GREENHOUSE GAS EMISSIONS IN ESTONIA 1990-2010

NATIONAL INVENTORY REPORT
under the UNFCCC and the Kyoto Protocol

Submission to the UNFCCC secretariat

Common Reporting Formats (CRF)
1990–2010

Tallinn 2012

PREFACE

Estonian National Inventory Report under the UNFCCC (United Nations Framework Convention on Climate Change) and the Kyoto Protocol contains the following parts:

Part I. Description of the greenhouse gas emission inventory according to the updated UNFCCC reporting guidelines (FCCC/SBSTA/2006/9) containing description of the organization of the national greenhouse gas inventory, IPCC and other methods applied in calculation of the year 2010 emissions and exemptions to the previous inventories. A summarizing table of the emissions data for the years 1990–2010 is included as well as description of the current emission trends.

Part II. Supplementary information required under Article 7, paragraph 1 of the Kyoto Protocol.

Department of Thermal Engineering (Ms Inge Roos), Department of Chemistry at Tallinn University of Technology (Ms Olga Gavrilova and Ms Tiina Randla), Estonian Environmental Research Centre (Ms Kristina Kaar, Ms Katri Saare and Ms Kaili Tuulik) and Estonian Environment Information Centre (Ms Kaie Kriiska and Mr Veiko Adermann) have made the inventory calculations, the description of the methodologies and other information included in the National Inventory Report.

Climate Department of Estonian Environmental Research Centre (Ms Kristina Kaar) and Climate and Radiation Department of the Ministry of the Environment (Ms Anne Mändmets) co-ordinated the process of the inventory preparation.

The Ministry of the Environment has responsibility of the preparation and finalization of inventory reports and their submission to the UNFCCC Secretariat and the European Commission.

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ES.1.1 Background information on climate change

Estonia has not carried out exhaustive study on impacts of climate change. According to available information the impacts of climate change in Estonia are expected to be relatively small compared to the southern and northern regions of Europe. Therefore no significant consequences are expected for biodiversity or public health. Some species may disappear and some new species will probably emerge, but these changes are quite negligible.

The rise in temperature and precipitation will have a positive rather than negative effect on Estonian economy. For example, it will probably be favourable for agriculture, especially grassland husbandry. The total growing season will lengthen and a greater number of harvests will become possible. In the case of higher temperatures and higher rainfall, the growth and development of herbaceous plants will quicken and harvesting times will shift to an earlier period. Livestock will be better provided with fodder in summer and winter.

The main hazards and economic losses in Estonia will result from the rise of sea level which will cause flooding in coastal areas, the erosion of sandy beaches and the destruction of harbour constructions.

ES.1.2 Background information on greenhouse gas inventories

Estonia signed the Framework Convention on Climate Change at the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992. In 1994 Estonia ratified the UNFCCC and in 2002, the Kyoto Protocol. Under the Protocol Estonia is obliged to reduce during the period 2008–2012 the emissions of air polluting greenhouse gases from its territory by 8% as compared with the 1990 level.

Estonia has prepared greenhouse gas inventories since the year 1994. Inventory reports are submitted to the UNFCCC Secretariat and the European Commission annually.

ES.1.3 Background information on supplementary information required under Article 7, paragraph 1, on the Kyoto Protocol

Estonia, as an Annex I Party that is also part of the Kyoto Protocol is required to report supplementary information in accordance with Article 7, paragraph 1, of the Kyoto Protocol. The required information is specified in the Annex of Decision 15/CMP.1.

Part II of this report includes information related to Article 3, paragraph 3 (Afforestation, Reforestation, Deforestation) in Chapter 11 and information related to Article 3, paragraph 14 (information on minimization of adverse impacts of climate change) in Chapter 15. Estonia has not selected activities under Article 3, paragraph 4 during the first commitment period.

A summary of information on accounting of Kyoto units is presented in Chapter 12 and more detailed information is presented in Standard Electronic Tables (SEF) which are part of

Estonia's inventory submission. Information related to changes in national system and in the national registry are provided in Chapter 13 and Chapter 14 accordingly.

ES2. Summary of national emission and removal related trends, and emission and removals from KP-LULUCF activities

ES.2.1 GHG inventory

In 2010 the total emissions of GHGs, measured as CO_2 equivalents, were 16 759.01 Gg, and without net CO_2 from LULUCF 20 516.76 Gg. From 1990 to 2010 the emissions decreased by 49.78%. Table ES.1. shows the trends in the total emissions during the period 1990–2010. Figure ES.1. shows greenhouse gas emissions trends in CO_2 equivalents.

In 2010, the most important GHG in Estonia was carbon dioxide (CO_2), contributing 88.80% to total national GHG emissions expressed in CO_2 equivalents, followed by nitrous oxide (N_2O), 5.31%, and methane (CH_4), 5.12%. Fluorocarbons (so-called "F-gases") account for about 0.77% of total emissions. The Energy sector accounted for 88.64% of total GHG emissions, followed by Agriculture (6.55%), Industrial Processes (2.43%), Waste (2.30%) and Solvent and Other Product Use (0.09%).

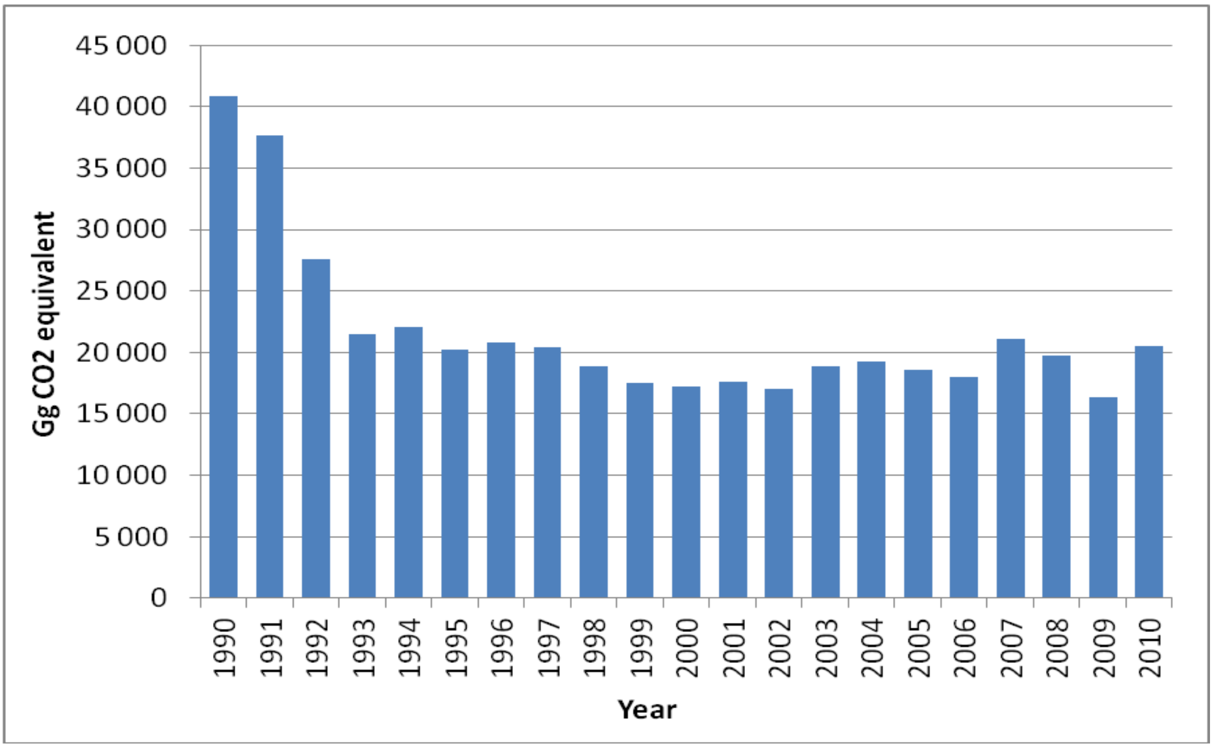

Figure ES.1. Overall development of greenhouse gases in Estonia, in CO_2 equivalents (without net CO_2 from LULUCF)

Table ES.1. Greenhouse gas emissions in Estonia. Emission trends

GREENHOUSE GAS EMISSIONS	Base year (1990)	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	CO2 equivalent (Gg)												
CO_2 emissions including net CO_2 from LULUCF	27 270.20	8 398.40	19 279.02	19 903.90	17 881.99	16 871.44	12 831.66	7 344.30	12 503.18	5 538.65	11 239.47	7 056.68	14 459.96
CO_2 emissions excluding net CO_2 from LULUCF	36 620.25	17 957.05	15 149.62	15 506.40	14 992.12	16 818.68	17 070.40	16 435.96	15 864.83	18 895.89	17 382.10	14 184.98	18 218.70
CH_4 emissions including CH_4 from LULUCF	1 856.45	1 071.15	1 042.55	1 072.81	1 019.77	1 041.29	1 070.77	1 038.56	1 053.07	1 049.35	1 043.84	1 015.26	1 050.68
CH_4 emissions excluding CH_4 from LULUCF	1 856.11	1 070.79	1 040.94	1 072.63	1 016.30	1 040.87	1 069.81	1 038.31	1 044.97	1 049.11	1 042.57	1 015.13	1 050.61
N_2O emissions including N_2O from LULUCF	2 381.40	1 137.63	958.30	950.80	887.99	924.53	974.20	971.50	955.03	1 034.72	1 148.28	1 051.30	1 090.23
N_2O emissions excluding N_2O from LULUCF	2 380.53	1 136.76	957.19	949.95	886.52	923.64	973.21	970.65	952.68	1 033.75	1 147.07	1 050.37	1 089.31
HFCs	NA,NE,NO	25.37	69.80	85.82	86.95	92.37	105.15	118.78	135.86	149.40	131.89	139.14	156.33
PFCs	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.07	0.06	0.04	NA,NE,NO	NA,NE,NO
SF_6	NA,NE,NO	3.22	2.74	1.74	1.44	1.32	1.08	1.08	1.15	0.97	1.35	1.44	1.81
Total (including LULUCF)	**31 508.05**	**10 635.77**	**21 352.42**	**22 015.07**	**19 878.14**	**18 930.95**	**14 982.86**	**9 474.22**	**14 648.37**	**7 773.14**	**13 564.87**	**9 263.82**	**16 759.01**
Total (excluding LULUCF)	**40 856.89**	**20 193.19**	**17 220.30**	**17 616.54**	**16 983.33**	**18 876.89**	**19 219.65**	**18 564.78**	**17 999.58**	**21 129.18**	**19 705.01**	**16 391.07**	**20 516.76**
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**Base year (1990)**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
	CO2 equivalent (Gg)												
1. Energy	35 942.49	17 572.35	14 778.46	15 138.91	14 813.57	16 581.09	16 711.03	16 037.45	15 407.32	18 291.45	16 770.10	14 157.38	18 185.24
2. Industrial Processes	1 047.92	675.28	705.08	745.77	544.85	605.43	764.69	807.42	871.43	1 059.03	1 051.52	451.98	497.57
3. Solvent and Other Product Use	20.77	26.02	26.76	24.47	24.84	24.69	25.07	26.16	27.23	26.46	22.21	18.19	17.65
4. Agriculture	3 464.68	1 628.54	1 290.67	1 285.72	1 197.38	1 241.44	1 278.03	1 271.80	1 247.06	1 302.43	1 422.86	1 317.60	1 344.12
5. Land Use, Land-Use Change and Forestry[(5)]	-9 348.84	-9 557.42	4 132.12	4 398.53	2 894.81	54.06	-4 236.79	-9 090.55	-3 351.21	-13 356.04	-6 140.14	-7 127.25	-3 757.75
6. Waste	381.02	291.00	419.33	421.68	402.69	424.24	440.83	421.94	446.52	449.82	438.33	445.92	472.19

Table ES.2. Greenhouse gas emissions in Estonia – annual contributions of the various greenhouse gases

GHG EMISSIONS [CO2 equivalent (Gg)]	1990		1995		2000		2005		2007		2008		2009		2010	
	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]
CO_2 emissions excluding net CO_2 from LULUCF	**36 620.25**	89.63	**17 957.05**	88.93	**15 149.62**	87.98	**16 435.96**	88.53	**18 895.89**	89.43	**17 382.10**	88.21	**14 184.98**	86.54	**18 218.70**	88.80
CH_4 emissions excluding CH_4 from LULUCF	**1 856.11**	4.54	**1 070.79**	5.30	**1 040.94**	6.04	**1 038.31**	5.59	**1 049.11**	4.97	**1 042.57**	5.29	**1 015.13**	6.19	**1 050.61**	5.12
N_2O emissions excluding N_2O from LULUCF	**2 380.53**	5.83	**1 136.76**	5.63	**957.19**	5.56	**970.65**	5.23	**1 033.75**	4.89	**1 147.07**	5.82	**1 050.37**	6.41	**1 089.31**	5.31
HFCs	**NA,NE,NO**		**25.37**	0.126	**69.80**	0.405	**118.78**	0.640	**149.40**	0.707	**131.89**	0.669	**139.14**	0.849	**156.33**	0.762
PFCs	**NA,NE,NO**		**NA,NE,NO**		**NA,NE,NO**		**NA,NE,NO**		**0.06**	0.000	**0.04**	0.000	**NA,NE,NO**		**NA,NE,NO**	
SF_6	**NA,NE,NO**		**3.22**	0.016	**2.74**	0.016	**1.08**	0.006	**0.97**	0.005	**1.35**	0.007	**1.44**	0.009	**1.81**	0.009
Total (excluding LULUCF)	**40 856.89**		**20 193.19**		**17 220.30**		**18 564.78**		**21 129.18**		**19 705.01**		**16 391.07**		**20 516.76**	

ES.2.2 KP-LULUCF activities

Under Article 3, paragraph 3 of the Kyoto Protocol (KP), Estonia reports emissions and removals from afforestation (A), reforestation (R) and deforestation (D).

Estimates of emissions and removals from Article 3.3 activities are presented in Table ES.3. In 2010, net removals from Article 3.3 activities were 47.06 Gg CO_2 eq. Uptake from afforestation and reforestation activities including emissions from biomass burning was estimated at 346.72 Gg CO_2 eq., whereas deforestation resulted in a net emission of 299.66 Gg CO_2 eq. Area subject to AR was 22 982 ha by the end of the third year of the commitment period. The area deforested since 1 January 1990 had reached to 20 633 hectares in the end of 2010. The rate of deforestation has fluctuated widely over the years, causing substantial variations in interannual CO_2 emissions.

Table ES.3. Net CO_2 emissions/removals in the KP LULUCF sector, Gg CO_2 equivalent

Greenhouse gas sources and sink activities	**Net CO_2 eq. emissions/removals, Gg**		
	2008	**2009**	**2010**
A. Article 3.3 activities	**566.49**	**-31.88**	**-47.06**
A.1. Afforestation and Reforestation	-303.03	-324.82	-346.72
A.1.1. Units of land not harvested since the beginning of the commitment period	-307.51	-329.87	-352.37
A.1.1. Biomass burning	4.48	5.05	5.65
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA
A.2. Deforestation	869.52	292.94	299.66
A.2.1 Biomass burning	NO	NO	NO
B. Article 3.4 activities	**NA**	**NA**	**NA**

ES.3. Overview of source and sink category emission estimates and trends, including KP-LULUCF activities

ES.3.1. GHG inventory

The greenhouse gas emissions and removals are divided into the following sectors according to the updated UNFCCC reporting guidelines on annual inventories (FCCC/SBSTA/2006/9): Energy (CRF 1), Industrial processes (CRF 2), Solvent and other product use (CRF 3), Agriculture (CRF 4), Land use, Land use change and Forestry (LULUCF) (CRF 5) and Waste (CRF 6).

Figure ES.2 shows the contributions of individual source and sink categories to total greenhouse gas emissions.

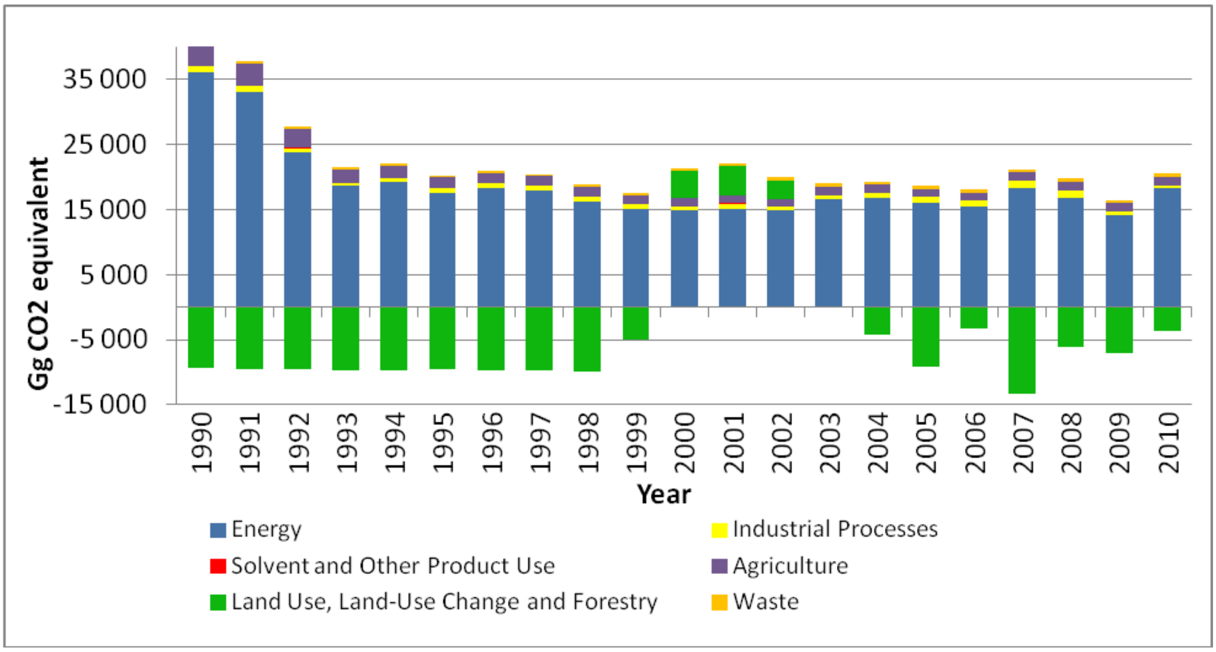

Figure ES.2. Greenhouse-gas emissions trends, by source groups, in CO_2 equivalents

The energy sector is the most significant source of greenhouse gas emissions in Estonia with 88.64% share of the total emissions in 2010. Since the base year, emissions have decreased by 49.40%. The key driver for the fall in emissions is the transition from a planned economy to a market economy.

Agriculture is the second most significant source of greenhouse gas emissions in Estonia. In 2010 the agriculture sector contributed 6.55% of the total emissions. Since the base year emissions have decreased by 61.21%, mostly due to the decreasing livestock population and quantity of synthetic fertilizers and manure applied to agricultural fields.

In 2010 industrial processes greenhouse gas emissions contributed 2.43% of the total greenhouse gas emissions in Estonia. Emissions have decreased by 52.52% between 1990 and 2010. Industrial CO_2 emissions have fluctuated strongly since 1990, reaching the lowest level in 1993. The decrease in the emissions during the early 1990s was caused by the transition from planned economy to market economy after 1991 when Estonia became independent.

The Waste sector contributed 2.30% of the total greenhouse gas emissions in 2010. The total emissions in CO_2 equivalents from the Waste sector increased by 23.93% compared to the base year: the emissions from solid waste landfilled increased by 31% and emissions from waste composting processes increased about 100 fold – from 1.26 Gg in 1990 to 138.61 Gg in 2010.

In 2010 the LULUCF sector acted as a CO_2 sink, totalling 3 757.75 Gg CO_2 equivalent. Reported net CO_2 removals in the LULUCF sector decreased by 59.81% between 1990 and 2010. The main sink of CO_2 in Estonia is forest land. Due to the comparatively intensive use of forest resources, carbon flows derived from that category have a major influence on the LULUCF sector´s total carbon balance. LULUCF sector is a net source of emissions in some years (2000–2003) and a net sink of carbon in other years.

ES.3.2. KP-LULUCF activities

Estonia reports activities under the Kyoto Protocol Article 3.3 - emissions and removals from afforestation, reforestation and deforestation. For these activities, Estonia has chosen commitment period accounting.

The total removal in 2010 was estimated at 47.06 Gg CO_2 eq. Afforestation and reforestation resulted in a net uptake of 346.72 Gg CO_2 eq. and deforestation a net emission of 299.66 Gg CO_2 eq. Areas of AR and D were 22 982 ha and 20 633 ha, respectively.

PART 1: ANNUAL INVENTORY SUBMISSION

1. INTRODUCTION

1.1. Background information on greenhouse gas inventories, climate change and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

1.1.1. Background information on climate change

According to the Intergovernmental Panel on Climate Change (IPCC) the territory of Estonia lies within the region where the most significant increase in air temperature has been observed over the past few decades. The annual mean air temperature in Estonia increased by 1.0–1.7 °C during the second half of the 20th century. Seasonality plays an important part in climate warming in Estonia. A statistically significant increase in the monthly mean temperature is present only during the period from January to May, with the greatest increase in March (up to 4 °C). For the rest of the year, practically no change in the annual mean air temperature has been identified.

Precipitation is the most variable climatic characteristic in Estonia. Its extreme values cause severe droughts and floods which have a significant influence on human activity. Since 1966 precipitation series in Estonia have been homogeneous. They indicate an increase during the cold half-year and also in June. A significant increase in precipitation has occurred in winter period (29%).

The duration of snow cover and sea ice decreased significantly during the second half of the 20th century. Over this period, the date by which sea ice appears has been very consistent, but the date by which it disappears at the end of winter has become earlier. The end of winter and the start of spring occur much earlier than before (by 19–39 days). The earlier melting of the snow cover causes changes in the hydrological regime. For instance, rivers reach their point of maximum runoff earlier and the magnitude of such runoff is generally smaller. The water content of the soil is comparatively smaller and drought conditions appear earlier. Drier climatic conditions in spring and in the first half of summer are projected for Estonia in the future.

The impacts of climate change in Estonia are relatively small compared to the southern and northern regions of Europe. Therefore no significant consequences are expected for biodiversity or public health. Some species may disappear and some new species will probably emerge, but these changes are quite negligible.

The rise in temperature and precipitation will have a positive rather than negative effect on Estonian economy. For example, it will probably be favourable for agriculture, especially grassland husbandry. The total growing season will lengthen and a greater number of harvests will become possible. In the case of higher temperatures and higher rainfall, the growth and development of herbaceous plants will quicken and harvesting times will shift to an earlier period. Livestock will be better provided with fodder in summer and winter.

The main hazards and economic losses in Estonia will result from the rise of sea level which will cause flooding in coastal areas, the erosion of sandy beaches and the destruction of harbour constructions. (Estonia's Fifth National Communication, 2009).

1.1.2. Background information on greenhouse gas inventories

Estonia signed the Framework Convention on Climate Change at the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992. In 1994 Estonia ratified the UNFCCC and in 2002, the Kyoto Protocol. In response to the UNFCCC and the Kyoto Protocol requirements Estonia has prepared the present emission National Inventory Report (NIR).

Single national entity with overall responsibility for the Estonian greenhouse gas inventory is the Estonian Ministry of the Environment (MoE). Financial resources are partly planned in the State Budget and partly applied from Environmental Investment Centre. Practical work is done mostly on the basis of contracts. The Institute of Ecology at Tallinn University was responsible for the inventories under contract to the Ministry of the Environment in Estonia until summer 2006. The 2008–2011 inventories were produced in collaboration between the MoE, Estonian Environment Information Centre (EEIC), Tallinn University of Technology (TUT) and Estonian Environmental Research Centre (EERC). The 2012 inventory was produced also in collaboration between MoE, EEIC, TUT and EERC, responsibilities between different institutions are shown in Figure 1.1.

This report presents the national inventory of greenhouse gas emissions and removals from 1990 to 2010. The components covered are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and F-gases - hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Estimates of the emission data for nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2) were also included in inventory data.

The report and associated Common Reporting Format (CRF) tables were prepared in accordance with the UNFCCC reporting Guidelines on Annual Inventories. The CRF Tables are produced with the CRF Reporter software (version 3.5.2). The methodology used in calculations of emissions is harmonized with the Guidelines for National Greenhouse Gas Inventories and those of Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories published by the Intergovernmental Panel of Climate Change (IPCC).

The structure of this NIR follows the UNFCCC reporting guidelines on annual inventories (UNFCCC 2006). The annotated outline of the NIR developed by the UNFCCC secretariat in 2009 has been followed. Chapter 1 gives an introduction to the background of greenhouse gas inventories and the arrangement for inventory preparation. Chapter 2 presents the overall emission trend in Estonia from the year 1990 to the year 2010. Chapters 3–8 give information of GHG emission trends from the base year 1990 to year 2010 for the following sectors: energy, industrial processes, solvent and other product use, agriculture, land use, land-use change and forestry, waste. In Chapter 10 improvements and recalculations since the previous submission are summarised. Chapter 11 provides description of KP LULUCF, Chapter 12 information on accounting of Kyoto units, Chapter 13 information on changes in national system and Chapter 14 information on changes in national registry. Chapter 15 gives information on minimisation of adverse impacts in accordance with Article 3, paragraph 14 of KP. Annex 1 contains key category reporting tables and Annex 2 the detailed discussion of methodology and data for estimating CO_2 emissions from fossil fuel combustion. Annex 3 gives information on other detailed methodological descriptions for individual source or sink categories. Annex 4 contains information on CO_2 reference approach and comparison with sectoral approach, and relevant information on the national energy balance. Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded is included in Annex 5. Annex 6 contains the Standard Independent Assessment Report and Annex 7 the mandatory uncertainty reporting table (table 6.1 of Good Practice Guidance 2000).

1.1.3. Background information on supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

Estonia, as an Annex I Party that is also part of the Kyoto Protocol is required to report supplementary information in accordance with Article 7, paragraph 1, of the Kyoto Protocol. The required information is specified in the Annex of Decision 15/CMP.1.

Part II of this report includes information related to Article 3, paragraph 3 (Afforestation, Reforestation, Deforestation) in Chapter 11 and information related to Article 3, paragraph 14 (information on minimization of adverse impacts of climate change) in Chapter 15. A summary of information on accounting of Kyoto units is presented in Chapter 12 and more detailed information in Standard Electronic Tables (SEF) which are part of Estonia's inventory submission. Information related to changes in national system and in the national registry are provided in Chapter 13 and Chapter 14 accordingly.

Estonia has chosen to report greenhouse gas emission removals from activities under Article 3.3 (i.e. afforestation, reforestation and deforestation) for the first commitment period (CP). Estonia did not choose to account greenhouse gas emissions/removals from activities under Article 3.4 for the first commitment period. For the LULUCF activities under Article 3.3 of Kyoto Protocol Estonia has chosen commitment period accounting. Thus the accounting quantity will be reported only in the annual report submitted for the last year of the CP (in 2014) and calculated over the entire CP.

1.2. A description of the institutional arrangements for inventory preparation

1.2.1. Overview of institutional arrangements for compiling GHG inventory

Single national entity with overall responsibility for the Estonian greenhouse gas inventory is MoE. The inventory is produced in collaboration between the MoE, EERC, EEIC and TUT.

The MoE is responsible for:

- Coordinating the overall inventory preparation process;
- Approving the inventory before official submission to the UNFCCC;
- Reporting the greenhouse gas inventory to the UNFCCC, including the National Inventory Report and CRF tables;
- Concluding the formal agreements with inventory compilers (TUT, EERC);
- Coordinating the cooperative work between the inventory compilers and UNFCCC Secretariat;
- Informing the inventory compilers about the requirements of the national system and ensuring that existing information in national institutions is considered and used in the inventory where appropriate;
- Informing the inventory compilers about new or revised guidelines;
- Coordinating the UNFCCC inventory reviews.

Climate Department in EERC is responsible for:

- Compiling the National Inventory Report according to the parts submitted by the inventory compilers;
- Coordinating of the implementation of the QA/QC plan;
- Coordinating the inventory process;
- Preparation of the UNFCCC inventory reviews and coordinating the communication with the expert review team, including responses to the review findings;
- Overall archiving system.

Department of Thermal Engineering and Department of Chemistry at TUT prepare the estimates for the Energy and Agriculture sectors. The EERC is responsible for the Industrial Processes, Solvents and Other Product Use and Waste sectors. Department of the National Forest Inventory at EEIC is responsible for the LULUCF and KP LULUCF sectors. All experts collect activity data, calculate emissions, prepare relevant QC, fill in the sectoral data to the CRF Reporter and prepare sectoral parts of the NIR. They also have archiving system for the sectors that they are working with.

1.2.1.1. Legal basis

In accordance with §117 of the Ambient Air Protection Act (RT I 2004, 43,298), activities for the reduction of climate change are organised by the Ministry of the Environment on the basis of the requirements for the restriction of the limit values of emissions of greenhouse gases provided by the UNFCCC and the Kyoto Protocol to the UNFCCC.

In accordance with §6 of the Statute of the Ministry of the Environment (RT I 2009, 63, 412), the Ministry is responsible for climate change related tasks and according to §23 section 8, the Climate and Radiation Department task is to organize, develop and implement climate change mitigation and adaptation policies.

In accordance with the Statute of the Climate and Radiation Department the department is responsible for organizing and coordinating the GHG emission reporting activities under the UNFCCC, the Kyoto Protocol and the European Union legislation.

In accordance with §6 section 3 and 4 of the Statute of the Estonian Environment Information Centre EEIC performs the following tasks: forest and forest sector data collection, analysis and assessments; National Forest Inventory compilation.

A co-operation agreement between MoE and TUT was signed on the 19 October 2007. The agreement sets out the mutual cooperation directions in the field of climate change, including greenhouse gas inventory compilation for 5 years. The contract agreement with TUT for inventory preparation is done on annual bases.

Contract agreements with EERC for inventory preparation (sectors Industrial Processes, Solvent and Other Product Use and Waste) were concluded for 3 years (2011, 2012 and 2013 inventory). The 3 years contracts were concluded for the first time and MoE is planning to use this approach for other sectoral contracts as well in the upcoming years in order to secure the continuousness of the inventory preparation.

Contract agreement with EERC for inventory coordination was concluded for the first time in 2010 and was done for 1 year. New contract agreement with EERC for inventory coordination was done in 2011. MoE is planning to use external coordinator for the coordination of the inventory also in the future.

The Statistics Estonia collects statistical data on the basis of the Official Statistics Act § 3(2), taking into consideration the official statistical surveys approved by the Government of the Republic.

1.2.1.2. Institutional cooperation

The four core institutions: MoE, EERC, EEIC and TUT work together to fulfill the requirements for the national system. The overview of the allocation of responsibilities is shown in Figure 1.1.

The EERC is a state hold joint stock company whose all shares belong to the Republic of Estonia. The EERC belongs to the government area of the Ministry of the Environment. The manager of this capital is the Ministry of the Environment and the Minister of the Environment is the sole representative of shareholders on the general meeting of shareholders.

The EEIC is a state organisation administered by MoE. The functions of the EEIC are covered with a Statute of Estonian Environment Information Centre.

The MoE has signed agreements with TUT and EERC for inventory preparation. Through these agreements, the institutions are committed to calculate emissions, to implement the QA/QC and archiving procedures, documentation, making information available for review, and delivering data and information in a timely manner to meet the deadline for reporting to EC and the UNFCCC. Also an agreement for inventory coordination has been signed between MoE and EERC.

All four institutions are in close contact with each other. Several cooperation meetings are held to discuss and agree on the methodological issues, problems that have arisen and improvements that need to be implemented. As Estonia is a small country there is close contact between inventory experts (TUT, EERC, EEIC) and inventory compiler (EERC) and as a result different problems and misunderstandings are also solved on a daily basis.

During the cooperation meetings the following subjects are addressed:

- Preparation of the annual review;
- Discussion on the comments received from the expert review and agreeing on possible changes that have to be made;
- Discussion on the different problems that came up during the last inventory preparation and find solutions to improve the overall system;
- Discussion on methodologies and possible changes in the future;
- Discussion on QA/QC plan, available resources and possible improvements;
- Discussion on data collection and agreeing on possible institutions that could be also involved;
- Agreement on recalculations;
- Archiving system, updating and possible improvements;
- Exchange of relevant information;
- Reporting the conclusions from the meetings and dividing the responsibilities.

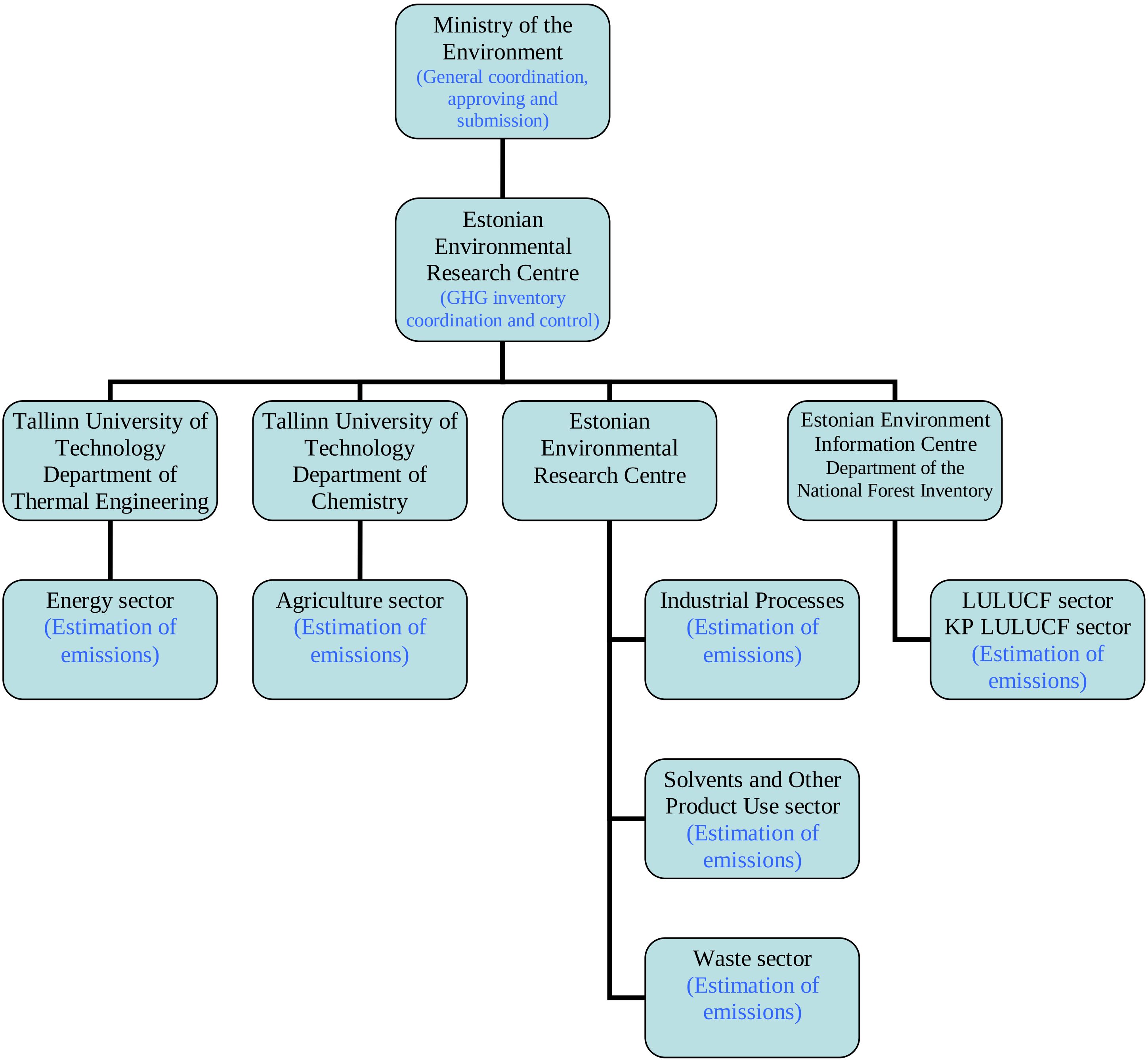

Figure 1.1. National System for GHG inventory in Estonia
Source: National Greenhouse Gas Inventory System in Estonia.

1.2.2. Overview of inventory planning

Estonia's national GHG inventory system is designed and operated according to the guidelines for national system under article 5, paragraph 1, of the Kyoto Protocol (Decision 20/CP7) to ensure the transparency, consistency, comparability, completeness and accuracy of inventories. Inventory activities include planning, preparation and management of the inventories.

EERC and MoE have worked out an inventory production plan that sets out the schedule for the inventory preparation. The schedule is a part of the Estonia's QA/QC plan and has to be followed by all the core institutions (MoE, EERC, EEIC and TUT). The inventory production plan is presented in the Table 1.1. More detailed information about Estonia's QA/QC plan is presented in the section 1.3.3.

Table 1.1. Inventory production plan

Activity	Responsible	Deadline
Annual meeting: Will be discussed how the previous inventory cycle has been, what should be improved/changed; new contracts, etc	*All*	*April 15*
Agreement on the changes and adjustments to be made for the next year's reporting	All	July 1
Sectoral experts notify the EERC and MoE of the planned methodological changes, reasons for changes and how they plan to incorporate the UNFCCC review results to the next report	Sectoral experts	Oct. 15
Annual meeting: Sectoral experts notify the EERC and MoE of the planned methodological changes, reasons for changes, overview of the planning of the new inventory cycle and how they plan to incorporate the UNFCCC review results to the next report. MoE and EERC give an overview of the new requirements, plans, etc	*All*	*Oct. 30*
Sectoral experts provide the XML files to the EERC and MoE	TUT, EERC, EEIC	Dec. 1
Sectoral experts send the necessary data for uncertainty analysis to EERC and MoE	TUT, EERC, EEIC	Dec. 5
QC checks are carried out (XML files) and documented by inventory coordinator (MoE and EERC) and sent to the sectoral experts	EERC, MoE	Dec. 1-6
MoE compiles the CRF tables and sends them to the sectoral experts for approval. CRF tables are also sent to the independent expert	MoE	Dec. 7
EERC performs the key category analysis and uncertainty analysis and sends the results to the sectoral experts and independent expert	EERC	Dec. 10
Sectoral experts provide the draft NIR to the EERC and MoE. Prior to this the QC checks should be carried out and documented	TUT, EERC, EEIC	Dec. 15
EERC compiles the draft NIR according to the submitted sectoral parts and sends it to the sectoral	EERC	Dec. 21

experts, independent expert, MoE and other institutes for approval		
Independent expert will carry out the QA for the CRF tables and submits the documented results to the sectoral experts and EEIC	TUT	Dec. 21
EERC and MoE perform QC of the NIR and send the comments to the sectoral experts and independent expert for review	EERC, MoE	Jan. 4
Sectoral experts send their comments and possible changes on the CRF tables according to the QA/QC (performed by independent expert, MoE and EERC) to EERC, MoE and independent expert	TUT, EERC, EEIC	Jan. 8
Reporting to the EU (CRF tables and draft NIR)	MoE	Jan. 15
The draft NIR along with the CRF tables is uploaded to the MoE webpage for public review	MoE	Jan. 18
Independent expert carries out QA of the NIR and submits the results to the sectoral experts, EERC and MoE	TUT	Febr. 8
MoE different departments carry out QC of the CRF tables and NIR and submits the results to the EERC	MoE	Febr. 8
EERC submits the results of the MoE QC to the sectoral experts and independent expert	EERC	Febr. 9
EERC performs source category-specific QA of the NIR and the CRF tables using Tier 2 QC elements focusing on key source categories	EERC	Febr. 15
Sectoral experts send their comments and possible changes according to the QA/QC (performed by the MoE and independent expert) to EERC, MoE and independent expert	TUT, EERC, EEIC	Febr. 22
Annual meeting: The independent expert will meet with the sectoral experts in order to discuss the results of the QA checks	*TUT, EERC, EEIC*	*Febr. 22*
Annual meeting: The comments given during the inventory preparation and the last UNFCCC review report will be looked through. Also questions/problems that have been raised will be discussed before the submission to the EU	*All*	*Before March 15*
Reporting to the EU (CRF tables and NIR)	MoE	March 15
Answers to the EU initial check and if possible then corrections are made to the inventory	All	Febr 28-April 15
MoE approves the final inventory	MoE	April 10
Reporting to the UNFCCC	MoE	April 15
NIR and CRF tables are uploaded to the MoE webpage	MoE	April 19

1.2.3. Overview of inventory preparation and management, including for supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

The inventory preparation is an annual process and is divided into three stages: planning, preparation and management. The specific functions are described below.

Inventory planning

- Designate a single national entity with overall responsibility for the national inventory;
- Make available the postal and electronic addresses of the national entity responsible for the inventory;
- Define and allocate specific responsibilities in the inventory development process, including those relating to choice of methods, data collection, particularly activity data and emission factors from statistical services and other entities, processing and archiving, and QA/QC. This definition shall specify the roles of, and cooperation between, government agencies and other entities involved in the preparation of the inventory, as well as the institutional, legal and procedural arrangements made to prepare the inventory;
- Elaborate an inventory QA/QC plan which describes specific QC procedures to be implemented during the inventory development process, facilitate the overall QA procedures to be conducted, to the extent possible, on the entire inventory and establish quality objectives;
- Establish processes for the official consideration and approval of the inventory, including any recalculations, prior to its submission and to respond to any issues raised by the inventory review process.

Inventory preparation

- Identify key source categories;
- Prepare estimates in accordance with the methods described in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and the IPCC Good Practice Guidance;
- Collect sufficient activity data, process information and emission factors as are necessary to support the methods selected for estimating anthropogenic GHG emissions by sources and removals by sinks;
- Make a quantitative estimate of inventory uncertainty for each source category and for the inventory in total, following the IPCC Good Practice Guidance;
- Ensure that any recalculations of previously submitted estimates of anthropogenic GHG emissions by sources and removals by sinks are prepared in accordance with the IPCC Good Practice Guidance and relevant decisions;
- Compile the national inventory;
- Implement general inventory QC procedures (tier 1) in accordance with its QA/QC plan following the IPCC Good Practice Guidance;
- Consider source-specific QC procedures and provide for a basic review of the inventory of personnel that have not been included in the inventory development.

Inventory Management

- Archive information for each year in accordance with relevant decisions;
- Provide a review team with access to archived information used by the Party to prepare the inventory;
- Respond to requests for clarifying inventory information resulting from different stages of the review process of the inventory information, and information on the national system, in a timely manner.

All information required pursuant to Article 7 of the Kyoto Protocol has been integrated within the reporting processes.

1.3. Inventory preparation

1.3.1. GHG inventory and KP-LULUCF inventory

The UNFCCC, the Kyoto Protocol and the Decision No 280/2004/EC of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol require Estonia to submit annually NIR and CRF tables. The annual submission contains emission estimates for the years between 1990 and the year before last year. So the 2012 submission contains estimates for the years 1990–2010.

The organization of the preparation and reporting of Estonia’s greenhouse gas inventory and the duties of its different parties are detailed in the previous section (1.2.1). Single national entity with overall responsibility for the Estonian greenhouse gas inventory is MoE. The inventory is produced in collaboration between the MoE, EERC, EEIC and TUT.

Under the EU monitoring mechanism the annual inventory is submitted to the Commission by 15 January. The Member States may complement and update their submission by 15 March. The final greenhouse gas inventory is submitted to the UNFCCC Secretariat by 15 April.

1.3.2. Data collection, processing and storage

The inventory process for the next year starts with examination of previous years and by analyzing the available datasets in order to improve the inventory due to new knowledge and activity data developed.

The sectoral experts from TUT, EERC and EEIC are collecting data and prepare the estimates for the national inventory. The main sources of data are from official Estonian statistics (Statistics Estonia, Estonian Animal Recording Center) and from company’s annual emission reports.

MoE has a bilateral agreement with Statistics Estonia (SE). SE collects statistical data on the basis of the Official Statistics Act §3(2), taking into consideration the official statistical surveys approved by the Government of the Republic.

The data collected from other institutions and private companies is done by sectoral experts that have personal contacts in order to receive the data.

The data sources for each sector are described below.

Energy

Activity data used in the estimates is obtained mainly from SE.

SE publishes:

1. Energy related data in the statistical data base of the homepage of SE (Energy Balance Sheets in natural units (in thousand tons) and in TJ-s). The data received from SE cover all fuels used in 6 main end-use sectors (Energy Industries, Manufacturing Industries, Transport, Agriculture, Residential and Commercial/Institutional) but also in sub-sectors of the main end-use sectors.

2. Additionally TUT asks every year by special inquiry Energy Balance Sheet in natural units (in tons), data on consumption of aviation fuels for international bunkering and inland consumption because this data is not published in the statistical data base (the data of aviation fuels is given in total and is not splitted into national and international use).

3. Other information sources used in estimates of GHG emissions from energy sector are:

Eesti Energia AS (Estonian Energy Ltd.) – data on oil shale consumption for pulverized combustion and for circulating fluidized bed combustion, data on use of oil shale semi–coke gas in the Eesti Power Plant.

Narva Oil Plant AS (at the Eesti Power Plant) – shale oil and semi-coke gas production data.

Viru Keemia Grupp AS (Viru Chemistry Group Ltd. in Kohtla-Järve) – shale oil and generator gas production data.

Kiviõli Keemiatööstuse OÜ (Kiviõli Oil Shale Processing and Chemicals Plant Ltd.) – shale oil and generator gas production data.

EEIC – GHG emission estimations from civil aviation and road transport sector. EEIC has a special model Copert IV for calculation of emissions from transport, incinerated waste fuel data.

EEIC – activity data on combustible waste amounts.

Ministry of Economic Affairs and Communication – activity data on transport biofuel amounts used in Estonia.

Industrial Processes

Activity data used in the estimates are obtained from SE, plants and in case of F-gases from national and international companies, associations, public institutions etc. CO_2 emissions from mineral industries are reported in six sub-sectors: cement production, lime production, soda ash use, glass production, bricks and tiles production and lightweight gravel production.

Data on clinker production (raw material in cement production) were received directly from the cement factory Kunda Nordic Cement AS. Activity data on lime production were collected mainly from the industry (Nordkalk AS and Limex AS) and taken partly from industrial statistics. Data on flat glass production were received from SE and data on container glass production from factory O-I Production Estonia AS. Data on bricks and roof tiles production were collected from production plants and taken partly from industrial statistics. Activity data on lightweight gravel production were received from factory.

In chemical industry sector only CO_2 emissions from ammonia production are calculated. Activity data were received directly from the ammonia factory Nitrofert AS.

Consumption of Halocarbons and SF_6 covers HFC, PFC and SF_6 emissions from refrigeration and air conditioning, foam blowing, aerosols and electrical equipment, as well as emissions from some smaller sources, such as fire extinguishers and other (other electrical equipment). In these sub- sectors data were collected from national and international companies, associations, public institutions etc.

Solvent and Other Product Use

The collection of NMVOC emission data from the solvent and other product use sector is performed at the EEIC. The NMVOC inventory is carried out to meet the obligations of the United Nations Economic Commission for Europe's Convention on Long-Range Transboundary Air Pollution (UNECE CLRTAP). Activity data used in the estimates are obtained from SE and from web-interface air emissions data system for the point sources (OSIS), that contains data reported by the facilities having pollution permit. In some sectors, also expert judgements have been used.

Activity data used to estimate N_2O emissions from the solvent and other product use was collected directly from the companies importing N_2O for medical use and other applications to Estonia.

Agriculture

Activity data used in the estimates were obtained mainly from SE. The data received from SE are the following (see also Table 6.3):

- number of livestock (by livestock category and sub-category);
- data on milk production per cow;
- crop yields and sown areas of filed crops (by crop type);
- volume of N fertilizers applied on agricultural soils;
- location of animal waste management systems.

SE opens the data annually by July–August.

Other information sources used in estimates of GHG emissions from agriculture sector are:

- Estonian Animal Recording Centre (fat content of milk, percentage of cows that give birth);
- Scientific publications (a model of gross intake by pigs, feed digestibility, nitrogen content in feed etc.);
- Activity data on organic soils cultivated, which were obtained in the framework of National Forest Inventory (NFI).

LULUCF

Activity data used in the estimates is obtained mainly from NFI. Data gained from NFI comprises:

- area (including differentiation of organic and mineral soil) of forest land, cropland, grassland, wetlands, settlements and other land;

- dynamics of land-use changes;
- volume of woody biomass (including dead wood) on different land use and land-use change categories.

Estimates of biomass burning on forest land, grassland and wetlands are based on compiled information obtained from Estonian Rescue Service, the State Forest Management Centre and Environmental Board.

Data about liming was received from the Ministry of Agriculture.

Waste

Activity data on solid waste generation and disposal are collected from EEIC. The data on the population of Estonia is obtained from the dataset of SE.

A staff of Waste Bureau of the EEIC and an expert of waste sector (from EERC) negotiate on further collaboration, which allows to the expert to receive activity data directly from EEIC waste datasets.

The data on methane recovery is obtained from EEIC Air bureau, as the landfills with the system of methane collection report their quantities of recovered methane directly to the Air bureau.

The quantities of domestic and industrial wastewater generation and treatment are obtained from the datasets of the EEIC Water Bureau. The data on the population of Estonia and the amount of products produced are used in calculating emissions are taken from SE.

For calculating N_2O emissions from human sewage, the data on population of Estonia is used as activity data and is obtained from the dataset of SE.

Activity data on waste incineration and biological treatment are collected from EEIC.

Activity data on biogas burnt in a flare is derived from EEIC Air bureau.

Archiving

All institutions are responsible for archiving the data they collect and the estimates they calculate. But it is necessary to have a central archiving system located at a single location. EERC bears the responsibility of archiving and Estonia’s central inventory archive is located there. More detailed information about the archiving system can be found in the section 1.6.1.3.

1.3.3. Quality assurance/quality control (QA/QC) procedures and extensive review of GHG inventory

It is important that the national GHG inventories would be readily assessed in terms of quality. It is good practice to implement QA/QC procedure in the development of national greenhouse gas inventories.

Quality Control (QC) is a system of routine technical activities to assess and maintain the quality of the inventory as it is being compiled. It is performed by personnel compiling the inventory. The QC system is designed to:

- Provide routine and consistent checks to ensure data integrity, correctness, and completeness;
- Identify and address errors and omissions;

- Document and archive inventory material and record all QC activities.

QC activities include general methods such as accuracy checks on data acquisition and calculations, and the use of approved standardised procedures for emission and removal calculations, measurements, estimating uncertainties, archiving information and reporting. QC activities also include technical reviews of categories, activity data, emission factors, other estimation parameters and methods.

Quality Assurance (QA) is a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews, preferably by independent third parties, are performed upon a completed inventory following the implementation of QC procedures. Reviews verify that measurable objectives were met, ensure that the inventory represents the best possible estimates of emissions and removals given the current state of scientific knowledge and data availability, and support the effectiveness of the QC programme.

All institutions involved in the inventory process (MoE, EERC, TUT and EEIC) are responsible for implementing the QC procedures to meet the data quality objectives. MoE as a national entity is responsible for overall QC and is in charge of checking on an annual basis that the appropriate QC procedures are implemented internally in TUT, EERC and EEIC. EERC as the quality coordinator has an overall responsibility for coordinating and implementing the QA/QC plan. EERC checks the QC reports of TUT, EERC and EEIC performed by sectoral experts, and the QA report performed by an independent expert from TUT. Also a public review is carried out annually. The draft NIR is uploaded to the MoE website www.envir.ee where all interested parties have an opportunity to comment on it.

One part of QA is the UNFCCC reviews. The reviews are performed by a team of experts (sectoral experts and a generalist) from other countries. They examine the data and methods used in Estonia, check the documentation, archiving system and the national system.

Estonia also had a Twinning Light project EE06-IB-TWP-ENV-06 “Improving the quality of Estonia’s National Greenhouse Gas Inventory” with Finland in 2009. The project was directed at improving the implementation of article 3.1 of Decision No 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring European Community GHG emissions and for implementing the Kyoto Protocol.

More detailed information about Estonia’s QA/QC plan is presented in Chapter 1.6.

1.4. Brief general description of methodologies and data source used

1.4.1. GHG inventory

The methodologies used for the Estonia’s greenhouse gas inventory are consistent with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and IPCC Good Practice Guidance (IPCC 2000), IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry (IPCC 2003) and 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006). Detailed descriptions of the methodologies used can be found in the sectoral Chapters 3 to 8.

The main methodologies and data sources used in current inventory are given in Table 1.2.

Table 1.2. Methodology, activity data and emission factor sources used

IPCC category	Methodology	Emission factor	Activity data
1. Energy	Revised 1996 IPCC, IPCC 2000, IPCC 2006	Revised 1996 IPCC, IPCC 2006	Statistics Estonia and energy companies (Eesti Energia AS, VKG AS, Kiviõli Keemiatööstuse OÜ); The Estonian Environment Information Centre (EEIC)
A. Fuel Combustion	T_1, T_2, T_3	D, CS, PS	National Energy Balances and Annual Yearbooks and the statistical data base of Statistics Estonia; data of energy companies; waste fuel data from the EEIC
A.1 Energy Industries	T_1, T_2, T_3	D, CS, PS	National Energy Balances and Annual Yearbooks and the statistical data base of Statistics Estonia; data of energy companies
A.2 Manufacturing Industries and Construction	T_1, T_2, T_3 (T_3 since 2000)	D, CS, PS (PS since 2000)	National Energy Balances and Annual Yearbooks and the statistical data base of Statistics Estonia; data on waste fuels from EEIC
A.3 Transport	T_1, T_2, T_3	D, CS	National Energy Balances and Annual Yearbooks and the statistical data base of Statistics Estonia; data on aviation and road transport fuels and corresponding GHG emission estimations from the EEIC
A.4 Other Sectors	T_1, T_2	D, CS	National Energy Balances from the statistical data base of Statistics Estonia

A.5 Other	T_1	D	National Energy Balances from the statistical data base of Statistics Estonia
B. Fugitive Emissions	T_1	D	National Energy Balances from the statistical data base of Statistics Estonia
2. Industrial Processes	Revised 1996 IPCC, IPCC 2000, IPCC 2006	Revised 1996 IPCC, IPCC 2000, IPCC 2006	Statistics Estonia; plant specific data; national and international companies; associations, public institutions
A. Mineral Industry	T_1, T_2	D, PS	Statistics Estonia; plant specific data
B. Chemical Industry	T_{1a}	PS	Plant specific data
F. Consumption of Halocarbons and SF_6	T_2, T_3	CS	National and international companies; associations, public institutions
3. Solvent and Other Product Use	IPCC 2006	IPCC 2006	Estonian Environment Information Centre; national companies
A. Paint Application	T_1	D	Estonian Environment Information Centre
B. Degreasing and Dry Cleaning	T_1	D	Estonian Environment Information Centre
C. Chemical Products, Manufacture and Processing	T_1	D	Estonian Environment Information Centre
D. Other	T_1, T_2	D, CS	Estonian Environment Information Centre; national companies
4. Agriculture	Revised 1996 IPCC, IPCC 2000	Revised 1996 IPCC, IPCC 2000	Statistics Estonia; IPCC default parameters
A. Enteric Fermentation	T_1, T_2	CS, D	Statistics Estonia; IPCC default parameters
B. Manure Management	T_1, T_2	CS, D	Statistics Estonia; IPCC default parameters
D. Agricultural Soils	T_1, $T1_b$, T_2	D	Statistics Estonia; IPCC default parameters

5. LULUCF	Revised 1996 IPCC, IPCC 2003	Revised 1996 IPCC, IPCC 2003	National Forest Inventory; Estonian Rescue Service; the State Forest Management Centre; Environmental Board; Ministry of Agriculture
A. Forest land	T_1, T_2	D	National Forest Inventory; Estonian Rescue Service; the State Forest Management Centre; Environmental Board
B. Cropland	T_1, T_2	D	National Forest Inventory; Ministry of Agriculture
C. Grassland	T_1, T_2	D	National Forest Inventory; Estonian Rescue Service; the State Forest Management Centre; Environmental Board
D. Wetlands	T_1, T_2	D	National Forest Inventory; Estonian Rescue Service; the State Forest Management Centre; Environmental Board
E. Settlements	T_1, T_2	D	National Forest Inventory
F. Other Land	T_1, T_2	D	National Forest Inventory
6. Waste	Revised 1996 IPCC, IPCC 2000, IPCC 2006	Revised 1996 IPCC, IPCC 2000, IPCC 2006	Estonian Environment Information Centre; Statistics Estonia
A. Solid Waste Disposal on Land	T_2 (the FOD method)	D	Estonian Environment Information Centre; Statistics Estonia
B. Wastewater Handling	T_1	D	Estonian Environment Information Centre; Statistics Estonia
C. Waste Incineration	T_1	D	Estonian Environment Information Centre
D. Other	T_1	D	Estonian Environment Information Centre

T_1 – IPCC Tier 1; T_2 – IPCC Tier 2; T_3 – IPCC Tier 3; CS – Country specific; D – IPCC default value, PS – Plant specific

1.4.2. KP-LULUCF inventory

Estonia implements the *Reporting Method 1* for lands subject to Article 3.3 activities. The area of Estonia is not divided into regions.

A *tier 1* approach is employed to estimate areas of land-use change in the LULUCF sector inventory. Information on the IPCC land use and land-use change category for each sample plot is presented in the forest inventory database. The annual land-use change areas were calculated for 1990–2010. The matrix was developed adding and subtracting the conversion areas to and from land-use category areas.

Afforestation/reforestation (AR) areas were obtained from Statistics Estonia (SE). Area of AR activities has been identified in stand-level.

Data about deforestation and land-use changes were compiled by National Forest Inventory (NFI). NFI is a sampling based inventory system that covers all land-use categories.

The total biomass increment in afforestation and reforestation areas was obtained by assuming that the mean increment per area unit of a certain age of forest (derived from NFI data) is the same as in the forest land under UNFCCC reporting. This means that increment was multiplied by the area estimate of forests included in KP reporting to obtain the total increment. Similar approach was applied for the drain. The tree biomass loss due to deforestation was estimated.

1.5. Brief description of key categories

1.5.1. GHG inventory

Key categories are the categories of emissions/removals, which have a significant influence on the total inventory in terms of the absolute level of emissions (1990 or 2010), the trend of emissions (change between 1990 and 2010) or both. There are two alternative methods for identifying key categories: Tier 1 and Tier 2. In this report Tier 2 method has been used- the emission categories are sorted according to their contribution to emission level or trend. The key categories are those that represent together 90% of inventory level or trend.

Detailed reporting tables can be found in Annex 1.

Table 1.3. Key categories identified using Tier 2 methodology

	IPCC Source Category	Gas	Key category	Criteria for identification (without LULUCF)	Criteria for identification (with LULUCF)
1.A.1.a	Energy Industries/Electricity and Heat Production – Solid Fuels	CO_2	yes	Level (1990, 2010), Trend	Level (1990, 2010), Trend
1.A.1.a	Energy Industries/ Electricity and Heat Production – Liquid Fuels	CO_2	yes	Trend	Trend
1.A.1.c	Energy Industries/Other Energy Industries – Solid Fuels	CO_2	yes	Level (2010), Trend	Level (2010), Trend
1.A.2	Manufacturing Industries and Constructions – Other Fuels	CO_2	yes	Trend	
1.A.2.c	Manufacturing Industries and Constructions/Chemicals – Solid Fuels	CO_2	yes	Level (1990), Trend	Level (1990), Trend
1.A.2.f	Manufacturing Industries and Constructions/Other – Solid Fuels	CO_2	yes	Level (1990, 2010), Trend	Level (1990, 2010), Trend
1.A.4.b	Other Sectors/Residential – Solid Fuels	CO_2	yes	Level (1990), Trend	Level (1990), Trend
1.A.4.b	Other Sectors/Residential – Biomass	CH_4	yes	Level (2010), Trend	Level (2010), Trend
1.A.4.b	Other Sectors/Residential – Biomass	N_2O	yes	Trend	
2.B.1	Ammonia Production	CO_2	yes	Trend	
4.A	Enteric Fermentation – Dairy Cattle	CH_4	yes	Level (1990, 2010)	Level (1990, 2010)
4.A	Enteric Fermentation – Non-Dairy Cattle	CH_4	yes	Level (1990, 2010), Trend	Level (1990, 2010), Trend
4.B	Manure Management – Solid Storage and Dry Lot	N_2O	yes	Level (1990, 2010), Trend	Level (1990, 2010)
4.D.1.1	Direct Soil Emissions – Synthetic Fertilizers	N_2O	yes	Level (1990, 2010), Trend	Level (1990, 2010), Trend
4.D.1.2	Direct Soil Emissions – Animal Manure Applied to Soils	N_2O	yes	Level (1990, 2010)	Level (2010)
4.D.1.3	Direct Soil Emissions – N-fixing Crops	N_2O	yes	Level (1990), Trend	Level (1990), Trend
4.D.1.4	Direct Soil Emissions – Crop Residue	N_2O	yes	Trend	Trend
4.D.1.5	Direct Soil Emissions – Cultivation of Histosols	N_2O	yes	Trend	
4.D.2	Pasture, Range and Paddock Manure	N_2O	yes	Level (1990, 2010)	Level (1990, 2010)
4.D.3.2	Indirect Emissions – Nitrogen Leaching and Run-off	N_2O	yes	Level (1990, 2010), Trend	Level (1990, 2010), Trend
5.A.1	Forest Land remaining Forest Land – living biomass	CO_2	yes		Level (1990, 2010), Trend
5.A.1	Forest Land remaining Forest Land – net carbon stock change in organic soils	CO_2	yes		Level (1990, 2010), Trend
5.A.1	Forest Land remaining Forest Land – deadwood	CO_2	yes		Level (2010), Trend
5.A.2.1	Cropland converted to Forest Land – net carbon stock change in living biomass	CO_2	yes		Level (2010), Trend
5.A.2.2	Grassland converted to Forest Land – net carbon stock change in living	CO_2	yes		Level (2010), Trend

	biomass				
5.A.2.4	Settlements converted to Forest Land – net carbon stock change in living biomass	CO_2	yes		Trend
5.A.2.5	Other Land converted to Forest Land – net carbon stock change in living biomass	CO_2	yes		Level (2010), Trend
5.C.1	Grassland remaining Grassland – living biomass	CO_2	yes		Trend
5.C.2	Land converted to Grassland – net carbon stock change in living biomass	CO_2	yes		Level (2010), Trend
5.E.2.1	Forest Land converted to Settlements – living biomass	CO_2	yes		Level (2010), Trend
6.A	Solid Waste Disposal on Land	CH_4	yes	Level (2010), Trend	Level (2010), Trend
6.B.1	Industrial Wastewater	CH_4	yes	Trend	Trend
6.D	Biological Treatment	CH_4	yes	Trend	Trend
6.D	Biological Treatment	N_2O	yes	Trend	Level (2010), Trend

1.5.2. KP-LULUCF inventory

Key category analysis for KP-LULUCF was performed according to chapter 5.4.4 of the IPCC Good Practice Guidance for LULUCF (IPCC 2003). The basis for assessment of key categories under Article 3.3 of the KP is the same as the assessment made for the UNFCCC inventory. The key categories, also reported in CRF table NIR-3, are CO_2 removals due to afforestation/reforestation and CO_2 emissions from deforestation.

1.6. Information on the QA/QC plan including verification and treatment of confidentiality issues where relevant

1.6.1. QA/QC procedures

This section presents the general QA/QC programme including the quality objectives and the QA/QC plan for the Estonian greenhouse gas inventory at the national inventory level. Source specific QA/QC details are discussed in the relevant sections of this NIR.

All institutions involved in the inventory process (MoE, EERC; TUT and EEIC) are responsible for implementing QC procedures to meet the data quality objectives.

MoE as the national entity is responsible for overall QC and is in charge of checking on an annual basis that the appropriate QC procedures are implemented internally in TUT, EERC and EEIC. The EERC as a coordinator has an overall responsibility for QC of the data of the emission inventory. EERC checks the QC reports of TUT, EERC and EEIC. When EERC disagrees with the report then the errors are discussed and changes are made if necessary. Each institution is responsible for reporting on their completion of the QC procedures on an annual basis. This reporting is based on a checklist of general and source-specific QC checks and a textual description of possible recalculations, issues to be followed up before the next submissions, and other relevant information. MoE as the national entity is responsible for the overall QA of the national system, including the UNFCCC reviews and any national reviews undertaken.

During the Twinning Light project “Improving the quality of Estonia’s National Greenhouse Gas Inventory” with Finland in 2009 Estonia updated its QA/QC plan. The Estonia’s QA/QC plan consist of six parts: (1) production plan (see Table 1.1); (2) annual meetings; (3) QA/QC checks; (4) archiving structure; (5) response tables to the review process and (6) a list of planned activities and improvements.

1.6.1.1. QC procedures

The Estonian Greenhouse Gas Inventory is compiled by the EERC. The data compilation and reporting for source sectors are performed by TUT, EERC and EEIC.

The quality of the inventory is ensured in the course of the compilation and reporting, that consists of four main stages: planning, preparation, evaluation and improvement. The quality management of inventory is a continuous process.

It starts from the consideration of the inventory principles. The setting of concrete annual quality objectives is based on this consideration. The next step is elaboration of the QA/QC plan and implementing the appropriate quality control measures (e.g. routine checks, documentation) focused on meeting the quality objectives set and fulfilling the requirements. In addition, the QA procedures are planned and implemented. In the improvement phase of the inventory, conclusions are made on the basis of the realized QA/QC process and its results.

The QC procedures used in Estonia's GHG inventory comply with the IPCC Good Practice Guidance. General inventory QC checks (IPCC GPG 2000, Table 8.1 and IPCC GPG LULUCF 2003, Table 5.5.1) include routine checks of the integrity, correctness and completeness of the data, identification of errors and deficiencies and documentation and archiving of the inventory data and quality control actions. Once the experts have implemented the QC procedures, they complete the QA/QC form for each source/sink category, which provides a record of the procedures performed. The QA/QC forms are part of Estonia's QA/QC plan. Also assessment of completeness is evaluated.

In addition, the quality control conducted under the European Community GHG Monitoring Mechanism (e.g. completeness checks, consistency checks) produces valuable information on errors and deficiencies, and the information is taken into account before Estonia submits its final annual inventory to the UNFCCC.

The sectoral experts send their xml files to the MoE and EERC and MoE puts all the sectors together and completes the CRF tables. During that time the numbers are cross-checked in the CRF reporter to make sure that no mistakes were made during the importing process. Also the CRF completeness check and recalculation check are carried out to make sure that all the necessary data is filled. When MoE has completed the CRF tables, then all data is checked by an independent expert from Tallinn University of Technology. The results of the independent expert will be looked through in collaboration with the experts and EERC and necessary adjustments will be carried out as a result.

When the CRF tables are finalized, the experts will start preparing the sectoral chapters of the NIR. These parts are sent to the compiler (EERC) who adds the introduction part and puts the draft NIR together. The compiler arranges the different chapters into one uniform document and makes sure that the structure of the report follows the UNFCCC guidelines (annotated outline of the National Inventory Report). All figures on emissions and removals in tables and text are checked to make sure that they are consistent with those reported in the CRF. The sectoral experts and the inventory compiler also check that all methodological changes, recalculations, trends in emission and removals are well explained.

When the draft NIR is completed it is sent to the MoE. The Climate and Radiation Department looks over the inventory report and makes sure that the submitted data is officially valid. Also the structure of the report is assessed based on the established requirements. When there are no contradictions the report is introduced for coordination to the Forestry, Waste and Water Department and Deputy Secretary General on International Co-operation and afterwards to the Secretary General. When the report is approved by the Secretary General the report can be sent to the European Commission (EC) and UNFCCC.

The inventory meetings with participants from all institutes participating in the inventory preparation are held four times a year and the bilateral quality meetings between the quality coordinator (EERC) and the expert organizations are held whenever necessary.

MoE and EERC, in collaboration with the expert organizations responsible for the inventory calculation sectors, set yearly quality objectives for the whole inventory at the inventory planning stage and design the QC procedures needed for achieving these objectives. In addition, the expert organizations set their own, sector and/or category specified quality objectives and prepare their QC plans.

The setting of quality objectives is based on the inventory principles presented in the UNFCCC Guidelines and in EU Decision 280/2004/EC concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol, that is, transparency, consistency, comparability, completeness, accuracy and timeliness. In addition, the principle of continuous improvement is included.

1.6.1.2. QA procedures

The objective of QA implementation is to involve reviewers that can conduct an unbiased review of the inventory and who may have a different technical perspective. It is important to use QA reviewers that have not been involved in preparing the inventory. Preferably these reviewers would be independent experts from other agencies or national experts or groups not closely connected with the national inventory compilation.

From the 2009 submission all data collected by institutions involved in the inventory process is being checked by an independent expert from Tallinn University of Technology. Quality assurance of the Energy, Industrial Processes, Solvents and Other Product Use, Agriculture, Waste and LULUCF sectors were carried out by Tiina Randla (MSc), assistant of Tallinn University of Technology, Institute of Chemistry.

The UNFCCC expert review team has recommended Estonia to use the results of the key category analysis as a driving force for setting priorities for improving the quality of the inventory. Taking into account the recommendation, additional QA was carried out in key categories in the 2012 submission. Quality assurance of the key categories were carried out by EERC experts that have not been involved in preparing inventory in respective category/sector. Source category-specific QC (Tier 2) elements were used in performing additional QA.

Also public review was carried out. The draft NIR was uploaded to the MoE website www.envir.ee where all interested parties had an opportunity to comment on it. The public reviews of the draft document offer a broader range of researchers and practitioners in non-governmental organizations, industry and academia, as well as the general public, the opportunity to contribute to the final document. The comments received during these processes are reviewed and, as appropriate, incorporated into the NIR.

The inventory is also checked by different Ministries and institutions. The inventory is sent to the Ministry of Economic Affairs and Communications, to Forest, Waste and Water Departments in MoE, to Ministry of Agriculture and Waste Department in EEIC.

One part of QA is UNFCCC reviews. The reviews are performed by a team of experts (sectoral experts and generalist) from other countries. They are examining the data and methods that Estonia is using, checking the documentation, archiving system and national system. In conclusion they report whether Estonia's overall performance is in accordance with current guidelines. The review report indicates the specific areas where the inventory is in need of improvements.

Peer review

Estonia also had a Twinning Light project with Finland in 2009. Project title was "Improving the quality of Estonia´s National Greenhouse Gas Inventory". The project was addressed at improving the implementation of Article 3.1 of Decision No 280/2004/EC of the European Parliament and of the Council of 11 February 2004, concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.

During this project all 5 sectors (Energy, Industrial Processes (except F-gases), Agriculture, Waste and Land Use, Land-Use Change and Forestry (LULUCF) were analyzed. Terms of reference was elaborated to develop a single national IT system to facilitate GHG emission data handling, calculation and reporting. Concept and suggestions were developed to improve the QA/QC procedures and the uncertainty management of GHG inventory.

1.6.1.3. Archiving

It is good practice for inventory compilers to maintain the documentation for every inventory produced and to provide it for review. It is good practice to maintain and archive this documentation in such a way that every inventory estimate can be fully documented and reproduced if necessary.

All institutions are responsible for archiving the data they collect and the estimates they calculate. EERC bears the responsibility of archiving and Estonia's central inventory archive is located there. When the reporting cycle ends and all inventory calculations are finalized all experts send their documentation to the compiler and it is stored in one place.

The data and information is archived for each submission year. The archiving includes all input data, all estimated emissions, corresponding letters, all partly filled-in or final CRF, recalculations of previous estimates, submissions to UNFCCC and EC and NIR-s. The archiving system is located in EERC server which undergoes a daily backup and the backups are securely saved. Also after inventory compilation the calculation results are archived on CD-ROM.

During the Twinning Light project with Finland in 2009 "Improving the quality of Estonia´s National Greenhouse Gas Inventory" a new improved archiving system was developed. The archiving system consists of two parts: data related (1) to the CRF and (2) to the NIR. The first part contains information and documentation on activity data, emission factors and methodology used and the second part all the relevant documents that were used for the preparation of NIR. Also all submissions to the UNFCCC and EC are archived. Materials used in the 2010 inventory submission were archived for the first time according to the new archiving system. The archiving system was modified after the first trial to make it better and remove all the inconsistencies that came up. The materials used in the 2011 inventory submission were archived and 2012 inventory submission will be archived according to the improved archiving system.

In addition to the main archive, the expert organizations contributing to the sectoral calculation archive the primary data used, internal documentation of calculations and sectoral CRF tables. These organizations keep records of their work on hard disks of individual expert's desktop workstations, with copies on backed up network servers. Also electronic copies on CD-ROMs are produced.

Starting from autumn 2010 a ftp site has been set up in order to collect all important documents into one location where everybody has the opportunity to use them. The ftp site is used for sharing documents (xml files, draft NIR's, QA/QC documents, aso), also previous submissions, review reports, answers to the reviews and guidelines are available. The ftp site is accessible by sectoral experts, inventory compiler and independent expert. The ftp site has been a success, as it compiles all the latest documents into one location and through the ftp site it can be assured that you are getting the latest version. Before all information was shared through e-mails, that was not that sufficient.

1.6.2. Verification activities

Detailed information about verification activities can be found under the sectoral chapters.

1.6.3. Treatment of confidentiality issues

Nearly all of the data necessary to compile the Estonia's inventory are publicly available. The main exceptions are related to the reporting of amounts of carbon stored with oil shale semi-coke (1.AD.10) and emissions from Consumption of Halocarbons and SF_6 (CRF 2.F). Activity data for calculating carbon stored with semi-coke are collected from private oil production companies and some of the data might be confidential.

Under the category Consumption of Halocarbons and SF_6 there are several subcategories (for example Commercial and Industrial Refrigeration, Foam Blowing, Fire Extinguishers etc) where activity data are collected directly from private companies active in this field on condition that the data remains confidential. Therefore data from companies has been summarised and presented on subcategory level.

1.7. General uncertainty evaluation, including data on the overall uncertainty for the inventory totals

1.7.1. GHG inventory

This section provides an overview of the approach to uncertainty analysis adopted for Estonia´s inventory. The mandatory reporting table of the analysis is presented in Annex 7.

The uncertainty estimates of the 2012 inventory has been done according to the Tier 1 method presented by the IPCC Good Practice Guidance 2000 (IPCC 2000). Tier 1 method combines the uncertainty in activity rates and emission factors, for each source category and greenhouse gas, and then aggregates these uncertainties, for all source categories and greenhouse gases, to obtain the total uncertainty for the inventory.

In many cases uncertainty values have been assigned based on default uncertainty estimates according to IPCC guidelines or expert judgement, because there is a lack of the information. For each source, uncertainties are quantified for emission factors and activity data.

Uncertainties are estimated for direct greenhouse gases, e.g. CO_2, CH_4, N_2O and F-gases. The uncertainty analysis was done for the all sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Waste and LULUCF sector.

In the 2012 inventory, uncertainty estimates and references were reviewed and some values revised. Detailed information about uncertainty evaluation is described in the sectoral chapters (Chapters 3–8).

Table 1.4 shows the estimated uncertainties for total greenhouse gas emissions in 2010 and the trend.

