cultivated land” and “Cropland and pasture” are in the compilation process included in this map layer. In IGLUD this map layer represent the Cropland category. The drained organic soil within Cropland is mapped on basis of density analyses of the digitized ditches (Gísladóttir et al. 2010).

Maps of reservoirs

The previous map of reservoirs has been supplemented with new map layer prepared by AUI on basis of available information (Sigurðsson 2002) and local knowledge. Included in this supplementary map are many smaller reservoirs and reservoirs managed by others than the main power plant company Landsvirkjun. This map layer needs still to be controlled.

Map of zone of recently retreated glaciers.

The comparison of previous map of glaciers and perpetual snows to the one from IS 50v 3.2 reveals less area included in the IS 50 v3.2. To meet this shrinkage of glaciers and perpetual snows a separate map layer was prepared for those areas recently exposed.

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	201	12
		Forest cultivations 1960-1989	202	7
		Forest cultivations 2000-2009	203	9
		Forest cultivations 1990-1999	204	8
		Forest cultivations >2m	205	10
		Forest cultivations 0-2m	206	11
	Natural birch forest	Natural birch forest >2m	205	13
3.**Cropland**	Cropland mineral soil	Cropland	301	19
	Cropland organic soil	Cropland with ditch density 10-15 km km^{-2}	302	16
		Cropland with ditch density 15-20 km km^{-2}	303	17
		Cropland with ditch density > 20 km km^{-2}	304	18
4.**Wetland**	Other wetlands	Semi-wetland (wetland upland eco-tone)	401	37
		Wetland	402	38
		Semi-wetland/wetland complex	403	39
	Rivers and lakes	Lakes and rivers 1	404	14
		Lakes and rivers 2	405	15
	Reservoirs	Reservoirs 1	406	1
		Reservoirs 2	407	2
5.Grassland	Natural birch shrubland	Natural birch Woodland <2m	515	24
	Other grassland	Grassland (true grassland)	501	26
		Richly vegetated heath land	502	27
		Cultivated land	503	35
		Poorly vegetated heath land	504	28
		Mosses	505	30
		Partly vegetated land (1)	506	29
		Shrubs and forest	507	25
		Grassland, heath-land shrubs and forest complex	508	33
		Partly vegetated land (2)	509	34
		Cropland and pasture	510	36
	Revegetated land	Revegetation before 1990	513	21
		Revegetation activity 1990-2010	514	20
		Farmers revegetation	511	22
	Drained grasl.	Drained land	512	23

Table 7.2 continued				
Land use categories	**Sub categories**	**Map layers included in land use category**	**ID**	**Hierarchy of map layers**
6.Other land	Other land	Historical lava fields with mosses (1)	601	31
		Historical lava fields with mosses (2)	602	32
		Sparely vegetated land (1)	603	41
		Sparely vegetated land (2)	604	42
		Zone of recently retreated glaciers	606	40
	Glaciers	Glaciers and perpetual snow	605	3

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.

Besides these main sources of information few derived maps are used in the compilation of the land use classes in IGLUD. These maps are ditch density maps of cropland, map of drained land and roads with defined buffer zones. The map layers used in compiling the IGLUD map are listed in Table 7.2. The compilation process is done by overlay analyses in GIS (Geographical Information System). In that process the hierarchy of the map layers plays an important role, as the map layer higher in the hierarchy replace all overlaid pixels in map layer of lover order with its own pixels. Thus the pixels common to the map layer “Reservoirs 1”, with hierarchy order 1, and the map layers “Reservoirs 2”,”Lakes and rivers 1 and 2”with hierarchy order 14 and 15 are defined as reservoirs.

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 with 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 at least 15 m wide road zone including primary roads 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 minimum width 20 m and also land which currently fall below these thresholds, but *in situ* expected to reach these thresholds 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 as land being converted to Grassland.

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 of identified land area 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.

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 in the land use map represented as five classes. The “Natural birch shrubland” is as mapped by IFR. The classes “Revegetation before 1990” and “Re-

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

vegetation since 1990" are as mapped by SCSI. The class "Grassland organic" soil is identified on basis of the map layer drained land. The class "Grassland other" is all other land included 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.

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 map layers were then compiled according to this order using ERDAS imaging 9.3, software and resulting layers grouped to estimate the total area of mapped land use categories

The resulting land use maps are shown in Fig. 7.2, Fig. 7.3, and Fig. 7.4. The IGLUD is still under development and the maps produced are expected to develop considerable in coming years, including allocation of land between categories and to subcategories. The area of each land use category in IGLUD as they appear 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 as they appear on 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 the modification 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.

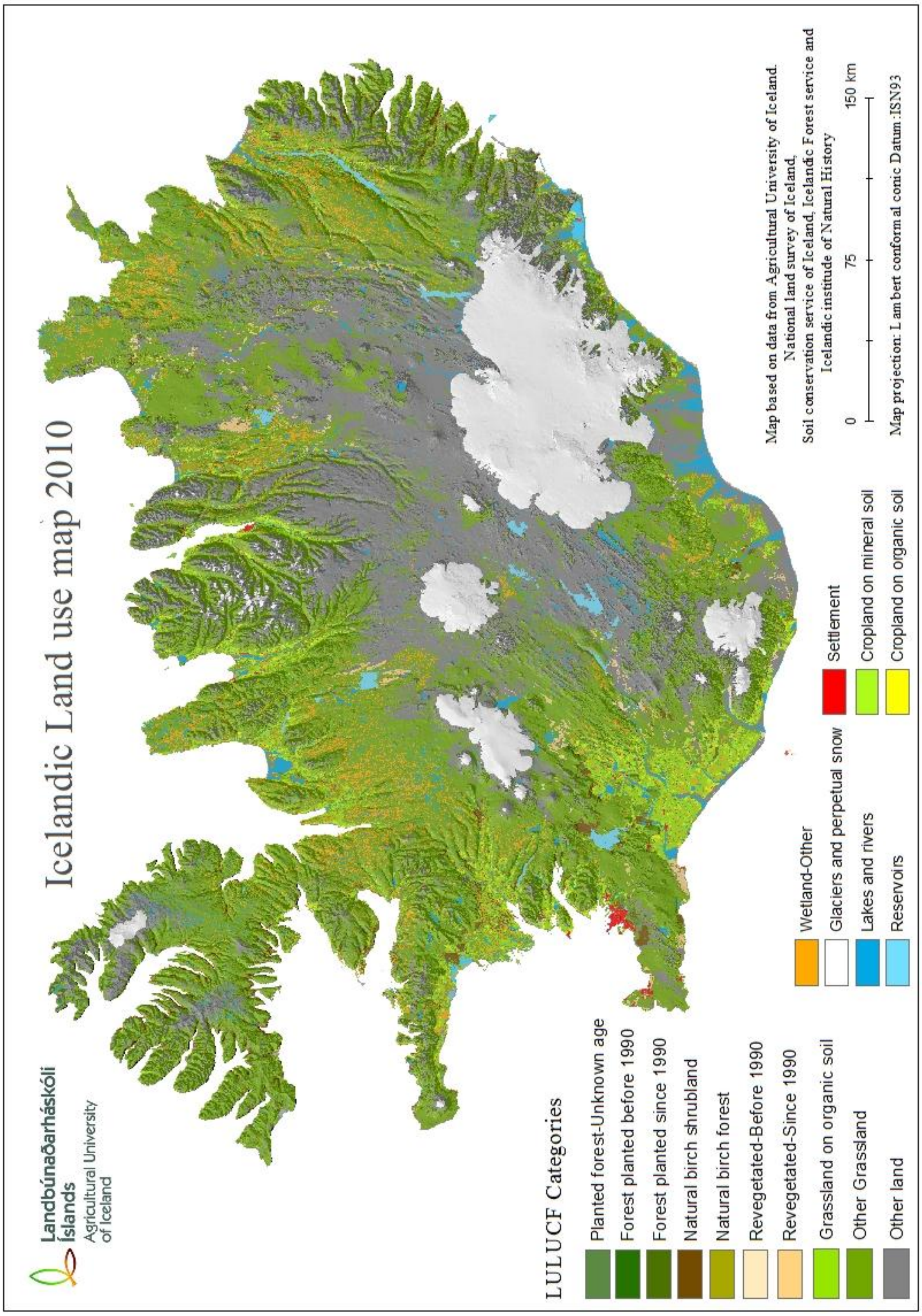

Fig. 7.2. Map of Iceland showing the present status of land use classification in IGLUD.

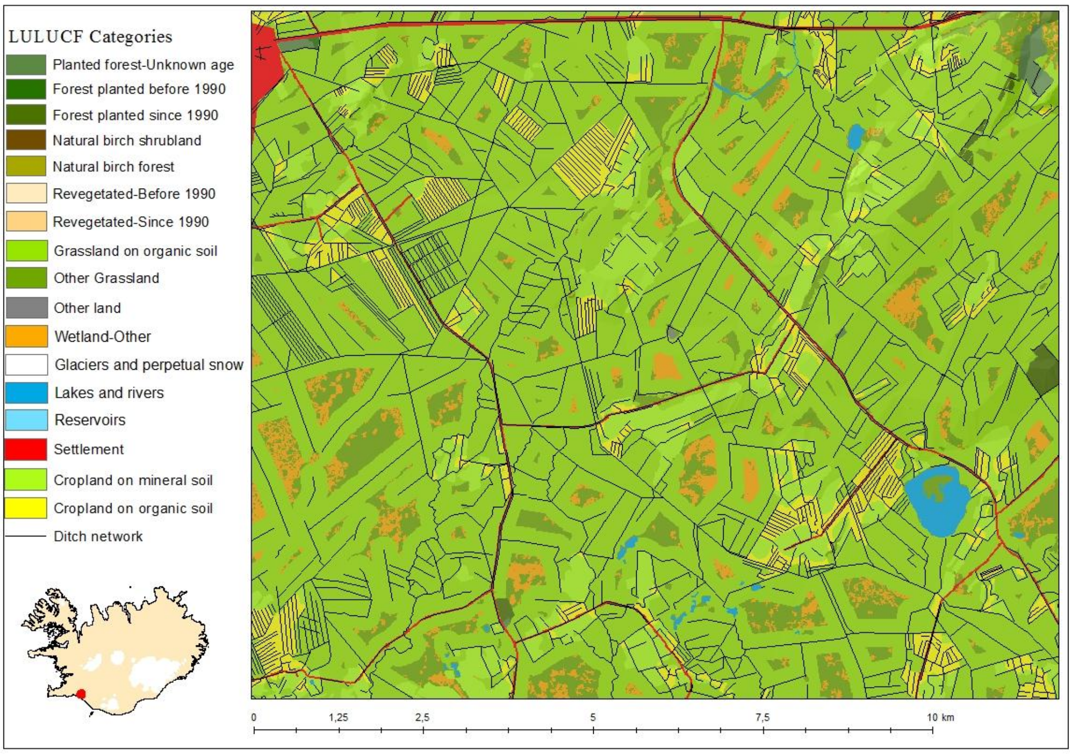

Fig. 7.3. Enlarged map (I) showing details in IGLUD land use classification.

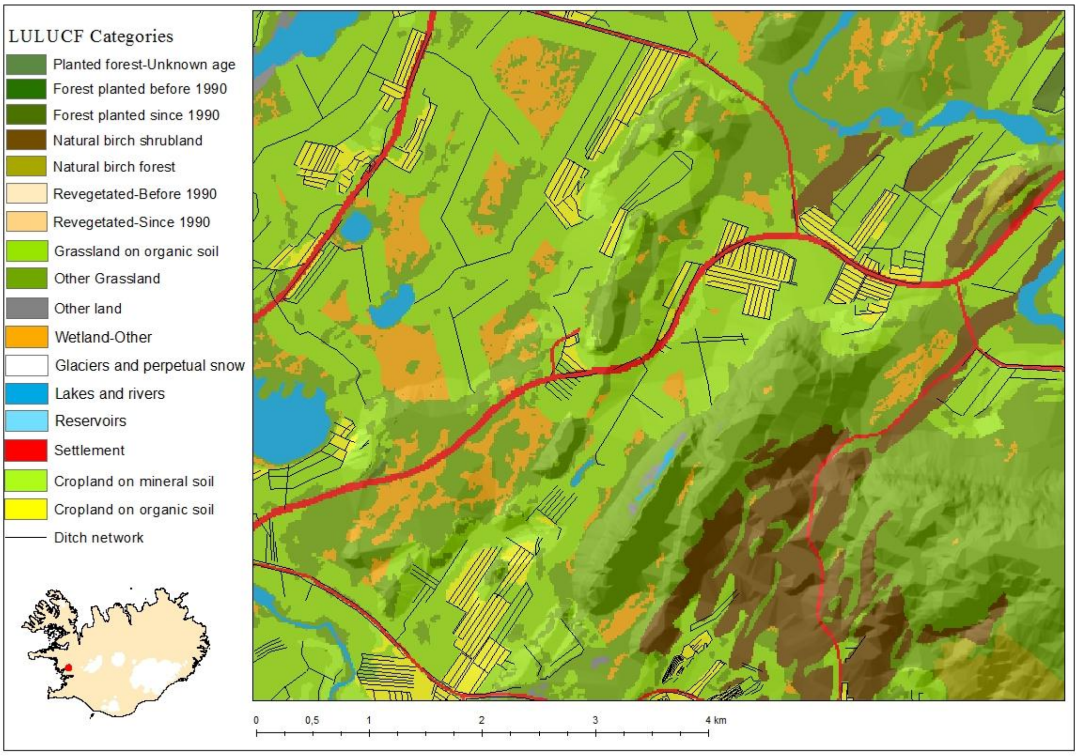

Fig. 7.4. Enlarged map (II) showing details in IGLUD land use classification

7.3.7 Time Series

In this submission independent time series for five new land use categories are used for the first time. In last submission only three categories where time series are based on yearly land use information, i.e. cultivated forest, revegetation activity and reservoirs were included. The time series of revegetation activity were improved by SCSI and much longer sequence provided enabling division of area according to conversion period. New time series were provided by AUI for following categories; Cropland remaining Cropland, total area and organic soil, Grassland converted to Cropland, Wetland converted to Cropland, Cropland converted to Grassland, total area and organic soil, Wetland converted to Grassland. All other reported time series on land use are derivates of these time series.

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. The cultivated forest is 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 are dominant.

Afforestation is considered one year old in the autumn of the year the seedlings were planted[5]. 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 to be 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 in the categories Forest planted before 1990 and Planted forest of unknown age.

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

Afforestation 1-50 years old: This category is reported under both Grassland converted to Forest land and Other land converted to Forest land. In the land use map there is no separation of these categories. The area reported for this category is to be located in areas mapped as Forest planted since 1990, Forest planted before 1990 and Planted forest of unknown age.

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 accordingly 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 nine 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 CRF categories i.e., Wetland drained for more than 20 years, and Wetland converted to Grassland are together represented by the mapping unit Grassland on organic soil. The CRF category Natural birch shrubland is all assumed to be part of the mapping unit with the same name. 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 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 i.e. Reservoirs, Grassland converted to Wetland – High SOC, Grassland converted to Wetland – Medium SOC and Other land converted to Wetland – Low SOC.

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 two land use mapping units representing Other land i.e.; Glaciers and perpetual snows, and Other land. 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 reported area of many categories is based either on direct activity data or time series prepared but area of other categories is estimated from the land use map. As the mapped area does not in many cases match, the activity data or area estimated through time series, 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.

In the adjustments of area only the total area of the category is adjusted no adjustments are made to the division between mineral and organic soils. 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 2010.

Forest land: The total area of cultivated forest as reported by IFR is for the year 2010 36.16 kha but mapped area of all forest cultivations is 51.99 kha. The difference 15.83 kha is added to the area of Other Grassland. The area of Natural birch forest as reported by IFR for the CRF is 55.09 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 24.40 kha. The difference 30.68 kha is added to the category from the mapped area of Natural birch shrubland.

Cropland: The total area of Cropland as estimated from AUI cropland time series is 129.94 kha but area mapped as Cropland is 169.69 kha. The difference 39.75 kha is added to the area of Grassland.

Grassland: The area of Grassland organic soil mapping unit is 340.85 kha. The total area of organic soils reported in the Grassland category is 357.45 kha. The difference is 16.60 kha. The mapping unit does not include organic soils of former Cropland included in the CRF total number. Area of organic soils of former Cropland reported as Grassland is 13.88 kha. The remaining difference 2.72 kha is added to the area of the mapping unit Grassland organic soil. This correction as represents the estimated drained areas since 2008. The area of Natural birch shrubland as estimated by IFR and reported in CRF is 29.88 kha but the area included in the mapping unit is 88.33 kha. The difference is 58.45 kha, of that 30.68 kha were added to the area of Natural birch forest, as explained above, but the remaining 27.77 kha were added to area of the mapping unit Grassland. 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 18.27 kha the difference 147.09 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 83.21 kha but the mapping unit Revegetated land since 1990 is 73.12

kha. The difference is 10. 09 and added to the area of the mapping unit with half of it coming from mapping unit Other land (5.045) and half from Grassland mapping unit. 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 398.65 kha while the area of the mapping unit is 401.37 kha. The difference 2.72 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 4,003.12 kha but the area included in the mapping unit Other land is 4,008.17 kha the difference is 5.05 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	51.85	Settlement	51.85
Forest Land	76.39	Forest Land	91.24
Natural birch forest	24.40	Natural birch forest	55.09
Cultivated forest	51.99	Cultivated forest total	36.16
Cropland	169.69	Cropland	129.94
Cropland on organic soil	55.19	Cropland organic soil	58.08
Cropland on mineral soil	114.49	Cropland mineral soil	71.86
Wetland	719.31	Wetland	716.59
Lakes and Rivers	260.04	Lakes and rivers	260.04
Reservoirs	57.90	Reservoirs	57.90
Other wetlands	401.37	Other wetlands	398.65
Grassland	5,263.06	Grassland	5,295.72
Natural birch shrubland	88.33	Natural birch shrubland	29.88
Other grassland	4,742.49	Other grasslands	4,676.42
Grassland organic soil	340.85	Grassland organic soil	357.45
Revegetated land (RL)	91.39	OL converted to GL + RL older than 60 years	248.57
RL before 1990	18.27	RL before 1990	165.36
RL since 1990	73.12	RL since 1990	83.21
Other Land	4,008.17	Other Land	4,003.12
Glaciers and perpetual snow	1,086.61	Glaciers and perpetual snow	Not rep

7.3.10 Land Use Change

Emission/removal of GHG due to land use changes is reported for ten types of land conversions, eight of which were reported in last submission i.e. “Grassland to Forest land”, “Other land to Forest land”, “Wetland to Cropland”, “Wetland to Grassland”, “Other land to Grassland”, “Grassland to Wetland”, “Other land to Wetland” and “Forest land to Settlement”. “Grassland converted to Cropland and Cropland converted to Grassland are reported additionally in this submission (Table 7.4)

Table 7.4. Land use classification used in GHG inventory 2010 submitted 2012 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		91.24	2.97
Forest Land remaining Forest Land		56.80	0.05
	Afforestation older than 50 years	0.69	0.05
	Natural birch forest	55.09	
	Plantation in natural birch forest	1.03	
Land converted to Forest Land		34.44	2.92
Grassland converted to Forest Land		29.10	2.92
	Afforestation 1-50 years old	29.10	2.92
Other Land converted to Forest Land		5.34	
	Afforestation 1-50 years old	5.34	
Total Cropland		129.94	58.08
Cropland remaining Cropland		124.54	55.21
Land converted to Cropland		5.40	2.87
Grassland converted to Cropland		2.53	
Wetlands converted to Cropland		2.87	2.87
Total Grassland		5,295.72	357.45
Grassland remaining Grassland		4,997.36	319.65
	Cropland abandoned for more than 20 years	18.89	4.11
	Natural birch shrubland	29.88	
	Other Grassland	4,631.76	
	Revegetated land older 60 years	1.69	
	Wetland drained for more than 20 years	315.54	315.54
Land converted to Grassland		298.36	37.80
Cropland converted to Grassland		23.46	9.77
Wetlands converted to Grassland		28.03	28.03
Other Land converted to Grass-land		246.88	
	Revegetation before 1990	163.67	

Table 7.4 continued			
Land-Use Category	**Sub-division**	**Area (kha)**	**Area of organic soil (kha)**
	Revegetation since 1990	83.21	
Total Wetlands		716.59	
Wetlands remaining Wetlands		690.16	
	Lakes and rivers	260.04	
	Other wetlands	398.65	
	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		18.48	
	Low SOC	18.48	
Total Settlements		51.85	
Settlements remaining Settlements		51.85	
Land converted to Wetlands		0.01	
Forest land converted to Settlement		0.01	
Total Other Land		4,003.12	
Other Land remaining Other Land		4,003.12	

The reporting of land use conversion is improved from last submission as independent time series are now available for Wetland converted to Cropland and Wetland converted to Grassland. In last submission the changes reported in these conversions were derivates of other conversions. SCSI has provided longer time series for Other land converted to Grassland enabling use of meaningful conversion period. Following improved time series conversion period is adopted for most conversions.

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 NYTJALAND classification were tested in extensive ground truth project. The current validity of that ground truth data remains to be assessed. 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.

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 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 lead to exclusion of many faults arising during the process establishing good confidence in the maps. This control is still only qualitative.

Uncertainty estimate for following maps estimates is 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 classification have been controlled through extensive ground truthing process. The map layers of Settlement are based on ground mapping of individual municipal planning authorities 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.

The uncertainty of area of reported categories is set at 20% for all categories except revegetation and Forest land, where more precise evaluations are available.

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. The project is thus expected to gradually provide new land use data and improve the existing data. Important part of data sampling for the land use database is to obtain information on various C-pools in each land use category. In this submission some of this data is applied. More data for estimating the size of different C-pools of the land use categories is therefore expected to be available in the coming years.

There are several projects related to individual land use categories, which are designed to improve the quality of their area estimates. These are described in their relevant following chapters.

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 Table 7.5,Table 7.6, and Table 7.7.

Table 7.5. 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	56.80			-105.44
Afforestation older than 50 years	0.69	T3	CS	-5.60
Living biomass		T3	CS	-5.63
Dead organic matter		NE		
Mineral soil		NE		
Organic soil	0.05	T1	D	0.03
Natural Birch forest	55.09			-88.66
Living biomass		T3	CS	-88.66
Dead organic matter		NE		
Mineral soil		NE		
Organic soil	NO			
Plantations in natural birch forest	1.03			-11.18
Living biomass		T3	CS	-11.18
Dead organic matter		NE		
Mineral soil		NE		
Organic soil	NO			
Land converted to Forest Land	34.44			-166,35
Grassland converted to Forest Land	29.10			-144.20
Afforestation 1-50 years old	29.10			-144.20
Living biomass		T3	CS	-95,81
Dead organic matter		T2	CS	-15,03
Mineral soil	26.18	T2	CS	-35,09
Organic soil	2.92	T1	D	1,72
Other Land converted to Forest Land	5.34			-22.15
Afforestation 1-50 years old	5.34			-22.15
Living biomass		T3	CS	-9.35
Dead organic matter		T2	CS	-2.75
Mineral soil	5.34	T2	CS	-10.05
Organic soil	NO			
Cropland remaining Cropland	124.54			1,012.25
Living biomass		T1		NO
Dead organic matter		T1		NO
Mineral soil		NE		NE
Organic soil	55.21	T1		1,012.25
Agricultural liming	NA			4.02
Limestone $CaCO_3$		T1	D	0.42
Dolomite $CaMg(CO_3)_2$		T1	D	0.23
Shellsand (90% $CaCO_3$)		T2	CS	1.63
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	-0.95

Table 7.5 continued				
Source/sink	**Area (kha)**	**Method**	**EF**	**Gg Emis-sion/ Re-moval (-)**
Organic soil	NO			
Wetlands converted to Cropland	2.87			60.48
Living biomass		NE		7.92
Dead organic matter		IE		
Mineral soil	NO			
Organic soil	2.87	T1	D	52.54
Grassland remaining Grassland	4,997.36			274.95
Cropland abandoned for > 20 years	18.89			3.77
Living biomass		NO		
Dead organic matter		NO		
Mineral soil		NO		
Organic soil	4.11	T1	D	3.77
Natural birch shrubland	29.88			-18.07
Living biomass		T3	CS	-18.07
Dead organic matter	NE			
Mineral soil	NE			
Organic soil	IE			
Other Grassland	4,631.36	NE		
Revegetated land older than 60 years	1.69	NE		
Wetland drained for > 20 years	315.54			289.24
Living biomass		NE		
Dead organic matter		NO		
Mineral soil		NO		
Organic soil	315.54	T1	D	289.24
Land converted to Grassland	298.36			-445,50
Cropland converted to Grassland	23.46			44.79
Living biomass		T1	CS	-45.50
Dead organic matter		IE		
Mineral soil	13.69	T1	CS	5.21
Organic soil	9.77	T2	CS	85.07
Wetlands converted to Grassland	28.03			25.69
Living biomass		NO		
Dead organic matter		NO		
Mineral soil	NO	NA		
Organic soil	28.03	T1	D	25.69
Other Land converted to Grassland	246.88			-515.98
Revegetation before 1990	163.67			-342.06
Living biomass		T2	CS	-34.21
Dead organic matter		IE		
Mineral soil	163.67	T2	CS	-307.85
Organic soil	NO			
Revegetation since 1990	83.21			-173.92
Living biomass		T2	CS	-17.38

Table 7.5 continued				
Source/sink	Area (kha)	Method	EF	Gg Emis-sion/ Re-moval (-)
Dead organic matter		IE		
Mineral soil	83.21	T2	CS	-156.53
Organic soil	NO			
Wetlands remaining Wetlands	690.16			
Lakes and rivers	260.04	NA		
Other wetlands	398.65	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	51.85	NA		
Land converted to Settlement	0.01			0.22
Forest land converted to Settlement	0.01			0.22
Living biomass		T3	CS	0.22
Dead organic matter		NE		
Soil		NE		
Other Land remaining Other Land	3,996.87	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 7.6. 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
Wetlands remaining Wetlands	690.16				
- Lakes and rivers	260.04	NA			
- Other wetlands	398.65	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 7.7. 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	56.80				
- Mineral Soil					
- Organic Soils N_2O	0.05	IE	D		
Land converted to Forest Land	34.44				
- N_2O fertilizers		T1	D	0.00	0.12
Grassland converted to Forest Land	29.10				
- Mineral Soil	26.18	NE			
- Organic Soils N_2O	2.92	T1	D	0.00	0.87
Cropland remaining cropland	124.54				
- Mineral Soil	69.33	NE			
- Organic Soils N_2O	55.21	IE			
Wetland converted to cropland	2.87				
- Mineral Soil	NO	NA			
- Organic Soils N_2O	2.87	IE			
Grassland remaining Grassland	4,997.36				
Grassland former Cropland remaining Grassland					
- Organic Soils N_2O	4.11	T2	CS	0.00	0.88
Grassland former Wetland remaining Grassland					
- Organic Soils N_2O	315.54	T2	CS	0.22	67.63
Land converted to Grassland	298.36				
Cropland converted to Grassland	23.46				
- Organic Soils N_2O	9.77	T2	CS	0.01	3.40
Wetlands converted to Grassland	28.03				
- Organic Soils N_2O	28.03	T2	CS	0.02	6.01

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). Further description of the forest definition will be found in a methodological report of carbon accounting of forest (Snorrason in prep). 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 ages. Until the middle of the last 19th century it was the main source for fuel wood for house heating and cooking in Iceland (Ministry for the Environment 2007). Most of the woodland was used for grazing and still is although some areas have been protected from grazing.

Natural birch woodland is included in the IFR national forest inventory (NFI). In 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 2010b). 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 data obtained through plot measurement in 2005-2010.

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 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 (see also Chapter 7.12.1.3). 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 2010 is estimated in NFI as 36.16 kha (±1.65 kha 95% CL) whereof; 29.10 kha (±1.69 kha 95% CL) are Afforestation 1-50 years old on “Grassland converted to Forest land”, 5.34 kha (±0.97 kha 95% CL) are Afforestation 1-50 years old on “Other Land converted to Forest land”, 1.03 kha (±0.45 kha 95% CL) are Plantations in natural birch forests and 0.69 (±0.37 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. In 2011 submission this area was estimated 34.55 kha (±1.66 kha 95% CL) in 2009 but in this year’s submission the estimate for 2009 is 34.06 kha (±1.67 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 was for the inventory year 2009 reported 2.65 kha (±0.70 kha 95% CL) in 2011 submission but is estimated 3.38 kha (±0.79 kha 95% CL) for 2009 in this year’s submission reflecting the recalculation.

Aggregated category of all Afforestation and category of Natural Birch Forest are both recognized as key sources/sinks in level (2010) and in trend.

The area of Forest Land used in the CRF is based on the NFI updated with new field measurements annually. As mentioned before maps provided by IFR shows larger area of cultivated forests and less area of natural birch forests (natural birch woodland reaching >2 m in height) than the NFI estimate. Cultivated forest cover map is built on an aggregation of maps used in forest management plans and reports. This result highlights the overestimation of the area of cultivated forest on these maps (Traustason and Snorrason 2008). The less 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 second time in this year's submission based on the data of NFI. Total woody C-stock of the natural birch woodland was estimated at 1300 kt C with average of 11 t C ha^{-1} from data sampled in an inventory conducted in 1987-1991 (Sigurðsson and Snorrason 2000). New estimate of the C-stock of the natural birch woodland by the NFI data is 353 kt C with average of 4.15 t C ha^{-1}. The C-stock in the forest and the shrub part of the natural birch woodland is estimated to 302 kt C with average of 5.47 t C ha^{-1} and 51 kt C with average of 1.72 t C ha^{-1} accordingly.