Table 1.4. Inventory uncertainties in 2010

	Combined as % of total national emissions in 2010	Introduced into the trend in total national emissions
	Uncertainty [%]	
Without LULUCF	24.3	2.6
With LULUCF	31.0	7.8

1.7.2. KP-LULUCF inventory

Uncertainty rates related to activity data and emission factors employed in the estimates under Article 3.3 are calculated based on the same methodology (*Tier 1*) as used under UNFCCC reporting following the guidelines from the IPCC GPG for LULUCF (2003) Chapters 4.2.4.2 and 5. Uncertainties are estimated at the 95% confidence limits.

1.8. General assessment of the completeness

1.8.1. GHG inventory

Estonia has provided estimates for all significant IPCC source and sink categories according to the detailed CRF classification. Estimates are provided for the following gases: CO_2, N_2O CH_4, F-gases (HFC, PFC and SF_6), NMVOC, NOx, CO and SO_2.

Assessment of completeness is presented in Annex 5.

1.8.2. KP-LULUCF inventory

Estonia provides emissions/removals estimates for following carbon pools: above- and belowground biomass, dead wood and organic soils under AR activites, in addition to abovementioned pools, emissions from litter and mineral soils under deforestation are reported in the 2012 submission for the first time.

In the 2012 inventory, emissions from AR area burning were estimated for the first time.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

2.1. Description and interpretation of emission trends for aggregated greenhouse gas emissions

This chapter provides the trends in GHG emissions and removals by sinks in Estonia for the years 1990–2010.

The GHGs covered are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases- hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Estimates of the emissions for nitrogen oxides (NOx), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2) are also included in the inventory.

Estonia´s base year for calculating the emissions of CO_2, CH_4, N_2O and fluorinated gases is 1990.

Total emissions of the six greenhouse gases in Estonia (excl. net emissions from the LULUCF) decreased steadily from 40 856.89 Gg CO_2 equivalent in 1990 to 20 516.76 Gg CO_2 equivalent in 2010 (Figure 2.1). From 1990 to 2010 the GHG emissions decreased by 49.78%. This decrease was mainly caused by the transition from planned economy to market economy and the successful implementation of the necessary reforms.

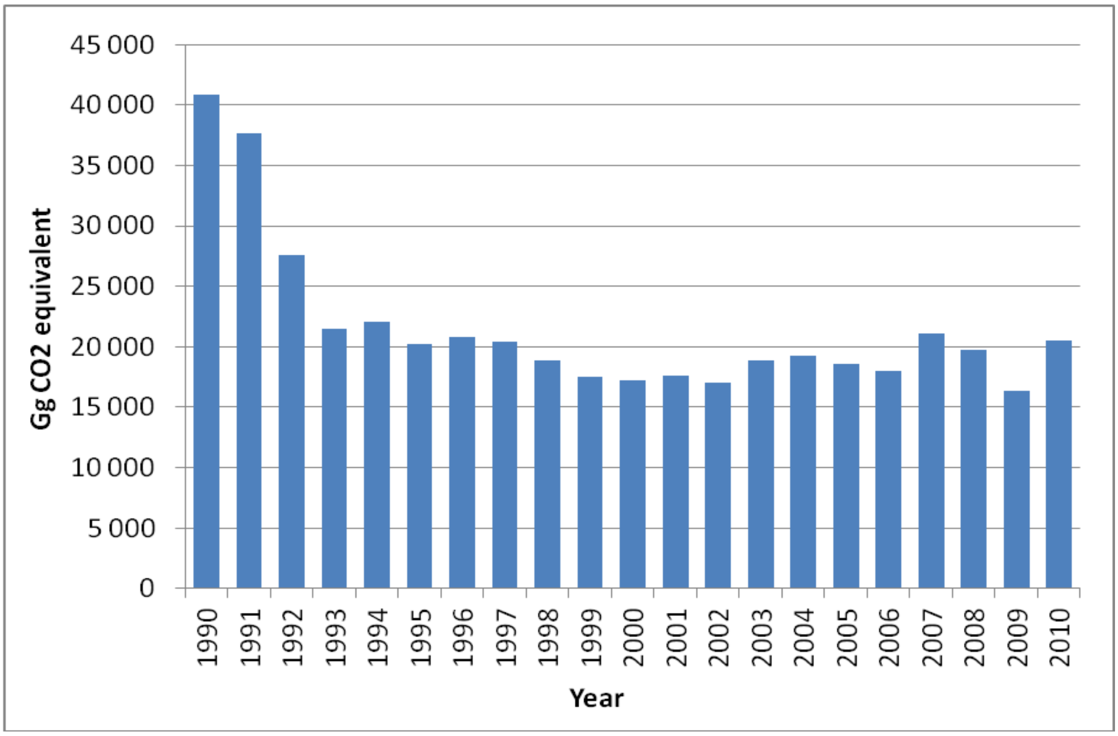

Figure 2.1. Overall development of greenhouse gases in Estonia, in CO_2 equivalents (without CO_2 from LULUCF)

2.2. Description and interpretation of emission trends by gas

In 2010, the most important GHG in Estonia was carbon dioxide (CO_2), contributing 88.80% of the total GHG emissions (excl. LULUCF) expressed in CO_2 equivalent, followed by nitrous oxide (N_2O), 5.31% and methane (CH_4), 5.12%. Fluorinated gases (the so-called „F-gases“) account for about 0.77% of the total emissions (Figure 2.2).

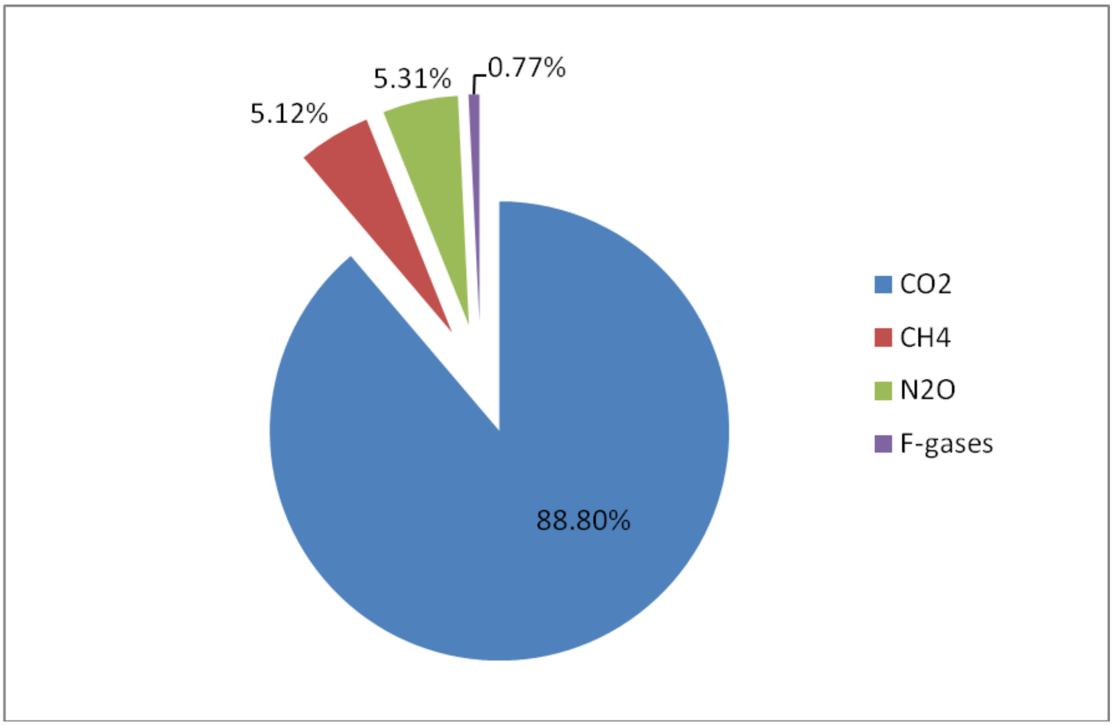

Figure 2.2. GHG emissions by gas in 2010, %

Figure 2.3 shows GHG emission trends in 1990 to 2010. Emissions of CO_2 decreased by 50.25% from 36 620.25 Gg in 1990 to 18 218.70 Gg in 2010, especially CO_2 emissions from Energy sub-sector Public Electricity and Heat Production, which is the major source of CO_2 in Estonia.

N_2O is the second most significant contributor to greenhouse gas emissions in Estonia after CO_2. Emissions of N_2O decreased by 54.24% from 2 380.53 Gg CO_2 equivalent in 1990 to 1 089.31 Gg CO_2 equivalent in 2010, especially N_2O emissions from Agriculture sub-sector Agricultural Soils, which is the major source of N_2O in Estonia.

Emissions of methane decreased by 43.40% from 1 856.11 Gg CO_2 equivalent in 1990 to 1 050.61 Gg CO_2 equivalent in 2010, especially from Agriculture sub-sector Enteric Fermentation, which is the major source of CH_4 in Estonia.

Emissions of the F-gases (HFCs, PFCs and SF_6) increased from 0 Gg CO_2 equivalent in 1990 to 158.14 Gg CO_2 equivalent in 2010, especially HFC emissions from refrigeration and air- conditioning equipment, which is the major source of halocarbons in Estonia. A key driver behind the growing emission trend in refrigeration and air conditioning sector has been the substitution of ozone depleting substances with HFCs. The second largest source is foam blowing which shows relatively steady increase of emissions throughout the years, except 2 major decreases (in 2001 one of two big Estonian producers of One Component Foam replaced HFC-134a with HFC-152a, followed by the other producer starting from 2007. Due to much lower GWP of HFC-152a the emissions decreased suddenly in the corresponding years).

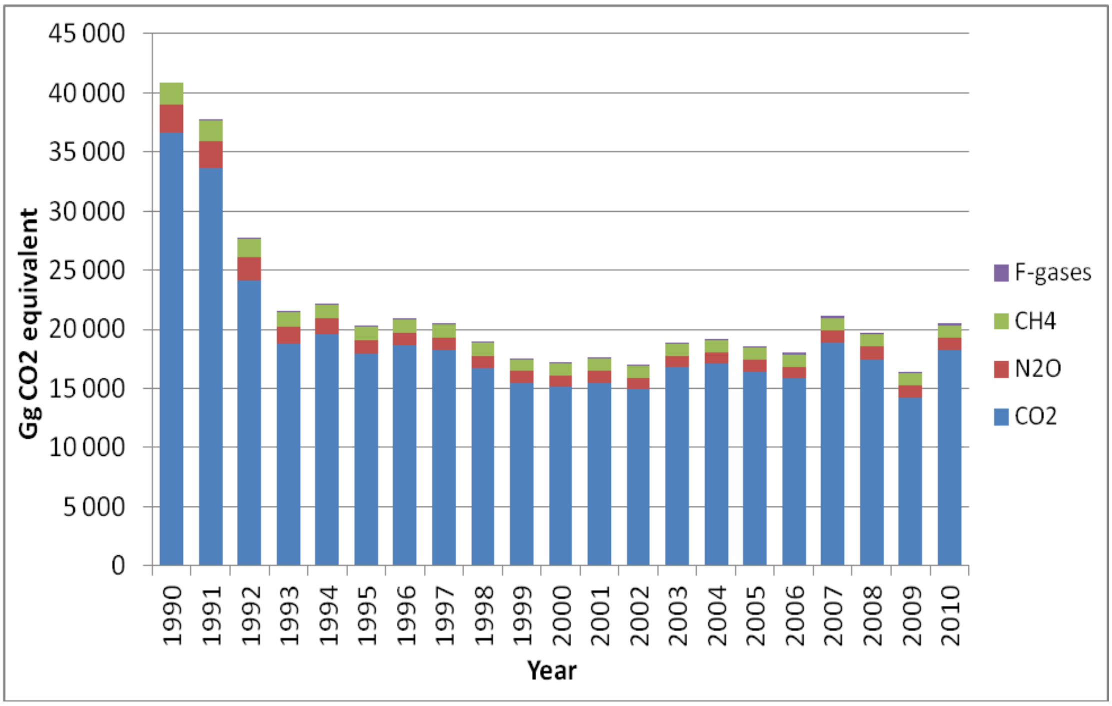

Figure 2.3. Greenhouse gas emission trends (CO_2 equivalent) in 1990 to 2010

2.3. Description and interpretation of emission trends by category

Greenhouse gas emissions broken down by IPCC sector are presented in Figure 2.4. It can be clearly seen that the largest contribution is from Energy sector, which in 2010 contributes 88.64% of total greenhouse gas emissions (excl. LULUCF). The second largest sector is Agriculture, which accounted for 6.55% of the total emissions in 2010. Emissions from Industrial Processes, Waste and Solvent and Other Product Use sectors accounted 2.43%, 2.30% and 0.09%, respectively of total emissions in 2010. Emissions of indirect gases are discussed in section 2.4.

Over the period 1990–2010, emissions from Energy sector decreased by 49.40%, emissions from the Industrial Processes, Agriculture and Solvent and Other Product Use sectors decreased by 52.52%, 61.21% and 15.05%, respectively. Emissions from Waste sector increased by 23.93%. Reported net CO_2 removals on Land Use, Land Use Change and Forestry sector decreased by 59.81% between 1990 and 2010. See Figure 2.4. Greenhouse gas emission trends, by source groups, in CO_2 equivalents.

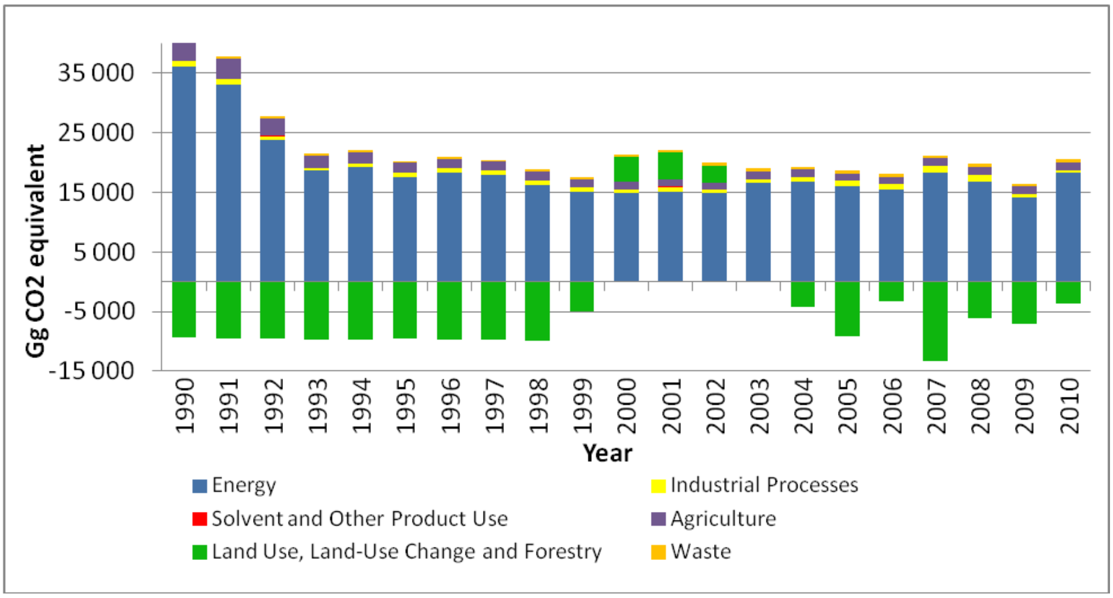

Figure 2.4. Greenhouse gas emission trends, by source groups, in CO_2 equivalents

The following sub-sectors discuss the main contributors to trends within each IPCC source sector incl. LULUCF.

2.3.1. Trends in Energy (CRF 1)

Estonia's emissions from Energy sector are divided into the following emission categories: Fuel Combustion, including Energy Industries, Manufacturing Industries and Construction, Transport, Other Sectors, Other and Fugitive emissions from fuels. The share of emissions by category is presented in Figure 2.5.

Energy sector is the main source of GHG emissions in Estonia. In 2010, the Energy sector contributed 88.64% of the total emissions. Most of the Energy sector emissions, 99.54%, originated from Fuel Combustion and only 0.46% is contributed by fugitive emissions.

Energy related CO_2 emissions varied mainly in relation to the economic trend, the energy supply structure and climate conditions.

Compared to the base year 1990, the emissions of energy sector decreased by 49.4% (incl. Energy Industries – 49.0%; Manufacturing Industries and Construction – 79.5%; Transport – 9.3%; Other Sector – 67.8%; Other – 6.4% and Fugitive Emissions from Fuels – 54.1%). This big decrease was caused by the structural changes in the economy after 1991 when Estonia became independent. There has been a drastic decrease in the consumption of fuels and energy in energy industries (closing of the factories), in agriculture (reorganisation and dissolution of collective farms), in transport (the proportion of new and environmentally friendly cars has increased; the number of agricultural machines has decreased), in households (energy saving), etc. The overall progressing of GHGs in the Energy sector in CO_2 equivalent is presented in Figure 2.5.

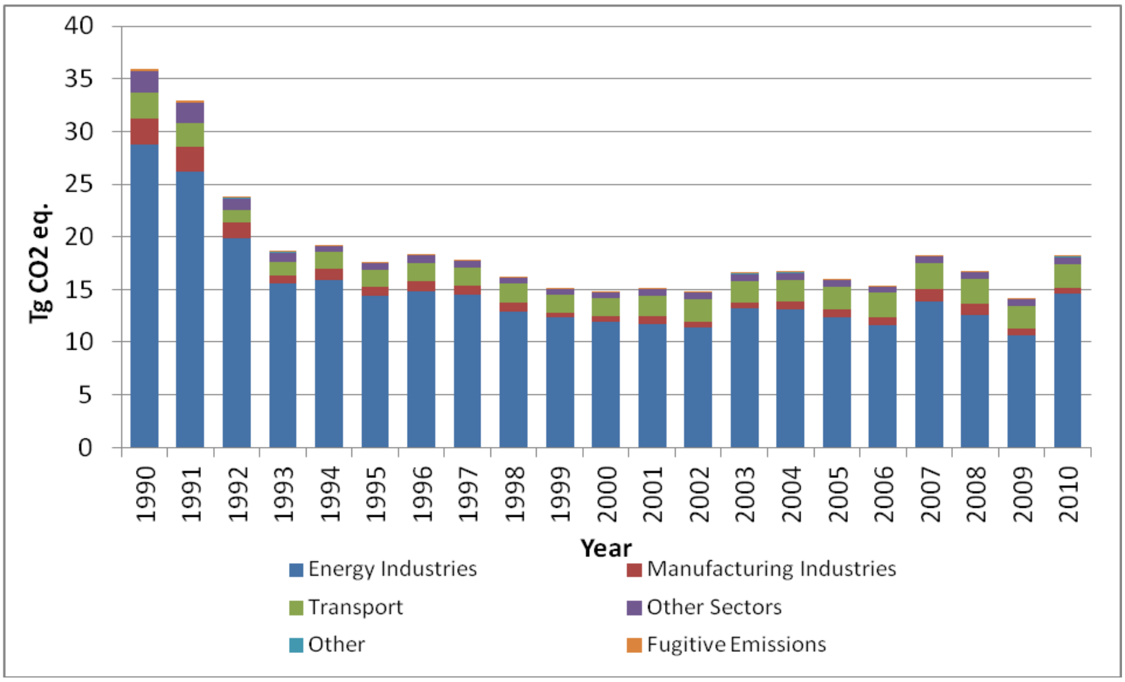

Figure 2.5. Trend in Emissions from Energy Sector 1990–2010

2.3.2. Trends in Industrial Processes (CRF 2)

Estonia´s emissions from Industrial Processes sector are divided into the following emissions categories: Mineral Products, Chemical Industry, Consumption of Halocarbons and SF_6 and Other Production. Under Mineral products Estonia reports emissions from cement, lime, glass, bricks and tiles production as well as emissions from lightweight gravel production and soda ash use. Also NMVOC emissions from road paving with asphalt are reported in this category. Emissions from ammonia production are reported under Chemical Industry. The category Consumption of Halocarbons and SF_6 covers the emissions of F-gases from refrigeration and air conditioning, foam blowing, aerosols and electrical equipment, as well as some smaller sources, such as fire extinguishers and other. Under Other production Estonia reports NMVOC emissions from pulp and paper and food industries. The share of emissions by category in CO_2 equivalent is presented in Figure 2.6.

In 2010 industrial GHG emissions contributed 2.43% of the total GHG emissions in Estonia, totalling 497.57 Gg CO_2 equivalent. The most important GHG emissions from Industrial Processes in Estonia’s inventory in 2010 are the CO_2 emissions from Cement Production and Lime Production with 1.51% and 0.09%, respectively, and HFC emissions from Refrigeration and Air Conditioning Equipment with 0.70% of the total GHG emissions in Estonia. F-gas emissions comprised together 0.77% of the total GHG emissions.

Industrial CO_2 emissions have fluctuated strongly since 1990, reaching the lowest level in 1993. The decrease in the emissions during the early 1990´s was caused by the transition from planned economy to market economy after 1991 when Estonia became independent. This led to lower emissions in industrial production, and to an overall decrease in the emissions from industrial processes between 1991 and 1993. In 1994 the economy began to recover and production increased. The decrease in emissions in 2002 and 2003 was caused by the decrease in ammonia production, because the only existing ammonia factory was being reconstructed. The sudden increase in emissions in 2007 is mainly caused by the increase of cement production, as the only cement factory Kunda Nordic Cement AS renovated its third kiln. In 2009, industrial processes sector was affected by the economic recession. Decline in production was mainly caused by the insufficient demand both in domestic and external markets. The overall progressing of GHGs in the Industrial Processes sector in CO_2 equivalent is presented in Figure 2.6.

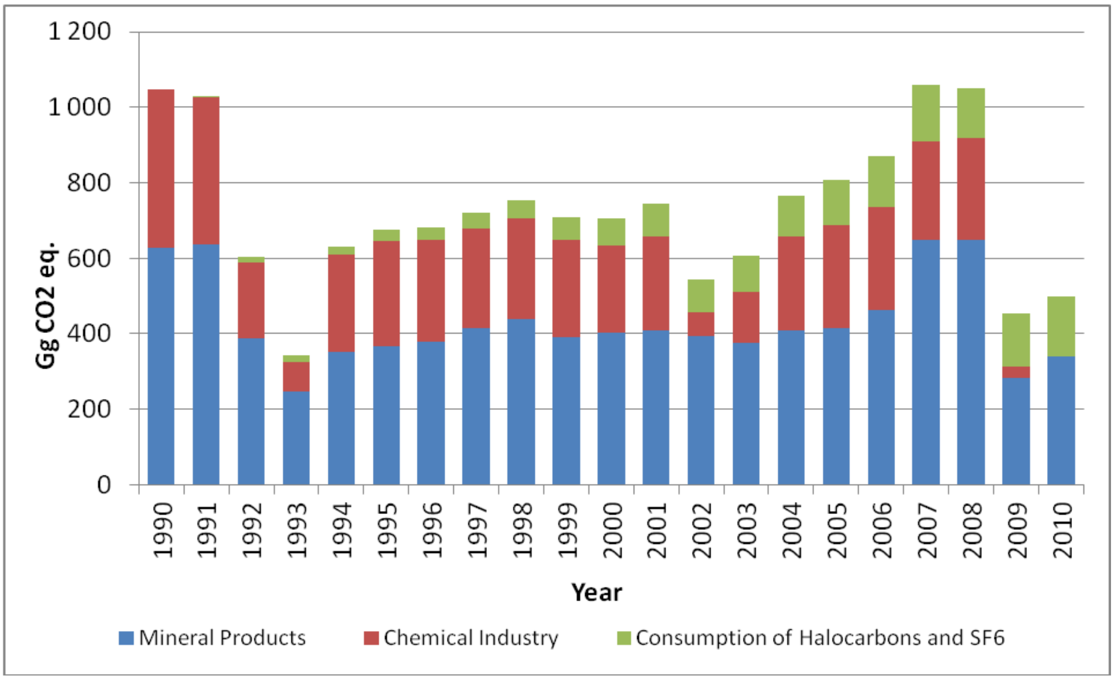

Figure 2.6. Trend in Emissions from Industrial Processes Sector 1990–2010

2.3.3. Trends in Solvent and Other Product Use (CRF 3)

Estonia's emissions from Solvent and Other Product Use sector are divided into the following emissions categories: Paint Application, Degreasing and Dry Cleaning, Chemical Products, Manufacture and Processing and Other. Under Other Estonia reports N_2O emissions from the use of N_2O in medical and other applications, N_2O emissions from aerosol cans and indirect CO_2 emissions from printing industry, domestic solvent use and other product use. The trend in emissions in CO_2 equivalents by category is presented in Figure 2.7.

In 2010, the Solvent and Other Product Use sector contributed 0.09% of the total GHG emissions in Estonia, totalling 17.65 Gg CO_2 equivalent. Indirect CO_2 emissions from paint application and indirect CO_2 emissions from other contributed the main share of the total emissions from the solvent and other product use sector – namely 29.6% and 28.5% accordingly.

Emissions from the solvent and other product use sector have decreased by 15.05% compared to the base year 1990. Two major categories where decrease of NMVOC emissions, and due to that decrease of indirect CO_2 emissions, have occurred in later years are paint application (CRF 3.A) and other product use (CRF 3.D.5). The fluctuation of NMVOC emissions in the period 1990–2010 has occurred mostly due to the welfare of the economic state of the country. The overall progression of GHG in the solvent and other product use sector in CO_2 equivalents is presented in Figure 2.7.

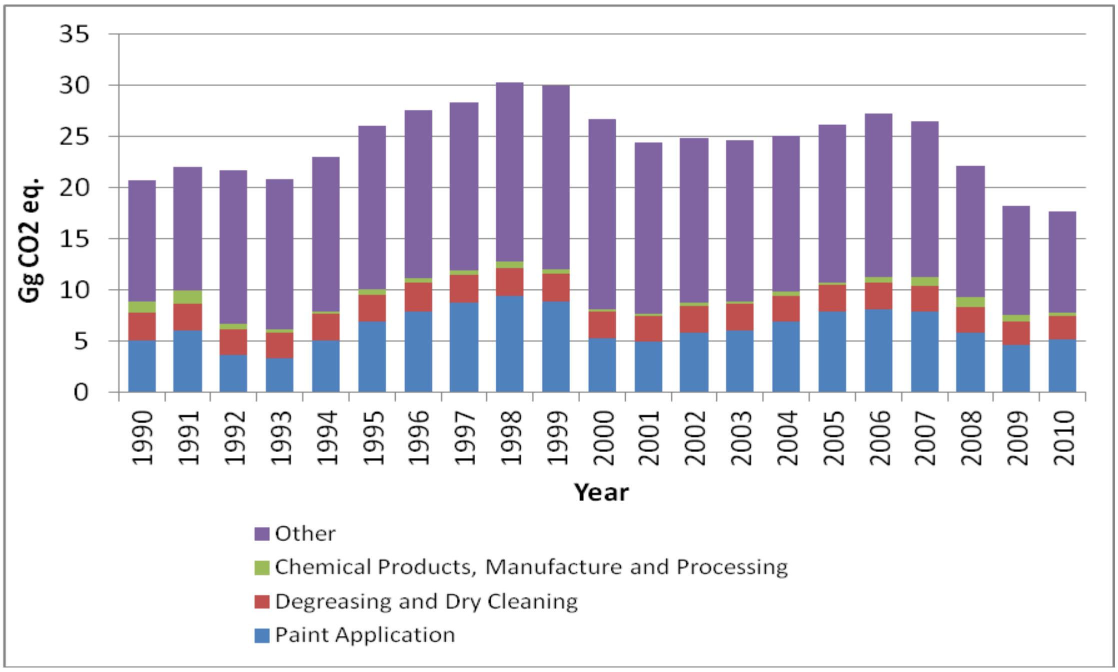

Figure 2.7. Trend in Emissions from Solvent and Other Product Use Sector 1990–2010

2.3.4. Trends in Agriculture sector (CRF 4)

Agricultural GHG emissions in Estonia consist of CH_4 emissions from the enteric fermentation of domestic livestock, N_2O emissions from manure management systems, direct and indirect N_2O emissions from agricultural soils. Direct N_2O emissions include emissions from synthetic fertilizers, animal manure and sewage sludge applied onto agricultural soils, and emission occurred from crops growing (i.e., N-fixing crops and crop residues) and due to cultivation of histosols. Indirect N_2O emissions include emissions due atmospheric deposition and due to nitrogen leaching and run-off. The trend in emissions in CO_2 eq. by category is presented in Figure 2.8.

In 2010 the Agriculture sector contributed 6.55% of the total emissions, totalling 1 344.12 Gg CO_2 eq. Emissions from enteric fermentation of livestock and direct emissions from agricultural soils contributed the main share of the total emissions from the agricultural sector – namely 33.2% and 55.64%, accordingly.

Emissions from the agricultural sector have declined 61.2% compared to the base year, mostly due to the decreasing livestock population and quantity of synthetic fertilizers and manure applied to agricultural fields. The overall progression of GHG in the agriculture sector in CO_2 eq. is presented in Figure 2.8.

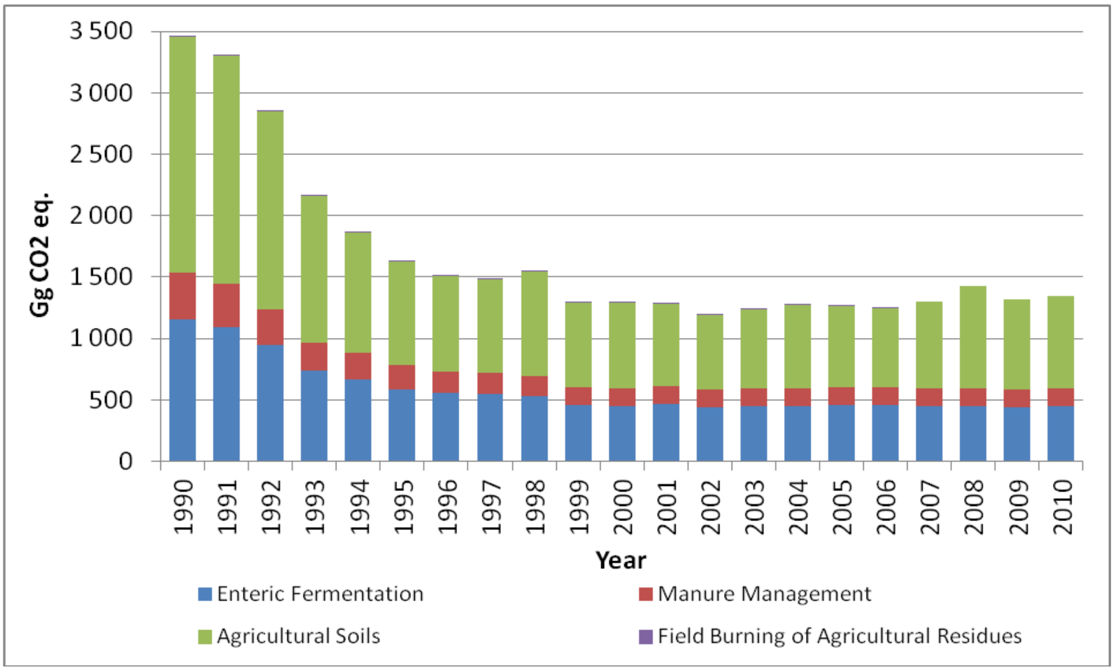

Figure 2.8. Trend in Emissions from Agriculture Sector 1990–2010, Gg CO_2 eq

2.3.5. Trends on Land Use, Land Use Change and Forestry sector (CRF 5)

LULUCF sector, acting as the only possible sink of greenhouse gas emissions in Estonia, plays an important role in the national carbon cycle. Emissions and removals from the LULUCF sector are divided into the following categories: Forest Land, Cropland, Grassland, Wetlands and Settlements, each category is further divided into 'land remaining' and 'land converted to' category. Forest Land conversion to Other Land was also estimated in order to assure consistency between UNFCCC and Kyoto Protocol Deforestation activity reporting.

The share of LULUCF sector emissions and removals by category during the time period 1990–2010 is presented in Figure 2.9. In 2010, the Land use, land-use change and forestry sector acted as a CO_2 sink, totalling uptake of 3 757.75 Gg CO_2 equivalent. Compared to the base year 1990, uptake of CO_2 has decreased by 59.8% and compared to the previous year 2009, 47.3%. In the last decade, CO_2 emissions have varied widely due to the highly unstable rates of felling and deforestation. As seen in Figure 2.9, LULUCF sector has also acted as a net source in 2000–2003, when harvesting exceeded biomass increment in forests. A key driver behind these trends has been the socio-economic situation in Estonia.

Most of the removals in the LULUCF sector come from forest growth in Forest Land remaining Forest Land and land converted to Forest Land subcategories. In 2010, Forest Land and Grassland acted as GHG sinks in the LULUCF sector, whereas all other land categories lost biomass compared to the previous year.

During 2002–2008, Grasslands constituted a significant CO_2 sink in addition to Forest Land. The relative importance of grasslands as a sink has declined gradually since 2004 mostly due to the reallocation of grasslands into forest land category when the tree grown cover of grasslands exceeds 30% due to natural succession and reduction of management activities.

The majority of emissions in the LULUCF sector are derived from biomass loss followed by land conversion to Settlements and drainage of organic soils, minor sources of CO_2 are biomass burning, cropland liming and Forest land conversion to Other land.

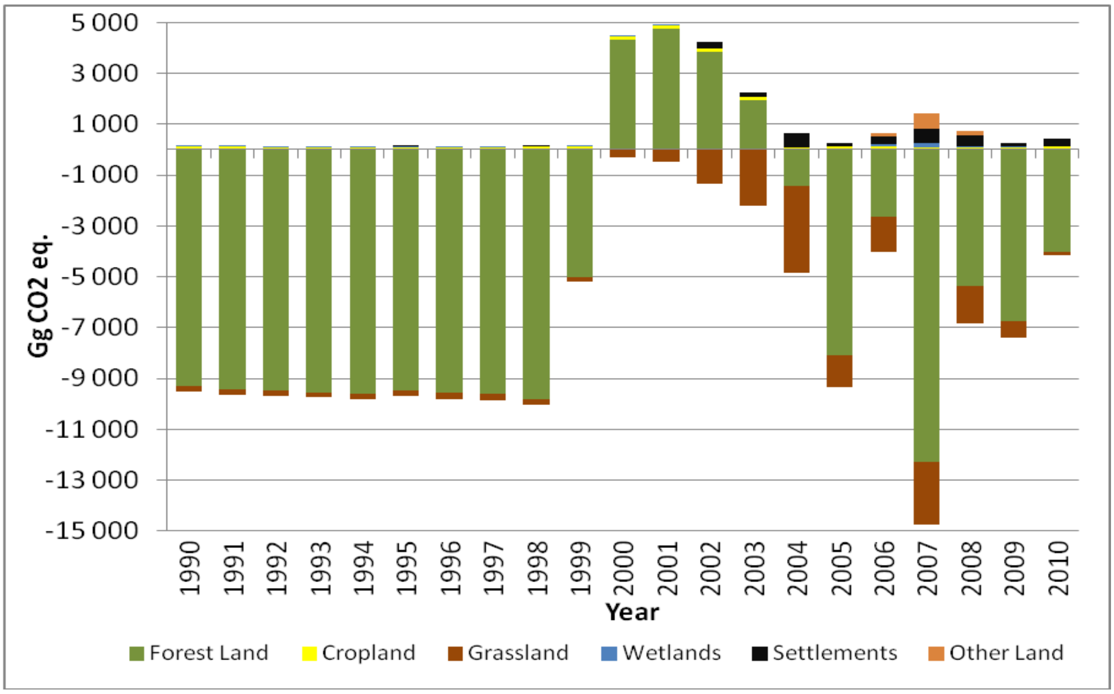

Figure 2.9. Trend in Emissions from Land Use, Land-Use Change and Forestry Sector 1990–2010

2.3.6. Trends in Waste (CRF 6)

The Estonian inventory of GHG in waste sector covers CH_4 emissions from solid waste disposal sites including solid municipal and industrial waste, domestic and industrial sludge. The waste sector also covers GHG emissions from waste incineration (incl biogas burnt in a flare), biological treatment and wastewater handling including domestic, commercial and industrial wastewater. The share of emissions by category is presented in Figure 2.10.

In 2010 the Waste sector contributed 2.30% of the total GHG emissions, totalling 472.19 Gg CO_2 equivalent. Solid Waste Disposal on Land contributed the most to the total emissions for the Waste sector in Estonia on 2010.

The total emissions in CO_2 equivalent from the Waste sector increased 23.93% in comparison with the base year: the emission from solid waste landfilled increased by 31% and emission from waste composting processes increased about 100 fold – from 1.26 Gg to 138.6 Gg in 2010. As seen from the Figure 2.10 in 1995 GHG emissions from waste sector decreased, which is due to CH_4 emissions from paper and sludge waste from solid waste disposal on land in 1995 has decreased, also since 1995 Estonia started to collect methane from waste disposal, which effected the reduction in emissions from landfills. There has been a sharp fluctuation in the quantities of N_2O emissions from waste incineration in 1999, 2000, 2008 and 2009. The main reason for the augmentation is that, in 1999 and 2000 large amounts of inert waste, nafta and oil waste and wood were burnt and in 2008 the sudden fallout took place, as no wastes were incinerated (D10 operation) without energy recovery. The total CO_2 equivalent in 2008–2009 is lower than previous years (2006, 2007) and the following year 2010, which is likely caused by the economic crisis and decrease in consumption in Estonia in 2009. The total CO_2 equivalent in 2010 is the highest during the whole period due to fluent increase in emissions from solid waste disposal, biological treatment and slight economic rise in country. The overall progression of GHGs in the Waste sector in CO_2 equivalent is presented in Figure 2.10.

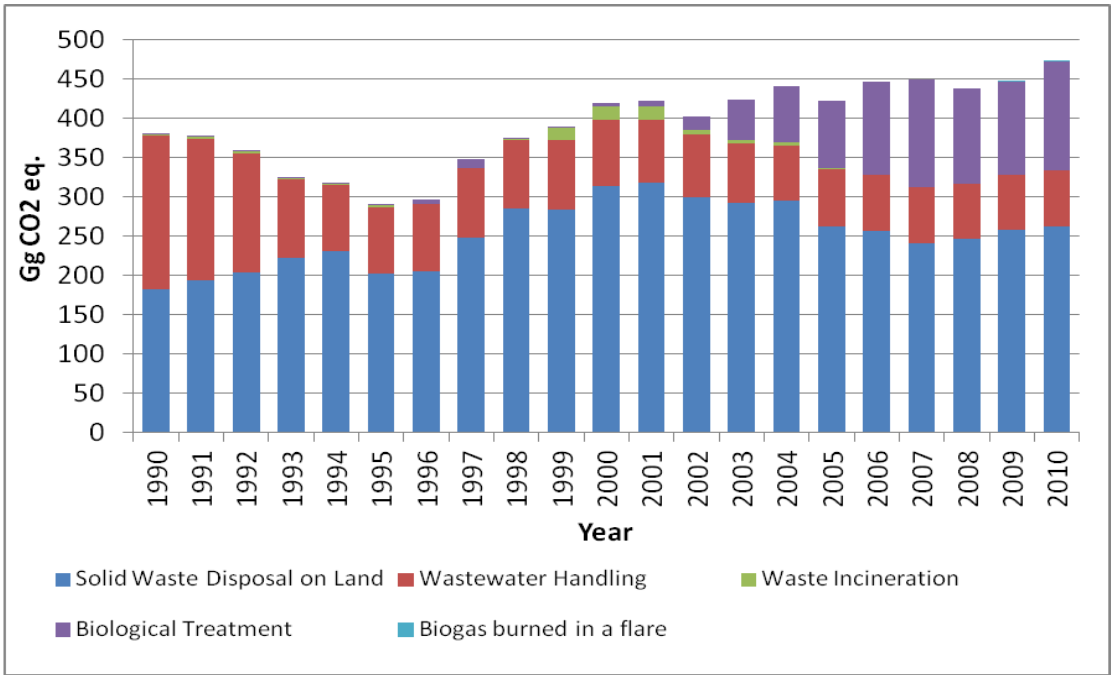

Figure 2.10. Trend in Emissions from Waste Sector 1990–2010

2.4. Description and interpretation of emission trends for indirect greenhouse gases and SO_2

The emissions of NOx, CO, NMVOC and SO_2 for the years 1990 to 2010 are presented in Figure 2.11. Total NOx emissions decreased by 52.80% from 77.20 Gg in 1990 to 36.44 Gg in 2010. Total CO emissions decreased by 19.62% from 190.01 Gg in 1990 to 152.73 Gg in 2010. Total NMVOC emissions decreased by 39.06% from 53.80 Gg in 1990 to 32.79 Gg in 2010. Total SO_2 emissions decreased by 60.27% from 167.25 Gg in 1990 to 66.44 Gg in 2010.

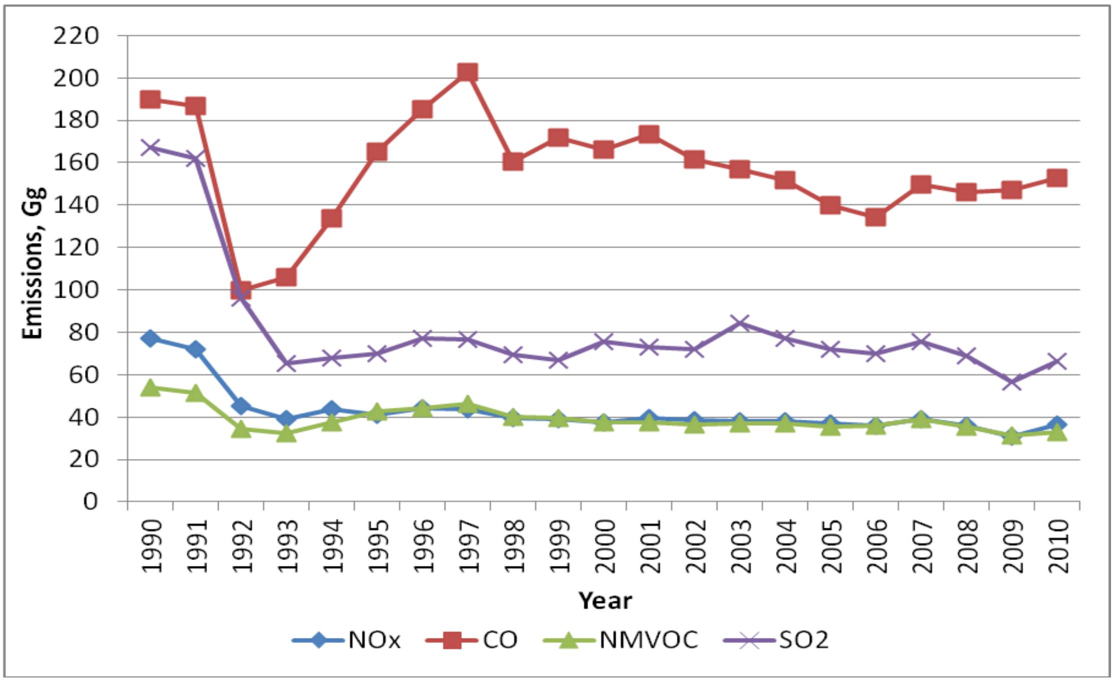

Figure 2.11. Emissions of NOx, CO, NMVOC and SO_2 1990–2010, Gg

2.5. Description and interpretation of emission trends for KP-LULUCF inventory in aggregated and by activity, and by gas

In 2010, Article 3.3 activities were a net sink in Estonia. The total net uptake was estimated at 47.06 Gg CO_2 eq. Afforestation and reforestation resulted in a net removal of 346.72 Gg CO_2 eq. and deforestation a net emission of 299.66 Gg CO_2 eq.

Areas of AR have been continuously increased, resulting a steady rise in the uptake of CO_2 during the first commitment period. Area of land deforested has been highly variable throughout the reporting period, causing remarkable fluctuations in interannual CO_2 emissions. Emissions from deforestation was estimated at 869.52 Gg CO_2 eq. in 2008, 292.94 and 299.66 Gg CO_2 eq. in 2009 and 2010 respectively. Significantly higher amount of emissions in 2008 can be explained by the fact that the total area deforested in 2008 was three times higher compared to the following years.

3. ENERGY (CRF 1)

3.1. Overview of sector (CRF 1)

Energy sector is the main source of greenhouse gas emissions in Estonia. In 2010, the energy sector contributed about 88.6% of total emissions, totalling 18.19 Tg of CO_2 equivalent (see Figure 3.1). Compared to the base year 1990, the emissions were about 49.4% below that level (35.94 Tg CO_2). Most of the energy sector emissions – 99.5% originate from fuel combustion and only 0.5% are contributed by fugitive emissions.

The substantial amount of energy related emissions are caused by extensive consumption of fossil fuels for power and heat production.

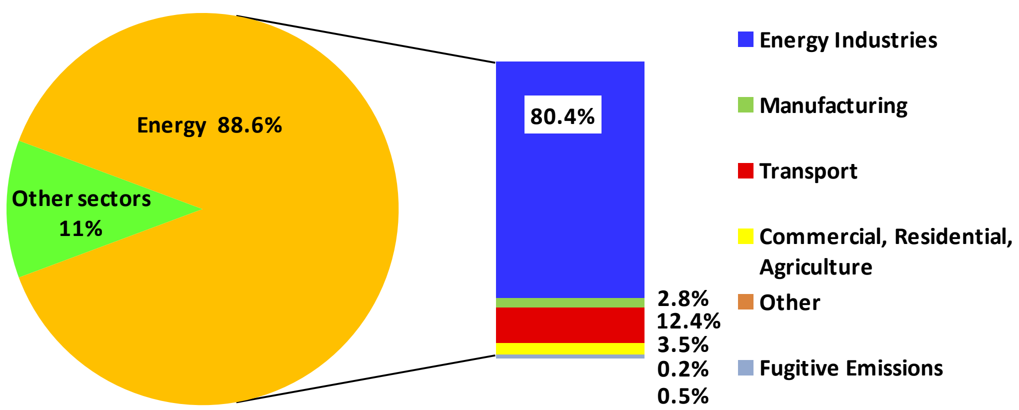

Figure 3.1. Emissions from the energy sector compared to the total emissions in 2010

The share of domestic fuels is large in Estonia's total energy resources and in the balance of primary energy which is based mainly on oil shale. This gives strategic independence to the supply of electricity – the share of imported fuels accounts for approximately 1/3 by us, in the European Union (EU) Member States on average it is about 2/3. The volume of exported electricity essentially influences the share of oil shale in the balance of primary energy – the bigger the exports of electricity is, the bigger is the share of oil shale in the balance of primary energy.

The development of primary energy supply in Estonia is presented in Figure 3.2.

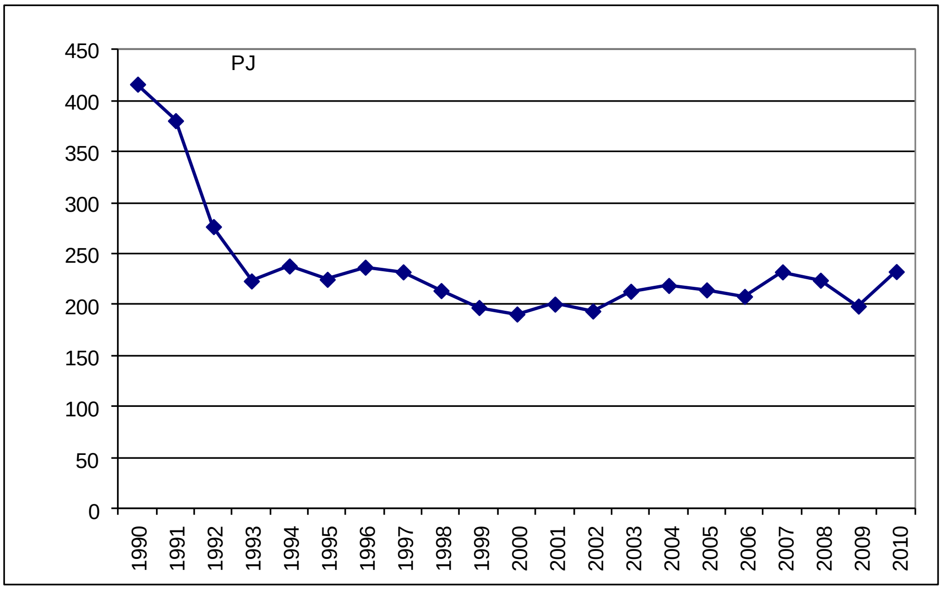

Figure 3.2. Development of Total Primary Energy Supply in Estonia in 1990–2010, PJ (Source: Statistics Estonia)

In 2010 the supply of primary energy was 232.6 PJ, of which oil shale formed 65%, and peat and wood together – 15%. The share of renewable energy sources amounted to approximately 14%, of which wood fuels comprised the main portion and other sources 0.1%. 50% of the primary fuel energy was used for electricity and 18% for heat generation. The total primary energy supply increased in 2010 by 17% compared with the previous year (see Figure 3.2).

The structure of primary energy supply in 1990 and 2010 accordingly is presented in Figure 3.3.

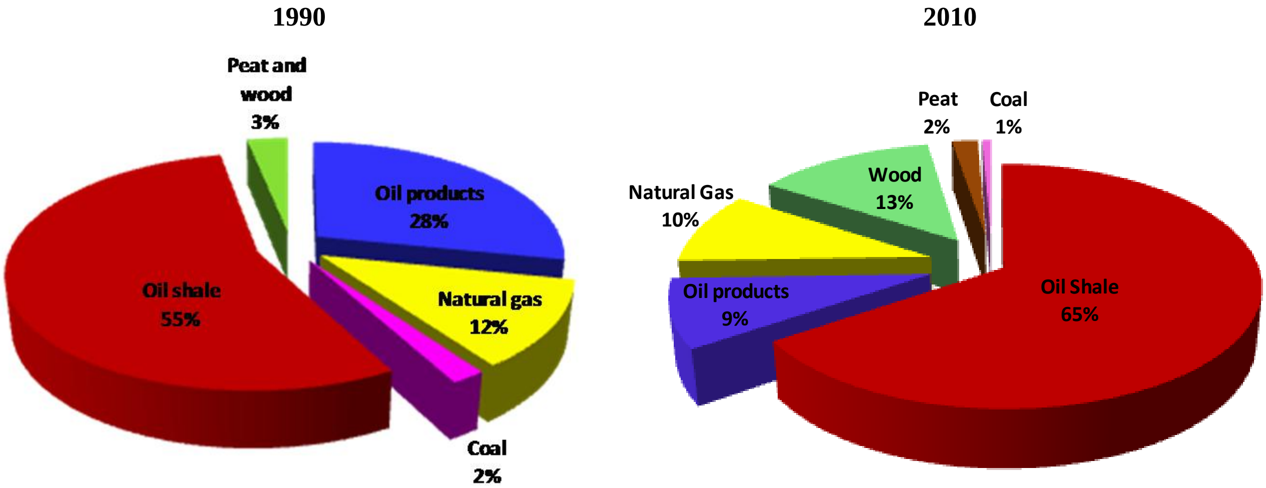

Figure 3.3. Structure of primary energy supply in Estonia in 1990 and 2010

Perking up of the economic environment also influenced the energy sector**.** A relatively fast recovery of the business sector from the crisis caused the demand for energy products to increase. In 2010, the production of all kinds of fuels and energy increased. As more than 90% of electric energy is oil shale based, the increasing demand for electric energy led to a 20% increase in oil shale production. The production of shale-derived fuel oil, wood fuels and peat increased, too. In 2010 compared to 2009, the shale oil production grew by nearly 8% due to an increased consumption by local heating plants. Over a half of produced shale oil was exported, but the exported quantities remained the same as in the previous year. The production of wood pellets was 7% bigger than in 2009 due to a stable external demand, and the production of peat grew by more than 10% (Figure 3.3).

Emissions from the energy sector by subcategory in 1990–2010 are presented on the Figure 3.4.

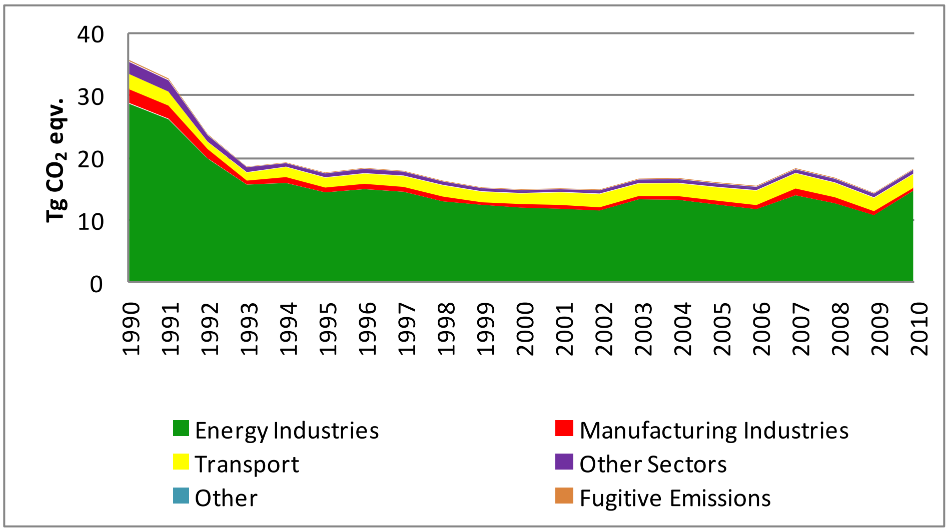

Figure 3.4. Emissions from the energy sector by subcategory in 1990–2010 (Tg CO_2 equivalent)

Trend of fuel consumption in Energy sector in 1990–2010 is presented on the Figure 3.5.

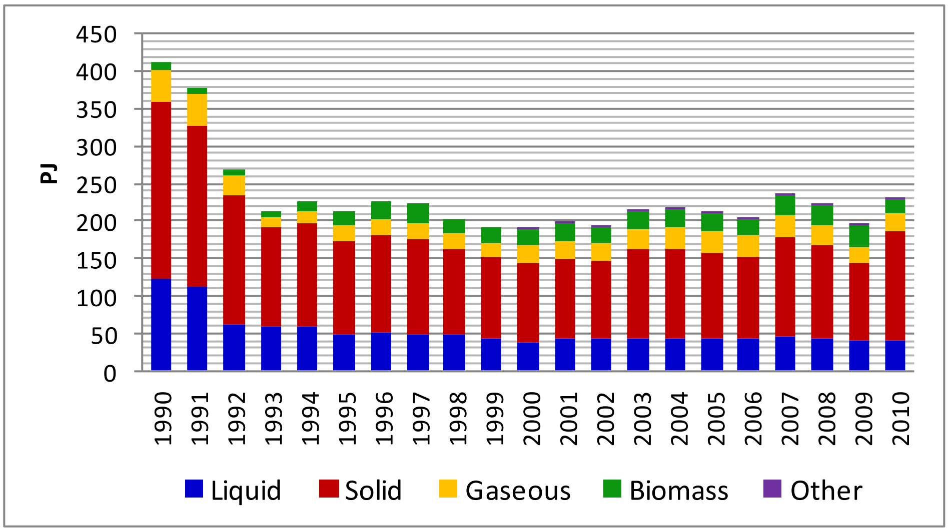

Figure 3.5. Fuel consumption in 1990–2010, PJ

Table 3.1. Emissions from the energy sector in 1990–2010 by sub-category and gas (Tg, CO_2 equivalent)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1.Energy	**35.94**	**32.95**	**23.79**	**18.58**	**19.21**	**17.57**	**18.32**	**17.84**	**16.20**	**15.11**	**14.78**	**15.14**	**14.81**	**16.58**	**16.71**	**16.04**	**15.41**	**18.29**	**16.77**	**14.16**	**18.19**
1.A Fuel combustion total	35.76	32.77	23.68	18.53	19.13	17.49	18.22	17.74	16.12	15.03	14.68	15.03	14.73	16.48	16.60	15.92	15.29	18.17	16.66	14.08	18.10
CO_2	35.55	32.57	23.55	18.41	18.99	17.29	17.99	17.51	15.93	14.84	14.50	14.83	14.52	16.29	16.39	15.73	15.11	17.97	16.45	13.86	17.87
CH_4	0.10	0.09	0.06	0.06	0.07	0.12	0.14	0.15	0.12	0.11	0.11	0.11	0.11	0.12	0.12	0.11	0.10	0.12	0.12	0.13	0.14
N_2O	0.11	0.11	0.07	0.06	0.06	0.08	0.09	0.08	0.07	0.07	0.07	0.09	0.10	0.08	0.09	0.09	0.08	0.08	0.09	0.09	0.10
1.B Fugitive emissions	**0.18**	**0.18**	**0.11**	**0.05**	**0.08**	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.10**	**0.11**	**0.09**	**0.10**	**0.11**	**0.12**	**0.12**	**0.12**	**0.11**	**0.08**	**0.08**

The energy sector releases three greenhouse gases, carbon dioxide (CO_2) and small amounts of methane (CH_4) and nitrous oxide (N_2O) (Figure 3.4). Energy related CO_2 emissions vary mainly according to the energy supply structure and climate conditions. As suggested in the IPCC 1996 guidelines, the emissions in the energy sector are divided into emissions from fossil fuel combustion (CRF 1.A) and fugitive emissions from fuels (CRF 1.B).

Emissions from the energy sector in 1990–2010 by sub-category and gas are presented in the Table 3.1.

3.2. Emissions from fuel combustion (CRF 1.A)

The emissions from fuel combustion comprise all fuel combustion, including point sources, transport and other fuel combustion. Direct and indirect GHGs (CO_2, CH_4, N_2O, CO, NMVOC, NOx) as well as SO_2 are reported. Emissions from fuel combustion in the energy sector are divided into four subcategories as follows:

CRF 1.A 1 – Energy Industries
CRF 1.A 2 – Manufacturing industries and construction
CRF 1.A 3 – Transport
CRF 1.A 4 – Other sectors (including Commercial, Residential and Agriculture/Forest/Fishery sectors)
CRF 1.A 5 – Other/Military Fuels

Reported GHG emissions are listed in Table 3.2.

Table 3.2. Reported emissions under the subcategory fuel combustion in the Estonian inventory

CRF	**Source**	**Emissions reported**
1.A.1	Energy Industries	
	a. Public Electricity and Heat Production	CO_2, CH_4, N_2O
	c. Manufacture of Solid Fuels and Other Energy Industries	CO_2, CH_4, N_2O
1.A.2	Manufacturing industries and construction	
	a. Iron and Steel	CO_2, CH_4, N_2O
	b. Non-Ferrous Metals	CO_2, CH_4, N_2O
	c. Chemicals	CO_2, CH_4, N_2O
	d. Pulp, Paper and Print	CO_2, CH_4, N_2O
	e. Food Processing, Beverages and Tobacco	CO_2, CH_4, N_2O
	f. Other	CO_2, CH_4, N_2O
1.A.3	Transport	CO_2, CH_4, N_2O
	a. Civil Aviation	CO_2, CH_4, N_2O
	b. Road Transportation	CO_2, CH_4, N_2O
	c. Railways	CO_2, CH_4, N_2O
	d. Navigation	CO_2, CH_4, N_2O
1.A.4	Other sectors	
	a. Commercial/Institutional	CO_2, CH_4, N_2O
	b. Residential	CO_2, CH_4, N_2O

	c. Agriculture/Forestry/ Fisheries	CO_2, CH_4, N_2O
1.A.5	Other/b. Mobil	CO_2, CH_4, N_2O

Quantitative overview

CO_2 emissions from fossil fuel combustion (17.87 Tg) accounted for 98.25% of the energy sector's total emissions and 87.08% of total greenhouse gas emissions in 2010.

The share of CH_4 emissions from fuel combustion (137.02 Gg) was 0.76% in 2010, mainly due to the incomplete combustion of wood fuels (small combustion). N_2O emissions from fuel combustion are relativly small (98.59 Gg CO_2 eq.) was about 0.54%. N_2O emissions come mainly from energy industries and transport sectors (Table 3.3).

Table 3.3. Emissions from fuel combustion in Estonia in 1990–2010 (Tg CO_2 equivalent)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1.A Fuel combustion total	**35.76**	**32.77**	**23.68**	**18.53**	**19.13**	**17.49**	**18.22**	**17.74**	**16.12**	**15.03**	**14.68**	**15.03**	**14.73**	**16.48**	**16.60**	**15.92**	**15.29**	**18.17**	**16.66**	**14.08**	**18.10**
CO_2	**35.55**	**32.57**	**23.55**	**18.41**	**18.99**	**17.29**	**17.99**	**17.51**	**15.93**	**14.84**	**14.50**	**14.83**	**14.52**	**16.29**	**16.39**	**15.73**	**15.11**	**17.97**	**16.45**	**13.86**	**17.87**
1. Energy Industries	28.70	26.20	19.82	15.59	15.85	14.33	14.85	14.43	12.88	12.32	11.87	11.68	11.40	13.21	13.13	12.35	11.61	13.85	12.56	10.65	14.60
2. Manufacturing	2.48	2.34	1.57	0.74	1.04	0.88	0.96	0.88	0.82	0.47	0.57	0.70	0.48	0.55	0.66	0.71	0.71	1.18	1.07	0.60	0.51
3. Transport	2.45	2.23	1.15	1.27	1.59	1.55	1.62	1.72	1.78	1.66	1.65	1.97	2.08	1.99	2.04	2.14	2.31	2.44	2.32	2.13	2.23
4. Other Sectors	1.88	1.76	0.98	0.79	0.49	0.49	0.56	0.47	0.43	0.38	0.38	0.46	0.54	0.52	0.54	0.50	0.45	0.47	0.49	0.46	0.49
5. Other	0.04	0.05	0.03	0.01	0.01	0.03	0.02	0.01	0.02	0.02	0.02	0.02	0.01	0.02	0.03	0.03	0.03	0.03	0.01	0.03	0.04
CH_4	**0.10**	**0.09**	**0.06**	**0.06**	**0.07**	**0.12**	**0.14**	**0.15**	**0.12**	**0.11**	**0.11**	**0.11**	**0.11**	**0.12**	**0.12**	**0.11**	**0.10**	**0.12**	**0.12**	**0.13**	**0.14**
N_2O	**0.11**	**0.11**	**0.07**	**0.06**	**0.06**	**0.08**	**0.09**	**0.08**	**0.07**	**0.07**	**0.07**	**0.09**	**0.10**	**0.08**	**0.09**	**0.09**	**0.08**	**0.08**	**0.09**	**0.09**	**0.10**

Methods

Emissions from fuel combustion (CRF 1.A.1–1.A.2) are in general calculated by multiplying fuel consumption with either a fuel type-specific emission factor or technology-specific emission factor. When calculating CO_2 emissions, adjustment the fraction of carbon oxidised is included.

Calculations of all emissions from fuel combustion are done with the Excel Work Tables created by energy sector expert.

Key Categories

Several emission sources in the energy combustion sector are key categories. The key categories in 2010 by level and trend and with and without LULUCF are listed in the Table 3.4, Table 3.5, Table 3.6 and Table 3.7.

Table 3.4. Key categories in the Energy sector in 2010 Level Assessment (without LULUCF) (quantitative method used: Tier 2)

IPCC code	IPCC source category	GHG	2010 Gg CO_2 equivalent
1.A.1.a	Energy Industries/Electricity and Heat Production – Solid Fuels	CO_2	12 544.63
1.A.1.c	Energy Industries/Other Energy Industries – Solid Fuels	CO_2	673.78
1.A.2.f	Manufacturing Industries and Constructions/Other – Solid Fuels	CO_2	246.90
1.A.4.b	Other Sectors/Residential – Biomass	CH_4	111.52

Table 3.5. Key sources in the Energy sector in 2010, Trend Assessment (without LULUCF) (quantitative method used: Tier 2)

IPCC code	IPCC source category	GHG	1990 Gg CO_2 equivalent.	2010 Gg CO_2 equivalent
1.A.1.a	Energy Industries/Electricity and Heat Production – Solid Fuels	CO_2	21 823.68	12 544.63
1.A.1.a	Energy Industries/Electricity and Heat Production – Liquid Fuels	CO_2	4 825.04	376.58
1.A.1.c	Energy Industries/Other Energy Industries – Solid Fuels	CO_2	84.05	673.78
1.A.2.f	Manufacturing Industries and Constructions/Other – Solid Fuels	CO_2	792.78	246.90
1.A.4.b	Other Sectors/Residential – Biomass	CH_4	33.67	111.52
1.A.2.f	Manufacturing Industries and Constructions/Other – Other Fuels	CO_2	0.00	44.08
1.A.4.b	Other Sectors/Residential – Solid Fuels	CO_2	669.20	34.34
1.A.4.b	Other Sectors/Residential – Biomass	N_2O	6.63	21.95
1.A.2.c	Manufacturing Industries and Constructions/Chemicals – Solid Fuels	CO_2	620.79	0.00

Table 3.6. Key categories in Energy sector in 2010, Level Assessment (with LULUCF) (quantitative method used: Tier 2)

IPCC code	IPCC source category	GHG	2010Gg CO_2 equivalent.
1.A.1.a	Energy Industries/Electricity and Heat Production – Solid Fuels	CO_2	12 544.63
1.A.1.c	Energy Industries/Other Energy Industries – Solid Fuels	CO_2	673.78
1.A.2.f	Manufacturing Industries and Constructions/ Other – Solid Fuels	CO_2	246.90
1.A.4.b	Other Sectors/Residential – Biomass	CH_4	111.52

Table 3.7. Key sources in Energy sector in 2010, Trend Assessment (with LULUCF) (quantitative method used: Tier 2)

IPCC code	IPCC source category	GHG	1990 Gg CO_2 equivalent.	2010 Gg CO_2 equivalent.
1.A.1.a	Energy Industries/Electricity and Heat Production – Solid Fuels	CO_2	21 823.68	12 544.63
1.A.1.a	Energy Industries/Electricity and Heat Production – Liquid Fuels	CO_2	4 825.04	376.58
1.A.1.c	Energy Industries/Other Energy Industries – Solid Fuels	CO_2	84.05	673.78
1.A.2.f	Manufacturing Industries and Constructions/ Other Sectors – Solid Fuels	CO_2	792.78	246.90
1.A.4.b	Other Sectors/Residential – Biomass	CH_4	33.67	111.52
1.A.4.b	Other Sectors/Residential – Solid Fuels	CO_2	669.20	34.34
1.A.2.c	Manufacturing Industries and Constructions/ Chemicals – Solid Fuels	CO_2	620.79	0.00

3.2.1. Comparison of the sectoral approach with the reference approach (CRF 1.AB)

Reference approach (RA) is carried out using import – export, production and stock change data from the National Energy Balance published by Statistics Estonia (www.stat.ee).

In the 2012 inventory, the difference of CO_2 emissions between RA and Sectoral Approach (SA) was 2.52%.

Following the recommendation of the 2011 review team amounts of lubricants and bitumen are included into reference approach and amounts of carbon stored with peat are removed from the reference approach. CEF of jet kerosene has been changed, which are now in line with CEF values used in 1.C.1.a Aviation Bunkering. The gaseous fuel consumption was equal in SA and RA because there was no non-energy use of natural gas in 2010.

However, differences in solid and liquid fuel consumption between RA and SA are caused by the fact that there is lot of secondary fuels used in final consumption (SA): shale oil, semi coke and oil shale gas – all made from oil shale, etc.

3.2.2. International Bunker Fuels

International bunkers cover international aviation and navigation according to the IPCC Guidelines.

In 2010, GHG emissions from international bunkering were 812.42 Gg including marine bunkers 697.79 Gg and aviation bunkers 114.64 Gg of CO_2 equivalent.

Amount of emissions in international navigation has increased since 2006. In the last years volume of goods transport and also the volume of goods transit has been increased in Estonian ports. The trend of emissions in international aviation has been pretty stable, small increases of GHG emissions in 2005 and 2007 were caused by lower bunker fuel price in Estonia (Figure 3.6).

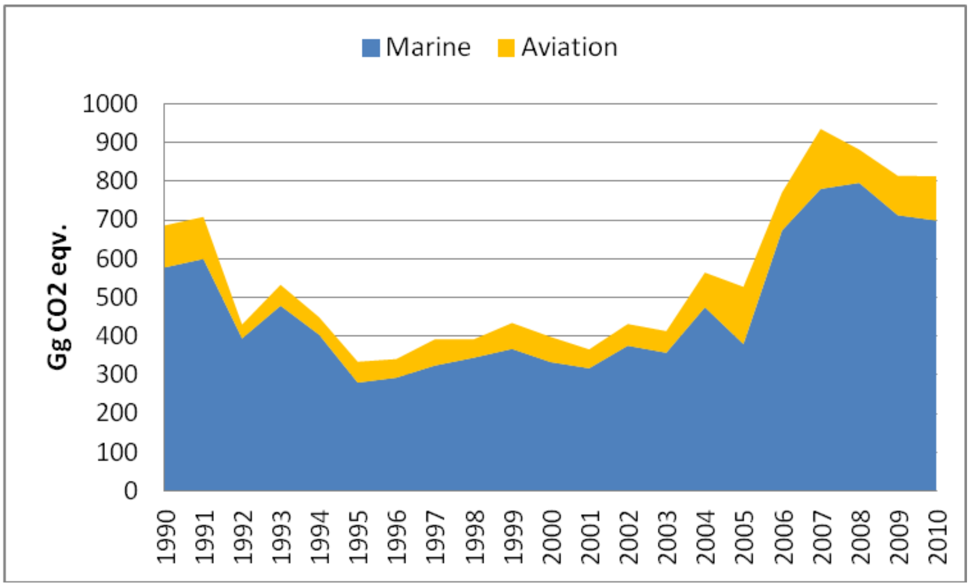

Figure 3.6. Emissions from international bunkers in 1990–2010, Gg CO_2 equivalent

The emissions were calculated using the IPCC methodology and default emission factors. Fuel consumption data for marine bunkering and aviation bunkering was obtained from Statistics Estonia.

The emissions are calculated using the national calculation model of the Estonian Environment Information Centre. Fuel consumption data are obtained from the energy statistics and it includes fuel sales to ships and aircrafts going abroad. The IPCC 1996 CO_2 emission factors are the same as for domestic aviation and navigation. The average non–CO_2 emission factors have been selected from the IPCC 1996 Guidelines, taking into account estimated fuel consumption and emissions from international landings and take-offs from the Estonia region.

3.2.3. Feedstocks and Non-Energy Use of Fuels

The following fuels are reported under CRF source category 1.AD Feedstocks and non–energy use of fuels:

1.AD.2 Lubricants
1.AD.3 Bitumen
1.AD.5 Natural Gas
1.AD.10 Other/Oil Shale

Activity data on lubricants and bitumen consumption is received from IEA statistics; the national statistics does not publish this data. Data on natural gas use for non-energy use are taken from national energy balance sheet. Activity data on oil shale reported in the CRF 1.AD is calculated (see Annex 3). This is oil shale semi coke – the by product of shale oil production and contains a small amount of organic matter (carbon). Oil shale semi-coke is stored in the oil shale waste dumps (carbon stored).

Bitumen is used for asphalt production and the corresponding emissions have been taken into account in the CRF source category 2.A.6.

Natural gas for non-energy purposes are used for ammonia production and are reported in the CRF source category 2.B.1. In 2010, the ammonia production factory in Estonia was temporary closed down because of low ammonia price in the Word market and there was no natural gas consumption for-non energy purposes.

Lubricants are used in energy sector for lubricating (mainly in transport and manufacturing sub-sectors). Some used lubricants (waste oils) are incinerated and corresponding emissions are taken into account in the CRF 1.A.2.f/Other fuels.

Source-specific recalculations

In the 2011 national submission carbon stored from non-energy consumption of natural gas, bitumen and lubricants was not reported in line with Revised 1996 IPCC Guidelines. In the current inventory submission data in the CRF table 1.AD.5 are reported correctly.

3.2.4. CO_2 capture from flue gases and subsequent CO_2 storage, if applicable

Up to now, there is no CO_2 capture and storage used in Estonia.

3.2.5. Energy Industries and Manufacturing Industries and Construction (CRF1.A.1, CRF1.A.2)

3.2.5.1. Source category description

Energy Industries (CRF1.A.1) and Manufacturing Industries and Construction (CRF1.A.2) include emissions from fuel combustion in point sources in energy production and industrial sectors (power plants, boilers and industrial plants with boilers and/or other combustion).

In 2010, the category Energy Industry (1.A.1) contributed about 80.5% of energy sector emissions, totalling 14.64 Tg of CO_2 equivalent and 71.4% of total GHG emissions. Compared to the base year 1990, the emissions were about 49% below that level (28.7 Tg CO_2).

The emissions from energy industries by relevant subcategories and gases in 1990–2010 are presented in the Table 3.8. The Figure 3.7 presents the trend of GHG emissions from Energy Industries by relevant subcategories in 1990 to 2010.

In general, the trend of GHG emissions in Energy Industries follows the trend of fuel consumption (Figure 3.5). In 2010, the emissions of Energy Industries decreased by 49.0% compared to the base year 1990. The increase of GHG emissions in electricity and heat production sub-sector was 51%. This big decrease was caused by the structural changes in the economy after 1991 when Estonia became independent. There has been a drastic decrease in the consumption of fuels and energy in energy industries (closing of the factories, decrease of electricity import, etc.). At the same time GHG emission trend of other energy industries (1.A.1.c) has increased about 88% copared to 1990 due to enlarged export volumes of shale oil.

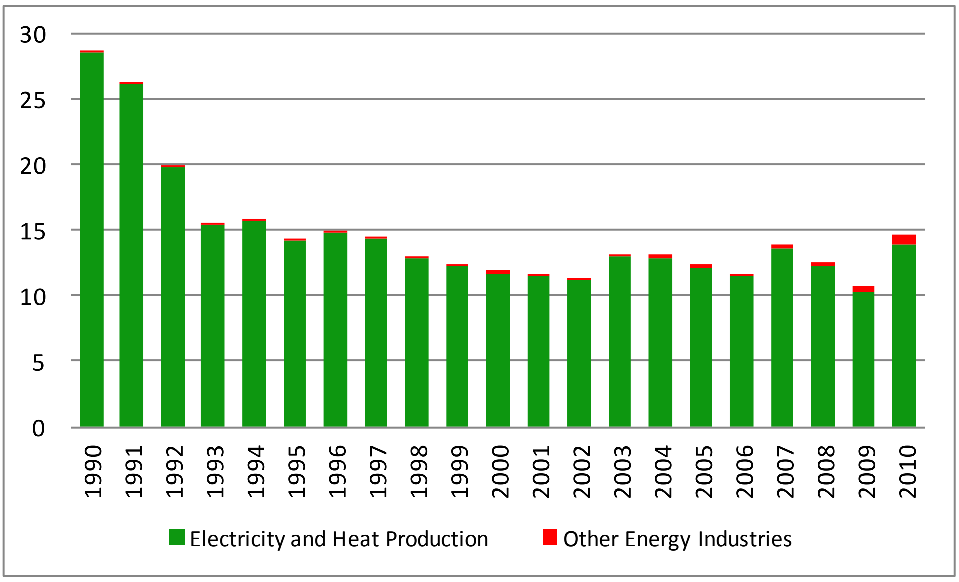

Figure 3.7. Trend of GHG emissions from Energy Industries by relevant subcategories in 1990–2010 (Tg CO_2 equivalent)

In 2010, the production of electricity totalled 12,964 GWh – nearly 1.5 times more than in 2009. After the interim decline period, electricity production regained the level of 2007. The growth in electricity production was first and foremost facilitated by the opening of electricity market, launch of electricity exchange and upturn in the inland economy. Exports of electricity increased nearly 50%. The largest part or 38% of exported electricity was sold to Finland and more than a third to Lithuania due to the close-down of their nuclear power plant. At the same time, also the inland consumption of electric energy increased about 5% mainly in industry, commercial and public services and also due to a bigger consumption by households.

In Estonia, renewable energy is generated from hydro- and wind energy and biomass. Since electricity generation has perked up in hydroelectric power plants and wind parks, the proportion of renewable energy has increased. In 2010 compared to 2009, the production of wind energy increased by more than 40%. Generation of hydroenergy has been stable during the last three years. In 2008 the share of electricity generated from renewable sources was only 2.1% in the total electricity consumption, in 2009 it was 6.1%, and in 2010 – 8.1%. The growth was due to the enlargement of the existing wind parks and commissioning of new wood fuel-based combined heat and power plants.

According to the data of Eurostat, the volume of electricity production is small in Estonia in comparison with other EU Member States, but by the production of electricity per capita (9.5 MWh per capita in 2010) Estonia ranks higher than the EU average (6.4 MWh per capita). In the comparison of the Baltic Republics, Estonia's electricity production per capita is bigger than in Latvia and Lithuania.

In 2010 compared to 2009, the production of heat increased by nearly 8%. Besides the livening economy, lower ambient temperature, too, contributed to an increase in production compared to the previous year. About 60% of heat was produced by heating plants – by 4% more than in 2009. Heating plants produced more than a half of heat from natural gas and about a third from wood fuels. A 17% increase was announced in the production of heat from shale oil.

40% of heat was produced at power plants, and compared to 2009 the production grew by nearly 15%. Over a third of the heat produced by power plants was generated by applying a fuel saving cogeneration mode. Starting up of new co-generation plants caused the share of heat produced by the heat and power co-generation mode to increase by nearly 7% compared to 2009.

In 2010, imports of energy products included natural gas, liquid fuels, coal and coke. In connection with a growth in the fuel consumption by power plants and households, imports of natural gas increased by about 7% compared to a year before. At the same time, imports of liquid fuels decreased by about 9%. The decrease was influenced by the reserves of motor fuel stored as at the end of 2009 and by a small decline in the consumption of motor gasoline.

In 2010, the category Manufacturing Industries and Construction (1.A.2) contributed about 2.8% of energy sector emissions, totalling 0.51 Tg of CO_2 equivalents and 2.5% of total GHG emissions.

The emissions from manufacturing industries and construction by relevant subcategories and gases in 1990–2010 are presented in Table 3.9 and Figure 3.9. Compared to the base year, 1990, the emissions of Manufacturing Industries and Construction decreased by 79.5%. This big decrease was caused by the structural changes in the economy after 1991 when Estonia became independent.

To follow the structure of CRF Reporter all Manufacturing Industries and Construction sub-sectors are presented in the six CRF Reporter sub-categories: 2.a Iron and Steel, 2.b Non-Ferrous Metals, 2.c Chemicals, 2.d Pulp, Paper and Print, 2.e Food Processing, Beverage and Tobacco and 2.e Other. The share of GHG emissions of relevant Manufacturing Industries and Constructions subcategories in 2010 are presented in the Figure 3.8.

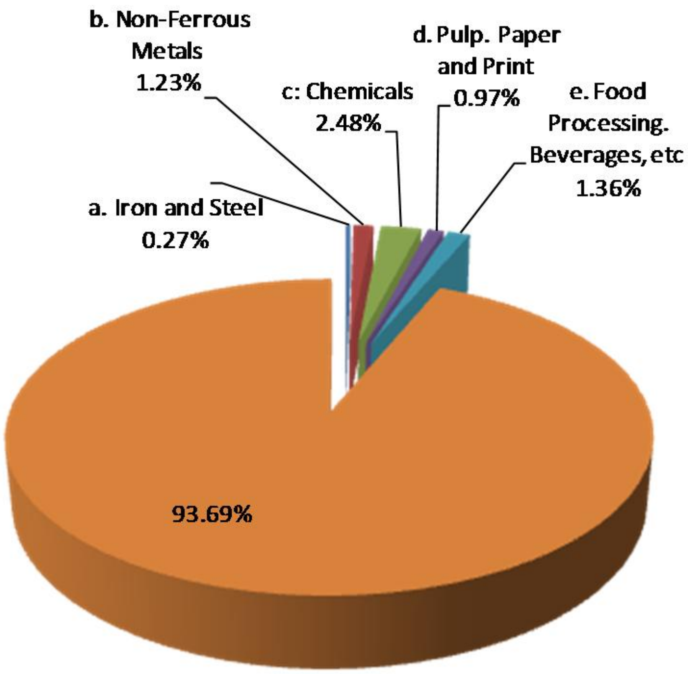

Figure 3.8. The share of GHG emissions from manufacturing industries and construction by relevant subcategories in 2010, %

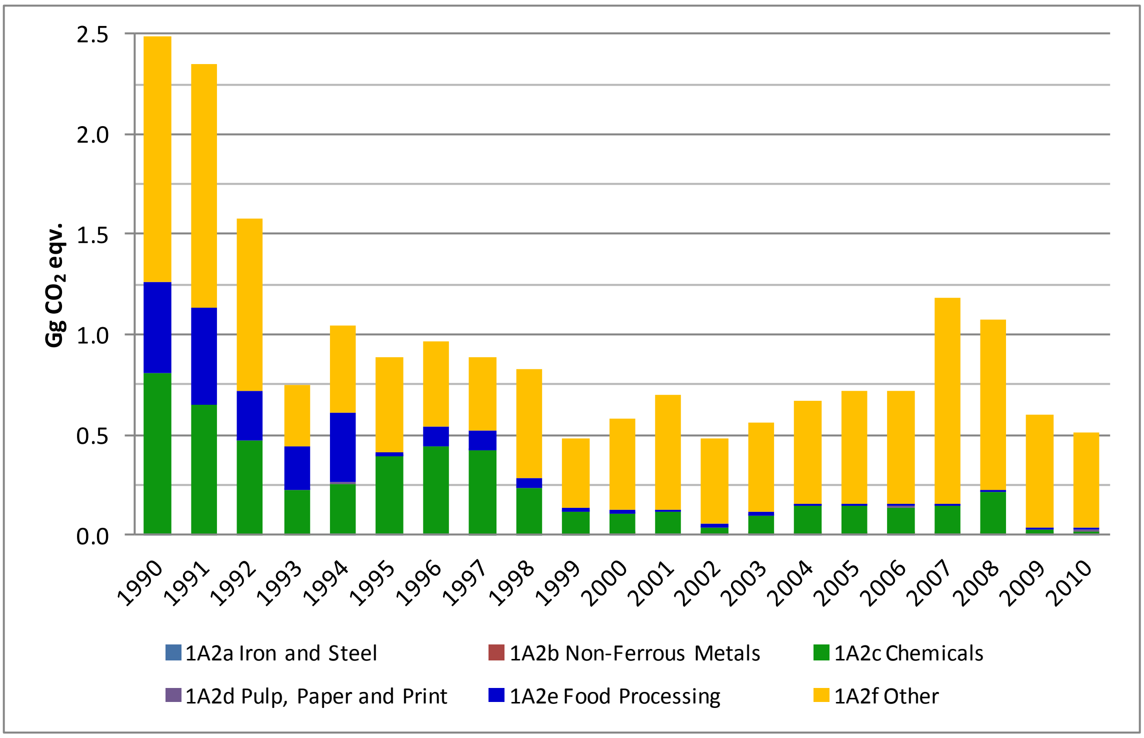

Figure 3.9. Trend of emissions GHG from manufacturing industries and construction by relevant subcategories in 1990–2010, Tg CO_2 equivalent

In Estonia, the share of the CRF sub-category 1.A.2.a Iron and Steel is very small forming only 0.27% of the manufacturing industries GHG emissions in 2010 (see Figure 3.8).

The source category '1.A.2.a Iron and Steel' consists mainly from factories using fuel for manufacturing goods from imported iron and steel. Since row material (iron and steel) for this industry was imported from Russia, then after regaining independence in Estonian in 1991 all iron and steel using factories were closed. In 1994 those factories started working again. As the production of goods depends from the raw material supply and final production export possibilities, the production decrease in 1997–1999 was directly caused by economic crisis in Russia at the same period. The production stabilised in 2000 up to 2007 and small decrease of emissions in 2008 and 2009 is connected with the last economic depression which started in the end of 2008. In 2010 the emissions of GHG increased to the 2008 level due to upturn of export possibilities of the sector.

The trend of GHG emissions of the CRF source category 1.A.2.a Iron and Steel in 1990–2010 is presented in Figure 3.10.

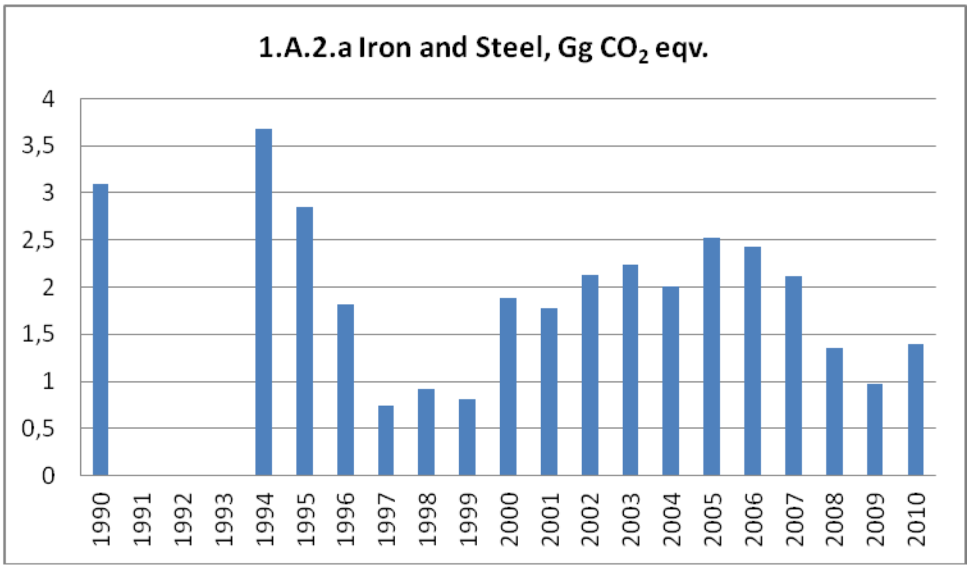

Figure 3.10. Trend of GHG emissions of the sub-sector Iron and Steel in 1990–2010, Gg CO_2 eq

The trend of GHG emissions of the CRF source category 1.A.2.b Non-Ferrous Metals in 1990–2010 is presented in Figure 3.11.

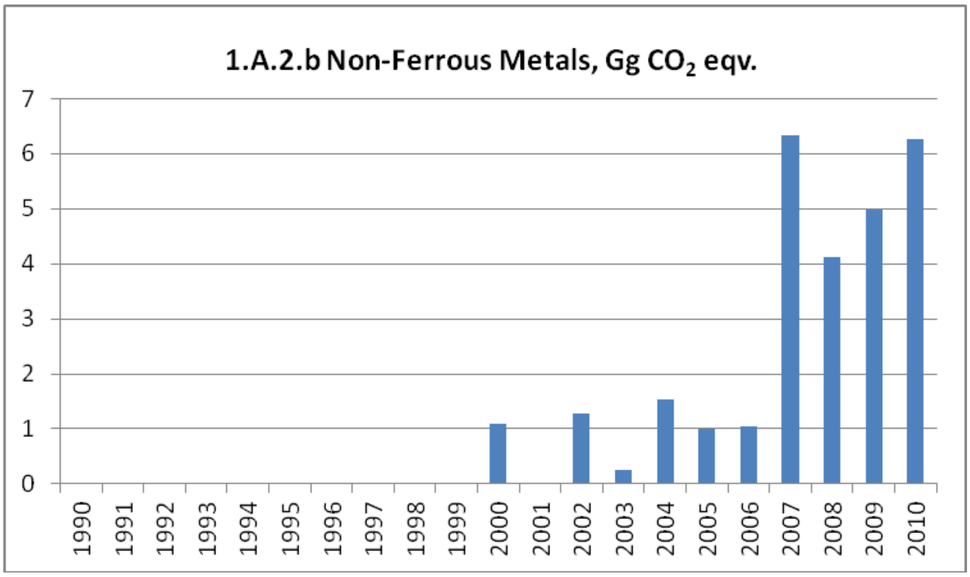

Figure 3.11. Trend of GHG emissions of the sub-sector Non-Ferrous Metals in 1990–2010, Gg CO_2 eq

The non-ferrous metal sub-sector is very small in Estonia consisting of 2–3 enterprises only. The big increase of GHG emissions in 2007 comparing with previous years is connected with fuel consumption increase and is probably caused by same large order(s) for some of these enterprises. The share of the CRF sub-category 1.A.2.b Non-Ferrous Metals is very small forming 1.23% of the manufacturing industries GHG emissions in 2010 (see Figure 3.8). The shape of the GHG emission trend follows the trend of fuel consumption in the sub-category.

The trend of GHG emissions of the sub-category Chemicals in 1990–2010 is presented in the Figure 3.12.

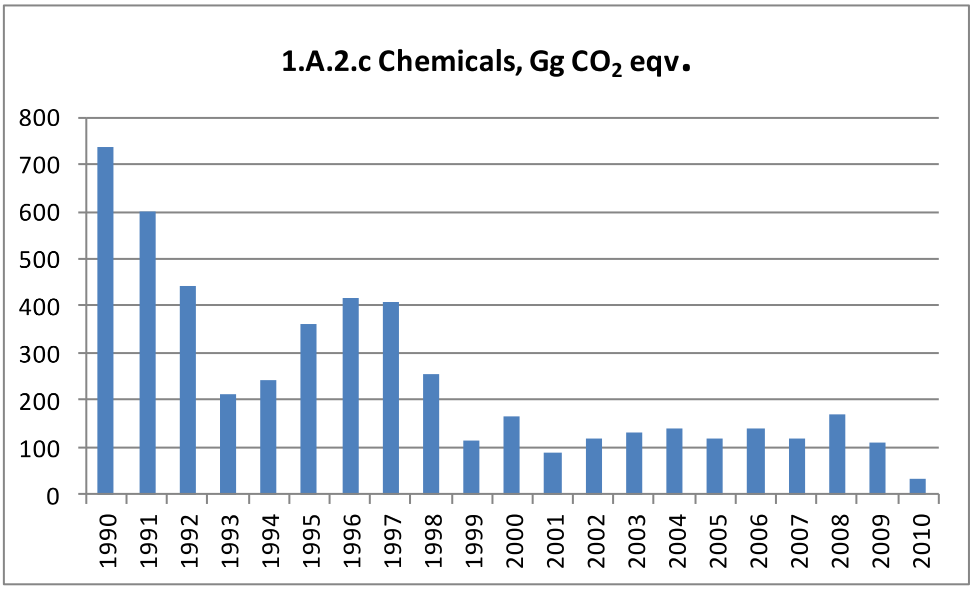

Figure 3.12. Trend of GHG emissions of the sub-sector Chemicals in 1990–2010, Gg CO_2 eq

Under this sub-category emissions from several chemical factories are reported. The biggest fuel consumer (mainly of natural gas) is the ammonia and urea producer Nitrofert AS.

The share of the CRF sub-category 1.A.2.c Chemicals sub-sector is small forming about 2.48% of the manufacturing industries GHG emissions in 2010 (see Figure 3.8).

The first decrease in the trend of GHG emissions in 1992/1993 was caused by privatisation of chemical enterprises after regaining independence in 1991 and by transition from eastern markets to the western markets. The second big decrease in 1999 is caused by extensive restructuring in the Estonian biggest chemical enterprise – Kiviter AS. The main product of the Kiviter was shale oil (a liquid fuel made from oil shale (a solid fuel)), but since 1999 shale oil production is reported under energy sector not under chemical industry as earlier. Only the productions of oil shale industry by-products like formalin, toluene, etc are still under chemical industry. In 2002 and 2009 the production of the Nitrofert was very small and in 2010 the factory standstill because of low ammonia prices in world market. Since the shape of the GHG emission trend follows the trend of fuel consumption are the fluctuations of the trend determined by the ammonia export possibilities of the chemical factory Nitrofert.

In the Figure 3.13 trend of GHG emissions from the sub-sector Pulp, Paper and Print in 1990–2010 is presented.

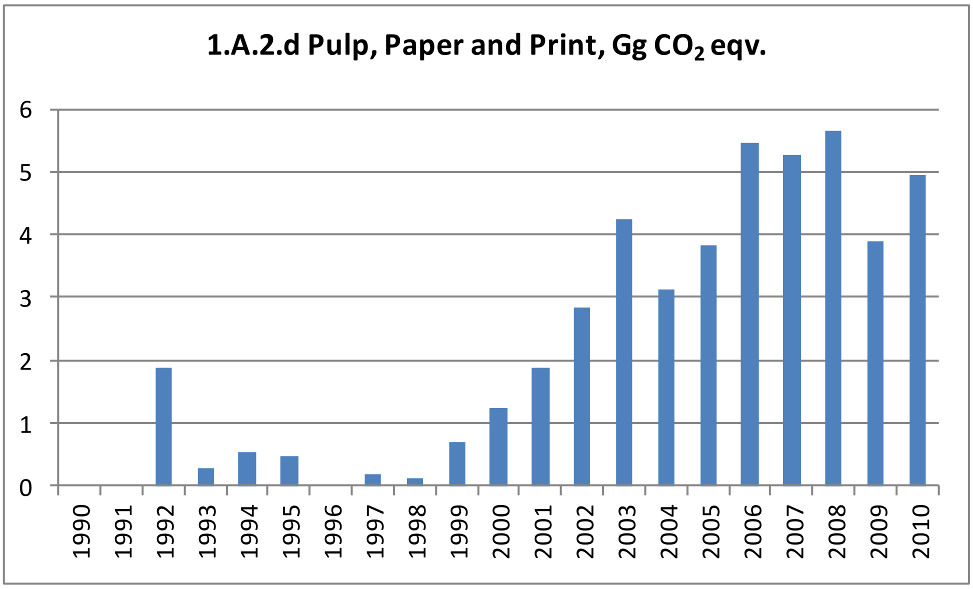

Figure 3.13. Trend of GHG emissions from the sub-sector Pulp, Paper and Print in 1990–2010, Gg CO_2 eq

The share of the CRF sub-category 1.A.2.d Pulp, Paper and Print is small forming about 0.97% of the manufacturing industries GHG emissions in 2010 (see Figure 3.8).

There are only a few major pulp and paper factories in Estonia: Horizon Tselluloosi ja Paberi AS (Horizon Pulp and Paper Ltd, former Kehra paper factory), Kohila Paber AS (Kohila paper factory) and Räpina Paberivabrik AS (Räpina paper factory) using waste paper for paper and carton production. In 2006 a new aspen pulp factory Estonian Cell AS was commissioned. There was no pulp and paper production in 1990–1991 since the big Tallinn

Pulp and Paper factory was closed in the end of 80s and all small factories were not yet privatized.

In 1992–1998 the production of paper fluctuated because of standstill of some factories caused by ownership changes. Since 1999–2003 the production of paper grew every year compared to the previous year. In 2004 manufacturing of wood pulp fell. In 2005 manufacturing of paper and paper products increased due to lively investment and growth of export. In 2009 the production of paper decreased again due to the economic depression. In 2010 manufacturing of paper and paper products increased again due growth of export.

All above described factors are behind the GHG emission trend changes.

The trend of GHG emissions of the sub-sector Food Processing, Beverages and Tobacco in 1990–2010 is presented in the Figure 3.14.

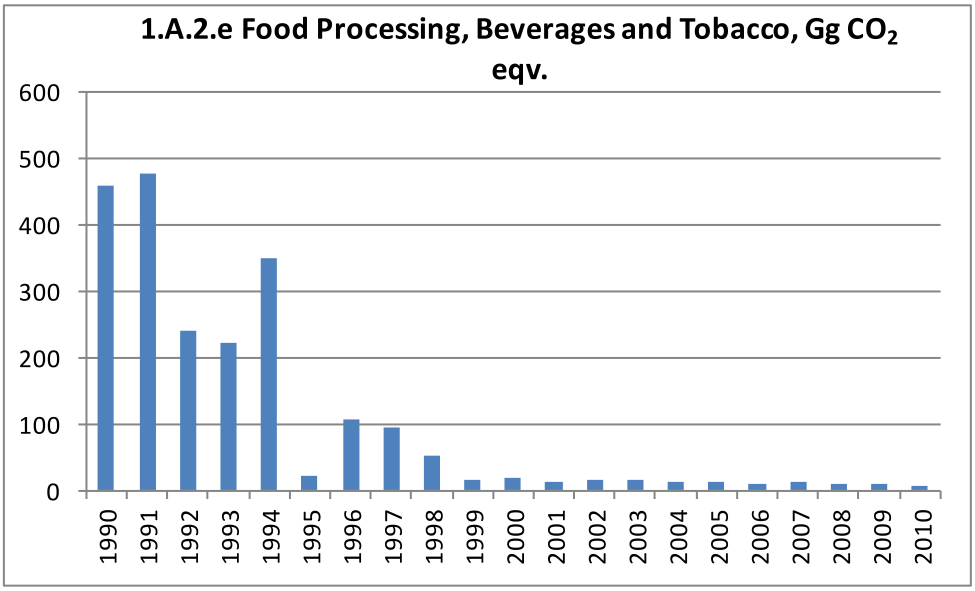

Figure 3.14. Trend of GHG emissions of the sub-sector Food Processing, Beverages and Tobacco in 1990–2010, Gg CO_2 eq

The share of the CRF sub-category 1.A.2.e Food Processing, Beverage and Tobacco is small forming about 1.36% of the manufacturing industries GHG emissions in 2010 (see Figure 3.8).

Manufacture of food products is the largest branch of manufacturing in Estonia giving about 15% of the total manufacturing output. Compared with other branches of industry, the manufacture of food products has been one of the most stable ones. While before the economic crisis the growth in production was 3–4% a year, in 2007 production slowed down and during the following three years the volume of output at constant prices decreased a bit. Economic crisis influenced the manufacture of food products somewhat less than other branches, because food products are basic commodities directed mainly to the domestic market. Situation in the foreign market did not affect this sector so much.

The trend of GHG emissions of the sub-sector Other in 1990–2010 is presented in the Figure 3.15.

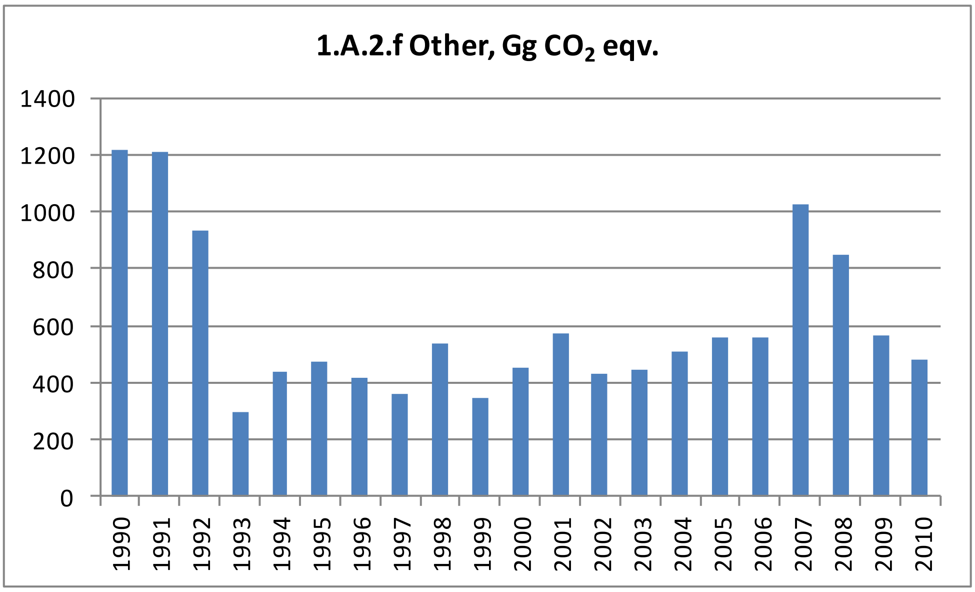

Figure 3.15. Trend of GHG emissions of the sub-sector Other in 1990–2010, Gg CO_2 eq

The share of the CRF sub-category 1.A.2.f Other is the biggest forming about 93.69% of the manufacturing industries GHG emissions in 2010 (see Figure 3.8).

In Estonia, the Manufacturing Industries and Construction sector's sub-category 1.A.2.f Other includes following sub-sectors: "Production of other non-metallic minerals"; "Production of transport equipment"; "Machinery"; "Mining and quarrying"; "Production of wood and wood products construction"; "Textile, leather and clothing industry" and "Other industry". In general, the shape of the GHG emission trend follows the trend of fuel consumption of the sector. The fluctuations of the trend are determined by the export possibilities of the sectors factories. The decrease of emissions in 2010 is connected with economic depression which started in 2008. Despite the upturn of economy in some branches of manufacturing industries the total volume of output in the manufacturing industry decreased in 2010. Recession in the construction market low, which caused a low demand for building materials in the domestic and international markets, was the main reason for that. According to Statistics Estonia, in 2010 compared to the previous year, the production of industrial enterprises decreased about 24%.

The values of CO_2 IEFs of liquid fuels in the Manufacturing Industries and Construction are between 72.78 t/TJ (in 2007) and 75.24 t/TJ (in 1995) and the values of CO_2 IEF of solid fuels are between 98.06 t/TJ (in 2009) and 127.3 t/TJ (in 1997). The trends are fluctuating due to changes in the contribution of different solid and liquid fuels over time.

Table 3.8. The emissions from Energy Industries by relevant subcategories and gases in 1990–2010 (Tg, CO_2 equivalent)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
CO_2 eq. Energy Industries	**28.73**	**26.22**	**19.83**	**15.60**	**15.87**	**14.35**	**14.87**	**14.45**	**12.90**	**12.34**	**11.89**	**11.71**	**11.43**	**13.23**	**13.15**	**12.38**	**11.64**	**13.88**	**12.59**	**10.68**	**14.64**
1. CO_2 Energy Industries	28.70	26.20	19.82	15.59	15.85	14.33	14.85	14.43	12.88	12.32	11.87	11.68	11.40	13.21	13.13	12.35	11.61	13.85	12.56	10.65	14.60
CO_2 a. Electricity and Heat Production	28.617	26.148	19.756	15.488	15.736	14.225	14.747	14.313	12.780	12.210	11.694	11.509	11.210	12.976	12.903	12.103	11.400	13.651	12.272	10.259	13.926
CO_2 c. Shale Oil Production	0.084	0.048	0.060	0.100	0.115	0.107	0.100	0.115	0.098	0.107	0.178	0.175	0.194	0.229	0.223	0.243	0.205	0.198	0.289	0.387	0.674
CH_4 1. Energy Industries	0.008	0.007	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.008	0.007	0.008	0.010	0.013
N_2O 1. Energy Industries	0.020	0.018	0.013	0.012	0.013	0.014	0.016	0.015	0.015	0.015	0.013	0.016	0.016	0.016	0.020	0.025	0.022	0.021	0.024	0.025	0.032

Table 3.9. The emissions from Manufacturing Industries and Construction by relevant subcategories and gases in 1990–2010 (Tg, CO_2 equivalent)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
CO_2 eq 2. Manufacturing Industries	**2.49**	**2.35**	**1.58**	**0.75**	**1.05**	**0.88**	**0.96**	**0.88**	**0.83**	**0.48**	**0.58**	**0.70**	**0.49**	**0.56**	**0.66**	**0.72**	**0.71**	**1.18**	**1.08**	**0.60**	**0.51**
CO_2 2. Manufacturing Industries	2.48	2.34	1.57	0.74	1.04	0.88	0.96	0.88	0.82	0.47	0.57	0.70	0.48	0.55	0.66	0.71	0.71	1.18	1.07	0.60	0.51
a. Iron and Steel	0.003	NO	NO	NO	0.004	0.003	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.001	0.001	0.001
b. Non-Ferrous Metals	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.001	NO	0.001	0.000	0.002	0.001	0.001	0.006	0.004	0.005	0.006
c. Chemicals	0.799	0.653	0.472	0.224	0.254	0.387	0.434	0.424	0.235	0.111	0.102	0.109	0.030	0.090	0.137	0.136	0.135	0.131	0.206	0.017	0.013
d. Pulp. Paper and Print	NO	NO	0.002	0.000	0.001	0.000	NO	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.003	0.004	0.005	0.005	0.006	0.004	0.005
e. Food Processing. Beverages, etc	0.458	0.475	0.240	0.220	0.350	0.021	0.105	0.094	0.051	0.017	0.017	0.013	0.016	0.015	0.013	0.013	0.009	0.011	0.009	0.009	0.007

f. Other	1.217	1.209	0.857	0.298	0.437	0.469	0.417	0.359	0.536	0.345	0.449	0.571	0.430	0.439	0.503	0.559	0.557	1.020	0.844	0.561	0.474
CH_4 2.Manufacturing Industries	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.001	0.001
N_2O 2 Manufacturing Industries	0.006	0.006	0.004	0.002	0.003	0.002	0.003	0.002	0.002	0.001	0.002	0.003	0.002	0.002	0.003	0.003	0.003	0.006	0.005	0.003	0.003

3.2.5.2. Methodological issues

Methods

Emissions from fuel combustion are in general calculated by using the methodology of the IPCC 1996 Guidelines. Different tiers have been applied for different fuels and gases.

For imported fuels mainly Tier 1 approach has been applied. For domestic fuels – oil shale, shale oil, oil shale semi-coke, oil shale semi-coke gas and generator gas and peat Tier 2 and Tier 3 approaches were used.

Tier 1 for CO_2 emissions:

CO_2 EMISSIONS FROM STATIONARY COMBUSTION

$$Emission_{fuel} = Fuel\ Consumption_{fuel} \bullet Emission\ Factor_{fuel} \bullet Oxidation\ Factor_{fuel}$$

Where:
Emission $_{fuel}$ = emissions of CO_2 by type of fuel (Gg)
Fuel Consumption $_{fuel}$ = amount of fuel combusted (TJ)
Emission Factor $_{fuel}$ = default emission factor of CO_2 by type of fuel (t/TJ)
Oxidation Factor $_{fuel}$ = fuel specific oxidation factor

For other GHG:

GREENHOUSE GAS EMISSIONS FROM STATIONARY COMBUSTION

$$Emission_{GHG,\ fuel} = Fuel\ Consumption_{fuel} \bullet Emission\ Factor_{GHG,\ fuel}$$

Where:
Emissions $_{GHG,\ fuel}$ = emissions of a given GHG by type of fuel (Gg)
Fuel consumption $_{fuel}$ = amount of fuel combusted (TJ)
Emission Factor $_{GHG,\ fuel}$ = default emission factor of a given GHG by type of fuel (t/TJ).

Tier 2 for CO_2 emissions:

CO_2 EMISSIONS FROM STATIONARY COMBUSTION

$$Emission_{fuel} = Fuel\ Consumption_{fuel} \bullet Emission\ Factor_{fuel} \bullet Oxidation\ Factor_{fuel}$$

Where:
Emission $_{fuel}$ = emissions of CO_2 by type of fuel (Gg)
Fuel Consumption $_{fuel}$ = amount of fuel combusted (TJ)
Emission Factor $_{fuel}$ = country specific emission factor of CO_2 by type of fuel (t/TJ)
Oxidation Factor $_{fuel}$ = fuel specific oxidation factor

GREENHOUSE GAS EMISSIONS FROM STATIONARY COMBUSTION

$$Emission_{GHG,\ fuel} = Fuel\ Consumption_{fuel} \bullet Emission\ Factor_{GHG,\ fuel}$$

Where:
Emissions $_{GHG,\ fuel}$ = emissions of a given GHG by type of fuel (Gg)

Fuel consumption $_{fuel}$ = amount of fuel combusted (TJ)
Emission Factor $_{GHC, fuel}$ = country specific emission factor of a given GHG by type of fuel (t/TJ).

Tier 3 for CO_2 emissions:

CO_2 EMISSIONS FROM STATIONARY COMBUSTION

$$Emission_{fuel,technology} = Fuel\ Consumption_{fuel,technology} \bullet EF_{fuel,technology} \bullet Oxidation\ Factor_{fuel}$$

Where:

Emissions $_{GHG, fuel, technology}$ = emissions of a given GHG by type of fuel and technology (Gg)

Fuel consumption $_{fuel, technology}$ = amount of fuel combusted by each technology (TJ)
Emission Factor $_{GHG, fuel, technology}$ = technology specific emission factor of a given GHG by type of fuel (t/TJ).

Oxidation Factor $_{fuel}$ = fuel specific oxidation factor

GREENHOUSE GAS EMISSIONS BY TECHNOLOGY

$$Emission_{GHG,\ fuel,technology} = Fuel\ Consumption_{fuel,technology} \bullet Emission\ Factor_{GHG,\ fuel,technology}$$

Where:
Emissions $_{GHG, fuel, technology}$ = emissions of a given GHG by type of fuel and technology (Gg)
Fuel consumption $_{fuel, technology}$ = amount of fuel combusted by each technology (TJ)
Emission Factor $_{GHG, fuel, technology}$ = technology specific emission factor of a given GHG by type of fuel (t/TJ).

Oil Shale

As oil shale is the main indigenous fuel of Estonia, its short description is given below. Estonian oil shale as fuel is characterised by a high ash content (45–47%), a moderate content of moisture (11–13%) and sulphur (1.5–1.7%), a low net calorific value (8.3–8.7 MJ/kg) and a high content of volatile matter in the combustible part (up to 90%). The dry matter of Estonian oil shale is considered to consist of three main parts: organic, sandy-clay and carbonate (Arvo Ots, 2004).

Oil shale is produced in two qualities: with the grain size of 0÷25 mm and 25÷125 mm. The enriched lumpy oil shale (25÷125 mm) with higher calorific value is used in oil shale industry to produce oil shale oil (shale oil) and as fuel in cement kilns. About 77% of the mined oil shale (grain size 0÷25 mm) with lower calorific value is used as boiler fuel in large power plants. The net calorific value of oil shale is decreasing, because oil shale layers of the best quality have mostly been exhausted already.

From the point of view of greenhouse gas emissions it is important that during combustion of pulverised oil shale CO_2 is formed not only as a burning product of organic carbon, but also as a decomposition product of the ash carbonate part.

Therefore, the total quantity of carbon dioxide increases up to 25% in flue gases of oil shale.

Two different combustion technologies, the old pulverised combustion of oil shale (PC) and the circulated fluidised bed combustion (CFBC) technology are at present used in the Estonian Power Plants.

The first CFBC power unit (215 MW_{el}) started at the Eesti Power Plant at the end of 2003. The conducted tests showed that the transition at an oil shale power plant from pulverised combustion boilers to circulating fluidised bed boilers is accompanied by several changes: the CFBC boiler CO_2 discharge is merely 82–84% of that figure for pulverised combustion boilers, the carbonate decomposition rate was about 0.75 (sometimes even less), the SO_2 atmospheric discharges stopped almost completely (k_S=0.999), the boiler efficiency increased from 81–82% to ~90–95%, thus also the fuel consumption decreased, power production efficiency at nominal load was in the range 35–36%, versus 29–30% at oil shale fluidised bed combustion.

The second CFBC power unit (215 MWel) started at the Narva PP in 2004. The successful operation of the new CFBC units allows continuing the construction of additional units.

A formula for the calculation of Estonian (pulverised combustion) oil shale carbon emission factor, taking into consideration the decomposition of its ash carbonate part and CO_2 binding at ash fields, is as follows:

$$CEF_{oilshale} = 10 \cdot \left[C_t^r + k \cdot (CO_2)_M^r \cdot 12/44\right] / Q_i^r, \left[tC/TJ\right] \quad (1)$$

where:

Q_i^r – lower heating value oil shale, MJ/kg;

C_t^r – carbon content of oil shale, %;

$(CO_2)_M^r$ – mineral carbon dioxide content of oil shale, %;

k decomposition rate of ash carbon part (*k* = 0.64 for pulverised combustion of oil shale).

In 2004, a new regulation of the Minister of the Environment for calculation the amount of carbon dioxide discharged into the atmosphere at oil shale power plants was issued (Method…, 2006).

Formula (1) gives:

$$CEF_{oilshalePC} = 10 \cdot (20.7 + 0.64 \cdot 17.7 \cdot 12/44) / 8.4 = 27.85 \ tC/TJ$$

Where:

Average heating value Q_i^r = 8.40 MJ/kg;

Mineral carbon dioxide content of oil shale $(CO_2)_M^r$ = 17.7%;

Carbon content of oil shale C_t^r = 20.7%;

k, decomposition rate of ash carbon part = 0.64 for pulverised combustion of oil shale.

With the introduction in 2004 of new power units with circulating fluidised bed (CFB) boilers at the Eesti and Balti Power Plants, the situation concerning the carbon emission factor has changed. Firing temperatures in CFB boilers are lower (780–820°C) than those in pulverised combustion (PC) boilers (>1400 C). This circumstance exerts a considerable influence on the intensity of carbonate decomposition.

The researchers of the Department of Thermal Engineering (DTE) of TUT recommend to use a new value of *k* for CFB boilers (0.40 instead of the previously used 0.64) (Emissions of…, 2006).

$$CEF_{oilshaleCFB} = 10 \cdot \left(20.7 + 0.4 \cdot 17.7 \cdot 12/44\right)/8.4 = 26.94\ tC/TJ$$

Therefore, the value of carbon emission factor for oil shale CFB combustion is lower than that for pulverised combustion.

It means that for National GHG Inventories emissions of CO_2 from pulverised combustion and circulating fluidised bed combustion boilers are calculated separately.

Shale oil

In Estonia, the oil shale thermal processing for shale oil production takes place in three plants: in ***Kiviõli Keemiatööstuse OÜ*** (*Kiviõli Oil Shale Processing and Chemicals Plant Ltd*.), in ***Viru Keemia Grupp AS*** (*Viru Chemistry Group(VKG) Ltd*. in Kohtla-Järve) and in ***Narva Oil Plant AS*** at the Eesti Power Plant.

There are two different technologies in use – since 1924 up to the present: the technology of processing large-particle oil shale in vertical retorts with gaseous heat carrier, and since 1980 that of processing fine-grained oil shale with solid heat carrier (SHC) are in operation. Since 2010, in Kohtla-Järve and Kiviõli both technologies and in the Narva Oil Plant the solid heat carrier technology is used.

The technology of processing oil shale in **vertical retorts** with gaseous heat carrier is universal technology and suitable for retorting high-calorific oil shale. The vertical retort is a metal vessel lined from inside with refractory bricks. The oil shale charging device and spent shale discharge chute and extractor are arranged on the top and in the lower part of the retort vessel, respectively. Thermal processing of oil shale takes place in retorting chambers in the cross flow of gaseous heat carrier. By influence of gases oil shale is warmed and dried up and after achieving needful temperature for retorting, the organic part of oil shale starts quickly to decompose. The mixture of the heat carrier with oil and water vapour moves into collector chambers, semi-coke (retorted oil shale) moves downward to cooling chambers. Oil vapour and gas are let out of the retort via outlet connections to condensation system. (J. Soone, S. Doilov, 2003). Cleaned generator gas is delivered to heating boilers for burning. Thermal processing of oil shale in vertical retorts takes place without any contact with the ambient atmosphere; therefore no pollutants are emitted.

In **Solid Heat Carrier installation (SHC),** hot oil shale dust as a heat carrier is used. Pre-dried fine-grained oil shale with hot oil shale dust (800°C) is delivered to a horizontal rotating reactor where during just a few minutes the retorting process is occurring. The mixture of heat carrier with oil and water vapours moves into dust separation chamber. Oil vapours and gas are sent to the condensing chamber where the condensed oil is separated and semi-coke gas is sent for burning to power plant. Mixture of semi-coke and dust will delivered to an aero fountain combustor chamber, where semi-coke is burned and flue gases separated. The flue gases are partly used for pre-heating of oil shale in dryer but partly emitted into atmosphere. Dust is delivered to ash fields but partly back to the reactor.

Therefore, in 2010, 65.77 PJ of shale oil was consumed for shale oil production in total but only processing of 40.52 PJ of oil shale caused CO_2 emissions at the plants (see Table 3.10).

Table 3.10. Oil shale consumption for shale oil production by different technologies, PJ

Year	Solid Heat Carrier			Total in SHC	Gas generators		Total in gas generators	Total Oil shale
	Narva	VKG	Kiviõli		VKG	Kiviõli		
1990	3.24			3.24	21.56	5.55	27.11	**30.36**
1991	1.77			1.77	19.05	5.24	24.29	**26.06**
1992	2.57			2.57	18.22	5.26	23.47	**26.05**
1993	4.20			4.20	20.09	5.44	25.53	**29.73**
1994	4.75			4.75	18.14	5.00	23.14	**27.89**
1995	4.31			4.31	20.14	5.35	25.49	**29.81**
1996	4.58			4.58	21.42	5.37	26.79	**31.38**
1997	5.15			5.15	21.22	5.47	26.69	**31.84**
1998	4.35			4.35	13.14	4.34	17.49	**21.83**
1999	4.14			4.14	9.75	0.47	10.23	**14.37**
2000	5.86			5.86	13.57	5.30	18.87	**24.73**
2001	6.24			6.24	15.38	5.29	20.67	**26.91**
2002	6.74			6.74	16.13	5.52	21.65	**28.38**
2003	7.66			7.66	16.93	5.49	22.42	**30.08**
2004	8.13			8.13	17.63	4.69	22.32	**30.44**
2005	8.87			8.87	17.78	4.21	22.00	**30.86**
2006	8.40			8.40	19.73	4.17	23.90	**32.30**
2007	7.96			7.96	20.72	4.26	24.98	**32.94**
2008	10.85			10.85	19.99	3.87	23.86	**34.70**
2009	13.07			13.07	20.45	4.04	24.49	**37.56**
2010	14.74	3.31	0.32	18.37	21.15	4.10	25.25	**43.50**

Oil shale gas

Oil shale gas is a by-product of the thermal processing of oil shale. There are different types of oil shale gases depending on the technology used for oil shale processing. Oil shale gas as the by-product of oil shale thermal processing in solid heat carrier installation (SHC) is called as semi-coke gas and gas formed in the oil shale processing in vertical reactors (gas generators) called as generator gas. In the Table 3.11 semi-coke and generator gas production data of different oil plants are presented.

Table 3.11. Semi-coke and generator gas production by oil plants, PJ

Year	Solid Heat Carrier			Total in SHC	Gas generators		Total in gas generators	Total Oil shale gas
	Narva	VKG	Kiviõli		VKG	Kiviõli		
1990	0.70			0.70	2.82	0.39	3.20	**3.90**
1991	0.37			0.37	2.47	0.37	2.84	**3.21**
1992	0.54			0.54	2.52	0.41	2.94	**3.48**
1993	0.70			0.70	2.65	0.42	3.07	**3.77**
1994	0.91			0.91	2.74	0.41	3.14	**4.05**

1995	0.90			0.90	2.69	0.46	3.15	**4.05**
1996	1.00			1.00	2.91	0.43	3.34	**4.34**
1997	1.05			1.05	2.85	0.42	3.27	**4.32**
1998	0.92			0.92	1.30	0.35	1.66	**2.58**
1999	0.79			0.79	1.20	0.04	1.24	**2.03**
2000	1.04			1.04	1.75	0.43	2.17	**3.21**
2001	1.26			1.26	1.97	0.47	2.44	**3.70**
2002	1.26			1.26	2.15	0.49	2.64	**3.90**
2003	1.32			1.32	2.27	0.48	2.74	**4.06**
2004	1.48			1.48	2.28	0.48	2.76	**4.24**
2005	1.59			1.59	2.26	0.53	2.78	**4.38**
2006	1.62			1.62	2.66	0.55	3.21	**4.83**
2007	1.53			1.53	2.92	0.54	3.46	**4.99**
2008	2.00			2.00	2.79	0.50	3.29	**5.28**
2009	2.40			2.40	2.88	0.50	3.38	**5.78**
2010	2.83	3.31	0.20	6.34	3.17	0.60	3.77	**10.11**

In the Table 3.12 the calorific values and CO_2 emission factors of different oil shale gases are presented (plant data).

Table 3.12. Calorific values and carbon emission factors of different oil shale gases

Plant/technology	**Calorific value, MJ/Nm3**	**Carbon Emission Factor, tC/TJ**
Semi-coke gas (SHC -140[1] technology)		
Narva Oil Plant	47.37	18.74
VKG Oil Plant	40.47	18.876
Kiviõli Oil Plant	28.65	16.443
Generator gas (vertical retort technology)		
VKG Oil Plant, in Kohtla-Järve	3.19	50.30
Kiviõli Oil Plant	2.74	53.43

CO_2 emissions from the combustion of different oil shale gases are calculated separately and included into CRF source-category CRF 1.A.1.a Public Electricity and Heat Production/Solid Fuels (see also Annex 2, Table A.2.1–A.2.5).

CO_2 emission factors and other parameters

Both, country specific and IPCC default CO_2 emission factors are used in GHG emission calculations. CO_2 emission factors, oxidation factors and net caloric values of different fuels are presented in Table 3.13 below. In order to improve the accuracy of the inventory, some of the CO_2 factors were checked and updated for the current inventory.

[1] SHC 140: solid heat carrier technology with oil yield 140 tons of oil per hour.

Table 3.13. CO_2 emission factors, oxidation factors and net caloric values by fuel

Fuels	NCV average	Unit	CEF tC/TJ	CO_2 EF CO_2/TJ	Oxidation factor	Source
Liquid fuels						
LPG (Liquefied petrol Gas)	44.517	GJ/t	17.2	63.1	0.99	D, IPCC 1996, Vol. 2, Table 1-2
Gasoline	44.00	GJ/t	19.9	72.97	0.99	CS, LT (Lithuania)
Jet Kerosene	43.00	GJ/t	19.5	71.5	0.99	D, IPCC 1996
Aviation Gasoline	43.00	GJ/t	19.5	71.5	0.99	D, IPCC 1996
Gasoil (light fuel oil)	42.297	GJ/t	20.2	74.1	0.99	CS, LT (Lithuania) = D, IPCC 1996, Vol. 2, Table 1-2
Gasoil (for non-road use)	42.297	GJ/t	20.2	74.1	0.99	CS, LT (Lithuania) = D, IPCC 1996, Vol. 2, Table 1-2
Shale Oil	39.216	GJ/t	21.1	77.4	0.99	CS, MoE 2006
Diesel Oil	42.57	GJ/t	20.2	74.1	0.99	CS, LT (Lithuania) = D, IPCC 1996, Vol. 2, Table 1-2
Residual Fuel Oil (heavy fuel oil)	40.146	GJ/t	21.1	77.4	0.99	D, IPCC 1996, Vol. 2, Table 1-2
Recycled Waste Oil	20.18	GJ/t	20.2	74.1	1	PS, Kunda Nordic Cement
Lubricants	40.19	GJ/t	20.0	73.3		D, IPCC 1996, Vol. 2, Table 1-2
Bitumen	40.19	GJ/t	22.0	80.7		D, IPCC 1996, Vol. 2, Table 1-2
Solid fuels						
Coal	27.16	GJ/t	26.8	98.3	0.98	D, IPCC 1996, Vol. 2, Table 1-2
Coke Oven Coke	28.50	GJ/t	29.50	108.2	0.98	D, IPCC 1996, Vol. 2, Table 1-2
Oil $Shale_{FB}$ (Fludised Bed Combustion)	8.449	GJ/t	27.85	102.1	0.98	CS, MoE 2006
Oil $Shale_{PC}$ (Pulverised Combustion)	8.449	GJ/t	26.94	98.8	0.98	CS, MoE 2006
Milled Peat	10.0	GJ/t	28.9	106.0	0.99/0.97*	CS, FI (Finland) = D, IPCC 1996, Vol. 2, Table 1-2
Sod Peat	12.0	GJ/t	27.82	102.0	0.99/0.97*	CS, FI (Finland)
Peat Briquette	16.0	GJ/t	26.45	97.0	0.97	CS, FI (Finland)
Oil Shale semi-coke (SHC technology, Narva plant)	8.9	GJ/t	8.29	30.4	0.7	CS, Expert Estimation 2011
Oil Shale semi-coke gas (SHC technology, Narva plant)	47.37	GJ/1000 m^3	18.745	68.7	0.995	CS, Expert Estimation 2011
Oil Shale semi-coke gas (VKG plant)	40.47	GJ/1000 m^3	18.876	69.21	0.995	CS, Expert Estimation 2011
Oil Shale generators gas (VKG)	3.19	GJ/1000 m^3	50.30	184.4	0.995	CS, Expert Estimation 2011
Oil Shale semi-coke gas (Kiviõli plant)	28.65	GJ/1000 m^3	16.443	60.3	0.995	CS, Expert Estimation 2011

Fuels	NCV average	Unit	CEF tC/TJ	CO_2 EF CO_2/TJ	Oxidation factor	Source
Oil Shale generator gas (Kiviõli plant)	2.74	GJ/1000 m^3	53.43	195.9	0.995	CS, Expert Estimation 2011
Waste Oils	16.0	GJ/t	20.2	74.0	1	PS, Kunda Nordic Cement
Other Fossil based Solid Waste (MSW)	19.0	GJ/t	21.82	80.0	1	PS, Kunda Nordic Cement
Plastic Waste	21.0	GJ/t	20.45	75.0	1	PS, Kunda Nordic Cement
Gaseous fuels						
Natural Gas	33.6	GJ/1000 m^3	15.07	55.3	0.995	CS, RUS (Russian)
Biomass fuels						
Solid Biomass (solid, includes e.g. firewood, wood chips, sawdust pellets, briquettes, etc.)	6.13 – 16.92	GJ/m^3s	29.9	109.6	0.98	D, IPCC 1996, Vol. 2, Table 1-2
Black Liquors	13.4	GJ/t	29.9	109.6	0.98	D, IPCC 1996, Vol. 2, Table 1-2
MSW biomass fraction	19.0	GJ/t	30.0	110.0	0.98	CS, Kunda
Biogas (landfill gas and biogas from wastewater treatment)	19.73	GJ/1000 m^3	14.89	54.6	0.995	D, IPCC2006, Chp. 2, Table 2.2, p.2.17

* oxidation factor of peat is 0.99 for electricity generation and 0.97 for other sectors
D - IPCC default value; CS – country specific; EE – expert estimation (Annex 2)

Sources:

IPCC 1996: Greenhouse Workbook, Vol. 2, 1996.

MoE 2006: Method for determining the amount of carbon dioxide discharged into the atmosphere. The Regulation of the Minister of the Environment. State Gazette No 22, 11.2006, 85, 1546 (in Estonian).

RUS (Russia) – Greenhouse Gas Emissions in Russian Federation 1990–2009 (2011).

LT (Lithuania) – Greenhouse Gas Emissions in Lithuania 1990–2009 (2011).

Estonia uses Finnish carbon EFs of milled peat (corresponds with IPCC default value), sod peat and peat briquette, because the IPCC methodology does not give CEF values for sod peat and peat briquette. The calorific values of these peat fuels are practically the same. NCV of milled peat is in Estonia 10.0 MJ/kg (in Finland 10.1 MJ/kg) and NCV of sod peat is 12.0 MJ/kg (12.3 MJ/kg in Finland, see NIR Finland 1990-2011). The only difference is in the NCV value of peat briquette, in Estonia 16.0 but in Finland 20.9 MJ/kg, but this difference could be explained. In Estonia, the net calorific value of peat briquette is given at the moisture content about 14-16% (Q^r) but in Finland for the dray matter of peat briquette (Q^d). When to convert the calorific value as received to the calorific value of dray matte the Finnish and Estonian NCVs of peat briquette will be relatively the same.

The ERT (2011) recommended Estonia not to use the Lithuanian CO_2 emission factor for gasoline as a CS one but elaborate the Estonian own EF for gasoline using the weighted average method of country specific emission factors from main importer countries. This is a large work and needs gasoline import data by countries which are not available in the electronic database of Statistics Estonia and have to be requested by special order from the statistical office. In the current submission

Estonia still decided to use Lithuanian CO_2 EF of gasoline because according to the rough estimation made by ERT the value of Lithuanian CO_2 EF of gasoline is more close to Estonia's one when the IPCC default value.

Calorific values of different fuels are mainly received from Statistics Estonia excluding oil shale semi-coke and generator gas (calculated by expert) and wast fuels what are plant specific.

CH_4 and N_2O emission factors of different fuels are presented in Table 3.14 below.

Table 3.14. CH_4 and N_2O emission factors by fuel, kg/TJ

Fuels	**Energy Industry**		**Manufacturing Industry**		**Source**
	CH_4	**N_2O**	**CH_4**	**N_2O**	
Liquid fuels					
LPG (Liquefied Petrol Gas)	1	0.1	5	0.1	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Gasoline	3	0.6	2	0.6	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Jet Kerosene	3	0.6	2	0.6	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Aviation Gasoline	3	0.6	2	0.6	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Gasoil (light fuel oil)	3	0.6	2	0.6	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Gasoil (for non-road use)	3	0.6	2	0.6	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Shale Oil	3	0.6	2	0.6	CS, MoE 2006
Diesel Oil	3	0.6	2	0.6	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Residual Fuel Oil (heavy fuel oil)	3	0.6	2	0.6	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Recycled Waste Oil	30	0.6	4	0.6	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Solid fuels					
Coal	1	1.4	10	1.4	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Coke Oven Coke			10	1.4	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Oil Shale $_{PC}$*	0	0	10	1.4	CS, A.Ots/ D, IPCC 2006
Oil Shale $_{FBC}$**	0	0.82			CS, EE/ D, IPCC 2006
Milled Peat	30	4	30	4	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Sod Peat	30	4	30	4	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Peat Briquette	30	4	30	4	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Oil Shale Semi-coke	1	0.1			D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Oil Shale Generator Gas	1	0.1	5	0.1	D, IPCC 1996, Vol. 2, Table 1-7, 1-8 (of natural gas)
Other Fossil based Waste			30	4	D, IPCC 1996, Vol. 2,

Fuels	Energy Industry		Manufacturing Industry		Source
	CH_4	N_2O	CH_4	N_2O	
(MSW)					Table 1-7, 1-8
Plastic Waste			30	4	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Gaseous fuels					
Natural Gas	1	0.1	5	0.1	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Biomass fuels					
Solid Biomass (solid, includes e.g. firewood, bark, chips, sawdust and other industrial wood residues, pellets and briquettes)	30	4	30	4	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Black Liquors	30	4	30	4	D, IPCC 1996, Vol. 2, Table 1-7, 1-8
Biogas (landfill gas and biogas from wastewater treatment)	1	0.1			D, IPCC 1996, Vol. 2, Table 1-7, 1-8

*Source:*A.Ots (2006). Oil Shale; ** Expert estimation*

Emission Factors of Indirect Greenhouse Gases from Fuel Combustion

The NOx, CO and NMVOC emission factors used in the Estonian inventory are mainly taken from the Revised IPCC 1996 Guidelines, but some emission factors and new data from national research were used as well. (See Table 3.15, Table 3.16, Table 3.17).

Table 3.15. NOx from fuel combustion (kg/TJ)

	Coal	*Natural Gas*	*Oil*	*Wood*	*Oil Shale**	*Peat/ Briquette*
Energy Industries	300	150	200	100		300
- *pulverized combustion*					110	
- *fluidized bed combustion*					0.06	
Manufacturing and Construction	300	150	200	100	110	300

Table 3.16. CO from fuel combustion (kg/TJ)

	Coal	*Natural Gas*	*Oil*	*Wood*	*Oil Shale**	*Peat/ Briquette*
Energy Industries	20	20	15	1000	26	1000
Manufacturing and Construction	150	30	10	2000	87	4000

Table 3.17. NMVOC from fuel combustion (kg/TJ)

	Coal	*Natural Gas*	*Oil*	*Wood*	*Oil Shale**	*Peat/ Briquette*
Energy Industries	5	5	5	50		100
- *pulverized combustion*					60	

- *fluidized bed combustion*					50	
Manufacturing and Construction	20	5	5	50	50	100

*Source: IPCC 1996 Default values; * Country specific- (Procedure…, 2004)*

Activity data

Activity data for GHG emission calculations are collected from several data sources. The main fuel consumption data by fuel types and final consumption sectors, including sub-sectors are received from the Energy Department of Statistics Estonia. This data are also presented in the database of SE and added to the *Estonian National Inventory Report 1990–2010 (Annex 4)*. Some detailed data (i.e. technology specific – pulverised and fludised bed combustion of oil shale consumption in Narva power plants; shale oil and semi-coke gas production by the Narva Oil Plant) are obtained from the energy company Eesti Energia AS. Data on oil shale, shale oil and semi-coke and generator gas consumption in Kiviõli and VKG Oil Plants are obtaned directrly from the oil plants.

Fuel consumption in Energy Industries (CRF 1.A 1) and Manufacturing Industries and Construction (CRF 1.A 2) in 1990–2010 are presented in the Table 3.18 and on Figure 3.16 and Figure 3.17.

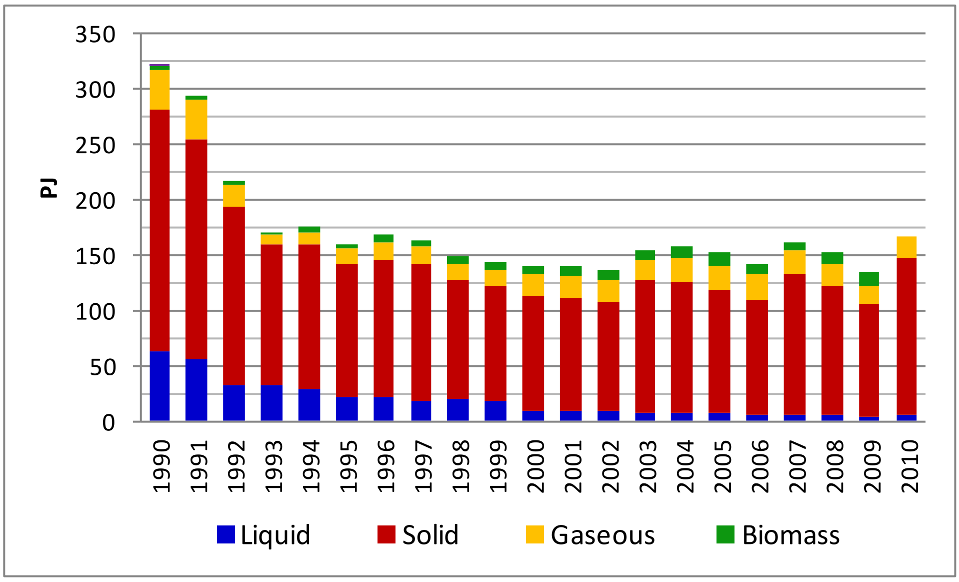

Figure 3.16. Trend of fuel consumption in Energy Industries, PJ

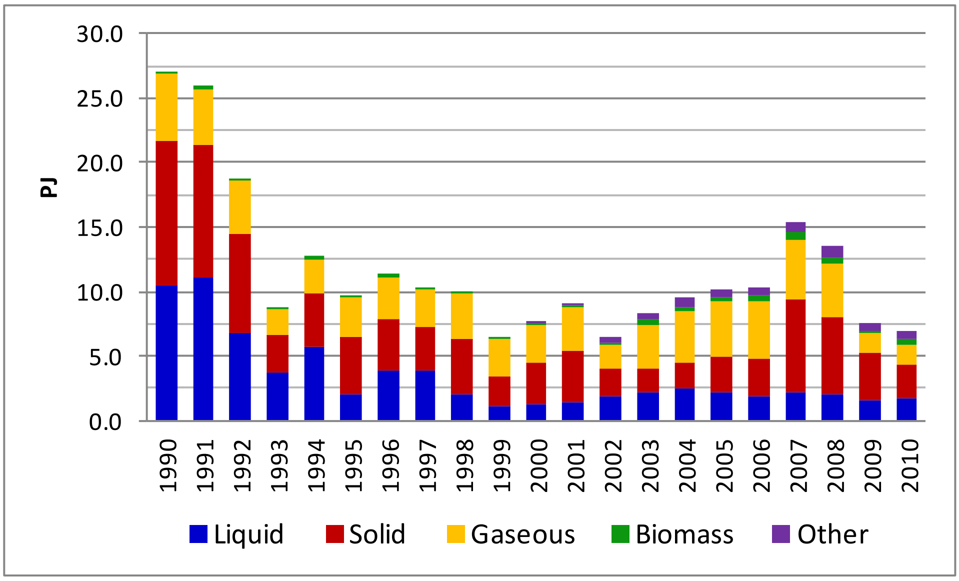

Figure 3.17. Trend of fuel consumption in Manufacturing Industries and Construction, PJ

Table 3.18. Fuel consumption in Energy Industries (CRF 1.A 1) and Manufacturing Industries and Construction (CRF 1.A 2) in 1990–2010 (PJ)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1.A.1 Energy Industries																					
Liquid Fuels	63.13	56.62	32.27	33.24	28.09	21.25	21.22	18.64	19.14	17.84	9.71	9.82	8.64	8.12	7.41	7.17	5.65	5.42	4.71	4.56	5.00
Solid Fuels	218.89	197.36	162.19	126.41	132.06	119.97	123.80	122.36	108.32	103.67	103.44	101.01	99.46	118.53	118.05	111.29	104.59	126.96	117.78	101.74	143.26
Gaseous Fuels	35.81	36.75	19.80	8.71	11.12	14.30	17.16	16.63	14.56	14.73	18.87	20.14	19.72	19.47	21.65	21.91	21.99	21.24	19.77	16.35	18.27
Biomass	2.44	2.58	2.48	2.26	3.99	4.98	6.26	6.15	6.57	7.13	7.17	8.51	8.90	8.94	9.90	11.44	9.08	8.15	9.81	11.76	16.34
1.A.2 Manufacturing Industries and Construction																					
Liquid Fuels	10.46	11.07	6.81	3.64	5.73	2.00	3.91	3.76	2.00	1.13	1.31	1.43	1.84	2.22	2.45	2.23	1.80	2.21	1.98	1.60	1.72
Solid Fuels	11.27	10.33	6.92	2.92	4.15	4.44	4.01	3.37	4.36	2.29	3.18	3.99	2.23	1.77	2.00	2.75	2.91	7.19	6.04	3.59	2.56
Gaseous Fuels	5.10	4.31	4.09	2.08	2.55	3.06	3.22	3.05	3.48	2.97	2.93	3.42	1.82	3.40	4.03	4.21	4.47	4.53	4.13	1.61	1.55
Biomass	0.25	0.27	0.24	0.05	0.26	0.15	0.30	0.14	0.14	0.13	0.14	0.15	0.16	0.48	0.31	0.33	0.45	0.70	0.49	0.20	0.50
Other Fuels (Waste fuels)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.008	0.135	0.348	0.394	0.778	0.610	0.601	0.766	0.947	0.523	0.564

3.2.5.3. Uncertainties and time series consistency

Uncertainty evaluation of CO_2 emission has been conducted for four fuel types used in Estonia in 2010: liquid, solid, gaseous fuels and other fuels. The availability of data allows the estimation of uncertainty by a fuel type rather than by a sector in fuel combustion in Estonia (Metrosert AS, 2007).

Incomplete details of source-specific measurement data of activities and emission factors lead to the approach to estimate quantitative uncertainty of CO_2 emission in Estonia in 2010 by using available estimates and the combination of available measured data;

Data has been obtained from database of SE.[2]

In estimation of uncertainty two main components have been considered:

- Uncertainty component due to measurement procedure which provides the comparability of results.
- Uncertainty component due to spread (dispersion) of the input quantity which, in some cases, indicates the level of disaggregating of the data.
  The calculation formula of combined uncertainty in emission u_E is

$$u_E = \sqrt{u_{AD}^{\ 2} + u_{EF}^{\ 2}}\ .$$

Where u_{AD} is the uncertainty estimation of activity data and u_{EF} is the uncertainty estimation of emission factor. In obtaining expanded uncertainty the coverage factor k=2 has been used to provide approximately 95% confidence level of the results

$$U_E = 2 \cdot u_E.$$

The uncertainty in CO_2 emission due to fuel combustion in category Energy was evaluated separately by fuel types. The key points of the evaluation are listed below

- Liquid Fuels

All liquid fuels, except shale oil and residual fuel are imported to Estonia. Quality requirements for liquid fuels and instrumentation were used in evaluation of uncertainty of activity data and emission factors.

- Solid Fuels

There are two fuel types produced locally: oil shale and peat. The largest contribution to the uncertainty is caused by fluctuation in emission factors of those fuels.

- Gaseous Fuels

The gaseous fuels are imported to Estonia. Quality requirements for gaseous fuels and instrumentation were used in evaluation of uncertainty of activity data and emission factors.

- Other Fuels

[2] Statistics Estonia / Endla 15, 15174 Tallinn / Statistical information: Tel: + 372 625 9300, e-mail stat@stat.ee/ Contact Centre of respondents: Tel: +372 625 9100, e-mail klienditugi@stat.ee.

For calculation of uncertainty in CO_2 emission due to other fuel (waste fuel) combustion in category Energy, Finnish uncertainty factors were used. The contribution to total uncertainty of fuel combustion from this type is rather small.

The uncertainties factors of carbon emission factors and activity data due to fuel combustion are presented in the Table 3.19. The largest uncertainty contribution of 60% was caused by incomplete data of emission factor of other fuels (waste fuels).

Table 3.19. Estimated relative uncertainties of CO_2 emission due to fuel combustion in Estonia in 2010

GHG Source and Sink Categories	Gas	Uncertainty of activity data, %	Uncertainty of emission factor, %	Combined relative uncertainty, %
1.A. Fuel Combustion				
Liquid Fuels	CO_2	1.7	1.8	2.5
Solid Fuels	CO_2	3.3	38.9	39.0
Gaseous Fuels	CO_2	1.4	3.6	3.9
Other Fuels*	CO_2	5	60	60.21

*Source: IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

In estimation of uncertainties in greenhouse gases CH_4 and N_2O the IPCC[3] default values for activity data (5% and 10%) and for CH_4 emission factors (25–150%) were used. In estimation of N_2O emission factor uncertainties (50–125%) IPCC default and some Finnish values were used (see Table 3.20).

Table 3.20. Summary of uncertainty estimates non-CO_2 (CH_4 and N_2O) emission factors and activity data (95% confidence interval)

Source and Sink	GHG	Activity data uncertainty U_A	Emission factor uncertainty U_E	Reference U_A. U_E
1.A.1 Energy Industries				
Liquid, solid and gaseous fuels	CH_4	5%	50%	**U_A** – IPCC Good, Table 2.6, p. 2.41 **U_E** – IPCC Good, Table 2.5, p. 2.41
	N_2O	5%	60%	**U_A –** IPCC Good, Table 2.6, p. 2.41 **U_E –**Finnish
Biomass	CH_4	5%	60%	**U_A –** IPCC Good, Table 2.6, p. 2.41 **U_E –** Finnish
	N_2O	5%	60%	**U_A –** IPCC Good, Table 2.6, p. 2.41 **U_E –** Finnish
1.A.2. Manufacturing Industries and Constructions				
Liquid, solid and gaseous fuels	CH_4	5%	50%	**U_A** – IPCC Good, Table 2.6, p. 2.41 **U_E** – IPCC Good, Table 2.5, p. 2.41
	N_2O	5%	60%	**U_A** – IPCC Good, Table 2.6, p. 2.41 **U_E** – Finnish

[3] Intergovernmental Panel on Climate Change Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

Biomass	CH_4	5%	60%	**U_A** – IPCC Good, Table 2.6, p. 2.41 **U_E** – Finnish*
	N_2O	5%	60%	**U_A –** IPCC Good, Table 2.6, p. 2.41 **U_E –** Finnish*
Other Fuels	CH_4	5%	60%	**U_A –** IPCC Good, Table 2.6, p. 2.41 **U_E –** Finnish*
	N_2O	5%	60%	**U_A –** IPCC Good, Table 2.6, p. 2.41 **U_E –** Finnish*
1.A.3. Transport				
Liquid and solid fuels	CH_4	5%	40%	IPCC Good .... p. 2.49
	N_2O	5%	50%	IPCC Good .... p. 2.49
Biomass	CH_4	5%	100%	**U_A** – IPCC Good, Table 2.6, p. 2.41 **U_E** – Finnish*
	N_2O	5%	150%	**U_A** – IPCC Good, Table 2.6, p. 2.41 **U_E** – Finnish*
1.A.4. Other Sectors				
Liquid, solid and gaseous fuels	CH_4	5%	50%	**U_A** – IPCC Good, Table 2.6, p. 2.41 **U_E** – IPCC Good, Table 2.5, p. 2.41
Solid and gaseous fuels	N_2O	5%	50%	**U_A** – IPCC Good, Table 2.6, p. 2.41 **U_E** – Finnish*
Liquid fuels	N_2O	5%	75%	**U_A** – IPCC Good, Table 2.6, p. 2.41 **U_E** – Finnish*
Biomass	CH_4	10%	150%	**U_A** – IPCC Good, Table 2.6, p. 2.41 **U_E** – Finnish*
	N_2O	10%	150%	**U_A** – IPCC Good, Table 2.6, p. 2.41 **U_E** – Finnish*
1.B. FUGITIVE EMISSIONS from FUELS				
1.B.2.b Natural Gas	CH_4	10%	25%	IPCC Good .... p. 2.92

*Source: NIR Finland 1990–2011, www.unfccc.int

In the current inventory submission all uncertainty factors and references have been over checked and some U_E and U_A values revised. In the previous inventory submission some of the uncertainty factor values and references were incorrect. As the Good Practice Guidance does not give CH_4 emission factors uncertainty estimations (U_E) for biomass, and also for N_2O emission factors (U_E) for biomass and fossil fuels, those factors have been taken from the Finnish 2011 national inventory.

Detailed uncertainty estimations by source-categories are presented in Annex 7, Table 6.1.

3.2.5.4. Source-specific QA/QC and verification

There are several QC procedures, which are used. The most resource demanding is the checking the fuel consumption data received from SE.

Fuel consumption data in natural units (in tons or thousand cubic meters, etc) and year average calorific value data of fuels are received from SE by special request of the Ministry of Environment. Fuel consumption data in energy units (in TJ-s) are available in the statistical database on the website of SE (www.stat.ee). Before entering the fuel consumption data into emission calculation tables we check first the current year data by multiplying fuel amounts in natural units with NCV and compare the result with fuel consumption data in TJ-s presented in the statistical database. Sometimes there are some small differences due the rounding. The second step is checking all previous year activity data because statistical office sometimes corrects also the old data. The third step is the checking of national energy balance data with IEA data. There are some differences between National and IEA energy data but they are not very big. IEA use constant NCV-s of fuels but National energy data in TJ-s are calculated using year specific NCV. Some differences are also in reporting of heat produced. In IEA statistic only fuels used for sold heat produced by DH power plants and autoproducers are reported in Energy conversion sector, but fuels used for heat production by autoproducers and used by themselves (own consumption) is reported under the final consumption. In the national energy balance only fuels used for heating technological processes is reported under the final consumption of fuels of the sector.

After the fuel consumption data emission factors of fuels will be checked. If there is some new research on estimation of country specific emission factors available all necessarily corrections will be made for whole time series. In 2012 inventory submission carbon emission factors of oil shale semi-coke, semi-coke gas and oil shale generator gas have been revised.

In 2012 inventory submission Energy Sector CO_2 emission factors were compared also with EF-s used by Emission Trading System (ETS) enterprises.

There is a more comprehensive list about Tier 1 and 2-level QC activities in the Energy sector in the internal documentation (in Estonian).

3.2.5.5. Source-specific recalculations

The following recalculations have been made in CRF 1.A.1 and 1.A.2 within the 2012 inventory submission:

1. In the CRF source category 1.A.1.a Electricity and Heat Production/Solid Fuels and Biomass the following activity data have been revised: These AD have been corrected in national energy balance by Statistics Estonia:

	Year	2011 submission	2012 submission
Oil shale $_{PC}$, TJ	2006	64 259	62 164.82
Wood, TJ	2003	8 823	8 936
Wood, TJ	2009	10 430	10 444

2. In the CRF source categories 1.A.1.a Electricity and Heat Production/Solid Fuels carbon emission factors of generator gas were revised. There was a mistake in CEF calculations (carbon mole ratio of ethane (C_2H_4) was wrong).

	CEF, tC/TJ	
	2011 submission	2012 submission
Generator gas (VKG oil factory)	47.81	53.43
Generator gas (Kiviõli oil factory)	42.16	50.03

3. In the CRF source categories 1.A.1.a and 1.A.2/Gaseous Fuels carbon emission factor of natural gas has been revised. In the previous submission Finnish country specific CEF of natural gas was used. In the current submission Russian CS CEF of natural gas was implemented because Estonia uses Russian natural gas and the NCV of the natural gas is the same (ERT 2011 recommendation).

	CEF, tC/TJ	
	2011 submission	2012 submission
Natural gas	15.01	15.07

4. In the CRF source categories 1.A.1.a and 1.A.2/Liquid Fuels carbon emission factor of gasoline has been revised. CEF value 19.90 tC/TJ has been used instead 19.91 tC/TJ because Lithuania revised in the 2011 inventory submission the value of their CEF of gasoline.
5. In the CRF source category 1.A.1.a Electricity and Heat Production/Solid Fuels oxidation factor of peat was revised. In the 2011 submission the oxidation factor value 0.97 has been used, but according to the Revised 1996 IPCC Guideline (Vol. 2, Energy, p.1.8, table 1-4) oxidation factor of peat in Energy Industries is 0.99.
6. In the CRF source category 1.A.2.c Chemicals/Solid fuels CH_4 EF of generator gas was revised. In the 2012 submission CH_4 EF value 5 kg/TJ was used instead 1 kg/TJ in 2011.
7. In the CRF source category 1.A.2.c Chemicals/Liquid fuels total sum on 1997 was invalid.

	1997	
	2011 submission	2012 submission
Liquid Fuels, TJ	1 602	1 568

8. In the CRF source category 1.A.2.f Other/Biomass activity data on solid biomass waste (MSW biomass fraction) was revised of the years 2005-2009 (by Estonian Environment Centre waste department).
9. In the CRF source category 1.A.2.f Other/Other Fuels CH_4 and N_2O emission factors of waste fuels were revised of the years 2004-2009 (ERT 2011 recommendation).
10. In the CRF source category 1.A.2.f Other activity data on oil shale consumption in 1992 were revised.

	1992	
	2011 submission	2012 submission
Oil shale, TJ	5 178	4 455

11. Minor changes were made caused by rounding mistakes in previous submission.

3.2.5.6. Source-specific planned improvements

For the next inventory submission Estonia plannes to evaluate and implement country specific CO_2 emission factors for gasoline.