Carbon Stock Changes in Living Biomass

Carbon stock gain in the living biomass of trees is estimated based on data from direct field measurement in the NFI. The figures provided by IFR are based on the inventory data from the first national forest inventory conducted in 2005-2009 (Snorrason 2010a; Snorrason in prep). 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 2011 same procedure was taken for the 2006 plots.

Carbon stock losses in the living woody biomass is estimated based on data on activity statistics of commercial round-wood and wood-products production from domestic thinning of cultivated forest (Gunnarsson 2010; Gunnarsson 2011). Carbon stock losses caused by natural mortality in the natural birch forest are accounted for as carbon losses from selective cuttings in the natural birch forest

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

In the already mentioned ICEWOODS research project, the carbon stock in other vegetation than trees did show very low increase 50 years after afforestation by the most 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.

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. Measurements of dead wood are also performed on the field plots. Estimate of carbon stock changes in dead organic matter will be available from the NFI data when sampling plots have been revisited in the next three years.

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 $ha^{-1}yr^{-1}$.

Carbon stock changes in dead wood are still not estimated. Dead wood is measured on the field plot of the NFI. Current occurrence of dead wood that meet the definition of dead wood (>10 cm in diameter and >1 m length) on the field plot is rare but with increased cutting activity carbon pool of dead wood will probably increase. With re-measurements of the permanent plot it will be possible to estimate the Carbon stock changes in this pool. Meanwhile carbon pool of dead wood will be assumed not to change in line with Tier 1 approach and changes in dead organic matter reported as the changes in woody debris, twigs and fine litter.

Net carbon Stock Change in Soils

In this year's submission drained forest organic soil is reported in the category "Grassland converted to Forest Land- Afforestation 1-50 years' old" and in "Forest Land remaining Forest Land" – subcategory "Afforestation older than 50 years".

The estimated area is 10.3% of the category total area based on NFI data and has been revised from last submission according to new data from the national forest inventory. The natural birch forest and the remaining afforested areas are mostly situated on mineral soils which can be highly variable regarding carbon content. 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} $year^{-1}$ 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 afforested sites 1-50 years old. Measurements of carbon stock changes in soil on revegetated and afforested areas are currently sparse but work is in progress that is expected to increase our understanding in that field. A comparison of 16 years old plantation on poorly vegetated area to a similar open land gave e.g. an annual increase of C-SOM of 0.9 t C ha^{-1} (Snorrason et al. 2003). For the mineral soil of Other land converted to Forest land same removal factor as for revegetation 0.51 t C ha^{-1} yr^{-1} is used

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 is not occurring. The reported use of N fertilizers is based on data collected by IFR from the actors in Icelandic forestry. 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 every else in the inventory categorized under Land converted to Forest Land.

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 “Other land” and from “Grassland”. Small part of the land converted to Forest land is converted from Cropland or Wetland, but this land is included as Grassland converted to Forest land as data for separating these categorise is unavailable. Organic soil is only reported under land converted from “Grassland- Afforestation 1-50 years old” and in “Forest Land remaining Forest Land – Afforestation older than 50 years”. Organic soils are not found in the land use category “Other land”. Accordingly organic soils are reported as not occurring.

7.5.4 Methodological Issues

The methodology for NFI is based on systematic sampling consisting of a total amount of nearly 1000 permanent plots. One fifth of the plots are measured each year and measurements are repeated at 5 year intervals for the cultivated forest and at ten years interval for the natural birch forest. The sample is used to estimate both the division of area to subcategories and C-stock changes over time (Snorrason and Kjartansson 2004; Snorrason 2010a). 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 two first years of the second inventory (Snorrason in prep).

The area of both natural birch forests and cultivated forest are estimated from output of the systematic sampling of the NFI. 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 field of left out private cultivated forest. 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. More detailed description of the methodology will be given by Snorrason (in prep.).

The area of natural birch forest is assumed to be unchanged since 1990. Historical area of cultivated forest is estimated by the age distribution of the forest in the sample. The changes in the C-stock of cultivated forest for other years than 2009 are built on a tree species specific growth model but are calibrated towards the inventory results of 2009.

7.5.5 Emission/Removal Factors

Tier 3 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 (Snorrason in prep). Emission from wood removals caused by thinning or clear cutting in the cultivated forest is included. Currently they have minor importance as the mean age of plantation forest is low. Clear cuttings are not yet practiced but thinning is an increasing activity.

The losses reported in living biomass removed as wood are estimated by Tier 3 on basis of activity data of annual wood utilization from cultivated forest(Gunnarsson 2011).

In accordance to the Forest Law in Iceland the State Forest Service does hold register on planned activity that can lead to deforestation (Skógrækt ríkisins 2008). When deforestation activity takes place the State Forest Service is to be announced. Deforestation is reported for the inventory year 2010. A special inventory of deforestation was conducted by IFR in 2008 to map deforested area and measure carbon stock changes in the years 1990-2007. Estimated deforested area and carbon stock changes for that period are built on that special inventory.

Carbon stock changes in living biomass in the natural birch forest are reported as for the scecond time. A similar procedure and methodology is used as for the cultivated forest.

Carbon stock change in living biomass in other vegetation than trees is not estimated at current state. In-country research results (Sigurdsson et al. 2005) 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 in 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. The changes in litter are reported as changes in dead organic matter assuming no changes in dead wood in line with the Tier 1 method for that component (see also chapter 0)

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.

7.5.6 Uncertainties and QA/QC

The estimate of C-stock in living biomass of the trees is based on results from the national forest inventory of IFR. The C-stock changes estimated through the forest inventory fit well with these 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 although some sources are still not included (e.g. dead wood). Because of the design of the NFI it is possible to estimate realistic uncertainties by calculating statistical error of the estimates. Error estimate for all data sources and calculation processes have currently not been conducted but are planned in the nearest future. For the moment, error estimates are only available for the area of both natural birch forest and cultivated forest.

The IFR estimates the statistical error for total area of cultivated forest to be ± 1.65 kha (95% confidence limits). Error estimates for the area of Forest land subcategories are shown in the beginning of the Forest land chapter.

7.5.7 Recalculations

As described above the emission/removal estimate for forest land has been revised from 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 since then. As result of these recalculations the total reported removal has increased from -257.93 Gg CO_2-equivalents for the year 2009 as reported in 2011 submission to -259.53 Gg CO_2-equivalents in this year's submission or a 0.6% increase 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 fourth time to estimate main sources of carbon stock changes in the cultivated forest where changes in carbon stock are most rapid. In the nearest future efforts will be on improving the time series of the main source as the biomass changes in both the cultivated forest and the natural birch forest

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 remeasurement of the permanent sample plot will be available.

It is planned to improve estimates on area and stock changes of deforestation and reduction of living carbon stock due to wood removals in the national forests inventory. Also, a new mapping of the natural birch woodlands which started the summer

2010 will continue. That will *inter alia* make it possible to detect natural afforestation. One can therefore expect gradually improved estimates of carbon stock and carbon stock changes in forest 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 negligible but increasing part 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.

Mapping of cropland based on satellite images and support of aerial photographs has been included in the construction of IGLUD. Previous mapping of Cropland was revised in 2009 by the AUI through on screen digitations. The total area of Cropland mapping unit in IGLUD, taking into account the order of compilation applied, is estimated at 169.69 kha. The area reported in CRF is 129.94 kha, where of 58.08 kha are estimated as organic soil. The reported area is product of 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 Fig. 7.5.

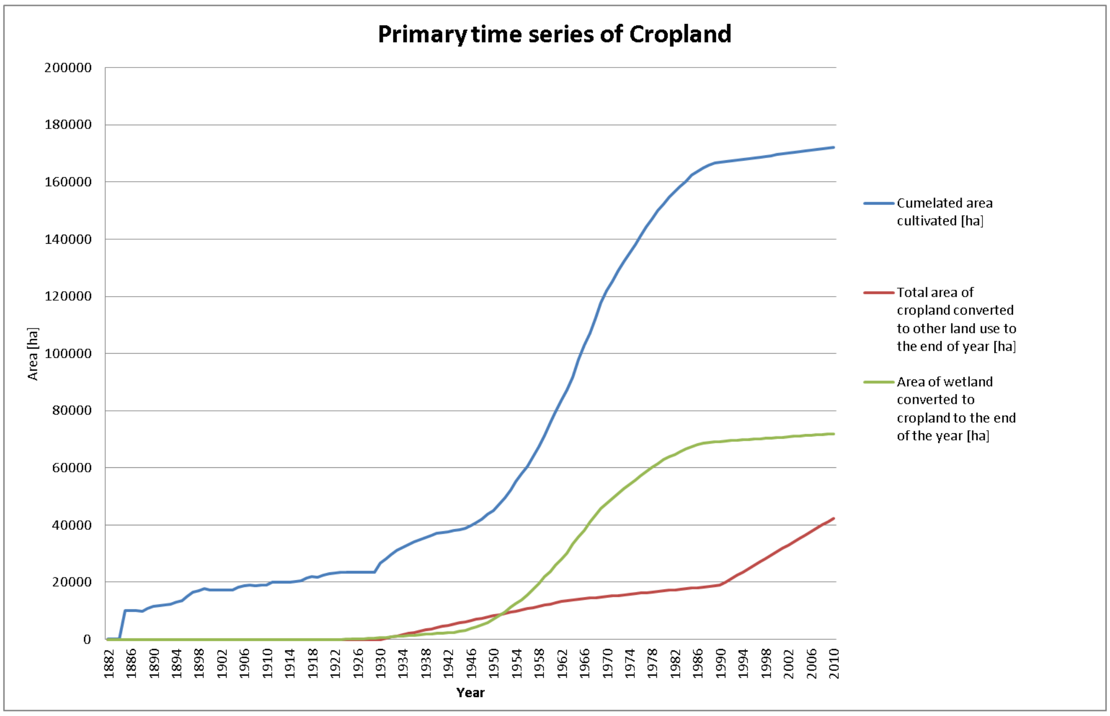

Fig. 7.5. Primary time series of Cropland area: Cumulated area represents all land that has been cultivated to that time. Area of wetland converted to cropland represents the organic soil part of that area. Total area converted to other land use represents the estimated area of abandoned Cropland.

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 (Fig. 7.6).

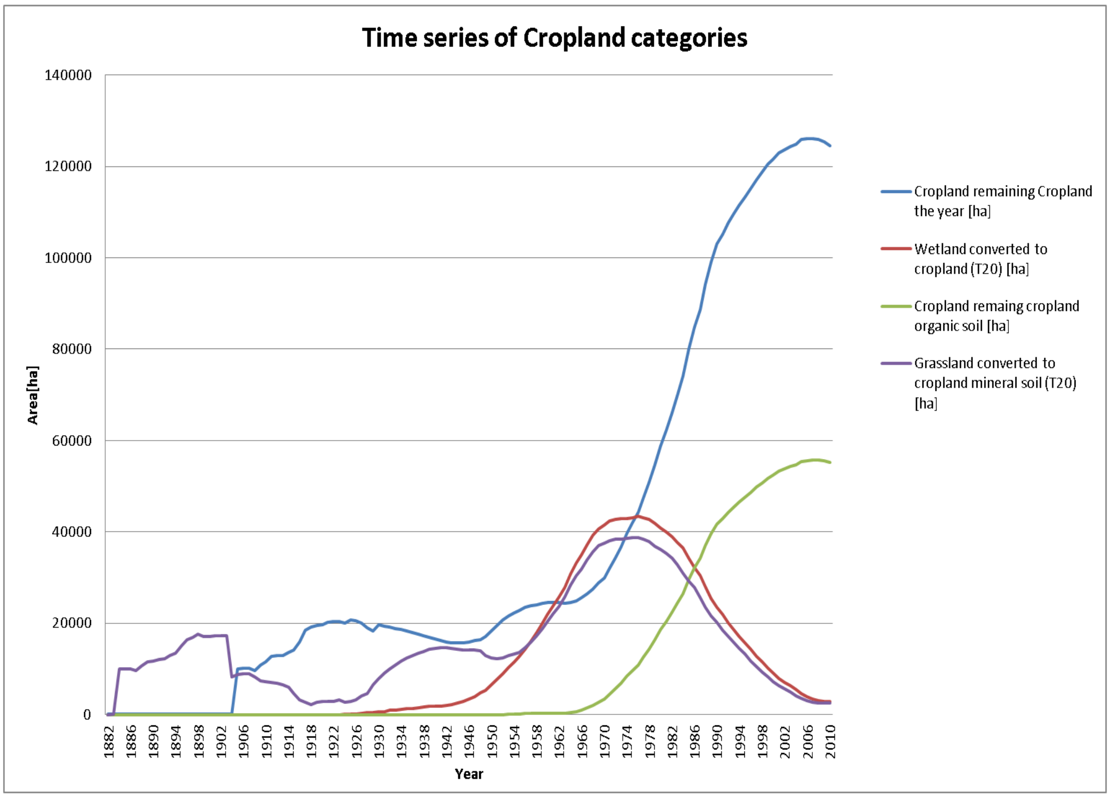

Fig. 7.6. Time series of Cropland as reported. Area in hectares as estimated at the end of the year.

The area of drained soils within Cropland was in last submission estimated separately on basis of a density study on the ditches network (Gísladóttir et al. 2009). All Cropland area where the ditches density was more than 10 km ditches km^{-2} was estimated as drained cropland. This results in 55.20 kha of the Cropland mapping unit meeting that criteria, while the time series result in 71.94 kha organic soil of all land cultivated. Total area cultivated according to time series is 172.15 kha or comparable to the Cropland mapping unit. The geographical identification of Cropland organic soil needs to be improved.

No information is available on emission/removal regarding different cultivation types and subdivision of areas according to 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. Two time series for land converted to Cropland are for the first time in this year's submission available. 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 years 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 a.s.l. 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, where of 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 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 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 of hayfields are also used for livestock grazing 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 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. 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). All soils of Wetland converted to Cropland are assumed 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. Numbers reported included lime application in the form of shell-sand, which contains 90% $CaCO_3$, dolomite and limestone. Limestone or other calcifying agents included in many of the imported fertilizers are also included. Although the ratio of calcifying materials is low in these fertilizers the amount of fertilizers applied make this source relatively large. Numbers on lime application are only available at the national level and all of it is assumed to be applied on cropland. The 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 originate 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.

Land converted to Cropland is recognized as a key source/sink including LULUCF.

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 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 IGLUD soil sampling preliminary results. 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 CO_2 emissions due to liming of cropland are calculated by conversion of carbonated carbon to CO_2.

7.6.5 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. In last year's submission the area was estimated from geographic analysis of the ditches network as also described above. The area estimated from the density analysis is underestimating the area of drained Cropland compared to the time series. 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 carried out 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 and also indicate that the criteria used to delineate the area of organic soils on basis of ditch density is to high, i.e. area identified with lower density of ditches should be included. Applying lower density limits should decrease the difference of the two methods i.e. time series and density analyse. 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.

7.6.6 Recalculations

In this submission the area of the category has been revised and the structure of the data changed. New stock changes are previously not estimated are now estimated. As result of this almost all calculation of the Cropland category is revised. Emission from liming is the only component not revised.

7.6.7 Planned Improvements regarding Cropland

The use of IGLUD maps in last year submission to estimate the area of Cropland and its subdivision into drained cropland and other croplands was an important step in improving the emission/removal estimate of the category. In this 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. 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 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 in the summer 2012.

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 ongoing 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 land included under the Grassland category is subdivided into nine subcategories. Time series for Cropland and Grassland subcategories and use of defined conversion period result in four new subcategories compared to last year's submission. The time series and defined conversion period also cause reallocation of land between subcategories compared to last submission. The division of Grassland to subcategories in this year's submission is as following. Grassland remaining Grassland is subdivided to; "Cropland abandoned for more than 20 years", "Natural birch shrubland", "Other Grassland", "Revegetated land older than 60 years" and "Wetland drained for more than 20 years". Land converted to Grassland is reported under the subcategories; "Cropland converted to Grassland", "Wetland converted to Grassland" and "Other land converted to Grassland" which is further divided to "Revegetation before 1990" and "Revegetation since 1990". All subcategories except "Natural birch shrubland" and "Revegetation since 1990" are effected by the changes in structure and application of defined conversion period.

All the Grassland time series reported are prepared from three primary time series (Fig. 7.7), except the time series of Other Grassland. That time series is prepared from the Grassland mapping unit when all other mapping units of grassland subcategories have been taken into account representing the area 2010. 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 (Fig. 7.8, Fig. 7.9, and Fig. 7.10).

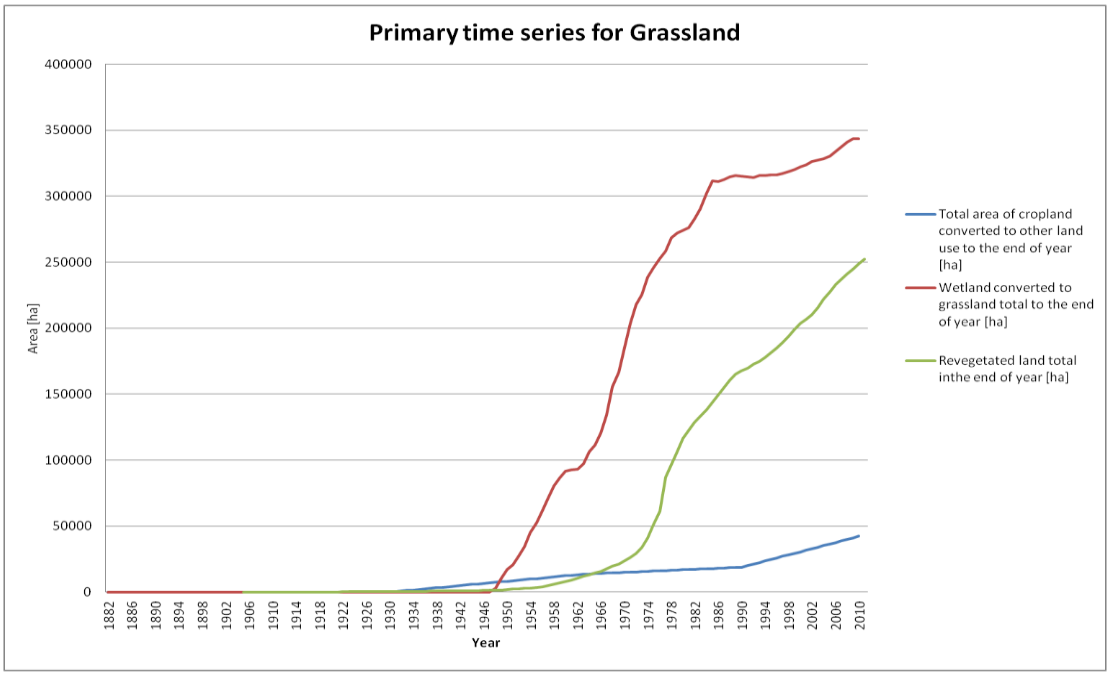

Fig. 7.7. Primary time series for Grassland: Total area of Cropland converted to other land uses at the end of the year, Wetland converted to Grassland at the end oft the year, Revegetated land at the end of the year. All graphs showing cumulative area at the end of the year from the beginning of time series.

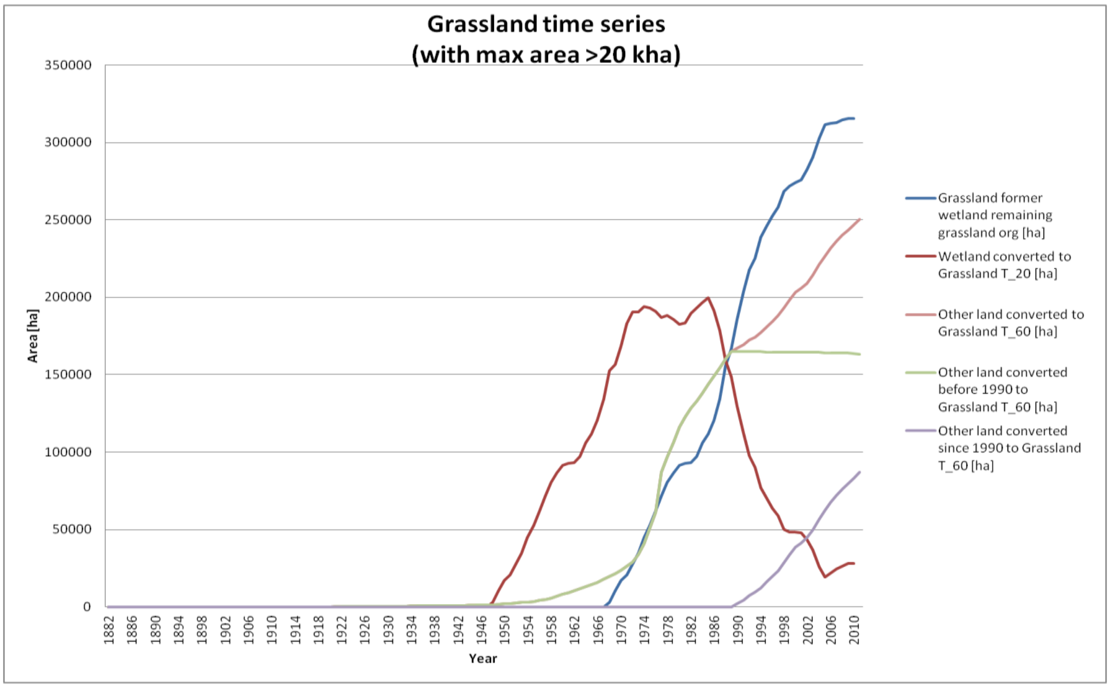

Fig. 7.8. Time series of reported Grassland categories with max area >20 kha: Grassland former Wetland remaining Grassland organic soil, Wetland converted to Grassland T_20, Other land converted to Grassland T_60, Other land converted to Grassland before 1990 T_60, Other land converted to Grassland since 1990 T_60. All graphs showing the area in hectares at the end of the year.

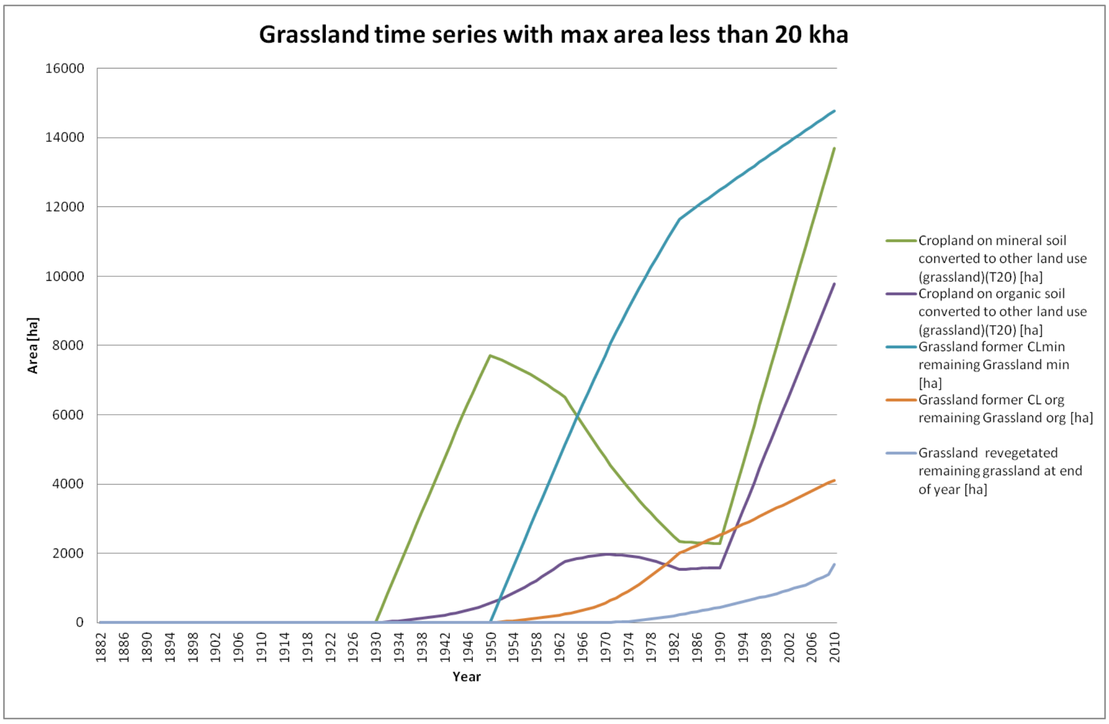

Fig. 7.9. Time series of reported Grassland categories with max area <20 kha: Cropland on mineral soil converted to Grassland T_20, Cropland on organic soil converted to Grassland T_20, Grassland former Cropland remaining Grassland mineral soil, Grassland former Cropland remaining Grassland organic soil, Grassland former revegetated Other land remaining Grassland. All graphs showing the area in hectares at the end of the year.

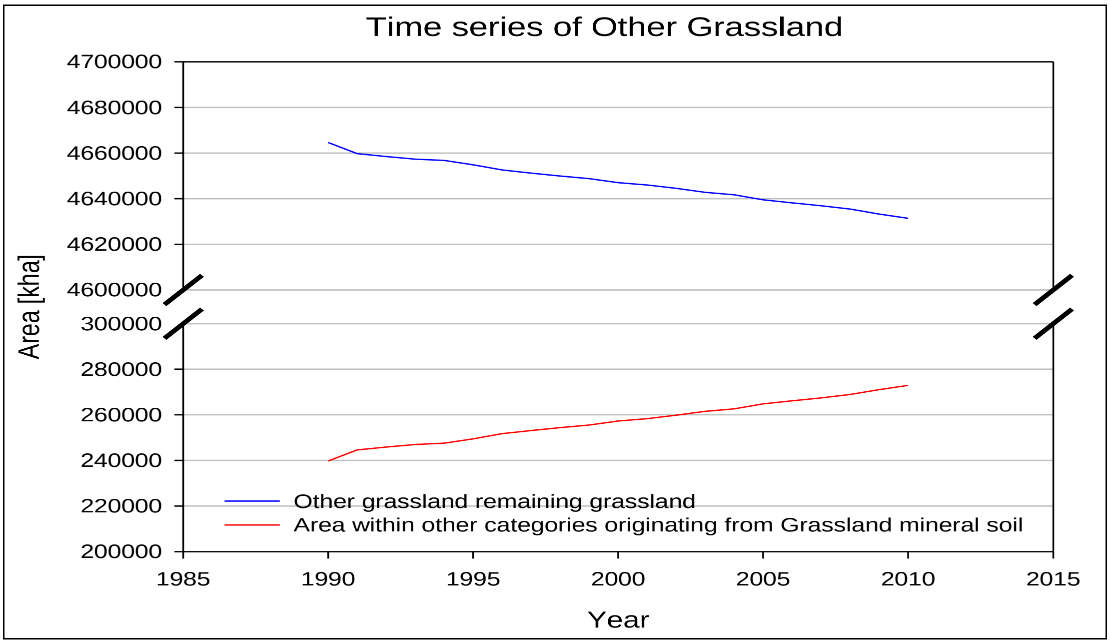

Fig. 7.10. Time series for Other Grassland as prepared from changes in area of former Grassland within other land use categories.

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.

The reporting of this category is enabled for the first time in this year's submission because of new time series introduced. In last year submission the part of that area defined as mineral soil was included as Cropland remaining Cropland and the organic part as Wetland converted to Cropland. The area reported for this category is estimated as 18.89 kha with 4.11 kha as organic soil.

Natural Birch Shrubland

Natural birch shrubland is a birch-woodland not meeting the thresholds to be accounted 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.

In IGLUD this area is mapped as Natural birch Woodland less than 2m. There is a considerable overlap between the categories Natural birch forest and Natural birch shrubland in the maps. The area mapped as forest is much smaller than the area reported (24.40 kha vs. 55.09 kha). The reallocation of land mapped as natural birch forest less than 2 m in height are explained in chapter 7.3.9.

The Natural birch shrubland is included in the NFI the estimate of total area and changes in carbon pools are based on the data collected through that inventory.

Other Grassland

The mapping unit Other grassland includes all land where vascular plant cover is 20% or more as compiled from IGLUD. Accordingly all land within the land use categories, above Grassland in the hierarchy (Table 7.2), are excluded a priory. The map layers classified as Land converted to grassland are all above map layers included in the category “Other grassland”. The land in this category is e.g. heath-lands with dwarf shrubs, small bushes except birch (*Betula pubescens*), grasses and mosses in variable combinations, fertile grasslands, and partly vegetated land. The area mapped is the adjusted and time series prepared as described above (chapter 7.7 p.175).

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 large areas of the former vegetated areas have been severely eroded and in large areas the entire soil mantle has been lost. 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 ongoing 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 size of this loss being of 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). 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 conversion period 60 years, for Other land converted to Grassland (Revegetation) shorter than the assumed conversion in previous submission and shorter than the revegetation of other land has been practiced in Iceland, small area of revegetated land older than 60 years emerges as category. The total area of the category is in this year’s submission 1.69 kha. This area is not at present recognised as separate mapping unit but assumed included in the mapping unit Revegetation before 1990, despite limited area of that mapping unit.

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 area drained were drained for at least 20 years the majority of the land previously reported under wetland converted to Grassland is now reported under this category. The total area reported in this year's submission is 315.54 kha and all of it assumed organic soil. 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 (Ch 0 p.180 and Ch 0 p.144)

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 new time series available for Cropland use of default conversion period 20 years now enables the reporting of this category. The category is at present not identified as mapping unit but is included in the Cropland mapping unit both mineral and organic soil part of that unit. The total area reported for this category is 23.46 kha with 9.77 kha on organic soil.

Wetland converted to Grassland

The time series for conversion of Wetland to Grassland and adapting 20 years as conversion period enable separation of drained Grassland between subcategory "Wetland drained fro more than 20 years" within Grassland remaining Grassland and "Wetland converted to Grassland". The latter only including the area drained last 20 years. In previous submissions all drained area outside Cropland and Forestland was reported in this category. Most of that area has in this submission been reallocated to the category "Wetland drained for more than 20 years". The total area reported for this category is 28.03 kha the whole area assumed to be on organic soil.

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 ongoing 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 animals 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 lymegrass (*Leymus arenarius* L.) and other graminoids. These activities are recorded to a large extent. The emphasis on aerial spreading has decreased since 1990 as other methods have proven more efficient, such as increased participation and cooperation with farmers and other groups interested in land reclamation work. Methods for recording 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. In 2008 almost all activities were 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 Icelandic Forestry Service (IFS) 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 will be visited. 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. For the first time in this year's submission time series of revegetated land before 1990 are available. 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.

In last submission the area of revegetation activity since 1990 was revised according to the available data from the NIRA at that time. As more data is now available from NIRA and further analysis of the data has been done, the area reported as Revegetation since 1990 is revised also in this year's submission. The area reported for the year 2010 is 83.21 kha compared to 78.37 kha reported in last year's submission for the year 2009. In this submission the area reported for 2009 is 79.44 kha showing the effect of this revision.

The CO_2 removal of the category "Other land converted to Grassland-(Revegetation)" is recognised as key source/sink including LULUCF.

The area reported as Revegetation before 1990 is calculated from the first time available time series 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, are assumed to be located within 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. It will be provided in next year's submission (Thorsson J. personal communication)

7.7.3 Carbon Stock Change (5C)

Carbon stock changes are for the first time in this submission estimated for all subcategories included both under Grassland remaining Grassland and Land converted to Grassland.

Carbon Stock Change in Living Biomass

Of "Grassland remaining Grassland" subcategories changes in living biomass are only assumed to occur in category "Natural birch shrubland. The carbon stock in living biomass of that category is estimated to gained 6.27 Gg C through growth but losses through natural mortality are estimated as 1.34 Gg C the net increase is 4.93 Gg C and thereby removing 18.07 Gg CO_2 from the atmosphere. These changes in living biomass area estimated by IFR based on NFI data. 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 12.41 Gg C in 2010, consequently removing 45.50 Gg CO_2. "Other land converted to Grassland (Revegetation)". The stock changes in living biomass 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 9.33 Gg C and 4.74 Gg C respectively for the categories Revegetation before 1990 and Revegetation since 1990 removing 34.21 Gg CO_2 and 17.38 Gg CO_2 from the atmosphere, respectively. The removal 2009 is in this submission estimated as 9.35 Gg C for the category Revegetation before 1990 and 4.53 for the category Revegetation since 1990. In last submission the reported removal was 6.68 Gg C and 5.30 Gg C respectively for the year 2009, reflecting changes in area estimate and emission factor.

Net Carbon Stock Changes in Dead Organic Matter

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 is 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 carbon stock in mineral soils of land under categories 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. Changes in mineral soil of Cropland converted to Grassland are reported for the first time in this year’s submission. The changes reported are assumed to be reversed chances as estimated for Grassland converted to Cropland (see chapter 0). The mineral soils of Cropland converted to Grassland are reported as loosing 1.42 Gg C and consequently emitting 5.21 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 83.96 Gg C and 42.69 Gg C respectively for the categories Revegetation before 1990 and Revegetation since 1990 removing 307.85 Gg CO_2 and 156.65 Gg CO_2 from the atmosphere. For 2009 the reported increase in mineral soil C-stock are 84.11 Gg C and 40.75 Gg C in the same order compared to 60.15 Gg C and 47.70 Gg C reported for 2009 in last year’s submission, reflecting changes in area estimate and emission factor.

Organic soils are reported for the Grassland subcategories “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 Wetland converted to Grassland 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 110.12 Gg C in the inventory year emitting 403.77 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 3.5.2, 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*” (see chapter 0).

The N_2O emissions resulting from use of fertilizers in revegetation has in previous submissions been reported under “5.G. Other” but is in this submission reported under 4.D.1.1, following ERT recommendation.

7.7.5 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. New emission factors for changes in C-stocks are based on analyses of these samples. Based on new data already collected in NIRA the emission/removal factors have now been revised from last years submission (Thorsson et al. in prep). The new 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 in the present submission.

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 2.38 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 (Guðmundsson and Óskarsson in prep) 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 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 ch. 7.6.4) EF= -0.10 t C ha^{-1}.

7.7.6 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.).

7.7.7 Uncertainty and QA/QC

The uncertainty of area of the categories reported is estimate 20% except for Revegetation where the uncertainty in area is 10% according to SCSI.

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 until reaching new equilibrium would be expected. As no specific actions have been taken to increase the living biomass of that category the observed changes indicate that 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 analyse indicate 20-30% uncertainty of area. Many factors can potentially contribute to the uncertainty of the size of drained area. Among these is the quality of the map of ditches. Ongoing survey on the type of soil drained has already revealed that some features mapped as ditches are not ditches but tracks or fences for example. During the summer 2010 the reliability of the map of ditches was tested. Randomly selected squares of 500*500m 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 on the ditches to estimate area of drained land, have their own uncertainty, which is transferred to the estimate of 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 these 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%.

7.7.8 Planned Improvements regarding Grassland

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

Data for dividing the drained area according to soil type drained have been collected for part of the country. It is planned to continue that sampling and use the results 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. This project involved testing of plant index and soil characters as proxies to evaluate the effectiveness of drainage. It is planned to continue that project and thereby improving the area estimate of drained land and effectiveness of the drainage. In connection with planned HiRes mapping of some land use categories within the CORINE project, training sets for remote sensing of some land use categories including wetland and different drainage stages will be identified. This project is expected to give high resolution maps of several land use categories and thereby improving the mapping of drained wetlands.

Age of drainage can be important component affecting emission from the drained soil, the effectives 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.

In this submission the subdivision of the category is increased from previous submissions. Most of the new subcategories emerge from application of time series and defined conversion period. 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. That subdivision is expected to make it possible to report changes that are occurring (Magnússon et al. 2006) in some areas.

Carbon stock changes in living biomass and mineral soil of Cropland converted to Grassland are now reported for the first time. It is planned to improve the estimate of the relevant C- stocks behind that reporting.

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. This revision will be concluded by the end of 2010. 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 ongoing. 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.

7.7.9 Recalculation

As explained in the beginning of this chapter (page 137) the information reported for the Grassland have been restructured according to available time series and meaningful conversion period. This major revision of structure has affected almost all categories reported. Accordingly the estimated emissions for all subcategories have been recalculated for the years 1990-2009.

The emissions for subcategory Cropland converted to Grassland are now reported for the first time. These emissions are also calculated for the years 1990-2009.

The emission/removal factors for revegetation have been revised. Accordingly emission/removal for both soil carbon and carbon stock in living biomass for the years 1990-2009 have been recalculated for both "Revegetation before 1990" and "Revegetation since 1990". The area of revegetation activities since 1990 has been revised for all the years 1990-2009 and the revised area is included in the recalculations.

7.8 Wetland

The reported emissions for this category are structured as in last year's submission. Flooded land is divided to "Land converted to wetland" and "Wetland remaining wetland". An improved map-layer for the category "Lakes and rivers" is used to prepare the land use maps of this submission (see chapter 0 p. 142). The map layer of reservoirs has been improved (see chapter 0 p.146) and several previously defined lakes now defined as reservoirs. All the redefined reservoirs are included in this submission as "Wetland remaining Wetland- Reservoirs" and accordingly no emission estimated. The area reported as "Lakes and rivers" decreased from 262.61 kha reported last year and the area reported as "Wetland remaining Wetland- Reservoirs" increased from 19.64 kha as reported in last submission to 31.47 kha. The area of the category "Other wetland" reported in this submission is 398.65 kha compared to 395.10 kha reported in last submission. The increase in area is explained new map layers used in preparing this year submission but also 0.27 kha are estimated as new drainage.

Emissions are only estimated for the categories Grassland and Other land converted to wetland resulting from flooding of land due to establishment of hydropower reservoirs. The emission estimates for this category has not 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 2010 equals 9.72 Gg and is the same as reported in last year’s submission for the year 2009.

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 7.8).

Table 7.8. 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 for the latter also bubble emission.

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 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. Effort in connection with HiRes mapping under the CORINE program is planned and expected to improve maps of all wetland categories.

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 maid for the category Wetland.

7.9 Settlement

The area of Settlement reported is the area estimate of IGLUD. A new map layer was used for the Settlement area (see chapter 0 p.144). The reported area is 51.85 kha compared to last year's submission 71.04 kha.

7.9.1 Carbon Stock Changes (5E)

The AFOLU Guidelines are more extensive with respect to reporting emissions from settlements and land converted to settlement than the previous GPG for LULUCF, where the focus was only on stock changes in living tree biomass for this category.

Carbon stock changes are only estimated for Forest land converted to Settlement. The emissions reported are based on carbon stock estimates of the living biomass of the trees on the deforested land. The area reported in the inventory year as “Forest land converted to Settlement” is 0.01 kha and the attached emission is estimated 0.22 Gg CO_2.

Potential sources of emissions and removals by sinks involve excavated organic soils as sources and growth of trees, shrubs and herbaceous vegetation as sinks.

Organic soils are sometimes excavated and used in landscaping or for other purposes when former wetlands areas converted into settlements or areas already included under settlement are prepared for construction of streets or buildings. This excavation of organic soil enhances decomposition of the organic material and emissions of both CO_2 and N_2O. This source is not estimated in the inventory. There is no data presently available on the amount extracted.

Part of the drained land is within the area classified as Settlement. Due to disaggregation of drained land to individual land use categories drained organic soils in Settlement area are not included as drained Grassland soils and no emissions are reported for this land in this year’s submission. The total overlap of Settlement map layers after compilation in to IGLUD with the map layer of drained land before compilation in IGLUD is 17 kha, representing a maximum estimate for the size of drained land within Settlement. The methodology for estimating the emission from this potential source has not yet been elaborated.

Newly established neighbourhoods have in general less vegetation both woody and herbaceous than older neighbourhoods. This increase in biomass is not estimated in the inventory.

7.9.2 Other Emissions (5)

As discussed above the area of drained wetlands, which is inside Settlement area, has not been estimated. The N_2O emissions due to this land use have not been estimated in this year’s submission since the methodology and area estimate need to be elaborated. Burning of biomass in open areas within the category Settlement does take place (see chapter 7.12). No other sources of CH_4 or N_2O have been recognized.

7.9.3 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.

7.9.4 Planned Improvements regarding Settlement

The present estimate of Settlement area is based on IS50 v3.2 maps. Updated of IS50 maps are expected to reflect future changes in area of Settlement. Revision of changes in Settlement area using available supplementary data as total basal area of buildings as proxy is planned.

Geographic identification of the drained land under Settlement, and an independent estimate of emissions from that area, is planned in coming years.

7.10 Other Land (5F)

No emission/removal are reported for "other land remaining other land" 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 of areas with vegetation cover < 20% or covered with mosses.

7.10.1 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. 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 Reporter software (version 3.5.2) 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 77.93 Gg CO_2-equivalents compared to last year's estimate, 0.23 Gg N_2O or 71.88 Gg CO_2-equivalents.

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

Grasslands in Iceland are not generally fertilized. The main exception is fertilization as part of a 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 sown or fertilized and are not agricultural soils as 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 are for the year 2006 due to single large wild-fire event in western Iceland.

No other emissions due to biomass burning are reported. Controlled burning of forest land is considered as not occurring. The same applies to land converted to forest land, land converted to cropland, forest land converted to grassland, forest land converted to wetland and wildfires on forest land converted to: cropland, grassland or wetland. It has not been estimated for other categories due to lack of information.

Burning the biomass 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.

7.12.1 Planned Improvements regarding Biomass Burning

A large wildfire broke out in the year 2006. It initiated a research project aimed at assessing the effects of biomass burning on ecosystems. This project is expected to provide data for a Tier 2 assessment of amount of biomass burned per area. Systematic compilation of existing information on approved burning and improved recording of the controlled and wild-fire is planned.

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.

In parallel with gathering of land use information for the purpose of the new geo-referenced land use database IGLUD, data will be collected regarding the carbon stocks of the land use category used in the classification. These efforts are aimed at gradually improving the reliability of reported emission/removal of the LULUCF sector and enable the transfer from Tier 1, which is presently used to calculate emission/removal in many categories, to higher tier levels.

The results of ongoing and recent research activity on emissions/removal and stocks in several ecosystems will be used in emissions calculations.

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. Totalled up they burned around 15,000 tonnes of waste annually. They operated at low or varying temperatures and the energy produced was not utilised. Waste incineration in Iceland as such 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 2010 a total of six waste incinerators were in use. 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 (2012). The last place to burn waste openly was the island of Grímsey which stopped doing so during 2011.

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 as energy source. In 1996 the Hazardous waste commission (*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 included 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 commission was succeeded by the Icelandic recycling fund in late 2002. In 2010, 953 tonnes of hazardous waste were landfilled, 523 tonnes were incinerated, 4560 tonnes were recycled, and 343 tonnes of acid were neutralized.

Clinical waste has been incinerated in incinerators either at hospitals or at waste incineration plants. 160 tonnes of clinical waste were incinerated in incineration plants in 2010.

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 2010, almost 80% 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 2010, about 34% of all waste generated was landfilled, 58% recycled or recovered, 4% incinerated, and 3% composted.

For the most part, wastewater treatment consists of 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%.

The added up greenhouse gas emissions from solid waste disposal on land (SWDS), wastewater treatment, incineration without energy recovery, and composting amounted to 214 Gg CO_2 equivalents in 2010, which is tantamount to a 45% increase since 1990 (148 Gg CO_2 equivalents). Between 2009 and 2010, however, emissions from the waste sector have decreased by 4.4% due to a decrease of SWDS emissions. Around 90% of all emissions from the waste sector (2010) are caused by solid waste disposal, 5% 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 Fig. 8.1.

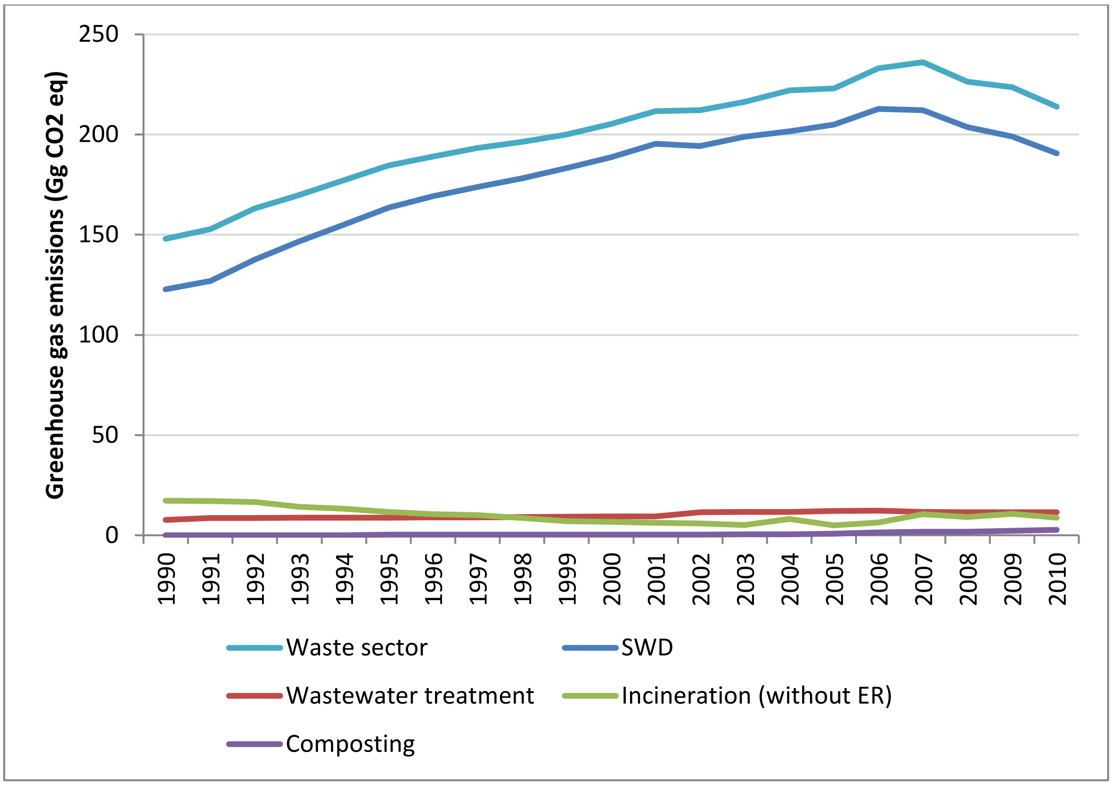

Fig. 8.1. Greenhouse gas emissions from the waste sector in Iceland. CO_2, CH_4 and N_2O emissions were aggregated by calculating CO_2 equivalents for CH_4 and N_2O (factors 21 and 310, respectively). The uppermost line is the sum of the four lines below.

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

As indicated in Table 1.1, the key source analysis performed for 2010 has revealed that in terms of total level and/or trend uncertainty the key sources in the agriculture sector are as follows:

- Managed waste disposal on land – CH_4 (6A)
- This is a key source in level (2010) 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	NM-VOC
Solid waste disposal on land (6A)						
- **Managed (6A1)**	NE	E	NE	NE	NE	NE
- **Unmanaged (6A2)**	NE	E	NE	NE	NE	NE
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 a few decades, during which methane and carbon dioxide are formed. 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 generated and published data on total amount of waste generated since 1995. During the last few years the EA has gathered information from the waste industry on amounts and kinds of waste landfilled, incinerated, composted, and recycled otherwise. The data for the period before 2005 is based on both data from the waste industry and assumptions by the EA. With two exceptions this data was used in order to generate data about waste generation before 1995. These exceptions are the amount of timber burned in bonfires on New Year and waste from metal production. Until this year (2012) the amount of material burned annually in bonfires had been estimated to amount to up to 6 Gg. This year the amount was calculated: first the material (mainly timber) that went into one of the country´s biggest bonfires was weighted and its weight correlated with the height and diameter of the timber pile. Then height and diameter for most of the country´s bonfires were collected and their weight calculated. As a result the amount of timber burned in bonfires was less than 2 Gg in 2011. The result was projected back in time using expert judgement. 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 Gg 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 Gg. Because of the data inconsistency and since 90% of the anyway inert material (regarding CH_4 production) is recycled, the amounts are 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 (Fig. 8.2).

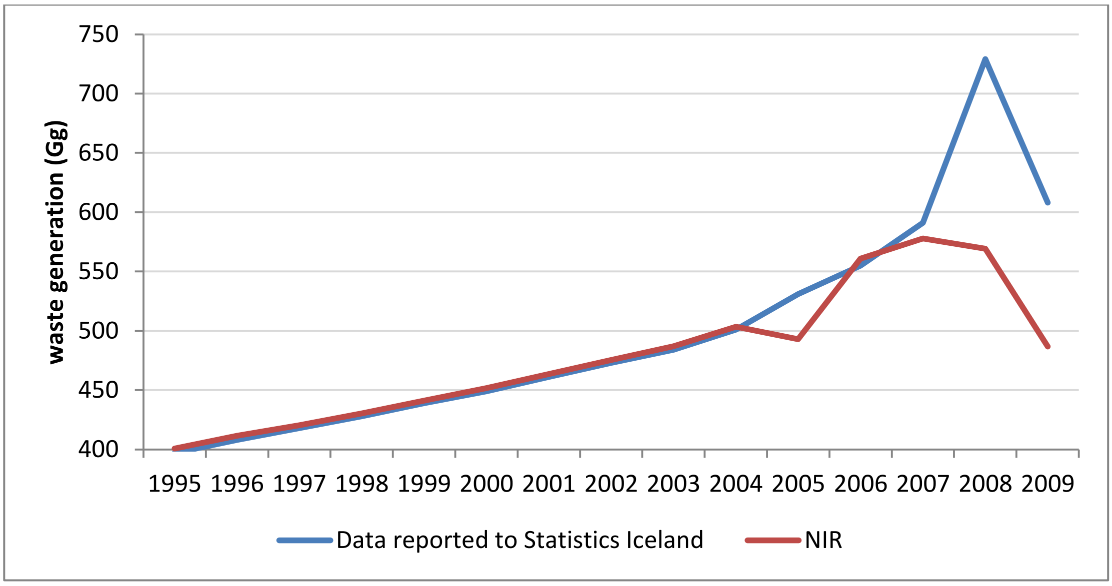

Fig. 8.2. Comparison between waste amounts reported by Statistics Iceland and the 2012 National Inventory Report.

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 0.674. A polynomial regression of the 2nd order had more explanation power (R^2 = 0.91) and predicted waste for GDPs closer to the reference period, i.e. from 1990 to 1994, more realistically (Fig. 8.3). 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:

$$\textbf{Waste amount generated (t)} = -17.649 * \text{GDP index}^2 + 7032.2 * \text{GDP index}$$

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).

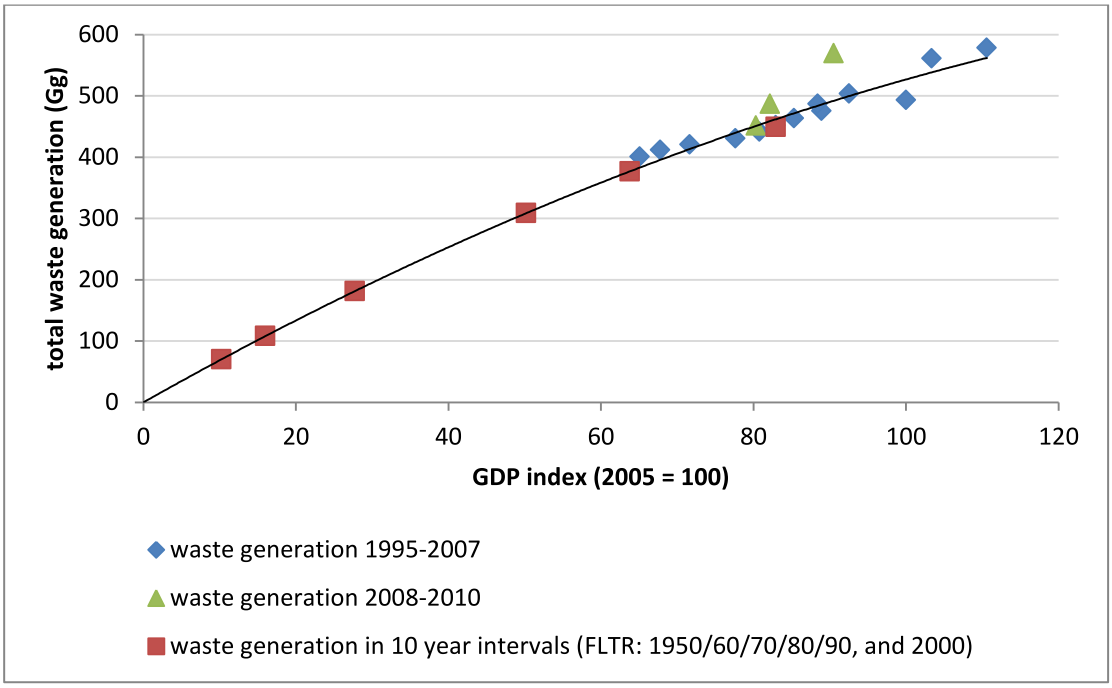

Fig. 8.3. Waste generation from 1950-2010. Blue rhombuses denote waste generation between 1995 and 2007 and were used to calculate waste amounts before 1995, which are shown as red squares in 10 year intervals along the trend line. Green triangles denote annual waste generation from 2008-2010, which was not used in calculations (see: text above).

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 1950-2010 are shown in Fig. 8.4.

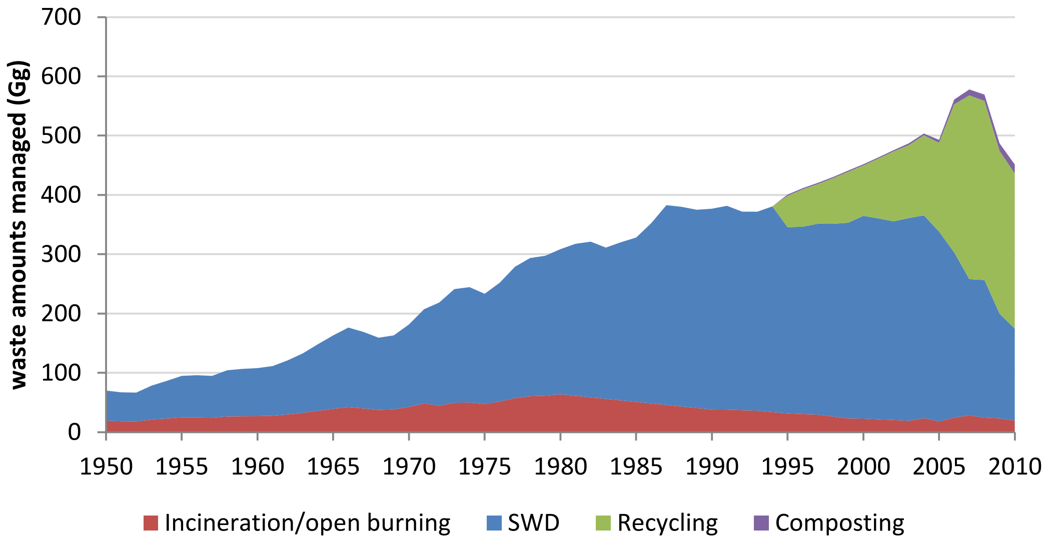

Fig. 8.4. Waste amount and allocation to incineration/open burning, solid waste disposal, recycling and composting.

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 sometimes 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 (Fig. 8.5), i.e. shallow landfill sites receive a disproportionate amount of waste compared to the share of population they are serving.

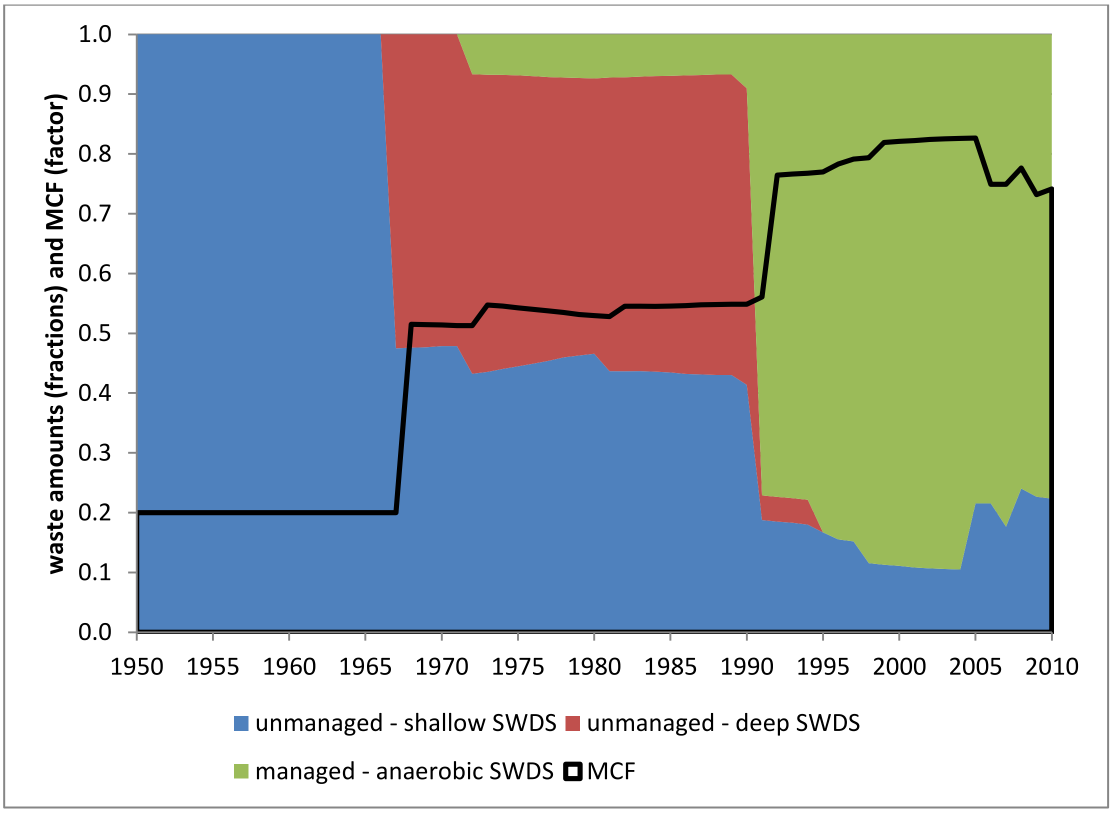

Fig. 8.5. Fractions of total waste disposed of in unmanaged and managed SWDS and corresponding methane correction factor (see also: chapter 8.2.4)

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

- Paper/cardboard
- Textiles
- Wood
- Garden and park waste
- Nappies (disposable diapers)
- Construction and demolition waste
- Sludge
- Manure
- 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 2005-2010 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 2005-2010. 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.
manure	linear reduction by 100% between 1990 and 1950%	The manure landfilled from 2005-2010 is mainly manure from horse stables around the capital area. This kind of animal keeping has increased during the last decades.
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.