3.2.6. Transport (CRF 1.A.3)

Transport activity affects practically all the remaining branches of economy and service sector and is strongly influenced by these sectors itself. Transport sector of Estonia is influenced not only by domestic factor but also by circumstances from outside. In 2010 a lot of enterprises involved in international transport market face the increasing competition on the market.

3.2.6.1. Source category description

In 2010, the greenhouse gas emissions from transport sector amounted to 2.26 Tg CO_2 equivalent. The share of the transport sector of the energy sector was 12.43% and of the total greenhouse gas emissions approximately 11.0% in 2010. In 1990 the share was 6.9%.

Emissions from Transport (CRF 1.A 3) include all domestic transport sectors (Table 3.21):

- Civil Aviation (CRF 1.A.3.a)
- Road Transport (CRF 1.A.3.b)
- Railways (CRF 1.A.3.c)
- Domestic navigation (CRF 1.A.3.d)

Table 3.21. Reporting categories in the transport sector

CRF source category	Description	Remarks
CRF 1.A.3		
1.A.3.a Civil Aviation	Jet and turboprop powered aircraft (turbine engine fleet) and piston engine aircraft	Emissions from helicopters are not calculated separately.
1.A.3.b Road Transport	Transportation on roads by vehicles with combustion engines: passengers cars, vans, buses, lorries, motorcycles and mopeds	Farm and forest tractors are included in CRF 1.A.4.c Agriculture/Forestry/Fishery. Fuel consumption and emissions from military vehicles are included in category 1.A.5 Other. Fuel consumption and emissions from military cares are included in category 1.A.3.b Road.
1.A.3.c Railways	Railway transport operated by steam and diesel locomotives	Coal was used for locomotives in 1990-2002 and in 2006.
1.A.3.d Navigation	Merchant ships, passenger ships, technical ships, pleasure and tour ships and other inland vessels.	Fishing boat emissions are included in the CRF 1.a.4.c

The trend of the emissions of these categories is given in Figure 3.19. In the Figure 3.18 emissions of the transport sector are given by gases.

CO_2 emission trend decreased strongly after 1991. The reason of the decrease was the rapid increase of fuel prices after regaining independency in Estonia in 1991 and also difficulties in fuel supply. Estonia imported in the beginning of 90s all transport fuels from Russia. The bottom was reached in year 1992 and after that increase has been fairly constant reaching the 1990 emission level in 2007. The increase has happened mainly in the road transport. In 2010 emissions from transportation sector increased about 4.7% comparing with previous year. The reason for this increase was the perking up of the economic environment after economic depression in 2008 and 2009 (see Figure 3.19).

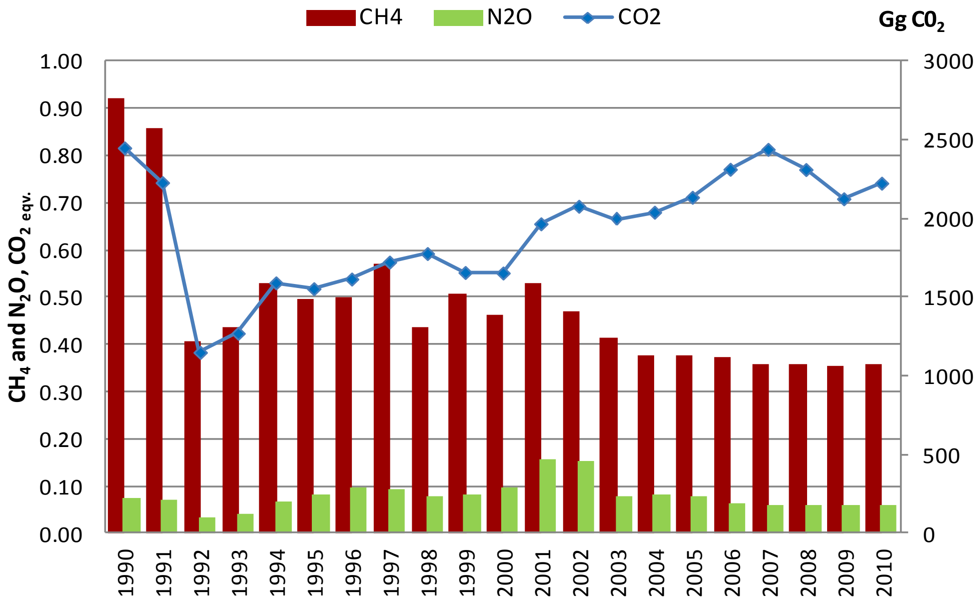

Figure 3.18. Emissions from transport sector by gas in 1990–2010, Gg CO_2 equivalent

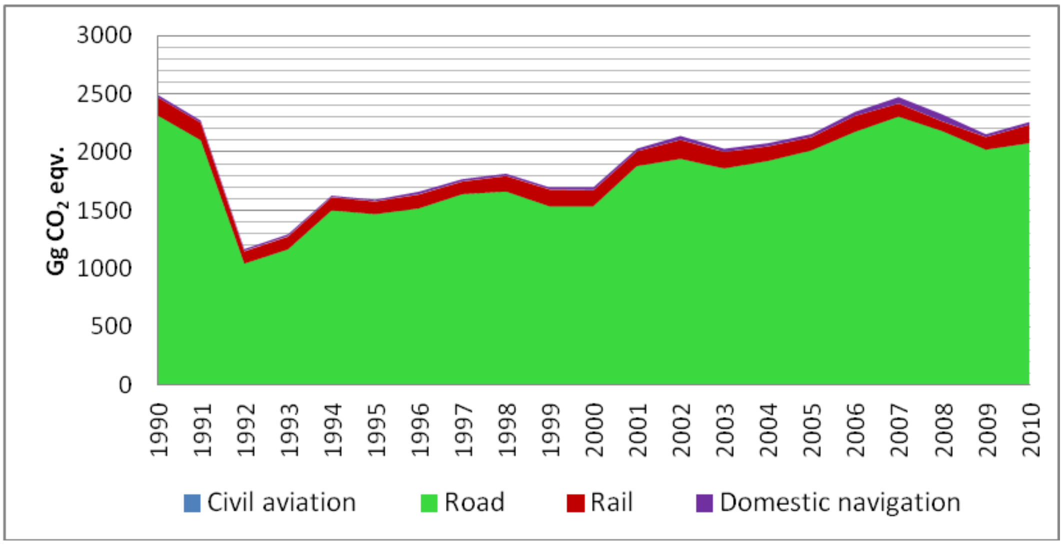

Figure 3.19. Emissions from transport by subcategory in 1990–2010, Gg CO_2 equivalent

Road transportation is the most important emission source in transport sector covering over 90% of sector's emissions (see Figure 3.19).

Table 3.22. Emissions from the transport sector in 1990–2010 by subcategories, Tg CO_2 equivalent

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3. Transport	**2.49**	**2.27**	**1.17**	**1.29**	**1.62**	**1.59**	**1.66**	**1.76**	**1.81**	**1.69**	**1.69**	**2.03**	**2.14**	**2.03**	**2.07**	**2.17**	**2.34**	**2.47**	**2.34**	**2.15**	**2.26**
CO_2	**2.45**	**2.23**	**1.15**	**1.27**	**1.59**	**1.55**	**1.62**	**1.72**	**1.78**	**1.66**	**1.65**	**1.97**	**2.08**	**1.99**	**2.04**	**2.14**	**2.31**	**2.44**	**2.32**	**2.13**	**2.23**
a. Civil Aviation	0.006	0.006	0.002	0.004	0.003	0.004	0.003	0.004	0.003	0.003	0.003	0.002	0.003	0.002	0.003	0.002	0.001	0.001	0.002	0.002	0.002
b. Road transport	2.267	2.055	1.028	1.143	1.465	1.430	1.473	1.594	1.625	1.495	1.493	1.817	1.881	1.824	1.887	1.979	2.144	2.273	2.172	1.996	2.053
c. Railways	0.155	0.149	0.104	0.109	0.111	0.108	0.118	0.107	0.132	0.144	0.136	0.125	0.162	0.140	0.124	0.130	0.136	0.112	0.082	0.107	0.156
d. Domestic Navigation	0.022	0.019	0.016	0.016	0.012	0.012	0.022	0.019	0.018	0.017	0.023	0.022	0.033	0.026	0.026	0.025	0.034	0.054	0.060	0.024	0.023
CH_4 , CO_2 eq	**0.019**	**0.018**	**0.009**	**0.009**	**0.011**	**0.010**	**0.010**	**0.012**	**0.009**	**0.011**	**0.010**	**0.011**	**0.010**	**0.009**	**0.008**	**0.008**	**0.008**	**0.008**	**0.007**	**0.007**	**0.008**
N_2O, CO_2 eq	**0.023**	**0.021**	**0.010**	**0.013**	**0.021**	**0.025**	**0.030**	**0.029**	**0.024**	**0.026**	**0.030**	**0.048**	**0.048**	**0.024**	**0.025**	**0.025**	**0.019**	**0.019**	**0.019**	**0.019**	**0.019**

Table 3.23. Fuel consumption in transportation sector in 1990–2010, TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
a. Civil Aviation																					
Aviation Gasoline	78	81	26	53	35	46	43	48	35	37	34	33	34	32	45	24	17	18	31	24	24
b. Road transport																					
Gasoline	21 406	19 259	9 020	9 632	12 339	10 557	11 558	12 847	12 353	11 816	11 872	14 148	12 981	12 438	11 995	12 249	13 323	13 977	13 845	12 661	11 745
Diesel Oil	9 500	8 787	4 966	5 976	7 563	8 989	8 570	8 940	9 862	8 615	8 540	10 697	12 726	12 488	13 797	14 795	15 974	17 091	15 843	14 612	16 302
LPG	139	92	90	27	166	17	14	19	11	10	10	9	18	11	8	8	4	2	5	4	5

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Bioethanole	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	1	58	4	185
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	6	47	21	120	70	137
c. Railways																					
Diesel Oil	1 951	1 843	1 360	1 413	1 445	1 425	1 537	1 413	1 781	1 956	1 842	1 701	2 202	1913	1 689	1 774	1 853	1 528	1 121	1 463	2 125
Coal	119	143	49	53	55	39	59	37	14	3	6	8	1	NO	NO	NO	0.4	NO	NO	NO	NO
d. Navigation																					
Diesel Oil	298	256	213	215	170	168	298	257	252	227	316	298	450	354	355	341	465	740	816	322	319

3.2.6.2. Civil Aviation

Despite the fact that the volcanic eruption in Iceland disturbed the aviation of Europe last year, in 2010 more passengers visited the airports of Estonia than in 2009. While due to the economic crisis the number of air passengers in the European Union fell 6% in 2009 compared to the previous year, the decrease in Estonia was more than 25%. Latvia was the only country where the number of air passengers did not decrease but increased 10%. In 2010 the airports of Estonia were visited by over 1.4 million passengers, which is 4% more than a year earlier. Nearly 55 200 passengers were transported on domestic flights which is a tenth more than in 2009. Also, new airlines were launched and there were slightly more scheduled flights per week than a year ago. Cargo and mail services through airports declined over the previous year.

The emissions from civil aviation (CRF 1.A.3.a) include all domestic civil aviation transport within Estonian flight information regions, mostly islands (see Figure 3.20). Helicopters are not included in the calculations due to the small number of flights and the lack of emission factors. However, the fuel consumption of helicopters is included as part of the sector 3.A.3.a (Table 3.22).

The share of the civil aviation from the transport sector was only 0.08% and the amount of emissions was 1.83 Gg of CO_2 equivalents in 2010. The corresponding figure was 5.76 Gg (CO_2 equivalent) in 1990. See the Figure 3.20 and Table 3.22.

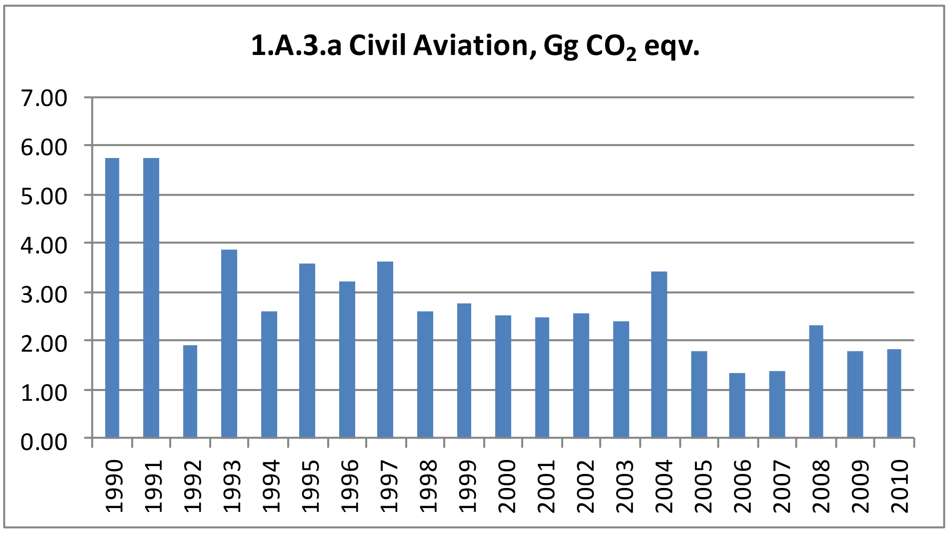

Figure 3.20. GHG emissions from civil aviation in 1990–2010, Gg CO_2 equivalent

Methods

For estimation of emissions from Civil Aviation the *Tier 2* approach was used. Operations of aircraft were divided into LTO and Cruise phases. The Tier 2 approach breaks the calculation of emissions from aviation into the following steps:

1. *Total Emissions = LTO Emissions + Cruise Emissions*
2. *LTO Emissions = Number of LTOs * Emission Factor of LTOs*
3. *Cruise Emissions = (Total Fuel Consumption – LTO Fuel Consumption) * EF Cruise*

Activity data

The activity data on aviation gasoline used in national aviation are obtained from Statistics Estonia and presented in the Table 3.23. In the National Energy Balance sheet aviation fuels are not presented separately for national and international fights, but this data still exist in the database of SE. Ministry of Environment asks every year the detailed data on aviation fuel use for GHG inventory submission. Data are collected from different fuel supply companies by special statistical questionnaire “Transport Fuels” were fuel use should be reported separately for national and international use.

To separate the fuel consumption further into landing and take-off (LTO) phase and the cruise phase we use following principle:

For the LTO phase, fuel consumed is based on representative aircraft type group data. The energy use by aircraft is calculated for both domestic and international LTOs by multiplying the LTO fuel consumption factor for each representative aircraft type by the corresponding number of LTOs (eq 1).

The cruise energy use is estimated as the difference between the total fuel use from aviation fuel sale statistics and the total calculated LTO fuel use (eq 2).

1. $LTO_{Fuel\ Consumption} = Number\ of\ LTOs_{by\ aicraft\ type} * Fuel\ Consumption\ per\ LTO_{by\ aicraft\ type}$, *(eq.1)*
2. $Cruise_{Fuel\ Consumption} = Total_{Fuel\ Consumption} - LTO_{Fuel\ Consumption\ Cruise}$, *(eq. 2)*

Number of LTO’s.

Detailed aircraft type data with take-off and landing activity is supplied by airports. Estonian aircraft movement statistics count landing and take-off as two different activities. However methodology defines both one landing and one take-off as a full LTO cycle. Therefore statistical aircraft movement data is divided by two.

The methodology needs information of the number of LTO’s grouped by representative aircraft types. This kind of detailed knowledge is hard to obtain (individual aircraft with their specific engines) and therefore data is aggregated level for practical reasons. Assumptions are made if there is missing data in some situations.

In spite of the different levels of aviation statistics it is possible to divide the air traffic activity into the number of LTOs per aircraft type by using different statistical sources. Estonian emission calculations are based on the EMEP/EEA methodology and other referred sources in guidebook (IPCC, FOCA, ICAO engine database etc.).

A complete calculation has been carried out by EEIC for the years 1992–2010. There has been done extrapolation for 1990 and 1991 (see Table 3.24).

Table 3.24. Number of LTO-cycles

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Domestic LTO	2 249	2 398	2 366	3 754	4 819	4 516	4 922	4 672	4 778	4 255	8 720
International LTO	5 247	5 595	5 520	8 760	11 243	10 537	11 484	10 901	12 303	10 408	15 894

	2003	2004	2005	2006	2007	2008	2009	2010
Domestic LTO	8 025	6 243	7 740	7 219	7 958	8 212	7 598	7 637
International LTO	14 040	15 868	17 907	15 460	17 078	20 501	14 122	14 855

Emission factors and other parameters

1) Cruise emission factors of the CO_2, CH_4, N_2O, NOx, CO, NMVOC and SO_2 used in the calculation of emissions from national aviation are taken from the EMEP/EEA air pollutant emission inventory guidebook 2009 (chapter: 1.A.3.a Aviation, table 3–3, p.18).

2) LTO emission factors of the CO_2, CH_4, N_2O, NOx, CO, NMVOC and SO_2 used in the calculation of emissions from national aviation are taken from the EMEP/EEA air pollutant emission inventory guidebook 2009 (chapter: 1.A.3.a Aviation, table 3–3, p.18) and other referred sources in guidebook (IPCC, FOCA, ICAO engine database etc). The share of different aircraft types varies every year and due to that the average emission factor changes from year to year. In the Table 3.25 is presented average emission factors for 2010 emission calculations.

Table 3.25. Emission factors used in the calculation of emissions from national aviation (1.A.3.a)

	CO_2	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**	**SO_2**
	kg/t	kg/t	kg/t	kg/t	kg/t	kg/t	kg/t
Cruise*	3 150.0	0.0	0.1	10.3	2.0	0.1	1.0
LTO**	3 218.2	0.5	0.1	6.0	103.3	5.1	0.9

**Table 3-3, p.18 (average fleet); **Average emission factors in 2010*

Emission factors in kg per ton of aviation gasoline (Table 3.25) are converted to kg/TJ using net average calorific value of aviation gasoline (43 MJ/kg) (see Table 3.26).

Table 3.26. Emission factors of national aviation (1.A.3.a)

	CO_2	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**	**SO_2**
	t/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
Cruise*	73.3	0	2.3	239.5	46.5	2.3	23.3
LTO**	74.8	11.6	2.3	139.5	2 402.3	118.6	20.9

3.2.6.3. Road transportation

Road transport (CRF 1.A.3.b) includes all transportation on the roads in Estonia. The types of vehicles with combustion engines are: passenger cars, vans, buses, lorries, motorcycles and mopeds. The source category does not cover farm and forest tractors driving occasionally on the roads because they are included in the source-category 1.A.3.c Agriculture.

Road transport is the most important emission source in the transport sector. The emissions of road transportations was 2.08 Tg (CO_2 equivalent) in 2010, it is about 91.96% of the transport sector emissions, 11.4% of the Energy sector and 10.04% of the total emissions. In 2010 the GHG emissions of the road transport sector were about 10% lower than in 1990 (2.31 Tg CO_2 eq.).

The trend of CO_2 emissions follows in general the fuel consumption trend in the road transportation sector. The lowest emission level in the road transportation was achieved in 1992/1993, it was caused by rapid increase of fuel prises after regaining independency in Estonian in 1991 and also with difficulties in fuel supply (Estonia imported in the beginning of 90s all transport fuels from Russia). The second decrease in the emission trend was in 1999/2000 and it was connected with economic crises in Russia (fuel supply problems). In 2007 the emissions from road transport were on the level of 1990, but since 2008 a small decrease of emissions (in 2008/2007 about 6% and in 2009/2008 about 7%) started which reflects the overall economic depression in Estonia. In 2010, GHG emissions from road transportation increased about 4% compared to 2009 (see Figure 3.21).

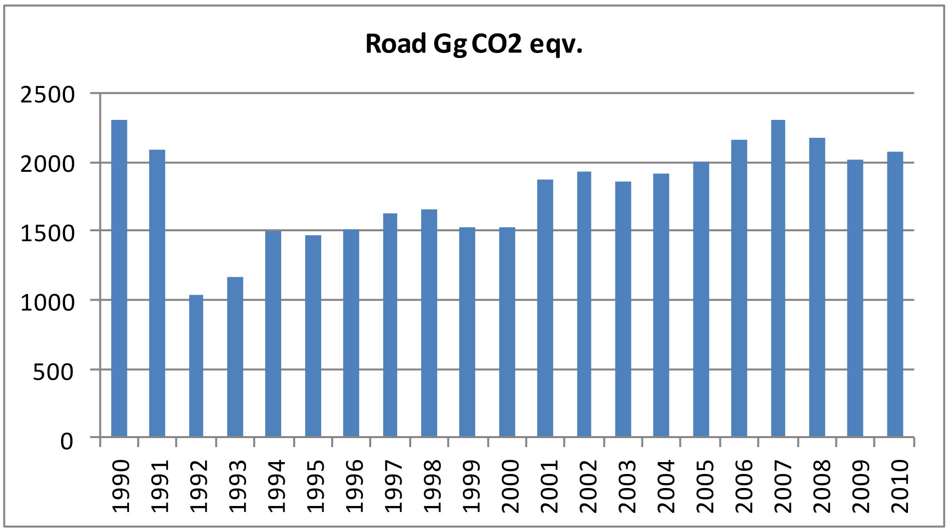

Figure 3.21. Emissions from the road transportation in 1990–2010, Gg CO_2 equivalent

Methods

Emission estimations from road transportation are made using the IPCC1996 Tier 1 method (for CO_2 emissions) and COPERT IV model for CH_4 and N_2O emissions which corresponds to the IPCC Tier 3 method. The same model was also used for the calculation of SO_2, CO, NOx and NMVOC emissions. CH_4 and N_2O emissions of the combustion of LPG are calculated using IPCC1996 Tier 1 method because the Copert model doas not include LPG fuel.

Calculation of CO_2 emissions from road transportation is based on fuel consumption of road vehicles and fixed emission factors.

In the current inventory report the emissions of CO_2 is calculated on basis of the amounts and type of fuel combusted and its carbon content. The *Tier 1* approach calculates CO_2 emissions by multiplying the estimated fuel sold with a default emission factor. This approach can be expressed as:

$$Emission = \sum_{a} [Fuel_a \bullet EF_a]$$

where:
Emission = emissions of CO_2 (Gg)
$Fuel_a$ = fuel sold (TJ)
EF_a = emission factor (kg/TJ). This is equal to the carbon content of the fuel multiplied by 44/12.
a = type of fuel (e.g. petrol, diesel, LPG etc).

The emission equation of Tier 3 of CH_4 and N_2O:

$$Emission = \sum_{a,b,c,d} [Distance_{a,b,c,d} \bullet EF_{a,b,c,d}] + \sum_{a,b,c,d} C_{a,b,c,d}$$

where:
Emission = emission or CH_4 or N_2O
$EF_{a.b.c.d}$ = emission factor (kg/km)
$Distance_{a.b.c.d}$ = distance traveled (VKT) during thermally stabilized engine operation phase for a given mobile source activity (km)
$C_{a.b.c.d}$ = emissions during warm-up phase (cold start)
a = fuel type (e.g. diesel, gasoline, LPG, etc)
b = vehicle type
c = emission control technology (such as uncontrolled, catalytic converter, etc.)
d = operating conditions (e.g. urban or rural road type, climate, or other environmental factors).

N_2O and CH_4 emissions are calculated for gasoline and diesel vehicles separately. The kilometrage (km/a) of each automobile type and model on different road types and in different speed classes are multiplied with corresponding CH_4 and N_2O emission factor. Calculations are made by using COPERT 4 model, which is based on EMEP/EEA air pollutant emission inventory guidebook – 2009 sector 1.A.3.b Road transport[4]. The calculation model COPERT IV is located in the Estonian Environment Information Centre.

Road vehicles are classified according to their level of emission control technology, which is actually defined in terms of the emission legislation with which they are compliant. So therefore the emission factor values are differentiated per vehicle

[4] http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-road-transport.pdf.

category and Euro standard. N_2O emission factors depend on vehicle category and also on fuel sulphur content[5].

Activity data

The activity data in CO_2 calculation is the amount fuel consumed in road traffic. Data on motor fuel consumption are received from the Statistics Estonia and are presented in the Table 3.23. The definition of consumption of fuel on the country level is based on fuel sales.

For obtaining more detailed activity data (distance travelled, emission control technology, vehicle type, operating conditions, etc.) for CH_4 and N_2O emission calculations the Estonian Environment Information Centre has concluded a contract to the Estonian Motor Vehicle Registration Centre.

In the Table 3.28 number of vehicles, in the Table 3.29 road traffic kilometrage and on the Figure 3.22 road traffic kilometrage per vehicle in 1990–2010 are presented.

There has been a small amount of biofuels used in Estonia in recent years, but the share has been very small: 0.01% in 2005, 0.12% in 2006, 0.06% in 2007, 0.6% in 2008, 0.26% in 2009 and 1.2% in 2010 taking into account the energy content. The data on biofuels production and inland consumption are received from the Ministry of Economic Affairs and Communication (Source: Report on the promotion of the use of biofuels and other renewable fuels in transport. Estonia, 2006–2010). The biofuels consumption figures in PJ are reported in Table 3.23 and in tons in Table 3.27.

Table 3.27. Consumption of pure bioethanol and biodiesel in Estonia, 2005–2010

	Bioethanol consumption, kt	**Biodiesel consumption, kt**
2005	NO	0.17
2006	NO	1.23
2007	0.02	0.56
2008	2.15	3.15
2009	0.15	1.82
2010	6.86	3.57

In the current inventory report the emissions from the use of bioethanol and biodiesel are reported separately from the fossil based diesel oil and gasoline emissions.

The use of LPG in road transport in Estonia is very small and it is not included into COPERT model. The emissions are calculated separately based on activity data obtained from annual energy statistics.

[5] *Additional information about hot emission factors may be obtained from following Guidebook pages: N_2O emission factors on pages 76-81 and CH_4 emission factors by legislative steps are available on pages 68-69 (Tier 3 method).*

Table 3.28. Number of vehicles in Estonia, thousand vehicles

	Cars	Vans	Lorries	Buses	MC and Mopeds	Vehicles total
1990	241	31	37	8	106	**422**
1991	261	35	42	9	100	**447**
1992	284	34	40	8	100	**467**
1993	317	34	40	9	97	**497**
1994	338	25	29	6	2	**400**
1995	383	30	35	7	3	**459**
1996	407	33	39	7	5	**489**
1997	428	35	41	6	5	**516**
1998	451	37	44	6	6	**544**
1999	459	36	45	6	7	**553**
2000	464	34	48	6	7	**559**
2001	407	37	44	6	9	**502**
2002	401	39	41	5	7	**493**
2003	434	41	42	5	8	**531**
2004	471	45	41	5	9	**571**
2005	494	47	39	5	10	**595**
2006	554	44	33	4	11	**577**
2007	524	46	33	4	15	**622**
2008	552	49	34	4	18	**657**
2009	546	48	33	4	19	**650**
2010	553	47	35	4	17	**656**

Source: Statistics Estonia:

Table 3.29. Road traffic kilometrage in Estonia (Million km/a)

	Cars	Vans	Lorries	Buses	MC+Mopeds	Vehicles total
1990	5 601	687	1 363	221	317	**8 190**
1991	5 612	668	1 020	176	230	**7 707**
1992	2 278	347	678	105	230	**3 638**
1993	2 620	378	679	152	223	**4 053**
1994	4 225	422	679	165	5	**5 495**
1995	3 880	447	631	211	8	**5 177**
1996	4 172	495	657	194	10	**5 528**
1997	4 396	555	725	199	13	**5 888**
1998	3 165	456	839	226	10	**4 696**
1999	4 012	512	709	193	15	**5 441**
2000	4 126	505	725	175	16	**5 547**
2001	5 271	729	844	167	16	**7 028**
2002	5 177	873	871	183	17	**7 120**

2003	5 219	825	764	178	19	**7 006**
2004	5 420	958	767	176	33	**7 354**
2005	5 802	959	724	175	11	**7 670**
2006	6 451	950	767	175	19	**8 362**
2007	6 990	978	777	185	28	**8 958**
2008	6 865	966	817	174	30	**8 852**
2009	6 547	727	675	142	27	**8 118**
2010	6 518	764	808	155	27	**8 272**

Source: Estonian Environment Information Centre

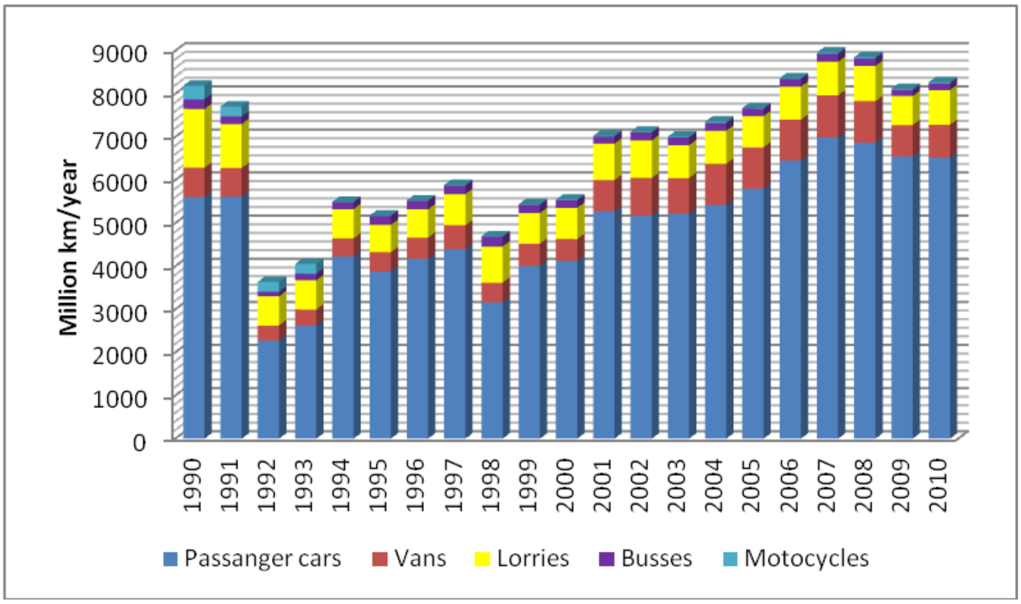

Figure 3.22. Road traffic kilometrage per vehicle in 1990–2010, Million km/a

Emission factors and other parameters

CO_2 emission factors of LPG and Diesel oil (IPCC1996 default values) and gasoline (country specific, CS) are presented in the Table 3.30. Estonia uses Lithuanian CS carbon emission factors because their are more close to Estonian circumstances.

Table 3.30. Emission factors, oxidation factors and net caloric values by fuel used in calculation of CO_2 emission from road transportation

Fuel type	**NCV average GJ/t**	**CEF (tC/TJ)**	**OF**	**CO_2 EF tCO2/TJ**	**Source**
LPG	44.52	17.2	0.99	63.1	D. IPCC1996, Vol. 2, Table 1-2
Gasoline	44.00	19.9	0.99	71.5	CS, Lithuania
Diesel Oil	42.30	20.2	0.99	74.1	CS, Lithuania = IPCC1996
				tCO_2/t	

Bioethanol	27.00			0.698	Copert IV, version 9.0
Biodiesel	38.25			0.97788	Copert IV, version 9.0

Source: LT (Lithuania) – Greenhouse Gas Emissions in Lithuania 1990-2009 (www.unfccc.int).

The same CH_4 and N_2O emissions factors are used for bioethanol and biodiesel as for fossil fuels (CH_4 EF: 3 kg/TJ and N_2O EF: 0.6 kg/TJ IPCC2006).

3.2.6.4. Railway

There were 318 diesel locomotives, 23 rolling stock units of electrical trains, 32 rolling stock units of diesel trains, 217 passenger wagons and 17 358 freight wagons registered in the Railway Traffic Register at the end of 20 (Statistical Yearbook 2011).

Railway transportation in Estonia is a small emission source in transport sector. The emissions of railway transportation were 156.44 Gg of CO_2 equivalents in 2010, it is about 6.92% of the transport sector emissions. In 1990 the corresponding figure was 155.16 Gg (CO_2 equivalent).

All non-electric locomotives in Estonia use diesel oil or coal in Estonia. Since 2002 there is no coal burning locomotives in operation.

Compared to other countries, the rail transport of passengers in Estonia is used seldom also the rail network density (in meters per km^2) is one of the smallest in Europe. 2% less passengers were carried by rail in domestic trips compared to 2009.

The rail transport is used mostly for transport of goods. The volume of goods transported decreased in 2010, 17% compared to 2009 (while volume of transit goods increased by 8%) (Statistical Yearbook 2009).

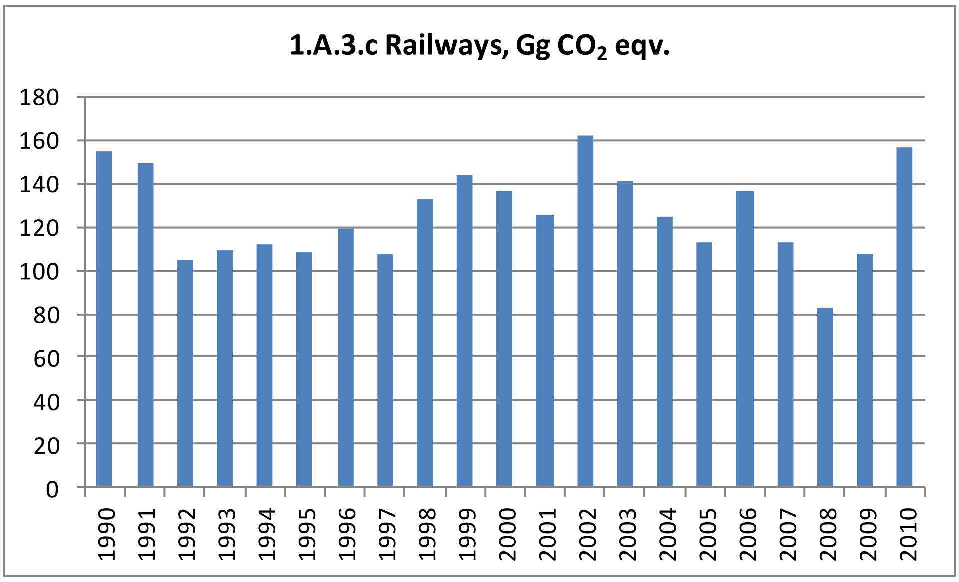

Figure 3.23. Emissions from the rail transportation in 1990–2010, Gg CO_2 equivalent

The trend of CO_2 emissions follows in general the fuel consumption trend in the rail transportation sector (Figure 3.23). The lowest emission level in the rail transportation was achieved in 2008, it was caused by rapid increase of amount of goods carried by Estonian transport enterprises. The decrease in the goods transported by rail that started in 2007 has kept falling and the freight turnover was at the same level as it was ten years ago. The volume of transit goods decreased by 29% (mainly coal and oil product transit). The rail passanger traffic was disturbed due to capital repair of railways in 2008. In 2009, GHG emissions from road transportation increased about 30% compared to 2008 and in 2010 by 46% compared to 2009 due to increase of the volume of transit goods. In 2009 the volume of transit goods inceased by 8% compared to 2008 and in 2010 by 11% compared to 2009 (see Figure 3.25).

Methods

Emissions of railway transportation are calculated by multiplying the estimated fuel (diesel oil. coal. etc) with a default IPCC 1996 emission factor (tier 1).

Activity data

The activity data on fuel consumption used in railway transportation are obtained from the Statistics Estonia and presented in the Table 3.23.

Emission factors and other parameters

Emission factors of the CO_2. CH_4, and N_2O used in the calculation of emissions from railway transportation are taken from the Revised IPCC1996 Guidelines, emission factors of NOx, CO and NMVOC for coal from EMEP/EEA Guidelines and SO_2 EF is country specific (an expert estimation). The values of EF are presented in the Table 3.31.

Table 3.31. Emission factors used in the calculation of emissions from railway transportation (1.A.3.c)

Fuel	NCV average. GJ/t	GHG	EF	Oxi-dation factor	Source
Diesel Oil	42.3	CO_2	20.2 tC/TJ	0.99	IPCC1996, Vol.2, Table 1-2
		CH_4	5 kg/TJ		IPCC1996, Vol.3, Table 1-7
		N_2O	0.6 kg/TJ		IPCC1996, Vol.3, Table 1-8
		NOx	1 500 kg/TJ		IPCC1996, Vol.3, Table 1-49
		CO	1 000 kg/TJ		IPCC1996, Vol.3, Table 1-49
		NMVOC	200 kg/TJ		IPCC1996, Vol.3, Table 1-49
		SO_2	141.2 kg/TJ		CS, EE
Coal	27.16	CO_2	26.8 tC/TJ	0.98	IPCC1996, Vol.2, Table 1-2
		CH_4	10 kg/TJ		IPCC1996, Vol.3, Table 1-7
		N_2O	1.4 kg/TJ		IPCC1996, Vol.3, Table 1-8

		NOx	173 kg/TJ		EMEP/EEA/small combustion, Table 3_7, p.5
		CO	931 kg/TJ		EMEP/EEA/small combustion, Table 3_7, p.5
		NMVOC	88.8 kg/TJ		EMEP/EEA/small combustion, Table 3_7, p.5
		SO_2	1 028 kg/TJ		CS, EE

**EE - expert estimation*

3.2.6.5. Domestic Navigation

In the Estonian Register of Ships 30 inland waterway vessels were registered at the end of 2010.

Domestic navigation in Estonia is also a small emission source in transport sector. The emissions of domestic navigation were 23.48 Gg of CO_2 equivalent in 2010, it is only 1.04% of the transport sector emissions. In 1990 the corresponding figure was 21.95 Gg in CO_2 equivalent.

Emissions from deep sea fishing are not included in the reporting for national navigation, because the deep sea fishing vessels buy their fuel abroad. Therefore, the emissions are reported as international bunkers for the neighbouring Parties.

The trend of GHG emissions from the Domestic Navigation is presented on the Figure 3.24.

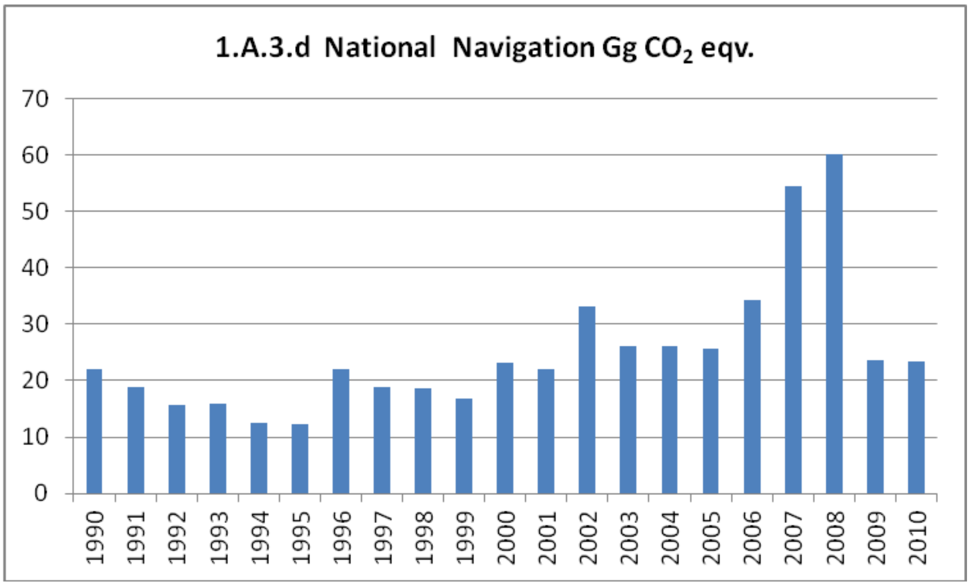

Figure 3.24. Emissions from the National Navigation in 1990–2010, Gg CO_2 equivalent

Methods

Emissions from domestic navigation are calculated by multiplying the estimated fuel (diesel oil) with a default IPCC1996 emission factor.

Activity data

The activity data on fuel consumption used in domestic navigation are obtained from the Statistics Estonia and presented in the Table 3.23.

Emission factors and other parameters

CO_2, CH_4 and N_2O emission factors for diesel oil and coal and NOx, CO and NMVOC EF for diesel oil used in the calculation of emissions are taken from the Revised IPCC 1996 Guidelines. NOx, CO and NMVOC EF for coal are taken from the EMEP/EEA Gudelines, SO_2 EFs are country specific. All emission factors are presented in the Table 3.32.

Table 3.32. Emission factors used in the calculation of emissions from domestic navigation (1.A.3.d)

Fuel	NCV average. GJ/t	GHG	EF	Oxi-dation factor	Source
Diesel Oil	42.3	CO_2	20.2 tC/TJ	0.99	IPCC1996, Vol.2, Table 1-2
		CH_4	5 kg/TJ		IPCC1996, Vol.3, Table 1-7
		N_2O	0.6 kg/TJ		IPCC1996, Vol.3, Table 1-8
		NOx	1 500 kg/TJ		IPCC1996, Vol. 3, Table 1-9
		CO	1 000 kg/TJ		IPCC1996Vol. 3, Table 1-10
		NMVOC	200 kg/TJ		IPCC1996Vol. 3, Table 1-11
		SO_2	141.2 kg/TJ		CS, EE

3.2.6.6. Source-specific recalculations

1. Activity data on aviation gasoline are updated. In 2011, the Statistics Estonia revised and specified the old data on fuel consumption for national aviation. AD of the CRF source category 1.A.3.a is in line with IEA data.

	2011 submission	2012 submission
	Fuel consumption, TJ	Fuel consumption, TJ
1993	39.35	53.35
1994	32.20	35.20
1995	36.60	45.60
1996	34.10	43.10
1997	35.00	48.00
2004	29.88	44.88
2005	23.68	23.68
2006	17.00	17.38
2007	17.93	17.93

2008	26.90	30.90

2. Activity data on gasoline, diesel oil and LPG in 1.A.3.b revised and updated for the following years:

	2011 submission	2012 submission
	Fuel consumption, TJ	Fuel consumption, TJ
LPG		
1992	27.00	90.00
1993	2.00	27.00
Gasoline		
1995	10 527.32	10 556.88
2007	13 977.76	13 977.22
2008	13 903.16	13 845.00
2009	12 664.98	12 660.97
Diesel oil		
1994	7 564.73	7 562.73
1995	8 999.83	8 989.10
1996	8 577.20	8 569.60
1997	8 950.90	8 940.20
1998	9 869.89	8 615.49
1999	8 625.68	8 615.49
2005	14 801.95	14 795.45
2006	16 020.89	15 973.87
2007	17 112.98	17 091.37
2008	15 963.11	15 842.70
2009	14 681.68	14 611.94

3. Activity data on diesel oil in 1.A.3.c revised and updated for the following years:

	2011 submission	2012 submission
	Fuel consumption, TJ	Fuel consumption, TJ
Diesel oil		
2005	1 785	1 774

4. CH_4 and N_2O emission from the use of gasoline and diesel oil in road transportation (1.A.3.b) have been changed due to implementation of the new version of the calculation model Copert IV.

5. CO_2 emissions from the use of gasoline and diesel oil in road transportation (1.A.3.b) have been changed due to change of methodology. In 2012 submission first time biofuels where calculated separately from fossil fuels. Amounts of biofuels are taken off from amounts of fossil gasoline and fossil diesel oil. Bioethanol was first time used in 2007 and biodiesel oil since 2005.

6. In the CRF source categories 1.A.3.b Road/Liquid Fuels carbon emission factor of gasoline has been revised. CEF value 19.90 tC/TJ has been used instead 19.91 tC/TJ because Lithuania revised in the 2011 inventory submission the value of their CEF of gasoline.

The ERT (2011) recommended Estonia not to use the Lithuanian CO_2 emission factor for gasoline as a CS one but elaborate the Estonian own EF for gasoline using the weighted average method of country specific emission factors from main importer countries. This is a large work and needs gasoline import data by countries which are not available in the electronic database of Statistics Estonia and have to be requested by special order from the statistical office. In the current submission Estonia still decided to use Lithuanian CO2 EF of gasoline because according to the rough estimation made by ERT the value of Lithuanian CO2 EF of gasoline is more close to Estonia's one.

3.2.6.7. Source-specific planned improvements

For the next inventory submission Estonia plannes to evaluate and implement country specific CO_2 emission factors for gasoline.

3.2.7. Other Sectors (CRF 1.A.4) and Other (CRF 1.A.5)

3.2.7.1. Source category description

Sub-category CRF 1.A.4 includes emissions from the small combustion of fuels in the following sectors:

- 1.A.4.a Commercial/Institutional
- 1.A.4.b Residential (Households)
- 1.A.4.c Agriculture/Forestry/Fisheries

These cove mainly fuels used in heating of buildings, but also emissions from heating of agricultural buildings, off-road machinery in agriculture and forestry as well fishing boats are included in this source category.

In 2010, emissions of the CRF sub-category CRF 1.A.4 Other Sectors were 646.05 Gg in CO_2 equivalent, it is over 3.55% of the energy sector's emissions and about 3.1% of total GHG emissions in Estonia. Corresponding emissions were 2009.24 Gg of CO_2 equivalent in 1990 (see Figure 3.25 and Table 3.33).

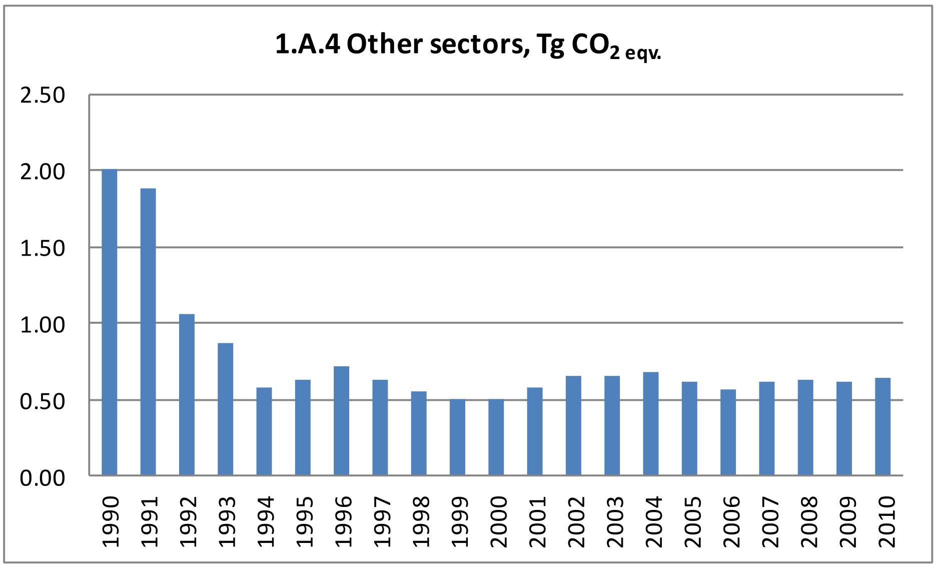

Figure 3.25. Trend of GHG **e**missions in the CRF category 1.A.4 Other Sectors, Tg CO_2 eq

The sub-category CRF 1.A.4.a contains GHG emissions from commercial and institutional subsectors including: wholesale and retail trade; repair of motor vehicles;

hotels and restaurants; financial intermediation; real estate, renting and business activities; public administration and defence; compulsory social security; education; health and social work; other community, social and personal service activities, etc.

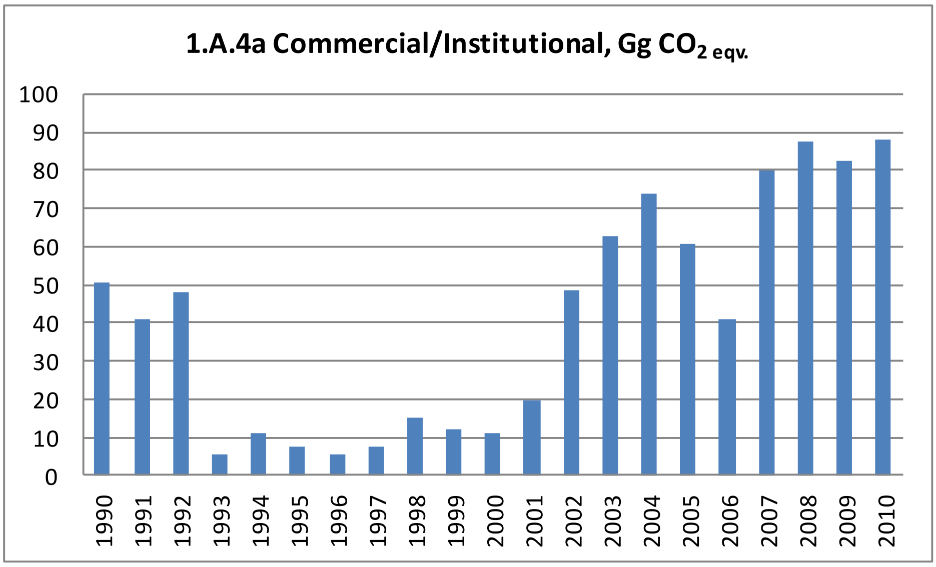

Figure 3.26. Trend of GHG emissions in the CRF category 1.A.4.a Commercial/Institutional, Gg CO_2 eq

The decreasing trend of GHG emissions in the beginning of 90s (since 1993 up to 2000) is logical and reflects the general economical development trend after regaining independence in 1991. The increase of emission trend in 2001 is connected with big growth of some sub-sectors like financial intermediation; real estate, hotels and restaurants, etc. The rapid decrease in 2006 was caused by structural changes of used fuels – use of wood fuels decreased about 72% when at the same time the use of gaseous fuels increased by 12% compared to 2006. Since 2007 the GHG emission trend is pretty stable (see Figure 3.26).

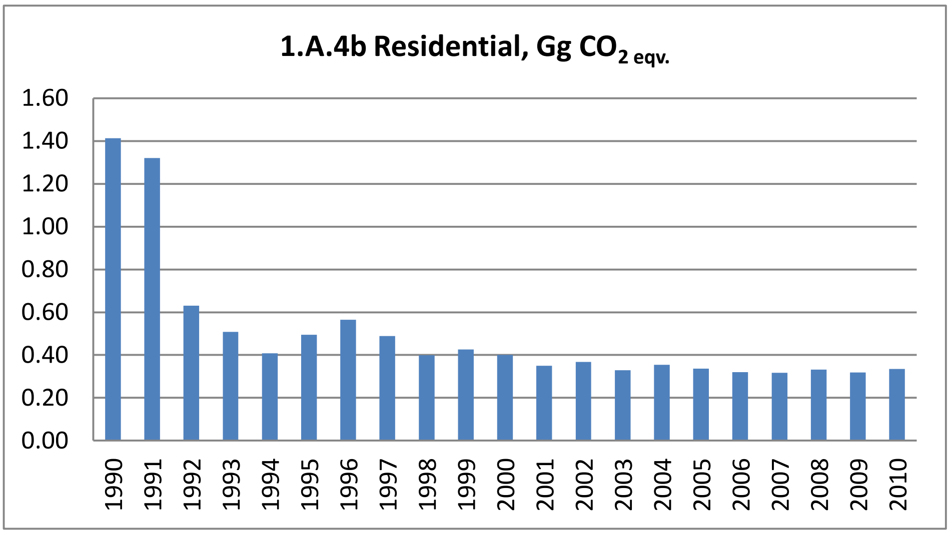

Figure 3.27. Trends of GHG emissions in the CRF categories 1.A.4.b Residential, Gg CO_2 eq

The source-category 1.A.4.b includes GHG emissions from fuel combustion in households. The overall trend of GHG emissions is decreasing and follows the fuel consumption trend of the sector. The decreasing trend is logical because of energy efficiency and saving measures, renovation of houses, building more new houses, etc. But the most important reason for the decrease of GHG emissions is a big change in the fuel consumption structure in the residential sector. Consumption of fuel oils decreased rapidly after 1991 but consumption of wood fuels increased in last years more than three times compared to 1990/1991 (see Figure 3.27).

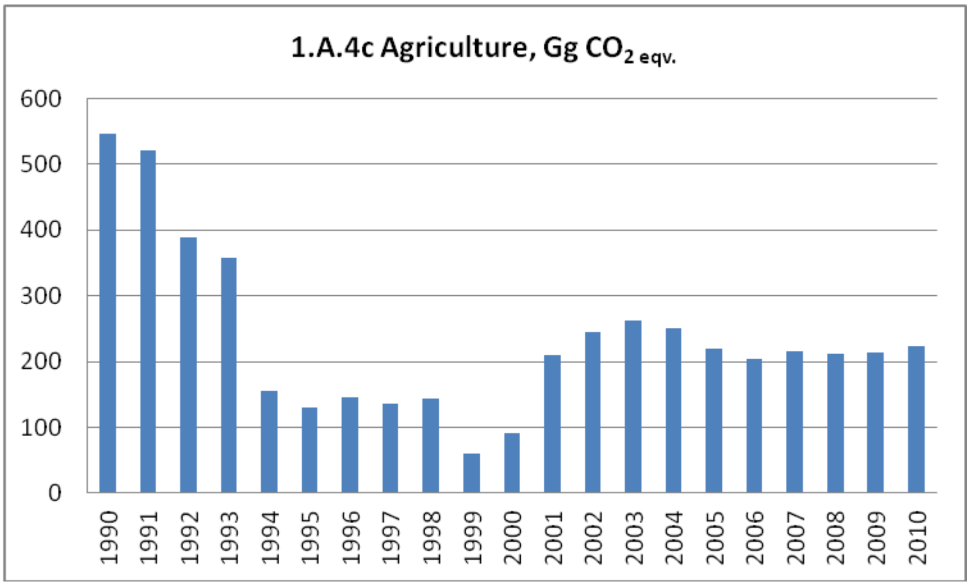

Figure 3.28. Trends of GHG **e**missions in the CRF categories 1.A.4.c Agriculture, Gg CO_2 eq

Under source-category 1.A.4.c Agriculture, GHG emissions from fuel combustion in agriculture, fishing and hunting are reported. The trend of GHG emissions follows the fuel consumption trend of the sector and reflects the whole sector development trend. The number of farms decreased since 1994 drastically and reached the bottom in 1999. Since 2002 the production in agriculture stabilised and small fluctuation in different years is explained mainly with different weather conditions (see Figure 3.28).

The values of CO_2 IEFs of liquid fuels in the Other Sector are between 71.73 t/TJ (in 1999) and 73.53 t/TJ (in 1993) and the values of CO_2 IEF of solid fuels are between 94.68 t/TJ (in 1994) and 96.01 t/TJ (in 2004). The trends are fluctuating due to changes in the contribution of different solid and liquid fuels over time.

Sub-category CRF 1.A.5 includes emissions from military use of fuels (see Table 3.34).

The emissions of the CRF 1.A.5 were 41.58 Gg CO_2 equivalent in 2010, it is over 0.2% of the energy sector's emissions and about 0.2% of total GHG emissions in Estonia. Corresponding emissions were 44.43 Gg of CO_2 equivalent in 1990.

3.2.7.2. Methodological issues

Methods

Emissions from sub-category CRF 1.A.4 and CRF 1.A.5 are calculated by using the methodology of the IPCC1996 and 2006 Guidelines.

Activity data

The activity data for source categories CRF 1.A 4 and CRF 1.A.5 are taken from annual energy statistics . It covers fuel used in commercial/institutional and residential and agricultural/forestry/fisheries sectors. Activity data on liquid fuels (gasoline and diesel oil) reported under source-category 1.A.5./Military are taken from the Commercial/Institutional sector of the national energy balance. Same small amounts of gasoline and diesel used in military passanger cars are taken off and reported under category 1.A.3.c road transportation. Activity data on fuel amounts used for military passanger cars are collected from the Ministry of Defence.

The fuel consumption data by main fuel groups for CRF 1.A4 are presented in the Table 3.35 and Figure 3.29. Fuel consumption data of the source category CRF 1.A.5 Other/Military are presented in the Table 3.36.

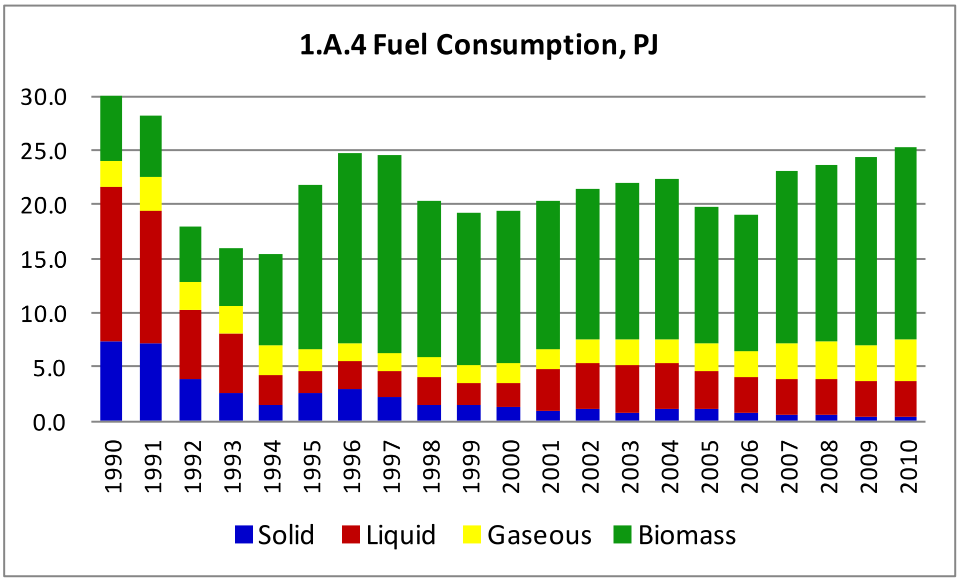

Figure 3.29. Fuel Consumption in the CRF category 1.A.4 Other Sectors, PJ

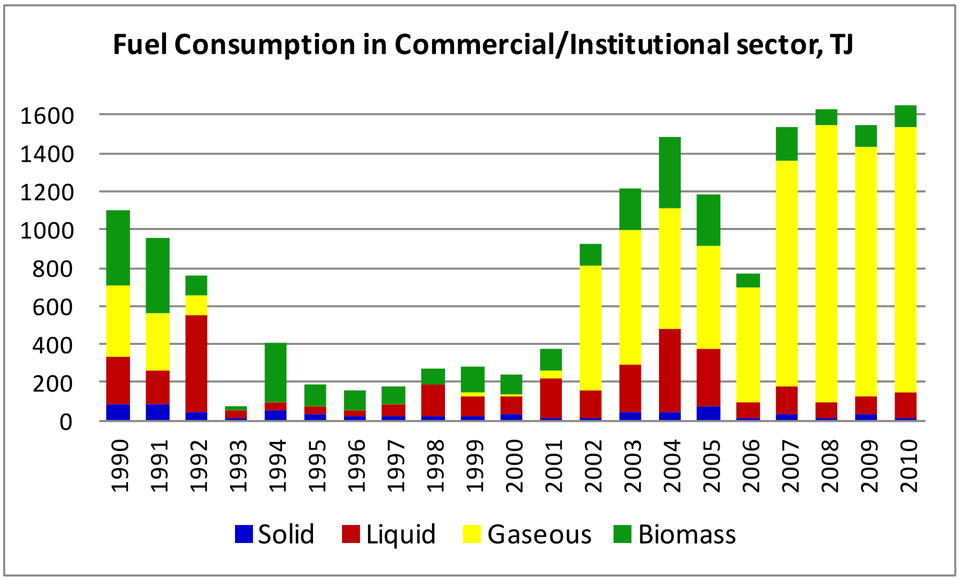

Figure 3.30. Fuel consumption by main fuel groups in Commercial/Institutional sector, PJ

The fuel consumption trend of the Commercial/Institutional sector shows the big increase of the natural gas use since 2002. The increase of the natural gas consumption is connected with the construction boom which started in 2002 in Estonia. Lot of new logistics buildings and hypermarkets (using gas heating) were built.

Consumption of other fuels: liquid, solid and biomass fuels were more stable, some fluctuations are in the liquid fuel consumption trend in 1992, 2001 and 2004 (see Figure 3.30).

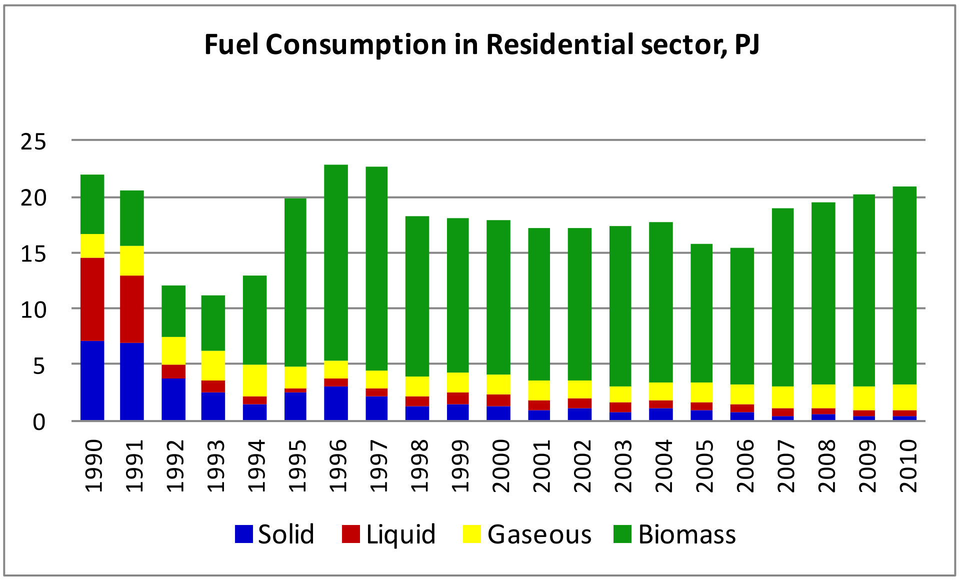

Figure 3.31. Fuel consumption by main fuel groups in Residential sector, PJ

In the Figure 3.31 the fuel consumption trend by main fuel groups of the Residential sector is presented. The most dominating fuel of the sector is biomass. The big increase in the use of biomass in residential sector started in the middle of the nineties when several different biofuels conversion projects were launched to replace fossil fuel with biomass. The increase of the biomass consumption trend in 1996/1997 is connected with the methodology change of the SE and decreases in 2005/2006 with warm winters. Since 2007 the use of biofuels in residential sector is slightly increasing.

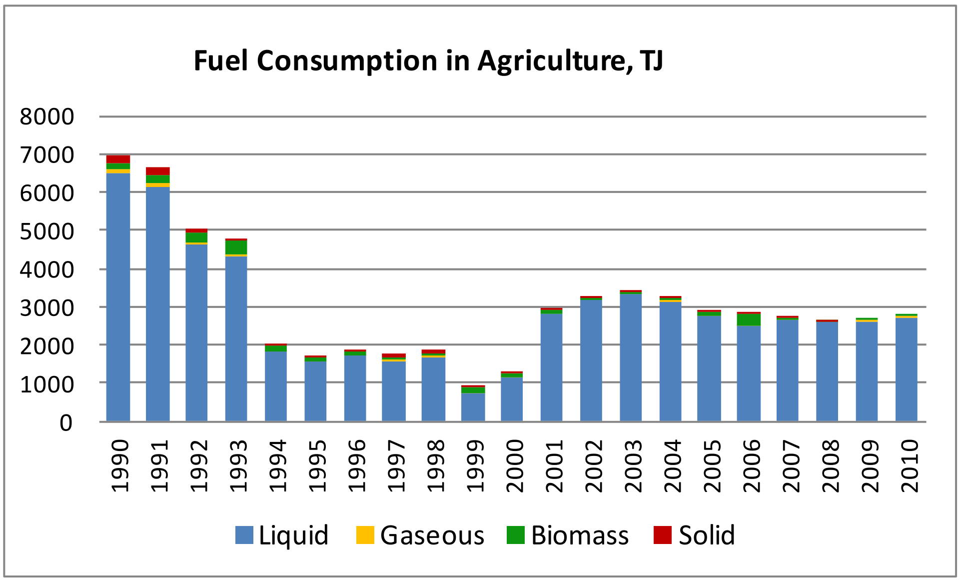

Figure 3.32. Fuel consumption by main fuel groups in Agriculture, TJ

In the Figure 3.32 fuel consumption trend by main fuel group of the Agriculture sector is presented. The main fuel group in agriculture is liquid fuels, the other fuel groups have a small share in the sector and the consumption trend has been quite stable since 2001.

The amount of liquid fuels used in agriculture has been decreased since 1990 up to 1999 almost 60%, mostly due to the decreasing of whole agricultural production caused by the structural changes in the economy after 1991 when Estonia became independent. After 2000 the agricultural production started to increase bringing together the increase of liquid fuel consumption. The fuel consumption in agriculture has been stable during four last year.

Table 3.33. Emissions from Other Sectors (incl. Commercial/Institutional, Residential and Agriculture) in 1990–2010, Tg CO_2 eq

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4. Total Other Sectors	**2.01**	**1.88**	**1.07**	**0.87**	**0.58**	**0.63**	**0.72**	**0.63**	**0.56**	**0.50**	**0.50**	**0.58**	**0.66**	**0.65**	**0.68**	**0.62**	**0.56**	**0.61**	**0.63**	**0.61**	**0.65**
CO_2 4. Other Sectors	1.88	1.76	0.98	0.79	0.49	0.49	0.56	0.47	0.43	0.38	0.38	0.46	0.54	0.52	0.54	0.50	0.45	0.47	0.49	0.46	0.49
a. Commercial/ Institutional	0.047	0.038	0.047	0.005	0.008	0.006	0.005	0.006	0.014	0.011	0.010	0.019	0.048	0.061	0.070	0.059	0.040	0.079	0.087	0.082	0.087
b. Residential	1.335	1.244	0.578	0.461	0.345	0.371	0.419	0.339	0.284	0.313	0.288	0.240	0.257	0.215	0.238	0.236	0.222	0.194	0.206	0.186	0.198
c. Agriculture/Forestry/Fisheries	0.497	0.473	0.352	0.327	0.140	0.117	0.133	0.123	0.131	0.055	0.084	0.205	0.233	0.244	0.231	0.203	0.185	0.197	0.195	0.192	0.201
CH_4 , CO_2 eqv.	0.069	0.067	0.047	0.042	0.055	0.103	0.121	0.126	0.098	0.096	0.095	0.094	0.094	0.097	0.100	0.087	0.084	0.104	0.106	0.112	0.115
N_2O, CO_2 eqv.	0.061	0.060	0.043	0.038	0.027	0.034	0.039	0.038	0.032	0.025	0.025	0.023	0.030	0.037	0.038	0.033	0.033	0.039	0.038	0.042	0.045

Table 3.34. Emissions from CRF 1.A.5 Other in 1990–2010, Gg CO_2 equivalent

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
5. Total Other	**44.43**	**54.42**	**34.85**	**11.03**	**11.19**	**29.32**	**16.56**	**13.95**	**17.51**	**17.51**	**17.19**	**18.90**	**14.97**	**19.34**	**28.26**	**35.47**	**32.21**	**31.16**	**10.97**	**29.70**	**41.58**
CO_2 5. Other/Mobile	43.61	53.43	34.24	10.83	10.99	28.80	16.27	13.70	17.21	17.20	16.89	18.56	14.68	18.98	27.75	34.85	31.65	30.62	10.78	29.17	40.86
CH_4 , CO_2 eq.	0.05	0.06	0.04	0.01	0.01	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.03	0.01	0.03	0.05
N_2O, CO_2 eq.	0.77	0.93	0.56	0.19	0.18	0.48	0.27	0.23	0.29	0.29	0.28	0.32	0.27	0.33	0.47	0.58	0.52	0.50	0.18	0.50	0.67

Table 3.35. Fuel consumption in CRF categories 1.A 4 Other Sectors, PJ

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1.A.4																					
Liquid Fuels	14.27	12.22	6.42	5.49	2.64	1.98	2.53	2.38	2.66	1.86	2.27	3.79	4.21	4.41	4.20	3.61	3.21	3.35	3.39	3.27	3.39
Solid Fuels	7.28	7.25	3.93	2.57	1.52	2.55	3.04	2.23	1.42	1.55	1.27	0.95	1.11	0.80	1.13	1.05	0.78	0.50	0.50	0.34	0.37
Gaseous Fuels	2.55	3.15	2.52	2.62	2.87	2.01	1.55	1.55	1.84	1.75	1.78	1.78	2.26	2.23	2.26	2.43	2.52	3.23	3.53	3.44	3.72
Biomass	5.94	5.62	5.39	5.43	8.29	15.21	17.71	18.49	14.41	14.01	14.12	13.90	13.83	14.68	14.79	12.74	12.47	16.06	16.37	17.38	17.85

Table 3.36. Fuel consumption in CRF categories 1.A 5 Other, PJ

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1.A.5 (mobile)																					
Liquid Fuels	0.60	0.73	0.47	0.15	0.15	0.39	0.22	0.19	0.23	0.23	0.23	0.25	0.20	0.26	0.38	0.48	0.43	0.42	0.15	0.40	0.56

Emission Factors

Both, IPCC and national (country specific) emission factors are used. Estonia uses Finnish CH_4 and N_2O EF for sod peat and peat briquettes, because IPCC 1996 Revised Guideline does not give EFs of different peat fuels (see Table 3.37). CH_4 and N_2O EFs for oil shale were taken from the IPCC2006 Guideline because IPCC1996 Revised Guideline gives no EF for these fuels.

Table 3.37. Emission factors of small combustion of fuels, kg/TJ

	CH_4	N_2O	NOx	CO	NMVOC	Source[6]
Oil	10	0.6	100	20	5	IPCC1996, Vol.3, Tables 1-7 – 1-11
LPG	5	0.1	100	20	5	IPCC1996, Vol.3, Tables 1-7 – 1-11
Natural Gas	5	0.1	50	50	5	IPCC1996, Vol.3, Tables 1-7 – 1-11
Coal (commercial)	10	1.4	100	2 000	200	IPCC1996, Vol.3, Tables 1-7 – 1-11
Coal (residential, agriculture)	300	1.4	100	2 000	200	IPCC1996, Vol.3, Tables 1-7 – 1-11
Oil Shale (commercial)	10	1.4	110	87	60	IPCC2006 (for CH_4 and N_2O) CS, (Procedure, 2004) for NOx, CO and NMVOC
Oil Shale	300	1.4	110	87	60	IPCC2006 (for CH_4 and N_2O) CS, (Procedure, 2004) for NOx, CO and NMVOC
Peat/Briquette	50	4	100	5 000	600	CH_4 FIN, other EFs IPCC1996 (other biomass)
Wood	300	4	100	5 000	600	IPCC1996, Vol.3, Tables 1-7 – 1-11

Under the CRF source category 1.A.4.c Agriculture/Mobile emissions from off-road agricultural transport are estimated. In the Table 3.38 emission factors of motor fuels used for off-road transportation and fishing and leasure boats are presented.

Table 3.38. Emission factors for agricultural off-road fuels

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	Source
Motor Gasoline	19.9	80	2	1 200	1 000	200	IPCC2006, Chapter 3, Table 3.3.1
Diesel	20.2	4.15	28.6	1 200	1 000	200	IPCC2006, Chapter

[6] Revised IPCC1996 Guidelines for National Greenhouse Gas Inventories, Reference Manual, Table 1-7, Table 1-8, Table 1-9, Table 1-19, Table 1-11, pages 1.35-1.42.

Oil							3, Table 3.3.1

Under the CRF source category 1.A.5 Other/Mobile emissions from military fuel use are estimated. In the Table 3.39 emission factors of motor fuels used in military are presented.

Table 3.39. Emission factors for military fuels (CRF 1.A.5), kg/TJ

	CO_2 (t C/TJ)	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**	**Source**
Motor Gasoline	19.9	3.8	5.7	600	8 000	1 500	IPCC2006, Chapter 3, Table 3.2.3
Diesel Oil	20.2	3.9	3.9	800	8 000	1 500	IPCC2006, Chapter 3, Table 3.2.3; (CEF: IPCC1996)

3.2.7.3. Source-specific recalculations

1. In the 2011 national submission Estonia used Finnish carbon emission factor (CEF=15.01 tC/TJ) of natural gas. In the current submission Estonia uses Russian CEF (15.07 tC/TJ) because all natural gas is imported from Russia and the calorific value of natural gas is the same (ERT 2011 reccommendation).
2. In the CRF source categories 1.A.4 and 1.A.5/Liquid Fuels carbon emission factor of gasoline has been revised. CEF value 19.90 tC/TJ has been used instead 19.91 tC/TJ because Lithuania revised in the 2011 inventory submission the value of their CEF of gasoline.
3. In the current inventory submission CH_4 and N_2O emission factors of all fuels used in CRF 1.A.4 are taken from the Revised 1996 IPCC Guideline. In the previous submission IPCC 2006 CH_4 and N_2O emission factors were used (ERT 2011 reccommendation) (see the table below).

Recalculations in the CRF source category 1.A.4 Other sectors

CRF source category	**Fuel**	**GHG**	**2011 submission, IPCC2006**	**2012 submission, IPCC1996**	
1.A.4.a, b, c	Natural gas	N_2O	1	0.1	
11.A.4.a, b, c	Gas oil (LFO)	N_2O	2	0.6	
1.A.4.a, b, c	Residual Fuel Oil	N_2O	2	0.6	
1.A.4.a, b, c	Shale oil	N_2O	2	0.6	
1.A.4.a, b, c	LPG	N_2O	2	0.1	
1.A.4.a, c	Coal	N_2O	4	1.4	
1.A.4.a, b	Wood	N_2O	2	4	
1.A.4.a, b, c	Natural gas	CH_4	3	5	
1.A.4.b, c	LPG	CH_4	10	5	
1.A.4.a	Oil Shale*	CH_4	1	10	IPCC2006

1.A.4.b, c	Oil Shale*	CH_4	1	300	IPCC2006
1.A.4.a, b, c	Wood	CH_4	50	300	

*CH_4 EF of oil shale is taken from the IPCC2006 Guideline because IPCC1996 Guideline does not give any EF for oil shale.

4. In the National Energy Balance some amounts of Jet Kerosene were allocated under Commercial /Institutional sector: 1 TJ (in 1993); 9 TJ (in 1996); 13 TJ (in 1997); 15 TJ (2004) and 4 TJ (in 2008). In the current submission these amounts and corresponding emissions are reported under CRF sub-category 1.A.3.a National Aviation.
5. The following changes were made in the sub-sectors of the category 1.A.4 in activity data:

	Fuel; TJ	Year	2011 submission	2012 submission
1.A.4.a Commercial/Solid Fuels	Peat briquette	1997	8	5
	Peat	1999	1	0
1.A.4.a Commercial/Biomass	Biomass total	1992	109	404
	Wood	1993	18	109
	Biomass total	2006	75.634	76.634
1.A.4.b Residential/Biomass	Biomass total	2003	14 290	14 400
1.A.4.b Residential/Solid	Milled peat	2007	3	0
1.A.4.c Agriculture/Liquid	Shale oil	2008	0	54

6. The following changes were made in the sub-sectors of the category 1.A.4 in activity data:

	Fuel; TJ	Year	2011 submission	2012 submission
1.A.4.a Commercial/Biomass	Wood	1993	18	109
1.A.4.b Residential	Milled peat	2007	3	0
	Peat briquette	2010	115	150
1.A.4.c Agriculture	Shale oil	2008	0	54

AD of the years 2007–2010 have been revised and corrected by SE in 2010, AD on wood consumption in 1993 was inserted from energy balance to calculation tables wrongly.