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

	food	paper	tex-tiles	wood	gar-den	dia-pers	demo-lition	sludge	ma-nure	inert
1950	57.2%	8.8%	2.4%	3.3%	3.1%	0.0%	5.5%	1.7%	0.0%	18.1%
1960	50.4%	11.0%	2.4%	3.3%	3.1%	0.0%	5.5%	1.7%	1.6%	21.1%
1970	43.6%	13.1%	2.4%	3.3%	3.1%	0.0%	5.5%	1.7%	3.2%	24.1%
1980	36.8%	15.3%	2.4%	3.3%	3.1%	0.0%	5.5%	1.7%	4.8%	27.1%
1990	20.3%	17.5%	2.4%	3.3%	3.1%	3.6%	5.5%	1.7%	6.4%	36.1%
2005	17.9%	18.2%	1.4%	4.1%	0.6%	3.1%	6.9%	0.4%	13.0%	34.2%
2006	15.7%	18.9%	1.8%	2.0%	5.5%	2.2%	9.0%	2.2%	1.4%	41.4%
2007	18.5%	17.9%	2.6%	5.6%	4.0%	3.2%	8.7%	2.1%	6.1%	31.3%
2008	22.0%	19.8%	3.1%	3.0%	3.9%	3.6%	2.0%	2.2%	4.3%	36.1%
2009	28.1%	10.5%	4.3%	2.9%	2.9%	5.5%	2.1%	2.0%	5.7%	36.1%
2010	24.9%	17.6%	1.8%	1.3%	1.6%	5.9%	1.2%	1.4%	6.5%	37.9%

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

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

Where:

CH_4 Emissions = CH_4 emitted in year T, 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 covered 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.

cate-gory	food	paper	tex-tiles	wood	gar-den	dia-pers	demo-lition	sludge	man-ure[1]	inert
DOC	0.15	0.4	0.24	0.43	0.2	0.24	0.04	0.05	0.15	0
k	0.185	0.06	0.06	0.03	0.1	0.1	0.03	0.185	0.185	NA
y	4	12	12	23	7	7	23	4	4	NA

The DOC of waste going to SWDS each year was weighted by multiplying individual waste category fractions (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 (Fig. 8.5).

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

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

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 currently recovering landfill gas is Álfsnes. The operator of Álfsnes provides the EA with the amount of normal cubic meters of landfill gas recovered annually. This data dates back to 1997, when recovery started. This amount minus losses around 4% is converted to methane cubic meters using a measured methane content of landfill gas of 50%. The cubic meters are transformed to Gg CH_4 by multiplying them with 0.717 (default for standard temperature and pressure) and division by 10^6. During the first five years recovered methane amounted to 0.1 to 0.2 Gg. Between 2002 and 2005 recovery increased to 0.5-0.75 Gg. During recent years recovery has been less again, with a low of 0.2 Gg in 2007, but has increased to 0.5 Gg in 2010. This is shown in Fig. 8.6.

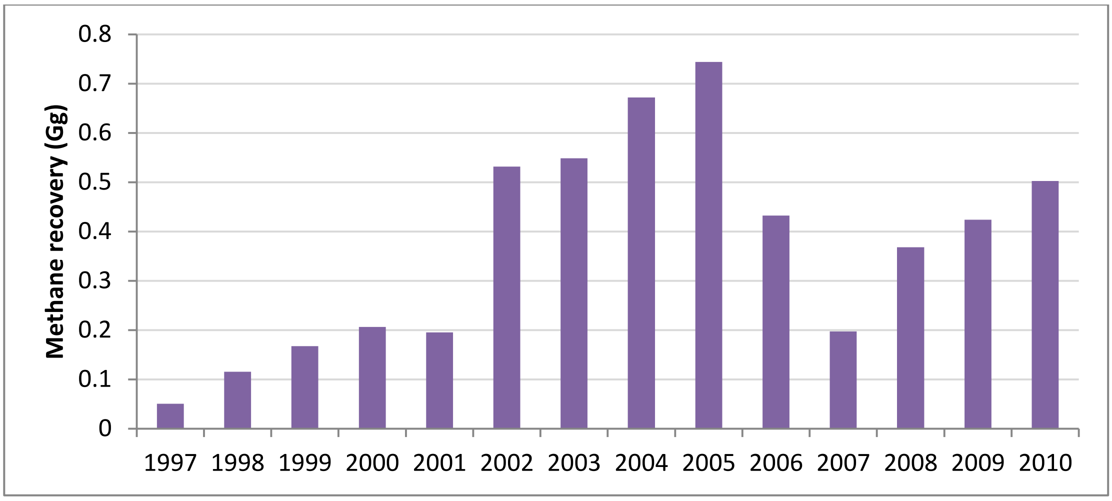

Fig. 8.6. Methane recovery at solid waste disposal site Álfsnes (Gg CH_4). The column colour is identical with the colour used for methane recovery in Fig. 8.7.

Methane emissions

In 1990 methane emissions from SWDS amounted to 5.85 Gg. Between then and 2006 they increased to 10.13 Gg. During the last three years they decreased again. In 2010 methane emissions from SWDS amounted to 9.08 Gg. This is tantamount to an increase of 55% between 1990 and 2010.

The main reason behind the increasing trend until 2007 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 Fig. 8.7. 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 2010 85% of SWDS emissions originated from managed SWDS. The main event underlying this development is the close down of the unmanaged SWDS Gufunes accompanied by the simultaneous opening of the managed SWDS Álfsnes, which services more than half the population of Iceland and receives corresponding waste amounts.

The reason for the decrease since 2007 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 - food, sludge and manure comprise about one third of total waste landfilled - the relatively new trend away from landfilling can already be seen in emissions.

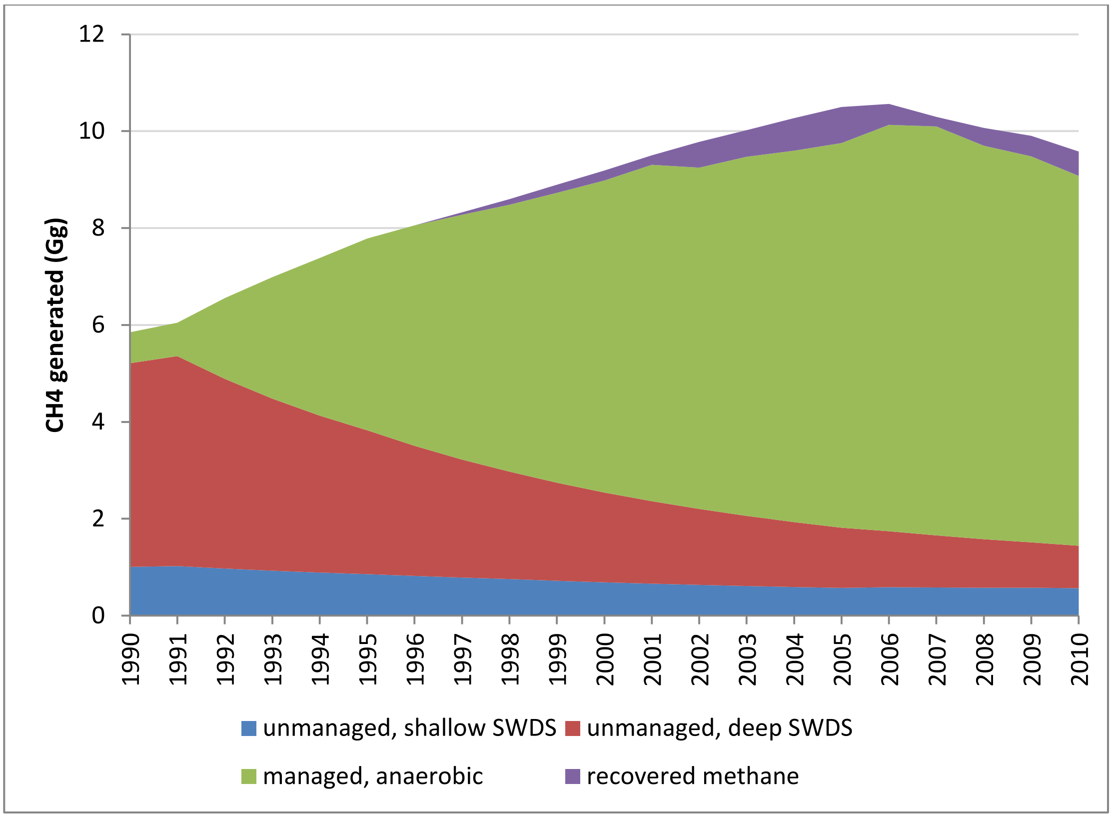

Fig. 8.7. Methane emissions from SWDS, separated into SWDS types. The amount of methane recovered at the managed SWDS Álfsnes is shown as purple area (reducing the size of the green area for emissions from managed SWDS)

8.2.5 Changes to previous submissions and recalculations

There have been numerous changes and recalculations between the 2011 and 2012 submissions.

A) Industrial waste

The distinction between industrial waste (IW) and municipal solid waste (MSW) was discarded since it was not backed by existing data. All waste formerly allocated to industrial waste was allocated to one of the ten categories described above. This change in methodology impacts both waste generation and waste composition.

B) Waste generation

Since waste was not divided into MSW and IW anymore, a single regression analysis replaced the two used before to calculate historic waste generation. This increased historic waste amounts. The increases, along with recalculations of waste generation data for the first decade of the 21st century, are shown in Table 8.7.

Table 8.7. Mean increase of generated waste amounts between 2011 and 2012 submissions.

Decade	1950s	1960s	1970s	1980s	1990s	2000s
Mean increase of generated waste amount between submissions: (2012-2011)/2011	57%	46%	35%	25%	15%	1%

C) Waste allocation

In the 2011 submission all waste generated before 1979 is allocated to SWDS. In this submission around 23% of waste generated between 1950 and 1979 is allocated to open burning of waste. Since 1980 the fractions allocated to each of the four waste management systems SWDS, burning/incineration, composting and recycling are very similar.

D) Waste composition

In the 2011 submission the majority of waste – on average 70% of total waste – was allocated to industrial waste. In the 2012 submission this fraction was allocated to one of ten waste categories. Five of these ten categories have higher DOC values than industrial waste (0.15), two have the same value and three of them have lower values. Annual calculations of DOCs, however, showed that the weighted average of the categories in this submission resulted in DOCs around 15%.

In last year´s submission MSW was composed of only seven waste categories. Sludge, manure and demolition waste were not included or allocated to other categories. The MSW composition for the whole time period from 1950-2010 was calculated based on the results of the average composition from 1999-2004 of the aforementioned waste composition study by SORPA ltd., thus not accounting for either temporal changes or the fact that the study represented only mixed waste categories and not separated waste categories. This resulted in a DOC content of 17.3%, which is higher than the average DOC content of this year´s submission.

E) Methane correction factor

In the 2011 submission SWDS were categorized differently. Until 1979 all SWDS were categorized as uncategorized (neither managed nor unmanaged) with an MCF of 0.6. From 1980 onwards SWDS were either categorized as unmanaged, shallow or managed, anaerobic; and the amount of waste deposited at unmanaged SWDS was bigger than the one at managed SWDS until 2007. This does not take into account actual developments in the waste sector described above such as the commissioning of Iceland´s biggest SWDS Álfsnes in 1991. In this year´s submission no SWDS were categorized as uncategorized and all waste went to either unmanaged (shallow or deep) or managed, anaerobic SWDS. In addition to that the MCFs for unmanaged, shallow and managed, anaerobic SWDS were lowered. The influence of both reallocation and revaluation on the MCF is shown in Fig. 8.8.

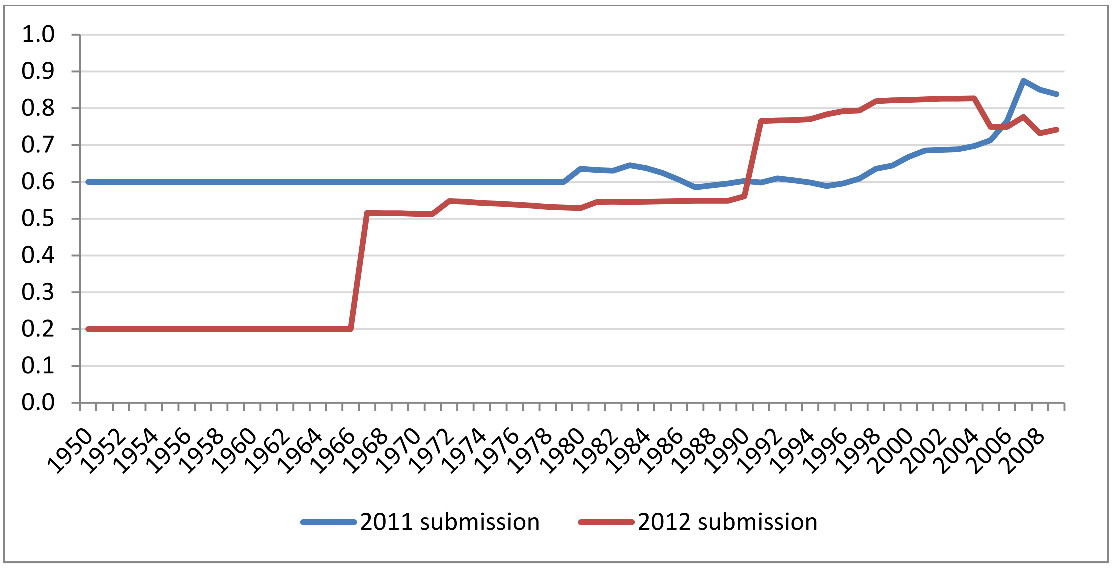

Fig. 8.8. Methane correction factor for SWDS from 2011 and 2012 submissions

F) Methane gas recovery

Until the 2012 submission there was a mistake in the calculation of methane gas recovery. Landfill gas was mistaken for methane. By correcting this mistake methane gas recovery was reduced by 52% for 2009 and similar fractions for all years since recovery began in 1997.

G) Summary

Quantifying the increase in emissions caused by the change in MCF and recalculations made for methane recovery was straightforward. Although the MCF of the 2012 submission was lower than the one of the 2011 submission from 1950 to 1990 and since 2006, the higher MCF between 1991 and 2005 causes a net increase of emissions of 0.75 Gg (all values for 2009). The net increase of emissions caused by recalculations of methane recovery was 0.46 Gg. The net changes between emissions caused by changes in waste generation, waste allocation and waste composition were not as easily quantifiable. The reasons for this are their interrelationships. Nevertheless, it is possible to state that the increase in waste generation in the 2012 submission has increased the emissions from SWDS considerably whereas the revaluation of (MSW) waste composition resulted in a decrease of emissions (Table 8.8). The table does not sum up the changes between emissions in order to account for the interrelatedness of estimations for waste generation, allocation, and composition.

Table 8.8. Differences in methane emissions between submissions due to changes in activity data, emission factors and recalculations.

	Waste generation	Waste allocation	Waste composition	MCF	Methane recovery
Increase between 2011 and 2012 submissions (Gg CH_4)	1.2[1]	-0.03[1]	-0.7[1]	0.75	0.46

1: approximations

All things considered 2009 methane emissions from solid waste disposal on land in the 2012 submission were 12.7% above emissions from the 2011 submission. 1990 methane emissions, however, were 8.2% lower in the 2012 submission than they were the year before.

8.2.6 Uncertainties

The uncertainty associated with activity data is assumed to be higher for unmanaged SWDS (30%) than for managed SWDS (20%). This is because of the fact that the bulk of waste going to managed SWDS has been disposed of in recent decades when more information existed whereas the bulk of waste going to unmanaged SWDS has been disposed of during earlier decades with less knowledge about waste amounts and composition. In combination with an emission factor uncertainty of 50% for countries with poor quality data on CH_4 generation per tonne of waste, the uncertainty estimates for managed and unmanaged SWD are 53.8 and 58.3%, respectively.

8.2.7 Planned improvements

Slaughterhouse waste is currently included in food waste. Kamsma and Meyles (2003) showed that emissions from SWDS with a high slaughterhouse waste content were low. Therefore efforts will be made to reclassify slaughterhouse waste with lower methane generation rates for the 2013 submission.

8.3 Emission 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 treated 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 including 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 shows in nitrous oxide emissions from wastewater.

Total CH_4 and N_2O emissions from wastewater amounted to 11.42 Gg CO_2 equivalents in 2010. Compared to 1990 emissions of 7.77 Gg CO_2 equivalents this meant an increase of 47%.

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 septage. The 2006 GL default for Canada, Europe, Russia, and Oceania of 60 g BOD per person and day was used. Between 1990 and 2010 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 8.9 along with respective shares of total wastewater discharge and MCFs.

Table 8.9. 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
MCF	0	0	0	0.3	

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 the one hand and its fast running streams and rivers on the other hand. In Iceland the annual mean temperature is 4 °C and maximum temperature rises rarely 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 system.

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 domestic septage removed annually from septic tanks was known and transformed from kg to kg BOD using a literature value of 6480 mg/litre (McFarland, 2000). Removal of domestic septage removed TOW by less than 1%. 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 Fig. 8.9. 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 2010. 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.

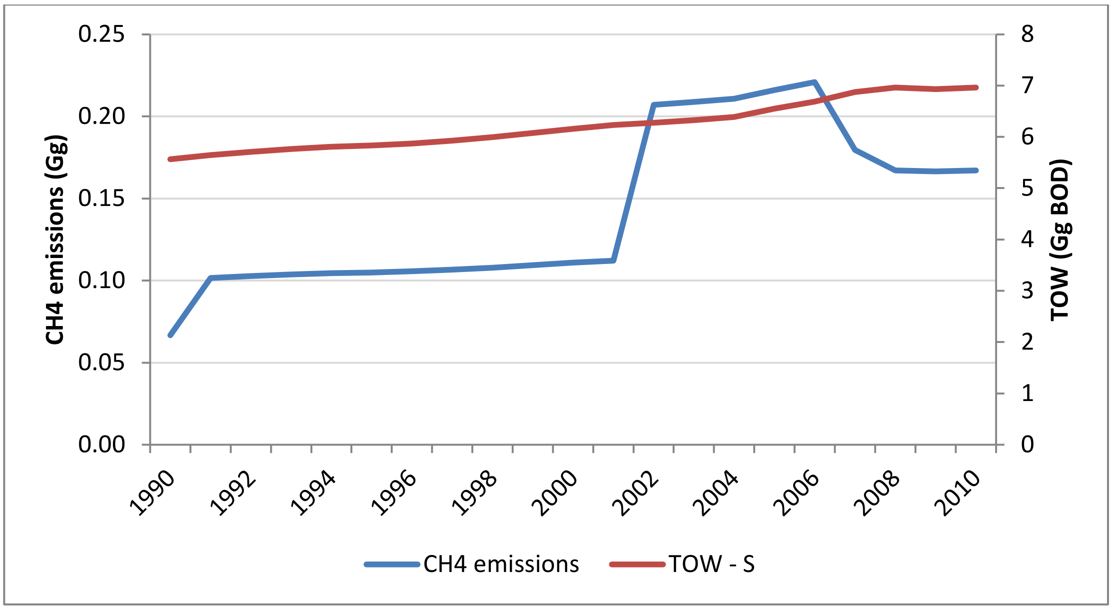

Fig. 8.9. Methane emissions and total organics in wastewater (adjusted for removal of domestic septage (S)).

Changes to previous submissions and recalculations

The MCF for untreated discharge was lowered from 0.1 to zero. Nevertheless did methane emissions from domestic wastewater increase from 0.07 Gg to 0.17 Gg between 2011 and 2012 submissions (2009 values). This is mainly due to a miscalculation in the 2011 submission. There the MCFs for discharge pathways were used twice: firstly while calculating emission factors and secondly while calculating emissions. Thus emissions were lowered wrongly by a factor of seven to nine (time dependent). Less impact had the revaluation of the organic component removed as sludge. During the 2011 submission sludge removal was calculated without regard to actual removed amounts reported. These calculations resulted in a sludge fraction equal to 10% of total organics in wastewater. By taking reported sludge amounts removed into account the fraction of sludge removed was lowered to below 1%, thus increasing emissions slightly.

Industrial wastewater

Activity data

Wastewater emissions of fish processing, dairy industry, and meat and poultry industry were assessed. These categories produce the majority of total organics in industrial wastewater (TOW_i) in Iceland. Vegetables and beer production were also taken into account. TOW_i are calculated by multiplying wastewater generated with chemical oxygen demand (COD), a measure of organic degradable component in industrial wastewater. Kg COD per m^3 wastewater were taken from the 2006 GL for all industries except fish processing. Wastewater generated was calculated using 2006 GL parameters which predict wastewater generated using product (dairy products, meat, etc.) as proxy. For fish processing species specific COD values based on product generated were used (Nordisk Ministerråd, 1997). For uncategorized fish (fish species that are captured as by-catch) 2006 GL defaults were used for wastewater generation and kg/DOC per m^3 wastewater. Resulting TOW_i are shown in Fig. 8.10. The fishing industry accounted for roughly 80% of organics in wastewater.

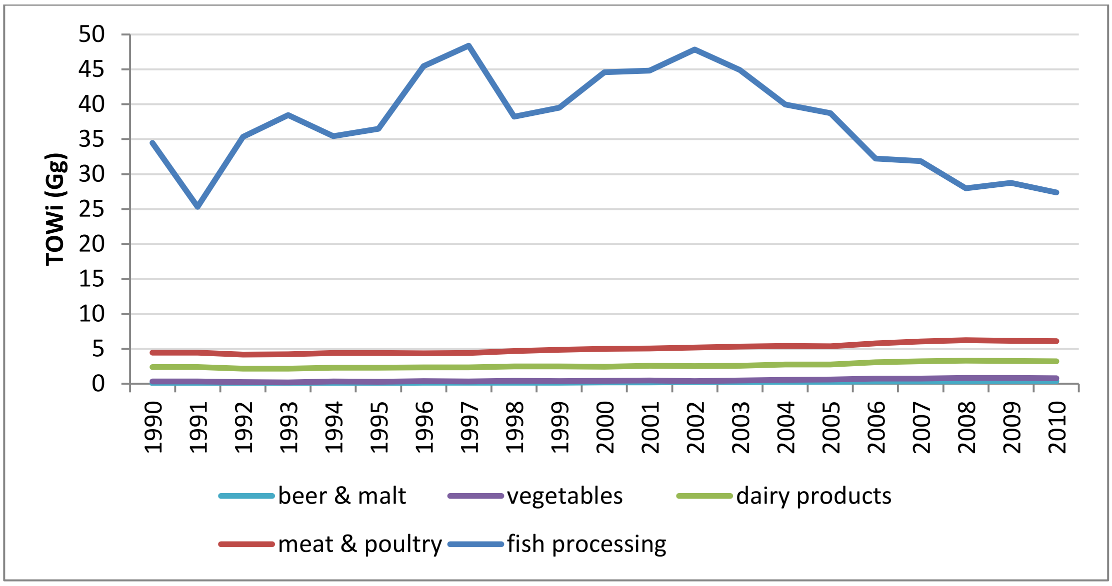

Fig. 8.10. Total organics in industrial wastewater. Lines are stacked.

Emission factors and emissions

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.

Changes to previous submissions and recalculations

The MCF for untreated discharge was lowered from 0.1 to zero. Thus methane emissions from industrial wastewater were lowered from 0.7 Gg (2009) to zero Gg.

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 8.10.

Table 8.10. 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.

The other parameters influencing the nitrogen amount of wastewater are national values. The Icelandic Directorate of Health conducted one dietary survey for adults (Steingrímsdóttir et al., 2002) and one for adolescents (Þórsdóttir and Gunnarsdóttir, 2006). The studies showed a high protein intake of Icelanders. Adults consumed 90 g/day, adolescents 78 g/day. Together that resulted in a mean annual intake of 31.76 kg per head and year. The Directorate of Health published a new dietary survey this year (Þorgeirsdóttir et al., 2012). The study came to the result that protein consumptions stayed unchanged. 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 3.5% (average 1990-2010).

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 Fig. 8.11. Emissions rose from 0.021 Gg in 1990 to 0.026 in 2010. This is tantamount to an increase of 27%. The main driver behind this development was a 25% increase of population during the same time. Of minor influence are the fluctuating fractions of sludge and septage removed.

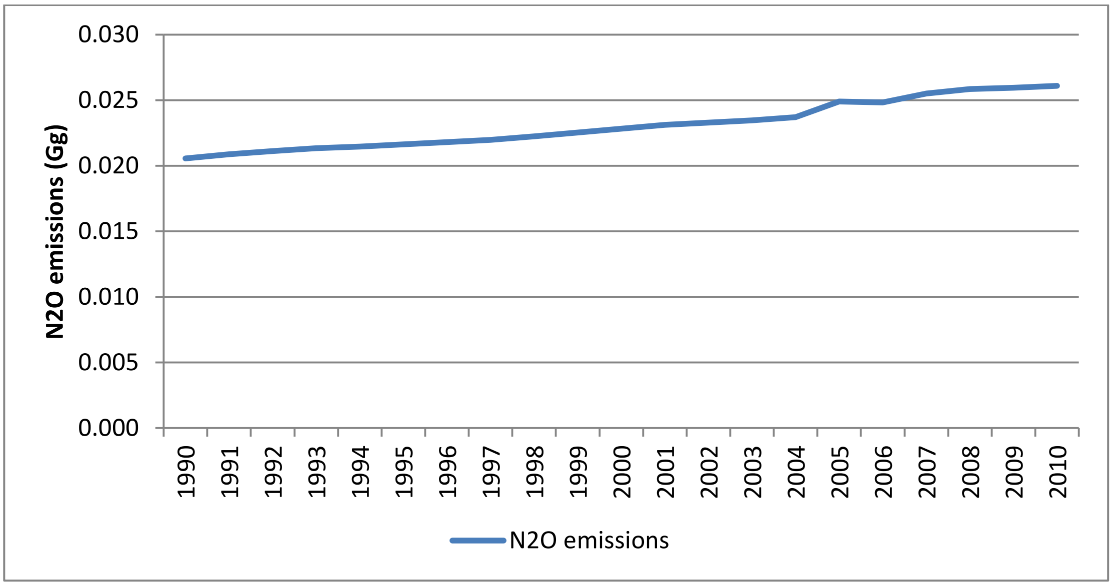

Fig. 8.11. N2O emissions from wastewater effluent between 1990 and 2010 in Gg.

8.3.4 Changes to previous submissions and recalculations

The only change since last submission consisted of the inclusion of nitrogen removed with sludge. The inclusion of sludge removal reduced nitrous oxide emissions by 4.1% (1990) and 2.6% (2009) between 2011 and 2012 submissions.

8.3.5 Uncertainties

Quantitative uncertainties for CH_4 and N_2O emissions from wastewater handling were estimated to be 58.3% (with activity data uncertainties of 50% and emission factor uncertainties of 30%). This can be seen in the quantitative uncertainty table in Annex II.

8.3.6 Planned improvements

Currently there are no improvements planned regarding greenhouse gas emissions from wastewater treatment.

8.4 Waste incineration (6C)

8.4.1 Overview

This chapter deals with incineration and open burning of waste. Open burning of waste includes combustion in nature and open dumps as well as combustion in incineration devices that do not control the combustion air to maintain adequate temperature and do not provide sufficient residence time for complete combustion. Incineration devices on the other hand are characterised by creating conditions for complete combustion. Therefore the burning of waste in historic incineration devices 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 consists of biogenic carbon, CO_2 emissions from bonfires are not included in national emissions.

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 Gg waste were burned. Between 2005 and 2011 there was only one place left burning waste openly: the island of Grímsey. It was assumed that around 50 tonnes of waste were burned there annually. The amount of material burned in bonfires has also decreased from around 4 Gg in 1990 to less than 2 Gg in 2010. Incineration of waste with energy recovery started in 1993 and has been around 20 Gg annually since 2006.

Total greenhouse gas emissions from waste incineration decreased from 17.3 Gg in 1990 to 8.9 in 2009, i.e. 47%.

Methodology

The methodology for calculating carbon dioxide emissions from waste incineration is in accordance with the 2006 GL Tier 2a method, the methodologies for calculating methane and nitrous oxide emissions are in accordance with the 2006 GL Tier 1 methods.

Consistent with the 1996 Guidelines (IPCC, 1997), only CO_2 emissions resulting from oxidation during incineration and open burning of carbon in waste of fossil origin (e.g., plastics, certain textiles, rubber, and liquid solvents) are considered net emissions and therefore included in the national CO_2 emissions estimate. The CO_2 emissions from combustion of biomass materials (e.g., food, and wood waste) contained in the waste are biogenic emissions and therefore not included in national total emission estimates.

The situation is different for incineration of waste used for energy purposes. Here, both CO_2 emissions of fossil and biogenic origin are reported.

In addition to CO_2 CH_4, N_2O, NO_x, CO, and NMVOC emissions were estimated for both incinerations with and without energy recovery. The setup of the Icelandic NIR is so that, although emissions from incineration with energy recovery are reported under the energy chapter (1A1a and 1A4a), the activity data and methodology used to calculate them are described in the waste chapter - with the exception of waste oil incineration with energy recovery. Emissions are reported twice in the NIR: in the waste chapter in order to compare them to emissions from waste incineration without energy recovery and in the energy chapter in order to satisfy methodological standards.

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 amount of waste incinerated (both with and without energy recovery) is based on actual data from the incineration sites since 2004. Prior to 2004, the amount incinerated with energy recovery is based on information from incineration sites supplemented by expert judgement. The amounts of waste incinerated are shown in Fig. 8.12.

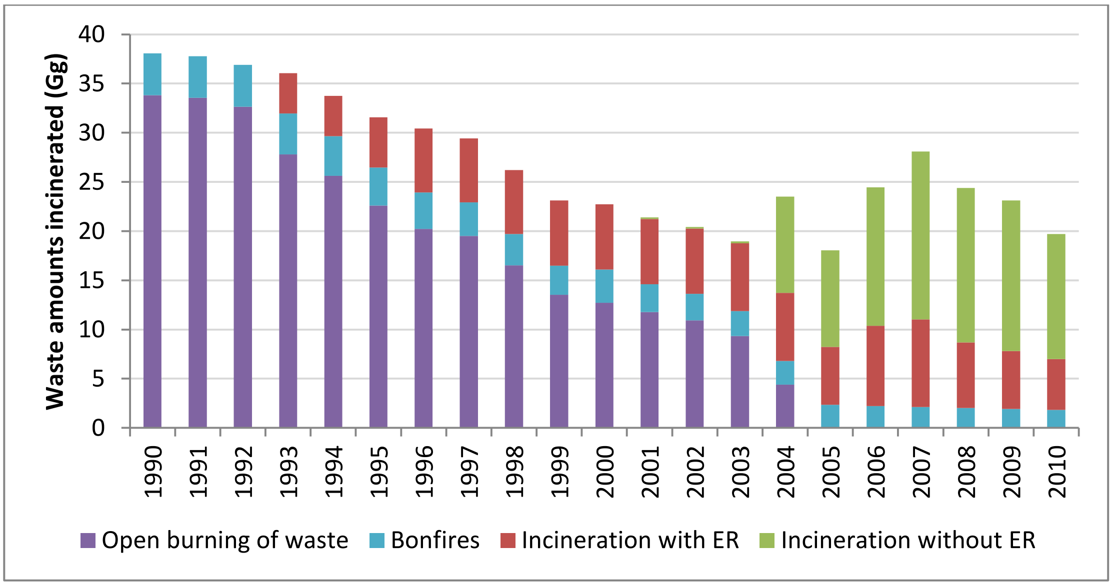

Fig. 8.12. Amounts of waste incinerated with and without energy recovery, burned openly and amount of material burned in bonfires.

Fig. 8.11 shows that waste was only burned openly (here this includes waste incinerators with low/varying combustion temperatures) and in bonfires during the early 1990s. In 1993 the first two waste incineration plants were opened on the Vestmannaeyjar archipelago and in Svínafell in southeast Iceland. These two plants and the next two, which were opened in 1995 (Isafjörður) and 1999 (Skaftárhreppur) recover the energy of the incineration and use it for either public heat production (Vestmannaeyjar, Isafjörður) or commercial/institutional heat production (Svínafell, Skaftárhreppur). The incineration plant Kalka produces energy and electricity for its own requirements and therefore rates as auto producer. Thus it is categorized as incineration plant without energy recovery as are the two remaining incineration plants: Húsavík in northeast Iceland and Tálknafjörður, which operated only from 2001 to 2004.

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 Table 8.11 along with their weight fractions from 2005 to 2010. The category inert waste is defined differently here than it was defined for the SWDS chapter since it excludes plastics, rubber and hazardous waste.

Table 8.11. Waste categories for incineration along with weight fractions for 2005-2010 and the average weight fraction of whole period.

category	paper	textiles	wood	garden	diapers	food	inert	plastic	hazard.	clinical	rubber
2005	0.305	0.023	0.008	0.071	0.049	0.211	0.165	0.138	0.000	0.018	0.013
2006	0.307	0.047	0.006	0.011	0.032	0.175	0.259	0.116	0.022	0.020	0.005
2007	0.318	0.026	0.053	0.006	0.047	0.124	0.202	0.184	0.003	0.017	0.020
2008	0.256	0.042	0.059	0.008	0.045	0.131	0.240	0.165	0.025	0.008	0.022
2009	0.167	0.036	0.056	0.010	0.060	0.177	0.222	0.203	0.036	0.008	0.023
2010	0.212	0.020	0.040	0.013	0.069	0.192	0.191	0.207	0.029	0.009	0.017
mean 05-10	0.263	0.033	0.039	0.017	0.050	0.164	0.216	0.169	0.019	0.014	0.017

This data exists only for waste incineration and for the years from 2005 to 2010. For want of data weighted average fractions from 2005-2010 were applied to the all years from 1990 to 2004 and 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 2010 in Table 8.12.

Table 8.12. Calculation of fossil carbon amount incinerated in 2010. 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	3797	0.21	0.90	0.46	0.01	0.004	16
textiles	356	0.02	0.80	0.50	0.20	0.080	28
wood	709	0.04	0.85	0.50	0.00	0.000	0
garden	241	0.01	0.40	0.49	0.00	0.000	0
diapers	1235	0.07	0.40	0.70	0.10	0.028	35
food	3429	0.19	0.40	0.38	0.00	0.000	0
inert	3421	0.19	0.90	0.03	1.00	0.027	92
plastics	3703	0.21	1.00	0.75	1.00	0.750	2777
hazardous	523	0.03	0.50	0.55	1.00	0.275	144
clinical	160	0.01	0.65	0.62[1]	0.63[1]	0.250	40
rubber	307	0.02	0.84	0.67	0.20	0.113	35
sum	17881	1.00					3167

1: generated to result in 2006 GL default fossil carbon content of 0.25

The input for individual years from 2005 to 2009 differed from Table 8.12 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 2005-2010 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, and NMVOC 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 8.13.

Table 8.13. 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
Incineration EF	237	60	1800	700	20
Open burning EF	6500	150[1]	1800	700	20

1: g/tonne dry waste

8.4.4 Emissions

CO_2 emissions

CO_2 emissions from incineration and open burning of waste are shown in Fig. 8.13. Emissions from open burning of waste decreased from 10.7 Gg CO_2 to 0.02 Gg CO_2. Incineration of waste without energy recovery started in 2001. They were highest in 2009 when they amounted to 10 Gg. Since then they decreased to 8.2 Gg in 2010. Emissions from incineration with energy recovery started in 1993 and amounted to 3.4 Gg CO_2 in 2010.

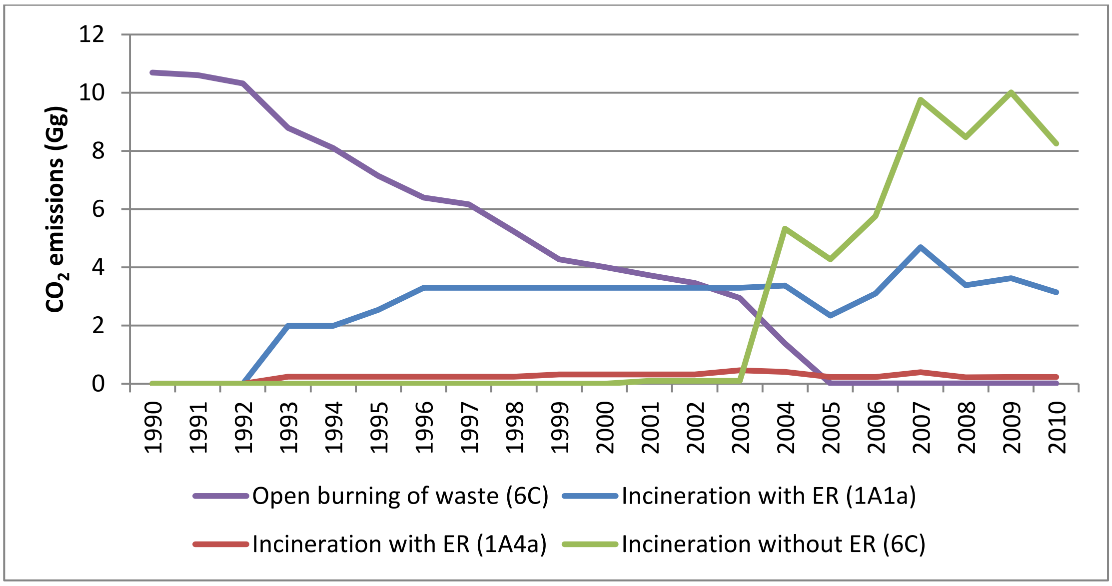

Fig. 8.13. CO_2 emissions from incineration and open burning of waste in Gg.

CH_4, N_2O, NO_x, CO, and NMVOC emissions

CH_4 emissions from waste incineration are shown in Fig. 8.14. In contrast to the distribution of CO_2 emissions, CH_4 emissions from open burning of waste (including bonfires) are many times higher than emissions from waste incineration. This is caused by the differences in emission factors shown in Table 8.13. CH_4 emissions from open burning of waste including bonfires amounted to 5.2 Gg CO_2 equivalents in 1990. Because of the steep decrease of the amount of waste burned openly, emissions decreased to 0.25 Gg CO_2 equivalents (97% of which were caused by bonfires). Methane emissions from waste incineration without energy recovery amounted to 0.06 Gg CO_2 equivalents in 2010, those from incineration with energy recovery to 0.03 Gg CO_2 equivalents.

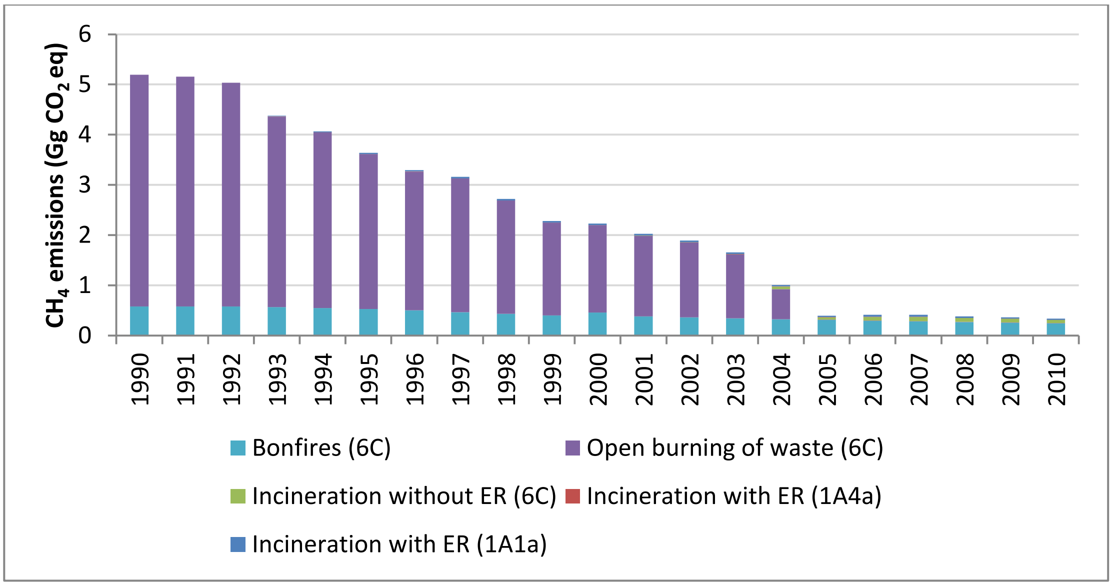

Fig. 8.14. Methane emissions from waste incineration in Gg CO2 eq.

N_2O emissions from open burning of waste amounted to 1.4 Gg CO_2 equivalents in 1990 and decreased to 0.07 Gg CO_2 equivalents in 2010. Emissions from waste incineration without energy recovery amounted to 0.24 Gg CO_2 equivalents in 2010, those from incineration with energy recovery to 0.1 Gg CO_2 equivalents (Fig. 8. 15)

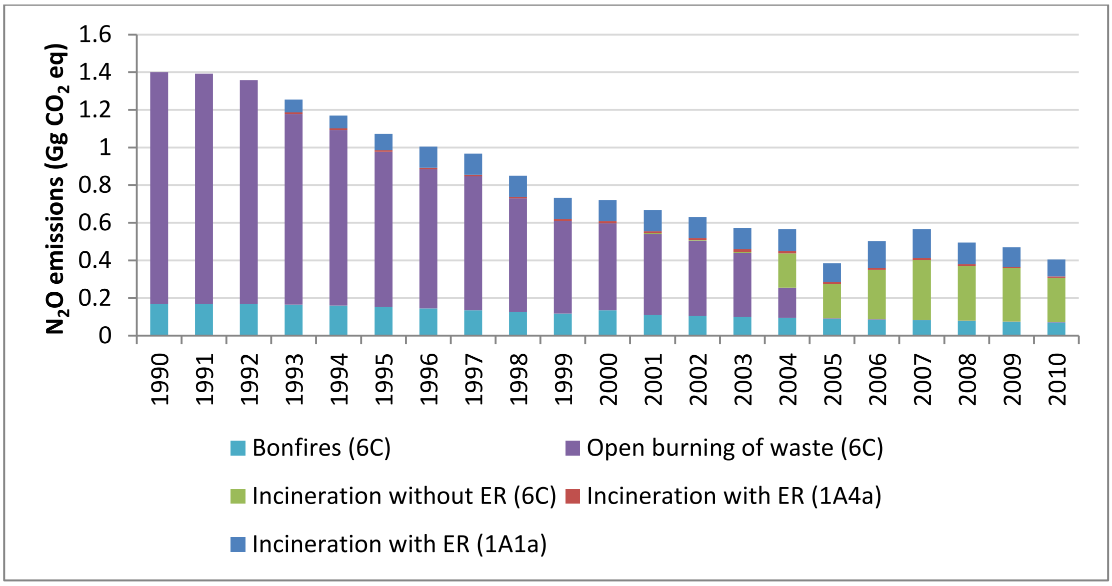

Fig. 8. 15. N_2O emissions from waste incineration in Gg CO_2 eq.

NO_x, CO, and NMVOC emissions from open burning of waste, incineration with and without energy recovery are shown for selected years in Table 8.14.

Table 8.14. NO_x, CO, and NMVOC emissions from open burning of waste, incineration with and without energy recovery in tonnes.

		1990	1995	2000	2005	2009	2010
NO_X	open burning of waste[1]	68.5	47.6	29.0	4.2	3.4	3.3
	incineration without energy recovery	0.0	0.0	0.0	17.7	27.5	22.9
	incineration with energy recovery	0.0	9.2	11.9	10.6	10.6	9.3
CO	open burning of waste[1]	26.6	18.5	11.3	1.6	1.3	1.3
	incineration without energy recovery	0.0	0.0	0.0	6.9	10.7	8.9
	incineration with energy recovery	0.0	3.6	4.6	4.1	4.1	3.6
NMVOC	open burning of waste[1]	0.8	0.5	0.3	0.0	0.0	0.0
	incineration without energy recovery	0.0	0.0	0.0	0.2	0.3	0.3
	incineration with energy recovery	0.0	0.1	0.1	0.1	0.1	0.1

1: including bonfires

8.4.5 Changes to previous submissions and recalculations

There have been changes to activity data and emission factors between submissions, which impact CO_2 emissions and, to a smaller extent, CH_4 and N_2O emissions.

1. Two incineration plants that were allocated to waste incineration with ER in the 2011 submission were allocated to waste incineration without ER in the 2012 submission. The incineration plant in Húsavík does not recover its energy. The incineration plant Kalka uses a part of the energy it produces during combustion for own energy needs. As auto producer it was allocated to incineration without energy recovery. This increased CO_2 emissions since 2004 greatly.

2. There have been minor changes to the amount of waste incinerated based on new information. The increase since 2001 (on average 6%) had an increasing effect on emissions from all greenhouse gases.

3. The amount of wood burned in bonfires has been reassessed for the 2012 submission. The reduced amount had a lowering effect on emissions from all greenhouse gas emissions except CO_2 (stayed zero).

4. In the 2011 waste composition was not assessed and the fossil carbon fraction of waste was calculated using IPCC defaults for dry weight, carbon fraction, fossil carbon fraction, and assumed shares of municipal solid and industrial waste. This resulted in a fossil carbon content of 22%. In the 2012 submission national fractions for waste composition were used in order to calculate fossil carbon fractions of waste. The resulting fraction of 15% (average for years 2005-2010) had a lowering effect on CO_2 emissions from incineration of waste.

5. In the 2011 submission the division between MSW and IW led to the use an additional emission factor: 100g N_2O/t industrial waste for all types of incin-

eration. The omission of this emission factor had a lowering impact on N_2O emissions.

The impact of the interaction of these changes on greenhouse gas emissions from open burning of waste and waste incineration without ER between 2011 and 2012 submissions is shown in Table 8.15.

Table 8.15. Changes in greenhouse gas emissions between 2011 and 2012 submissions. All emissions in Gg CO_2 equivalents.

green-house gas	year	2011 sub-mission	2012 sub-mission	change between submissions	main reason for change
CO_2	1990	19.19	10.69	-44%	reduction of fossil carbon content
	2009	0.03	10.02	37866%	allocation of two plants to incineration **without** ER
CH_4	1990	5.16	5.19	1%	activity data
	2009	0.69	0.34	-51%	reduction of amount of wood burned in bonfires
N_2O	1990	1.17	1.40	20%	omission of EF for indus-trial waste
	2009	0.16	0.36	130%	allocation of two plants to incineration **without** ER
total	1990	25.53	17.28	-32%	reduction of fossil carbon content
	2009	0.87	10.72	1130%	allocation of two plants to incineration **without** ER

8.4.6 Uncertainties

The activity data uncertainty regarding the amount of waste incinerated was estimated to be 20%. The CO_2 emission factor uncertainty was estimated to be 40% thus resulting in a combined uncertainty for CO_2 emissions of 44.7%. The uncertainty for CH_4 and N_2O default emission factors is 100%. This resulted in a combined uncertainty of 102% for CH_4 and N_2O emissions from waste incineration.

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 composted waste has been increasing since the year 2005 and amounted to 15 Gg in 2010 or roughly 3% of all waste generated.

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 (Fig. 8.13). 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 0.06 Gg CH_4 or 1.3 Gg CO_2 equivalents in 2010. N_2O emissions amounted to 0.005 Gg N_2O or 1.4 Gg CO_2 equivalents in 2010. This is shown in Fig. 8.16 .

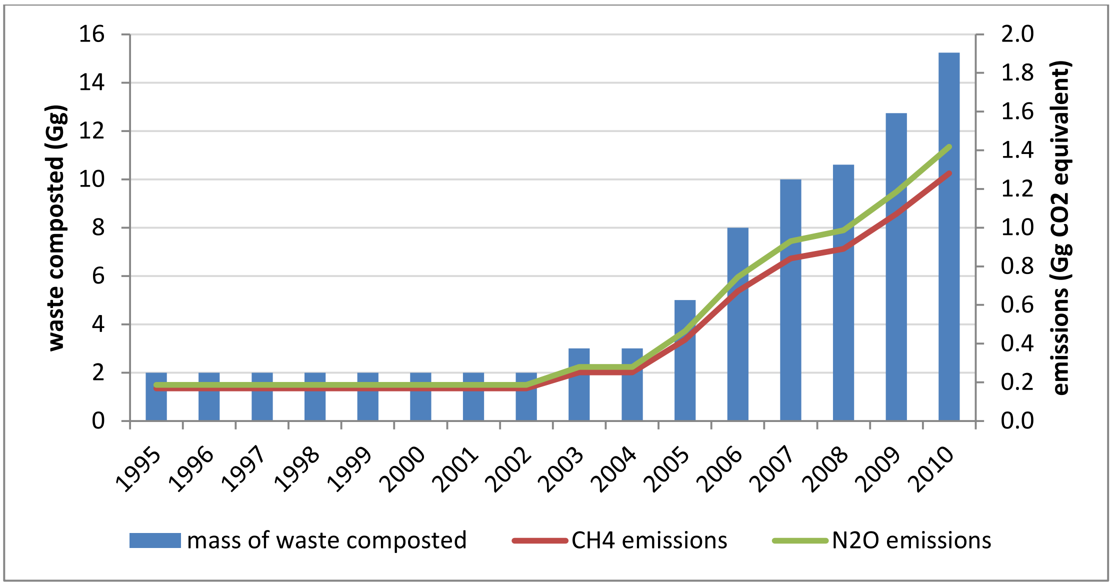

Fig. 8.16. Mass of waste composted and resulting CH_4 and N_2O emissions (in Gg CO_2 eq).

8.5.5 Uncertainties

Activity data uncertainty was assumed to be 20%, emission factor uncertainties were assumed to be 50% for both N_2O and CH_4 emission factors, thus resulting in a combined uncertainty of 53.8%.

8.5.6 Planned improvements

Currently there are no improvements planned regarding greenhouse gas emissions from composting.

9 RECALCULATIONS AND PLANNED IMPROVEMENTS

9.1 Overall Description of Recalculations

The Icelandic 2012 greenhouse gas emission inventory has been recalculated to a considerable extent (Table 9.1). All recalculations made, except for road transport (see chapter 3.4.2), are calculated for the entire time series 1990-2010. 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 and LULUCF sectors. The revision of nitrogen excretion rates for livestock increased N_2O emissions from manure management and agricultural soils by a total of more than 100 Gg CO_2 equivalents during the whole time period. This development was slightly offset by decreased estimates for methane emissions from manure management. CO_2 emissions from cropland for the year 1990 increased by 207 Gg CO_2 equivalents between submissions. The difference in emission estimates decreases over the time period and was 93 Gg CO_2 equivalents for 2009. This increase is partially offset by the category grassland. Grassland in 1990 was estimated to be a net source in the 2011 submission. In the 2012 submission it was estimated to be a net sink. The difference between submissions was 110 Gg CO_2 equivalents. Both submissions estimated grassland to be a net sink of CO_2 and the difference between estimates decreased to 15 Gg.

Table 9.1. Total recalculations in 2011 submission compared to 2010 submissions (without LULUCF) in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	3415.02	3501.36	86.33	2.53
1995	3203.56	3274.23	70.68	2.21
2000	3766.07	3845.09	79.02	2.10
2005	3727.40	3819.00	91.60	2.46
2009	4618.16	4700.22	82.06	1.78

9.2 Specific description of recalculations

9.2.1 Energy

Recalculations in this sector are:

- Reallocation of fuel in the sectors 1A1a, 1A2 and 1A4.
- Reallocation of emissions from waste incineration (from 1A1a and 1A4 to 6C).

- Reallocation of fuel for different vehicle types, including motorcycles for the first time, for the years 2006 to 2010.
- Estimate of methane emissions from geothermal power plants.

Recalculations between submissions led to slight emission estimate decreases over the complete time period. They amounted to a 5 Gg CO_2 equivalents decrease in for 1990 and a 15 Gg CO_2 equivalents decrease for 2009.

9.2.2 Industry

Recalculations in this sector involve correcting activity data for limestone use in 2008 leading to minor increase in emissions and changed estimates of emissions due to consumption of halocarbons and SF_6.

Consumption of Halocarbons and SF_6

The import of HFCs was revised. The result was that activity data for industrial refrigeration deviated between last submission and this year´s submission. The deviations are bidirectional, i.e. the amounts of imported refrigerants of this year's submission were up to 16% above as well as up to 11% below the ones of last year´s submission. For most years though, the difference was only few%. For 2009 it was only 0.1%.

Annual emission rates were updated for all three refrigeration and air conditioning sub-applications. They were lowered from 15% (all three subcategories) in the 2011 submission to 10% (MACs and industrial refrigeration) and 0.3% (domestic refrigeration) in the 2012 submission.

The combination of changes in activity data and emission factors led to the changes shown in Table 9.2.

Table 9.2. Recalculations results for consumption of Halocarbons in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	NO	NO	NA	NA
1995	4.24	0.34	-3.90	-92.08
2000	26.96	19.13	-7.83	-29.04
2005	48.54	35.13	-13.41	-27.63
2009	85.82	55.24	-30.58	-35.63

9.2.3 Solvent and other Product Use

The methodology to estimate NMVOC emissions from Solvents and other product use has been revised thoroughly. Changes include inclusion of new activity data, relocation of activity data between subcategories, emission factors and methodology. These changes and recalculations are discussed at length in chapter 5. Their combined effect on emission estimates is shown in Table 9.3.

Table 9.3. Recalculation results for NMVOC emissions from solvents and other product use in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	7.94	3.07	-4.87	-61.35
1995	9.38	3.21	-6.17	-65.76
2000	10.36	3.71	-6.65	-64.20
2005	12.89	3.53	-9.36	-72.60
2009	4.98	3.16	-1.82	-36.47

The inclusion of previously unconsidered activity data led to a sizable increase of N_2O emissions from product use in 2009. The slight differences for prior years are due to a change in methodology (Table 9.4).

Table 9.4. Recalculation results for N_2O emissions from product use in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	6.00	6.00		
1995	4.71	4.29	-0.42	-8.88
2000	4.53	4.60	0.08	1.70
2005	3.29	3.35	0.06	1.86
2009	0.90	3.15	2.25	250.60

9.2.4 Agriculture

Activity data

Activity data has been revised for the following livestock categories: cattle, sheep, horses, swine, and poultry. Additionally, input data for the enhanced livestock categorization of cattle and sheep has been revised. These changes affected all agriculture emission subcategories.

Enteric fermentation

Methane emission estimates from enteric fermentation were lowered between submissions. The main driver behind this reduction is the reduction of methane emissions from mature ewes. This reduction is mainly due to decreased net energy for lactation which in turn is caused by the correction of weight of lambs at weaning. The combined effect of activity data and emission factor changes on total methane emissions from enteric fermentation is shown Table 9.5.

Table 9.5. Recalculation results for CH_4 emissions from enteric fermentation in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	264.98	243.90	-21.08	-7.96
1995	242.95	224.14	-18.81	-7.74
2000	234.99	221.33	-13.66	-5.81
2005	223.17	214.19	-8.97	-4.02
2009	232.79	225.68	-7.11	-3.05

Manure management – CH_4

Emission factors for cattle and sheep were moved from Tier 1 (1996 GL default) to Tier 2 (enhanced livestock characterisation with national input data). This led to an increase in manure management CH_4 emissions from other mature cattle and all sheep subcategories with the exception of lambs. The enhanced livestock characterization resulted in an implied emission factor of 0.5 kg CH_4 per head and year for sheep (all subcategories), which was considerably higher than the default value of 0.19 kg CH_4 used in the 2011 submission. The combined effect of activity data and emission factor changes on total methane emissions from manure management are shown in Table 9.6.

Table 9.6. Recalculation results for CH_4 emissions from manure management in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	22.28	30.48	8.20	36.79
1995	21.72	27.98	6.26	28.84
2000	21.12	28.45	7.33	34.73
2005	19.72	27.60	7.88	39.97
2009	21.01	29.75	8.75	41.63

Manure management – N_2O

Nitrogen excretion rates in the 2012 submission were calculated using 2006 GL methodology (with the exception of mature dairy cattle for which national values exist). This changed emission actors for all livestock categories between submissions. The increase of nitrogen excretion rates for sheep had the most impact due to their big population size. The combined effect of activity data and emission factor changes on total N_2O from manure management is shown in Table 9.7.

Table 9.7. Recalculation results for N_2O emissions from manure management in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	31.74	52.04	20.30	63.95
1995	29.21	41.02	11.81	40.41
2000	28.95	43.13	14.18	48.96
2005	27.18	41.74	14.56	53.56
2009	28.63	42.92	14.30	49.95

Direct and indirect N_2O emissions from agricultural soils

The changes in livestock nitrogen excretion rates discussed above increased N_2O emissions from agricultural soils as well. Direct N_2O emissions were further increased by the increase in the area of cultivated organic soils. The combined effect of activity data and emission factor changes on total N_2O emissions from soils is shown in Table 9.8.

Table 9.8. Recalculation results for N_2O emissions from agricultural soils in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	256.23	376.71	120.47	47.02
1995	248.18	342.43	94.25	37.98
2000	266.93	359.96	93.04	34.86
2005	228.33	326.43	98.10	42.97
2009	256.83	356.07	99.24	38.64

9.2.5 LULUCF

Forest land

The emission/removal estimate for forest land has been revised from 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 since then. As result of these recalculations the total reported removal has increased from -257.93 Gg CO_2-equivalents for the year 2009 as reported in 2011 submission to -258.54 Gg CO_2-equivalents in this year's submission or a 0.3% increase in removal (Table 9.9).

Table 9.9. Recalculation results for CO_2 and N_2O emissions from forest land in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	-23.73	-31.82	8.09	-34.08
1995	-46.62	-52.32	5.70	-12.23
2000	-114.21	-120.04	5.83	-5.11
2005	-180.38	-184.55	4.17	-2.31
2009	-257.93	-258.54	0.61	-0.24

Cropland

In this submission the area of the category has been revised and the structure of the data changed. New stock changes are previously not estimated are now estimated. As result of this almost all calculation of the Cropland category is revised. Emission from liming is the only component not revised (Table 9.10).

Table 9.10. Recalculation results for CO_2 emissions from cropland in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	991.33	1198.36	207.03	20.88
1995	991.33	1169.54	178.21	17.98
2000	991.33	1139.59	148.27	14.96
2005	994.78	1112.15	117.37	11.80
2009	995.34	1087.18	91.83	9.23

Grassland

Information reported for grassland has been restructured according to available time series and meaningful conversion period. This major revision of structure has affected almost all categories reported. Accordingly the estimated emissions for all subcategories have been recalculated for the years 1990-2010 (Table 9.11)

The emissions for subcategory Cropland converted to Grassland are now reported for the first time. These emissions are also calculated for the years 1990-2009.

Table 9.11. Recalculation results for CO2 emissions from grassland in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	59.26	-50.39	-109.65	-185.02
1995	23.68	-69.20	-92.88	-392.18
2000	-36.84	-105.47	-68.62	186.26
2005	-99.59	-141.69	-42.10	42.27
2009	-150.05	-165.37	-15.32	10.21

9.2.6 Waste

Solid Waste Disposal on Land

There have been numerous changes to activity data and emission factors. The distinction between industrial waste and municipal solid waste was abandoned. Waste generation was recalculated and increased thus. Waste allocation shares going to managed and unmanaged SWDS were revised. Waste composition shares now have annual resolution. The methane correction factors for managed, aerobic SWDS and unmanaged, shallow SWDS were lowered. A calculation error regarding methane gas recovery was corrected. All these changes are discussed at length in chapter 8.2.5. Their combined effect on CH4 emission estimates from SWD is shown in Table 9.12.