3.2.7.4. Source-specific planned improvements

For the next inventory submission Estonia plannes to evaluate and implement country specific CO_2 emission factors for gasoline.

3.3. Fugitive Emissions from fuels (CRF 1.B)

3.3.1. Solid Fuels (CRF 1.B.1)

In Estonia oil shale is mined for energy generation and shale oil production. The amounts of oil shale mined in 1990–2010 are presented in Table 3.40. There are no coal mines in Estonia.

Unlike coal mines there is no CH_4 emissions from oil shale mines, because methane is non-existent in Estonian Oil Shale (see the Explanation Letter from the Department of Mining of the Tallinn University of Technology in Annex 2).

Table 3.40. Oil shale production in Estonia, million tons

Year	Mt	Year	Mt
1990	22.49	2001	9.89
1991	19.61	2002	10.51
1992	17.03	2003	12.61
1993	14.26	2004	11.74
1994	14.02	2005	12.35
1995	12.10	2006	11.98
1996	13.07	2007	13.99
1997	12.86	2008	13.71
1998	10.91	2009	12.60
1999	9.60	2010	15.11
2000	9.97		

Source: Table KK501 Exstraction of mineral resources,Statistical Data base of the Statistics Estonia, www.stat.ee

Data presented in Table 3.40 is not the same what data on oil shale production in National Energy balance Sheet but show the decrease of oil shale reserves. Estonian oil shale active reservs are estimated according to the energy raiting of the bed >35 GJ/m^2 (cut-off grade).

3.3.2. Source category (CRF 1.B.2)

Sources of fugitive emissions within oil and gas systems include releases during normal operation, such as emissions associated with emissions during maintenance and emissions during system upsets and accidents. In Estonia, liquid fossil fuels and natural gas are mainly imported. Only shale oil is produced in Estonia.

3.3.2.1. Source category description

Under fugitive emissions from fuels Estonia reports CH_4 emissions from: oil storage and natural gas distribution.

Natural gas is imported into Estonia from Russia and from the Inchukalns underground gas storage in Latvia.

AS Eesti Gaas has two gas metering stations on the border of Estonia (in Värska and Karksi) where the volumes of imported gas are measured. Gas is distributed to customers through gas pipelines, distribution stations and gas pressure reducing stations.

There are no compressor stations in Estonia and it means that there is no fugitive CO_2 emission from gas distribution in Estonia. CO_2 forms from natural gas consumption in compressor stations.

Map of high-pressure gas distribution pipelines

In 2010, fugitive emissions from oil and natural gas were 3.96 Gg CH_4 (83.19 Gg CO_2 eq.). It is about 0.46% of the energy sector's emissions and about 0.4% of total GHG emissions in Estonia. Corresponding emissions were 181.10 Gg CO_2 equivalent in 1990.

3.3.2.2. Methodological issues

The equation for calculating CH_4 emissions from oil and gas activities is following:

$$CH_4\ Emissions\ (Gg\ CH_4) = \{Activity\ (PJ)\ x\ Emission\ Factor\ (kg\ CH_4/PJ)\}/10^6$$

Activity data

The activity data for sub-category CRF 1.B.2 are taken from the annual energy statistics (National Energy Balace Sheet 2010).

Emission factors and other parameters

Emission factors for calculating emissions of oil and gas activities are based on the default factors given in the Revised IPCC 1996 Guidelines (see Table 3.41).

As noted in the IPCC Good Practice Guidelines (p. 2.84), "fugitive emissions from gas distribution cover emissions at residential and commercial sectors and in industrial plants and power stations. Therefore these emissions were not calculated separately and marked with notation key "IE".

Emission from natural gas storage was not estimated due to there are no natural gas storage facilities in Estonia. Estonia uses storage facilities located in Latvia.

Table 3.41. CH_4 emission factors for fugitive emissions from oil and gas activities

	Emission Factor	**Unit**	**Source**
OIL			
Transport of oil products	745	kg CH_4/PJ	D, IPCC1996, Reference Manual, P.1.121, Table 1-58.
Storage of oil products	150	kg CH_4/PJ	D, IPCC1996, Reference Manual, P.1.121, Table 1-58.
GAS			
Distribution of natural gas	165 016	kg CH_4/PJ	D, IPCC1996, Reference Manual, P.1.121, Table 1-58.

3.3.2.3. Quantitative overview

In the Table 3.42 CH_4 emissions from oil and gas activities are presented.

Table 3.42. CH_4 emissions from Oil and Gas activities, Gg CO_2 equivalent

	Fugitive emissions Gg CO_2 eq	**1.B.2 Oil and Natural Gas**	**1.B.2.A Total Oil**	1.B.2.A.3 Transport	1.B.2.A.4 Storage	**1.B.2.B Natural Gas**	1.B.2.B.4 Distribution
	Gg CO_2 eq	Gg CH_4	Gg CH_4	Gg CH_4	Gg CH_4	Gg CH_4	Gg CH_4
1990	**181.36**	**8.64**	**0.18**	0.14	0.04	**8.45**	8.45
1991	**181.16**	**8.63**	**0.15**	0.12	0.03	**8.48**	8.48
1992	**105.81**	**5.04**	**0.09**	0.07	0.02	**4.95**	4.95
1993	**53.53**	**2.55**	**0.09**	0.07	0.02	**2.46**	2.46
1994	**76.31**	**3.63**	**0.10**	0.08	0.02	**3.53**	3.53
1995	**86.47**	**4.12**	**0.09**	0.07	0.02	**4.02**	4.02
1996	**94.96**	**4.52**	**0.08**	0.07	0.02	**4.44**	4.44
1997	**92.89**	**4.42**	**0.11**	0.09	0.02	**4.31**	4.31
1998	**88.17**	**4.20**	**0.11**	0.08	0.02	**4.09**	4.09
1999	**85.92**	**4.09**	**0.11**	0.08	0.02	**3.98**	3.98
2000	**97.21**	**4.63**	**0.05**	0.04	0.01	**4.58**	4.58
2001	**105.15**	**5.01**	**0.09**	0.07	0.02	**4.92**	4.92
2002	**87.71**	**4.18**	**0.06**	0.05	0.01	**4.12**	4.12
2003	**97.33**	**4.63**	**0.10**	0.08	0.02	**4.54**	4.54
2004	**113.78**	**5.42**	**0.06**	0.05	0.01	**5.36**	5.36
2005	**117.29**	**5.59**	**0.06**	0.05	0.01	**5.52**	5.52
2006	**118.99**	**5.67**	**0.07**	0.06	0.02	**5.59**	5.59
2007	**118.70**	**5.65**	**0.09**	0.07	0.02	**5.56**	5.56
2008	**113.58**	**5.41**	**0.08**	0.06	0.02	**5.33**	5.33
2009	**77.78**	**3.70**	**0.08**	0.07	0.02	**3.62**	3.62

2010	**83.31**	**3.97**	**0.08**	0.06	0.02	**3.89**	3.89

3.3.2.4. Uncertainties and time-series consistency

To estimate the uncertainties of this category the IPCC Tier1 method was used.

Uncertainties of activity data (±10) and emission factors (±25) were taken from the IPCC 2000. Good Practice Guidance.

Combined uncertainty in the category fugitive emissions from fuel as % of total national emissions in year 2010 was around ±0.12%.

3.3.2.5. Source specific recalculations

1. CRF source-category 1.B.2.b 5 Other Leakage (including other leakage at industrial plants and power plants and in residential and commercial sectors) has been removed from the 2012 inventory submission because that emissions from natural gas distribution cover emissions of other leakige at residential and commercial sectors and in industrial plants and power stations.
2. CH_4 emissions factor for natural gas distribution was changed according to the Review Team (2011) recommendations (in 2012 submission the CH_4 emissions factor for natural gas distribution 165016 kg CH_4/PJ was used, in 2011 submission – 458 000 kg CH_4/PJ).

Table 3.43. Recalculations of fugitive emissions in the CRF 1.B.2 Oil and Natural Gas

	Fugitive emissions, Gg CO_2 eq		**1.B.2 Oil and Natural Gas, Gg**		**1.B.2.A Total Oil, Gg**		**1.B.2.B Natural Gas, Gg**	
	2011 submission	2012 submission	2011 submission	2012 submission	2011 submission	2012 submission	2011 submission	2012 submission
1990	**791.07**	**181.36**	37.67	8.64	0.18	0.18	37.49	8.45
1991	**790.86**	**181.16**	37.66	8.63	0.15	0.15	37.51	8.48
1992	**459.9**	**105.81**	21.9	5.04	0.09	0.09	21.81	4.95
1993	**224.91**	**53.53**	10.71	2.55	0.09	0.09	10.62	2.46
1994	**324.87**	**76.31**	15.47	3.63	0.10	0.10	15.37	3.53
1995	**373.8**	**86.47**	17.8	4.12	0.09	0.09	17.71	4.02
1996	**413.91**	**94.96**	19.71	4.52	0.09	0.08	19.62	4.44
1997	**402.57**	**92.89**	19.17	4.42	0.11	0.11	19.06	4.31
1998	**380.94**	**88.17**	18.14	4.20	0.11	0.11	18.04	4.09
1999	**371.07**	**85.92**	17.67	4.09	0.11	0.11	17.57	3.98
2000	**425.67**	**97.21**	20.27	4.63	0.05	0.05	20.22	4.58
2001	**458.43**	**105.15**	21.83	5.01	0.09	0.09	21.74	4.92
2002	**383.25**	**87.71**	18.25	4.18	0.06	0.06	18.19	4.12
2003	**423.78**	**97.33**	20.18	4.63	0.10	0.10	20.08	4.54
2004	**499.38**	**113.78**	23.78	5.42	0.06	0.06	23.72	5.36
2005	**514.29**	**117.29**	24.49	5.59	0.06	0.06	24.43	5.52

	Fugitive emissions, Gg CO_2 eq		**1.B.2 Oil and Natural Gas, Gg**		**1.B.2.A Total Oil, Gg**		**1.B.2.B Natural Gas, Gg**	
	2011 submission	2012 submission	2011 submission	2012 submission	2011 submission	2012 submission	2011 submission	2012 submission
2006	**521.01**	**118.99**	24.81	5.67	0.07	0.07	24.73	5.59
2007	**518.07**	**118.70**	24.67	5.65	0.09	0.09	24.58	5.56
2008	**496.02**	**113.58**	23.62	5.41	0.08	0.08	23.54	5.33
2009	**335.58**	**77.78**	15.98	3.70	0.08	0.08	15.89	3.62

3.3.2.6. Source-specific planned improvements.

In 2011, it was planned to find country specific emission factors for fugitive CH_4 emissions from distribution of natural gas. A special study for estimation of CS emission factors was planned to carry out but due to difficult financial situation in 2010 the study was not financed.

4. INDUSTRIAL PROCESSES (CRF 2)

4.1. Overview of the sector

4.1.1. Description and quantitative overview

Emissions from Industrial Processes sector in Estonia are divided into following emission categories: Mineral products (CRF 2.A), Chemical industry (CRF 2.B), Consumption of halocarbons and SF_6 (CRF 2.F) and other production (CRF 2.D). Under Mineral products Estonia reports emissions from cement, lime, glass, bricks and tiles production as well as emissions from lightweight gravel production and soda ash use. Also NMVOC emissions from road paving with asphalt are reported in this category. Emissions from ammonia production are reported under Chemical industry. CRF category 2.F covers emissions of F-gases from refrigeration and air conditioning, foam blowing, aerosols and electrical equipment, as well as some smaller sources, such as fire extinguishers and other. Under Other production (CRF 2.D) Estonia reports NMVOC emissions from the pulp and paper and food industries.

Industrial GHG emissions contribute to 2.43% of the total anthropogenic GHG emissions in Estonia (Figure 4.1). As outlined in the inventory for 2010 the most important greenhouse gas emissions from industrial processes in Estonia are the CO_2 emissions from the cement and lime production with 1.51% and 0.09% and HFC emissions from Refrigeration and Air Conditioning Equipment with 0.70%. F-gas emissions comprised together 0.77% of the total GHG emissions.

Industrial CO_2 emissions have fluctuated strongly since 1990 (Figure 4.2 and Table 4.1) having the lowest value in 1993. The decrease in the emissions during early 1990´s was caused by the transition from planned economy to a market economy after 1991 when Estonia became independent. This led to decrease in industrial production, and to an overall decrease in emissions from industrial processes between 1991 and 1993. In 1994 the economy began to recover and also the production increased. Since 1995 (the base year for F-gases under the Kyoto Protocol) emissions of F-gases have significantly increased. In 2002 and 2003 there were reconstructions in ammonia production plant, which strongly decreased the industrial processes emissions in the corresponding years. In 2009, industrial processes sector was affected by the economic recession. Decline in production was mainly caused by the insufficient demand both in domestic and external markets. Compared to 2009, the emissions from industrial processes increased by 10.09% in 2010.

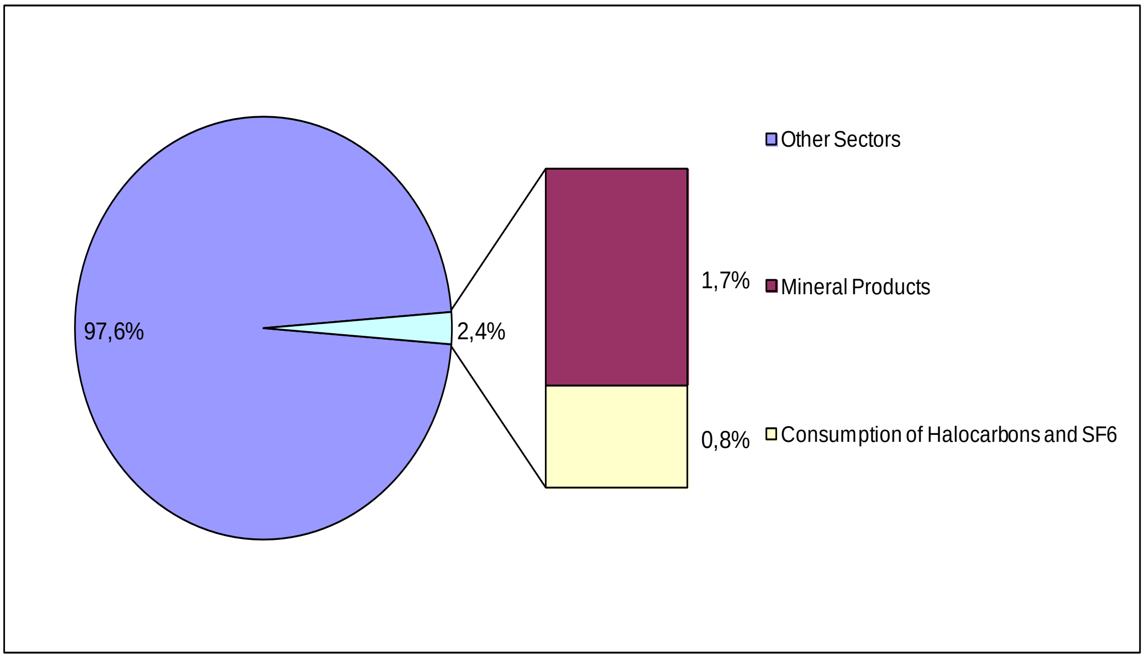

Figure 4.1. Emissions from industrial processes compared with total emissions in 2010

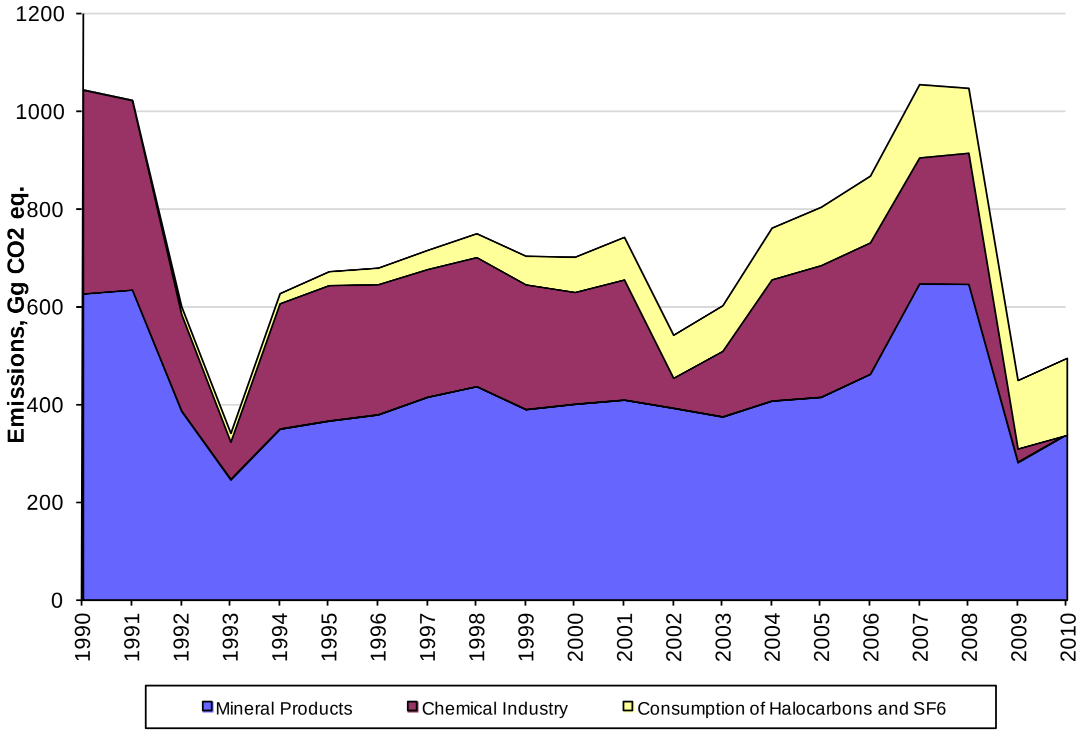

Figure 4.2. Emissions from industrial processes in Estonia in 1990–2010 (Gg CO_2 equivalent)

Table 4.1. Trend in the greenhouse gas emissions from industrial processes (Gg CO_2 equivalent)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2.A Mineral Products	628	636	387	246	350	367	380	416	437	390	401	410	393	375	408	415	463	649	648	282	339
2.B Chemical Industry	420	391	200	79	259	280	269	264	267	258	231	248	64	137	251	272	272	260	271	30	NO
HFCs	NO	NO	16	18	21	25	31	36	46	56	70	86	87	92	105	119	136	149	132	139	156
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.07	0.06	0.04	NO	NO
SF_6	NO	0.05	0.09	0.14	0.18	3.22	3.51	3.0	2.99	3.01	2.74	1.74	1.44	1.32	1.08	1.08	1.15	0.97	1.35	1.44	1.81
Total	**1048**	**1027**	**603**	**343**	**630**	**675**	**683**	**719**	**753**	**707**	**705**	**746**	**545**	**605**	**765**	**807**	**871**	**1059**	**1052**	**452**	**498**

Key categories

Key categories in industrial processes in 2010 by level (L) and trend (T) are summarised in Table 4.2 (without LULUCF) in accordance with IPCC Tier 2 method.

Table 4.2. Key categories in Industrial processes (CRF 2) in 2010 (without LULUCF)

IPCC code	IPCC source category	Gas	Identification criteria
2.B.1	Ammonia Production	CO_2	T

4.2. Mineral Products (CRF 2.A)

In this category non-fuel emissions from cement production (2.A.1), lime production (2.A.2), soda ash use (2.A.4.2) and other (2.A.7) are reported. In the source category other (2.A.7), emissions from glass production (2.A.7.1), bricks and tiles production (2.A.7.2a) and lightweight gravel production (2.A.7.2b) are reported. In addition, NMVOC emissions from road paving with asphalt are reported under Mineral products. Emissions from Limestone and Dolomite Use are reported as included elsewhere (allocation 2.A.1, 2.A.2 and 2.A.7).

CO_2 emissions from mineral products have fluctuated since 1990 (Table 4.3) having the lowest value in 1993, after what the trend of CO_2 emissions have stabilized (except a rise in 2007–2008 and sudden decrease in 2009). The decrease in the emissions during early 1990´s was caused by the transition from planned economy to market economy after 1991 when Estonia became independent. This led to decrease in industrial production, and to an overall decrease in emissions from mineral products between 1991 and 1993. In 1994 the economy began to recover and also production increased. Sudden increase in 2007–2008 emissions was caused by increase of cement production (in 2007 Kunda Nordic Cement AS renovated third kiln). In 2009, mineral products sector was affected by the economic recession. Decline in production was mainly caused by the insufficient demand both in domestic and external markets. Increase in 2010 emissions was caused by increase of cement production.

Table 4.3. CO_2 emissions from Mineral products (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2.A.1 Cement production	483	479	315	228	330	348	361	396	404	361	374	380	356	335	365	373	414	597	603	257	310
2.A.2 Lime production	131	143	65	16	14	13	12	12	20	15	13	13	18	20	22	24	27	28	25	16	18
2.A.4.2 Soda ash use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.004	0.03	0.07	0.07	0.09	0.09	0.07	0.08
2.A.7.1 Glass production	1.2	1.2	0.8	2.3	3.3	4.0	3.4	5.6	7.4	6.4	7.3	7.3	8.7	8.9	9.1	8.0	9.3	10.5	8.7	7.6	9.6
2.A.7.2a Bricks and tiles production	12.3	12.5	6.3	0.03	2.9	2.2	2.2	1.7	1.4	2.8	1.4	2.4	2.3	2.7	2.8	2.5	3.2	5.8	4.9	1.1	1.6
2.A.7.2b Lightweight gravel production	NO	NO	NO	NO	NO	NO	NO	NO	4.7	5.0	6.0	7.5	7.4	8.5	8.9	7.9	9.8	7.7	5.8	NO	NO
Total	**628**	**636**	**387**	**246**	**350**	**367**	**380**	**416**	**437**	**390**	**401**	**410**	**393**	**375**	**408**	**415**	**463**	**649**	**648**	**282**	**339**

4.2.1. Cement Production

4.2.1.1. Source category description

In cement production CO_2 is emitted when an intermediate product, clinker, is produced. In that process limestone is heated to high temperature, which results in emissions, as the main component of limestone, calcium carbonate, breaks down, calcinates, into calcium oxide and carbon dioxide. Limestone contains also small amounts of magnesium carbonate ($MgCO_3$), which will also calcinate in the process causing CO_2 emissions.

In Estonia, there is only one plant producing clinker and cement – Kunda Nordic Cement AS. Cement is produced in Kunda by standard wet process. The clinker burning process takes place in rotary kilns. Dust caught with rotary kilns electric filters is party directed into kiln and partly into dust silo. In production process the most important fuels are oil shale, coal and petcoke. Also different alternative fossil fuels are used, such as waste oil, plastics.

4.2.1.2. Methodological issues

Methods

Emissions from cement production were calculated using Tier 2 methodology from the good practice guidance (IPCC 2000, equation 3.1 page 3.10 and equation 3.3 page 3.12). This method assumes that all of the CaO is from a carbonate source (e.g. $CaCO_3$).

According to the Tier 2 method:

$$\text{Emissions} = EF_{clinker} \bullet \text{Clinker Production} \bullet \text{CKD Correction Factor}$$

Emission factors

Emission factors used in calculating the emissions from cement production are plant-specific provided by the industry (i.e. production plants). Emission factors vary slightly due to the parameters affecting them from year to year (Table 4.5).

Emission factors from cement production are based on the actual CaO and MgO contents of clinker. Cement kiln dust and by pass dust as well as the amounts of CaO and MgO that are already calcinated before the process (and therefore do not cause emissions) are taken into account at plant.

Activity data

In calculating the emissions from cement production the amount of clinker produced annually is used as activity data. The clinker production data was received directly from the plant – Kunda Nordic Cement AS – throughout the time series. Data on the cement kiln dust was also provided by the plant.

CKD correction factors were calculated by dividing the total CO_2 process emissions (emissions from clinker production and cement kiln dust, but not emissions from the biological substance) with CO_2 emissions from the clinker production. The total CO_2 emissions from process and emissions from clinker production and cement kiln dust were provided by the plant for all of the years. Each year has a different CKD correction factor due to different amounts of cement kiln dust (calcination rate of

CKD and CaO content of the clinker). The calcination rate of CKD was 82% in years 1990–2006, and 79% in years 2007–2010. Data on clinker production as well as CKD correction factors between 1990–2010 are presented in Table 4.5.

4.2.1.3. Uncertainties and time-series consistency

IPCC Tier 1 method was used in estimating the uncertainties of this category.

The uncertainty of activity data (±2%) and emission factors (±5%) were taken from the IPCC Good Practice Guidance. The uncertainty of activity data took into account the fact that clinker production data is collected on plant-level. Plants generally do not weight clinker better than this.

The uncertainty of emission factor took into account the following error sources:

- Error associated with assuming that all CaO in clinker is from calcium carbonate;
- Uncertainty of plant-level data on CaO content of clinker. This is the best case error of chemical analysis on a production basis.

4.2.1.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

The emissions of last six years (including 2010 emissions) have been compared with ETS data (as recommended by the UNFCCC review team). Differences between those two figures have been less than 1%.

4.2.1.5. Source-specific recalculations

No source-specific recalculations have been done.

4.2.1.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.2.2. Lime Production

4.2.2.1. Source category description

CO_2 emissions from lime production are due to calcination of calcium and magnesium carbonates at high temperatures. In Estonia there are currently two lime production plants: Nordkalk AS and Limex AS.

4.2.2.2. Methodological issues

Methods

Emissions from lime production are calculated by multiplying emission factors with activity data. Activity data are collected mainly directly from the industry but in the earlier years (1990–1996) industrial statistics have also been used. Emission factors are calculated by the industry or are based on IPCC's default factors. The methods for calculating emissions from lime production are consistent with the IPCC Tier 1 level method.

Emission factors

There are three different emission factors used to calculate emissions from lime production. Two emission factors are received directly from the plants, based on the actual CaO and MgO contents. From Limex AS emission factor has been available since 1994 (production in Limex AS started in 1994). From Nordkalk AS emission factor based on actual CaO and MgO content has been available since 2005. As this emission factor differs strongly from default emission factor, emission factors from 1990–2004 are established as a mean value from emission factors in 2005–2008. Third emission factor used is IPCC default value for quicklime. This value is applied to those companies that were closed before 1996, as no better data is available.

Activity data

Activity data (Table 4.5) for lime production is collected mainly directly from the industry and taken partly from industrial statistics (1990–1996). Since 1997 there have been two lime producing plants in Estonia and therefore activity data is collected directly from the industry (1997–2010). From 1990-1996 there were more producing plants and therefore industrial statistics have also been used. From 1990–1996 activity data is collected on one hand directly from plants producing lime nowadays, on the other hand industrial statistics have been used to calculate emissions from plants closed during 1990–1996.

4.2.2.3. Uncertainties and time-series consistency

IPCC Tier 1 method was used in estimating the uncertainties of this category.

Since the activity data was prepared in cooperation with manufacturers the rate of emissions is considered sufficiently precise. The activity data uncertainty was estimated at ±5% and emission factors uncertainty at ±5%. The uncertainty of plant-level data was taken into consideration when estimating the uncertainty of activity data.

4.2.2.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.2.2.5. Source-specific recalculations

In the 2012 Submission, CO_2 emissions from lime production were corrected for year 2006. Recalculation was made due to mistake in production data of one company. The difference between 2011 Submission emissions and 2012 Submission emissions from lime production in 2006 is shown in Table 4.4.

Table 4.4. CO_2 emissions from lime production in 2011 Submission and in 2012 Submission

Year	Production of lime, kt (the 2011 submission)	Reported emissions of CO_2, Gg (the 2011 submission)	Production of lime, kt (the 2012 submission)	Recalculated emissions of CO_2, Gg (the 2012 submission)
2006	42.227	27.313	41.507	26.723

4.2.2.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.2.3. Soda Ash Use

4.2.3.1. Source category description

Soda ash (= sodium carbonate) is used in glass production and in processes of electrolyte neutralisation and lead paste desulphurisation in Estonia. Emission from sodium carbonate used in glass production are reported under category glass production (CRF 2.A.7.1). According to the information received, CO_2 emissions do not occur from lead paste desulphurisation. The usage of soda ash in electrolyte neutralisation process started in 2003 in Estonia.

4.2.3.2. Methodological issues

Methods

Emissions from soda ash use are calculated by multiplying emission factors with the amount of used soda ash. Activity data are gathered directly from the industry. The method for calculating emissions from soda ash use is consistent with the IPCC 1996 Tier 1 level method.

Emission factors

Emission factors for calculating CO_2 emissions from soda ash use are based on the IPCC default factors (IPCC 1996 workbook, page 2.8). For the calculation of CO_2 emissions from soda ash use, emission factor 0.415 t of CO_2 per tonne of soda ash is used.

Activity data

The consumption of sodium carbonate was used as activity data when calculating emissions from soda ash use. Activity data was collected directly from plant.

4.2.3.3. Uncertainties and time-series consistency

IPCC Tier 1 method was used in estimating the uncertainties of this category.

The uncertainty of emission factor for this source category is relatively low, as the emission factor is the stoichometric ratio reflecting the amount CO_2 released upon calcinations of the carbonate. The emission factor uncertainty was estimated ±5%.

The uncertainty of activity data is greater than the uncertainty of emission factor and is estimated at ±10%.

4.2.3.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.2.3.5. Source-specific recalculations

In 2011 Submission, CO_2 emissions from soda ash use were not estimated. CO_2 emissions from soda ash use were established during ERT 2011 review and submitted with resubmission of 2011 greenhouse gas inventory to the UNFCCC secretariat.

4.2.3.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.2.4. Road Paving with Asphalt

4.2.4.1. Source category description

In this source category NMVOC emissions from road paving with asphalt are reported. The NMVOC emissions are calculated at the Estonian Environment Information Centre.

4.2.4.2. Methodological issues

NMVOC emissions from road paving with asphalt were calculated using Tier 1 default approach from the EMEP/EEA Guidebook (EMEP/EEA, 2009).

According to the Tier 1 method:

$$E_{pollutant} = AR_{production} \bullet EF_{pollutant}$$

Where:

$E_{pollutant}$ = the emissions of the specified pollutant
$AR_{production}$ = the activity rate for the road paving with asphalt
$EF_{pollutant}$ = the emission factor for this pollutant

The annual weight of asphalt used in road paving was used as activity data when calculating NMVOC emissions from this source category. Activity data was received from the Estonian Asphalt Pavement Association for the years 1990–2010.

Default NMVOC factors are taken from EMEP/EEA air pollutant emission inventory guidebook – 2009. For the calculations of NMVOC emissions from road paving with asphalt, emission factor 16 g of NMVOC per Mg of asphalt was used.

4.2.4.3. Uncertainties and time-series consistency

IPCC Tier 1 method was used in estimating the uncertainties of this category.

The data on road paving with asphalt is deemed precise because the relevant association provided it. The uncertainty of activity data is estimated at ±10%. The uncertainty of emission factor is greater than the uncertainty of activity data and is estimated at ±50%.

4.2.4.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.2.4.5. Source-specific recalculations

No source-specific recalculations have been done.

4.2.4.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.2.5. Glass Production

4.2.5.1. Source category description

Under this source category, Estonia reports CO_2 emissions from flat glass and container glass production. Currently only container glass is produced in Estonia and there is one production plant – O-I Production Estonia AS (previously Järvakandi Klaas AS). O-I Production Estonia AS started container glass production in 1992, and flat glass was produced in Estonia from 1990 to 1996.

4.2.5.2. Methodological issues

Methods

There are two methods in use for calculating CO_2 emissions from glass production, both methods are consistent with Tier 1. Process emissions in container glass production are generated from limestone and soda ash use and they are calculated by multiplying emission factors with the amount of carbonates used. Activity data (1993–2010) was collected directly from glass producing company – O-I Production Estonia AS.

Emissions from flat glass production were calculated using Tier 1 methodology from the IPCC 2006 Guidelines (equation 2.10, page 2.28). This method was used since carbonates used in flat glass manufacturing are not known and only national-level production statistics was available.

According to the Tier 1 method:

$$CO_2 \text{ Emissions} = M_g \bullet EF \bullet (1 - CR)$$

Where:

CO_2 Emissions = emissions of CO_2 from glass production, tonnes
M_g = mass of glass produced, tonnes
EF = default emission factor for manufacturing of glass, tonnes CO_2/tonne glass
CR = cullet ratio for process (default), fraction.

Emission factors

Emission factors for calculating emissions from limestone and soda ash use are based on the IPCC default factors (1996 Revised Guidelines). For the calculation of CO_2 emissions from limestone use, emission factor 0.44 t of CO_2 per tonne of limestone is used. For the calculation of CO_2 emissions from soda ash use, emission factor 0.415 t of CO_2 per tonne of soda ash is used.

Emission factors for calculating emissions from flat glass production are based on the IPCC default factors (IPCC 2006, equation 2.13, page 2.29). For the calculation of CO_2 emissions from flat glass, emission factor 0.20 t of CO_2 per tonne of glass is used.

Activity Data

The consumption of limestone and sodium carbonate has been used as activity data when calculating emissions from container glass production. Activity data was collected directly from glass producing plant- O-I Production Estonia AS (Table 4.5).

Activity data for calculating emissions from flat glass production are based on national statistics, however the numbers were corrected for the quantity of culled used in glass production. The default cullet ratio of 50 percent was taken into account and national level data on the mass of flat glass produced was multiplied by 0.20 • (1 – 0.50) = 0.10 tonnes CO_2/tonnes glass produced (IPCC 2006, page 2.30).

4.2.5.3. Uncertainties and time-series consistency

IPCC Tier 1 method was used in estimating the uncertainties of this category.

Since the activity data was prepared in cooperation with manufacturer the rate of emissions is considered sufficiently precise. The activity data uncertainty was estimated at ±10% and emission factors uncertainty at ±10%.

4.2.5.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.2.5.5. Source-specific recalculations

No source-specific recalculations have been done.

4.2.5.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

Table 4.5. Activity data and emission factors for cement, lime, glass production and soda ash use

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2.A.1																					
Clinker production, kt	790	773	517	378	540	571	591	651	659	590	620	629	590	560	623	635	705	1 043	1 040	449	537
$EF_{clinker}$, t/t	0.549	0.557	0.548	0.542	0.549	0.547	0.546	0.543	0.546	0.546	0.538	0.538	0.538	0.538	0.542	0.547	0.547	0.546	0.548	0.548	0.549
CKD correction factor	1.113	1.113	1.113	1.113	1.113	1.113	1.121	1.121	1.121	1.121	1.121	1.122	1.122	1.113	1.081	1.073	1.073	1.048	1.058	1.046	1.054
2.A.2																					
Lime production, kt	185	207	92	21	18	16.8	17.4	18.9	31.6	23.4	19.9	19.9	28.3	30.7	34.3	37.2	41.5	43.4	39.5	24.2	26.9
IEF_{lime}, t/t	0.71	0.69	0.70	0.76	0.77	0.75	0.72	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.65	0.64	0.64	0.64	0.66	0.66
2.A.4.2																					
Soda ash use, kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.01	0.08	0.16	0.18	0.21	0.21	0.18	0.20
$EF_{default}$, t/t	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415
2.A.7.1																					
Container glass production, kt	NO	NO	0.6	10.8	20.6	27.9	35	53	57.9	53.6	59.1	59.2	56.1	61.9	66.8	62.1	70.5	76	65.7	63	81.6
Limestone consumption, kt	NO	NO	0.15	1.71	3.2	3.86	4.15	7.96	8.2	7.9	8.99	9.65	8.79	8.97	9.46	8.64	10.37	11.85	9.82	7.9	11.2
$EF_{default}$, t/t	NA	NA	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Sodium carbonate consumption, kt	NO	NO	0.31	2.4	2.58	2.9	3.8	5.1	9.13	7.0	8.1	7.35	11.65	11.9	12.0	10.2	11.38	12.74	10.47	9.89	11.25
$EF_{default}$, t/t	NA	NA	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415
Flat glass production, kt	12.3	12	5.9	5.5	8.5	11.2	0.02	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
$EF_{default}$ x (1 - CR), t/t	0.1	0.1	0.1	0.1	0.1	0.1	0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

4.2.6. Bricks and Tiles Production

4.2.6.1. Source category description

In bricks and roof tiles production process-related CO_2 emissions result from the calcination of carbonates in the clay. Carbonates are heated to high temperatures in a kiln, producing oxides and CO_2.

4.2.6.2. Methodological issues

Methods

Emissions from ceramic bricks and roof tiles production were calculated using Tier 1 methodology from the IPCC 2006 Guidelines (equation 2.14 page 2.34). According to the Tier 1 method:

$$CO_2 \text{ Emissions} = M_c \cdot (0.85\ EF_{ls} + 0.15\ EF_d)$$

Where:

CO_2 Emissions = emissions of CO_2 from other process uses of carbonates, tonnes
M_c = mass of carbonate consumed, tonnes
EF_{ls} or EF_d = emission factor for limestone or dolomite calcinations, tonnes CO_2/tonne carbonate

Emission factors

Emission factors for calculating emissions from limestone and dolomite use are based on the IPCC default factors (IPCC 2006, page 2.7, table 2.4). For the calculation of CO_2 emissions from limestone use, emission factor 0.44 t of CO_2 per tonne of limestone is used. For the calculation of CO_2 emissions from dolomite use, emission factor 0.477 t of CO_2 per tonne of dolomite is used.

Activity data

Mass of carbonates consumed has been used as an activity data when calculating CO_2 emissions from production of bricks and roof tiles (see Table 4.7). Data on the amount of clay used in bricks production was directly collected from the plants from 1992 to 2010. The amount of clay consumed in bricks production in 1990–1992 was calculated by multiplying production with a default loss factor of 1.1. In 1993, only two small plants produced ceramic bricks in Estonia. Data on the amount of clay used in production of roof tiles has been directly collected from the plant since 1997 (production of ceramic roof tiles began in 1997).

As no other information was available, default carbonate content of 10 percent was applied for clays. It was assumed that 85 percent of carbonates consumed are limestone and 15 percent of carbonates consumed are dolomite (IPCC 2006, page 2.36).

For the years 1992–2010 data about bricks production was directly collected from the plants. The amount of bricks produced between 1990–2000 was taken from industrial statistics for one company. Data on production of ceramic roof tiles was received directly from the plant for all the years (Table 4.7).

4.2.6.3. Uncertainties and time-series consistency

IPCC Tier 1 method was used in estimating the uncertainties of this category.

The uncertainty of emission factor for this source category is relatively low, as the emission factor is the stoichiometric ratio reflecting the amount of CO_2 released upon calcinations of the carbonate. The emission factor uncertainty was estimated at ±5%.

The uncertainty of activity data is greater than the uncertainty of emission factor and is estimated at ±10%. The uncertainty of activity data took into account the uncertainty associated with weighting and proportioning the carbonates in clay and the uncertainty associated with the assumption of a default breakdown of limestone and dolomite of 85%/15%.

4.2.6.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.2.6.5. Source-specific recalculations

Activity data in 1992–2010 was recalculated due to data about bricks and tiles production was included by two plants. The difference between 2011 Submission emissions and 2012 Submission emissions from bricks and tiles production in 1992–2010 is shown in Table 4.6.

Table 4.6. CO_2 emissions from bricks and tiles production in 2011 Submission and in 2012 Submission

Year	Bricks and tiles production, kt (the 2011 submission)	Reported emissions of CO_2, Gg (the 2011 submission)	Bricks and tiles production, kt (the 2012 submission)	Recalculated emissions of CO_2, Gg (the 2012 submission)
1992	129.05	6.32	129.18	6.33
1993	NO	NO	0.72	0.03
1994	46.69	2.89	47.89	2.94
1995	27.55	2.14	28.75	2.19
1996	29.29	2.14	29.91	2.17
1997	33.72	1.68	33.88	1.69
1998	23.37	1.42	23.67	1.44
1999	31.12	2.82	31.42	2.83
2000	32.36	1.4	32.66	1.41
2001	49.37	2.37	49.67	2.39
2002	57.22	2.28	57.52	2.30
2003	64.59	2.71	64.89	2.72
2004	66.07	2.82	66.37	2.83
2005	68.71	2.50	69.01	2.52
2006	79.96	3.16	80.26	3.17

2007	147.65	5.82	147.96	5.83
2008	119.51	4.92	119.83	4.94
2009	25.53	1.13	25.60	1.13
2010	38.28	1.61	38.34	1.62

4.2.6.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.2.7. Lightweight Gravel Production

4.2.7.1. Source category description

In lightweight gravel production process-related CO_2 emissions result from the calcination of carbonates in the clay. Carbonates are heated to high temperatures in a kiln, producing oxides and CO_2. In lightweight gravel production plant dolomite is used as a flux. Therefore, CO_2 emissions occur from carbonates in the clay as well from dolomite used as a flux. In 2009–2010, there was no production of lightweight gravel in Estonia.

4.2.7.2. Methodological issues

Methods

Emissions from lightweight gravel production were calculated using Tier 1 methodology from the IPCC 2006 Guidelines (equation 2.14 page 2.34). According to the Tier 1 method:

$$CO_2 \text{ Emissions} = M_c \bullet (0.85\ EF_{ls} + 0.15\ EF_d)$$

Where:

CO_2 Emissions = emissions of CO_2 from other process uses of carbonates, tonnes
M_c = mass of carbonate consumed, tonnes
EF_{ls} or EF_d = emission factor for limestone or dolomite calcinations, tonnes CO_2/tonne carbonate

Emission factors

Emission factors for calculating emissions from limestone and dolomite use are based on the IPCC default factors (IPCC 2006, page 2.7, table 2.4). For the calculation of CO_2 emissions from limestone use, emission factor 0.44 t of CO_2 per tonne of limestone is used. For the calculation of CO_2 emissions from dolomite use, emission factor 0.477 t of CO_2 per tonne of dolomite is used.

Activity data

Mass of carbonates consumed has been used as an activity data when calculating CO_2 emissions from lightweight gravel production (see Table 4.7). Data about the amount of clay used for lightweight gravel production was directly collected from the plant from 1998 to 2008. As no other information was available, default carbonate content of 10 percent was applied for clays. It was assumed that 85 percent of carbonates consumed are limestone and 15 percent of carbonates consumed are dolomite (IPCC 2006, page 2.36).

Data on production of lightweight gravel was received directly from the plant for all the years, 1998–2008 (Table 4.7).

4.2.7.3. Uncertainties and time-series consistency

IPCC Tier 1 method was used in estimating the uncertainties of this category.

The uncertainty of emission factor for this source category is relatively low, as the emission factor is the stoichiometric ratio reflecting the amount of CO_2 released upon calcinations of the carbonate. The emission factor uncertainty was estimated at ±5%.

The uncertainty of activity data is greater than the uncertainty of emission factor and is estimated at ±10%. The uncertainty of activity data took into account the uncertainty associated with weighting and proportioning the carbonates in clay and the uncertainty associated with the assumption of a default breakdown of limestone and dolomite of 85%/15%.

4.2.7.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.2.7.5. Source-specific recalculations

No source-specific recalculations have been done.

4.2.7.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

Table 4.7. Activity data and emission factors for bricks, roof tiles and lightweight gravel production

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Limestone consumption, kt																					
2.A.7.2a																					
Bricks	23.48	23.86	12.07	0.05	5.59	4.17	4.12	2.65	2.45	5.1	2.25	3.67	3.47	4.29	4.59	3.84	5.3	10.12	8.63	1.78	3.08
Roof tiles	NO	NO	NO	NO	NO	NO	NO	0.56	0.27	0.28	0.43	0.85	0.89	0.88	0.79	0.95	0.72	0.99	0.77	0.38	NO
2.A.7.2b																					
Lightweight gravel	NO	NO	NO	NO	NO	NO	NO	NO	8.29	8.55	9.46	11.44	11.16	13.4	14.18	12.65	14.87	11.89	8.84	NO	NO
Dolomite consumption, kt																					
2.A.7.2a																					
Bricks	4.14	4.21	2.13	0.01	0.99	0.74	0.73	0.47	0.43	0.9	0.4	0.65	0.61	0.76	0.81	0.68	0.94	1.79	1.52	0.31	0.54
Roof tiles	NO	NO	NO	NO	NO	NO	NO	0.1	0.05	0.05	0.08	0.15	0.16	0.16	0.14	0.17	0.13	0.17	0.14	0.07	NO
2.A.7.2b																					
Lightweight gravel	NO	NO	NO	NO	NO	NO	NO	NO	2.3	2.5	3.8	5.16	5.21	5.5	5.57	4.83	6.82	5.21	4.01	NO	NO
$EF_{limestone}$, t/t	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
$EF_{dolomite}$, t/t	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477	0.477

4.3. Chemical Industry (CRF 2.B)

4.3.1. Ammonia Production

4.3.1.1. Source category description

This category of the inventory includes the non-fuel emissions from ammonia production (Table 4.8). In Estonia there is only one ammonia production company- Nitrofert AS.

CO_2 emissions from ammonia production have decreased considerably since 1990, having the lowest values in 1993, 2002 and 2009. The decrease in the emissions during early 1990´s was caused by the transition from planned economy to a market economy after 1991 when Estonia became independent. This led to decrease in industrial production, and to an overall decrease in emissions from industrial processes between 1991 and 1993. In 1994 the economy began to recover and production started to increase, emissions stabilized till 2002 and 2003, when there was sudden decrease in emissions. In 2002 and 2003 there were reconstructions in Nitrofert AS that strongly affected production. The lowest point in production and also in emissions was in 2009. In 2009, Nitrofert AS temporarily stopped production at the beginning of February. In 2010, there was no production of ammonia in Estonia.

4.3.1.2. Methodological issues

Emissions of CO_2 will depend on the amount and composition of gas used in the technological process. It is assumed that all carbon will be emitted to air. In Estonia part of the CO_2 from ammonia production is used as a raw material for urea (carbamide) production and part of it is sold to food companies. This carbon will be stored only for a short time and therefore those emissions are also taken into account.

Methods

There are two different methods in the IPCC 1996 Guideline (Workbook page 2.14) for calculation of CO_2 emissions from ammonia production: Tier 1a and Tier 1b method. Estonia uses method Tier 1a in calculating CO_2 emissions from ammonia production (Annex 3, Table A.3.2_1).

According to the Tier 1a method:

$$\text{Emissions, kg} = \text{Consumption of gas } (m^3) \bullet \text{carbon content of gas } (kg/m^3) \bullet 44/12$$

where carbon content of natural gas is plant specific.

Emission factors

Emission factors were calculated by dividing CO_2 emissions from technological process with amount of ammonia produced. As activity data is received directly from plant and emissions are calculated based on amount of natural gas used and carbon content of gas provided by industry, the emission factors for calculations of CO_2 emissions from ammonia production are plant specific throughout time series. In Estonia, ammonia production emission factors are, depending on the year, between 1.243–1.446 t CO_2/tonne NH_3 produced (Table 4.8).

Activity data

The annual ammonia production figures 1990–2010 have been obtained from the production plants and presented in Table 4.8.

4.3.1.3. Uncertainties and time-series consistency

IPCC Tier 1 method was used in estimating the uncertainties of this category.

Since the activity data was prepared in cooperation with manufacturer, the rate of emissions is considered sufficiently precise. The activity data uncertainty was estimated at ±5% and emission factors uncertainty at ±10%.

4.3.1.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.3.1.5. Source-specific recalculations

No source-specific recalculations have been done.

4.3.1.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

Table 4.8. Activity data, emission factors and CO_2 emissions from ammonia production in 1990–2010

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2.B.1																					
Ammonia production, kt	294	270	140	55	180	201	203	206	211	199	177	183	47	98	202	213	211	202	209	23	NO
$EF_{ammonia}$, t/t	1.43	1.45	1.43	1.43	1.44	1.39	1.33	1.28	1.27	1.29	1.31	1.36	1.35	1.39	1.24	1.28	1.28	1.29	1.29	1.31	NO
CO_2 from ammonia production, Gg	420	391	200	79	259	280	269	264	267	258	231	248	64	137	251	272	272	260	271	30	NO
including																					
CO_2 for carbamide production, Gg	140	130	68	26	82	90	83	67	50	65	61	63	39	54	98	150	157	155	147	15	NO
CO_2 sold for food industry, Gg	2.75	2.67	1.36	0.23	0.45	1.66	1.76	2.14	2.32	2.64	4.16	6.83	1.89	3.2	6.05	6.05	7.07	7.10	7.77	1.05	NO

4.4. Other Consumption (CRF 2.D)

4.4.1. Source category description

This source category includes the NMVOC emissions from the pulp and paper (2.D.1) and food (2.D.2) industries. In addition, NOx, CO and SO_2 emissions from pulp and paper are reported under Other consumption. The non-fuel based CO_2 emissions from pulp and paper industry are estimated to be negligible in Estonia. All N_2O emissions from the pulp and paper and food industry are reported as fuel based emissions under CRF 1.

4.4.2. Methodological issues

NMVOC emissions from the pulp and paper and food industry are calculated by Estonian Environmental Research Centre. Activity data of the years 1990–1994 is obtained from the annual proceeding of Statistics Estonia “Industry” and of the years 1995–2010 from the electronic database on the website of statistical office. Emission factors are taken from the IPCC 1996 Guideline. All SO_2 emissions of different sulphur compounds are calculated as SO_2 equivalents.

4.4.3. Source-specific recalculations

NMVOC emissions from food and drink were corrected for the year 2009. The recalculation in 2009 was due to corrections in food and drink production data. Every year Statistics Estonia gives out initial data and they have a practice to correct statistical data for previous years.

4.4.4. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5. Consumption of Halocarbons and SF_6 (CRF 2.F)

In 2010, greenhouse gas emissions under the category CRF 2.F emissions of Consumption of Halocarbons and SF_6 amounted to 158.14 Gg CO_2 equivalent, which is about 0.77% of the total greenhouse gas emissions in Estonia.

Under this category, Estonia reports HFC emissions from all refrigeration and air conditioning equipment (CRF 2.F.1), HFC emissions from foam blowing and use of HFC-containing foam products (CRF 2.F.2), HFC emissions from fire extinguishers (CRF 2.F.3), HFC emissions from aerosols (CRF 2.F.4) and SF_6 emissions from electrical and other electrical equipment (CRF 2.F.8 and 2.F.9).

The consumption of Halocarbons and SF_6 in Estonia depends on import. F-gases are imported either in bulk by trade or industry for domestic productive consumption (manufacturing) – filling of newly manufactured products, refilling of equipment – or in imported preliminary and final products respective equipment already filled with F-gases.

The total emissions of F-gases have increased significantly since 1993 (see Table 4.9 and Figure 4.3), especially HFC emissions from refrigeration and air-conditioning equipment, which is the major source of halocarbons in Estonia (see Figure 4.4). The second largest source is foam blowing which shows relatively steady increase of emissions throughout the years, except 2 major decreases (in 2001 one of two big Estonian producers of One Component Foam replaced HFC-134a with HFC-152a, followed by the other producer starting from 2007. Due to much lower GWP of HFC-152a the emissions decreased suddenly in the corresponding years). All remaining sources are comparatively small emitters of fluorinated greenhouse gases.

Table 4.9. Actual emissions of HFCs, PFCs and SF_6, 1990–2010 (CO_2 equivalent Gg)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
HFCs	NO	NO	15.92	18.06	20.67	25.37	30.58	36.38	46.01	55.82	69.80	85.82	86.95	92.37	105.15	118.78	135.86	149.40	131.89	139.14	156.33
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.07	0.06	0.04	NO	NO
SF_6	NO	0.05	0.09	0.14	0.18	3.22	3.51	3.0	2.99	3.01	2.74	1.74	1.44	1.32	1.08	1.08	1.15	0.97	1.35	1.44	1.81
Total	**NO**	**0.05**	**16.02**	**18.20**	**20.85**	**28.59**	**34.09**	**39.38**	**49.00**	**58.83**	**72.55**	**87.56**	**88.39**	**93.69**	**106.23**	**119.9**	**137.09**	**150.43**	**133.28**	**140.58**	**158.14**

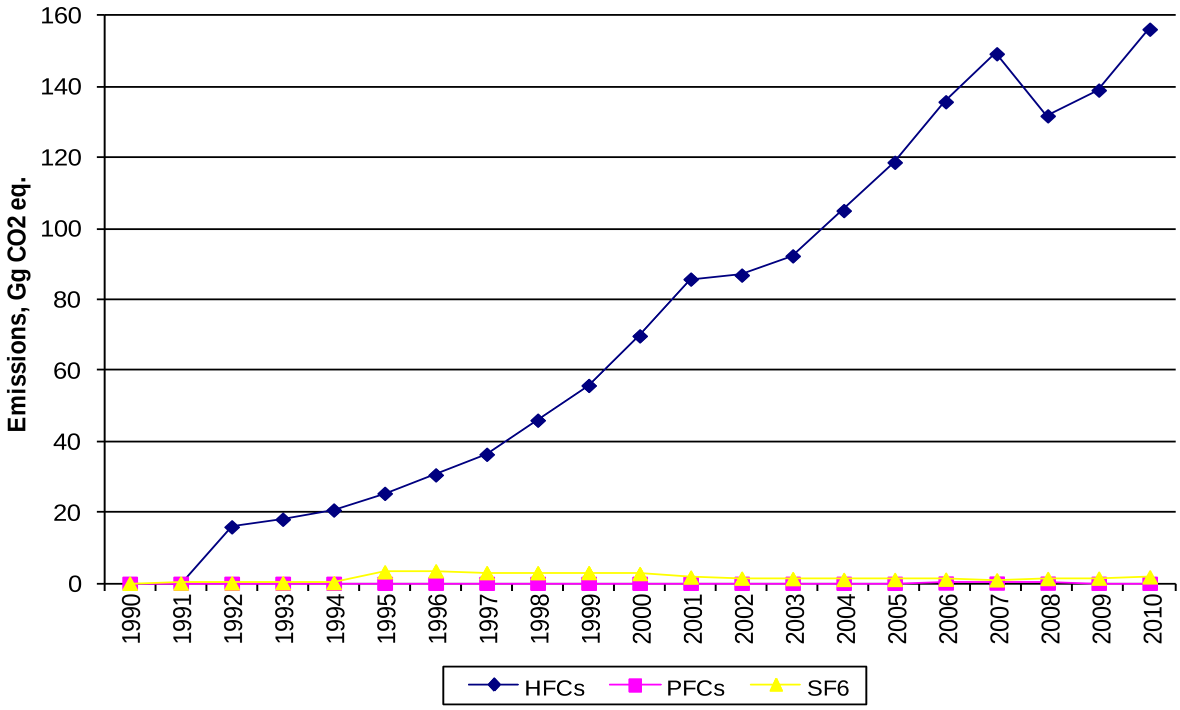

Figure 4.3. Actual emissions of HFCs, PFCs and SF_6, 1990–2010 (Gg CO_2 equivalent)

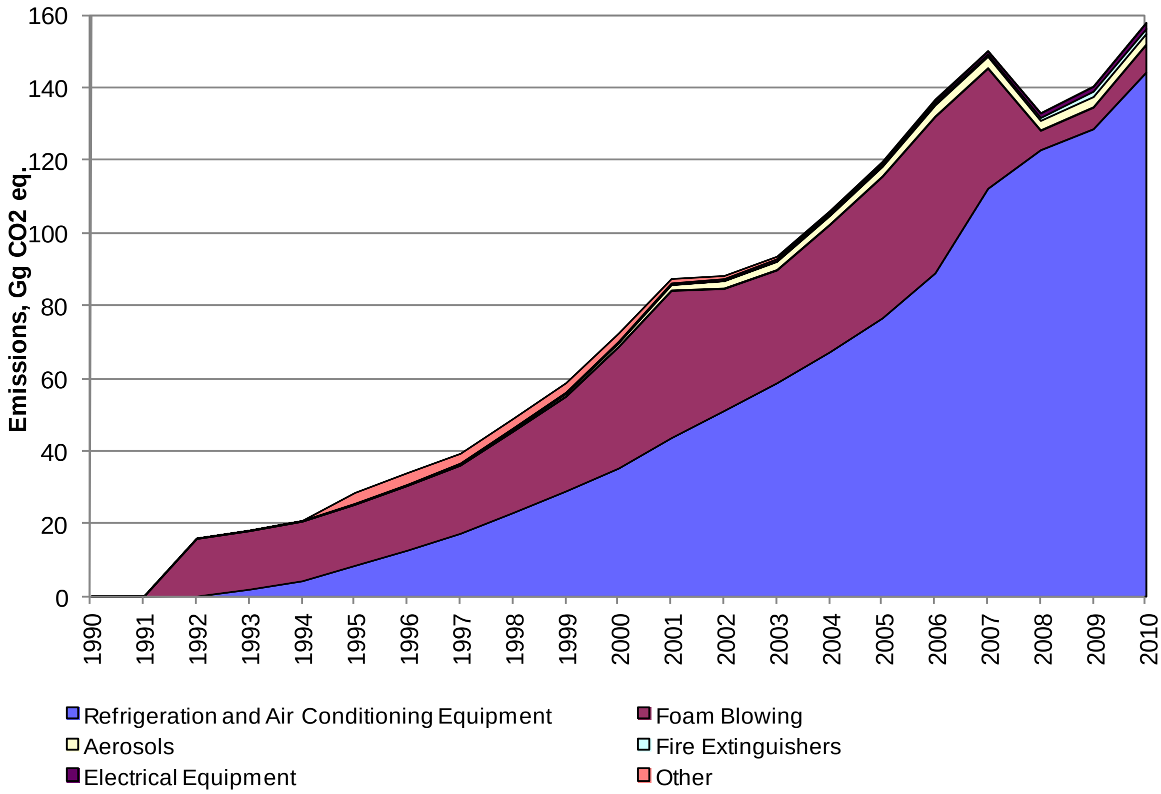

Figure 4.4. Actual emissions of F-gases by subcategory, 1990–2010 (Gg CO_2 equivalent)

In 2006, the first assessment of F-gas consumption in Estonia based on results from the Twinning Project EE2005/IB/EN/01 "Enhancing the capacity to reduce the emissions of fluorinated greenhouse gases in Estonia" (Twinning project between the Estonian Ministry of Environment and the German Ministry for the Environment, Nature Conservation and Nuclear Safety) was made. Within the project all sectors of possible F-gas consumption as described in the IPCC Guidelines for National Greenhouse Gas Inventories (2006 edition) were investigated. Experts had to start from zero with emissions estimation from Consumption of Halocarbons and SF_6. IPCC 2006 methodology was selected for Estonia due to it was appropriate with regard to the Estonian situation and the possibilities to get basic data. The 2006 Guidelines also allow for more complex modelling approaches, particularly at higher tiers[7].

The research has been bottom-up orientated. Manufacturers of and traders with F-gas containing goods, domestic and international suppliers of the Estonian market as well as consumers of such goods in industry and tertiary sector and the F-gas trade itself are the main sources of information, including experts from domestic and international companies, from associations, from academia and from public institutions (e.g. statistical office, car register, ship register etc.). Data collection and examination of data quality is carried out in a direct contact with the sources including visits at companies, factories etc. By this activity data, emission factors and emissions are determined methodologically as far as possible in a country specific way (Tier 2a and Tier 3 according to IPCC guidelines 2006).

Quality control of activity data, emission factors and data on measured emissions was made by the data collecting experts from the Estonian Environmental Research Centre.

4.5.1. Refrigeration and Air Conditioning Equipment

Refrigeration and Air Conditioning Equipment are responsible for about 91.26% of the Estonian F-gas emissions (144.32 Gg CO_2 equivalents). The big sub sectors are:

a) Domestic Refrigeration (fridges and freezers for domestic use),
b) Commercial Refrigeration (refrigeration units for supermarkets and smaller shops, restaurants etc.),
c) Transport Refrigeration (refrigerated vehicles and reefer containers),
d) Industrial Refrigeration (refrigeration units in the food and other industries),
e) Stationary Air Conditioning (heat pumps and room air-conditioning systems),
f) Mobile Air Conditioning (AC systems for passenger cars, trucks, buses, ships, railcars, wheel tractors/mobile machinery).

4.5.1.1. Domestic Refrigeration

4.5.1.1.1. Source-category description

Refrigerators (fridges and freezers) for domestic use are not manufactured in Estonia but were imported from 1993–2009 (new and second hand). To some degree HFC-

[7] Justification of the use of the methodology described in the 2006 IPCC Guidelines was included as the recommendation of the UNFCCC review team.

134a is used as refrigerant and as foam insulating gas. HFC-134a as refrigerant was introduced by industry at the end of 1993 as replacement for CFC-12. In the following years, its replacement by R600A (isobutane) started in some countries (Germany) but not in all countries in Europe and North-America. According to Estonian experts there was no import of domestic refrigerators with refrigerant HFC-134a in 2010. The share of HFC-134a in the Estonian stock of fridges/freezers is estimated 12.5% (without new equipment in 2007–2010).

4.5.1.1.2. Methodological issues

In 2010 Estonia had – according to the statistical office – about 609 100 households. The number of domestic refrigerators is estimated at 591 990 and the number of newly imported fridges/freezers in 2010 is estimated at 57 640 (data from importers and EES Ringlus [Estonian Association for Recycling of Electrical and Electronic Equipment]). The share of fridges/freezers with HFC-134a in the stock is estimated by Estonian experts at 48 470 (12.5% without new equipment in 2007–2010) à 150 g HFC-134a refrigerant, in total 7 270.5 kg HFC-134a. In newly imported/bought systems in 2007–2009 – annually 172 265 units – some 1% contains HFC-134a, in total 258 kg HFC-134a. Lifetime of domestic refrigeration equipment in Estonia is calculated by industry at not less than 15 years.

Emission factors: EES Ringlus has reported in previous years that about 5% of fridges collected for recycling contained HFC-134a as refrigerant. In 2011, EES Ringlus estimated that about 6% of the original charge has already emitted by the time that fridges are collected for recycling. The annual operating emission rate is, following this information, 0.4%/year (EF_{op}). This country specific emission factor is within the value range given by IPCC guidelines, 0.1–0.5% (IPCC 2006, table 7.9, page 7.52 and IPCC 2000, table 3.22, page 3.106).

The number of refrigerators decommissioned per annum can be calculated (based on 15 years lifetime) at 37 353 from which 14 545 are collected by the recycling companies and sent for treatment to foreign countries; remaining 22 808 are disposed without refrigerant recovery. According to EES Ringlus experts estimates, this number in reality is not as high and could be maximum 11 400 units. If we assume (i) that 5% of these 11 400 non-collected refrigerators contain R-134a, and (ii) that in each of them 94% of the original 150 gram charge is left (6% already emitted), the disposal HFC-134a emissions are 80.4 kg ($EF_{disposal}$ = 100%).

Method according to IPCC guidelines 2006: Tier 2a with country specific EF.

- Country specific average refrigerant charge per unit: 150 g R-134a
- Country specific operating emission factor: 0.4%

The total 2010 amount of R-134a emissions is 0.11 tons (stock emissions: 30.12 kg, end-of-life emissions: 80.37 kg) representing 0.144 Gg CO_2 equivalent.

4.5.1.1.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the 2006 IPCC Guidelines.

The data are based on direct information from industry, so that the UN of the activity data on the number of units (stock, annual importation, annual decommissioning) can be estimated to be relatively low (± 10%). The UN of the emission factor is assessed ±

~10%, so that the combined UN of the emissions (operating and disposal) is estimated to be ± 15%.

4.5.1.1.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.1.1.5. Source-specific recalculations

The leakage rate of domestic refrigerators was reviewed as the recommendation of the UNFCCC review team. According to the new information received from EES Ringlus, the average refrigerant loss of the fridges collected for recycling is 6% of the original charge. Based on 15 years lifetime, the annual operating emission rate is 0.4%/year (EF_{op}). Emissions from stock were recalculated accordingly from 1995–2009.

Also, investigation was carried out over time series. The results indicated that refrigerant HFC-134a was introduced by the industry at the end of 1993. As there is no backdating information available about Estonia, the German percentages of the years 1993–1994 were applied to Estonia. According to lifetime of domestic refrigerators, disposal emissions did not occur before 2006.

4.5.1.1.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.2. Commercial Refrigeration

4.5.1.2.1. Source-category description

Commercial refrigeration and its main sub sector, supermarkets, is one of the big application sectors of fluorinated refrigerants and emissions in Estonia. This category distinguishes between:

- Supermarkets and other food retail shops with mostly on-site assembled centralized systems; main HFC refrigerant: R-404A.
- Small shops and institutions with comparable refrigeration units (only one compressor and/or less than 15 kg refrigerant; this sub sector includes small shops with less than 3 kg refrigerant); HFC-refrigerants in use: mostly R-404A and R-134a.
- Refrigeration equipment for restaurants, hotels, pubs, canteens etc. (mostly small stand alone equipment for kitchens and cold rooms, 0.75 kg average refrigerant charge); HFC-refrigerants: 1/3 R-404A, 2/3 R-134a.
- Stand alone or plug-in equipment (mostly vending machines for shops, filling stations etc., on average 250 g R-134a/device).

The commercial refrigeration sector is dominated by the refrigerants R-404A, which make 90.2% of the 2010 HFC stock (mostly used in supermarket systems) and R-134a (about 8.7%, mainly used in vending machines, small shops and restaurants). Other HFC refrigerants (R-407C, R-410A, the R-152a containing mixture R-401A or the R-125 and R-134a containing mixture R-422A) are only of less importance.

Estonian refrigeration equipment in general is quite modern because the change from the formerly so called open market system to the present-day supermarket system occurred during the last 15 years. The biggest sector with older equipment including second hand cabinets is the small shop sector.

The 2010 number of food retail supermarkets in Estonia – hypermarkets, supermarkets, discounters, department stores – was according to the Estonian Traders Association about 600, the number of small commercial and public customer orientated service institutions with refrigeration equipment (like small shops, medical institutions, hotels, restaurants, canteens etc.) according to other statistical sources more than 10 000. This includes according to expert calculation from refrigeration service companies about 7 000 small shops with less than 3 kg refrigerant charge plus about 3 500 hotels, bars, restaurants, pubs, canteens etc. with 0.75 kg refrigerants on average. The number of vending machines for cooling of beverages and other goods (stand alone equipment) was calculated at about 15 000 units.

4.5.1.2.2. Methodological issues

Supermarkets: The refrigeration systems of supermarkets are maintained by specialised service companies. Most of them install and service the systems, some are specialised on service activities. Nine service companies provided the activity data (stock, new installations in 2010, refilling data) on the HFC refrigerant consumption of their clients in the supermarket sector. One supermarket chain has its own service management. In addition, three service companies provided 2009 stock data and new installations had to be added by their estimations. The 2010 stock data compilation from the service companies (59.5 tons HFC) had to be completed in two cases by the assessment of the stock (additional 6 tons or 9% of the sum of 65.4 tons). This assessment was based on the refilling data. In this case the amount of HFC used for refilling is estimated to be in the order of 10% of the stock. The assessment is conservative and low with the aim not to overestimate the stock (the country specific emission rate EF_{op} is calculated higher [15%], see below).

According to Estonian experts the service companies covered – in terms of quantity of refrigerants – 90% of the supermarket HFC consumption (except refrigerant R-422A, 100% is assumed to be reported). Thus 10% was added resulting in a total amount of 71.933 tons of HFC for the 2010 stock of supermarkets.

Small shops: Eight service companies (seven of them also active in the supermarket sector) submitted activity data about smaller shops. In one case the stock data had to be estimated by the inventory compilers (same method as with the supermarkets, based on a low refilling ratio of 10%). Three service companies provided only stock data and new installations had to be added by service company’s and inventory compilers estimations. In this sub sector also a 10% surcharge was added (662 kg) resulting in a total stock of 7.277 tons HFC.

Restaurants etc.: The companies installing and servicing refrigeration equipment for restaurants, canteens and similar institutions did not provide stock data. The respective stock was estimated based on a number of 3 500 possible clients with on average 0.75 kg refrigerant quantity resulting in about 2.6 tons HFC-refrigerant. The percentage of R-134a is estimated by Estonian experts at 2/3 (1.75 tons), the percentage of R-404A with 1/3 (0.875 tons).

The number of vending machines in Estonia (15 000 à 250 g refrigerant) was extrapolated on basis of data from the two biggest manufacturers of beer and other beverages delivering such machines to Estonian shops. The HFC-charge amounts to 3.712 tons R-134a and 0.038 tons of R-404A.

The lifetime of refrigeration systems for supermarkets and small shops including kitchen systems in Estonia is according to experts from the mentioned companies on average about 15 years (vending machines shorter, 5–10 years). As 1993 was the starting point of using HFC-134a in commercial refrigeration, based on 15 years lifetime, first decommissioning emissions occurred in 2008. Amount of HFC-134a filled in new equipment in 1995 was decommissioned according to 15 years lifetime in 2010.

Emissions: The service companies were asked for 2010 stock data and refilling data of their clients. In 2010, more detailed research of refilling ratios was carried out in the supermarket sub sector. Seven service companies provided complete stock and refilling data with total refilling ratio 12.9%. Complete 2010 stock (25.7 tons of HFC-404A) and refilling data was available about five supermarket chain systems – refilling ratio 15.3%. When all companies are considered, amongst them also such ones without refilling data and incomplete stock, refilling ration in commercial refrigeration sector is 10%.

Normally emissions are higher than the refilling ratio. A certain fraction of emissions is never replenished by refilling. Therefore an EF_{op} of 15% is applied to all sectors covering emissions from operating and servicing, except vending machines. The vending machines in Estonian market are modern and should be very tight; the emission rate EF_{op} is estimated at 1.5%/year. These emission factors are in the range of the IPCC guidelines 2006 (10–35% for medium and large commercial refrigeration and 1–15% for stand alone commercial refrigeration)[8].

The EF_{manu} (filling of new equipment) is estimated at a low value of 0.5%, which is likewise in accordance with the IPCC Guidelines 2006 and IPCC Good Practice Guidance. The EF_{disp} (disposal loss factor) is estimated at a value of 50%.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{manu} (filling): 0.5%.
- Country specific operating emission factor EF_{op}: 15% (vending machines: 1.5%)
- Country specific disposal emission factor EF_{disp}: 50%.

The total quantity of HFC filled into new commercial refrigeration equipment in 2010 amounts to 6.179 tons (5.554 tons R-404A and 0.023 tons R-422A). The manufacturing emissions from this filling are 31 kg. The HFC stock amounts to 85.585 tons (77.155 tons R-404A, 7.42 tons R-134a and small amounts of R-407C, R-410A, the R-152a containing mixture R-401A and the R-125 and R-134a containing mixture R-422A). The stock emissions are in total 12.331 tons. The biggest part of them is HFC-404A (11.568 tons) and HFC-134a (0.612 tons), the emissions of the other HFC are only 151 kg. Amount of HFC-404A and HFC-134a filled in new

[8] Information about the development of the PLF for commercial refrigeration was included as the recommendation of the UNFCCC review team.

equipment in 1995 was decommissioned according to 15 years lifetime in 2010. The amount of fluid remained at products at decommissioning amounts to 3.672 tons of HFC-404A and 0.211 tons of HFC-134a. The disposal emissions are in total 1.942 tons (1.836 tons of HFC-404A and 0.105 tons of HFC-134a).

The CO_2 equivalent of all 2010 HFC emissions is 45.038 Gg (45 038 tons).

4.5.1.2.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the 2006 IPCC Guidelines.

The UN of the three activity data “Filled in new manufactured products”, “HFC stock in operating systems” and “Remained in products at decommissioning” is estimated ± 20% (0.2). The combination of this value with the respective emission factors (± 10%) results in the UN of manufacturing, operating and disposal HFC emissions of ± ~22%.

4.5.1.2.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.1.2.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.1.2.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.3. Transport Refrigeration

4.5.1.3.1. Refrigerated Vehicles

Source category description

By 31.12.2010, 1 006 refrigerated vans and trucks and 1 052 refrigerated trailers were registered in Estonia. Most of these vehicles are second hand vehicles imported from Western Europe. Approximately half the refrigeration units fitted to the imported second-hand trucks and trailers are empty and are charged with refrigerant within the country. Only a small number of new vans are fitted with refrigeration units first in Estonia, and as a consequence, first-filled in the country. The refrigerants in use are R-134a in case of vans and smaller trucks, and the blend R-404A in case of bigger trucks and of trailers. Refrigeration units of older vehicles still operate with HCFC R-22.

Methodological issues

The Estonian Motor Vehicle Registration Centre provided a list of all refrigerated vehicles registered at the end of 2010, subdivided in weight classes (N1, N2, and N3 according to 2001/16/EC), makes, models and production years dating back to 1995 and beyond.

Information on the types of refrigeration units of the Estonian vehicles, the HFC-types they are charged with, the refrigerant charges, the emissions and the frequency of refilling based on findings of the 2006/2007 investigation (information provided by the two biggest service companies for refrigerated vehicles, both linked to the leading international manufacturers of refrigeration units for trucks and trailers).

Investigation was conducted in attempt to improve the estimation on the number of the second hand vehicles with empty refrigeration units. It concluded that there is no better data available.

The share of older refrigeration units with non-HFC-refrigerants was estimated max. 7%. Vans and smaller trucks (class N1 and half of class N2 according to 2001/16/EC) run R-134a systems (average charge 2.0 kg/unit), bigger trucks (half of class N2 and the class N3) run R-404A systems (average charge 5.8 kg/unit). For trailers an average charge of 8.0 kg R-404A is supposed.

The Estonian experts estimate the emissions at first domestic filling (empty units of imported new and second-hand vehicles) at 1%, which is in accordance with the IPCC Guidelines 2006 (IPCC 2006, table 7.9, page 7.52) and IPCC Good Practice Guidance. These emissions are equated to the CRF emission category “emissions from manufacturing”. The annual losses from the operating systems (emissions from stocks) including service emissions on refilling amount to average 30% (EF_{op} – operating emission factor) of the refrigerant stock in the refrigerated vehicles. This country specific emission factor is within the value range given by IPCC guidelines (IPCC 2006, table 7.9, page 7.52) and IPCC Good Practice Guidance.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific average refrigerant charges per unit: weight classes N1 and half N2: 2 kg; N3 and half weight class N2: 5.8 kg; trailers: 8.0 kg.
- Country-specific manufacturing emission factor: 1%
- Country-specific operating emission factor: 30%.

The total 2010 quantity of HFCs filled in empty units of refrigerated vehicles in Estonia amounts to 132.7 kg R-134a and 1 417.8 kg R-404A, the “manufacturing” emissions on these first fills are 1.33 kg R-134a and 14.2 kg 404A. The HFC stock in refrigerated vehicles amounts to 774 kg R-134a and 14 250.8 kg R-404A; the stock emissions are 232.2 kg R-134a and 4 275.24 kg R-404A. The CO_2 equivalent of all 2010 HFC emissions is about 14.29 Gg.

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the 2006 IPCC Guidelines.

The UN of the two activity data “First fill of empty systems” and “HFC stock in operating vehicles” is estimated ± 8.5%, which is the combination of the individual UN of a) total registrations (new or operating) by weight categories in 2009 (± 1%), b) refrigerant charges (± 6%) and c) refrigerant split into R-134a and R-404A (± 6%).

The combination of the UN of new fill or of stock (± 8.5%) with the UN of the respective emission factors (± 5%) results in the UN of both manufacturing and operating HFC emissions of ± 10%.

Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

Source-specific recalculations

The investigation over time series was made. Emissions were estimated for years 1993–1994 due to HFCs (HFC-134a and R404A) have been used since 1993 as refrigerants in refrigerated vehicles.

Activity data in 2009 was recalculated due to more detailed data from service companies for refrigerated vehicles was available.

Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.3.2. Reefer Containers

Source category description

Reefer containers are being transported on sea ships around the world, and HFC emissions from their refrigeration systems do not occur inside a particular country. As a consequence, it is plausible to attribute the emissions of the worldwide reefer container fleet to a particular nation according to the share of this country in world trade. Estonia’s share in the world trade amounted according to the Statistical Office to 0.1% (0.09%), so that it is responsible of 0.09% of HFC stock and HFC emissions of the worldwide reefer container fleet.

Methodological issues

The starting point of the estimation is not country-specific but worldwide data. As this data for the 1995–2006 period was already available in the German F-gas inventory, own research on worldwide HFC stock and emissions was not necessary. Only the share of Estonia in the world trade had to be identified.

The worldwide HFC stock (German F-gas inventory) was estimated in three steps:

1. Annual number of 20 feet units (new manufactured, decommissioned, total stock).
2. Refrigerant charge per set (6 kg of 134a or 4 kg of 404A).
3. HFC-split between R-134a and R-404a (80% to 20%).

The emissions of R-134a and R-404A are calculated by means of emission factors. The operating emission factor is 10% (UNEP, 2002). The disposal emission factor is 30%, which lies at the upper boundary of the range given in IPCC Good Practice Guidance. (Manufacturing emissions are not distributed by world trade shares but are estimated in the (few) countries of container manufacturing).

Information about the 2010 share of Estonia in the world trade (both export and import) was given by Statistics Estonia.

Data on the worldwide reefer production are annually published by the information service *World Cargo News*.

Method according to IPCC Guidelines 2006: Tier 2a with international default EF.

The 2010 HFC stock emissions from reefer containers attributable to Estonia are 406.87 kg R-134a (528.93 t CO_2 equivalent) and 73 kg R-404A (238 t CO_2 equivalent). The 2010 emissions from the decommissioning of reefer containers attributable to Estonia are 78.1 kg R-134a (101.57 t CO_2 equivalent). The total is 868.49 t or 0.87 Gg CO_2 equivalent.

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the 2006 IPCC Guidelines.

The UN of the basic activity data “worldwide HFC stock” is the same as in the German inventory: ± 8.4%, which is the combination of the individual UN of a) number of units (± 3%), b) HFC-charges (± 5%), c) HFC-split (± 6%).

The UN of the Estonia share in world trade is estimated ± 3%, and the UN of the operating emission factor ± 5%. The combined UN of the HFC emissions (both 134a and 404A) can be calculated ± 10.2%.

Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

Source-specific recalculations

The investigation over time series was made. Emissions were estimated for years 1993–1994 due to HFCs have been used since 1993 as refrigerants in reefer containers. HFC-134a has been the most commonly used refrigerant since 1993. R404A has been used since 1997.

According to product lifetime of 14 years, first decommissioning emissions of R-134a occurred in 2007.

R-134a emissions were recalculated in 1995–2005 and 2007–2008 due to more detailed data for reefer containers was available.

Source-specific improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.4. Industrial Refrigeration

4.5.1.4.1. Source-category description

Industrial refrigeration is a big application sector of fluorinated greenhouse gases, mainly of HFC R-404A. The dominant application is the food industry (fish, meat, dairy, beverage industries, breweries, etc), which is Estonia's most important industrial sector. The food industry's dynamic may be exemplified by the fact that its output has tripled in the 1995–2005 decade (Ministry of Economic Affairs and Communications, 2006). The HFC consumption of other industries (e.g. chemical industry) is comparably small.

In contrast to commercial refrigeration, in industrial refrigeration non-HFC/HCFC refrigerants – especially NH_3 – play a major role than HFC. With regard to the HFC stock R-404A is the prevailing refrigerant with about 93%. Other HFC refrigerants (R-134a, R-407C, R-507A, R-410A, the R-152a containing mixture R-401A or the R-125 and R-134a containing mixture R-422A) are of minor importance.

The refrigeration systems are very often served by bigger service companies; however, self-maintenance and cooperation with smaller (locally based) service companies is of more importance than in the supermarket and food retail sector.

4.5.1.4.2. Methodological issues

Information on potential HFC users in the food and other industries was compiled in cooperation with experts from refrigeration service companies specialized on industrial application. Food industry's basic data can be found in the statistics of the Veterinary and Food Board (VTA; cf. www.vet.agri.ee) because companies wishing to handle foodstuff must be approved by the VTA. Approved enterprises: fish industry – about 70 plants with chilling/freezing equipment; meat industry – 100 plants; dairy industry – 40 plants.

Twelve service companies provided the activity data (stock, new installations in 2010, refilling data) on the HFC consumption of their industrial clients. In two cases the service companies could not report on 2010 stock data. These data had to be completed by our assessment (stock is assumed to be 10 times higher than the annual refills; same method as with the supermarket sector).

In addition to the service companies, approx. seventy companies from the fish, meat, dairy, bakery, beverages and other food-industries, and from several non-food industries (including e.g. ice rinks) were directly interviewed by dedicated questionnaires about their HFC refrigerant consumption.

As the refrigerant stock based on the data from service companies and directly interviewed industry covers the total stock to a certain part only, the remaining stock had to be estimated by us in cooperation with national sector experts. The thus assessed percentage of HFC stock in industrial refrigeration is 19.9 tons or 40.1% of the total HFC stock (49.7 tons, reported and assessed).

The average lifetime of industrial refrigeration systems in Estonia is about 15 years or more, according to experts from the mentioned companies. As 1993 was the starting point of using HFC-134a in industrial refrigeration, based on 15 years lifetime, first decommissioning emissions occurred in 2008. Amount of HFC-404A and HFC-134a filled in new equipment in 1995 was decommissioned according to 15 years lifetime in 2010.

Emissions: The service companies and the industrial companies surveyed by questionnaires were asked for 2010 stock and refilling data. Complete stock and refilling data for HFC-404A are available for 25 individual companies in the fish, meat, milk and other industry, with an HFC-404A stock of 7.088 tons. Detailed research indicated that the refilling ratios of the individual companies range from 0 to 41%. The average refilling rate is 10.7%. Six service companies provided complete stock (4.722 tons of HFC-404A) and refilling data with total refilling ratio 16.5%.

As in the case of commercial refrigeration the emission factor (EF_{op}) for the stock is country specific, i.e. is based on the average refilling ratio in the industry, with 14%. This emission factor is in the range of the IPCC 2006 Guidelines and IPCC Good Practice Guidance (7-25% of the stock).

The EF_{manu} (filling of new equipment) is estimated at a low value of 0.5%, which is likewise in accordance with the IPCC Guidelines 2006 and IPCC Good Practice Guidance. The EF_{disp} (disposal loss factor) is estimated at a value of 50%, which is higher than the range given in IPCC Good Practice Guidance, 10 to 20 percent.

Method according to IPCC Guidelines 2006: Tier 2a with country specific EF.

- Country specific EF_{manu} (filling): 0.5%.
- Country specific operating emission factor EF_{op}: 14%.
- Country specific disposal emission factor EF_{disp}: 50%.

The total quantity of HFCs filled into new industrial refrigeration equipment in 2010 amounts to 2.262 tons (1.114 tons HFC-143a, 0.959 tons HFC-125, 0.182 tons HFC-134a and 0.007 tons of HFC-32). The manufacturing emissions from filling are 11.311 kg. The HFC stock amounts to 49.704 tons (24.256 tons HFC-143a, 21.329 tons HFC-125, 3.597 tons HFC-134a, 0.52 tons HFC-32 and small amount of HFC-152a). The stock emissions total 6.959 tons. The biggest parts of them are HFC-143a (3.396 tons), HFC-125 (2.986 tons) and HFC-134a (504 kg); the emissions of the other HFCs are only 73.053 kg. Amount of HFC-404A and HFC-134a filled in new equipment in 1995 was decommissioned according to 15 years lifetime in 2010. The amount of fluid remained at products at decommissioning amounts to 3.12 tons of HFC-404A and 0.016 tons of HFC-134a. The disposal emissions are in total 1.568 tons (1.56 tons of HFC-404A and 0.008 tons of HFC-134a).

The CO_2 equivalent of all 2010 HFC emissions is 27.099 Gg (27 099 tons).

4.5.1.4.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the 2006 IPCC Guidelines.

The UN of the three activity data “Filled in new manufactured products”, “HFC stock in operating systems” and “Remained in products at decommissioning” is estimated ± >25% (26%). This high value mainly results from the high share of estimations in the determination of total HFC stock. The combination of this value with the UN of the respective emission factors (± 15%) results in the UN of emissions of ± 30%.

4.5.1.4.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.1.4.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.1.4.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.5. Stationary Air Conditioning

4.5.1.5.1. Heat Pumps

Source category description

The use of heat pumps with HFC refrigerants – ground and air heat pumps – started in Estonia in 1993. Ground heat pumps generally operate with HFC-407C, air heat pumps with HFC-410A. In general, heat pumps are imported to the country and already charged with refrigerant. Only a small number of ground heat pumps was manufactured and filled with refrigerant in Estonia itself.

Methodological issues

The leading experts of the Estonian Heat Pump Association provided information on heat pumps in Estonia. In order to avoid double counting, the classification of heat pumps on the one hand and stationary respective room air conditioning systems on the other hand was discussed together with experts from the Estonian Refrigeration Association. According to the experts the stock of installed heat pumps in Estonia amounts to approx. 48 996 systems in 2010 (6 388 ground, 41 905 air and 703 other heat pumps), 10 376 of them were installed in 2010. According to the experts 30 ground and 95 air HP went for decommissioning in 2010. The average charge was estimated at 2.0 kg for ground (and other HP), 1.0 kg refrigerant for air HP. The discussion with Estonian experts resulted in emission factors for manufacturing (EF_{manu}) of 2.0%, which lies above the value range proposed in IPCC Guidelines 2006 and IPCC Good Practice Guidance (0.2–1%); for operating systems (EF_{op}) of 2.5%, which is in accordance with the IPCC Guidelines 2006 (IPCC 2006, table 7.9, page 7.52) and IPCC Good Practice Guidance. The disposal emission factor is 30.0%, which lies in the upper part of the range proposed in IPCC Good Practice Guidance (20–30%).

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific EF_{manu}: 2%
- Country-specific EF_{op}: 2.5%
- Country-specific EF_{disp}: 30%.

The domestic consumption filled in new ground HP is 204 kg R-407C, the manufacturing emissions 4.08 kg R-407C. The 2010 operating stock amounts to 14 182 kg R-407C (ground and other HP) and 41 905 kg R-410A (air HP). The 2010 operating emissions total 354.55 kg R-407C and 1 047.63 kg R-410A. The amount of fluid remained in HP at decommissioning was 60 kg R-407C and 95 kg R-410A. The 2010 disposal emissions in total 18 kg R-407C and 28.5 kg R-410A.

All global warming emissions together amount to 2 430.865 t CO_2 equivalent (2.43 Gg).

Uncertainties and time-series consistency

Öko-Recherche experts assessed the emissions uncertainty (UN) pursuant to approach 1 of the 2006 IPCC Guidelines. The data on heat pumps are deemed precise because the relevant associations, companies and experts for heat pumps and refrigeration systems in Estonia, provided them.

The UN of the three activity data “Filled in new manufactured products”, “HFC stock in operating systems” and “Remained in products at decommissioning” is estimated at ± 9%. The emission factors are estimated ± 5%. The combination of the UN of the three activity data with the UN of the emission factors results in the UN of the HFC emissions of ± 10.3%.

Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

Source-specific recalculations

No source-specific recalculations have been done.

Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.5.2. Stationary and Room Air-Conditioning

Source category description

Stationary and room air-conditioning systems including chillers, ventilation and split systems are generally imported. Split systems are imported with HFC charge, newly installed chillers and ventilation systems are first-filled inside the country. In these cases emissions from filling (manufacturing) have to be considered. Refrigerants in use for chillers are HFC-134a and the blend R 407C, for ventilation systems and split systems the blends 407C and R 410A.

Methodological issues

The 2010 newly installed systems, the total 2010 equipment stock, the refrigerant charges by weight and HFC types, and the EF for domestic manufacturing and operating stock were determined in cooperation with the experts from the Estonian Refrigeration Association and companies (manufacturers, traders, service companies) belonging to this association. As mentioned in the heat pump section, the heat pumps on the one hand, and stationary and room air conditioning systems on the other hand were discussed together with the Estonian Heat Pump Association to avoid double counting. The interviews revealed for 2010 the following numbers of operating systems: 636 chillers, 4 350 ventilation systems and 63 750 split systems ("mini-splits"). The EF_{manu} (first filling loss) was established at 20g/system for chillers (0.019%) and 40g/system (factor: 0.24%) for ventilation systems, the EF_{op} (Product Life Factor) at 1% (chillers), 10.5% (ventilation systems) and 2% (split systems). Chillers and split systems are industrially manufactured and tighter than ventilation systems that are assembled on site. Although the emission factor of chillers estimated by the national experts is deemed too low compared with values discussed in other countries, there is currently no more reliable data available. Emissions factors of ventilation systems and split systems are in the range of the IPCC 2006 Guidelines (IPCC 2006, table 7.9, page 7.52). The country-specific emission factor used for disposal (EF_{disp}=30%), is higher than the range proposed in IPCC Good Practice Guidance (5–20%).

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific EF_{manu}: 0.019% (chillers) and 0.24% (ventilation);
- Country-specific EF_{op}: 1% (chillers), 10.5% (ventilation) and 2% (split)
- Country-specific EF_{disp}: 30%.

The operating stock amounts to 99.531 t R-134a, 60.624 t R-32 and 62.922 t R-125. Operating emissions: 4.373 t R-134a, 2.795 t R-32, 2.948 t R-125. As 1995 was the starting point of using HFCs in stationary air-conditioning equipment, first decommissioning emissions occurred in 2010. The amount of fluid remained at products at decomissioning amounts to 2.077 t R-134a. Disposal emissions: 0.623 t R-134a.

All global warming emissions together amount to 16.584 Gg CO_2 equivalent (16 584 t CO_2 equivalent).

Uncertainties and time-series consistency

Öko-Recherche experts assessed the emissions uncertainty (UN) pursuant to approach 1 of the 2006 IPCC Guidelines. The relevant associations, companies and experts in Estonia very roughly estimated the data on stationary AC systems, especially on emission factors of split systems and chillers.

The UN of the activity data HFC consumption and stock is estimated at ± 15%. The UN of the ventilation emission factors is ± 10%. The UN of the EF for chillers and split systems are more uncertain (± 26%); they are supposed to be too low. The combination of the UN of stock/consumption with the UN of the (given) emission factors results in the UN of the HFC emissions of ± 30% (chillers, splits), and ± 18% (ventilation systems).

Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

Source-specific recalculations

No source-specific recalculations have been done.

Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.6. Mobile Air Conditioning

4.5.1.6.1. Passenger Cars

Source category description

In 2009, there were about 552 664 passenger cars in traffic register of Estonia. In Western Europe systematic air-conditioning of passenger cars with the refrigerant HFC-134a had started in 1994. As 360 900 vehicles of the Estonian passenger cars have been manufactured from 1994 onwards approx. 66% the vehicles are potentially air-conditioned. Equipment of these younger vehicles with air-conditioners is high – reaching over 90% in most recent years. The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on car makes and models. The refrigerant charge of passenger car MAC systems ranges from 0.39 kg to 1.24 kg, the emission rate is estimated 10%.

Methodological issues

The Estonian Motor Vehicle Registration Centre provided a list of all passenger cars registered at the end of 2010, subdivided in production years (dating back to 1994 and beyond). No official data about air conditioning were obtainable.

MAC data depends on specific car models. While making the 2006 investigation the experts were facing the problem that the essential information for the estimation of the HFC stock in the cars of Estonia was available only for the most recent registration year. Thus a model for estimating the MAC data for the registration years 1994–2005 was elaborated and applied. This model was based on the fact that the predominant origin of the Estonian cars is Western Europe (Germany is the biggest source of second hand cars in Estonia), suggesting the conjecture that the average MAC data of the Estonian car park does not significantly differ from the analogous West European figures. In order to validate this hypothesis the quantitative model composition of the Estonian registration year 2006 was compared with the quantitative 2006 model composition of the German car park. As a result it emerged that the Estonian average figures indeed only marginally deviate from the German ones.

This substantial congruence in the 2006 MAC figures made the assumption plausible that such congruence also exists for the previous and the next registration years. Consequently, the German average figures were applied to respective registration years in the Estonian car park. This approach allows that the individual Estonian registration years do not need to be divided into the numerous models they consist of. The Estonian MAC quotas are considered equal to the German MAC quotas, the Estonian MAC charges are considered 2% smaller than the analogous German charges.

The emissions from the refrigerant stock in the car park are estimated applying the leakage rate established in the 2003 EU study (Schwarz & Harnisch, 2003), which the authors of this study claim to be representative of EU countries.

Different types of vehicles have different product life factor (PLF). PLF for different types of vehicles (passenger cars, trucks, buses, ships, railcars, wheel tractors and mobile machinery) that have mobile air conditioning is calculated as follows: actual emissions from stocks / amount of fluid in operating systems (average annual stocks) • 100. Total PLF for mobile air conditioning category is calculated as follows: total actual emissions from stocks / total amount of fluid in operating systems (average annual stocks) • 100.[9]

Method according to IPCC Guidelines 2006: Tier 2a with Europe specific determination of EF.

- Country-specific average refrigerant charge: 613 grams.
- Emission factor: 10%, which is in accordance with the IPCC Guidelines 2006 (IPCC 2006, table 7.9, page 7.52) and IPCC Good Practice Guidance.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.

The total HFC-134a stock in passenger car MACs in Estonia amounts to 130 tons in the year 2010. The HFC-134a emissions from the Estonian passenger car fleet in 2010 total 13 017 kg (10%), the CO_2 equivalent of which is 16 923 tons.

The amount of HFC-134a in the passenger cars MACs disposed in 2010 was estimated 10 013 kg. Disposal emissions from the Estonian passenger car fleet in 2010 total 5 007 kg (EF=50%), the CO_2 equivalent of which is 6 509 tons.

The CO_2 equivalent of all 2010 HFC emissions is 23 431 tons (23.43 Gg).

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

The UN of the basic activity data “HFC stock” is estimated ± 8.5%, which is the combination of the individual UN of a) total registrations in 2006 (± 1%), b) MAC quotas (± 6%), c) refrigerant charges (± 6%) – with most quotas and charges being taken from Germany.

The combination of the UN of the stock (± 8.5%) with the UN of the operating emission factors (± 5%) result in the UN of the HFC emissions of ± 10%.

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[9] Information about the development of the PLF for different types of vehicles that have mobile air conditioning was included as the recommendation of the UNFCCC review team.

Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

Source-specific recalculations

The investigation over time series was made. Emissions were estimated for year 1994 due to in Western Europe systematic air-conditioning of passenger cars with the refrigerant HFC-134a started in 1994.

According to product lifetime of 13 years, first decommissioning emissions of R-134a occurred in 2007.

Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.6.2. Trucks

Source category description

In 2010, there were about 81 202 trucks of the weight classes (according to 2002/16/EC) N1, N2, and N3 in traffic register of Estonia, 64% of which are younger than 13 years. In Western Europe systematic air-conditioning of trucks with the refrigerant HFC-134a had started in 1994/95. As a consequence, more than of half Estonian trucks are potentially air-conditioned. Equipment of these younger vehicles with air-conditioners is relatively high – reaching 90% in case of N3 trucks. The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on truck makes and models. The refrigerant charge of truck MAC systems ranges from 0.65 kg to 1.2 kg, the emission rate is 10–15% depending on the weight class.

Methodological issues

The Estonian Motor Vehicle Registration Centre provided a list of all trucks registered at the end of 2010, subdivided in weight classes (N1, N2, and N3), makes, models and production years dating back to 1995 and beyond. No official data about air conditioning were available.

As the 2006 investigation results had showed congruence between Estonian and German passenger car fleets and their MAC data (based on the high share of imported used vehicles from Germany) the following approach was applied to establish necessary truck MAC data. The German F-gas inventory treats the MAC quotas and charges of certain vehicles (12 truck models altogether) as representatives of their respective weight classes and extrapolates their specific figures to the total N1, N2, and N3 trucks in the country. The same truck models as in Germany were identified in the Estonian truck park for each weight category (N1, N2, N3). The German MAC quotas and refrigerant charges of these representative models were applied to the same models in the Estonian truck fleet. The total values of N1, N2 and N3 trucks in Estonia result from extrapolation of the particular model values pursuant to the share that these models have in the total Estonian fleet, by the three different weight classes N1, N2 and N3.

Method according to IPCC Guidelines 2006: Tier 2a with Europe specific determination of EF.

- Country-specific average refrigerant charges: weight class N1: 0.87 kg; weight class N2: 0.88 kg; and weight class N3: 1.1 kg.
- Emission factors (Schwarz, 2007): weight class N1: 10%; weight classes N2 and N3: 15%, which are likewise in accordance with the IPCC Guidelines 2006 (IPCC 2006, table 7.9, page 7.52) and IPCC Good Practice Guidance.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.

The total HFC-134a stock in truck MACs in Estonia amounts to 21 772 kg in the year 2010. The HFC-134a emissions from the Estonian truck fleet in 2010 total 2 792 kg (12.82%), the CO_2 equivalent of which is 3 629 tons.

The amount of HFC-134a in the truck MACs disposed in 2010 was estimated 1 675 kg. Disposal emissions from the Estonian truck fleet in 2010 total 837.4 kg (EF=50%), the CO_2 equivalent of which is 1 088.6 tons.

The CO_2 equivalent of all 2010 HFC emissions is 4 718 tons (4.72 Gg).

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

The UN of the basic activity data "HFC stock" is estimated ± 8.5%, which is the combination of the individual UN of a) total registrations by weight categories in 2006 (± 1%), b) MAC quotas (± 6%), c) refrigerant charges (± 6%) – with quotas and charges being taken from Germany.

The combination of the UN of the stock (± 8.5%) with the UN of the operating emission factors (± 5%) results in the UN of the HFC emissions of ± 10%.

Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

Source-specific recalculations

The investigation over time series was made. Emissions were estimated for year 1994 due to in Western Europe systematic air-conditioning of trucks with the refrigerant HFC-134a started in 1994/95.

According to product lifetime of 13 years, first decommissioning emissions of R-134a occurred in 2007.

Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.6.3. Buses

Source category description

In 2010, about 3 088 buses were operated in Estonia, 1 671 of which were less than 16 years old (built as of 1992). Equipment of these younger vehicles with air-conditioners is relatively high (approx. 50%). This is because most of them are second-hand vehicles from Western Europe where also most of the few new buses were manufactured. In Western Europe large-scale air-conditioning of buses with the refrigerant HFC-134a had started in 1995 and has reached a high level, now. The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on whether a bus is a city, intercity or a tourist bus. City buses can be subdivided into single and articulated buses; intercity and tourist buses are usually single vehicles, with a small part of tourist buses being double-deckers. The refrigerant charge of bus MAC systems is large, ranging from 7 kg to 20 kg, the emission rate is high mainly because of the up to 50 metres long refrigerant piping.

Methodological issues

The Estonian Motor Vehicle Registration Centre provided a list of all buses registered at the end of 2010 (M3 category), subdivided in makes, models and production years dating back to 1992 and beyond. Data on the city-intercity-tourist bus split were not included, nor are there official data available about air conditioning.

Several big national and local bus operators (TAK, Taisto, SEBE, Hansabuss, GoBus) were interviewed about the MAC data of their own fleet and of the countrywide bus fleet – resulting in two conclusions. Firstly, the shares of the three main bus types are even thirds of the total registrations. Secondly, the average Estonian data on quota, charge, and leakage (refills) largely match the data of Western Europe (Schwarz, 2007) in consequence of the extensive importation of second-hand vehicles from there. In addition, an essential quantity of air-conditioned buses turned out to be manufactured before 1995 so that the decision was made to shift the starting point for the reporting to the years 1992/1993.[10]

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific average refrigerant charges: Single buses (city, intercity, tourist): 10 kg; articulated buses and double deckers: 18 kg.
- Country-specific emission factors: Single buses (city, intercity, tourist): 1.5 kg/a; Articulated buses and double deckers: 3 kg/a, which are likewise in accordance with the IPCC Guidelines 2006 (IPCC 2006, table 7.9, page 7.52) and IPCC Good Practice Guidance.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.

The total HFC-134a stock in bus MACs in Estonia amounts to 8 566 kg in the year 2010. The HFC-134a emissions from the Estonian bus fleet in 2010 total 1 296 kg (15.13%), the CO_2 equivalent of which is about 1 684 tons.

[10] It was believed that at least the newer of the 120 trolleybuses in Estonia are air-conditioned. This assumption turned out to be wrong. According to the only Estonian operator (TTTK) none of the vehicles is equipped with a MAC.

The amount of HFC-134a in the bus MACs disposed in 2010 was estimated 659 kg. Disposal emissions from the Estonian bus fleet in 2010 total 329.5 kg (EF=50%), the CO_2 equivalent of which is 428.3 tons.

The CO_2 equivalent of all 2010 HFC emissions is 2 113 tons (2.11 Gg).

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

The UN of the basic activity data "HFC stock" is estimated ± 8.7%, which is the combination of the individual UN of a) total registrations in 2006 (± 1%), b) bus split (± 5%), c) MAC quota (± 5%), d) refrigerant charge (± 5%).

The combination of the UN of the stock (± 8.7%) with the UN of the operating emission factor (± 5%) results in the UN of the HFC emissions of ± 10%.

Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

Source-specific recalculations

The investigation over time series was made. Emissions were estimated for years 1992–1994 due to in Estonia air-conditioning of buses with the refrigerant HFC-134a started in 1992.

According to product lifetime of 13 years, first decommissioning emissions of R-134a occurred in 2005.

Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.6.4. Ships

Source category description

Usually, merchant ships >100 Gross Tonnage (GT) are equipped with air-conditioning systems and provision refrigeration, tugs with air-conditioning only, and fishing vessels >18 m with refrigeration. Ship air-conditioning with HFC started from 1996 onwards substituting HCFC-22. Refrigerants in use are HCFC-22, HFC 407C (mixture), HFC 404A (mixture), HFC 427A (mixture) and HFC-134a as the new standard refrigerant (Schwarz & Rhiemeier, 2007). By far most HFC-refrigerants are used for air-conditioning (R-134a); only a small part is used for provision cooling (R-134a, R-404A, R-407C). The cooling and freezing systems of the Estonian deep-sea freezer trawlers operate without HFC (refrigerants: R-22 and ammonia).

Methodological issues

Ships under Estonian flag built in 2000 or later with GT 100 or more and fishing vessels >18 m are listed in the Estonian Ship Register (Estonian Maritime Authority). Data on AC and provision cooling systems of these ships were collected from the operating companies, additionally data on all ferries of the two relevant Estonian ferryboat companies – altogether 36 vessels. (The oldest ship with HFC air-conditioning and provision cooling was built in 1968.) The data on type of refrigerant, charge and refilling in 2010 were provided directly by the ship owners. The estimation of the stock emissions is based on direct measurement (refilling data 2010).

According to Estonian Maritime Administration tugboats >100 GT have no air-conditioning devices.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific HFC refrigerant stock: 5 968 kg R-134a; 1 522.5 kg R-404A; 408 kg R-407C and 135 kg R-427A.
- Country-specific stock emissions (refills), EF = 30%, which is in accordance with the IPCC Good Practice Guidance: 1 790.5 kg R-134a; 456.75 kg R-404A; 122.4 kg 407C and 40.5 kg R-427A.

The CO_2 equivalent of the stock emissions (all HFC together) is 4 077.34 tons (4.08 Gg).

Uncertainties and time-series consistency

The data on refills are reliable and complete. As a consequence, the uncertainty of the HFC emissions is nevertheless estimated ± 5%, considering that tugboats and naval ships are not yet investigated.

The investigation over time-series was made. Time series (R-134a) started in 1997 due to in 1990–1996 there was no ship with HFC refrigerants in use in Estonia. Ship air-conditioning with R-404A started in 2001 and with R-407C in 2002. The use of R-427A started in 2010.

Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

Source-specific recalculations

Activity data in years 2006–2009 were recalculated due to more data about ship air-conditioning was available from Estonian ferryboat companies and data about air-conditioning systems on Estonian naval ships was available from Ministry of Defence.

Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.6.5. Railcars

Source category description

In 2010, there were 24 railcars (restaurant cars, sleeping cars, passenger coaches) of the Estonian fleet equipped with a working air conditioner. All systems had been retrofitted from CFC-12, and the refrigerant in use until 2009 was R-401A. It is a blend containing 13% of HFC-152a by weight, in addition to R-22 (53%) and R-124 (34%); the latter are HCFCs and out of the scope of this report. Beginning from 2010 the refrigerant in use was R-134a.

The relevant MAC properties (refrigerant charge, leakage rate) do not depend on the type of the railcars. The refrigerant charge of railcar MAC systems ranges from 28 kg to 30 kg. The emission rate is high and the losses demand refilling after each arrival at the station in case of the long trips (10 to 17 hrs) between Estonia and Russia.

Methodological issues

Estonian Technical Surveillance Authority was contacted to establish the size of the countrywide fleet. For obtaining MAC data all three local rail operators involved in passenger transport (GoRail, Edelaraudtee, Elektriraudtee) and one service company (Ühinenud Depood) were interviewed. The results revealed that there are 24 air-conditioned and regularly maintained railcars. Although usually MAC charges depend on the type of a railcar (dining cars and sleeping cars having much higher charges than coaches) it became evident that this rule does not apply in case of Estonia, the refrigerant charges of MAC systems being around 30 kg in all types of railcars. The refrigerant quantity refilled annually into the railcar stock amounts to 200 kg. This corresponds to the experience of local experts that the MAC systems release 20 grams of refrigerant per operating hour.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific average refrigerant charges: 30 kg/a of R-134a.
- Country-specific emission factors: calculation based on annual losses of R-134a and the amount of refrigerant stock leads to the implied emission factor of 0.2777 for all types of railcars in 2010, which is in accordance with the IPCC Good Practice Guidance.

The total HFC-134a stock in railcar MACs in Estonia amounts to 720 kg in the year 2010. The HFC-134a emissions from the Estonian railcars in 2010 total 200 kg (27.78%), the CO_2 equivalent of which is 260 tons based on the GWP 1300 of HFC-134a (0.26 Gg).

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

The UN of the basic activity data “HFC stock” is estimated ± 8.5%, which is the combination of the individual UN of a) number of operating vehicles with air conditioning in 2006 (± 0%), and b) refrigerant charges (± 3%).

The combination of the UN of the stock (± 3%) with the UN of the operating emission factors (± 5%) results in the UN of the HFC emissions of ± 5.8%.

The investigation over time-series was made. Time series (R-152a) started in 2000 due to in 1990–1999 there was no railcar with HFC refrigerants in use in Estonia.

Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

Source-specific recalculations

No source-specific recalculations have been done.

Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.1.6.6. Wheel Tractors and Mobile Machinery

Source category description

First agricultural machines (wheel tractors, combine harvesters) equipped with mobile air conditioners on Estonian market were manufactured in 1997/1998. With regard to construction machines (excavators, loaders) and other mobile machinery (forestry vehicles, roadwork machines) this equipment appeared later, in 2000. In 2010, there were about 6 163 wheel tractors and mobile machinery in traffic register of Estonia. Thus only 15% of the operating agricultural machines, 32% of the construction machines, and 20% of the other mobile machines in use in Estonia are potentially air conditioned. Air conditioning of these machines is rapidly growing. The equipment quota of the new agricultural machines has reached 75% in recent years. Among new construction and other mobile machines this quota is still lower (40%) but also increasing. The refrigerant in use is HFC-134a. The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on the type and purpose of a specific machine. The refrigerant charge of tractors and mobile machinery MAC systems ranges from 1.0 kg to 2.0 kg. The emission rate is high due to powerful vibration of these machines causing amongst others the connections in the MAC system to become loose.

Methodological issues

The Estonian Motor Vehicle Registration Centre provided a list of all wheel tractors and mobile machinery registered at the end of 2010. Official data about air conditioning of the vehicles were not available.

The average charges and quotas of Estonian agricultural machines match the respective values of Western Europe. The authors of this report taking into account the particularities of the Estonian vehicle fleet estimated the amount of leakages and refills.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific average refrigerant charges: wheel tractors, construction machines, forestry and roadwork machines 1.0 kg/a; combine harvesters: 1.6 kg/a.
- Country-specific emission factors: wheel tractors 20% (EF is in the range of the IPCC 2006 Guidelines and IPCC Good Practice Guidance); combine harvesters, construction machines, forestry and roadwork machines 25%, which is likewise in accordance with the IPCC Good Practice Guidance.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.

In 2010, the total HFC-134a stock in tractor and mobile machinery MACs in Estonia amounts to 11 099 kg. The HFC-134a emissions from the entire Estonian fleet total 2 347 kg (21.14%) the CO_2 equivalent of which is about 3 051 tons (3.051 Gg).

The amount of HFC-134a in the tractor/mobile machinery MACs disposed in 2010 was estimated 854 kg. Disposal emissions from the Estonian fleet in 2010 total 171 kg (EF=20%), the CO_2 equivalent of which is 222 tons.

The CO_2 equivalent of all 2010 HFC emissions is 3 273 tons (3.27 Gg).

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

The UN of the basic activity data “HFC stock” is estimated ± 14.5% for every vehicle type, which is the combination of the individual UN of a) total registrations by vehicle types in 2006 (± 3%), b) MAC quotas (± 10%), c) refrigerant charges (± 10%).

The combination of the UN of the stock (± 14.5%) with the UN of the operating emission factors (± 10%) results in the UN of the HFC emissions of ± 17.6%.

The investigation over time-series was made. Time series started in 1997 due to first agricultural machines (wheel tractors, combine harvesters) equipped with mobile air conditioners on Estonian market were manufactured in 1997/1998.

Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

Source-specific recalculations

No source-specific recalculations have been done.

Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.2. Foam Blowing

4.5.2.1. PU Insulation Panels

4.5.2.1.1. Source category description

In 2010 HFC blown and containing insulation panels made of polyurethane rigid foam were neither manufactured nor used in Estonia; however, imported products had been applied for several years. In 2001, one Estonian company manufacturing PU sandwich panels (consisting of facings and a rigid polyurethane foam core) had substituted the blowing agent CFC directly by the water/CO_2 reaction. The only manufacturer of industrially prefabricated insulation panels for buildings (some type of sandwich element) combining PU spray foam with polystyrene changed in 2004 from the blowing agent HCFC-141b to CO_2/water and methyl formate. From 1998 onwards, a certain amount of PU sandwich elements manufactured with HFC-134a as blowing agent had been imported from abroad. Although the use of these products in Estonia stopped in 2006, the HFCs enclosed in the foam cells of these panels form a small bank that is a source of emissions in the long run.

4.5.2.1.2. Methodological issues

The present bank of HFC-134a as insulating gas in imported sandwich elements was assessed by a model (because the import/export data from the Estonian customs only indicate origin and total weight of sandwich elements without information on the insulating gases). The model is based on information from the Statistical Board (annual import of sandwich elements minus export), Estonian experts/importers (average quota of imported sandwich elements with PU-core 1998–2001: 15%, 2002–2006: 40%), and foreign manufacturers of sandwich elements (average quota of PU-foam with HFC-134a: 1998/99: 100%, 2000: 50%, 2001: 10%, 2002ff: 5%; PU core: 30% of the sandwich elements weight). As a result, the bank of HFC containing PU panels (about 760 t) in 2006 was estimated to contain approx. 230 tons PU with HFC-134a with the HFC-134a content in the foam-stock of 6.75%.[11]

The annual use-phase HFC-134a emissions from the bank (EF_{op}) are estimated according to experts from manufacturing companies at 0.5% (cf. UBA 2005: 142), which is likewise in accordance with the IPCC Guidelines 2006 (IPCC 2006, table 7.6, page 7.37) and IPCC Good Practice Guidance.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{op}: 0.5%.

The 2010 Estonian HFC-134a bank in PU insulation panels amounts to 15.1 tons, the annual use-phase emissions are 0.075 tons (97.98 tons or 0.098 Gg CO_2 equivalent).

4.5.2.1.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

[11] The panels are manufactured according to experts with 7,5% HFC-134a; after a first year loss (FYL) of 10% during and after manufacturing 6,75% of the blowing agent remain within the foam.

The UN of the basic activity data “HFC stock” is estimated at ± >10% because it is based on both official statistical data and expert judgment.

The combination of the UN of the stock (± >10%) with the UN of the operating emission factor (± 10%) results in the UN of the HFC emissions of ± 15%.

4.5.2.1.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.2.1.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.2.1.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.2.2. Spray and Injection PU Foam

4.5.2.2.1. Source category description

This sector of on-site insulation with spray respectively injection foam blown with the new-developed HFC-365mfc (with HFC-227ea add-on to reduce the flammability) is small. However, there must not only use-phase emissions be considered but also emissions upon manufacturing until year 2008. The manufacturing emissions are relatively high because the foaming process is an open application. It should be mentioned that HFC-free (water based) PU spray foam systems are also in use, namely for in-site insulation of soil-laid heating pipes, up to some tons/year. In 2009–2010, there was no production of spray and injection PU foam in Estonia.

4.5.2.2.2. Methodological issues

In the EU, for on-site applied foam the hardly inflammable blowing agent HCFC-141b was no longer permitted as of 2004 at the latest. Difficulties with alternative blowing agents arose from two sides. On the one hand the application of HFC-365mfc is not trivial from a technical point of view. On the other hand the manufacturer of this fluid could not satisfy the demand for HFC-365mfc in 2004 because of problems in his production plant. As a consequence, in the EU the HCFC-141b was still in use after 2004 - according to PU system suppliers also in Estonia.

Until 2008, one company in Estonia used HFC-365mfc/HFC-227ea (in addition to a small amount of HFC-134a) as blowing agent for on-site applied PU foam. HFC quota in this mixture: HFC-365mfc = 93%, HFC-227ea = 7%.

According to chemical suppliers, the HFC content in the spray foam system before application is 7.5%. On application (manufacturing), a blowing agent loss (EF_{manu}) must be considered which includes two HFC fractions: one released directly upon application and another being released within one year after application. Both fractions together are called first year loss (FYL). The FYL amounts to 20%; 80% of the original blowing agent remain in the foam cells during the use-phase.[12] The product life factor (EF_{op}) is according to chemical suppliers 1%.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{manu}: 20%.
- Country specific EF_{op}: 1%.

In 2010 the stock constituted of 270.83 kg HFC-365mfc, 34.24 kg HFC-227ea and 31.13 kg HFC-134a. Stock emissions: 2.71 kg HFC-365mfc, 0.342 kg HFC-227ea and 0.3 kg HFC-134a, altogether 3.808 t CO_2 equivalent.

Total global warming emissions: 3.808 t CO_2 equivalent (0.0038 Gg).

4.5.2.2.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The UN of the basic activity data "HFC consumption" is estimated at ± >10% because it is based on sales data and expert judgment. The combination of the UN of the consumption (± >10%) with the UN of the manufacturing emission factor (FYL) of ± 10% results in the UN of the HFC emissions of ± 15%.

4.5.2.2.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.2.2.5. Source-specific recalculations

Activity data in year 2009 was recalculated due to more detailed data about spray and injection PU foam manufacturing was available from production company.

4.5.2.2.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.2.3. PU Integral Skin Foam

4.5.2.3.1. Source category description

In Estonia the PU Integral Skin Foam production started in 2004 with HFC-365mfc which was introduced to the market in 2003. Beforehand, ozone-depleting HCFC-141b was used; it is no longer allowed from 2004 onwards. All blowing agent applied on manufacturing is supposed to emit to the atmosphere the same year. Until 2009, one company in Estonia used HFC-365mfc and HFC-227ea for manufacturing of a very small amount of PU integral skin products. In 2010, PU Integral Skin Foam was neither manufactured nor used in Estonia.

[12] In contrast to the IPCC guidelines (2006, p. 7.35: FYL 10%), in this report an FYL of 20% is used (Krähling/Solvay 2002: 15% loss on manufacturing, 5% additional loss within the first year).

4.5.2.3.2. Methodological issues

For manufacturing of PU integral skin foam small quantities (1-2%) of HFC are added as auxiliary blowing agent in order to improve product quality. As integral skin is open-cell foam, upon foaming the blowing agent is released almost completely within one year (according to the industrial foam system supplier, and UBA 2005, p. 144). The EF manu (First Year Loss) is 100%. This means methodologically that there is no need for estimating an HFC bank and operating emissions from this bank. Information on the consumption of HFC-365mfc was provided by the manufacturer of integral skin products in Estonia. The EF_{manu} is likewise in accordance with the IPCC Guidelines 2006 (IPCC 2006, page 7.33). IPCC Good Practice Guidance default emission factor is 95%, which is lower than country-specific emission factor.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{manu}: 100%.

4.5.2.3.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The UN of the activity and emissions data “HFC consumption” is estimated at only ± 3% because it is based on information of the only user.

4.5.2.3.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.2.3.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.2.3.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.2.4. XPS Insulation Foam

4.5.2.4.1. Source category description

The 2006 basic research showed that XPS foam was not manufactured in Estonia whereas imported XPS board for thermal insulation was of some importance in the country. The European manufacturers have stepwise shifted from HCFC blowing agents to HFC-134a/152a and to CO_2. The main XPS suppliers to the Estonian market are using CO_2. One international manufacturer currently using both CO_2 and HFC-134a blowing agents supplies the Estonian market from a Scandinavian factory with CO_2 blown foam. From 2001 to 2006, this company sold a considerable amount of HFC-134a containing XPS panels to Estonia where these panels were used. It is generally accepted that in case of HFC-134a some 27% of the blowing agent release to the atmosphere on manufacturing (EF_{manu} = 27%). As a consequence, 73% of the blowing agent remains in the panels as insulating cell gas, in the long term. Thus, in

Estonia an HFC bank in the XPS board stock was considered as a source of domestic emissions.

4.5.2.4.2. Methodological issues

Seven international chemical companies gave data on the XPS foam market in Estonia. Based on this information, both the year-on-year growth in the domestic XPS-foam bank and the HFC content in the annual sales quantities were assessed for the 2001-2005 periods. From 12.5% (2001) a gradual decrease in the HFC-134a content to 0% (2006) was established, resulting in 5% HFC content of the final 2006 XPS stock (72 000 m^3 XPS, thereof 3,600 m^3 HFC-containing XPS). As the HFC quantity used for the production of one m^3 XPS foam is known (3.3 kg), the HFC bank was calculated from the volume of XPS sold to Estonia. A use-phase emission factor (EF_{op}) of 0.66% was applied to this long-term bank of enclosed HFC-134a. Country specific EF_{op} is lower than the value given in IPCC Good Practice Guidance, 0.75 %.

- Country specific EF_{op}: 0.66%.
- 2010 HFC-134a bank: 8.4 tons.
- 2010 use-phase emissions: 55.73 kg (0.66%) which is 72.44 t (0.0724 Gg) CO_2 equivalent.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

4.5.2.4.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts.

No official statistical data on the XPS board consumption in Estonia is available. Thus the annual sales and the current stock of XPS foam with HFC-134a had to be calculated with sector experts. The UN of the activity data "HFC stock" is estimated at ± 20%. The uncertainty of the emission factor is estimated 10% so that the UN of the annual use-phase emissions is ± 22.34%.

4.5.2.4.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.2.4.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.2.4.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.2.5. One Component PU Foam

4.5.2.5.1. Source category description

Estonia is amongst the four biggest EU countries manufacturing polyurethane one-component foam (OCF). To a considerable part, the propellant gases in the foam cans are HFCs (HFC-152a) that are added to halogen-free flammable gases. By far most of the domestically used fluorinated greenhouse gases (HFCs) are imported for filling million of OCF cans that are, on their part, predominantly exported, especially to Eastern Europe. There is, however, also a considerable domestic market for OCF, which is supplied by both domestic manufacturers and – to lesser degree – foreign companies. Due to the restrictions of the EU F-gas Regulation on the use of HFCs in OCF both Estonian producers, in 2008, have stopped producing OCF with HFC-134a as propellant, using HFC-152a instead. This has led to major decrease of the emissions (both manufacturing and stock emissions) in the Foam Blowing sector. In 2010, one Estonian producer manufactured OCF with HFC-134a as propellant, but all products were located outside the EU markets.

4.5.2.5.2. Methodological issues

The following data was collected for emission estimation from manufacturing and use of OCF:

- Number of cans (in terms of 750 ml volume) with HFC as blowing agent manufactured in Estonia, average amount of HFC per can, emissions on filling;
- Number of OCF cans (in terms of 750 ml content) with HFC as blowing agent sold to the Estonian market, average amount of HFC propellant per can.

Information sources: The two Estonian companies manufacturing OCF within the country and selling OCF to the Estonian market. The share of foreign OCF companies selling to the Estonian market was also estimated. The EF_{manu} (1.7%) is based on information from the two domestic manufacturers and was compared to international data. As to the application of OCF, it is assumed that all HFC is emitted from the cans in the year of the OCF use. In contrast to the method of the IPCC Guidelines 1999 and 2006 but in accordance with other submissions under the UNFCCC it is assumed that all use-phase emissions occur in the year of sale (use and disposal occurring promptly after sale). The category "stock 2010" is equated to the HFC content of OFC cans sold to the Estonian market and used in 2010. Hence only emissions from manufacturing and use (= stock) are entered in the CRF table, no emissions from disposal. Country specific EF_{manu} is 2.5% (HFC-134a), which is likewise in accordance with the IPCC Guidelines 2006 and IPCC Good Practice Guidance. EF_{op} is 100%, which is higher than the value given in IPCC Good Practice Guidance and IPCC Guidelines 2006 (95 %). The 2010 HFC-152a consumption was in total 1037 t and HFC-134a consumption was 30 t.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{manu}: 1.7% (HFC-152a).
- Country specific EF_{manu}: 2.5% (HFC-134a).
- Country specific EF_{op}: 100%.
- Manufacturing emissions: 17.59 tons HFC-152a or 2 462.6 t CO_2 equivalent and 0.75 tons HFC-134a or 975 t CO_2 equivalent.

- Stock = use-phase emissions: 28.2 tons HFC-152a or 3 948 t CO_2 equivalent.

The HFC emissions from manufacturing and from stock total to 7 385.6 t or 7.39 Gg CO_2 equivalent.

4.5.2.5.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. As the domestic and foreign manufacturers themselves provided all the relevant data, the data uncertainty is estimated low. The uncertainty of the annual HFC consumption and – consequently – use-phase emissions by quantity and HFC type is ± 15%. The same value applies to the manufacturing emissions.

4.5.2.5.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.2.5.5. Source-specific recalculations

The investigation over time series was made. Emissions were estimated for years 1992–1994 due to production of OCF with HFC-134a as propellant started in 1992 in Estonia.

4.5.2.5.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.3. Fire Extinguishers

In Estonia different types of HFC are used for substituting halons in fire protection (flooding equipment): mostly HFC 227ea (FM-200), the mixture R-866 consisting of HFC-134a, HFC-125 and CO_2, and furthermore HFC-23. This group is responsible for about 0.98% of the Estonian F-gas emissions (1.555 Gg CO_2 equivalent).

4.5.3.1. Source-category description

F-gases are more expensive than environmentally friendlier substances for fire fighting in indoor flooding systems (e.g. nitrogen, argon). The latter are characterized as overpressure gases. Compared to them, the advantage of F-gases is their lower pressure: The pressure of FM 200 (HFC 227ea) in the piping is about one fifth of the pressure of argon. This makes the F-gases suitable for flooding systems of smaller rooms where the higher pressure of e.g. argon could cause damages. F-gas consumption for fire fighting includes also its usage in military objects.

F-gases for fire fighting are imported to Estonia in closed cylinders. Installation is carried out by connecting the cylinder with the piping system. The cylinder has, according to the supplying companies, no valve outside but only inside so that a mistake upon installation (e.g. opening of the wrong valve) is hardly possible. In case of false alarm or fire the whole charge of the cylinder is blown out. Refilling in site does normally not take place. Emptied cylinders are replaced by full cylinders.

4.5.3.2. Methodological issues

Data on the amount of the three mentioned HFC-based fluids for fire protection in the 2010 stock was provided directly by six companies dealing with fire protecting systems incl. maintenance and by one supplier of fire fighting agents who submitted the basic data (stock) of eight additional clients. According to experts from these companies no other players were active in this field. The first HFC installation dates back to 2000.

According to IPCC Guidelines 2006 the annual emissions from installed flooding systems are in the range of 2 ± 1 percent of the installed base. As there are no detailed indications on operating emissions from flooding systems in Estonia for a longer period, an EF_{op} of 2% is applied to the bank. Emissions upon filling/refilling (EF_{manu}) are not calculated. According to the long lifetime of flooding systems (15–20 years) and the possibilities of recovery we do not assume end-of-life emissions.

Method Tier 2a according to IPCC guidelines 2006, using IPCC default EF_{op}.

- Operating emission factor EF_{op}: 2%.

In Estonia, the total 2010 quantity of F-gases in installed fire fighting systems amounted to 23.303 t (16.997 t HFC-227ea, 1.877 t HFC-23 and 4.815 t R866, the latter containing 8% CO_2 in mixture with HFC-134a and HFC-125). The emissions from this stock are calculated 2 percent: 37.532 kg HFC-23, 9.629 kg HFC-125, 78.958 kg HFC-134a and 339.932 kg HFC-227ea. The CO_2 equivalent of all 2010 HFC emissions is about 1.555 Gg (1 555 tons).

4.5.3.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the 2006 IPCC Guidelines.

The data are based on direct information from industry, so that the UN of the data on the different HFC stocks can be estimated comparably low (± 10%). The UN of the emission factor is assessed ± ~10%, so that the combined UN of the emissions is estimated ± 15%.

4.5.3.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.3.5. Source-specific recalculations

In the 2012 Submission, activity data was corrected for year 2009. Recalculation was made due to more data was available from companies dealing with fire protecting systems.

4.5.3.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.4. Aerosols

4.5.4.1. Metered Dose Inhalers

4.5.4.1.1. Source-category description

Under the category of Metered Dose Inhalers (MDI) with HFCs of pharmaceutical grade two aerosol applications are discussed: aerosols for natural medicine and aerosols for the treatment of asthma/COPD (chronic obstructive pulmonary diseases).

4.5.4.1.2. Methodological issues

The domestic manufacturer provided the data on manufacturing, domestic consumption and export of MDIs for natural drug products including the emissions rate from manufacturing (EF_{manu} = 3%). Use-phase emissions: The number of MDIs for both natural and anti-asthma drugs sold to the domestic market in 2010 (production + import - export) is the stock of the same year 2010. (A surcharge factor for hospitals and doctors' samples of 5% is applied.) As the consumption of the products follows the purchase immediately, annual stock and the annual emissions are the same size. HFC-134a is completely exhaled after inhalation so that 100% is the appropriate value for the use-phase emission factor, which is likewise in accordance with the IPCC Guidelines 2006 and IPCC Good Practice Guidance.

In 2010 MDIs (asthma/COPD) with HFC-134a as propellant were sold to Estonian market by eight companies. Sales figures on the various pharmaceutical products were provided by the Estonian Medical Board and information on HFC content per device was provided by respective companies.

Method according to IPCC guidelines 2006: Tier 2a with country specific EF.

- Country specific EF_{manu}: 3%.
- Country specific EF_{op}: 100%.
- Natural MDIs: The 2010 domestic consumption of HFC-134a was 0.89 tons (manufacturing emissions: 26.7 kg), of which 0.79 tons were sold to the domestic market, resulting in use-phase emissions of the same amount.
- Anti-Asthma MDIs: The 2010 domestic market was 1 406 kg, with the same quantity of emissions.
- Overall emissions: 2.225 tons HFC-134a or 2 892.2 tons CO_2 equivalent (2.89 Gg).

4.5.4.1.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the 2006 IPCC Guidelines.

The data are based on direct information from manufacturers and from trade departments in industry, so that the activity data domestic production and domestic market are deemed highly reliable. As a consequence, the UN of the emissions (manufacturing and use-phase) is estimated ± 10%.

The investigation over time-series was made. Time series started in 1997 due to the use of HFCs in Metered Dose Inhalers began in 1997 when CFCs were replaced gradually.

4.5.4.1.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.4.1.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.4.1.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.4.2. General and Novelty Aerosols

4.5.4.2.1. Source-category description

HFC-134a is used as propellant in some technical aerosols like solvent and cleaning sprays and in novelty aerosols such as signal horns for sport events or hunting. The signal horns are manufactured in Estonia, solvent and cleaning sprays with HFC-134a are imported.

4.5.4.2.2. Methodological issues

The Estonian manufacturer has stopped producing signal horns. At the moment there is only one manufacturer of solvent and cleaning sprays from Germany active on Estonian market in this particular sub-sector, in 2010 the use of HFC-134a in solvent and cleaning sprays has stopped in Estonia due to the supplier exchange and changes in product prescription.

As in MDIs, the HFC-consumption for general aerosols in 2009 is equated to emission in the same year 2009 (EF_{op} 100%), which is in accordance with the IPCC Guidelines 2006 and IPCC Good Practice Guidance.

Method according to IPCC guidelines 2006: Tier 2a with country specific EF.

- Country specific EF_{op}: 100%.
- Country specific charge of aerosol cans: 12.9 g

4.5.4.2.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the 2006 IPCC Guidelines.

The data are based on direct information from industry, so that the UN of the activity data on the number of units and on charges can be estimated low (± 10%). The same UN value applies to the emissions because the emission factor is 100%.

The investigation over time-series was made. Time series started in 1995 due to general aerosols were exported to Estonia in 1995. In 1995 and 1996 emissions from these applications were the only HFC emissions from aerosol use in Estonia. The data on novelties and natural-drug aerosols were obtained from the manufacturing company which started domestic production in Estonia in 1997.

4.5.4.2.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.4.2.5. Source-specific recalculations

Activity data in year 1997 and 1998 was recalculated due to entry mistake.

4.5.4.2.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.5. Electrical Equipment

4.5.5.1. Source-category description

SF_6 is used as an arc quenching and insulating gas in high-voltage (110-380 kV) and medium-voltage (6-35 kV) switchgear (GIS) and control gear. In Estonia the use of SF_6 in this sector started in 1991 (high-voltage) and 1999 (medium-voltage), respectively. The equipment is not manufactured within the country. Medium-voltage GIS (distribution equipment) operate with low over-pressure and little gas quantities of only some kg/system. They are already SF_6 charged when imported and are hermetically closed ("sealed for life"). High-voltage GIS (transmission equipment) with a higher operating pressure (up to 7 bar) and bigger gas quantities ("closed for life") have to be replenished in their lifetime. They are imported with a transport filling and are filled up in site (on site erection).

4.5.5.2. Methodological issues

Estonian companies of electrical power distribution data provided data on their equipment, on their SF_6 consumption in total and on refilling during the last year. The refilling data of the HV equipment reported from different power suppliers ranged from 0.1% to 0.7%/year. In case of MV-GIS no losses occurred according to the companies. The main operator of HV-GIS estimated the EF_{manu} (topping up of imported HV-GIS within the country) 0.1%. The EF_{op} of HV- and MV-GIS used in this report is based on the default emission factors of the IPCC Guidelines 2006 with 0.7% (high voltage) and 0.1% (medium voltage) per year, respectively.

Method according to IPCC guidelines 2006: Tier 3.

- Country specific EF_{manu} (manufacturing emission factor, on site erection): 0.1%.
- EF_{op} (according to IPCC GL): 0.7% (HV), 0.1% (MV).

Manufacturing emissions amount to 1.89 kg. The respective stock amounts to 9 749 kg (HV) and 3 705 kg (MV). Stock emissions: 68.25 kg (HV), 3.705 kg (MV). Total: 71.954 kg.

Total global warming emissions: 1 765 t CO_2 equivalent (1.76 Gg).

4.5.5.3. Uncertainties and time-series consistency

Öko-Recherche experts assessed the emissions uncertainty (UN) pursuant to approach 1 of the 2006 IPCC Guidelines. As the activity data are based on direct information from industry, their UN is estimated low: ± 3%. The UN of the default emission factors is ± 10% (IPCC GL 2006, Tier 3). The combined UN of the emissions is ± ~10.4%.

4.5.5.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.5.5. Source-specific recalculations

The investigation over time series was made. Emissions were estimated for years 1991–1994 due to high voltage equipment was installed in Estonia first in 1991.

4.5.5.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

4.5.6. Other

Under this category SF_6 emissions from radiotherapy devices are reported. This is very small category, which is responsible of about 0.03% Estonian F-gas emissions (0.046 Gg CO_2-equivalent). PFC emissions from sport shoes with gas cushion occurred in Estonia from 2006 to 2008 and SF_6 emissions from 1995 to 2006. For more information, please read 2010 Submission inventory report.

Under this category SF_6 emissions from car tires are reported. As a considerable part of the Estonian passenger cars are imported second hand vehicles from Germany, SF_6 in tires came also to Estonia. In Estonia, SF_6 has never been filled into car tires. The gas is assumed to be released completely to the atmosphere on disposal three years after the filling or one year after importation. SF_6 emissions from car tires occurred in Estonia from 1995 to 2003.

4.5.6.1. Other Electrical Equipment

4.5.6.1.1. Source-category description

Under “Other Electrical Equipment” Estonia reports emissions of SF_6 from radiotherapy devices. Two hospitals in Estonia use SF_6 insulated radiotherapy equipment (oncology), in one hospital there are two devices. The two devices in one hospital are in same size, device in another hospital is in different size. Other applications – e.g. SF_6 insulated particle accelerators or gas impregnation of power capacitors – do not occur in Estonia.

4.5.6.1.2. Methodological issues

Data on charge and use-phase losses were directly submitted from the medical operator. The operator calculated the emission rate of the two operating systems at 10% a year (one in 2006 other in 2008 installed modern systems). In case of the smaller system the EF_{op} was calculated at 30% a year, bases on the operator's experience from the last similar devices. The country specific EF_{op} deduced from this information is 10.5%.

Method according to IPCC guidelines 2006: Tier 2a with country specific EF.

- Country specific EF_{op}: 10.5%.

The 2010 stock of SF_6 totals 18.3 kg, the 2010 operating emissions 1.93 kg.

Global warming emissions: 46.127 t CO_2 equivalent (0.046 Gg).

4.5.6.1.3. Uncertainties and time-series consistency

The data are based on estimation of the operators. The emissions uncertainty is estimated ± 30%.

4.5.6.1.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial Processes sector according to IPCC Tier 1 method.

4.5.6.1.5. Source-specific recalculations

The investigation over time-series was made. Emissions were estimated for years 1999–2003. Time series starts in 1995 because SF_6 containing radiotherapy devices have been used in Estonia since 1995.

4.5.6.1.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

5. SOLVENT AND OTHER PRODUCT USE (CRF 3)

5.1. Overview of the sector

5.1.1. Description and quantitative overview

Emissions from Solvent and Other Product Use sector in Estonia are divided into following categories: Paint application (CRF 3.A), Degreasing and dry cleaning (CRF 3.B), Chemical products, manufacture and processing (CRF 3.C) and Other (CRF 3.D).

Under categories Paint application (CRF 3.A), Degreasing and dry cleaning (CRF 3.B), Chemical products, manufacture and processing (CRF 3.C) and Other (CRF 3.D.5) Estonia reports indirect greenhouse gas emissions (NMVOCs) and also indirect CO_2 emissions from NMVOC emissions (see Table 5.1). The compiling of NMVOC emission data from the solvent and other product use sector is performed at the Estonian Environment Information Centre. The NMVOC inventory is carried out to meet the obligations of the United Nations Economic Commission for Europe's Convention on Long-Range Transboundary Air Pollution (UNECE CLRTAP). Activity data used in the estimates are obtained from SE and from web-interface air emissions data system for the point sources (OSIS), that contains data reported by the facilities having pollution permit. In some sectors, also expert judgements have been used.

Under category Use of N_2O for Anaesthesia (CRF 3.D.1) Estonia reports N_2O emissions from the use of N_2O in medical and other applications. N_2O is also used as a propellant in aerosol products, emissions from this are reported under category N_2O from Aerosol Cans (CRF 3.D.3). N_2O is not used in fire extinguishers in Estonia.

Table 5.1. Reported emissions from Solvent and Other Product Use in Estonia in 2010

CRF	Source	Emissions	Method	Emission factor
3.A	Paint application	NMVOC, CO_2	Tier 1	D
3.B	Degreasing and dry cleaning	NMVOC, CO_2	Tier 1	D
3.C	Chemical products, manufacture and processing	NMVOC, CO_2	Tier 1	D
3.D	Other			
3.D.1	Use of N_2O for Anaesthesia	N_2O	Tier 2	CS
3.D.3	N_2O from Aerosol Cans	N_2O	Tier 2	CS
3.D.4	Other Use of N_2O	IE (3.D.1)		
3.D.5	Other			
	Printing industry	NMVOC, CO_2	Tier 1	D
	Domestic solvent use	NMVOC, CO_2	Tier 1	D
	Other product use	NMVOC, CO_2	Tier 1	D

Emissions from Solvent and Other Product Use contribute to 0.09% of the total anthropogenic greenhouse gas emissions in Estonia. The most important greenhouse gas emissions from solvent and other product use in Estonia are indirect CO_2 emissions from Paint application (CRF 3.A) and Other (CRF 3.D.5) with 29.6% and 28.5% of the total greenhouse gas emissions in solvent and other product use sector (see Table 5.2 and Figure 5.1).

Emissions from the solvent and other product use sector have decreased by 15.1% compared to the base year 1990. Two major categories where decrease of NMVOC emissions have occurred in later years are paint application (CRF 3.A) and other product use (CRF 3.D.5). The fluctuation of NMVOC emissions in the period 1990–2010 has occurred mostly due to the welfare of the economic state of the country. The decrease in the emissions between 1991 and 1993 was due to the economic crisis what was conditioned by the fall of the Soviet Union and the independence of the Estonian Republic. Between 1993 and 1998 the economic growth induced the growing usage of NMVOC containing paints in decorative and industrial coating application. At the end of 1998 the world was struck by the economic crisis, which affected the construction sector and as a consequence the usage of decorative coatings also. From 2001 the economy turned again into growth until in 2008 the world suffered the economic depression. Because of that, compared with the year 2007, the NMVOC emissions decreased 41.1% by the year 2010 (see Table 5.2).

Table 5.2. Emissions from solvent and other product use in 1990–2010 (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Indirect CO_2																					
Paint application	5.13	6.04	3.68	3.39	5.11	6.96	7.9	8.81	9.49	8.88	5.32	4.98	5.83	6.11	6.93	7.97	8.15	7.94	5.81	4.68	5.23
Degreasing and dry cleaning	2.64	2.6	2.55	2.5	2.54	2.6	2.83	2.7	2.64	2.69	2.62	2.52	2.58	2.55	2.55	2.54	2.61	2.52	2.5	2.27	2.29
Chemical products, manufacture and processing	1.09	1.35	0.44	0.3	0.3	0.55	0.43	0.42	0.68	0.48	0.24	0.25	0.33	0.28	0.4	0.28	0.5	0.85	1.03	0.64	0.30
Other	11.92	12.09	10.37	9.86	9.82	10.33	10.5	10.21	10.94	10.85	10.84	9.95	10.04	9.68	9.01	9.21	10.63	10.49	7.98	6.17	5.03
NMVOC																					
Paint application	2.33	2.75	1.67	1.54	2.32	3.16	3.59	4.01	4.31	4.04	2.42	2.26	2.65	2.78	3.15	3.62	3.70	3.61	2.64	2.13	2.38
Degreasing and dry cleaning	1.2	1.18	1.16	1.14	1.15	1.18	1.29	1.23	1.2	1.22	1.19	1.14	1.17	1.16	1.16	1.16	1.19	1.14	1.14	1.03	1.04
Chemical products, manufacture and processing	0.5	0.62	0.2	0.13	0.14	0.25	0.2	0.19	0.31	0.22	0.11	0.11	0.15	0.13	0.18	0.13	0.23	0.38	0.47	0.29	0.13
Other	5.42	5.5	4.71	4.48	4.46	4.7	4.77	4.64	4.97	4.93	4.93	4.52	4.56	4.4	4.09	4.19	4.83	4.77	3.63	2.81	2.29
N_2O																					
Use of N_2O for Anaesthesia Other Use of N_2O	NO	NO	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02
N_2O from Aerosol Cans[13]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.01	0.01	0.01	0.01

[13] N_2O emissions from aerosol cans are presented in tons.

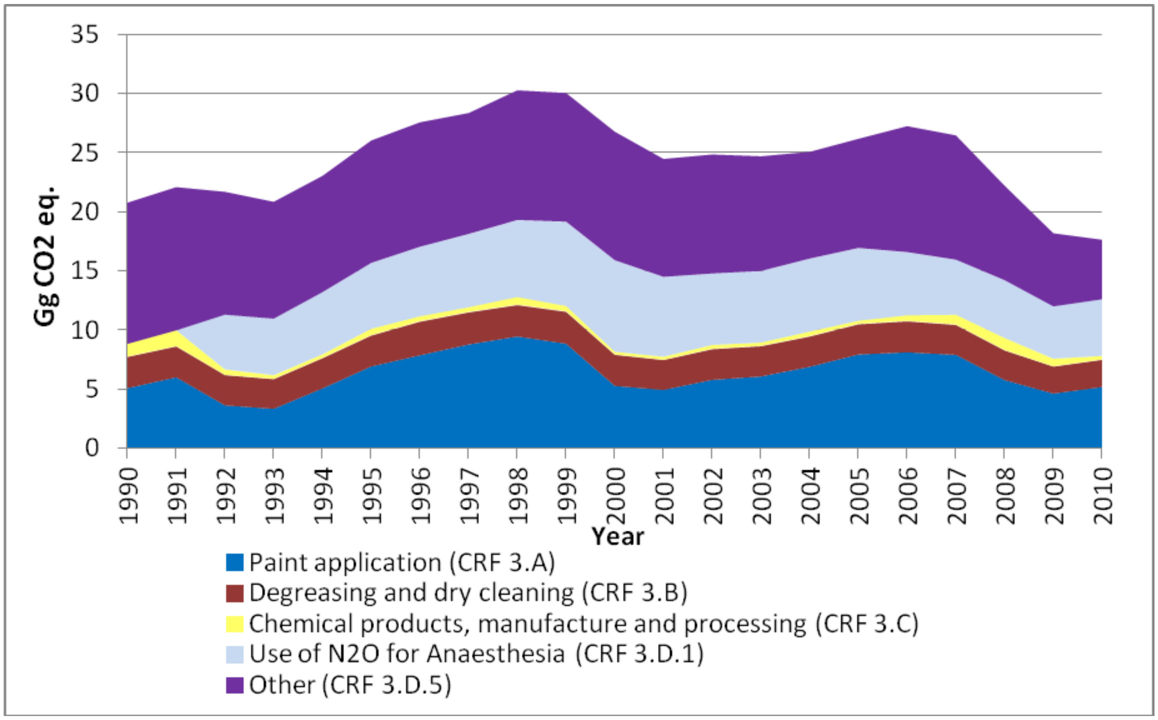

Figure 5.1. Emissions from Solvent and Other Product Use in Estonia in 1990–2010 (Gg CO_2 eq.)

5.2. Paint application (CRF 3.A), Degreasing and dry cleaning (CRF 3.B), Chemical products, manufacture and processing (CRF 3.C) and Other (CRF 3.D.5)

5.2.1. Source category description

Under categories Paint application (CRF 3.A), Degreasing and dry cleaning (CRF 3.B), Chemical products, manufacture and processing (CRF 3.C) and Other (CRF 3.D.5) Estonia reports indirect greenhouse gas emissions (NMVOCs) and also indirect CO_2 emissions from NMVOC emissions.

5.2.2. Methodological issues

Indirect CO_2 emissions from solvent and other product use were calculated using methodology from the IPCC 2006 Guidelines (Box 7.2, page 7.6). According to the method:

$$Emissions_{CO2} = Emissions_{NMVOC} \bullet \text{Percent carbon in NMVOCs by mass} \bullet 44/12$$

It was assumed that the average carbon content is 60% by mass for all categories under the sector of solvent and other products used according to the 2006 IPCC Guidelines.

5.2.3. Uncertainty and times series consistency

IPCC Tier 1 method was used in estimating the uncertainties of this category.

The uncertainty of activity data is estimated at ±25% and the uncertainty of emission factor is estimated at ±10%. The uncertainty of emission factor took into account the fact that the default fossil carbon content fraction of NMVOC is 60 percent by mass, is based on limited published national analyses of the speciation profile, as described in the IPCC 2006 Guidelines.

5.2.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Solvent and Other Product Use sector according to IPCC Tier 1 method.

5.2.5. Source-specific recalculations

NMVOC and indirect CO_2 emissions from paint application were corrected for the years 2001–2002, 2004, 2009, from degreasing and dry cleaning for the year 2006 and from other product use for the year 2009. All recalculations were due to updates in activity data in databases of Statistics Estonia. The difference in indirect CO_2 emissions between 2011 Submission and 2012 Submission is shown in Table 5.3.

Table 5.3. Indirect CO_2 emissions from solvent and other product use in 2011 Submission and in 2012 Submission (Gg)

CRF	Source	Year	the 2011 Submission	the 2012 Submission
3.A	Paint application	2001	4.9675	4.9807
3.A	Paint application	2002	5.8389	5.8333
3.A	Paint application	2004	6.9191	6.9326
3.A	Paint application	2009	4.6768	4.6766
3.B	Degreasing and dry cleaning	2006	2.6112	2.6104
3.D.5	Other product use	2009	1.8275	2.7189

5.2.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

5.3. Use of N_2O for Anaesthesia (CRF 3.D.1), Other Use of N_2O (CRF 3.D.4) and N_2O from Aerosol Cans (CRF 3.D.3)

5.3.1. Source category description

Under category Use of N_2O for Anaesthesia (CRF 3.D.1) Estonia reports N_2O emissions from the use of N_2O in medical and other applications. N_2O emissions from aerosol cans are reported under category N_2O from Aerosol Cans (CRF 3.D.3).

5.3.2. Methodological issues

N_2O emissions from the categories Use of N_2O for Anaesthesia and N_2O from Aerosol Cans are calculated by Estonian Environmental Research Centre. N_2O emissions from N_2O used in medical and other applications are estimated taking into account the amount of N_2O sold to Estonian market. Activity data was collected directly from the companies importing N_2O for medical use and other applications to Estonia. It was assumed that all N_2O sold to Estonian market in a year was used in the same year. According to the 2006 IPCC Guidelines (IPCC 2006, page 8.36), it is assumed that none of the administered N_2O is chemically changed by the body and therefore emission factor of 1.0 was applied.

In 2011 Submission, N_2O emissions from aerosol cans were under investigation. The results of the investigation indicated that N_2O containing aerosol cans are not produced in Estonia but imported and sold to Estonian market. Total quantity of N_2O supplied to Estonian market was obtained from distributors of N_2O products. From 2007–2010 aerosols with N_2O as propellant were sold to Estonian market by one company. Number of cans sold and N_2O content in each can was obtained from this company. According to the 2006 IPCC Guidelines (IPCC 2006, page 8.36), none of the N_2O is reacted during the process and all of the N_2O is emitted to the atmosphere resulting in the emissions factor of 1.0 for this source.

5.3.3. Uncertainty and times series consistency

IPCC Tier 1 method was used in estimating the uncertainties of this category.

The data are based on direct information from companies importing N_2O to Estonia and selling it to Estonian market so that the uncertainty of activity data is estimated low: ± 5%. The uncertainty of emission factor is assumed to be extremely small and is estimated at ± 2%.

5.3.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Solvent and Other Product Use sector according to IPCC Tier 1 method.

5.3.5. Source-specific recalculations

As it was the first year of reporting N_2O emissions from aerosol cans, N_2O emissions from Aerosol Cans (CRF 3.D.3) were recalculated from 2007–2009.

5.3.6. Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

6. AGRICULTURE (CRF 4)

6.1. Description and quantitative overview

6.1.1. Overview of the sector

The total GHG emissions reported in the agricultural sector of Estonia were 1 344.12 Gg CO_2 eq. The sector contributed about 6.55%[14] to the total CO_2 eq emissions in Estonia (Figure 6.1).

Estonia's agricultural GHG emissions consist of
- CH_4 emissions from enteric fermentation of domestic livestock (for 14 sub-categories of livestock),
- CH_4 end N_2O emissions from manure management systems,
- direct and indirect N_2O emissions from agricultural soils. Direct N_2O emissions include emissions from synthetic fertilizers, emissions from animal waste and sludge applied to agricultural soil, emissions from cropping of N-fixing crops and emissions from crop residues and cultivation of organic soils. Indirect N_2O emissions include emissions due to atmospheric deposition and leaching and run-off.

Enteric fermentation of livestock and direct emissions from agricultural soils were the highest contributors to the total emissions from the agricultural sector (Figure 6.1).

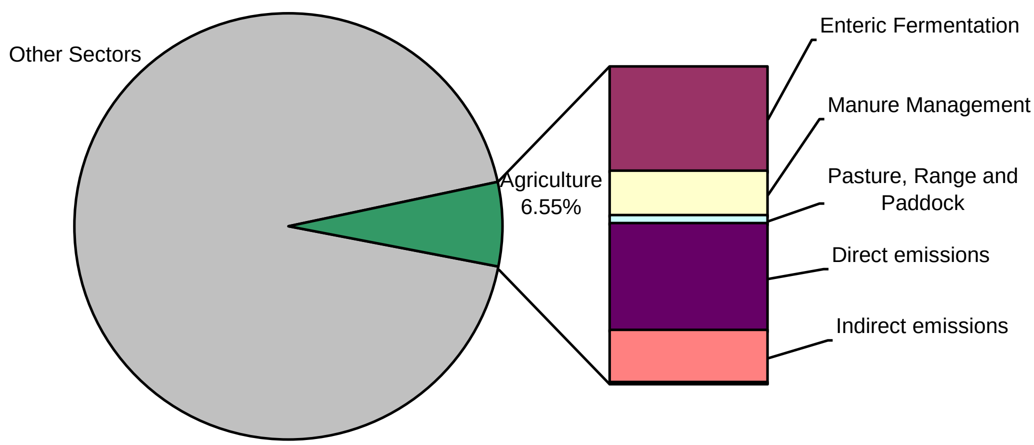

Figure 6.1. Emissions from agriculture compared to total CO_2 eq emissions in Estonia in 2010, %

[14] GHG emissions related to LULUCF sector are not included.

CO_2 eq emissions from the agricultural sector declined 61.21% by 2010 compared with the base year (i.e., 1990), mostly due to decrease in livestock population and amounts of synthetic fertilizers and manure applied on agricultural fields (Figure 6.2, Table 6.1).