Table 9.12. Recalculation results for CH_4 emissions from SWD in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	133.86	122.83	-11.03	-8.24
1995	151.43	163.46	12.03	7.94
2000	163.97	188.61	24.64	15.02
2005	166.74	204.85	38.11	22.85
2009	184.58	199.07	14.49	7.85

Wastewater

The MCF for untreated discharge of domestic wastewater was lowered from 0.1 to zero. Nevertheless did methane emissions from domestic wastewater increase from 0.07 Gg to 0.17 Gg methane between 2011 and 2012 submissions (2009). This is mainly due to a miscalculation in the 2011 submission. There the MCFs for discharge pathways were used twice: firstly while calculating emission factors and secondly while calculating emissions. Thus emissions were lowered wrongly by a factor of seven to nine (time dependent). Less impact had the revaluation of the organic component removed as sludge. During the 2011 submission sludge removal was calculated without regard to actual removed amounts reported. These calculations resulted in a sludge fraction tantamount to 10% of total organics in wastewater. By taking reported sludge amounts removed into account the fraction of sludge removed was lowered to below one%, thus increasing domestic wastewater emissions slightly.

The MCF for untreated discharge was lowered from 0.1 to zero. Thus methane emissions from industrial wastewater were lowered from 0.7 Gg (2009) to zero Gg.

N_2O emission estimates from wastewater decreased slightly due to the consideration of nitrogen removed with sludge.

Total wastewater emission estimates of the 2011 and 2012 emissions are shown in Table 9.13.

Table 9.13. Recalculation results for CH_4 and N_2O emissions from wastewater in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	20.18	7.77	12.40	61.47
1995	24.71	8.91	15.79	63.93
2000	25.95	9.40	16.54	63.76
2005	24.75	12.25	12.50	50.49
2009	24.38	11.54	12.84	52.67

Waste incineration

There have been changes to the allocation of activity data inside the source category. Two waste incineration plants that were allocated to incineration with energy recovery and whose emissions were thus allocated to the energy sector are now allocated to waste incineration without energy recovery. Thus their emissions are allocated to the waste sector. The amount of wood burned in bonfires was revised. The composition of waste incinerated was assessed for the first time in the 2012 submission. This affected CO_2 emissions. The combined effect of activity data and emission factor changes on former and current emission estimates from waste incineration are shown in Table 9.14.

Table 9.14. Recalculation results for CO_2, CH_4, and N_2O emissions from product use in Gg CO_2-equivalents.

	Previous submission	Latest submission	Difference (Gg)	Difference (%)
1990	25.53	17.28	8.24	32.30
1995	17.44	11.73	5.71	32.76
2000	10.34	6.81	3.53	34.16
2005	1.21	4.93	-3.72	-308.23
2009	0.87	10.72	-9.85	-1129.62

9.3 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, in accordance with the formal agreement between EA and NEA.
- 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 emissions from HFCs.
- Move emission estimates of SF_6 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 ongoing task of the AUI.
- Ongoing national forest inventory (NFI) will further improve both estimates of Forest land area and Carbon stock changes.
- Similar effort as the NFI regarding Revegetation began in 2007. The Revegetation inventory is expected to provide improved data on carbon stock changes and area of revegetated land in the next two years.
- Further improvement of the time series already presented for different land use categories and the estimate on past and present land use changes and preparation of time series for remaining land use categories.

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.

PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

10 KYOTO PROTOCOL – LULUCF

10.1 General Information

The Icelandic greenhouse gas emission inventory for the KP LULUCF is prepared by the AUI on basis of information provided by the IFS 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.

10.1.1 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 IFS

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 10.1.

Table 10.1. 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 native woodland will reach 5 m height at maturity according National Forest Inventory (NFI) data. By widening the definition of forest, 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.

10.1.2 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 inventories aimed at deforested areas are performed together with official annual register of deforestation in accordance with the forest act (no. 3/1955) (See further description in Chapter 10.4).

Within Region 1 all cultivated forests and natural birch woodland are already mapped. 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.

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 years interval. The NIRA started in 2007 and estimation of changes in C-pools on revegetated land based on the data from NIRA will be available before the 2013 submission as first SSPP will be revisited 2012. In the present submission the data already available from 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 7.14 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 7.14 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.

10.1.3 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 Iceland Forestry Service (IFS) 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 four years of the program, 822 sampling points have been selected as potential sampling points. 341 have been discarded after site visits or are still undetermined, (24%), 435 been sampled (53%), and 46 (6%) 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 will start in 2012.

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).

10.2 Land-Related Information

10.2.1 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 both cultivated forest and natural birch woodlands. The area of afforestation 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.

10.2.2 Methodology Used to Develop the Land Transition Matrix

Land transition matrix was prepared based on data for activity area in the years 1990, 2008 and 2009. All revegetation activity involving tree planting are categorized from the beginning as Afforestation and reported as Other land converted to Forest land. 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.

10.2.3 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.

10.3 Activity-Specific Information

10.3.1 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.

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 and dead wood is assumed not to occur, as described later in this chapter.

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 - 2008 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 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

The only carbon pool that is omitted under Article 3.3 in this year's submission is the carbon pool of dead wood. Measurements of dead wood are performed on the field

SSPPs in the NFI and dead wood is defined in similar way as in NFIs in other European countries (Snorrason 2010b). It is only possible to estimate changes in the dead wood pool after all the plots have been revisited in years 2010-2014. It can be stated that occurrence of dead wood in land Afforested since 1990 was very rare in the first NFI conducted in the year's 2005-2009 which can be explained by young age of the these afforestation sites.

Carbon stock samples of litter are collected on field plots under the field measurement in NFI. As for the dead wood, carbon stock changes in litter will also be available from NFI data when sampling plots have been revisited in the period 2010-2014. In the meantime results from two separate studies 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). They did show significant and considerable increase in the carbon stock of litter for up to 50 years old afforestation areas with different tree species on different sites. Similarly, 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).

Changes in other carbon pools are currently only partially omitted. Afforestation of natural birch forest on abandoned grazing land is currently omitted for all carbon pools as crucial mapping data for these afforestation sites are still lacking. Mapping of these afforestation sites started in 2010 and is planned to be finished in 2014.

Losses of aboveground biomass of trees because of wood removal after thinning or clear cutting are omitted as wood removal was not detected for afforestation since 1990 in the first NFI. Wood removal was only detected on older afforestation sites and in natural birch forests, where its extraction did not result in deforestation. These sources will be estimated as they are detected when revisiting field plots in future NFIs after commercial thinning with wood removal has started on sites afforested since 1990.

Article 3.4

Losses in Revegetation are not detected specifically. 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 30.30 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.

10.4 Article 3.3

10.4.1 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. As mentioned before afforestation of natural birch forest is still missing but will in the future also be estimated in field. They 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.

10.4.2 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.

10.4.3 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.

10.5 Article 3.4

10.5.1 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.

10.5.2 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.

10.5.3 Information Relating to Forest Management

Forest management is not elected.

10.6 Other Information

10.6.1 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 transport -(Civil aviation and Navigation) CO_2 emission (56.07 Gg CO_2) the smallest key category of level including LULUCF in the year 2010.

11 INFORMATION ON ACCOUNTING OF KYOTO UNITS

11.1 Background Information

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.

The Icelandic Greenhouse Gas Registry is maintained by the Environment Agency. A full description of the registry was given in Iceland's Initial Report. Some changes have been made since then and the Icelandic National Registry within the Union Registry has been established with limitation to aircraft operator holding accounts which are of no concern to the Kyoto Protocol. The status of the current Kyoto Protocol registry was presented in NIR 2010; the main changes are given in Chapter 13.

In May 2010 the Icelandic registry did go live with the ITL as non-operational registry during the period prior to the connection to the CITL, since CITL cannot recognize transactions made only within the ITL.

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 did not submit the SEF tables, as Iceland has not yet transferred or acquired any Kyoto Protocol units.

11.2 Summary of Information reported in the SEF Tables

Iceland has not reported information on its accounting of Kyoto Protocol units in the required SEF tables, as required by decisions 15/CMP.1 and 14/CMP.1 as Iceland has not issued its assigned amount or transferred any Kyoto Protocol units.

11.3 Discrepancies and Notifications

No discrepancies and notifications have occurred as Iceland has not issued its assigned amount or transferred any Kyoto Protocol units.

11.4 Publicly Accessible Information

No public information is available but will be made available as soon as the Union Registry will have operational live connection with the ITL and the EUTL has been established.

11.5 Calculation of the Commitment Period Reserve (CPR)

The Annex to Decision 11/CMP.1 specifies that: 'each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90% of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8 of the Kyoto Protocol, or 100% of 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 × 4,542,054 tonnes CO_2 equivalent

= 22,710,270 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.

11.6 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 147.321 Gg in 2008, 158.611 Gg in 2009 and 171.767 Gg in 2010 or to 477.699 Gg in total for these three years. Removals from Article 3.4 (Net-Net accounting) amounted to 152.412 Gg in 2008, 159.595 Gg in 2009 and 166.861 Gg in 2010 or to 478.867 Gg in total for these three years. This would allow issuance of 956,567 RMUs.

Table 11. 1. Removals from activities under Article 3.3 and 3.4 and resulting RMUs.

	2008	2009	2010	Total
Article 3.3 Gg	147.321	158.611	171.767	477.699
Article 3.4 Gg	152.412	159.595	166.681	478.867
RMUs (3 years of five)				956,567

11.7 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 and 2010. Further description of these projects can be found in Chapter 4.5. The total emissions fulfilling the provisions of Decision 14/CP.7 amounted to 1163 Gg in 2008 , to 1187 Gg in 2009 and to 1216 Gg in 2010.

12 INFORMATION ON CHANGES IN NATIONAL SYSTEM

No changes have been made regarding the national system since last submission.

13 INFORMATION ON CHANGES IN NATIONAL REGISTRY

The Icelandic Greenhouse Gas Registry is maintained by the Environment Agency. A full description of the registry was given in Iceland's Initial Report. Some changes have been made since then as well as the Icelandic National Registry within the Union Registry has been established with limitation to aircraft operator holding accounts which are of no concern to the Kyoto Protocol. The status of the current Kyoto Protocol registry was presented in NIR 2010.

In May 2010 the Icelandic registry did go live with the ITL as non-operational registry during the period prior to the connection to the CITL, since CITL cannot recognize transactions made only within the ITL.

13.1 Implementing and running the registry system

The Environment Agency of Iceland is responsible for the implementation and operation of Iceland's National Registry under the Kyoto Protocol. The software used for the Icelandic National Registry is GRETA (Greenhouse gases Registry for Emissions Trading Arrangements) The IT software supplier of GRETA is SFW.

As of 30 June 2012 the GRETA software will be terminated and the Icelandic National Registry will be a separate registry entity within the consolidate registries of the European Union, the Union Registry.

Contact details of registry administrators

Institution:	Environment Agency
Contact:	Department for Environmental Quality
Address:	Sudurlandsbraut 24 IS-108 Reykjavík, Iceland
Email:	(ets-registry@ust.is)
Telephone:	+354 591 2000
Fax:	+354 591 2020
Registry System Administrators:	Ágúst Angantýsson (agust.angantysson@umhverfisstofnun.is) Birna Hallsdóttir (birna@umhverfisstofnun.is)

13.2 Technical description

The technical description of the Icelandic National Registry, presented in NIR 2010 is in accordance with the reporting requirements in Annex II under decision 15/CMP.1.

13.3 Consolidated registry systems

Currently the Icelandic National Registry is a standalone registry; it is not operated together in a consolidated form with the registries of other nations.

Changes to the Icelandic National Registry will occur 30 June 2012 when it will be a separate registry entity within the consolidated registries of the EU ETS, the Union Registry. Technical description of the Union Registry will be reported when available.

13.4 Migration to the Union Registry

Assigned amount units have never been created in the current registry and due to this reason no migration from the current registry to the Union Registry will be necessary.

14 INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

Table 14.1. 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 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 has operated over thirty years, building up expertise in the utilization of geothermal energy, by training more than 400 experts from over 40 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

15 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 in Chapter 1 lists identified key sources. Table A1 shows the level assessment of the key source analysis for 2009, 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 – level assessment 2010.

	Emission/removal category	GHG	Current Year Estimate Non-LULUCF	Current Year Estimate LULUCF	Current Year Estimate Absolute Value	Level Assessment with-out LULUCF	Cumulative Total of Column to left	Level Assessment with LULUCF	Cumulative Total of Column to left
2.C.3	Aluminium	CO_2	1219.09	0	1219.09	0.268	0.268	0.177	0.177
5.B.1	Cropland remaining cropland	CO_2	0	1014.53	1014.53	0.000	0.268	0.147	0.325
1.AA.3b	Road transport	CO_2	805.52	0	805.52	0.177	0.446	0.117	0.442
1.AA.4c	Fishing	CO_2	534.65	0	534.65	0.118	0.563	0.078	0.520
5.C.2.5	Other land converted to grassland, revegetation	CO_2	0	-515.98	515.98	0.000	0.563	0.075	0.595
2.C.2	Ferroalloys	CO_2	359.43	0	359.43	0.079	0.643	0.052	0.647
5.C.1	Wetland drained for more than 20 years	CO_2	0	289.24	289.24	0.000	0.643	0.042	0.689
1.AA.2	Manufacturing industry and construction	CO_2	199.35	0	199.35	0.044	0.686	0.029	0.718
1.B.2	Geothermal energy	CO_2	188.98	0	188.98	0.042	0.728	0.027	0.745
5.A	Forest land- Afforestation	CO_2	0	-183.13	183.13	0.000	0.728	0.027	0.772
6.A.1	Managed waste disposal on land	CH_4	160.33	0	160.33	0.035	0.763	0.023	0.795
2.C.3	Aluminium	PFC	145.63	0	145.63	0.032	0.795	0.021	0.816
4.D.1	Direct soil emissions	N_2O	134.73	0	134.73	0.030	0.825	0.020	0.836
4.D.3	Indirect soil emissions	N_2O	127.14	0	127.14	0.028	0.853	0.018	0.854
4.A.3	Enteric fermentation, sheep	CH_4	123.16	0	123.16	0.027	0.880	0.018	0.872
5.A	Forest land- Natural birch forest	CO_2	0	-88.66	88.66	0.000	0.880	0.013	0.885
4.D.2	Animal production	N_2O	84.18	0	84.18	0.019	0.899	0.012	0.897
5.G	Grassland non CO2-emissions	N_2O	0	77.93	77.93	0.000	0.899	0.011	0.909
4.A.1	Enteric fermentation, cattle	CH_4	72.81	0	72.81	0.016	0.915	0.011	0.919
5.C.2.1-4	Other conversion to grassland	CO_2	0	70.48	70.48	0.000	0.915	0.010	0.930
2.F	Consumption of halocarbons and SF6	HFC	69.00	0	69.00	0.015	0.930	0.010	0.940
5.B.2	Land converted to cropland	CO_2	0	64.43	64.43	0.000	0.930	0.009	0.949

Table A1 continued									
	Emission/removal category	**GHG**	**Current Year Estimate Non-LULUCF**	**Current Year Estimate LULUCF**	**Current Year Estimate Absolute Value**	**Level Assessment without LULUCF**	**Cumulative Total of Column to left**	**Level Assessment with LULUCF**	**Cumulative Total of Column to left**
1.AA.3a/d	Transport	CO_2	56.07	0	56.07	0.012	0.942	0.008	**0.957**
4.B	Manure management	N_2O	42.94	0	42.94	0.009	**0.952**	0.006	0.963
1.AA.3b	Road transport	N_2O	36.66	0	36.66	0.008	0.960	0.005	0.969
4.A.4-10	Enteric fermentation, rest	CH_4	31.62	0	31.62	0.007	0.967	0.005	0.973
6.A2	Unmanaged waste disposal sites	CH_4	30.30	0	30.30	0.007	0.973	0.004	0.978
4.B	Manure management	CH_4	29.59	0	29.59	0.007	0.980	0.004	0.982
1.AA.4a/b	Residential/institutional/commercial	CO_2	15.69	0	15.69	0.003	0.983	0.002	0.984
5.C.1	Other remaining grassland	CO_2	0	-14.30	14.30	0.000	0.983	0.002	0.986
1.AA.2	Manufacturing industry and construction	N_2O	13.21	0	13.21	0.003	0.986	0.002	0.988
2.A	Mineral production	CO_2	10.64	0	10.64	0.002	0.989	0.002	0.990
5.D.2	Land converted to wetland (reservoirs)	CO_2	0	9.72	9.72	0.000	0.989	0.001	0.991
5.D.2	Land converted to wetland (reservoirs)	CH_4	0	8.33	8.33	0.000	0.989	0.001	0.992
6.C	Waste incineration	CO_2	8.26	0	8.26	0.002	0.991	0.001	0.994
6.B	Wastewater handling	N_2O	8.09	0	8.09	0.002	0.992	0.001	0.995
2.F	Consumption of halocarbons and SF6	SF_6	4.95	0	4.95	0.001	0.993	0.001	0.996
1.AA.1	Public electricity and heat production	CO_2	4.49	0	4.49	0.001	0.994	0.001	0.996
1.AA.4c	Fishing	N_2O	4.47	0	4.47	0.001	0.995	0.001	0.997
1.B.2	Geothermal energy	CH_4	3.72	0	3.72	0.001	0.996	0.001	0.997
6.B	Wastewater handling	CH_4	3.51	0	3.51	0.001	0.997	0.001	0.998
3	Solvent and other product use	N_2O	3.41	0	3.41	0.001	0.998	0.000	0.998
3	Solvent and other product use	CO_2	2.74	0	2.74	0.001	0.998	0.000	0.999
1.AA.3b	Road transport	CH_4	1.54	0	1.54	0.000	0.999	0.000	0.999

Table A1 continued									
	Emission/removal category	**GHG**	**Current Year Estimate Non-LULUCF**	**Current Year Estimate LULUCF**	**Current Year Estimate Absolute Value**	**Level Assessment without LULUCF**	**Cumulative Total of Column to left**	**Level Assessment with LULUCF**	**Cumulative Total of Column to left**
6.D	Other (composting)	N_2O	1.42	0	1.42	0.000	0.999	0.000	0.999
6.D	Other (composting)	CH_4	1.28	0	1.28	0.000	0.999	0.000	0.999
1.AA.4c	Fishing	CH_4	1.06	0	1.06	0.000	0.999	0.000	1.000
5.A	Forest land - Afforestation	N_2O	0	0.98	0.98	0.000	0.999	0.000	1.000
2.C	Metal production	CH_4	0.90	0	0.00	0.000	1.000	0.000	1.000
1.AA.3a/d	Transport	N_2O	0.48	0	0.48	0.000	1.000	0.000	1.000
6.C	Waste incineration	CH_4	0.31	0	0.31	0.000	1.000	0.000	1.000
6.C	Waste incineration	N_2O	0.31	0	0.31	0.000	1.000	0.000	1.000
5.E.2.1	Forest land converted to settlements	CO_2	0	0.22	0.22	0.000	1.000	0.000	1.000
1.AA.2	Manufacturing industry and construction	CH_4	0.17	0	0.17	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat production	N_2O	0.09	0	0.09	0.000	1.000	0.000	1.000
1.AA.3a/d	Transport	CH_4	0.07	0	0.07	0.000	1.000	0.000	1.000
1.AA.4a/b	Residential/institutional/commercial	N_2O	0.03	0	0.03	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat production	CH_4	0.03	0	0.03	0.000	1.000	0.000	1.000
1.AA.4a/b	Residential/institutional/commercial	CH_4	0.01	0	0.01	0.000	1.000	0.000	1.000
2.B	Chemical industry	CO_2	0.00	0	0.00	0.000	1.000	0.000	1.000
2.B	Chemical industry	N_2O	0.00	0	0.00	0.000	1.000	0.000	1.000
	Total		**4542.05**	**733.80**	**6879.08**				

Table A2: Key source analysis – level assessment 1990.

	Emission/removal category	**GHG**	**Current Year Esti-mate Non-LULUCF**	**Current Year Esti-mate LULUCF**	**Current Year Esti-mate Abso-lute Value**	**Level Assess-ment with-out LU-LUCF**	**Cumu-lative Total of Col-umn to left**	**Level Assess-ment with LU-LUCF**	**Cumula-tive Total of Col-umn to left**
5.B.1	Cropland remaining cropland	CO_2	0	764.03	764.03	0.000	0.000	0.140	0.140
1.AA.4c	Fishing	CO_2	655.49	0	655.49	0.187	0.187	0.120	0.260
1.AA.3b	Road transport	CO_2	521.26	0	521.26	0.149	0.336	0.096	0.356
5.B.2	Land converted to cropland	CO_2	0	434.33	434.33	0.000	0.336	0.080	0.436
2.C.3	Aluminium	PFC	419.63	0	419.63	0.120	0.456	0.077	0.513
1.AA.2	Manufacturing industry and con-struction	CO_2	360.79	0	360.79	0.103	0.559	0.066	0.579
5.C.2.5	Other land convert-ed to grassland, revegetation	CO_2	0	-349.12	349.12	0.000	0.559	0.064	0.643
2.C.2	Ferroalloys	CO_2	204.13	0	204.13	0.058	0.617	0.037	0.680
5.C.1	Wetland drained for more than 20 years	CO_2	0	170.15	170.15	0.000	0.617	0.031	0.711
4.D.1	Direct soil emis-sions	N_2O	145.53	0	145.53	0.042	0.659	0.027	0.738
4.A.3	Enteric fermenta-tion, sheep	CH_4	143.05	0	143.05	0.041	0.700	0.026	0.764
4.D.3	Indirect soil emis-sions	N_2O	141.43	0	141.43	0.040	0.740	0.026	0.790
2.C.3	Aluminium	CO_2	136.49	0	136.49	0.039	0.779	0.025	0.815
5.C.2.1/2/ 3/4	Other conversion to grassland	CO_2	0	126.26	126.26	0.000	0.779	0.023	0.839
6.A2	Unmanaged waste disposal sites	CH_4	109.42	0	109.42	0.031	0.810	0.020	0.859
1.AA.3a/d	Transport	CO_2	91.11	0	91.11	0.026	0.836	0.017	0.875
4.D.2	Animal production	N_2O	89.75	0	89.75	0.026	0.862	0.016	0.892
4.A.1	Enteric fermenta-tion, cattle	CH_4	71.51	0	71.51	0.020	0.882	0.013	0.905
5.G	Grassland non CO2-emissions	N_2O	0	68.73	68.73	0.000	0.882	0.013	0.918
1.B.2	Geothermal energy	CO_2	61.36	0	61.36	0.018	0.900	0.011	0.929
2.A	Mineral production	CO_2	52.28	0	52.28	0.015	0.915	0.010	0.938
4.B	Manure manage-ment	N_2O	52.04	0	52.04	0.015	0.930	0.010	0.948
2.B	Chemical industry	N_2O	48.36	0	48.36	0.014	0.944	0.009	**0.957**
1.AA.4a/b	Residen-tial/institutional/co mmercial	CO_2	42.84	0	42.84	0.012	**0.956**	0.008	0.965

Table A2 continued									
	Emission/removal category	GHG	Current Year Esti-mate Non-LULUCF	Current Year Esti-mate LULUCF	Current Year Esti-mate Abso-lute Value	Level Assess-ment with-out LU-LUCF	Cumu-lative Total of Col-umn to left	Level Assess-ment with LU-LUCF	Cumula-tive Total of Col-umn to left
5.A	Forest land- Affor-estation	CO_2	0	-32.17	32.17	0.000	0.956	0.006	0.971
4.B	Manure manage-ment	CH_4	30.48	0	30.48	0.009	0.964	0.006	0.976
4.A.4-10	Enteric fermenta-tion, rest	CH_4	29.35	0	29.35	0.008	0.973	0.005	0.982
1.AA.2	Manufacturing industry and con-struction	N_2O	15.91	0	15.91	0.005	0.977	0.003	0.984
1.AA.1	Public electricity and heat produc-tion	CO_2	13.64	0	13.64	0.004	0.981	0.003	0.987
6.A.1	Managed waste disposal on land	CH_4	13.42	0	13.42	0.004	0.985	0.002	0.989
6.C	Waste incineration	CO_2	10.69	0	10.69	0.003	0.988	0.002	0.991
6.B	Wastewater han-dling	N_2O	6.37	0	6.37	0.002	0.990	0.001	0.993
3	Solvent and other product use	N_2O	6.00	0	6.00	0.002	0.992	0.001	0.994
1.AA.4c	Fishing	N_2O	5.51	0	5.51	0.002	0.993	0.001	0.995
6.C	Waste incineration	CH_4	5.19	0	5.19	0.001	0.995	0.001	0.996
1.AA.3b	Road transport	N_2O	4.54	0	4.54	0.001	0.996	0.001	0.996
3	Solvent and other product use	CO_2	3.07	0	3.07	0.001	0.997	0.001	0.997
1.AA.3b	Road transport	CH_4	2.96	0	2.96	0.001	0.998	0.001	0.998
5.C.1	Other remaining grassland	CO_2	0	2.32	2.32	0.000	0.998	0.000	0.998
5.D.2	Land converted to wetland (reservoirs)	CO_2	0	1.86	1.86	0.000	0.998	0.000	0.998
5.D.2	Land converted to wetland (reservoirs)	CH_4	0	1.60	1.60	0.000	0.998	0.000	0.999
6.B	Wastewater han-dling	CH_4	1.40	0	1.40	0.000	0.998	0.000	0.999
6.C	Waste incineration	N_2O	1.40	0	1.40	0.000	0.999	0.000	0.999
1.AA.4c	Fishing	CH_4	1.31	0	1.31	0.000	0.999	0.000	0.999
2.F	Consumption of halocarbons and SF6	SF_6	1.13	0	1.13	0.000	0.999	0.000	1.000
1.AA.3a/d	Transport	N_2O	0.77	0	0.77	0.000	0.999	0.000	1.000
2.C	Metal production	CH_4	0.61	0	0.61	0.000	1.000	0.000	1.000
2.B	Chemical industry	CO_2	0.36	0	0.36	0.000	1.000	0.000	1.000
1.B.2	Geothermal energy	CH_4	0.27	0	0.27	0.000	1.000	0.000	1.000

Table A2 continued									
	Emission/removal category	GHG	Current Year Esti-mate Non-LULUCF	Current Year Esti-mate LULUCF	Current Year Esti-mate Abso-lute Value	Level Assess-ment with-out LU-LUCF	Cumu-lative Total of Col-umn to left	Level Assess-ment with LU-LUCF	Cumula-tive Total of Col-umn to left
1.AA.2	Manufacturing industry and con-struction	CH_4	0.25	0	0.25	0.000	1.000	0.000	1.000
1.AA.3a/d	Transport	CH_4	0.12	0	0.12	0.000	1.000	0.000	1.000
1.AA.4a/b	Residen-tial/institutional/commercial	N_2O	0.10	0	0.10	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat produc-tion	N_2O	0.02	0	0.02	0.000	1.000	0.000	1.000
1.AA.4a/b	Residen-tial/institutional/commercial	CH_4	0.02	0	0.02	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat produc-tion	CH_4	0.01	0	0.01	0.000	1.000	0.000	1.000
6.D	Other (composting)	CH_4	0.00	0	0.00	0.000	1.000	0.000	1.000
5.A	Forest land- Natural birch forest	CO_2	0	0.17	0.00	0.000	1.000	0.000	1.000
5.E.2.1	Forest land con-verted to settle-ments	CO_2	0	0.00	0.00	0.000	1.000	0.000	1.000
2.F	Consumption of halocarbons and SF6	HFC	0.00	0	0.00	0.000	1.000	0.000	1.000
5.A	Forest land - Affor-estation	N_2O	0	0.18	0.00	0.000	1.000	0.000	1.000
6.D	Other (composting)	N_2O	0.00	0	0.00	0.000	1.000	0.000	1.000
			3501.36	**1188.33**	**5451.92**				

Table A3: Key source analysis – trend assessment.