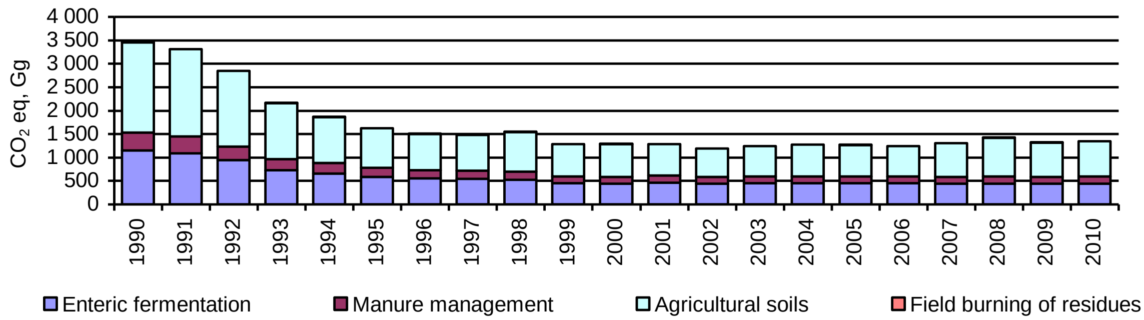

Figure 6.2. Trends in emissions by source categories in Estonia in 1990–2010, Gg CO_2eq

Table 6.1. Estonia's agricultural GHG emissions by sources in 1990–2010, Gg

Year	Enteric fermentation	Manure management		Agricultural soils		Field burning of agricultural residues		Total GHG emissions		Total CO_2 eq emissions
				Direct	Indirect					
	CH_4	CH_4	N_2O[15]	N_2O	N_2O	CH_4	N_2O	CH_4	N_2O	CO_2eq
1990	54.955	5.697	1.468	3.685	1.893	0.261	0.004	60.914	7.050	3 464.68
1991	51.920	5.305	1.386	3.592	1.811	0.250	0.004	57.475	6.793	3 312.67
1992	44.895	4.236	1.173	3.169	1.515	0.174	0.003	49.305	5.860	2 851.89
1993	34.913	3.421	0.923	2.476	0.981	0.213	0.003	38.547	4.383	2 168.28
1994	31.484	3.232	0.844	1.937	0.883	0.138	0.002	34.855	3.667	1 868.66
1995	27.864	2.973	0.740	1.681	0.731	0.144	0.002	30.980	3.155	1 628.54
1996	26.418	2.561	0.678	1.563	0.652	0.173	0.003	29.152	2.896	1 509.82
1997	25.970	2.592	0.667	1.467	0.701	0.179	0.003	28.741	2.839	1 483.55
1998	25.101	2.595	0.640	1.727	0.746	0.154	0.002	27.850	3.116	1 550.74
1999	21.601	2.279	0.549	1.356	0.625	0.112	0.002	23.992	2.532	1 288.81
2000	21.193	2.248	0.545	1.356	0.659	0.185	0.003	23.626	2.563	1 290.67
2001	22.078	2.402	0.564	1.277	0.636	0.149	0.002	24.628	2.479	1 285.72
2002	21.001	2.308	0.539	1.150	0.583	0.135	0.002	23.444	2.274	1 197.38
2003	21.372	2.303	0.540	1.177	0.673	0.130	0.002	23.805	2.392	1 241.44
2004	21.469	2.309	0.545	1.258	0.696	0.152	0.002	23.930	2.502	1 278.03
2005	21.628	2.296	0.543	1.259	0.665	0.193	0.003	24.117	2.469	1 271.80
2006	21.655	2.287	0.541	1.181	0.667	0.154	0.002	24.096	2.390	1 247.06
2007	21.294	2.322	0.535	1.371	0.696	-	-	23.616	2.602	1 302.43
2008	21.292	2.280	0.562	1.582	0.850	-	-	23.572	2.993	1 422.86
2009	20.981	2.244	0.555	1.387	0.735	-	-	23.226	2.677	1 317.60
2010	21.277	2.348	0.566	1.408	0.761	-	-	23.626	2.735	1 344.12

[15] N_2O emissions emitted during livestock pasturing are included into emission released from 'Manure management'.

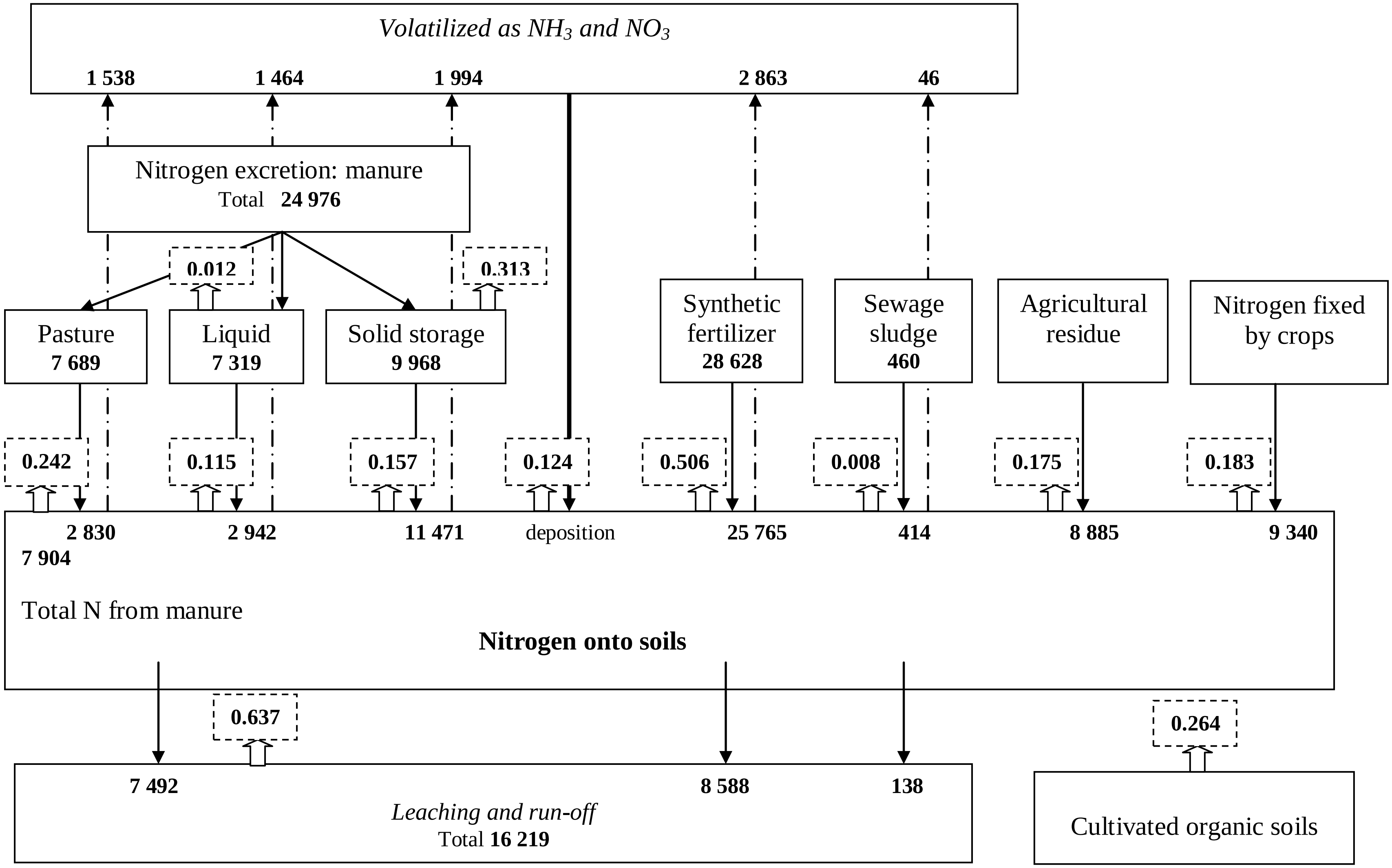

Figure 6.3. Nitrogen flow balance of Estonia's agriculture in 2010 (the scheme was adopted from Finland's NIR (2009))
(Bulk arrows stand for emissions, thin arrows for N flow. Nitrogen amounts are in Mg/year and emissions (fragmental line) in Gg/year)

The results of nitrogen balance of Estonia completed in the 2012 submission are presented in Figure 6.3.

6.2. Source category description and methodology

The *tier 1* and *tier 2* approaches were implemented to estimate GHG emissions from the agriculture sector in Estonia. A list of methods and emission factors employed in the estimates for each sub-category of the agriculture sector is presented in Table 6.2.

Rice is not cultivated in Estonia. Savanna areas do not exist in Estonia (Table 6.2).

Several recalculations were carried out to improve quality of the inventory in the following sub-sectors of the agriculture sector:

- Enteric fermentation (CRF 4.A);
- Manure management (CRF 4.B);
- Direct soil emissions (CRF 4.D.1);
- Pasture, range and paddock manure (CRF 4.D.2);
- Indirect soil emissions (4.D.3).

Agricultural key categories identified in 2010 in accordance with the *Tier 2* method are presented in Table 6.2.

Table 6.2. Methods and emission factors used to estimate GHG emissions of the agriculture sector

	CH_4		N_2O		Key category	
	Method applied	Emission factor	Method applied	Emission factor	LULUCF sector is not included	LULUCF sector is included
4.A. Enteric fermentation						
1. Cattle						
a. Cows, bulls and heifers (2 years and over)						
Dairy cattle	T2	D, CS			L	L
Non-dairy cattle					L, T	L, T
…Mature females	T2	D, CS				
…Mature males	T2	D, CS				
b. Bovine animals (ages between 1 and 2 years)	T2	D, CS				
c. Calves (less than 1 year old)	T1	D, CS				
2. Swine						
a. Piglets, live weight less than 20 kg	T2	D, CS				
b. Young pigs, live weight 20 - <50 kg	T2	D, CS				
c. Fattening pigs, live weight						
50 - <80 kg	T2	D, CS				
80 - <110 kg	T2	D, CS				
110 kg or more	T2	D, CS				
d. Breeding pigs, live weight 50 kg and more	T2	D, CS				
3. Sheep	T1	D				
4. Goats	T1	D				

	CH_4		N_2O		Key category	
	Method applied	Emission factor	Method applied	Emission factor	LULUCF sector is not included	LULUCF sector is included
5. Horses	T1	D				
6. Poultry	NA	NA				
7. Fur farming	T1	D				
4.B. Manure management						
1. Cattle						
a. Cows, bulls and heifers (2 years and over)						
Dairy cattle	T2	D, CS				
Non-dairy Cattle						
Mature females	T2	D, CS				
Mature males	T2	D, CS				
b. Bovine animals (ages between 1 and 2 years)	T2	D, CS				
c. Calves (less than 1 year old)	T2	D, CS				
2. Swine						
a. Piglets, live weight less than 20 kg	T2	D, CS				
b. Young pigs, live weight 20 - <50 kg	T2	D, CS				
c. Fattening pigs, live weight						
50 - <80 kg	T2	D, CS				
80 - <110 kg	T2	D, CS				
110 kg or more	T2	D, CS				
d. Breeding pigs, live weight 50 kg and more	T2	D, CS				
3. Sheep	T1	D				
4. Goats	T1	D				
5. Horses	T1	D				
6. Poultry	T1	D				
7. Fur farming	T1	D				
1. Anaerobic lagoon			NA	NA		
2. Liquid system			T2	D		
3. Daily spread			NA	NA		
4. Solid storage and dry lot			T2	D	L, T	L
5. Other AWMS			NA	NA		
4.C. Rice cultivation	NO	NA				
4.D. Agricultural soil						
1. Direct soil emissions						
a. Synthetic fertilizers			T1	D	L, T	L, T
b. Animal waste applied to soils			T1	D	L	L
c. N-fixing crops			T1b	D	L, T	L, T
d. Crop residues			T1b	D	T	T
e. Cultivation of histosols			T1	D	T	
f. Other direct emissions / Sewage sludge use			T1	D		
2. Pasture, range and paddock			T2	D	L	L
3. Indirect emissions						
a. Atmospheric deposition			T1b	D		
b. Leaching and run-off			T1b	D	L, T	L, T
4.E. Prescribed burning of savannas	NA	NA	NA	NA		
4.F. Field burning of agricultural residues	NA	NA	NA	NA		

T1 – Tier 1; T – Tier 2; D – IPCC default; CS – Country-specific; NO – Not occurring; NA – Not applicable.

6.2.1. References – sources of information

The estimates were carried out based on the approaches presented in the 1996 Revised IPCC Guidelines (IPCC, 1997) and in the IPCC Good Practice Guidance (IPCC, 2000).

Activity data were obtained from Estonian national statistics, emission factors were taken from the IPCC Guidelines (IPCC, 1997, 2000) and calculated as country-specific. The list of institutions directly and indirectly involved in the inventory process is presented in Table 6.3.

Table 6.3. List of institutions (datasets) involved in the emission inventory for the agricultural sector

References	Link	Abbreviation	Data, activity
Tallinn University of Technology	www.ttu.ee	TUT	- collecting of activity data; - estimation of emissions; - reporting (the CRF tables, the NIR).
Statistics Estonia – Agricultural Statistics	www.stat.ee	SE	- collecting and reporting of data on livestock population, quantities of crop produced and amounts of fertilizers applied on fields.
Estonian Animal Recording Centre	www.jkkeskus.ee	EARC	- collecting and reporting of data on milk production, fat content in milk. - collecting data on dairy cattle population by dairy-cattle breed.
Estonian Environment Information Centre	www.keskkonnainfo.ee	EEIC	- providing with data on areas of organic soils under cultivation. - collecting and reporting of data on amounts of sludge used for improvement of environment (on agricultural fields)

6.2.2. Livestock characterization

Estonia's livestock population decreased by 2010 in comparison with the base year: the number of dairy cattle decreased by 66 per cent: from 280.7 thousand heads to 96.5 thousand heads (Figure 6.4, Figure 6.7, Figure 6.8), the number of non-dairy cattle decreased from 475.1 thousand heads in 1990 to 139.8 thousand heads in 2010 (Figure 6.4, Figure 6.8). The total number of swine decreased by 57 per cent (Figure 6.4, Figure 6.9), horses – by 21 per cent (Figure 6.4) and poultry – by 69 per cent (Figure 6.5). The number of sheep decreased by 44 per cent, however, the population number of goats increased from 0.9 thousand heads to 4.1 thousand heads from 1990 to 2010 (Figure 6.4).

The decline in the livestock population was caused by the changes in the economy due to the disintegration of the Soviet Union. Estonia was left with a large excess capacity of supply of agricultural produce. Western markets remained closed to Estonian agricultural products due to high customs barriers and non-compliance of our products with the requirements and practices abroad (Estonica, 2010).

The population of fur animals remarkably decreased by 1999 compared to 1990 due to absence of markets (Figure 6.6). In 1998, Estonian fur farmers established a relationship with colleagues from Nordic countries. The new partners provided Estonian farmers with valuable assistance regarding breeding programmers, improving basic herds etc. (Saveli, 2004). Since 2000, the number of fur animals has started slightly to increase. A major share of the production of Estonian fur farming is exported currently (Estonica, 2010).

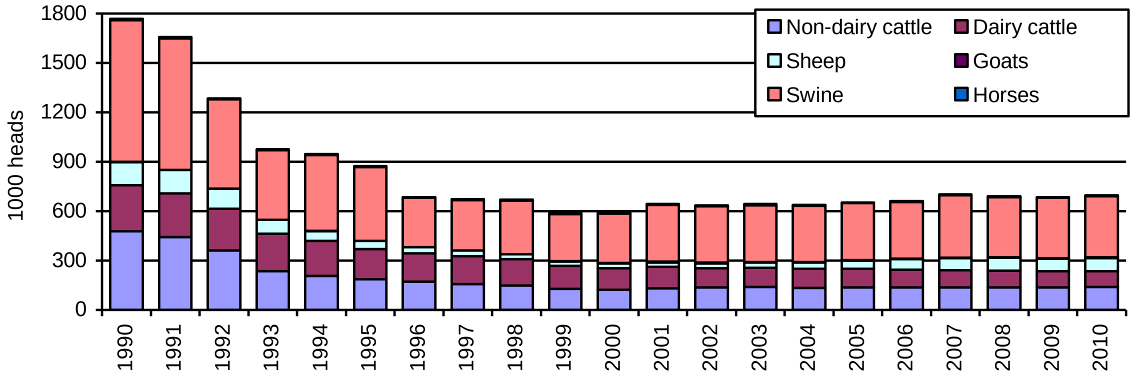

Figure 6.4. Population of livestock in Estonia in 1990–2010, 1000 heads

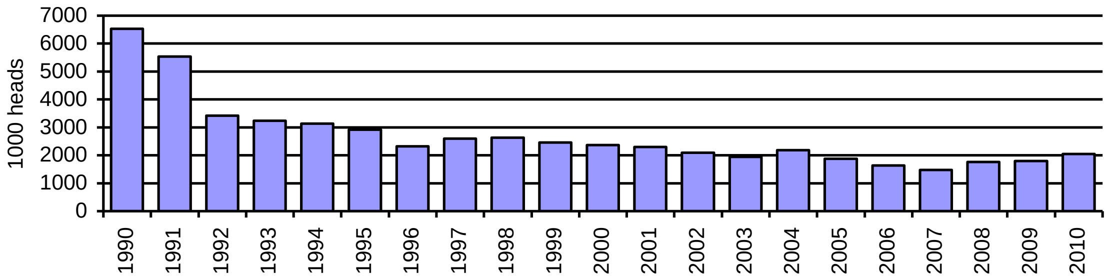

Figure 6.5. Population of poultry in Estonia in 1990–2010, 1000 heads

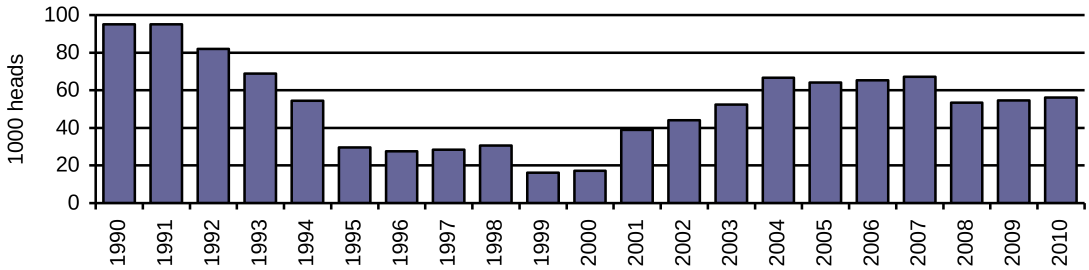

Figure 6.6. Population of fur animals in Estonia in 1990–2010, 1000 heads[16]

[16] The data on fur animal population in 1994–2010 were obtained from SE datasets; the data of 1991 – from (Saveli, 2004) and the data for years 1990, 1992–1993 were interpolated/extrapolated.

The data on mature non-dairy cattle population were collected and reported by SE according to two methodologies employed: for 1990–1998 – livestock population data were reported for two sub-categories (bovine animals and mature males) and for 1999–2010 – the population of three sub-categories of non-dairy mature cattle was reported by SE (bovine animals, mature males and females). In order to guarantee the consistency in the activity data used, the data of 1990–1998 were updated based on the assumptions applied in the 2010 submission, the results are illustrated in Figure 6.8 and Appendix A.3.3_I.

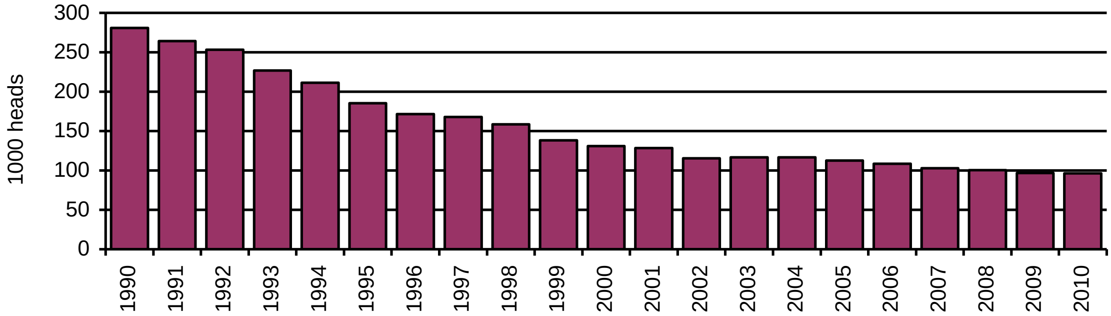

Figure 6.7. Population of dairy cattle in Estonia in 1990–2010, 1000 heads

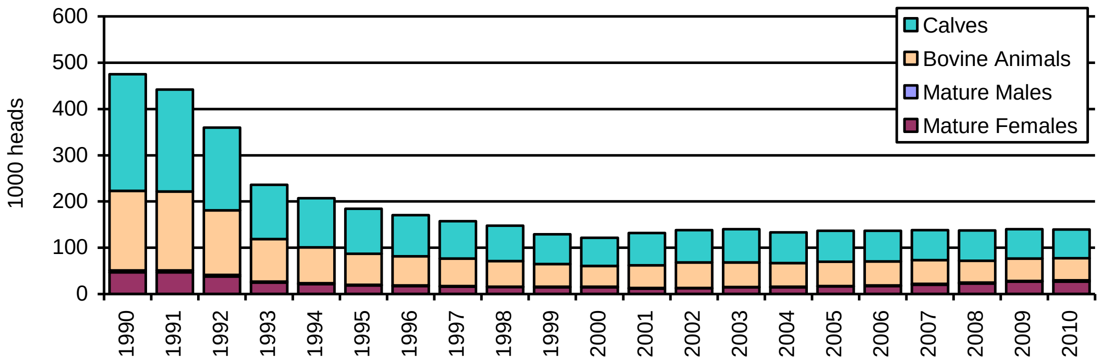

Figure 6.8. Population of non-dairy cattle in Estonia in 1990–2010, 1000 heads[17]

The activity data on swine population in 1990–1998 were updated in the 2009 submission. Since, the number of swine population for 1990–1998 was reported for three sub-categories of swine (breeding sows, fattening pigs and young swine), however, the number of swine population for 1999–2008 was reported for six sub-categories of swine (piglets, with live weight less than 20 kg; young pigs, with live weight 20–<50kg; pigs, with live weight 50–<80kg, 80–<110kg and 110 kg and more; and breeding sows). Hence, based on the average structure of swine population (by categories) of 1999–2008, the activity data on swine population in 1990–1998 were recalculated for six sub-categories instead of three reported earlier (Figure 6.9, Appendix A.3.3_I).

[17] Number of calves less than 6 months old is included.

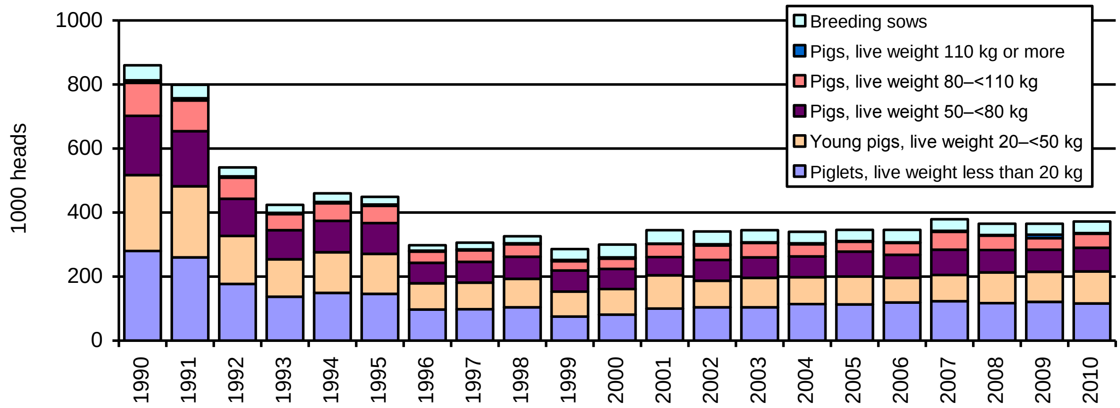

Figure 6.9. Population of swine in Estonia in 1990–2010, 1000 heads

The activity data used in the estimations in the 2012 submission differ from those reported in the FAO statistic dataset due to different methods of data reporting (Table 6.4). In the framework of the FAO datasets, the data on livestock population is reported according the following methodology – total number of live animal is given for the year ending 30 September (e.g. number of live animals enumerated in a given country any time between 1 October and 30 September of the following year should be considered for the later year). According to the methodology established in SE, total number of live animal is presented for the year ending 31 December.

The data of SE data were used in the estimates of the 2012 submission.

Table 6.4. The number of livestock population in Estonia in 1992–2010, in accordance with SE and the FAO datasets, 1000 heads (SE, 2011; FAOSTAT, 2011)

Year	Cattle		Pigs		Sheep		Goats		Horses		Poultry	
	SE	FAO	SE	FAO	SE	FAO	SE	FAO	SE	FAO	SE	FAO
1992	614.6	708.3	541.1	798.6	123.1	141.9	1.1	NR	6.6	7.8	3 418.1	5 538
1993	463.2	614.6	424.3	541.1	82.2	124.2	1.1	NR	5.2	6.6	3 226.1	3 418
1994	419.5	463.2	459.8	424.3	60	83.3	1.5	NR	5.0	5.2	3 129.7	3 226
1995	370.4	419.5	448.8	459.8	48.2	61.5	1.7	NR	4.6	5.0	2 911.3	3 130
1996	343.0	370.4	298.4	448.8	37.6	49.8	1.6	NR	4.2	4.6	2 324.9	2 911
1997	325.6	343.0	306.3	298.4	33.9	39.2	1.7	NR	4.2	4.2	2 602.0	2 325
1998	307.5	325.6	326.4	306.3	28.7	33.9	2.1	1.7	3.9	4.2	2 635.7	2 602
1999	267.3	307.5	285.7	326.4	28.2	28.7	2.7	2.1	3.9	3.9	2 461.8	2 636
2000	252.8	267.3	300.2	285.7	29	28.2	3.2	2.7	4.2	3.9	2 366.4	2 414
2001	260.5	252.8	345.0	300.2	28.8	29	3.6	3.2	5.5	4.2	2 294.9	2 318
2002	253.9	260.5	340.8	345.0	29.9	28.8	3.9	3.6	5.3	5.5	2 096.3	2 249
2003	257.2	253.9	344.6	340.8	30.8	29.9	3.5	3.9	5.8	5.3	1 945.2	2 070
2004	249.8	257.2	340.1	344.6	38.8	30.8	2.9	3.5	5.1	5.8	2 183.0	1 929
2005	249.5	249.8	346.5	340.1	49.6	38.1	2.8	2.9	4.8	5.1	1 878.7	2 161
2006	244.8	249.5	345.8	346.5	62.7	49.6	3.3	2.8	4.9	4.8	1 638.7	1 854
2007	240.5	244.8	379.0	345.8	72.4	62.7	4.0	3.3	5.3	4.9	1 477.6	1 638
2008	237.9	240.5	364.9	379.0	78.2	72.4	3.6	4.0	5.3	5.3	1 757.3	1 478
2009	234.7	237.9	365.1	364.9	76.5	78.2	3.9	3.6	5.4	5.3	1 792.2	1 757
2010	236.3	234.7	371.7	365.1	78.6	76.5	4.1	3.9	6.8	5.4	2 046.4	1 792

NR – the data are not reported by the FAO

6.3. Enteric fermentation (CRF 4.A)

6.3.1. Source category description

Methane is emitted as a by-product of livestock digestive process, in which microbes resident in the animals' digestive system ferment the feed consumed by the animal. This fermentation process is also known as enteric fermentation. Methane is then eructated or exhaled by the animal. Within livestock, ruminant livestock (cattle, buffalo, sheep, and goats) are the primary source of emissions (IPCC, 2000). Pigs are non-ruminant animals and convert a smaller proportion of feed intake into methane than ruminants.

The total CO_2 eq emissions from enteric fermentation of Estonian livestock made up 33% of the total CO_2 eq emissions of the agricultural sector in Estonia in 2010. CH_4 emissions of 2010 were 61 per cent lower than the emissions of the base year due to decrease in number of livestock population (Table 6.5, Figure 6.10).

Table 6.5. CH_4 emissions from enteric fermentation by animal type in 1990–2010 in Estonia, Gg

Year	Cattle	Swine	Sheep	Goats	Horses	Poultry	Fur animals	Total CH_4, Gg
1990	52.83	0.83	1.12	0.005	0.15	NE	0.010	54.95
1991	49.86	0.77	1.14	0.005	0.14	NE	0.010	51.92
1992	43.25	0.52	0.98	0.006	0.12	NE	0.008	44.89
1993	33.74	0.41	0.66	0.006	0.09	NE	0.007	34.91
1994	30.46	0.45	0.48	0.008	0.09	NE	0.006	31.48
1995	26.95	0.43	0.39	0.009	0.08	NE	0.003	27.86
1996	25.74	0.29	0.30	0.008	0.08	NE	0.003	26.42
1997	25.31	0.30	0.27	0.009	0.08	NE	0.003	25.97
1998	24.47	0.32	0.23	0.011	0.07	NE	0.003	25.10
1999	20.99	0.30	0.23	0.014	0.07	NE	0.002	21.60
2000	20.56	0.31	0.23	0.016	0.08	NE	0.002	21.19
2001	21.38	0.34	0.23	0.018	0.10	NE	0.004	22.08
2002	20.30	0.35	0.24	0.020	0.10	NE	0.004	21.00
2003	20.65	0.35	0.25	0.018	0.10	NE	0.005	21.37
2004	20.71	0.33	0.31	0.015	0.09	NE	0.007	21.47
2005	20.79	0.34	0.40	0.014	0.09	NE	0.006	21.63
2006	20.70	0.34	0.50	0.017	0.09	NE	0.007	21.66
2007	20.21	0.38	0.58	0.020	0.10	NE	0.007	21.29
2008	20.19	0.36	0.63	0.018	0.09	NE	0.005	21.29
2009	19.89	0.36	0.61	0.020	0.10	NE	0.005	20.98
2010	20.13	0.37	0.63	0.021	0.12	NE	0.006	21.28
%, 2010	94.6	1.7	3.0	0.1	0.6	-	0.0	100

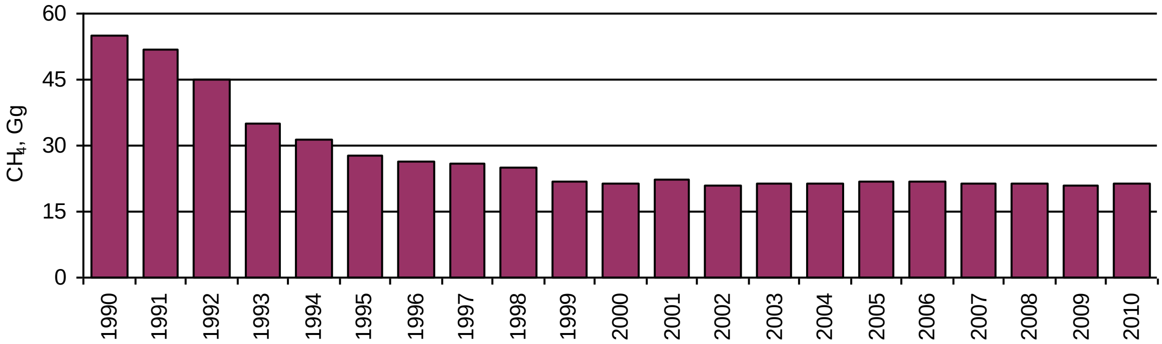

Figure 6.10. CH_4 emissions from enteric fermentation of Estonia's livestock in 1990–2010, Gg

6.3.2. Enteric fermentation of cattle

6.3.2.1. Methodology, data availability, data sources and emission factors

The *Tier 2* method (IPCC, 2000) was used to estimate CH_4 emissions from enteric fermentation of dairy cattle and mature non-dairy cattle, the emissions from young non-dairy cattle were calculated based on the Tier 1 method. Disaggregation of the data on county level of Estonia was applied (Table 6.6). Estonia's counties are visualized in Figure 6.11.

Table 6.6. Symbols used in the algorithm for cattle

County of Estonia	Cattle category
i1- Harju county	j1- Dairy cattle
i2- Hiiu county	j2- Mature females
i3- Ida-Viru county	j3- Mature males
i4- Jõgeva county	j4- Bovine cattle
i5- Järva county	j5- Calves (less than 1 year old)
i6- Lääne county	
i7- Lääne-Viru country	
i8- Põlva county	
i9- Pärnu county	
i10- Rapla county	
i11- Saare county	
i12- Tartu county	
i13- Valga county	
i14- Viljandi county	
i15- Võru county	

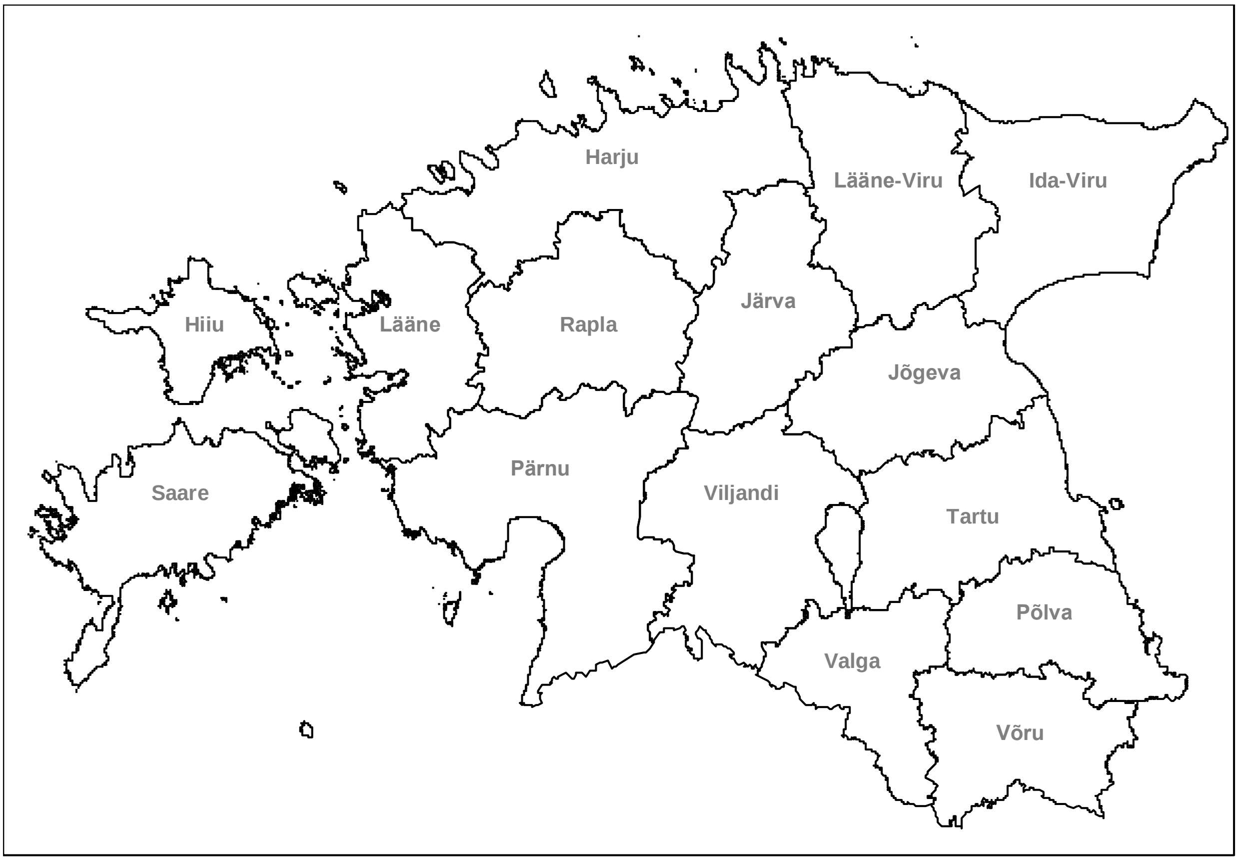

Figure 6.11. Administrative boundaries of Estonia's counties

Net energy for maintenance – Net energy required to keep the animals in energy equilibrium

$$NE_{mji} = C_{f\ ji} \bullet (weight_{ij})^{0.75} \quad (6.1)^{18}$$

NE_{mji} - Net energy for maintenance by *j* category of cattle in *i* county, MJ/head/day;

Weight – Live weight of *j* category of cattle in *i* county, kg;

C_f – Coefficient for calculating NE_m.

Table 6.7. C_f coefficient[19]

Animal category	C_{fi}
Cattle (non-lactating)	0.322
Cattle (lactating)	0.335

Net energy for activity for animals

$$NE_{aji} = C_a \bullet NE_{mji} \quad (6.2)^{20}$$

NE_{aji} - Net energy intake by *j* category of cattle in *i* county, MJ/head/day;

[18] IPCC 2000, Agriculture, Equation 4.1, pp. 4.13.
[19] IPCC 2000, Agriculture, Table 4-4 – Coefficient for calculating NEm, pp. 4.15.
[20] IPCC 2000, Agriculture, Equation 4.2a, pp. 4.14.

C_a - Coefficient corresponding to animal's feeding situation (Table 6.8);

NE_m – Net energy required for maintenance by *j* category of cattle in *i* county (6.1).

Table 6.8. Activity coefficients corresponding to animal's feeding situation[21]

Feeding situation	Definition	C_a
Pasture	Animals are confined in areas with sufficient means to forage, requiring a modest energy expense to acquire feed.	0.17

Net energy for growing – net energy needed for growth live weight gain

$$NE_{gji} = 4.18 \times \{(0.035 W_{ji}^{0.75} \times WG_{ji}^{1.119}) + WG_{ji}\} \qquad (6.3)^{22}$$

NE_{gji} – Net energy for growing by *j* category of cattle in *i* county, MJ/head/day;

W – Weight, kg;

WG – Weight gain by *j* category of cattle in *i* county, kg per day.

Net energy for lactation – energy for lactation

$$NE_{l_i} = kg\_of\_milk/day_i \times (1.47 + 0.40 \times Fat_i) \qquad (6.4)^{23}$$

NE_{li} – Net energy for lactation by dairy cattle in *i* county, MJ/head/day;

Fat – Fat content of milk in *i* county, %.

Net energy for pregnancy

$$NE_{pregnancy} = C_{pregnancy} \bullet NE_m \qquad (6.5)^{24}$$

$NE_{pregnancy}$ – net energy required for pregnancy, MJ/head/day;

$C_{pregnancy}$ – pregnancy coefficient = 0.1[25];

NE_m – net energy required by the animal for maintenance, MJ/head/day.

Ratio of net energy available in a diet for maintenance to digestible energy consumed

$$NE_{ma}/DE_{ji} = 1.123 - (4.092 \times 10^{-3} \times DE_{ji}\%) + (1.126 \times 10^{-5} \times (DE_{ji}\%)^2) - 25.4/DE_{ji}\% \qquad (6.6)^{26}$$

NE_{ma}/DE_{ji} – Ratio of net energy available in a diet for maintenance to digestible energy consumed for *j* category of cattle in *i* county;

[21] IPCC 2000, Agriculture, Table 4.5 – Activity coefficients corresponding to animal's feeding situation, pp. 4.15.
[22] IPCC 1997, Agriculture, Reference Manual, Equation 3, pp. 4.18.
[23] IPCC 2000, Agriculture, Equation 4.5a, pp. 4.17.
[24] IPCC 2000, Agriculture, Equation 4.8, pp. 4.18.
[25] IPCC 2000, Agriculture, Table 4.7 – Constants for use in calculating NEp, pp. 4.19.
[26] IPCC 2000, Agriculture, Equation 4.9, pp. 4.19.

DE_{ji} – Digestible energy expressed as a percentage of gross energy for *j* category of cattle in *i* county.

Ratio of net energy available for growth in a diet to digestible energy consumed

$$NE_g/DE_{ji} = 1.164 - (5.160 \times 10^{-3} \times DE_{ji}\%) + (1.308 \times 10^{-5} \times (DE_{ji}\%)^2) - (37.4/DE_{ji}\%) \quad (6.7)^{27}$$

NE_{gaji} – Ratio of net energy available for growth in a diet to digestible energy consumed for *j* category of cattle in *i* county.

Gross energy for cattle

$$GE = \frac{(NE_{m\,ji} + NE_{feedji} + NE_{lji} + NE_{workji} + NE_{pregnancyj}) \times \left(\frac{100}{DE_{ji}\%}\right)}{(NE/DE)_{ji} + (NE_{gji}/\{NE_g/DE\}_{ji})} \quad (6.8)^{28}$$

GE – Gross energy intake by *j* category of cattle in *i* county, MJ/head/day;

NE_m – Net energy required by the animal for maintenance by *j* category of cattle in *i* county, MJ/head/day;

NE_a or N_{feed} – Net energy for animal activity by *j* category of cattle in *i* county, MJ/day;

NE_l – Net energy for lactation by dairy cattle in *i* county, MJ/head/day;

NE_w – Net energy for work by *j* category of cattle in *i* county[29], MJ/head/day;

NE_p or $NE_{pregnancy}$ – Net energy required for pregnancy by dairy cattle in *i* county, MJ/head/day;

NE_g – Net energy needed for growth by *j* category of cattle in *i* county, MJ/head/day;

DE – Digestible energy as percentage of gross energy of *j* category of cattle in *i* county, %.

Methane emission factor from livestock category

$$E = [GE \times Y_m \times 365 days/year] / [55.65 MJ/CH_4\ kg] \quad (6.9)^{30}$$

E – Methane emissions from enteric fermentation of *j* category of cattle in *i* county, kg CH_4/year;

GE – Gross energy intake by *j* category of cattle in *i* county, MJ/head/day;

Y_m – Methane conversion rate, which is the factor of gross energy in feed converted to methane.

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[27] IPCC 2000, Agriculture, Equation 4.10, pp. 4.19.
[28] IPCC 2000, Agriculture, Equation 4.11, pp. 4.20.
[29] Net energy for work was not calculated.
[30] IPCC 2000, Agriculture, Equation 4.14, pp. 4.26.

Main sources of data used in the algorithm to estimate CH_4 EF for enteric fermentation by sub-categories of cattle:

Weight, kg – data on weight of dairy-cattle were calculated based on data of EARC and an expert judgment on weight of main categories of dairy-cattle in Estonia (Table 6.11, Appendix A.3.3_III).

Milk production per day, kg/day – a source of data is SE (Table 6.9, Appendix A.3.3_II).

Fat content of milk, % - data were obtained from EARC.

Percentage of cows that give birth in a year, % – data were employed from EARC (Appendix A.3.3_II).

Feed digestibility, % – data were used from (Kaasik et al., 2002).

The values of CH_4 EFs estimated for enteric fermentation of dairy cattle are presented in Table 6.9. The highest values of CH_4 EFs for dairy cattle among counties of Estonia were observed in Põlva and Tartu in 2010; these counties were characterized by high milk production per head of dairy cow.

Table 6.9. Milk yield per cow, fat content and CH_4 EF for dairy cattle by counties of Estonia in 2010

County	Milk yield per cow, kg/head/year	Fat content[31], %	Emission factor, kg CH_4/head/year
Harju county	6 402	4.11	124.53
Hiiu county	4 520	4.41	108.08
Ida-Viru county	6 334	4.07	123.56
Jõgeva county	7 230	4.14	132.78
Järva county	7 254	4.07	132.38
Lääne county	6 368	4.20	124.91
Lääne-Viru county	7 390	4.01	133.13
Põlva county	7 671	4.14	137.04
Pärnu county	6 948	4.12	129.88
Rapla county	7 355	4.18	134.35
Saare county	6 243	4.15	123.31
Tartu county	7 997	4.02	139.00
Valga county	6 127	4.17	122.34
Viljandi county	6 784	4.12	128.30
Võru county	6 461	4.24	126.14

The values of CH_4 EFs for enteric fermentation of non-dairy cattle (mature and young) are presented in Table 6.10.

Table 6.10. CH_4 EF of enteric fermentation of non-dairy cattle in 2010, kg CH_4/head/year

Livestock category of non-dairy cattle	Emission factor, kg CH_4/head/year
Mature males (2 years and over)	60.93
Mature females (2 years and over)	60.99
Bovine animals (aged between 1 and 2 years)	68.06
Calves (less than 1 year old)	40.18

[31] Results of animal recording in Estonia in 1997–2010. Annual Reports. Available at: www.jkkeskus.ee/page.php?page=0147.

The values of CH_4 EF have increased in the period of 1990–2010, mainly due to the increase in milk production by cows (Table 6.11). Figure 6.12 illustrates the trend of the annual changes in CH_4 EFs for dairy cattle, milk yield per cow and number of dairy cattle population in relation to the base year (1990 = 1).

Table 6.11. Weight, milk yield per cow and fat content of milk, gross energy intake and CH_4 EFs for dairy cattle in 1990–2010 (Appendix A.3.3_II)

Year	Weight of dairy-cattle, kg/head	Fat content of milk, %	Milk yield per cow, kg/head/year	Gross energy intake, MJ/head/day	Emission factor, kg CH_4/head/year
1990[32]	575.0	4.14	3 968	254.69	99.34
1991	576.0	4.14	3 968	254.90	99.42
1992	577.2	4.07	3 530	243.53	94.94
1993	578.8	4.10	3 322	239.17	93.23
1994	579.7	4.12	3 455	236.52	92.18
1995	580.2	4.20	3 588	238.73	93.06
1996	580.8	4.34	3 809	248.27	97.51
1997	581.6	4.32	4 484	257.77	101.21
1998	582.6	4.26	4 456	267.67	105.01
1999	583.8	4.23	4 171	256.78	102.15
2000	584.5	4.29	4 660	273.26	107.51
2001	585.3	4.31	5 313	291.53	112.35
2002	585.9	4.29	5 138	288.57	111.83
2003	586.2	4.31	5 231	289.78	113.19
2004	585.8	4.27	5 596	298.80	116.76
2005	585.7	4.21	5 886	305.54	119.52
2006	586.1	4.17	6 285	314.89	123.56
2007	586.4	4.15	6 484	319.53	124.05
2008	586.8	4.12	6 781	326.16	127.87
2009	587.4	4.14	6 838	328.13	128.82
2010	587.8	4.11	7 021	332.16	130.38
IPCC default					
EE[33]	550[(34)]		2 550		81[(35)]
WE	550		4 200		100

[32] Due to the lack of the activity data on milk yield and fact content of milk in 1990, the values of 1991 were used in the inventory.
[33] EE – Eastern Europe, WE – Western Europe.
[34] IPCC 1997. Agriculture. Reference Manual. Table A-1 – Data for estimating enteric fermentation emission factors for dairy cattle. pp.4.31.
[35] IPCC 1997. Agriculture, Reference Manual. Table 4-4 – Enteric fermentation emission factors for cattle. pp. 4.11.

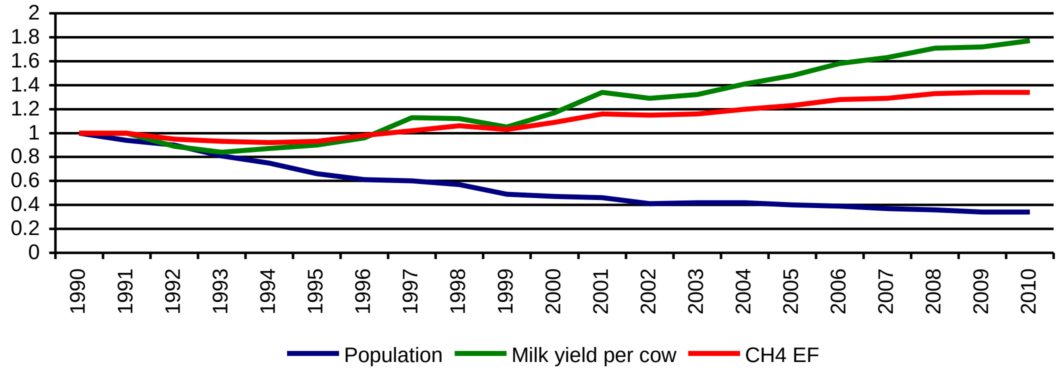

Figure 6.12. The changes in dairy cattle population, milk yield per cow and CH_4 EF in the period of 1990–2010 in relation to the base year (1990 = 1)

6.3.2.2. Quantitative overview – CH_4 emissions from enteric fermentation of cattle in 2010

The total CH_4 emissions from enteric fermentation of cattle were 20.13 Gg in 2010. Dairy cattle livestock was a main contributor to CH_4 emissions from cattle enteric fermentation in Estonia in 2010 (Table 6.12). The emissions decreased by 62 per cent by 2010 in comparison with the base year.

Table 6.12. CH_4 emissions from enteric fermentation of cattle in 1990–2010 in Estonia, Gg

Year	Cattle[36]			Total, CH_4 Gg
	Dairy cattle	Mature non-dairy cattle	Young cattle	
1990	27.89	14.83	10.12	52.83
1991	26.28	14.74	8.84	49.86
1992	24.06	12.01	7.18	43.25
1993	21.13	7.91	4.70	33.74
1994	19.49	6.72	4.25	30.46
1995	17.25	5.80	3.90	26.95
1996	16.73	5.43	3.58	25.74
1997	16.97	5.11	3.23	25.31
1998	16.65	4.72	3.10	24.47
1999	14.14	4.27	2.58	20.99
2000	14.08	4.02	2.46	20.56
2001	14.45	4.13	2.81	21.38
2002	12.93	4.55	2.81	20.30
2003	13.22	4.53	2.91	20.65
2004	13.60	4.45	2.66	20.71
2005	13.48	4.60	2.70	20.79
2006	13.39	4.66	2.65	20.70
2007	12.78	4.84	2.59	20.21
2008	12.84	4.72	2.64	20.19
2009	12.46	4.88	2.55	19.89
2010	12.58	5.03	2.52	20.13
%, 2010	62.5	25.0	12.5	100

[36] CH_4 emissions are reported according to the classification of the CRF reporter, since Option B was implemented to report emissions from enteric fermentation of cattle.

6.3.3. Enteric fermentation of swine

6.3.3.1. Methodology, data availability, data sources and emission factors

The *Tier 2* was used to estimate CH_4 emissions from enteric fermentation of swine. The estimation was carried out for the main sub-categories of pigs broken down by weight of animals (Table 6.13), methane conversion factor were taken from the revised 1996 IPCC Guidelines (IPCC, 1997), ratios of feed digestibility were obtained from (Kaasik et al., 2002).

Table 6.13. Symbols used in the equations

County of Estonia	Swine categories
i1- Harju county	j1- Piglets, live weight less than 20 kg
i2- Hiiu county	j2- Young pigs, live weight20–<50 kg
i3- Ida-Viru county	j3- Pigs, with live weight 50–<80 kg
i4- Jõgeva county	j4- Pigs, with live weight 80–<110 kg
i5- Järva county	j5- Pigs, with live weight 110 kg or more
i6- Lääne county	j6- Breeding pigs, live weight 50 kg or more
i7- Lääne-Viru county	
i8- Põlva county	
i9- Pärnu county	
i10- Rapla county	
i11- Saare county	
i12- Tartu county	
i13- Valga county	
i14- Viljandi county	
i15- Võru county	

Gross energy intake by swine

$$GE_{ji} = ME_{ji}/DE_{ji} \qquad (6.10)$$

GE_{ji} – Gross energy intake by *j* swine category in *i* county, MJ/head/day;
DE_{ji} – Digestible energy as percentage of gross energy of *j* category of swine in *i* county, %.

$$ME_{ji} = 2.0 \times w_{ji}^{0.63} \qquad (6.11)^{37}$$

ME_{ji} – Energy intake for maintenance and growth of *j* swine category in *i* county, MJ/head/day;
w_{ji} – Live weight of *j* category in *i* county, kg.

Methane emission factor from livestock category

$$E = \left[GE \times Y_m \times (365 days/yr)\right] / \left[55.65 MJ / CH_4 \ kg\right] \qquad (6.12)^{38}$$

E – Methane emissions from enteric fermentation, kg CH_4/year;

GE – Gross energy intake, MJ/head/day;

[37] Oll *et al.*, 1991; Turnpenny *et al.*, 2001.
[38] IPCC 2000. Agriculture. Equation 4.14, pp. 4.26.

Y_m – Methane conversion rate, which is the factor of gross energy in feed converted to methane.

CH_4 emission factor for each category of swine and the IPCC default EF for swine recommended for developed countries (IPCC, 1997) are presented in Table 6.14. The implied emission factors for swine enteric fermentation for the entire time-series are presented in Figure 6.13.

Table 6.14. Methane emission factors for swine enteric fermentation, kg CH_4/head/year

Swine category	Weight, kg/head	Gross energy intake, MJ/head/year	Emission factor, kg CH_4/head/year	
			calculated	IPCC default[39]
Total				1.5
Piglets, live weight less than 20 kg	10	10.0	0.39	
Young pigs, live weight 20–<50 kg	35	22.1	0.87	
Fattening pigs				
…live weight 50–<80 kg	65	34.7	1.36	
…live weight 80–<110 kg	95	44.0	1.73	
…live weight 110 kg or more	110	48.3	1.90	
Breeding pigs, live weight 50 kg or more	75	38.0	1.49	

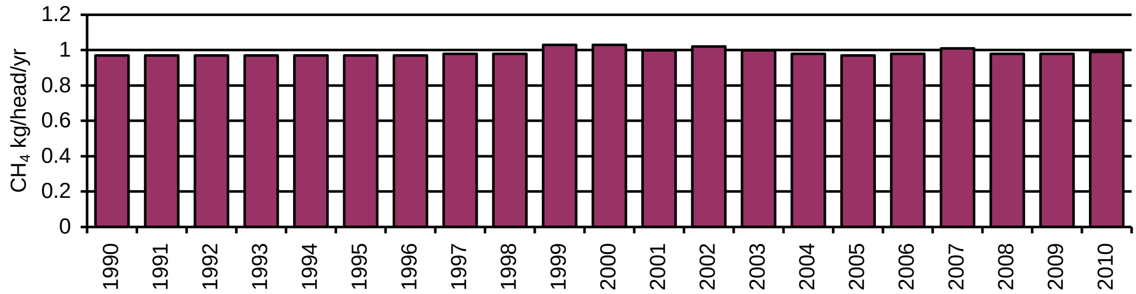

Figure 6.13. Implied emission factor (IEF) of swine enteric fermentation in 1990–2010, CH_4 kg/head/year

6.3.3.2. Quantitative overview – CH_4 emissions from enteric fermentation of swine in 2010

The total CH_4 emissions from swine enteric fermentation were 0.37 Gg in 2010. The emissions decreased by 56 per cent since the base year due to decreasing population of swine (Figure 6.14).

[39] IPCC 1997. Agriculture. Reference Manual. Table 4-3 – Enteric Fermentation Emission Factors. pp. 4.10.

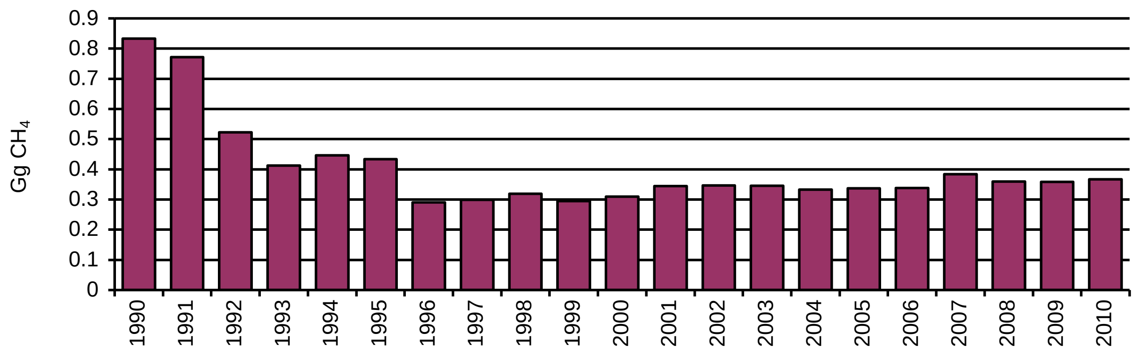

Figure 6.14. CH_4 emissions from enteric fermentation of swine in 1990–2010 in Estonia, Gg

6.3.4. Enteric fermentation of other livestock

6.3.4.1. Methodology, data availability, data sources and emission factors

The *Tier 1* (IPCC, 1997) was used to estimate CH4 emissions from enteric fermentation of other livestock (6.13).

$$CH_4\ \text{Emission} = EF_{ji} \times \text{population}_{ji} / (10^6\ \text{kg/Gg}) \qquad (6.13)^{40}$$

CH_4 Emission$_{ji}$ – Methane emissions from enteric fermentation from *j* category of animals in *i* county, Gg CH_4/year;

EF_{ji} – Methane emission factor for *j* category of animals in *i* county, CH_4 kg/head/year;

Population$_{ji}$ – The number of *j* category of animals in *i* county, head.

CH_4 emission factors, recommended by the 1996 Revised IPCC Guidelines for developed countries (IPCC, 1997), were used to estimate CH_4 emissions from enteric fermentation of sheep, goats and horses (Table 6.15). The emission factors for fur animals were provided by a Finnish expert in the Agriculture sector Sanna Pitkänen (personal communication).

Table 6.15. Enteric fermentation methane emission factors, kg CH_4/head/year[41]

Livestock category	Emission factor, kg CH_4/head/year
Sheep	8
Goats	5
Horses	18
Poultry	Not estimated
Fur animals	0.1[42]

[40] IPCC 2000. Agriculture. Equation 4.12, pp. 4.25.
[41] IPCC 1997. Agriculture. Reference Manual. Table 4-3 Enteric fermentation emission factors (default values for developed countries) pp. 4.10.
[42] For fur animals the Norwegian emission factor was used (0.1 kg/animal/year). The emission factor was derived by scaling the emission factor of swine based on comparison between the average weights of swine and fur animals. Swine was assumed to be similar to fur animals with regard to digestive system and feeding.

6.3.4.2. Quantitative overview – CH_4 emissions from enteric fermentation of other livestock categories in 2010

The total CH_4 emissions from enteric fermentation of other livestock were 0.78 Gg in 2010. CH_4 emissions of declined by 40 per cent by 2010 in comparison with the base year due to decrease in the other livestock population (Figure 6.15).

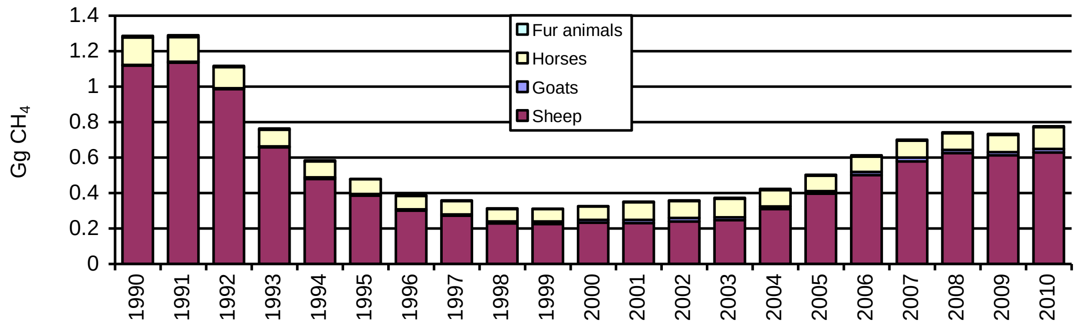

Figure 6.15. CH_4 emissions from enteric fermentation of other livestock categories in 1990–2010, Gg

6.3.5. Uncertainties and time-series consistency

The estimation of CH_4 emissions from enteric fermentation of cattle and swine were carried out based on the *Tier 2* approach with Estonian activity data and default factors obtained from the IPCC Guidelines (1997, 2000). The *Tier 1* method was used to estimate CH_4 emissions from other livestock: goats, horses, sheep and fur animals.

Uncertainty rates of activity data are not calculated in Estonia. The data were obtained from (Rypdal and Winiwarter, 2001), where uncertainties of activity data (livestock population) are presented for a few countries: Austria (±10%), Norway (±5–10%), the Netherlands (<±5%), USA (±2%). The experiences of Austria were used to calculate uncertainties in emissions from enteric fermentation of livestock (Table 6.16). The uncertainty in CH_4 emission factors for livestock categories (sheep, goats, horses) is reported to be ±20% (IPCC, 1997).

In spite of the fact that the *Tier 2* method is used in the calculation of emissions from cattle and swine, the default uncertainty rate was taken as ±50% due to the lack of uncertainty analysis of each parameters, separately (Table 6.16) (IPCC, 2000).

Table 6.16. Estimated values of uncertainties used in the agriculture sector

Input	Uncertainty	References
Activity data		
Estonia's livestock population (cattle, swine, sheep, goats, horses, poultry and fur animals)	± 10%	Rypdal and Winiwarter, 2001
Emission factors		
Enteric fermentation (CH_4) (cattle, swine, fur animals)	± 50%	IPCC, 2000. Agriculture. pp. 4.27
Enteric fermentation (CH_4) (sheep, goats, horses)	± 20%	Table 4-3 of the 1996 IPCC Guidelines, pp. 4.10

6.3.6. Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.3.3.

The QC/QA plan for the agricultural sector includes the QC activities described in the IPCC GPG (IPCC 2000, Table 8.1). The activities are carried out every year during the inventory. The QC check list is used during the inventory.

6.3.7. Source-specific recalculations

There are several recalculations carried out in the 2012 submission in framework of the estimation of CH_4 emissions from enteric fermentation of cattle and swine:

Cattle enteric fermentation:

(1) Values of feed digestibility were updated – country-specific values were used in the estimates;

(2) Values of daily weight gain for dairy cattle and mature female cattle were updated – country-specific values were used in the estimates;

(3) Classification of feeding situation of dairy cattle was updated – 'Pasture' was selected as the main feeding situation for dairy cattle;

(4) An omission made in the process of using the equation (6.8) was corrected.

The changes in the values of CH_4 EFs received due to the recalculations performed are presented in Table 6.17 and Table 6.18.

Table 6.17. CH_4 EFs for dairy cattle enteric fermentation in 1990–2009, kg CH_4/head/year

Year / Parameter	Reported in the 2011 submission	Reported in the 2012 submission
Feed digestibility (DE), %	60	67
Weight gain, kg/year	-	60
1990	101.39	99.34
1991	101.46	99.42
1992	96.19	94.94
1993	94.14	93.23
1994	92.90	92.18
1995	93.91	93.06
1996	99.14	97.51
1997	103.47	101.21
1998	107.91	105.01
1999	104.75	102.15
2000	110.81	107.51
2001	118.02	112.35
2002	116.98	111.83
2003	117.46	113.19
2004	121.65	116.76
2005	124.90	119.52
2006	129.64	123.56
2007	130.35	124.05
2008	134.68	127.87
2009	136.07	128.82

Table 6.18. CH_4 EFs for enteric fermentation of non-dairy cattle in 1990–2009, kg CH_4/head/year

Non-dairy cattle category	EFs, kg CH_4/head/year		Feed digestibility (DE), %	
	2011[43]	2012	2011	2012
Mature males (2 years and over)	65.60	60.93	60	62
Mature females (2 years and over)	57.22	60.99	60	63
Bovine animals (aged between 1 and 2 years)	61.41	68.06	60	63
Calves (less than 1 year old)	33.37	40.18	65	63

The total CH_4 emissions from cattle (i.e., dairy and non-dairy) enteric fermentation due the recalculations performed are reported in Table 6.19. The comparison with the total CH_4 emissions reported in the previous submission is presented.

Table 6.19. CH_4 emissions from enteric fermentation of cattle (dairy, mature non-dairy and young) in 1990–2009, Gg

Year	Reported CH_4 emissions in the 2011 submission	Recalculated CH_4 emissions in the 2012 submission
1990	50.39	52.83
1991	47.61	49.86
1992	41.30	43.25
1993	32.45	33.74
1994	29.30	30.46
1995	25.94	26.95
1996	24.94	25.74
1997	24.69	25.31
1998	23.99	24.47
1999	20.56	20.99
2000	20.23	20.56
2001	21.27	21.38
2002	20.01	20.30
2003	20.26	20.65
2004	20.44	20.71
2005	20.53	20.79
2006	20.51	20.70
2007	20.01	20.21
2008	20.04	20.19
2009	19.76	19.89

Swine enteric fermentation:

(1) The calculation algorithm of gross energy intake by swine was corrected – the formula used to estimate gross energy intake was interpreted incorrectly in the previous submissions. Since, the formula was used a basis to estimate gross energy intake instead of energy intake for maintenance and growth. However, in the present submission, the correction was implemented, the values of feed digestibility were used to calculate gross energy intake and CH_4 EFs and the total CH_4 emissions from swine enteric fermentation were re-estimated.

The values of CH_4 EFs due to recalculations performed are illustrated in Table 6.20. The results in the total CH_4 emissions from swine enteric fermentation are demonstrated in Table 6.21.

[43] 2011 – the 2011 submission; 2012 – the 2012 submission.

Table 6.20. CH_4 emission factors for swine enteric fermentation in 1990–2009, kg CH_4/head/year

Swine category	CH_4 EFs used in the 2011 submission	CH_4 EFs used in the 2012 submission
Piglets, live weight less than 20 kg	0.34	0.39
Young pigs, live weight 20–<50 kg	0.74	0.87
Fattening pigs		
…live weight 50–<80 kg	1.09	1.36
…live weight 80–<110 kg	1.39	1.73
…live weight 110 kg or more	1.52	1.90
Breeding pigs, live weight 50 kg or more	1.19	1.49

Table 6.21. CH_4 emissions from enteric fermentation of swine in 1990–2009, Gg

Year	Reported CH_4 emissions in the 2011 submission	Recalculated CH_4 emissions in the 2012 submission
1990	0.68	0.83
1991	0.63	0.77
1992	0.43	0.52
1993	0.34	0.41
1994	0.37	0.45
1995	0.36	0.43
1996	0.24	0.29
1997	0.24	0.30
1998	0.26	0.32
1999	0.24	0.30
2000	0.25	0.31
2001	0.28	0.34
2002	0.28	0.35
2003	0.28	0.35
2004	0.27	0.33
2005	0.28	0.34
2006	0.28	0.34
2007	0.31	0.38
2008	0.29	0.36
2009	0.29	0.36

6.3.8. Source-specific planned improvements

CH_4 emissions from enteric fermentation of calves fed on milk (less than 6 months old) were calculated and reported in the 2012 submission, in spite of the fact that CH_4 conversion rate of milk-fed calves is zero. Estonian national statistics (SE) has reported data on the total population of calves less than one year old (i.e., population of calves less than 6 months old is reported together with calves older than 6 months). Hence, there is a need for further data adjustment, which allows to determine population of calves fed on milk (less than 6 months old) in the total population number of calves (less than 1 year old). The adjustment will be performed in the next submission. The consultations with spetsialists of SE will be arranged. The data on weight, daily weight gain, digestibility of feed etc. of calves less than 6 months old and aged between 6 months and one year will be taken from scientific literature and additional consultations with agricultural experts will be carried out.

In addition, the adjusted data on calves population and parameters needed in the process of the estimation of emissions from enteric fermentation will be applied also to estimate nitrogen excretion rates for these categories of calves. The planned activity allows to improve inventory of nitrogen generated by calves and stored to manure management systems.

The parameters (weight, daily weight gain, etc.) used to estimate emission factors for enteric fermentation of non-dairy cattle will be developed on the basis of country-specific data in the literature as well.

6.4. Manure management (CRF 4.B)

6.4.1. CH_4 emissions from manure management

Methane is produced from the decomposition of the organic matter remaining in the manure under anaerobic conditions (IPCC, 2000). The quantities of CH_4 emissions from manure management directly depend on the manure management system and temperature.

CH_4 emissions (recalculated to CO_2 eq) from manure management comprised 4.5% in the total agricultural emissions in Estonia in 2010.

The total CH_4 emissions from livestock manure management were 2.348 Gg in Estonia in 2010, the emissions declined by 59 per cent by 2010 in comparison with the base year (Table 6.22, Figure 6.16).

Table 6.22. CH_4 emissions from manure management in 1990–2010 in Estonia, Gg

Year	Cattle	Swine	Sheep	Goats	Horses	Poultry	Fur animals	Total
1990	3.476	1.660	0.027	0.0001	0.012	0.510	0.013	5.697
1991	3.284	1.539	0.027	0.0001	0.011	0.432	0.013	5.305
1992	2.884	1.042	0.023	0.0001	0.009	0.267	0.011	4.236
1993	2.315	0.822	0.016	0.0001	0.007	0.252	0.009	3.421
1994	2.064	0.898	0.011	0.0002	0.007	0.244	0.007	3.232
1995	1.839	0.887	0.009	0.0002	0.006	0.227	0.004	2.973
1996	1.774	0.589	0.007	0.0002	0.006	0.181	0.004	2.561
1997	1.760	0.613	0.006	0.0002	0.006	0.203	0.004	2.592
1998	1.715	0.659	0.005	0.0003	0.005	0.206	0.004	2.595
1999	1.466	0.608	0.005	0.0003	0.005	0.192	0.002	2.279
2000	1.409	0.640	0.006	0.0004	0.006	0.185	0.002	2.248
2001	1.504	0.700	0.005	0.0004	0.008	0.179	0.005	2.402
2002	1.417	0.708	0.006	0.0005	0.007	0.164	0.006	2.308
2003	1.434	0.696	0.006	0.0004	0.008	0.152	0.007	2.303
2004	1.457	0.658	0.007	0.0003	0.007	0.170	0.009	2.309
2005	1.457	0.668	0.009	0.0003	0.007	0.147	0.009	2.296
2006	1.450	0.681	0.012	0.0004	0.007	0.128	0.009	2.287
2007	1.402	0.775	0.014	0.0005	0.007	0.115	0.009	2.322
2008	1.400	0.714	0.015	0.0004	0.007	0.137	0.007	2.280
2009	1.371	0.703	0.015	0.0005	0.008	0.140	0.007	2.244
2010	1.389	0.767	0.015	0.0005	0.010	0.160	0.007	2.348
%, 2010	59.2	32.8	0.6	0.0	0.4	6.8	0.3	100.0

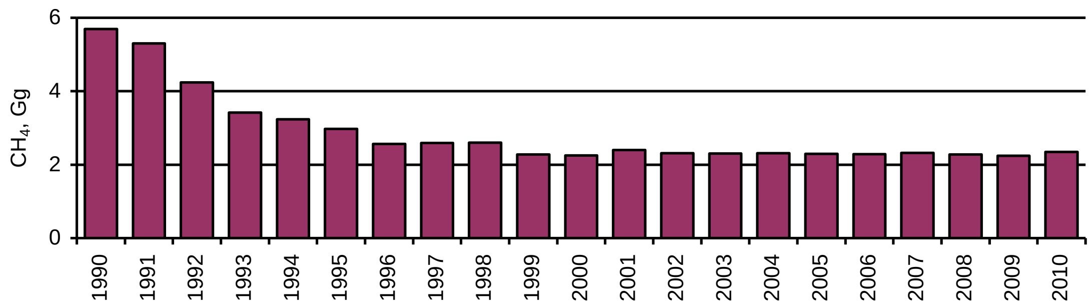

Figure 6.16. CH_4 emissions from Estonia's livestock manure management in 1990–2010, Gg

6.4.1.1. Cattle manure management

6.4.1.1.1. Methodology, data availability, data sources and emission factors

CH_4 production from manure management of dairy cattle and non-dairy cattle was estimated based on the algorithm presented in the IPCC (2000) using country-specific data and IPCC default factors.

$$CH_4\_Emissions_{ji} = EF_{ji} \times Population_{ji} / (10^6 \, kg/Gg) \qquad (6.14)^{44}$$

CH_4 Emissions$_{ji}$ – Methane emissions from manure management of *j* category of cattle in *i* county, Gg CH_4/year;
EF_{ji} – Methane emission factor for *j* category of cattle in *i* county, kgCH_4/head/year;
Population$_{ji}$ – The number of head in *j* category of cattle in *i* county, heads.

$$EF_{ji} = VS_{ji} \times 365\_days/yr \times B_{oji} \times 0.67 kg/m^3 \times \sum_{nK} MCF_{nk} \times MS\%_{jiK} \qquad (6.15)^{45}$$

EF_{ji} – Annual methane emission factor for *j* category of cattle in *i* county, kg;

VS_{ji} – Volatile solid excreted for for *j* category of cattle in *i* county, kg;

Bo_{ji} – Maximum CH_4 producing capacity for manure produced by *j* category of cattle in *i* county, kg of VS (Table 6.23);

MCF_{ik} – CH_4 conversion factors for each manure management system *n* by climate region *k*;

MS_{ijk} – Fraction of animal species/category *j*'s manure handled using manure system *n* in *i* country in climate region *k*.

$$VS_{ji} \; (kg \; dm/day) = \frac{GE_{ii}}{18.45} \times \left(1 - \frac{DE_{ji}\,\%}{100\%}\right) \times \left(1 - \frac{ASH\%}{100\%}\right) \qquad (6.16)^{46}$$

[44] IPCC 2000. Agriculture. Equation 4.15, pp. 4.30.
[45] IPCC 2000. Agriculture. Equation 4.17, pp. 4.34.
[46] IPCC 2000. Agriculture. Equation 4.16, pp. 4.30.

VS_{ji} – Volatile solid excretion per day on a dry-matter weight basis of *j* category of cattle in *i* county, kg DM/day;

GE_{ji} – Daily gross energy intake per head of *j* category of cattle in *i* county, MJ/day;

1 dm kg – 18.45 MJ;

DE_{ji} - Digestible energy of the feed for *j* category of cattle in *i* county, % (Table 6.23);

ASH – Ash content of the manure as a percentage, % (8%).

Table 6.23. Parameters used in the estimates

Cattle category	Feeding situation	Digestibility of feed (DE), %[47]	CH_4 Conversion, %	Bo, m^3 CH_4/kg VS
Mature cattle[48]				
...Dairy	Pasture/Range	67	6	0.24
...Non-Dairy Cattle:				
…...Mature Females	Pasture/Range	62	6.5	0.17
…...Mature Males	Pasture/Range	63	6.5	0.17
Bovine animals (aged between 1 and 2 years)[49]	Pasture/Range	63	6	0.17
Calves (less than 1 year old)[50]	Pasture/Range	63	6	0.17

Manure management systems: cattle and swine livestock

Country-specific module on manure management system (MMS) was developed and reported for the first time in the 2012 submission. The data on cattle and swine livestock population and the data on location of MMS were used as a basis for development of the module. The data were collected by SE in the framework of Agricultural Survey. The both databases contain data on village level. More than 30,500 holdings with different size of livestock herds and about 1,700 holdings, which have MMSs, were analyzed. The large difference in numbers of holdings keeping livestock and those, which have MMS, is explained by size of livestock herds. In Estonia, holdings with less than 10 livestock units are not under obligatory to build MMS for animal waste storage (Veeseadus, 2011), usually these holdings storage animal waste in cattle-shed or pigsty, in manure-heap, truck etc. i.e., there is typical for these farms to store animal waste in ‘solid manure management system’ (according to the classification established under the IPCC[51]).