	Emission/removal category	GHG	Base Year Esti-mate	Current Year Esti-mate	Asbo-lute Esti-mate	Level Assess-ment	Trend Assess-ment	Contri-bution to Trend	Cumu-lative Total
2.C.3	Aluminium	CO_2	136.5	1219.1	1219.1	0.177	0.138	0.262	0.262
5.B.2	Land converted to cropland	CO_2	434.3	64.4	64.4	0.009	0.055	0.104	0.366
2.C.3	Aluminium	PFC	419.6	145.6	145.6	0.021	0.042	0.080	0.446
1.AA.3b	Road transport	CO_2	521.3	805.5	805.5	0.117	0.028	0.054	0.500
1.AA.2	Manufacturing industry and con-struction	CO_2	360.8	199.4	199.4	0.029	0.027	0.051	0.551
1.AA.4c	Fishing	CO_2	655.5	534.7	534.7	0.078	0.026	0.050	0.601
5.B.1	Cropland remaining cropland	CO_2	764.0	1014.5	1014.5	0.147	0.020	0.038	0.639
5.A	Forest land- Affor-estation	CO_2	-32.2	-183.1	183.1	0.027	0.019	0.036	0.675
6.A.1	Managed waste disposal on land	CH_4	13.4	160.3	160.3	0.023	0.019	0.036	0.711
2.C.2	Ferroalloys	CO_2	204.1	359.4	359.4	0.052	0.017	0.032	0.743
5.C.2.5	Other land convert-ed to grassland, revegetation	CO_2	-349.1	-516.0	516.0	0.075	0.016	0.030	0.773
1.B.2	Geothermal energy	CO_2	61.4	189.0	189.0	0.027	0.016	0.029	0.803
5.C.1	Wetland drained for more than 20 years	CO_2	170.2	289.2	289.2	0.042	0.013	0.024	0.827
6.A2	Unmanaged waste disposal sites	CH_4	109.4	30.3	30.3	0.004	0.012	0.023	0.849
5.A	Forest land- Natural birch forest	CO_2	0.2	-88.7	88.7	0.013	0.011	0.022	0.871
5.C.2.1/2/3/4	Other conversion to grassland	CO_2	126.3	70.5	70.5	0.010	0.009	0.018	0.889
2.F	Consumption of halocarbons and SF6	HFC	0.0	69.0	69.0	0.010	0.009	0.017	0.906
2.A	Mineral production	CO_2	52.3	10.6	10.6	0.002	0.006	0.012	0.918
1.AA.3a/d	Transport	CO_2	91.1	56.1	56.1	0.008	0.006	0.011	0.929
4.A.3	Enteric fermenta-tion, sheep	CH_4	143.1	123.2	123.2	0.018	0.005	0.009	0.938
1.AA.4a/b	Residen-tial/institutional/commercial	CO_2	42.8	15.7	15.7	0.002	0.004	0.008	0.946
4.D.3	Indirect soil emis-sions	N_2O	141.4	127.1	127.1	0.018	0.004	0.008	0.954
1.AA.3b	Road transport	N_2O	4.5	36.7	36.7	0.005	0.004	0.008	0.962
4.D.1	Direct soil emis-sions	N_2O	145.5	134.7	134.7	0.020	0.004	0.007	0.969
5.C.1	Other remaining grassland	CO_2	2.3	-14.3	14.3	0.002	0.002	0.004	0.973
4.D.2	Animal production	N_2O	89.7	84.2	84.2	0.012	0.002	0.004	0.977

Table A3 continued									
	Emission/removal category	**GHG**	**Base Year Estimate**	**Current Year Estimate**	**Absolute Estimate**	**Level Assessment**	**Trend Assessment**	**Contribution to Trend**	**Cumulative Total**
4.B	Manure management	N_2O	52.0	42.9	42.9	0.006	0.002	0.004	0.981
1.AA.1	Public electricity and heat production	CO_2	13.6	4.5	4.5	0.001	0.001	0.003	0.984
5.D.2	Land converted to wetland (reservoirs)	CO_2	1.9	9.7	9.7	0.001	0.001	0.002	0.986
4.A.1	Enteric fermentation, cattle	CH_4	71.5	72.8	72.8	0.011	0.001	0.002	0.988
5.D.2	Land converted to wetland (reservoirs)	CH_4	1.6	8.3	8.3	0.001	0.001	0.002	0.989
6.C	Waste incineration	CH_4	5.2	0.3	0.3	0.000	0.001	0.001	0.991
4.B	Manure management	CH_4	30.5	29.6	29.6	0.004	0.001	0.001	0.992
1.AA.2	Manufacturing industry and construction	N_2O	15.9	13.2	13.2	0.002	0.001	0.001	0.993
6.C	Waste incineration	CO_2	10.7	8.3	8.3	0.001	0.000	0.001	0.994
2.F	Consumption of halocarbons and SF6	SF_6	1.1	4.9	4.9	0.001	0.000	0.001	0.995
1.B.2	Geothermal energy	CH_4	0.3	3.7	3.7	0.001	0.000	0.001	0.995
3	Solvent and other product use	N_2O	6.0	3.4	3.4	0.000	0.000	0.001	0.996
6.B	Wastewater handling	CH_4	1.4	3.5	3.5	0.001	0.000	0.000	0.997
1.AA.3b	Road transport	CH_4	3.0	1.5	1.5	0.000	0.000	0.000	0.997
1.AA.4c	Fishing	N_2O	5.5	4.5	4.5	0.001	0.000	0.000	0.998
6.D	Other (composting)	N_2O	0.0	1.4	1.4	0.000	0.000	0.000	0.998
4.A.4-10	Enteric fermentation, rest	CH_4	29.3	31.6	31.6	0.005	0.000	0.000	0.998
6.D	Other (composting)	CH_4	0.0	1.3	1.3	0.000	0.000	0.000	0.999
6.C	Waste incineration	N_2O	1.4	0.3	0.3	0.000	0.000	0.000	0.999
6.B	Wastewater handling	N_2O	6.4	8.1	8.1	0.001	0.000	0.000	0.999
5.A	Forest land - Afforestation	N_2O	0.2	1.0	1.0	0.000	0.000	0.000	0.999
3	Solvent and other product use	CO_2	3.1	2.7	2.7	0.000	0.000	0.000	1.000
5.G	Grassland non CO2-emissions	N_2O	68.7	77.9	77.9	0.011	0.000	0.000	1.000
1.AA.4c	Fishing	CH_4	1.3	1.1	1.1	0.000	0.000	0.000	1.000
1.AA.3a/d	Transport	N_2O	0.8	0.5	0.5	0.000	0.000	0.000	1.000
1.AA.2	Manufacturing industry and construction	CH_4	0.3	0.2	0.2	0.000	0.000	0.000	1.000

Table A3 continued									
	Emission/removal category	GHG	Base Year Esti-mate	Current Year Esti-mate	Asbo-lute Esti-mate	Level Assess-ment	Trend Assess-ment	Contri-bution to Trend	Cumu-lative Total
1.AA.4a/b	Residen-tial/institutional/commercial	N_2O	0.1	0.0	0.0	0.000	0.000	0.000	1.000
1.AA.1	Public electricity and heat produc-tion	N_2O	0.0	0.1	0.1	0.000	0.000	0.000	1.000
1.AA.3a/d	Transport	CH_4	0.1	0.1	0.1	0.000	0.000	0.000	1.000
1.AA.4a/b	Residen-tial/institutional/commercial	CH_4	0.0	0.0	0.0	0.000	0.000	0.000	1.000
1.AA.1	Public electricity and heat produc-tion	CH_4	0.0	0.0	0.0	0.000	0.000	0.000	1.000
2.B	Chemical industry	CO_2	0.4	0.0	0.0	0.000	0.000	0.000	1.000
2.B	Chemical industry	N_2O	48.4	0.0	0.0	0.000	0.000	0.000	1.000
5.E.2.1	Forest land con-verted to settle-ments	CO_2	NO	0.2	0.2	0.000	0.000	0.000	1.000
	Total		**4689.1**	**5275.0**	**6879.1**		**0.526**	**1.000**	

ANNEX II QUANTITATIVE UNCERTAINTY (including LULUCF)

	Input Data						Uncertainty of Emissions		Uncertainty of Trend				
	IPCC Source Category	Gas	Base year emissions (1990)	Year t emissions (2010)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2010	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
			Gg CO_2-equivalents		%	%	%	%	%	%	%	%	%
1.AA.1	Public electricity and heat production	CO_2	13.6	4.5	5	5	7.1	0.0	-0.002	0.001	-0.01	0.01	0.01
1.AA.1	Public electricity and heat production	CH_4	0.0	0.0	5	100	100.1	0.0	0.000	0.000	0.00	0.00	0.00
1.AA.1	Public electricity and heat production	N_2O	0.0	0.1	5	150	150.1	0.0	0.000	0.000	0.00	0.00	0.00
1.AA.2	Manufacturing industry and construction	CO_2	360.8	199.4	5	5	7.1	0.3	-0.044	0.043	-0.22	0.30	0.37
1.AA.2	Manufacturing industry and construction	CH_4	0.3	0.2	5	100	100.1	0.0	0.000	0.000	0.00	0.00	0.00
1.AA.2	Manufacturing industry and construction	N_2O	15.9	13.2	5	150	150.1	0.4	-0.001	0.003	-0.15	0.02	0.15
1.AA.3a/d	Transport	CO_2	91.1	56.1	5	5	7.1	0.1	-0.010	0.012	-0.05	0.08	0.10
1.AA.3a/d	Transport	CH_4	0.1	0.1	5	100	100.1	0.0	0.000	0.000	0.00	0.00	0.00
1.AA.3a/d	Transport	N_2O	0.8	0.5	5	200	200.1	0.0	0.000	0.000	-0.02	0.00	0.02

Table continued													
	IPCC Source Category	Gas	Base year emis-sions (1990)	Year t emis-sions (2010)	Ac-tivit y data un-cer-tain ty	Emis-sion factor uncer-tainty	Com-bined uncer-tainty	Com-bined uncer-tainty as % of total national emis-sions in year 2010	Type A sensi-tivity	Type B sensi-tivity	Uncer-tainty in trend in national emissions introduced by EF uncer-tainty	Uncer-tainty in trend in national emissions intro-duced by AD uncer-tainty	Uncer-tainty in-troduced into the trend in total na-tional emis-sions
1.AA.3b	Road transport	CO_2	521.3	805.5	5	5	7.1	1.1	0.047	0.172	0.23	1.21	1.24
1.AA.3b	Road transport	CH_4	3.0	1.5	5	40	40.3	0.0	0.000	0.000	-0.02	0.00	0.02
1.AA.3b	Road transport	N_2O	4.5	36.7	5	50	50.2	0.3	0.007	0.008	0.34	0.06	0.34
1.AA.4a/b	Residen-tial/institutional/commercial	CO_2	42.8	15.7	5	5	7.1	0.0	-0.007	0.003	-0.03	0.02	0.04
1.AA.4a/b	Residen-tial/institutional/commercial	CH_4	0.0	0.0	5	100	100.1	0.0	0.000	0.000	0.00	0.00	0.00
1.AA.4a/b	Residen-tial/institutional/commercial	N_2O	0.1	0.0	5	150	150.1	0.0	0.000	0.000	0.00	0.00	0.00
1.AA.4c	Fishing	CO_2	655.5	534.7	3	5	5.8	0.6	-0.043	0.114	-0.22	0.48	0.53
1.AA.4c	Fishing	CH_4	1.3	1.1	3	100	100.0	0.0	0.000	0.000	-0.01	0.00	0.01
1.AA.4c	Fishing	N_2O	5.5	4.5	3	150	150.0	0.1	0.000	0.001	-0.06	0.00	0.06
1.B.2	Geothermal energy	CO_2	61.4	189.0	6	8	10.0	0.4	0.026	0.040	0.20	0.34	0.40
1.B.2	Geothermal energy	CH_4	0.3	3.7	6	8	10.0	0.0	0.001	0.001	0.01	0.01	0.01
2.A	Mineral production	CO_2	52.3	10.6	5	7	8.2	0.0	-0.010	0.002	-0.07	0.02	0.07
2.B	Chemical industry	CO_2	0.4	0.0	3	1	3.2	0.0	0.000	0.000	0.00	0.00	0.00
2.B	Chemical industry	N_2O	48.4	0.0	30	40	50.0	0.0	-0.012	0.000	-0.46	0.00	0.46

Table continued													
	IPCC Source Category	**Gas**	**Base year emis-sions (1990)**	**Year t emis-sions (2010)**	**Ac-tivity data un-certainty**	**Emis-sion factor uncer-tainty**	**Com-bined uncer-tainty**	**Com-bined uncer-tainty as % of total national emis-sions in year 2010**	**Type A sensi-tivity**	**Type B sensi-tivity**	**Uncer-tainty in trend in national emissions introduced by EF uncer-tainty**	**Uncer-tainty in trend in national emissions intro-duced by AD uncer-tainty**	**Uncer-tainty in-troduced into the trend in total na-tional emis-sions**
2.C.2	Ferroalloys	CO_2	204.1	359.4	5	10	11.2	0.8	0.028	0.077	0.28	0.54	0.61
2.C.3	Aluminium	CO_2	136.5	1219.1	5	10	11.2	2.6	0.227	0.260	2.27	1.84	2.92
2.C.3	Aluminium - CF4	PFC	355.0	123.2	5	7	8.6	0.2	-0.059	0.026	-0.41	0.19	0.45
2.C.3	Aluminium - C2F6	PFC	64.6	22.4	5	22	22.6	0.1	-0.011	0.005	-0.24	0.03	0.24
2.F	Consumption of halocarbons and SF6	HFC	0.0	69.0	100	100	141.4	1.8	0.015	0.015	1.47	2.08	2.55
2.F	Consumption of halocarbons and SF6	SF_6	1.1	4.9	20	100	102.0	0.1	0.001	0.001	0.08	0.03	0.08
3	Solvent and other product use	CO_2	3.1	2.7	50	50	70.7	0.0	0.000	0.001	-0.01	0.04	0.04
3	Solvent and other product use	N_2O	6.0	3.4	5	50	50.2	0.0	-0.001	0.001	-0.04	0.01	0.04
4.A.1	Enteric fermentation, cattle	CH_4	71.5	72.8	20	20	28.3	0.4	-0.002	0.016	-0.03	0.44	0.44
4.A.3	Enteric fermentation, sheep	CH_4	143.1	123.2	20	20	28.3	0.7	-0.008	0.026	-0.16	0.74	0.76
4.A.4-10	4.A Enteric Fermentation, other	CH_4	29.3	31.6	20	20	28.3	0.2	0.000	0.007	-0.01	0.19	0.19
4.B	4.B Manure Management	CH_4	30.5	29.6	20	30	36.1	0.2	-0.001	0.006	-0.03	0.18	0.18
4.B	Manure management	N_2O	52.0	42.9	20	50	53.9	0.4	-0.003	0.009	-0.17	0.26	0.31

Table continued													
	IPCC Source Category	**Gas**	**Base year emis-sions (1990)**	**Year t emis-sions (2010)**	**Ac-tivit y data un-cer-tain ty**	**Emis-sion factor uncer-tainty**	**Com-bined uncer-tainty**	**Com-bined uncer-tainty as % of total national emis-sions in year 2010**	**Type A sensi-tivity**	**Type B sensi-tivity**	**Uncer-tainty in trend in national emissions introduced by EF uncer-tainty**	**Uncer-tainty in trend in national emissions intro-duced by AD uncer-tainty**	**Uncer-tainty in-troduced into the trend in total na-tional emis-sions**
4.D.1	Direct soil emissions	N_2O	145.5	134.7	20	25	32.0	0.8	-0.006	0.029	-0.15	0.81	0.83
4.D.2	Animal production	N_2O	89.7	84.2	20	50	53.9	0.9	-0.004	0.018	-0.18	0.51	0.54
4.D.3	Indirect soil emissions	N_2O	141.4	127.1	20	50	53.9	1.3	-0.007	0.027	-0.34	0.77	0.84
5.A	Forest land- Natural birch forest	CO_2	0.2	-88.7	14	10	17.2	-0.3	-0.019	-0.019	-0.19	-0.37	0.42
5.A	Forest land- Afforestation	CO_2	-32.2	-183.1	5	10	11.2	-0.4	-0.031	-0.039	-0.31	-0.28	0.42
5.A	Forest land - Afforestation	N_2O	0.2	1.0	5	400	400.0	0.1	0.000	0.000	0.07	0.00	0.07
5.B.1	Cropland remaining cropland	CO_2	764.0	1014.5	20	90	92.2	17.7	0.033	0.216	2.97	6.12	6.80
5.B.2	Land converted to cropland	CO_2	434.3	64.4	20	90	92.2	1.1	-0.090	0.014	-8.13	0.39	8.14
5.C.1	Wetland drained for more than 20 years	CO_2	170.2	289.2	20	90	92.2	5.1	0.021	0.062	1.88	1.74	2.56
5.C.1	Other remaining grassland	CO_2	2.3	-14.3	20	20	28.3	-0.1	-0.004	-0.003	-0.07	-0.09	0.11
5.C.2.1-4	Other conversion to grass-land	CO_2	126.3	70.5	20	90	92.2	1.2	-0.015	0.015	-1.37	0.43	1.44
5.C.2.5	Other land converted to grassland, revegetation	CO_2	-349.1	-516.0	10	10	14.1	-1.4	-0.026	-0.110	-0.26	-1.56	1.58
5.D.2	Land converted to wetland (reservoirs)	CO_2	1.9	9.7	20	50	53.9	0.1	0.002	0.002	0.08	0.06	0.10

Table continued													
	IPCC Source Category	**Gas**	**Base year emis-sions (1990)**	**Year t emis-sions (2010)**	**Ac-tivity data un-cer-tainty**	**Emis-sion factor uncer-tainty**	**Com-bined uncer-tainty**	**Com-bined uncer-tainty as % of total national emis-sions in year 2010**	**Type A sensi-tivity**	**Type B sensi-tivity**	**Uncer-tainty in trend in national emissions introduced by EF uncer-tainty**	**Uncer-tainty in trend in national emissions intro-duced by AD uncer-tainty**	**Uncer-tainty in-troduced into the trend in total na-tional emis-sions**
5.D.2	5.D Wetlands	CH_4	1.6	8.3	20	50	53.9	0.1	0.001	0.002	0.07	0.05	0.09
5.E.2.1	Forest land converted to settlements	CO_2	0.0	0.2	5	10	11.2	0.0	0.000	0.000	0.00	0.00	0.00
5.G	Grassland non CO2-emissions	N_2O	68.7	77.9	20	25	32.0	0.5	0.000	0.017	0.00	0.47	0.47
6.A.1	Managed waste disposal on land	CH_4	13.4	160.3	20	50	53.9	1.6	0.031	0.034	1.55	0.97	1.83
6.A2	Unmanaged waste disposal sites	CH_4	109.4	30.3	30	50	58.3	0.3	-0.020	0.006	-0.99	0.27	1.03
6.B	Wastewater handling	CH_4	1.4	3.5	50	30	58.3	0.0	0.000	0.001	0.01	0.05	0.05
6.B	Wastewater handling	N_2O	6.4	8.1	50	30	58.3	0.1	0.000	0.002	0.01	0.12	0.12
6.C	Waste incineration	CO_2	10.7	8.3	20	40	44.7	0.1	-0.001	0.002	-0.03	0.05	0.06
6.C	Waste incineration	CH_4	5.2	0.3	20	100	102.0	0.0	-0.001	0.000	-0.12	0.00	0.12
6.C	Waste incineration	N_2O	1.4	0.3	20	100	102.0	0.0	0.000	0.000	-0.03	0.00	0.03
6.D	Other (composting)	CH_4	0.0	1.3	20	50	53.9	0.0	0.000	0.000	0.01	0.01	0.02
6.D	Other (composting)	N_2O	0.0	1.4	20	50	53.9	0.0	0.000	0.000	0.02	0.01	0.02
	Total emissions		**4689**	**5275**	**Uncertainty of Emissions:**			**19.1 %**			**Trend uncertainty:**		**12.2 %**

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

Type.	No.	Category	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
			Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
	Gas/Diesel Oil																	
	10X40	house heating and swimming pools	8,535	10,511	7,559	9,797	10,034	7,625	6,349	5,756	3,665	4,428	4,240	2,417	2,420	1,546	1,626	1,637
	10X5X	industry	1,129	1,998	2,500	5,803	8,093	8,920	9,443	10,233	22,762	24,995	15,196	15,455	12,819	7,217	9,100	6,663
	10X60	energy industries	1,091	1,252	631	564	820	1,065	897	1,112	631	112	21	1,349	1,109	1,436	760	1,012
	10X90	other	458	69	12	909	1,063	1,386	1,323	756	1,832	8,124	8,928	8,296	2,033	1,336	1,499	2,728
	Residual Fuel Oil																	
	10840	house heating and swmimming pools	3,079	1,749	701	661	236	122	162	203	118	37	195	76	86	63	78	0
	1085X	industry	56,172	71,280	80,461	64,958	64,303	46,146	55,782	64,026	48,547	28,230	25,005	23,635	22,708	19,562	17,646	14,917
	10860	energy industries	0	18	58	816	230	-53	0	23	0	0	0	5	4,498	0	0	0
	10890	other	52	53	-4	669	319	67	4,978	6,465	319	6,139	0	0	45	913	0	1,629

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 categorie 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.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Swimming pools	1,600	1,600	1,600	1,600	1,600	1,600	1,400	1,400	1,200	1,100	1,000	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 SUMMARY 2 FOR 1990 TO 2010

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2012 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)	**3,271.33**	**410.96**	**586.64**	**NA,NE,NO**	**419.63**	**1.13**	**4,689.69**
1. Energy	**1,746.49**	**4.94**	**26.86**				**1,778.29**
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	0.27	NA,NO				61.63
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	61.36	0.27	NA,NO				61.63
2. Industrial Processes	**393.26**	**0.61**	**48.36**	**NA,NE,NO**	**419.63**	**1.13**	**862.99**
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	340.62	0.61	NA	NA,NE,NO	419.63	NA,NO	760.86
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,NE,NO	NA,NE,NO	1.13	1.13
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.07**		**6.00**				**9.07**
4. Agriculture		**274.38**	**428.74**				**703.12**
A. Enteric Fermentation		243.90					243.90
B. Manure Management		30.48	52.04				82.51
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	376.71				376.71
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)	**1,117.83**	**1.60**	**68.91**				**1,188.33**
A. Forest Land	-32.00	NE,NO	0.18				-31.82
B. Cropland	1,198.36	NE,NO	IE,NA,NE,NO				1,198.36
C. Grassland	-50.39	NE,NO	NE,NO				-50.39
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	NE,NO	68.73				68.73
6. Waste	**10.69**	**129.43**	**7.77**				**147.89**
A. Solid Waste Disposal on Land	NE,NO	122.83					122.83
B. Waste-water Handling		1.40	6.37				7.77
C. Waste Incineration	10.69	5.19	1.40				17.28
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	3,501.36
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,689.69

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1991
Submission 2012 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)]	**3,198.87**	**412.87**	**567.99**	**NA,NE,NO**	**348.34**	**3.28**	**4,531.35**
1. Energy	**1,710.48**	**5.06**	**26.31**				**1,741.85**
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	0.26	NA,NO				70.20
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	69.95	0.26	NA,NO				70.20
2. Industrial Processes	**359.70**	**0.51**	**46.81**	**NA,NE,NO**	**348.34**	**3.28**	**758.64**
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	310.74	0.51	NA	NA,NE,NO	348.34	NA,NO	659.59
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,NE,NO	NA,NE,NO	3.28	3.28
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.20**		**5.43**				**8.63**
4. Agriculture		**266.72**	**412.44**				**679.16**
A. Enteric Fermentation		236.58					236.58
B. Manure Management		30.13	48.33				78.46
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE	364.12				364.12
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)]	**1,114.89**	**6.31**	**69.13**				**1,190.33**
A. Forest Land	-32.56	NE,NO	0.24				-32.33
B. Cropland	1,193.22	NE,NO	IE,NA,NE,NO				1,193.22
C. Grassland	-53.13	NE,NO	NE,NO				-53.13
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	NE,NO	68.89				68.89
6. Waste	**10.60**	**134.27**	**7.86**				**152.73**
A. Solid Waste Disposal on Land	NE,NO	126.98					126.98
B. Waste-water Handling		2.13	6.47				8.60
C. Waste Incineration	10.60	5.16	1.39				17.15
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	3,341.02
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,531.35

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1992
Submission 2012 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)]	**3,310.06**	**417.75**	**537.38**	**NA,NE,NO**	**155.28**	**1.41**	**4,421.88**
1. Energy	**1,833.72**	**5.25**	**26.03**				**1,865.01**
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	67.61	0.22	NA,NO				67.83
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	67.61	0.22	NA,NO				67.83
2. Industrial Processes	**362.69**	**0.53**	**41.85**	**NA,NE,NO**	**155.28**	**1.41**	**561.76**
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	316.74	0.53	NA	NA,NE,NO	155.28	NA,NO	472.55
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,NE,NO	NA,NE,NO	1.41	1.41
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.20**		**4.82**				**8.02**
4. Agriculture		**260.82**	**387.40**				**648.22**
A. Enteric Fermentation		231.92					231.92
B. Manure Management		28.90	43.06				71.96
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE	344.34				344.34
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)]	**1,100.14**	**6.31**	**69.38**				**1,175.84**
A. Forest Land	-37.09	NE,NO	0.32				-36.77
B. Cropland	1,187.35	NE,NO	IE,NA,NE,NO				1,187.35
C. Grassland	-57.48	NE,NO	NE,NO				-57.48
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	NE,NO	69.06				69.06
6. Waste	**10.31**	**144.84**	**7.90**				**163.05**
A. Solid Waste Disposal on Land	NE,NO	137.65					137.65
B. Waste-water Handling		2.16	6.54				8.70
C. Waste Incineration	10.31	5.03	1.36				16.71
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
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	3,246.05
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,421.88

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1993
Submission 2012 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)	**3,420.18**	**426.27**	**548.55**	**0.04**	**74.86**	**1.42**	**4,471.32**
1. Energy	**1,910.01**	**5.36**	**27.52**				**1,942.89**
A. Fuel Combustion (Sectoral Approach)	1,824.64	5.11	27.52				1,857.27
1. Energy Industries	14.76	0.02	0.09				14.87
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	808.42	1.56	6.55				816.53
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	85.37	0.24	NA,NO				85.62
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	85.37	0.24	NA,NO				85.62
2. Industrial Processes	**410.31**	**0.60**	**44.02**	**0.04**	**74.86**	**1.42**	**531.24**
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	370.39	0.60	NA	NA,NE,NO	74.86	NA,NO	445.85
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)				0.04	NA,NE,NO	1.42	1.45
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.21**		**4.74**				**7.96**
4. Agriculture		**260.75**	**394.92**				**655.67**
A. Enteric Fermentation		231.97					231.97
B. Manure Management		28.79	43.74				72.53
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	351.18				351.18
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)	**1,087.86**	**6.31**	**69.56**				**1,163.73**
A. Forest Land	-41.44	NE,NO	0.33				-41.11
B. Cropland	1,181.43	NE,NO	IE,NA,NE,NO				1,181.43
C. Grassland	-59.48	NE,NO	NE,NO				-59.48
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	NE,NO	69.23				69.23
6. Waste	**8.78**	**153.25**	**7.79**				**169.82**
A. Solid Waste Disposal on Land	NE,NO	146.71					146.71
B. Waste-water Handling		2.18	6.61				8.79
C. Waste Incineration	8.78	4.36	1.18				14.32
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	3,307.59
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,471.32

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1994
Submission 2012 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)]	**3,355.76**	**435.26**	**555.07**	**0.00**	**44.57**	**1.42**	**4,392.08**
1. Energy	**1,857.15**	**5.34**	**27.69**				**1,890.19**
A. Fuel Combustion (Sectoral Approach)	1,787.04	5.10	27.69				1,819.82
1. Energy Industries	14.43	0.02	0.09				14.55
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	791.02	1.52	6.45				798.99
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	70.12	0.25	NA,NO				70.37
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	70.12	0.25	NA,NO				70.37
2. Industrial Processes	**411.28**	**0.57**	**44.33**	**0.00**	**44.57**	**1.42**	**502.17**
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	373.55	0.57	NA	NA,NE,NO	44.57	NA,NO	418.69
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)]				0.00	NA,NE,NO	1.42	1.42
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.20**		**4.29**				**7.49**
4. Agriculture		**261.77**	**401.28**				**663.04**
A. Enteric Fermentation		233.27					233.27
B. Manure Management		28.50	43.78				72.28
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	357.49				357.49
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)]	**1,076.04**	**6.31**	**69.74**				**1,152.09**
A. Forest Land	-43.25	NE,NO	0.34				-42.91
B. Cropland	1,175.47	NE,NO	IE,NA,NE,NO				1,175.47
C. Grassland	-63.54	NE,NO	NE,NO				-63.54
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	NE,NO	69.39				69.39
6. Waste	**8.09**	**161.26**	**7.75**				**177.10**
A. Solid Waste Disposal on Land	NE,NO	155.02					155.02
B. Waste-water Handling		2.19	6.65				8.85
C. Waste Incineration	8.09	4.05	1.09				13.24
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	3,240.00
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,392.08

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1995
Submission 2012 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)	**3,365.61**	**433.38**	**545.95**	**0.34**	**58.84**	**1.46**	**4,405.57**
1. Energy	**1,872.63**	**4.90**	**38.15**				**1,915.68**
A. Fuel Combustion (Sectoral Approach)	1,790.39	4.58	38.15				1,833.12
1. Energy Industries	18.75	0.03	0.12				18.90
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	800.05	1.54	6.54				808.13
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	82.23	0.32	NA,NO				82.55
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	82.23	0.32	NA,NO				82.55
2. Industrial Processes	**427.64**	**0.59**	**42.16**	**0.34**	**58.84**	**1.46**	**531.03**
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	389.32	0.59	NA	NA,NE,NO	58.84	NA,NO	448.75
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)				0.34	NA,NE,NO	1.46	1.79
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.21**		**4.29**				**7.51**
4. Agriculture		**252.12**	**383.44**				**635.57**
A. Enteric Fermentation		224.14					224.14
B. Manure Management		27.98	41.02				69.00
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	342.43				342.43
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)	**1,054.99**	**6.31**	**70.03**				**1,131.33**
A. Forest Land	-52.71	NE,NO	0.39				-52.32
B. Cropland	1,169.54	NE,NO	IE,NA,NE,NO				1,169.54
C. Grassland	-69.20	NE,NO	NE,NO				-69.20
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	NE,NO	69.64				69.64
6. Waste	**7.14**	**169.44**	**7.87**				**184.45**
A. Solid Waste Disposal on Land	NE,NO	163.46					163.46
B. Waste-water Handling		2.20	6.71				8.91
C. Waste Incineration	7.14	3.61	0.98				11.73
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	3,274.23
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,405.57

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1996
Submission 2012 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)]	**3,442.33**	**443.98**	**567.24**	**2.51**	**25.15**	**1.46**	**4,482.66**
1. Energy	**1,962.94**	**5.00**	**38.08**				**2,006.02**
A. Fuel Combustion (Sectoral Approach)	1,881.68	4.75	38.08				1,924.51
1. Energy Industries	11.43	0.03	0.13				11.59
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	866.81	1.66	7.06				875.52
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	81.26	0.25	NA,NO				81.51
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	81.26	0.25	NA,NO				81.51
2. Industrial Processes	**427.18**	**0.57**	**49.29**	**2.51**	**25.15**	**1.46**	**506.16**
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	385.00	0.57	NA	NA,NE,NO	25.15	NA,NO	410.72
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)]				2.51	NA,NE,NO	1.46	3.97
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.45**		**4.71**				**8.16**
4. Agriculture		**255.88**	**397.06**				**652.95**
A. Enteric Fermentation		227.36					227.36
B. Manure Management		28.52	42.01				70.53
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE	355.05				355.05
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)]	**1,042.36**	**7.70**	**70.27**				**1,120.33**
A. Forest Land	-56.42	NE,NO	0.41				-56.01
B. Cropland	1,163.64	NE,NO	IE,NA,NE,NO				1,163.64
C. Grassland	-73.83	NE,NO	NE,NO				-73.83
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	NE,NO	69.86				69.86
6. Waste	**6.40**	**174.82**	**7.82**				**189.04**
A. Solid Waste Disposal on Land	NE,NO	169.17					169.17
B. Waste-water Handling		2.22	6.75				8.97
C. Waste Incineration	6.40	3.27	0.88				10.55
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	3,362.33
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,482.66

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1997
Submission 2012 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)	**3,511.34**	**446.37**	**567.05**	**5.19**	**82.36**	**1.47**	**4,613.78**
1. Energy	**1,992.07**	**4.71**	**48.99**				**2,045.77**
A. Fuel Combustion (Sectoral Approach)	1,928.23	4.27	48.99				1,981.48
1. Energy Industries	7.99	0.03	0.12				8.15
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	837.11	1.62	6.88				845.61
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	63.85	0.44	NA,NO				64.29
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	63.85	0.44	NA,NO				64.29
2. Industrial Processes	**485.06**	**0.60**	**41.11**	**5.19**	**82.36**	**1.47**	**615.79**
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	438.08	0.60	NA	NA,NE,NO	82.36	NA,NO	521.04
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)				5.19	NA,NE,NO	1.47	6.66
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.55**		**4.71**				**8.26**
4. Agriculture		**254.07**	**393.76**				**647.83**
A. Enteric Fermentation		225.83					225.83
B. Manure Management		28.23	42.64				70.88
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE	351.12				351.12
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)	**1,024.49**	**7.70**	**70.64**				**1,102.83**
A. Forest Land	-63.06	NE,NO	0.44				-62.62
B. Cropland	1,157.66	NE,NO	IE,NA,NE,NO				1,157.66
C. Grassland	-79.09	NE,NO	NE,NO				-79.09
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	NE,NO	70.21				70.21
6. Waste	**6.17**	**179.30**	**7.84**				**193.31**
A. Solid Waste Disposal on Land	NE,NO	173.76					173.76
B. Waste-water Handling		2.24	6.81				9.05
C. Waste Incineration	6.17	3.13	0.85				10.14
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	3,510.95
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,613.78

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1998
Submission 2012 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)]	**3,500.11**	**455.89**	**569.74**	**9.07**	**180.13**	**1.84**	**4,716.77**
1. Energy	**1,974.18**	**4.87**	**49.50**				**2,028.54**
A. Fuel Combustion (Sectoral Approach)	1,890.49	4.24	49.50				1,944.22
1. Energy Industries	10.93	0.03	0.13				11.09
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	815.98	1.57	6.66				824.21
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	83.70	0.63	NA,NO				84.32
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	83.70	0.63	NA,NO				84.32
2. Industrial Processes	**512.73**	**0.44**	**35.84**	**9.07**	**180.13**	**1.84**	**740.05**
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	457.95	0.44	NA	NA,NE,NO	180.13	NA,NO	638.53
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)]				9.07	NA,NE,NO	1.84	10.90
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.80**		**4.84**				**8.63**
4. Agriculture		**259.53**	**400.59**				**660.12**
A. Enteric Fermentation		230.38					230.38
B. Manure Management		29.16	43.63				72.78
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE	356.96				356.96
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)]	**1,004.17**	**7.80**	**71.18**				**1,083.16**
A. Forest Land	-70.35	NE,NO	0.52				-69.84
B. Cropland	1,151.70	NE,NO	IE,NA,NE,NO				1,151.70
C. Grassland	-86.28	NE,NO	NE,NO				-86.28
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	NE,NO	70.66				70.66
6. Waste	**5.22**	**183.24**	**7.81**				**196.27**
A. Solid Waste Disposal on Land	NE,NO	178.12					178.12
B. Waste-water Handling		2.27	6.89				9.16
C. Waste Incineration	5.22	2.69	0.73				8.64
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	3,633.62
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,716.77

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1999
Submission 2012 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)]	**3,683.66**	**460.67**	**592.28**	**14.49**	**173.21**	**11.02**	**4,935.33**
1. Energy	**2,031.53**	**4.69**	**61.20**				**2,097.42**
A. Fuel Combustion (Sectoral Approach)	1,920.26	3.60	61.20				1,985.06
1. Energy Industries	8.06	0.03	0.12				8.22
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	801.40	1.54	6.55				809.49
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	111.27	1.09	NA,NO				112.36
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	111.27	1.09	NA,NO				112.36
2. Industrial Processes	**659.15**	**0.68**	**36.18**	**14.49**	**173.21**	**11.02**	**894.72**
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	597.26	0.68	NA	NA,NE,NO	173.21	NA,NO	771.15
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)]				14.49	NA,NE,NO	11.02	25.51
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.47**		**4.82**				**8.29**
4. Agriculture		**259.52**	**410.59**				**670.11**
A. Enteric Fermentation		230.26					230.26
B. Manure Management		29.26	43.74				73.00
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE	366.85				366.85
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)]	**985.24**	**7.80**	**71.71**				**1,064.75**
A. Forest Land	-75.27	NE,NO	0.54				-74.72
B. Cropland	1,145.63	NE,NO	IE,NA,NE,NO				1,145.63
C. Grassland	-94.23	NE,NO	NE,NO				-94.23
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	NE,NO	71.16				71.16
6. Waste	**4.27**	**187.98**	**7.78**				**200.03**
A. Solid Waste Disposal on Land	NE,NO	183.27					183.27
B. Waste-water Handling		2.30	6.99				9.28
C. Waste Incineration	4.27	2.25	0.61				7.13
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	3,870.58
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,935.33

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2000
Submission 2012 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)	**3,674.23**	**456.56**	**567.76**	**19.13**	**127.16**	**3.05**	**4,847.89**
1. Energy	**1,975.22**	**4.74**	**61.05**				**2,041.00**
A. Fuel Combustion (Sectoral Approach)	1,822.08	3.47	61.05				1,886.59
1. Energy Industries	7.06	0.03	0.12				7.22
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	748.48	1.45	6.14				756.07
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	153.14	1.27	NA,NO				154.41
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	153.14	1.27	NA,NO				154.41
2. Industrial Processes	**768.81**	**0.94**	**18.63**	**19.13**	**127.16**	**3.05**	**937.72**
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	702.72	0.94	NA	NA,NE,NO	127.16	NA,NO	830.82
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)				19.13	NA,NE,NO	3.05	22.18
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.71**		**4.60**				**8.31**
4. Agriculture		**249.78**	**403.09**				**652.88**
A. Enteric Fermentation		221.33					221.33
B. Manure Management		28.45	43.13				71.58
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	359.96				359.96
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)	**922.48**	**7.80**	**72.53**				**1,002.81**
A. Forest Land	-120.76	NE,NO	0.72				-120.04
B. Cropland	1,139.59	NE,NO	IE,NA,NE,NO				1,139.59
C. Grassland	-105.47	NE,NO	NE,NO				-105.47
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	NE,NO	71.81				71.81
6. Waste	**4.01**	**193.30**	**7.86**				**205.17**
A. Solid Waste Disposal on Land	NE,NO	188.61					188.61
B. Waste-water Handling		2.33	7.07				9.40
C. Waste Incineration	4.01	2.20	0.60				6.81
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	3,845.09
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,847.89

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2001
Submission 2012 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)	**3,655.93**	**465.42**	**560.72**	**20.70**	**91.66**	**4.60**	**4,799.03**
1. Energy	**1,938.94**	**4.74**	**60.23**				**2,003.91**
A. Fuel Combustion (Sectoral Approach)	1,795.17	3.35	60.23				1,858.75
1. Energy Industries	6.37	0.03	0.12				6.53
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	664.34	1.28	5.45				671.07
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	143.77	1.39	NA,NO				145.16
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	143.77	1.39	NA,NO				145.16
2. Industrial Processes	**805.29**	**0.91**	**16.15**	**20.70**	**91.66**	**4.60**	**939.30**
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	745.80	0.91	NA	NA,NE,NO	91.66	NA,NO	838.37
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)				20.70	NA,NE,NO	4.60	25.30
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.37**		**4.28**				**7.65**
4. Agriculture		**252.03**	**399.15**				**651.17**
A. Enteric Fermentation		223.06					223.06
B. Manure Management		28.96	41.67				70.63
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE	357.47				357.47
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)	**904.51**	**7.80**	**73.02**				**985.34**
A. Forest Land	-129.42	NE,NO	0.74				-128.68
B. Cropland	1,133.44	NE,NO	IE,NA,NE,NO				1,133.44
C. Grassland	-108.61	NE,NO	NE,NO				-108.61
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	NE,NO	72.28				72.28
6. Waste	**3.82**	**199.94**	**7.90**				**211.66**
A. Solid Waste Disposal on Land	NE,NO	195.42					195.42
B. Waste-water Handling		2.36	7.17				9.52
C. Waste Incineration	3.82	1.99	0.54				6.36
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	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	3,813.69
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,799.03

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2002
Submission 2012 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)]	**3,726.95**	**460.48**	**528.87**	**24.66**	**72.54**	**3.45**	**4,816.95**
1. Energy	**2,014.61**	**4.87**	**59.54**				**2,079.03**
A. Fuel Combustion (Sectoral Approach)	1,867.05	3.50	59.54				1,930.09
1. Energy Industries	8.34	0.04	0.12				8.50
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	727.76	1.42	6.01				735.18
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	147.57	1.38	NA,NO				148.94
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	147.57	1.38	NA,NO				148.94
2. Industrial Processes	**822.84**	**0.97**	**NA,NE,NO**	**24.66**	**72.54**	**3.45**	**924.46**
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	782.62	0.97	NA	NA,NE,NO	72.54	NA,NO	856.13
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)]				24.66	0.00	3.45	28.11
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.39**		**4.03**				**7.42**
4. Agriculture		**246.26**	**383.69**				**629.95**
A. Enteric Fermentation		218.32					218.32
B. Manure Management		27.93	41.75				69.68
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE	341.94				341.94
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)]	**882.55**	**7.80**	**73.70**				**964.05**
A. Forest Land	-141.56	NE,NO	0.79				-140.76
B. Cropland	1,127.26	NE,NO	IE,NA,NE,NO				1,127.26
C. Grassland	-112.27	NE,NO	NE,NO				-112.27
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	NE,NO	72.91				72.91
6. Waste	**3.56**	**200.57**	**7.91**				**212.04**
A. Solid Waste Disposal on Land	NE,NO	194.19					194.19
B. Waste-water Handling		4.35	7.22				11.57
C. Waste Incineration	3.56	1.86	0.51				5.93
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	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	3,852.90
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,816.95

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2003
Submission 2012 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)]	**3,696.86**	**462.41**	**519.33**	**26.48**	**59.79**	**3.64**	**4,768.51**
1. Energy	**2,007.48**	**4.87**	**58.78**				**2,071.13**
A. Fuel Combustion (Sectoral Approach)	1,870.97	3.52	58.78				1,933.28
1. Energy Industries	7.61	0.03	0.12				7.76
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	686.80	1.35	5.70				693.85
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	136.51	1.35	NA,NO				137.86
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	136.51	1.35	NA,NO				137.86
2. Industrial Processes	**826.79**	**0.94**	**NA,NE,NO**	**26.48**	**59.79**	**3.64**	**917.64**
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	792.83	0.94	NA	NA,NE,NO	59.78	NA,NO	853.56
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)]				26.48	0.00	3.64	30.12
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.33**		**3.88**				**7.21**
4. Agriculture		**243.63**	**374.54**				**618.17**
A. Enteric Fermentation		216.13					216.13
B. Manure Management		27.50	41.42				68.92
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE	333.12				333.12
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)]	**856.21**	**7.80**	**74.14**				**938.16**
A. Forest Land	-155.94	NE,NO	0.82				-155.12
B. Cropland	1,123.44	NE,NO	IE,NA,NE,NO				1,123.44
C. Grassland	-120.40	NE,NO	NE,NO				-120.40
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	NE,NO	73.32				73.32
6. Waste	**3.05**	**205.17**	**8.00**				**216.22**
A. Solid Waste Disposal on Land	NE,NO	198.91					198.91
B. Waste-water Handling		4.38	7.27				11.66
C. Waste Incineration	3.05	1.62	0.44				5.11
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	3,830.36
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,768.51

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2012 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)]	**3,737.53**	**460.84**	**517.39**	**31.41**	**38.58**	**4.44**	**4,790.17**
1. Energy	**2,051.96**	**5.01**	**64.13**				**2,121.10**
A. Fuel Combustion (Sectoral Approach)	1,929.06	3.59	64.13				1,996.78
1. Energy Industries	7.25	0.04	0.12				7.41
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	659.86	1.29	5.46				666.60
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	122.90	1.42	NA,NO				124.32
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	122.90	1.42	NA,NO				124.32
2. Industrial Processes	**848.59**	**0.96**	**NA,NE,NO**	**31.41**	**38.58**	**4.44**	**923.98**
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	796.75	0.96	NA	NA,NE,NO	38.58	NA,NO	836.29
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)]				31.41	0.00	4.44	35.85
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.60**		**3.57**				**7.16**
4. Agriculture		**239.85**	**367.01**				**606.86**
A. Enteric Fermentation		212.78					212.78
B. Manure Management		27.07	41.27				68.34
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE	325.74				325.74
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)]	**826.67**	**7.80**	**74.62**				**909.09**
A. Forest Land	-167.33	NE,NO	0.87				-166.47
B. Cropland	1,117.47	NE,NO	IE,NA,NE,NO				1,117.47
C. Grassland	-132.64	NE,NO	NE,NO				-132.64
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	0.07	NE	NE				0.07
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NE,NO	73.75				73.75
6. Waste	**6.72**	**207.20**	**8.06**				**221.98**
A. Solid Waste Disposal on Land	NE,NO	201.55					201.55
B. Waste-water Handling		4.43	7.35				11.77
C. Waste Incineration	6.72	0.98	0.44				8.13
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	3,881.08
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,790.17

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2005
Submission 2012 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)]	**3,638.35**	**465.54**	**526.87**	**35.13**	**26.10**	**4.23**	**4,696.22**
1. Energy	**1,998.56**	**4.80**	**71.70**				**2,075.05**
A. Fuel Combustion (Sectoral Approach)	1,882.21	3.21	71.70				1,957.11
1. Energy Industries	9.19	0.03	0.12				9.34
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	116.35	1.59	NA,NO				117.94
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	116.35	1.59	NA,NO				117.94
2. Industrial Processes	**837.77**	**0.97**	**NA,NE,NO**	**35.13**	**26.10**	**4.23**	**904.19**
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	782.04	0.97	NA	NA,NE,NO	26.09	NA,NO	809.10
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)]				35.13	0.00	4.23	39.36
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.53**		**3.35**				**6.88**
4. Agriculture		**241.79**	**368.17**				**609.96**
A. Enteric Fermentation		214.19					214.19
B. Manure Management		27.60	41.74				69.34
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE	326.43				326.43
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)]	**794.21**	**7.80**	**75.20**				**877.22**
A. Forest Land	-185.43	NE,NO	0.88				-184.55
B. Cropland	1,112.15	NE,NO	IE,NA,NE,NO				1,112.15
C. Grassland	-141.69	NE,NO	NE,NO				-141.69
D. Wetlands	9.11	7.80	NA,NE,NO				16.91
E. Settlements	0.07	NE	NE				0.07
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NE,NO	74.33				74.33
6. Waste	**4.28**	**210.18**	**8.45**				**222.92**
A. Solid Waste Disposal on Land	NE,NO	204.85					204.85
B. Waste-water Handling		4.54	7.71				12.25
C. Waste Incineration	4.28	0.37	0.27				4.93
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	3,819.00
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,696.22

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2006
Submission 2012 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)	**3,779.91**	**480.26**	**553.89**	**41.15**	**333.22**	**7.26**	**5,195.70**
1. Energy	**2,064.71**	**5.79**	**70.40**				**2,140.89**
A. Fuel Combustion (Sectoral Approach)	1,928.06	3.26	70.40				2,001.72
1. Energy Industries	7.00	0.04	0.15				7.19
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	562.91	1.10	4.64				568.65
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	136.64	2.53	NA,NO				139.17
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	136.64	2.53	NA,NO				139.17
2. Industrial Processes	**940.82**	**0.99**	**NA,NE,NO**	**41.15**	**333.22**	**7.26**	**1,323.46**
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	878.11	0.99	NA	NA,NE,NO	333.22	NA,NO	1,212.32
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)				41.15	0.00	7.26	48.42
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.89**		**3.36**				**7.25**
4. Agriculture		**245.95**	**394.69**				**640.65**
A. Enteric Fermentation		217.24					217.24
B. Manure Management		28.72	41.70				70.42
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	352.99				352.99
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)	**764.72**	**9.10**	**76.65**				**850.47**
A. Forest Land	-202.63	NE,NO	0.93				-201.70
B. Cropland	1,105.92	NE,NO	IE,NA,NE,NO				1,105.92
C. Grassland	-148.65	0.07	0.03				-148.56
D. Wetlands	9.11	9.03	0.45				18.60
E. Settlements	0.96	NE	NE				0.96
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NE,NO	75.24				75.24
6. Waste	**5.77**	**218.42**	**8.79**				**232.98**
A. Solid Waste Disposal on Land	NE,NO	212.74					212.74
B. Waste-water Handling		4.64	7.69				12.33
C. Waste Incineration	5.77	0.37	0.35				6.49
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	4,345.23
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,195.70

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2007
Submission 2012 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)]	**4,003.61**	**483.13**	**572.92**	**44.75**	**281.13**	**10.15**	**5,395.69**
1. Energy	**2,118.80**	**6.76**	**70.77**				**2,196.32**
A. Fuel Combustion (Sectoral Approach)	1,973.04	3.32	70.77				2,047.13
1. Energy Industries	21.30	0.05	0.18				21.53
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	579.18	1.13	4.76				585.07
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	145.76	3.43	NA,NO				149.19
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	145.76	3.43	NA,NO				149.19
2. Industrial Processes	**1,134.32**	**1.04**	**NA,NE,NO**	**44.75**	**281.13**	**10.15**	**1,471.38**
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	1,069.79	1.04	NA	NA,NE,NO	281.13	NA,NO	1,351.96
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)]				44.75	0.00	10.15	54.90
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**4.03**		**3.80**				**7.83**
4. Agriculture		**250.09**	**411.98**				**662.07**
A. Enteric Fermentation		220.42					220.42
B. Manure Management		29.67	42.46				72.13
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	369.52				369.52
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)]	**736.69**	**8.22**	**77.13**				**822.05**
A. Forest Land	-220.72	NE,NO	0.97				-219.75
B. Cropland	1,100.83	NE,NO	IE,NA,NE,NO				1,100.83
C. Grassland	-153.09	NE,NO	NE,NO				-153.09
D. Wetlands	9.60	8.22	NA,NE,NO				17.82
E. Settlements	0.07	NE	NE				0.07
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NE,NO	76.17				76.17
6. Waste	**9.77**	**217.03**	**9.24**				**236.04**
A. Solid Waste Disposal on Land	NE,NO	212.04					212.04
B. Waste-water Handling		3.77	7.91				11.68
C. Waste Incineration	9.77	0.37	0.40				10.55
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	4,573.64
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,395.69

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2008
Submission 2012 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)	**4,286.64**	**477.10**	**584.92**	**48.60**	**349.00**	**6.26**	**5,752.52**
1. Energy	**1,997.24**	**6.97**	**67.70**				**2,071.91**
A. Fuel Combustion (Sectoral Approach)	1,812.97	3.09	67.70				1,883.76
1. Energy Industries	5.74	0.03	0.12				5.89
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	3.87	NA,NO				188.14
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	184.27	3.87	NA,NO				188.14
2. Industrial Processes	**1,569.72**	**0.88**	**NA,NE,NO**	**48.60**	**349.00**	**6.26**	**1,974.46**
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	1,506.86	0.88	NA	NA,NE,NO	349.00	NA,NO	1,856.74
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)				48.60	0.00	6.26	54.86
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.55**		**3.63**				**7.18**
4. Agriculture		**252.64**	**426.31**				**678.96**
A. Enteric Fermentation		223.04					223.04
B. Manure Management		29.60	41.44				71.04
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE	384.87				384.87
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)	**707.66**	**8.22**	**77.96**				**793.84**
A. Forest Land	-239.33	NE,NO	0.94				-238.39
B. Cropland	1,095.15	NE,NO	IE,NA,NE,NO				1,095.15
C. Grassland	-157.76	NE,NO	NE,NO				-157.76
D. Wetlands	9.60	8.22	NA,NE,NO				17.82
E. Settlements	NA,NE,NO	NE	NE				NA,NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NE,NO	77.02				77.02
6. Waste	**8.48**	**208.39**	**9.31**				**226.18**
A. Solid Waste Disposal on Land	NE,NO	203.69					203.69
B. Waste-water Handling		3.51	8.01				11.52
C. Waste Incineration	8.48	0.35	0.37				9.20
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	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	4,958.68
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,752.52

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2009
Submission 2012 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)]	**4,218.06**	**476.14**	**551.16**	**55.24**	**152.75**	**5.94**	**5,459.28**
1. Energy	**1,949.84**	**7.49**	**60.70**				**2,018.03**
A. Fuel Combustion (Sectoral Approach)	1,781.39	3.12	60.70				1,845.21
1. Energy Industries	6.19	0.03	0.11				6.32
2. Manufacturing Industries and Construction	247.26	0.20	16.69				264.16
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	4.37	NA,NO				172.82
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	168.45	4.37	NA,NO				172.82
2. Industrial Processes	**1,583.03**	**0.91**	**NA,NE,NO**	**55.24**	**152.75**	**5.94**	**1,797.87**
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	1,552.98	0.91	NA	NA,NE,NO	152.75	NA,NO	1,706.64
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)]				55.24	0.00	5.94	61.18
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.16**		**3.15**				**6.31**
4. Agriculture		**255.43**	**398.99**				**654.43**
A. Enteric Fermentation		225.68					225.68
B. Manure Management		29.75	42.92				72.68
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE	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)]	**672.00**	**8.33**	**78.73**				**759.06**
A. Forest Land	-259.53	NE,NO	0.99				-258.54
B. Cropland	1,087.18	NE,NO	IE,NA,NE,NO				1,087.18
C. Grassland	-165.37	NE,NO	NE,NO				-165.37
D. Wetlands	9.72	8.33	NA,NE,NO				18.05
E. Settlements	NA,NE,NO	NE	NE				NA,NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NE,NO	77.74				77.74
6. Waste	**10.02**	**203.98**	**9.59**				**223.59**
A. Solid Waste Disposal on Land	NE,NO	199.07					199.07
B. Waste-water Handling		3.49	8.04				11.54
C. Waste Incineration	10.02	0.34	0.36				10.72
D. Other	NA	1.07	1.19				2.26
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	4,700.22
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,459.28

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2010
Submission 2012 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)]	**4,051.47**	**468.73**	**536.07**	**69.00**	**145.63**	**4.95**	**5,275.85**
1. Energy	**1,804.75**	**6.59**	**54.96**				**1,866.30**
A. Fuel Combustion (Sectoral Approach)	1,615.77	2.87	54.96				1,673.60
1. Energy Industries	4.49	0.03	0.09				4.61
2. Manufacturing Industries and Construction	199.35	0.17	13.21				212.73
3. Transport	861.59	1.61	37.14				900.34
4. Other Sectors	550.34	1.07	4.51				555.92
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	188.98	3.72	NA,NO				192.70
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	188.98	3.72	NA,NO				192.70
2. Industrial Processes	**1,589.15**	**0.90**	**NA,NE,NO**	**69.00**	**145.63**	**4.95**	**1,809.63**
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	1,578.52	0.90	NA	NA,NE,NO	145.63	NA,NO	1,725.04
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)]				69.00	0.00	4.95	73.95
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**2.74**		**3.41**				**6.15**
4. Agriculture		**257.19**	**388.98**				**646.17**
A. Enteric Fermentation		227.60					227.60
B. Manure Management		29.59	42.94				72.53
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	346.05				346.05
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)]	**646.56**	**8.33**	**78.91**				**733.80**
A. Forest Land	-271.79	NE,NO	0.98				-270.81
B. Cropland	1,078.95	NE,NO	IE,NA,NE,NO				1,078.95
C. Grassland	-170.55	NE,NO	NE,NO				-170.55
D. Wetlands	9.72	8.33	NA,NE,NO				18.05
E. Settlements	0.22	NE	NE				0.22
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NE,NO	77.93				77.93
6. Waste	**8.26**	**195.73**	**9.81**				**213.80**
A. Solid Waste Disposal on Land	NE,NO	190.63					190.63
B. Waste-water Handling		3.51	8.09				11.60
C. Waste Incineration	8.26	0.31	0.31				8.88
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	4,542.05
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,275.85

(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 2010 were 135.7 Gg or 6.3% 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 2010 to 89,767 tonnes of aluminium (189,965 tonnes in 2010 compared to 100,198 tonnes in 1995). The resulting CO_2 emissions are 135.7 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines. The implied emission factor in for the expanded part in 2009 is thus 1.512 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 2010 the total energy consumption was 3,305 tonnes of residual fuel oil and 122 tonnes of LPG leading to emissions of 10.6 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 0.06 t CO_2-equivalents per tonne of aluminium. These emissions are reported in the Energy sector. In 2010 the total use of electricity was 2,913 GWh, thereof 1,337 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 12.4 CO_2/kWh. The total CO_2 emissions from the electricity use for the project amounts to 17 Gg. Had the energy been from gas fired power plant the per kWh emissions would amount to 600 Gg. The resulting emissions from electricity use in the project would thus have amounted to 825 Gg. The resulting emissions savings are 808 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.

*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 cannot use wood in the process.
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 2010 were 142 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 2010 to 42,275 tonnes of ferrosilicon (all production in furnace 3). The resulting CO_2 emissions are 142 Gg. CO_2 emissions are calculated based on the quantity of coal and coke as reducing agents, as well as from the consumption of electrodes, using emission factors from the IPCC Guidelines. The implied emission factor in 2010 was 3.516 t CO_2 per tonne of ferrosilicon. QA/QC procedures include collecting activity data through elec-

	tronic 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 2010 the total energy consumption was 458 tonnes of gasoil leading to emissions of 1.5 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 2010 the total use of electricity was 930 GWh, thereof 385 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 12.4 g. The total CO_2 emissions from the electricity use for the project amounts to 4.8 Gg. Had the energy been from gas fired power plant the per kWh emissions would amount to 600 g. The resulting emissions from the project would thus have amounted to 231 Gg. The resulting emissions savings are 226 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.

[#] 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 2010 were 404.2 Gg or 18.7% 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 2010 to 276,113 tonnes of aluminium. The resulting CO_2 emissions are 404 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines. The implied emission factor in 2010 is thus 1.464 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 para-	Century Aluminium uses LPG and gasoil for heating of melting pots. In 2010 the total fuel consumption was 446 tonnes of gasoil and 224 tonnes of LPG leading to emissions of 2.1 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-

graph 5	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 2010 the total use of electricity was 4,114 GWh. As stated before all the electricity used is produced from renewable sources. The average emission from this electricity is 12.4 g/kWh. The total CO_2 emissions from the electricity used for the project amounts to 51 Gg. Had the energy been from gas fired power plant the per kWh emissions would amount to approximately 600 g. The resulting emissions from the project would thus have amounted to 2,467 Gg. The resulting emissions savings are 2,416 Gg.
Provide evidence that the project fulfils paragraph 2.(c)	As stipulated in the operating permit for Century Aluminium plant at Grundartangi, BAT as defined by the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is applied at the plant. Century Aluminium is preparing implementation of an environmental management system according to ISO 14001.

[#] 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. See also description previously in this annex.
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 2010 were 534 Gg or 24.7% 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 2010 to 352,781 tonnes of aluminium. The resulting CO_2 emissions are 534 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines. The implied emission factor in 2010 is thus 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 paragraph 5	Alcoa Fjarðaál uses LPG and gasoil for heating of melting pots. In 2010 the total fuel consumption was 424 tonnes of gasoil and 259 tonnes of LPG leading to emissions of 2.1 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-equivalents per tonne of fuel. The IEF for energy use is 0.006 t CO_2-

	equivalents per tonne of aluminium. These emissions are reported in the Energy sector. In 2010 the total use of electricity was 4,968 GWh. As stated before all the electricity used is produced from renewable sources. The average emission from this electricity is 12.4 g/kWh. The total CO_2 emissions from the electricity use for the project amounts to 62 Gg. Had the energy been from gas fired power plant the per kWh emissions would amount to approximately 600 g. The resulting emissions from the project would thus have amounted to 2,979 Gg. The resulting emissions savings are 2,917 Gg.
Provide evidence that the project fulfils paragraph 2.(c)	As stipulated in the operating permit for Alcoa Fjarðaál plant at Reyðarfjörður, BAT as defined by the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is applied at the plant. Alcoa Fjarðaál has implemented an ISO 14001 environmental management. The environmental management system was certified in 2012.

[#] All references to paragraphs are relating to the paragraphs of decision 14/CP.7