A share of small holdings keeping less than 10 heads of dairy cows was 93% of the total agricultural holdings with dairy cattle, these holdings kept about 24% of the total population of dairy cattle in 2000. A share of small holding keeping less than 10 livestock unit of pigs was 98% of the total number of holding, which kept pigs. The population of pigs in small swine holdings made up 13% of the total pig population in Estonia in 2000 (Table 6.24).

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[47] Kaasik et al., 2002.
[48] IPCC 1997. Agriculture. Reference Manual. Dairy Cattle – Table A-1 and Non-dairy cattle – Table A-2. pp. 4.42-4.43 (for Eastern European countries).
[49] IPCC 1997. Agriculture. Reference Manual. Bovine animals – Table A-2. pp. 4.42-4.43 (replacement/ growing cattle of Western European countries).
[50] IPCC 1997. Agriculture. Reference Manual. Calves – Table A-2, pp. 4.42-4.43 (young cattle of Eastern European countries).
[51] IPCC 1997. Agriculture. Reference Manual. Table 4-8 – Manure management systems and methane conversion factors. pp. 4.25.

Table 6.24. Cattle and swine in agricultural holdings (SE, 2011)

Cattle	Less than 10 dairy cows[52]	More than 10 dairy cows	Total
Number of holdings	16 499	1 276	17 775
Number of dairy cows	31 343	96 912	128 258
Swine	Less than 50 pigs[53]	More than 50 pigs	Total
Number of holdings	11 894	242	12 136
Number of pigs	41 330	288 455	329 785

The datasets were combined with each other based on village level. Hence, it was adjusted that type of MMS built and located in a certain village is a main type of storage for manure generated by livestock kept in this village. In addition, the data on MMSs received from SE, were consulted with data obtained in the framework of a project launched by Ministry of the Environment (ELLE, 2010) to monitor conditions of MMSs located on nitrate vulnerable zones. Also, the information presented in the environmental permits, which were applied by farms under the IPPC directive (Saastuse kompleksse..., 2011), was consulted to determine type of MMS built for storage animal waste in a certain agricultural holdings.

To specify grazing period of cattle and quantity of manure generated on pasture, the average pasture-period was used from (Taustauuring, 2009). The ratios of agricultural holdings, which graze cattle, were taken from the same study. The results of the study illustrated that a share of dairy and non-dairy cattle population, which is depastured, depends on size of herd. For example, agricultural holdings, which keep less than 20 dairy cattle, all depasture cattle; however, only 89% from the total cattle holding, with herd population at 200–400 heads of dairy cattle, depasture cattle livestock. Swine holdings do not have practice to graze swine livestock in Estonia.

The module on MMS was developed for each county of Estonia based on the data of 2000. However, the manure management allocation was used as a proxy for the entire time-series period, i.e., for 1990–2010. However, it is important to note that research continues in this area. The SE started a new cycle of agricultural survey in Estonia in 2010. The data on livestock population and MMSs on village level will be finalized by the beginning of 2012. The results of the survey will be obtained from the SE, in addition the information on grazing practice organic holdings will be studied as well. Hence, by the next submission, the data will be analysed and used in the estimations. In addition, country-specific literature will be analysed, together with data on structure of cattle population by herd size in the early of 1990th. The data will be interpolated between 1990th and 2000, and between 2000 and 2010. The data on biogas recovery practice and volumes of biogas recovered in Estonia will be investigated by the next submission. The results will be presented by the next submission.

The results of the analysis on cattle MMS used in each of Estonian county, together with CH_4 EFs, are presented in Table 6.25. The country-specific CH_4 EFs are higher than the IPCC default CH_4 EFs, because amount of manure, which stored in liquid/slurry system are higher than IPCC default for Eastern Europe.

[52] 1 dairy cow = 1 Livestock unit (Põllumajandusministri määrus nr 130, 12.12.2009).
[53] The data of the table were used from web-based dataset of SE. Therefore, an average conversion factor (at 5 swine heads = 1 livestock unit (Põllumajandusministri määrus nr 130, 12.12.2009)) to number of livestock unit was used for pigs. However, more detailed data (based on pig categories) were used in the analysis, these data are confidential.

Table 6.25. Manure management system usage, methane conversion factors (MCFs) and manure management emission factors for dairy cattle in 2010 by county of Estonia

County	Manure management system, %			Emission factor, kg CH_4/head/year
	Liquid/Slurry	Solid storage	Pasture/Range	
Harju	19.0	47.0	34.0	8.28
Hiiu	11.5	44.6	43.8	5.40
Ida-Viru	16.4	44.7	38.9	7.52
Jõgeva	26.8	42.3	31.0	11.11
Järva	35.6	31.3	33.1	13.66
Lääne	20.7	41.8	37.5	8.77
Lääne-Viru	28.9	37.0	34.1	11.77
Põlva	23.6	43.2	33.2	10.52
Pärnu	30.5	34.5	35.0	11.93
Rapla	22.2	40.0	37.7	9.90
Saare	17.9	44.1	38.0	7.90
Tartu	23.8	39.4	36.8	10.71
Valga	18.3	41.4	40.3	7.94
Viljandi	14.9	48.3	36.8	7.38
Võru	16.2	44.0	39.8	7.60
Estonian average	25.1	39.7	35.2	10.43
EE[54]	18	68 +1[(55)]	13	6.0
MCFs[56], %	10	1	1	

Implied CH_4 EFs has increased by 2010 since 1990, mainly due to increase in milk yield per cow (Figure 6.17).

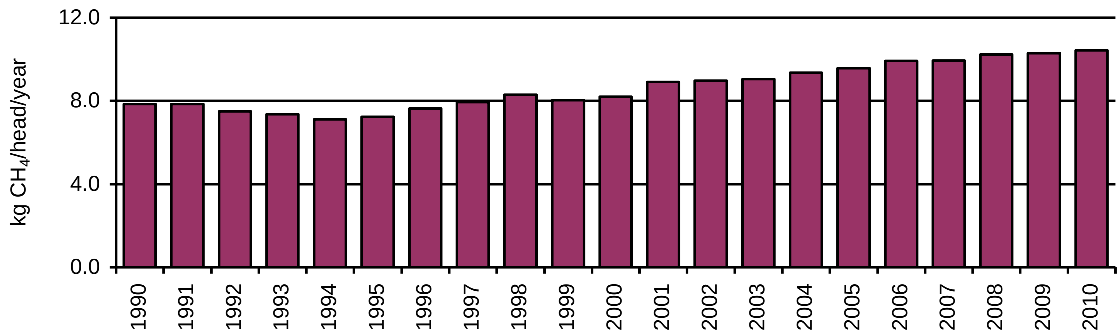

Figure 6.17. Implied CH_4 emission factor for dairy-cattle manure management system in 1990–2010, kg CH_4/head/year

The MMSs used to store animal waste from non-dairy cattle are presented in Table 6.26.

[54] IPCC 1997. Agriculture. Reference Manual. Table B-3 – Manure management emission factor derivation for dairy cattle. pp. 4.43.
[55] Daily spread.
[56] IPCC 2000. Agriculture. Table 4-10–MCF Values for manure management system (for cool climate). pp 4.37.

Table 6.26. Manure management system usage, methane conversion factors and manure management emission factors for mature non-dairy cattle in 2010 by county of Estonia

County	Manure management system, %			EFs, kg CH_4/head/year		
	Liquid/Slurry	Solid storage	Pasture/Range	Mature females	Mature males	Bovine animals
Harju	15.0	45.0	40.0	2.67	2.60	3.14
Hiiu	6.3	49.9	43.8	1.77	2.60	3.14
Ida-Viru	14.1	42.1	43.8	2.55	2.49	3.01
Jõgeva	22.4	35.3	42.3	3.39	3.31	4.00
Järva	29.3	29.8	40.9	4.10	3.99	4.83
Lääne	15.6	40.8	43.7	2.70	2.64	3.19
Lääne-Viru	26.9	31.5	41.6	3.85	3.75	4.54
Põlva	12.8	45.0	42.3	2.42	2.36	2.85
Pärnu	21.2	37.8	41.0	3.27	3.19	3.86
Rapla	21.8	39.3	38.9	3.34	3.26	3.94
Saare	13.7	42.4	43.8	2.52	2.45	2.97
Tartu	21.5	36.5	42.0	3.30	3.22	3.89
Valga	10.5	46.8	42.7	2.19	2.13	2.58
Viljandi	10.5	46.8	42.7	2.19	2.13	2.58
Võru	15.9	40.3	43.8	2.74	2.67	3.22
Estonian average	19.9	38.2	41.9			
EE[57]	28	48[58]	26	4.0		
MCFs[59], %	10	1	1			

CH_4 IEFs from MMSs of non-dairy cattle slightly have changed over 1990–2010 (Figure 6.18), because of the changes in the structure of MMSs of non-dairy cattle.

Figure 6.18. Implied CH_4 emission factor from MMSs of non-dairy cattle manure management system in 1990–2010, kgCH_4/head/year

The MMSs used to store animal waste generated by young cattle and CH_4 EFs for each county of Estonia are presented in Table 6.27. The values of EFs were used to estimate CH_4 emissions for the entire time-series.

57 IPCC 1997. Agriculture. Reference manual. Table B-4 – Manure management emission factor deviation for non-dairy cattle. pp. 4.44.
58 Other AMWS.
59 IPCC 2000. Agriculture. Table 4-10–MCF Values for manure management system (for cool climate). pp 4.37.

Table 6.27. Manure management system usage, methane conversion factors and manure management emission factors for non-dairy young cattle in 2010 by county of Estonia

County	Manure management system, %			EFs, kg CH_4/head/year
	Liquid/Slurry	Solid storage	Pasture/Range	
Harju	11.0	49.0	40.0	1.53
Hiiu	8.5	47.7	43.8	1.53
Ida-Viru	8.3	47.9	43.8	1.53
Jõgeva	17.3	39.5	43.2	2.00
Järva	28.3	30.5	41.2	2.78
Lääne	12.1	45.0	42.9	1.64
Lääne-Viru	16.5	41.1	42.4	1.95
Põlva	11.8	45.2	43.0	1.62
Pärnu	22.1	36.9	41.0	2.34
Rapla	15.8	41.8	42.5	1.89
Saare	8.9	47.3	43.8	1.41
Tartu	18.7	38.5	42.9	2.10
Valga	7.2	49.0	43.8	1.29
Viljandi	9.1	47.6	43.3	1.42
Võru	8.6	47.6	43.8	1.39
Average	15.7	41.8	42.5	
MCFs[60], %	10	1	1	

6.4.1.1.2. Quantitative overview – CH_4 emissions from cattle manure management in 2010

The total CH_4 emissions from cattle manure management were 1.389 Gg in Estonia in 2010, the emissions declined by 60 per cent by 2010 in comparison with the base year (Table 6.28).

Table 6.28. CH_4 emissions from cattle manure management activities in 1990–2010 in Estonia, Gg

Year	Dairy cattle	Mature non-dairy cattle	Young cattle	Total emissions
1990	2.202	0.798	0.476	3.476
1991	2.075	0.793	0.415	3.284
1992	1.900	0.646	0.338	2.884
1993	1.669	0.425	0.221	2.315
1994	1.506	0.356	0.202	2.064
1995	1.343	0.311	0.185	1.839
1996	1.312	0.292	0.171	1.774
1997	1.333	0.274	0.153	1.760
1998	1.314	0.253	0.147	1.715
1999	1.113	0.230	0.123	1.466
2000	1.075	0.216	0.117	1.409
2001	1.146	0.224	0.134	1.504
2002	1.036	0.247	0.133	1.417
2003	1.057	0.241	0.137	1.434
2004	1.090	0.239	0.127	1.457
2005	1.080	0.249	0.128	1.457
2006	1.076	0.249	0.125	1.450
2007	1.024	0.255	0.123	1.402
2008	1.028	0.248	0.124	1.400

[60] IPCC 2000. Agriculture. Table 4-10–MCF Values for manure management system (for cool climate). pp 4.37.

Year	Dairy cattle	Mature non-dairy cattle	Young cattle	Total emissions
2009	0.995	0.256	0.120	1.371
2010	1.007	0.264	0.119	1.389
%, 2010	72.5	19.0	8.6	100

6.4.1.2. Swine manure management

6.4.1.2.1. Methodology, data availability, data sources and emission factors

Methane production from the manure of swine by sub-categories was estimated based on the algorithm described in Chapter 6.3.3.1.

Methane conversion factors and the use of the different systems of manure management for swine manure storage are presented in Table 6.30. The factors (DE, B_o) used in the estimates were obtained from the IPCC tables (Table 6.29).

Table 6.29. Parameter used in the estimates[61]

Swine category	Feed digestibility (DE), %	VS, kg/head/day	Bo, m^3 CH_4/kg VS	MCF, %
Piglets, live weight less than 20 kg	85	0.08	0.45	0.6
Young pigs, live weight 20–<50 kg	85	0.18	0.45	0.6
Fattening pigs				
…live weight 50–<80 kg	80	0.37	0.45	0.6
…live weight 80–<110 kg	80	0.47	0.45	0.6
…live weight 110 kg or more	80	0.51	0.45	0.6
Breeding pigs, live weight 50 kg or more	80	0.40	0.45	0.6

Manure management systems

The algorithm and dataset used to develop the country-specific module on MMS in Estonia is described in Chapter 6.4.1.1.1. and the results obtained are presented in Table 6.30. CH_4 EFs calculated for the Estonian counties are reported in the same table. The values of CH_4 EFs were used to estimate CH_4 emissions from swine manure management for the entire time-series.

Table 6.30. Manure management system usage, methane conversion factor and manure management emission factors for swine in 2010 by county of Estonia

County	Manure management system, %		Emission factor, kg CH_4/head/year					
			Piglets, live weight less than 20 kg	Young pigs, live weight 20–<50 kg	Fattening pigs…			Breeding pigs, live weight 50 kg or more
	Liquid/ Slurry	Solid storage			...live weight 50–<80 kg	...live weight 80–<110 kg	…live weight 110 kg or more	
Harju	85.9	14.1	0.77	1.69	3.54	4.50	4.93	3.87
Hiiu	0.0	100.0	0.09	0.19	0.41	0.51	0.56	0.44
Ida-Viru	68.1	31.9	0.63	1.38	2.89	3.67	4.03	3.16
Jõgeva	66.0	34.0	0.61	1.35	2.82	3.58	3.92	3.08
Järva	88.5	11.5	0.79	1.74	3.63	4.61	5.06	3.98
Lääne	80.0	20.0	0.72	1.59	3.32	4.22	4.63	3.64

[61] IPCC 1997. Agriculture. Reference Manual. Table B-2 – Feed intake and manure production for swine and buffalo (for developed countries), pp. 4.42.

County	Manure management system, %		Emission factor, kg CH_4/head/year					
			Piglets, live weight less than 20 kg	Young pigs, live weight 20–<50 kg	Fattening pigs…			Breeding pigs, live weight 50 kg or more
	Liquid/ Slurry	Solid storage			...live weight 50–<80 kg	...live weight 80–<110 kg	…live weight 110 kg or more	
Lääne-Viru	92.0	8.0	0.82	1.80	3.76	4.78	5.24	4.12
Põlva	63.0	37.0	0.59	1.29	2.71	3.44	3.77	2.96
Pärnu	49.2	50.8	0.48	1.05	2.20	2.79	3.06	2.41
Rapla	84.8	15.2	0.76	1.67	3.50	4.45	4.88	3.83
Saare	83.6	16.4	0.75	1.65	3.46	4.39	4.81	3.78
Tartu	79.7	20.3	0.72	1.58	3.31	4.21	4.62	3.63
Valga	53.9	46.1	0.52	1.13	2.37	3.01	3.31	2.60
Viljandi	93.4	6.6	0.86	1.90	2.37	3.01	3.31	2.60
Võru	49.1	50.9	0.48	1.05	2.20	2.79	3.06	2.40
EE[62]	8[(63)]	39 +14+38[(64)]						4[(65)]
MCFs[66], %	10	1						

Implied CH_4 emission factors for swine manure management systems have changed slightly during the period of 1990–2010 due to changes in the structure of swine population, the values of IEFs are reported in Figure 6.19.

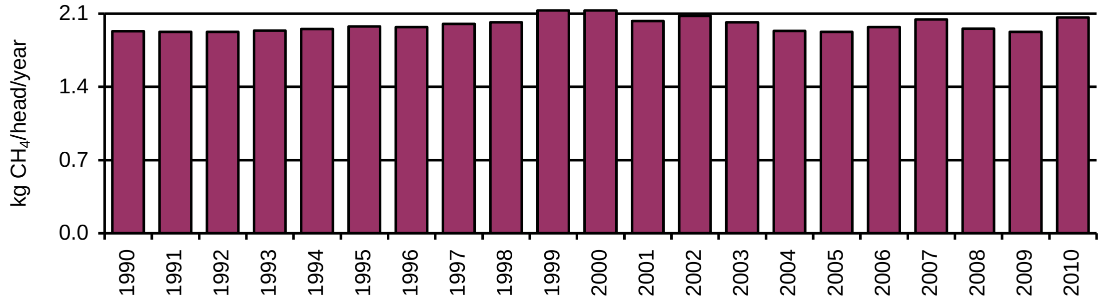

Figure 6.19. Implied CH_4 emission factor for swine manure management system in 1990–2010, kg CH_4/head/year

6.4.1.2.2. Quantitative overview – CH_4 emissions from swine manure management in 2010

The total CH_4 emissions from swine manure management were 0.767 Gg in Estonia in 2010 (Figure 6.20). The emissions decreased by 54 per cent by 2010 in comparison with the base year due to decrease in number of swine population.

[62] IPCC 1997. Agriculture. Reference Manual. Table B-6 – Manure management emission factor derivation for swine. pp. 4.46.
[63] Anaerobic lagoons.
[64] 14% - Dry lot and 38% – Pits less than 1 month and more than 1 month.
[65] IPCC 1997. Agriculture. Reference Manual. Table 4-6 – Manure management emission factors for cattle, swine and buffalo. pp. 4.13.
[66] IPCC 2000. Agriculture. Table 4-10–MCF Values for manure management system (for cool climate). pp 4.37.

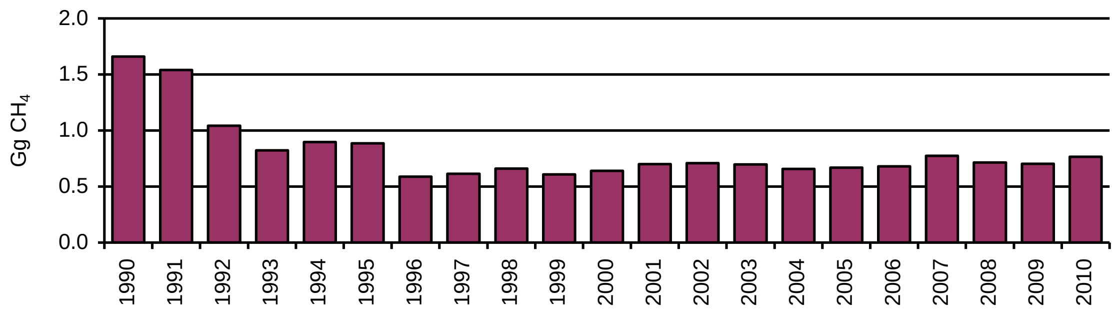

Figure 6.20. CH_4 emissions from swine manure management systems in 1990–2010 in Estonia, Gg

6.4.1.3. Other livestock manure management

6.4.1.3.1. Methodology, data availability, data sources and emission factors

CH_4 emissions from manure management for other livestock were calculated in accordance with the equation (6.13) using activity data on the population of livestock and the default IPCC emission factors (IPCC, 1997).

Manure management systems: other livestock categories and poultry

The module on MMS for sheep, goats and horse livestock categories was developed based on grazing-period of animals (Appendix A.3.3_IV). Animal wastes generated by these livestock categories are stored in 'solid manure management system'.

The module on MMS for poultry manure storage was developed based on data on poultry population kept by legal and in natural agricultural holdings. There were 38 main legal holdings of poultry in Estonia, which kept more than 78% of the total poultry population in 2000 (Table 6.31). According to the information presented in the environmental permits, which were submitted by large poultry holdings to the Environmental Board, the holdings use 'solid storage manure management system' for all amount of waste generated by poultry. Manure, generated by poultry kept by natural holdings, is stored in 'solid manure management system'. However, in addition, in natural holdings, in the summer time during daylight period, poultry are kept outside of hen-house, which could be classified as 'pasture' manure management system.

Table 6.31. Poultry in agricultural holdings, by form (SE, 2011)

	Natural person	Legal person	Total
Number of holdings	25 751	38	25 789
Number of poultry	506 889	1 756 568	2 263 457

The module on MMS applied to estimate emissions[67] from manure management of other livestock categories is presented in Table 6.32.

[67] The module was applied only in the estimation of N_2O emissions from manure management of other livestock, since CH4 emission from manure management was estimated based on Tier 1 of the IPCC Guidelines.

Table 6.32. Manure management system usage and methane emission factors from manure management of other livestock categories

Livestock category	Manure management system, %		Emission factor[68], kg CH_4/head/year
	Solid storage	Pasture/Range	
Sheep	50.68	49.32	0.19
Goats	50.68	49.32	0.12
Horses	58.90	41.10	1.4
Poultry	95.09	4.91	0.078
Fur animals[69]	100	-	
…Foxes and Raccoon			2.34
…Minks			1.305

6.4.1.3.2. Quantitative overview – CH_4 emissions from manure management other livestock categories in 2010

The total CH_4 emission from manure management system of other livestock categories was 0.192 Gg in Estonia in 2010 (Figure 6.21). The emission declined by 66 per cent by 2010 in comparison with the base year due to decrease in the number of other livestock population.

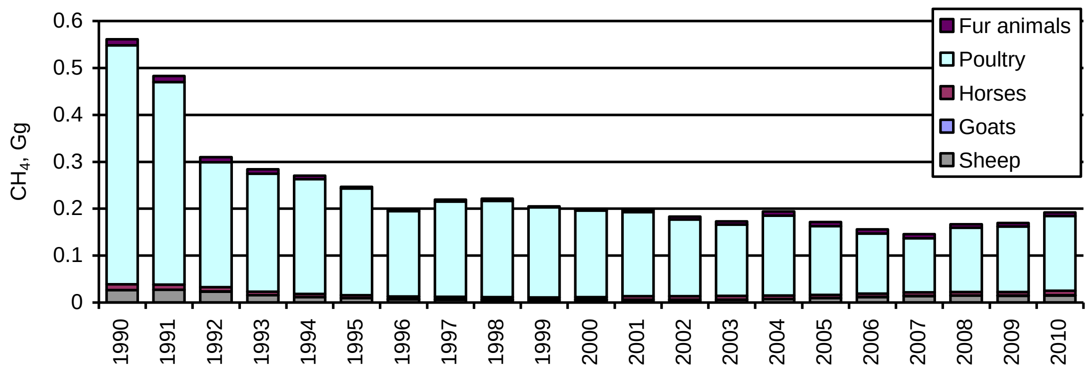

Figure 6.21. CH_4 emission from manure management other livestock categories in 1990–2010, Gg

6.4.1.4. Source-specific recalculations

There are several recalculations carried out in the 2012 submission:

Cattle manure management:

(1) Values of feed digestibility were updated – country-specific values were used in the estimates;

(2) Values of daily weight gain for dairy cattle and mature female cattle were updated – country-specific values were used in the estimates;

(3) Classification of feeding situation of dairy cattle was updated – ‘Pasture’ was selected as the main feeding situation;

(4) An omission made in the process of using the equation (6.8) was corrected;

[68] IPCC 1997. Agriculture. Reference Manual. Table 4-5 manure management emission factors (developed countries, cool climate region), pp. 4-12.
[69] The values of EF for fur animals were provided by a Finnish expert of the Agriculture sector.

(5) Estonian country-specific module on manure management system was developed.

CH_4 EFs for each category of cattle reported in the previous submission and the recalculated in the present are presented in Table 6.32.

Table 6.33. CH_4 EFs (implied) for cattle manure management in 1990–2009, Gg

Year	Dairy Cattle		Non-dairy cattle		Young cattle	
	2011[70]	2012	2011	2012	2011	2012
1990	7.87	7.85	4.42	3.58	2.17	1.89
1991	7.88	7.85	4.42	3.58	2.17	1.89
1992	7.47	7.50	4.42	3.58	2.17	1.89
1993	7.31	7.36	4.42	3.58	2.17	1.89
1994	7.22	7.12	4.42	3.52	2.17	1.91
1995	7.29	7.24	4.42	3.56	2.17	1.91
1996	7.70	7.64	4.42	3.57	2.17	1.92
1997	8.04	7.95	4.42	3.56	2.17	1.90
1998	8.38	8.29	4.42	3.57	2.17	1.91
1999	8.14	8.04	4.41	3.55	2.17	1.92
2000	8.20	8.21	4.40	3.57	2.17	1.92
2001	9.17	8.91	4.43	3.61	2.17	1.92
2002	9.09	8.97	4.44	3.62	2.17	1.90
2003	9.12	9.05	4.42	3.53	2.17	1.89
2004	9.45	9.36	4.41	3.57	2.17	1.92
2005	9.70	9.57	4.40	3.58	2.17	1.91
2006	10.07	9.93	4.40	3.53	2.17	1.89
2007	10.12	9.94	4.38	3.47	2.17	1.90
2008	10.46	10.23	4.35	3.45	2.17	1.88
2009	10.57	10.29	4.34	3.44	2.17	1.89

The results of the recalculations are reported in Table 6.34.

Table 6.34. CH_4 emissions from cattle manure management systems in 1990–2009, Gg

Year	Reported CH_4 emissions in the 2011 submission	Recalculated CH_4 emissions in the 2012 submission
1990	3.742	3.476
1991	3.540	3.284
1992	3.079	2.884
1993	2.437	2.315
1994	2.201	2.064
1995	1.948	1.839
1996	1.875	1.774
1997	1.862	1.760
1998	1.810	1.715
1999	1.550	1.466
2000	1.474	1.409
2001	1.605	1.504
2002	1.505	1.417
2003	1.523	1.434
2004	1.540	1.457
2005	1.546	1.457
2006	1.544	1.450
2007	1.504	1.402
2008	1.505	1.400

[70] 2011 – the 2011 submission; 2012 – the 2012 submission.

Year	Reported CH_4 emissions in the 2011 submission	Recalculated CH_4 emissions in the 2012 submission
2009	1.483	1.371

Swine manure management:

(1) The calculation algorithm of gross energy intake by swine was corrected – the formula used to estimate gross energy intake was interpreted incorrectly in the previous submissions. Since, the formula was used a basis to estimate gross energy intake instead of energy intake for maintenance and growth. However, in the present submission, the correction was implemented, the values of feed digestibility were used to calculate gross energy intake and CH_4 EFs and the total CH_4 emissions from swine enteric fermentation were re-estimated;

(2) Estonian country-specific module on manure management system was developed.

CH_4 EFs used to estimate CH_4 emissions from swine manure management in the 2011 and 2012 submission is presented in Table 6.35.

Table 6.35. CH_4 EFs for swine manure management in 2009, kg CH_4/head/year

Swine category	Calculated and used in the 2011 submission	Calculated and used in the 2012 submission[71]
Piglets, live weight less than 20 kg	1.32	0.78
Young pigs, live weight 20–<50 kg	2.91	1.60
Fattening pigs		
…live weight 50–<80 kg	4.29	3.04
…live weight 80–<110 kg	5.45	3.84
…live weight 110 kg or more	5.98	4.52
Breeding pigs, live weight 50 kg or more	4.70	3.20

CH_4 EFs used in the 2012 submission are lower than those used in the 2011 submission, because of there was no anaerobic lagoon (which has the highest MCFs) in country-specific manure management system.

The results of the recalculations are reported in Table 6.34.

Table 6.36. CH_4 emissions from swine manure management systems in 1990–2009, Gg

Year	Reported CH_4 emissions in the 2011 submission	Recalculated CH_4 emissions in the 2012 submission
1990	2.683	1.660
1991	2.488	1.539
1992	1.685	1.042
1993	1.327	0.822
1994	1.437	0.898
1995	1.398	0.887
1996	0.933	0.589
1997	0.963	0.613
1998	1.026	0.659
1999	0.949	0.608
2000	0.996	0.640

[71] Implied EFs are reported in Table 6.35, since CH_4 EFs for each county were calculated.

Year	Reported CH_4 emissions in the 2011 submission	Recalculated CH_4 emissions in the 2012 submission
2001	1.106	0.700
2002	1.114	0.708
2003	1.113	0.696
2004	1.070	0.658
2005	1.084	0.668
2006	1.087	0.681
2007	1.232	0.775
2008	1.155	0.714
2009	1.151	0.703

Other livestock:

In spite on the fact that the country-specific module on MMS for other livestock categories was developed, the IPCC default parameters were used and therefore it did not affect on the results of CH_4 emissions from manure management.

6.4.1.5. Source-specific planned improvements

As it was mentioned in Chapter 6.4.1.1.1., the research continues to develop country-specific manure management system. The SE started a new cycle of agricultural survey in Estonia in 2010. The data on livestock population and manure management systems on village level will be finalized by the beginning of 2012. The results of the survey will be obtained from SE, in addition the information on grazing practice organic holdings will be studied as well. Hence, by the next submission, the data will be analyzed and used in the estimations. In addition, country-specific literature will be analyzed, together with the data on structure of cattle population by herd size in the early of 1990th. The data will be interpolated between 1990th and 2000, and between 2000 and 2010. The data on biogas recovery practice and volumes of biogas recovered in Estonia will be investigated by the next submission. The results will be presented by the next submission.

6.4.2. N_2O emissions from manure management

6.4.2.1. Source category description

Production of N_2O during storage and treatment of animal wastes can occur via combined nitrification-denitrification of nitrogen contained in the wastes (Jun *et al.*, 2003).

6.4.2.2. Cattle manure management

6.4.2.2.1. Methodology, data availability, data sources and emission factors

The key methodology used for the estimation of N_2O emissions from manure management was the *Tier 2* method (IPCC, 1997).

$$(N_2O-N)_{(mm)} = \sum_{(S)} \{[\sum_{(T)} N_{(T)} \bullet Nex_{(T)} \bullet MS_{(T,S)}] \bullet EF_{3(S)}\} \quad (6.17)$$ [72]

[72] IPCC 2000. Agriculture. Equation 4.18. pp. 4.42.

$(N_2O\text{-}N)_{(mm)}$ – N_2O-N emissions from manure management in the country, kg N_2O-N/year;

$N_{(T)}$ – Number of head of livestock species *j* in the country;

$Nex_{(T)}$ – Annual average N excretion per head of livestock species *j* in the country, kg N/head/year;

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

$EF_{3(S)}$ – N_2O emission factor for manure management system *S* in the country, kg N_2O-N/kg N in manure management system *S* (Table 6.45);

S – Manure management system;

T – Species of livestock.

Conversion of $(N_2O\text{-}N)_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions for reporting purposes is performed by using the following equation:

$$N_2O_{(mm)} = (N_2O - N)_{(mm)} \bullet 44/28 \quad (6.18)$$

The data on livestock population by categories were obtained from database of SE (Appendix A.3.3_I). Nitrogen excretion factors for all categories of cattle were calculated based on nitrogen balance (6.19) described in (PVT, 2007).

$$N_{excreta_{ji}} = N_{feed_{ji}} - (N_{milk} + N_{weight\_gain} + N_{embryo})_{ji} \quad (6.19)$$

$N_{excreta\_ji}$ – Nitrogen excreted per *j* category of cattle in *i* country, kg/head/year;

N_{feed_ji} – Nitrogen consumption with feed by *j* category of cattle in *i* country, kg/head/year;

N_{milk_ji} – Nitrogen absorbed in milk, kg/head/year;

$N_{weight\ gain\_ji}$ – Nitrogen retained for growth per *j* category of cattle in *i* country, kg/head/year;

N_{embryo_ji} – Nitrogen required to support embryo development in *i* country, kg/head/year.

Nitrogen contained in feed consumed by different categories of cattle was calculated taken into account the values of gross intake (kg/head/yr, the algorithm is described in Chapter 6.3.2.1. and average rates of nitrogen content in animal feed (Appendix A.3.3_IV). N_{milk}, N_{gain} and N_{embryo} were estimated as follows (Standard values…, 1997):

N_{milk} = kg milk protein per cow per year / 6.35

N_{gain} = kg weigh gain per head per year * nitrogen content in body weight

N_{embryo} = kg calf * nitrogen content in embryo

The values of nitrogen content in milk, body weight and embryo are reported in (Appendix A.3.3_IV). The values of milk protein content in 1990–2010 were obtained from EERC[73].

The trend in (implied) nitrogen excretion factors reported in the CRF are presented in Table 6.37, nitrogen excretion factors for dairy cattle by county of Estonia in 2010 is presented in Table 6.38.

Table 6.37. Weight, milk yield per cow and protein content of milk in 1990–2010 (Appendix A.3.3_II)

Year	Weight of dairy-cattle, kg	Milk yield per cow, kg/head/year	Protein content of milk, g/kg	Gross energy intake, MJ/head/day	Nitrogen excretion rate, kg N/head/year
1990[74]	575.0	3 968	3.22	254.69	90.06
1991	576.0	3 968	3.25	254.90	90.89
1992	577.2	3 530	3.14	243.53	88.67
1993	578.8	3 322	3.11	239.17	87.90
1994	579.7	3 455	3.15	236.52	87.12
1995	580.2	3 588	3.17	238.73	87.74
1996	580.8	3 809	3.20	248.27	90.96
1997	581.6	4 484	3.15	257.77	93.57
1998	582.6	4 456	3.18	267.67	95.61
1999	583.8	4 171	3.15	256.78	90.21
2000	584.5	4 660	3.28	273.26	96.33
2001	585.3	5 313	3.31	291.53	99.96
2002	585.9	5 138	3.27	288.57	99.82
2003	586.2	5 231	3.30	289.78	99.36
2004	585.8	5 596	3.31	298.80	101.81
2005	585.7	5 886	3.34	305.54	102.99
2006	586.1	6 285	3.35	314.89	105.01
2007	586.4	6 484	3.36	319.53	105.03
2008	586.8	6 781	3.36	326.16	118.38
2009	587.4	6 838	3.37	328.13	119.10
2010	587.8	7 021	3.36	332.16	120.10
IPCC default					
EE[75]	550[(76)]	2 550			70[(77)]
WE	550	4 200			100

Table 6.38. Milk yield per cow, gross intake and nitrogen excretion rate in 2010 by counties of Estonia

County	Milk yield per cow, kg/head/year	Gross energy intake, MJ/head/day	Nitrogen excretion rate, kg N/head/year
Harju county	6 402	316.45	116.32
Hiiu county	4 520	274.65	106.21

[73] Results of animal recording in Estonia in 1997–2010. Annual Reports. Available at: www.jkkeskus.ee/page.php?page=0147.
[74] The values of 1991.
[75] IPCC 1997. Agriculture. Reference Manual. Table 4-4 – Enteric fermentation emission factors for cattle. pp. 4.11 and Table A-1 – Data for estimating enteric fermentation emission factors for dairy cattle. pp. 4.31.
[76] IPCC 1997. Agriculture. Reference Manual. Table A-1 – Data for estimating enteric fermentation emission factors for dairy cattle. pp. 4.31.
[77] IPCC 1997. Agriculture, Reference Manual. Table 4-20 – Tentative default values for nitrogen excretion per head of animal per region. pp. 4.99.

County	Milk yield per cow, kg/head/year	Gross energy intake, MJ/head/day	Nitrogen excretion rate, kg N/head/year
Ida-Viru county	6 334	313.99	115.50
Jõgeva county	7 230	337.40	122.01
Järva county	7 254	336.39	121.40
Lääne county	6 368	317.42	116.97
Lääne-Viru county	7 390	338.31	121.59
Põlva county	7 671	348.23	124.88
Pärnu county	6 948	330.03	119.96
Rapla county	7 355	341.39	123.27
Saare county	6 243	313.34	115.67
Tartu county	7 997	353.22	125.55
Valga county	6 127	310.87	115.10
Viljandi county	6 784	326.01	118.90
Võru county	6 461	320.53	117.98

The calculation of nitrogen excretion rates for non-dairy cattle categories were performed based on the algorithm presented by formula (6.19). The rates are reported in Table 6.39.

Table 6.39. Nitrogen excretion rates of non-dairy cattle in 1990–2010, kg CH_4/head/year

Livestock category of non-dairy cattle	Nitrogen excretion rate, kg N/head/year
Mature males (2 years and over)	65.15
Mature females (2 years and over)	44.74
Bovine animals (aged between 1 and 2 years)	71.96
Calves (less than 1 year old)	30.05

6.4.2.2.2. Quantitative overview – Nitrogen excretion by cattle livestock in 2010

The total quantity of nitrogen generated by cattle was 18 264 tonnes in Estonia in 2010. The allocation of nitrogen excreted among different types of MMS is presented in Table 6.40.

Table 6.40. The allocation of the quantity of nitrogen (in manure) excreted by cattle among different types of manure management system, tonnes N/year

Year	Liquid system	Solid storage	Pasture range and paddock	Total nitrogen
1990	10 356	18 924	18 322	47 602
1991	9 879	17 988	17 435	45 301
1992	8 760	15 809	15 222	39 792
1993	7 029	12 453	11 824	31 306
1994	5 977	11 492	10 810	28 280
1995	5 508	10 008	9 436	24 952
1996	5 288	9 460	8 938	23 687
1997	5 203	9 266	8 721	23 190
1998	5 016	8 838	8 320	22 174
1999	4 241	7 417	7 001	18 660
2000	4 196	7 324	6 896	18 415
2001	4 340	7 586	7 157	19 082

Year	Liquid system	Solid storage	Pasture range and paddock	Total nitrogen
2002	4 145	7 209	6 866	18 220
2003	4 113	7 275	6 890	18 278
2004	4 177	7 219	6 869	18 265
2005	4 148	7 187	6 840	18 174
2006	4 084	7 110	6 761	17 955
2007	3 937	6 935	6 606	17 479
2008	4 168	7 307	6 923	18 398
2009	4 082	7 193	6 827	18 102
2010	4 126	7 250	6 889	18 264

6.4.2.3. Swine

6.4.2.3.1. Methodology, data availability, data sources and emission factors

Activity data on swine population were obtained from national statistics, the method was used from the IPCC Guidelines (Chapter 6.3.3.1). Nitrogen excretion rates were used from (Keskkonnaministri määrus nr 48, 5.12.2008) (Table 6.41).

Table 6.41. Average N excretion factors used in the estimates, kg N/head/year

Swine category	Nitrogen excretion rate, kg N/head/year	IPCC default, kg N/head/year
Piglets, live weight less than 20 kg	4.57	
Young pigs, live weight 20–<50 kg	9.51	
Fattening pigs		
…live weight 50–<80 kg	10.53	
…live weight 80–<110 kg	10.53	
…live weight 110 kg or more	10.53	
Breeding pigs, live weight 50 kg or more	31.67	
Total swine category		20[78]

The (implied) nitrogen excretion factors reported in the CRF are presented in Figure 6.22. The rate has slightly changed over the entire time-series due to the changes in the structure of swine population.

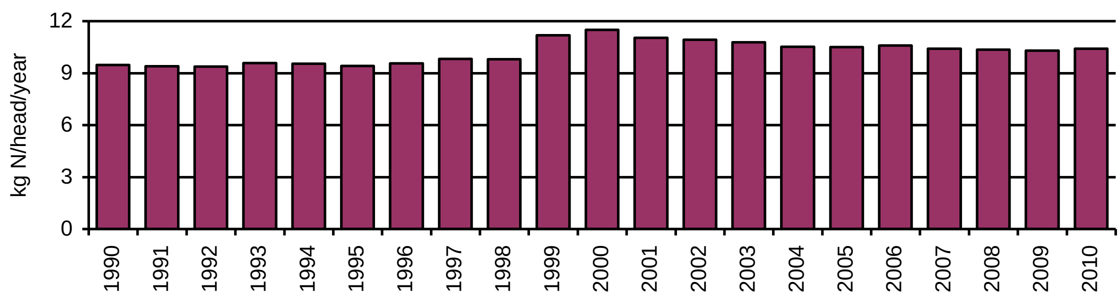

Figure 6.22. Implied swine nitrogen excretion factor reported in the CRF for 1990–2010, kg N/head/year

[78] IPCC 1997. Agriculture, Reference Manual. Table 4-20 – Tentative default values for nitrogen excretion per head of animal per region. pp. 4.99.

6.4.2.3.2. Quantitative overview – Nitrogen excretion by swine livestock in 2010

The total quantity of nitrogen generated by pigs was 3 875 tonnes in Estonia in 2010. The allocation of nitrogen excreted from different types of manure management system is presented in Table 6.42.

Table 6.42. The allocation of the quantity of nitrogen (contained in manure) excreted by pigs and stored in different types of MMSs, tonnes N/year

Year	Liquid system	Solid storage	Total nitrogen
1990	6 033	2 109	8 142
1991	5 564	1 945	7 509
1992	3 762	1 316	5 078
1993	3 013	1 053	4 066
1994	3 406	981	4 387
1995	3 286	936	4 222
1996	2 272	583	2 855
1997	2 447	559	3 006
1998	2 617	585	3 201
1999	2 611	584	3 195
2000	2 790	662	3 452
2001	3 117	692	3 809
2002	3 052	673	3 725
2003	3 036	680	3 716
2004	2 912	665	3 577
2005	2 963	674	3 637
2006	2 986	681	3 666
2007	3 210	734	3 944
2008	3 103	677	3 780
2009	3 077	683	3 760
2010	3 193	682	3 875

6.4.2.4. Other livestock

6.4.2.4.1. Methodology, data availability, data sources and emission factors

The activity data on other livestock population were obtained from national statistics, the module on MMS was used from Table 6.32 and nitrogen excretion factors (Table 6.43) were obtained from the Revised 1996 IPCC Guidelines (IPCC, 1997).

Table 6.43. Nitrogen excretion factors per head of animal, kg N/head/year

Livestock category	Nitrogen excretion rate, kg N/head/year
Poultry	0.6
Sheep	16
Horses, Goats	25
Fur farming[79]	
…Foxes and Raccoon	2.3
…Minks	1.3

[79] The values of emission factors from manure management of fur animals was provided by a Finnish expert in the agriculture sector.

6.4.2.4.2. Quantitative overview – Nitrogen excretion by other livestock in 2010

The total quantity of nitrogen generated by other livestock was 2 838 tonnes in 2010. The breakdown of the quantity of nitrogen excreted by other livestock categories is reported in Table 6.44.

Table 6.44. Nitrogen (in manure) excreted by other livestock categories, tonnes N/year

Year	by livestock category					by MMS		
	Sheep	Goats	Horses	Poultry	Fur animals	Solid storage	Pasture/ Range	Total
1990	2 237	23	215	3 922	153	5 154	1 395	6 549
1991	2 270	23	195	3 323	153	4 590	1 374	5 964
1992	1 970	28	165	2 051	136	3 198	1 151	4 349
1993	1 315	28	130	1 936	119	2 717	811	3 527
1994	960	38	125	1 878	103	2 468	635	3 104
1995	771	43	115	1 747	61	2 202	534	2 736
1996	602	40	105	1 395	60	1 774	428	2 202
1997	542	43	105	1 561	59	1 902	408	2 310
1998	459	53	98	1 581	62	1 882	370	2 252
1999	451	68	98	1 477	33	1 758	368	2 127
2000	464	80	105	1 420	36	1 723	381	2 105
2001	461	90	138	1 377	71	1 741	396	2 136
2002	478	98	133	1 258	78	1 644	400	2 044
2003	493	88	145	1 167	92	1 582	403	1 985
2004	621	73	128	1 310	116	1 788	459	2 247
2005	794	70	120	1 127	102	1 682	531	2 213
2006	1 003	83	123	983	105	1 662	634	2 296
2007	1 158	100	133	887	108	1 667	719	2 385
2008	1 251	90	130	1 054	77	1 836	767	2 602
2009	1 224	98	135	1 075	77	1 849	760	2 609
2010	1 258	103	170	1 228	80	2 037	801	2 838

6.4.2.4.3. Quantitative overview – N_2O emissions from manure management systems in Estonia in 2010

The total quantity of nitrogen generated by livestock and stored in solid and liquid types of MMSs was 17 287 tonnes in 2010 (Figure 6.46). N_2O emissions at 0.325 Gg was resulted from the stored manure. The breakdown of the N_2O emission released from different types of manure management systems is reported in Table 6.45.

Table 6.45. Emission factors of manure management practice[80]

Manure management system	EF_3 (kg N_2O-N/kg Nitrogen excreted)
Liquid system	0.001
Solid storage	0.02
Pasture range and paddock	0.02[(81)]

[80] IPCC 2000. Agriculture. Table 4.12 – Default emission factors for N_2O from manure management. pp 4.43.
[81] The factor was used in the 'Animal waste applied to soils and excreted on pasture' chapter.

Table 6.46. Nitrogen (in manure) excreted by other livestock categories and N_2O emissions from manure management systems in 1990–2010

Year	Nitrogen excreted, tonnes				N_2O emissions, Gg		
	Liquid/ Slurry	Solid storage	Pasture/ Range	Total	Liquid / Slurry	Solid storage	Total [82]
1990	16 389	26 188	19 717	62 294	0.026	0.823	0.849
1991	15 443	24 523	18 809	58 774	0.024	0.771	0.795
1992	12 523	20 323	16 373	49 219	0.020	0.639	0.658
1993	10 042	16 223	12 635	38 900	0.016	0.510	0.526
1994	9 384	14 941	11 446	35 770	0.015	0.470	0.484
1995	8 794	13 146	9 970	31 910	0.014	0.413	0.427
1996	7 560	11 818	9 366	28 744	0.012	0.371	0.383
1997	7 650	11 727	9 129	28 506	0.012	0.369	0.381
1998	7 633	11 305	8 690	27 628	0.012	0.355	0.367
1999	6 853	9 760	7 370	23 982	0.011	0.307	0.318
2000	6 986	9 710	7 277	23 972	0.011	0.305	0.316
2001	7 457	10 018	7 552	25 028	0.012	0.315	0.327
2002	7 198	9 525	7 266	23 990	0.011	0.299	0.311
2003	7 149	9 536	7 293	23 978	0.011	0.300	0.311
2004	7 089	9 673	7 327	24 089	0.011	0.304	0.315
2005	7 111	9 543	7 371	24 024	0.011	0.300	0.311
2006	7 069	9 453	7 395	23 917	0.011	0.297	0.308
2007	7 147	9 336	7 325	23 808	0.011	0.293	0.305
2008	7 270	9 820	7 689	24 780	0.011	0.309	0.320
2009	7 159	9 726	7 587	24 472	0.011	0.306	0.317
2010	7 319	9 968	7 689	24 976	0.012	0.313	0.325
2010, %	29.3	39.9	30.8		3.7	96.3	100

6.4.2.5. Uncertainties and time-series consistency

CH_4 emissions from manure management were calculated based on activity data and emission factors.

Uncertainties in estimates of CH_4 emissions from sheep, goats, horses and poultry manure management are reported in (IPCC, 1997) (Table 6.47).

Emission factors for cattle and swine were calculated using IPCC default parameters (volatile solids, CH_4 producing capacity, methane conversion factors, manure management system). IPCC default uncertainty was used in the estimates (±25%) (Table 6.47), the factor was developed based on the experience of other countries. Rypdal and Winiwarter documented that an uncertainty in CH_4 emissions from manure management is ±25% in Norway, ±25% in the Netherlands, ±30% in UK and ±36% in USA (Rypdal and Winiwarter, 2001) and ±30% in Finland (Monni and Syri, 2003).

N_2O emissions from livestock manure management was calculated based on activity data (livestock population), nitrogen excretion factors (Nex, kg/head/year) calculated based on nitrogen balance of animals and N emission factor related to manure management system. However, in spite of the use of nitrogen balance, default uncertainty rates for Nex (by categories of livestock) were used from the IPCC Guidelines (IPCC, 1997).

[82] N_2O emissions from 'Pasture/range and paddock' were considered under Direct soil emissions.

IPCC reports nitrogen emission factors for all systems of manure management used in Estonia's estimates of N_2O emissions from animal manure (Table 6.47).

Table 6.47. Estimated values of uncertainties used in agriculture sector

Input	Uncertainties	References
Activity data		
Estonia's livestock population (cattle, swine, sheep, goats, horses, poultry and fur animals)	± 10%	Rypdal and Winiwarter, 2001
Emission factors		
Manure management (CH_4) (cattle, swine)	± 25%	Rypdal and Winiwarter, 2001
Manure management (CH_4) (sheep, goats, horses, fur animals)	± 20%	Table 4-5 of the 1996 IPCC Guidelines, pp. 4.12
Manure management (N_2O)		
…Nitrogen excretion factor (Nex)	± 25%	IPCC, 2000. Agriculture. pp. 4.46
…Anaerobic lagoon	-50%...+100%	IPCC, 2000. Agriculture. pp. 4.43
…Liquid system	-50%...+100%	IPCC, 2000. Agriculture. pp. 4.43
…Solid storage	-50%...+100%	IPCC, 2000. Agriculture. pp. 4.43
…Pasture/range and paddock	-50%...+100%	IPCC, 2000. Agriculture. pp. 4.43
…Other systems (cattle and swine deep litter, poultry manure with bedding)	-50%...+100%	IPCC, 2000. Agriculture. pp. 4.43

6.4.2.6. Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.3.3.

The QA/QC plan for the agricultural sector includes the QC activities described in the IPCC GPG (IPCC 2000, Table 8.1). The activities are carried out every year during the inventory. The QC check list is used during the inventory.

Activity data are checked annually for updating. Emission factors are compared with IPCC default and with emission factors of other countries.

6.4.2.7. Source-specific recalculations

There are several recalculations carried out in the 2012 submission, in 'N_2O emissions from manure management system' sub-section:

The initial parameters used to estimate gross energy intake were recalculated (for cattle):

(1) Values of feed digestibility were updated – country-specific values were used in the estimates;

(2) Values of daily weight gain for dairy cattle and mature female cattle were updated – country-specific values were used in the estimates;

(3) Classification of feeding situation of dairy cattle was updated – 'Pasture' was selected as the main feeding situation;

(4) An omission made in the process of using the equation (6.8) was corrected;

Nitrogen excretion rates were recalculated:

(5) Nitrogen excretion rates for cattle livestock were recalculated based on nitrogen balance;

(6) Nitrogen excretion rates for swine livestock were used from country-specific literature (Keskkonnaministri määrus nr 48, 5.12.2008);

The module on MMS usage was changed:

(7) Estonian country-specific manure management systems were developed for all categories of livestock.

Table 6.48. Nitrogen excretion rates for cattle livestock categories in 1990–2009, kg N/head/year

Year	Dairy Cattle		Non-dairy cattle		Young cattle	
	2011[83]	2012	2011	2012	2011	2012
1990	76.74	90.06	45.16	66.10	16.71	30.05
1991	77.53	95.85	45.16	66.10	16.71	30.05
1992	73.50	88.67	45.16	66.10	16.71	30.05
1993	71.93	87.90	45.16	66.10	16.71	30.05
1994	69.60	87.12	45.16	66.10	16.71	30.05
1995	70.47	87.74	45.16	66.10	16.71	30.05
1996	74.29	90.96	45.16	66.10	16.71	30.05
1997	77.49	93.57	45.16	66.10	16.71	30.05
1998	80.83	95.61	45.16	66.10	16.71	30.05
1999	75.70	90.21	45.42	66.19	16.71	30.05
2000	83.51	96.33	44.95	65.23	16.71	30.05
2001	88.51	99.96	45.27	66.56	16.71	30.05
2002	87.82	99.82	45.38	67.03	16.71	30.05
2003	88.09	99.36	45.15	66.08	16.71	30.05
2004	91.30	101.81	45.10	65.85	16.71	30.05
2005	93.66	102.99	44.96	65.30	16.71	30.05
2006	97.12	105.01	44.95	65.18	16.71	30.05
2007	97.74	105.03	44.74	64.34	16.71	30.05
2008	101.13	118.38	44.47	63.16	16.71	30.05
2009	102.10	119.10	44.38	62.79	16.71	30.05

Table 6.49. Nitrogen excretion rates for all livestock categories of swine in 1990–2009, kg N/head/year

Swine category	Used in the 2011 submission	Used in the 2012 submission[84]
Piglets, live weight less than 20 kg	5.17	4.57
Young pigs, live weight 20–<50 kg	11.38	9.51
Fattening pigs		
…live weight 50–<80 kg	19.28	10.53
…live weight 80–<110 kg	24.49	10.53
…live weight 110 kg or more	26.86	10.53
Breeding pigs, live weight 50 kg or more	14.85	31.67

The differences in the modules on MMSs applied in the estimation in the 2011 and 2012 submissions are presented in Table 6.25, Table 6.26 and Table 6.30.

The results of the recalculations are reported in Table 6.50. Despite the fact that the values of nitrogen excretion rates of the 2012 submission are higher (for cattle and swine) than the values presented in the 2011 submission, the total N_2O emissions from manure management systems are lower for the entire time-series than those

[83] 2011 – the 2011 submission; 2012 – the 2012 submission.
[84] Implied CH4 EFs were reported in the table, since EFs for each county of Estonia were calculated.

reported in the 2011 submission, since a remarkable amount of animal wastes were generated during pasture of cattle animals (Chapter 6.5.13).

Table 6.50. N_2O emissions from Estonian livestock manure management systems in 1990–2009, Gg

Year	Reported N_2O emissions in the 2011 submission	Recalculated N_2O emissions in the 2012 submission
1990	0.911	0.849
1991	0.853	0.795
1992	0.683	0.658
1993	0.577	0.526
1994	0.540	0.484
1995	0.496	0.427
1996	0.431	0.383
1997	0.437	0.381
1998	0.442	0.367
1999	0.376	0.318
2000	0.388	0.316
2001	0.410	0.327
2002	0.381	0.311
2003	0.376	0.311
2004	0.393	0.315
2005	0.390	0.311
2006	0.388	0.308
2007	0.394	0.305
2008	0.390	0.320
2009	0.384	0.317

6.4.2.8. Source-specific planned improvements

The research is continued to develop country-specific manure management system. The SE started a new cycle of agricultural survey in Estonia in 2010. The data on livestock population and manure management systems on village level will be finalized by the beginning of 2012. The results of the survey will be obtained from the SE, in addition the information on grazing practice organic holdings will be studied as well. Hence, by the next submission, the data will be analyzed and used in the estimations. In addition, country-specific literature will be analyzed, together with data on structure of cattle population by herd size in the early of 1990th. The data will be interpolated between 1990th and 2000, and between 2000 and 2010. The data on biogas recovery practice and volumes of biogas recovered in Estonia will be investigated by the next submission. The results will be presented by the next submission.

In addition, the adjusted data on calves population and parameters needed in the process of the estimation of emissions from enteric fermentation will be applied to estimate nitrogen excretion rates for these categories of calves. The planned activity allows to improve inventory of nitrogen generated by calves and stored to manure management systems.

6.5. Direct emissions from agricultural soils (CRF 4.D.1)

N_2O oxide is produced naturally in soils through the microbial processes of nitrification and denitrification. A number of agricultural activities add nitrogen to soils, increasing the amount of nitrogen available for nitrification and the amount of N_2O emitted (IPCC, 2000).

The following agricultural activities influence N flows in agricultural soils:

- Application of synthetic fertilizers;
- Application of animal excreta nitrogen used as fertilizer;
- Sewage sludge application on agricultural soils;
- Biological nitrogen fixation;
- Crop residues returned to soils;
- Cultivation of high organic content soils;

6.5.1. Source category description

The total direct N_2O emissions from agricultural soils were 1.41 Gg in Estonia in 2010 (Figure 6.23). N_2O emissions decreased by 62% by 2010 in comparison with the base year due to decrease in number of livestock population (therefore amount of animal manure applied on agricultural soils) due to decline in quantity of fertilizers applied on agricultural land and due to N-fixing crops production (Figure 6.24).

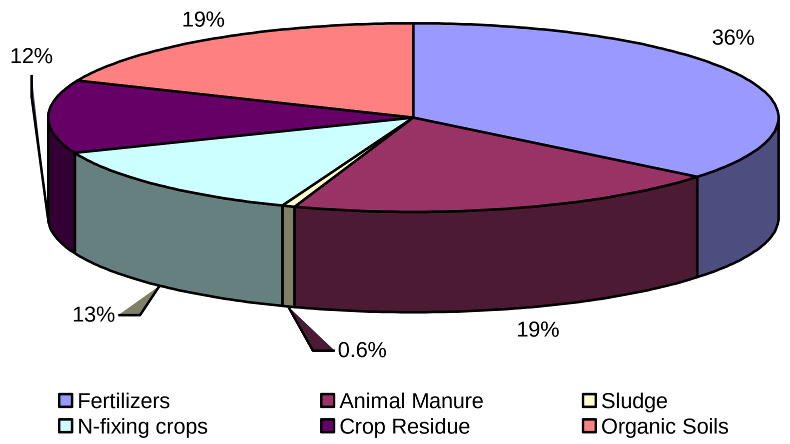

Figure 6.23. Direct N_2O emissions from agricultural soils in Estonia in 2010, %

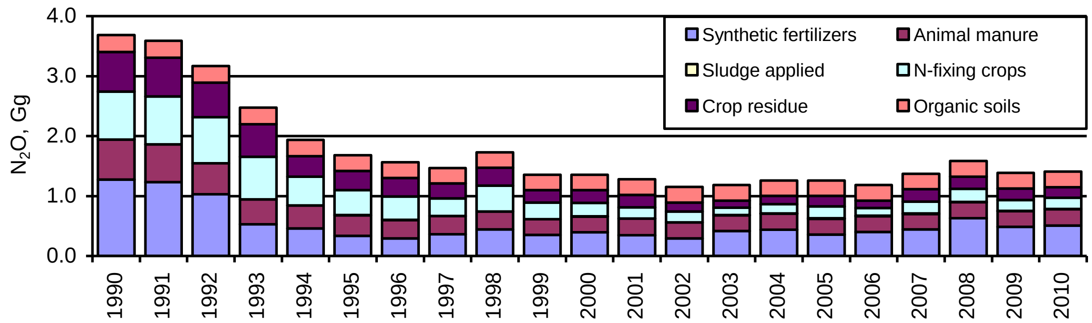

Figure 6.24. Direct N_2O emissions from agricultural soils in Estonia in 1990–2010, Gg

6.5.2. Activity data employed

The activity data on amount of synthetic fertilizers applied on agricultural fields, crop production in Estonia were obtained from the datasets of SE. The data on amounts of sludge used on agricultural lands were used from the EEIC. The data on areas of histosols under cultivation in Estonia were obtained in the framework of National Forest Inventory (Chapter LULUCF).

6.5.3. N_2O emissions from synthetic fertilizer nitrogen applied to soils (CRF 4.D.1.1)

N_2O emissions are estimated from annual synthetic nitrogen applied to soils. The algorithm reported in IPCC (2000) was used to estimate nitrogen input into agricultural soils adjusted for volatilization.

$$F_{SN} = N_{FERT} \times (1 - Frac_{GASF}) \qquad (6.20)^{85}$$

F_{SN} – Calculation of synthetic fertilizer use, N_2O Gg;

N_{FERT} - Total use of synthetic fertilizer in country, kg N/year;

$Frac_{GASF}$ – Fraction of total synthetic fertilizer nitrogen that is emitted as NO_x+NH_3, kg N/kg N (Table 6.51);

N_2O emissions into the atmosphere from using of synthetic nitrogen were calculated based on the formula (6.21).

$$N_2O_{direct} - N = F_{SN} \bullet EF \bullet 44/28_1 \qquad (6.21)$$

Table 6.51. IPCC default factors used in the estimation

Factors	Value
EF_1 for F_{SN}	1.25%[86]
$Frac_{GASF}$	0.1 kg NH_3-N + NO_x-N/kg of synthetic fertilizer nitrogen applied[87]

6.5.3.1. Quantitative overview – N_2O emissions from synthetic fertilizers applied to soils in 2010

The total N_2O emissions from synthetic fertilizers applied onto agricultural soils were 0.506 Gg in Estonia in 2010 (Figure 6.26). The emissions declined by 60 per cent by 2010 in comparison with the base year due to the decrease in the amounts of synthetic fertilizers applied to agricultural fields, mostly on fields sown with cereals and forage crops (Figure 6.25, Appendix A.3.3_VI).

[85] IPCC 2000. Agriculture. Equation 4.22, pp. 4.56.
[86] IPCC 2000. Agriculture. Table 4-17. Updated default emission factors to estimate direct N_2O emissions from agricultural soils, pp. 4.60.
[87] IPCC 1997. Agriculture. Reference Manual. Table 4-19 Default values for parameters, pp. 4.94.

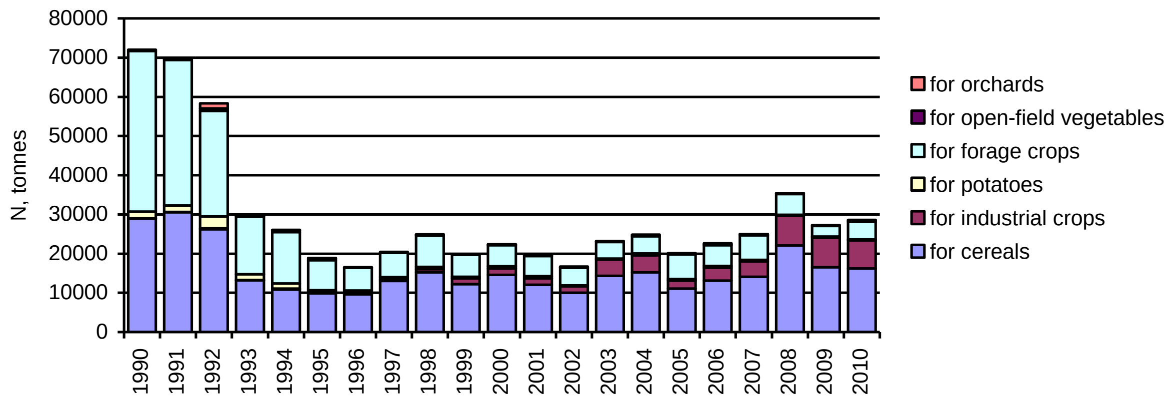

Figure 6.25. Quantity of synthetic fertilizers applied to agricultural soils in 1990–2010 in Estonia, tonnes[88]

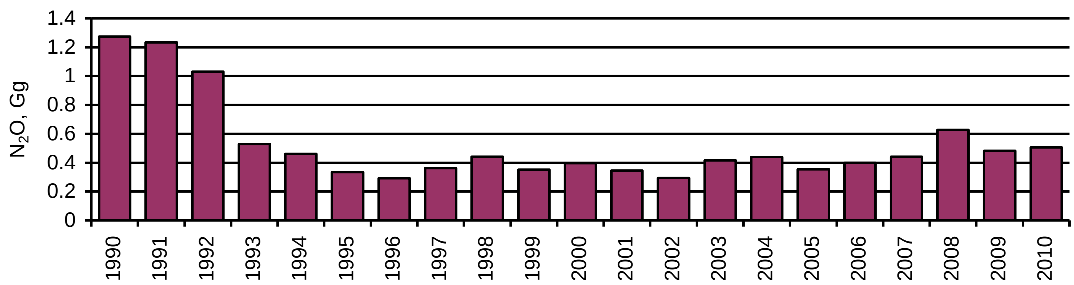

Figure 6.26. N_2O emissions from synthetic fertilizers applied to agricultural soils in 1990–2010 in Estonia, Gg

6.5.4. N_2O emissions from animal manure applied to soils (CRF 4.D.1.2)

N_2O emits from agricultural soil through manure application to fields as organic fertilizer.

6.5.4.1. Methodology, data availability, data sources and emission factors

N_2O emission into the atmosphere from animal waste applied to agricultural fields as organic fertilizer was estimated according to the algorithm proposed by the IPCC (1997).

$$N_2O_{direct} - N = F_{AW} \bullet EF_1 \qquad (6.22)$$

$$F_{AW} = \sum_T (N_{(T)} \bullet Nex_{(T)} \bullet (1 - Frac_{GASM}))[1 - (Frac_{FUEL\text{-}AM} + Frac_{PRP})] \qquad (6.23)$$ [89]

F_{AW} – Manure nitrogen used as fertilizer in country, corrected for NH_3 and NO_x emissions and excluding manure produced during grazing, kg N/year;

$N_{(T)}$ – Number of animals per type of animal in country;

[88] The fraction lost as NH_3 and NO_x has not been substracted.
[89] IPCC 2000. Agriculture. Equations 4.23, pp 4.56.

Nex – Total nitrogen excretion by animals in country, kg N/year;

$Frac_{GASM}$ – Fraction of total nitrogen excretion that is emitted as NOx or NH_3, kg N/kg N;

$Frac_{FUEL-AM}$ – Fraction of livestock nitrogen excretion contained in excrements burned for fuel, kg N/kg N totally excreted;

$Frac_{PRP}$ – Fraction of livestock nitrogen excreted and deposited onto soil during grazing, kg N/kg N excreted.

Nitrogen excreted per head of different categories of animals and per waste management systems was estimated in 'N_2O emissions from manure management' chapter. IPCC default factors were used to estimate nitrogen input to agricultural soils (Table 6.52).

Table 6.52. IPCC default factors used in the estimation of N_2O emissions from animal waste applied to soils

Factor	Value[90]
$Frac_{FUEL}$	0.0 kg N/kg nitrogen excreted
$Frac_{GASM}$	0.2 kg NH_3-N + NO_x-N/kg of nitrogen excreted by livestock

6.5.4.2. Quantitative overview – N_2O emissions from animal manure applied to soils in 2010

The total N_2O emissions from animal manure applied on agricultural soils were 0.272 Gg in Estonia in 2010 (Figure 6.27). The emission decreased by 59 per cent by 2010 compared to the base year, due to the decline in number of livestock population.

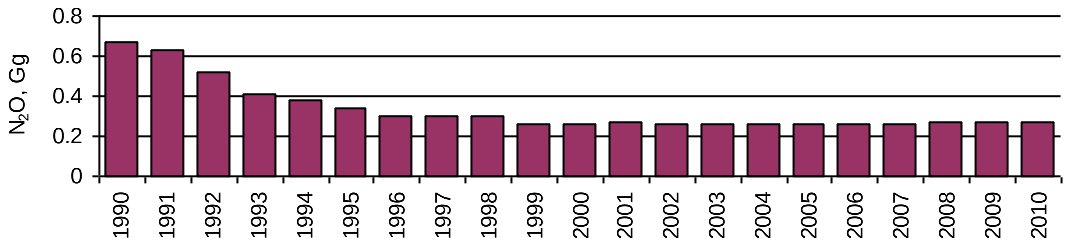

Figure 6.27. N_2O emissions from animal manure applied to agricultural soils in 1990–2010 in Estonia, Gg

6.5.5. Nitrogen input in N-fixing crops (CRF 4.D.1.3)

Amount of nitrogen fixed by N-fixing crops cultivated annually is based on the assumption that the amount of N contained in the aboveground plant material (crop product plus residues) is a reasonable proxy for the total amount of N fixed by the crop (IPCC, 2000).

90 IPCC 1997. Agriculture. Reference Manual. Table 4-19 Default values for parameters, pp. 9.94.

6.5.5.1. Methodology, data availability, data sources and emission factors

The *Tier 1b* method (IPCC, 1997) was used to estimate emissions from N fixing crops.

$$F_{BN} = \sum_i [Crop_{BF} \bullet (1 + Res_{BF_i} / Crop_{BF_i}) \bullet Frac_{DM_i} \bullet Frac_{NCRBF_i}] \qquad (6.24)^{91}$$

$Crop_{BF}$ – Production of N-fixing crops in country, kg dry biomass/year;

$Res_{BFi}/Crop_{BFi}$ – residue to crop product mass ratio specific to each crop type i;

FracDMi – the fraction of dry matter in the aboveground biomass of each crop type *i*;

$Frac_{NCRBF}$ – Fraction of nitrogen in N-fixing crop, kg N/kg of dry biomass.

The activity data on the production of N-fixing crops in Estonia were obtained from SE (Appendix A.3.3_IX). IPCC default factor was used in the estimation (Table 6.53).

Annual N_2O emissions from N-fixing crops were calculated using the formula (6.25).

$$N_2O_{direct} = F_{BN} \bullet EF_1 \bullet 44/28 \qquad (6.25)$$

EF_1 – IPCC default factor for N-fixing crops (1.25%)[92].

The values of conversion factor from fresh matter to dry matter, crop/residues product ratio and nitrogen fraction in crops are presented in Table 6.53; production data of N-fixing crops in Estonia in 1990–2010 are presented in Figure 6.30 and Figure 6.32.

6.5.5.2. Quantitative overview – N_2O emissions from growing of N-fixing crops in 2010

The total production of legumes (i.e., dry bean and peas) in Estonia was 12 653 tonnes and 588 240 tonnes of clover and alfalfa in Estonia in 2010.

The total N_2O emissions from growing of N-fixing crops were 0.183 Gg in Estonia in 2010 (Figure 6.28).

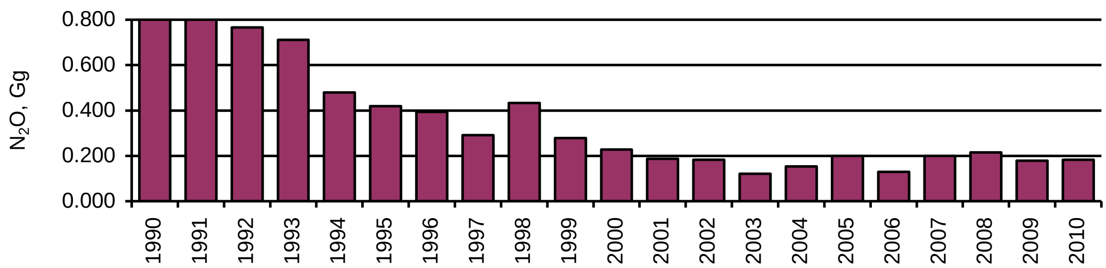

Figure 6.28. N_2O emissions from growing of N-fixing crops in 1990–2010 in Estonia, Gg

[91] IPCC 2000. Agriculture. Equation 4.26, pp. 4.57.
[92] IPCC 1997. Agriculture. Reference Manual. Table 4-18 Default emission factors for direct emissions of N_2O, pp. 4.89.

6.5.6. N_2O emissions from nitrogen input from crop residues (CRF 4.D.1.4)

The amount of nitrogen returned to soils annually through the incorporation of crop residues.

6.5.6.1. Methodology, data availability, data sources and emission factors

The default IPCC *Tier 1b* method was used to estimate emissions from crop residues returned to the soil.

$$F_{CF} = \sum_i (Crop_{O_i} \bullet Res_{O_i}/Crop_{O_i} \bullet Frac_{DM_i} \bullet Frac_{NCRO_i}) \bullet (1 - Frac_{BURN_i} - Frac_{FUEL\text{-}CR_i} - Frac_{CNST\text{-}CR_i} - Frac_{FOD_i}) + \sum_j Crop_{O_j} \bullet Res_{O_j}/Crop_{O_j} \bullet Frac_{DM_j} \bullet Frac_{NCRO_j}) \bullet (1 - Frac_{BURN_j} - Frac_{FUEL\text{-}CR_j} - Frac_{CNST\text{-}CR_j} - Frac_{FODj} \quad (6.26)$$[93]

$Crop_{BF}$ - Production of pulses in country, kg dry biomass/year;

$Crop_0$ – Production of non-N-fixing crops in country, kg dry biomass/year;

$Res_O/Crop_O$ and $Res_{BF}/Crop_{BF}$ – residue to crop product mass ratio;

$Frac_{NCRBF}$ – Fraction of nitrogen in N-fixing crops, kg N/kg of dry biomass;

$Frac_{NCR0}$ – Fraction of nitrogen in non-N-fixing crops, kg N/kg of dry biomass;

$Frac_R$ – Fraction of crop residue that is removed from the field as crop, kg N/kg crop-N;

$Frac_{BURN}$ – Fraction of crop residue that is burned rather than left on field.

Annual N_2O emissions from crop residues were calculated using the formula (6.27).

$$N_2O_{direct} = F_{CR} \bullet EF_1 \bullet 44/28 \quad (6.27)$$

Table 6.53. Selected crop residue statistics

Crop type	Residue/Crop product ratio	Dry matter fraction	Nitrogen fraction
Wheat	1.3	0.82-0.88	0.0028
Barley	1.2	0.82-0.88	0.0043
Maize	1	0.70-0.86	0.0081
Oats	1.3	0.92	0.007
Rye	1.6	0.9	0.0048
Triticale	1.45	0.85-0.92	0.0038
Peas	1.5	0.87	0.0142
Beans	2.1	0.82-0.89	0.0142
Potatoes	0.4	0.30-0.60	0.011
Feed beet and sugar beet	0.3	0.10-0.20	0.0228
Clover[94]	-	0.86	0.018
Alfalfa	-	0.86	0.018

[93] IPCC 2000. Agriculture. Equation 4.29, pp. 4.59.
[94] Austria's NIR 2011, Table 196. pp. 293.

Table 6.54. Factors used in the algorithm to estimate N2O emissions from crop residues[95]

Factor	Unit
$Frac_R$	0.45 kg N/kg crop-N
$Frac_{BURN}$	0 [(96)], kg N/kg crop-N
EF_1 for F_{CR}	1.25%[(97)]

6.5.6.2. Quantitative overview – N_2O emissions from crop-residues in 2010

In 2010, the production of cereals was 670.1 thousand tonnes, industrial crops – 0.2 thousand tonnes, potatoes – 163.4 thousand tonnes and legumes and fodder roots – 12.6 and 0.3 thousand tonnes, respectively (Figure 6.29–Figure 6.39). The inter-annual changes in crop production are explained by decline in the total sown area and by weather conditions (Appendix A.3.3_VII).

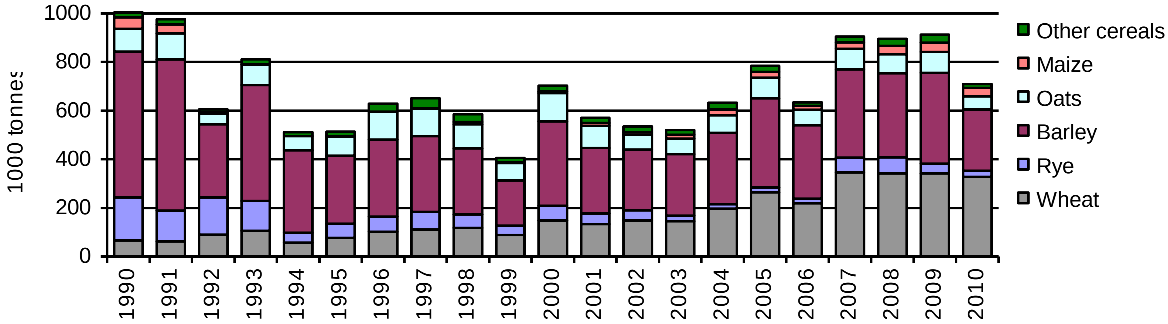

Figure 6.29. Cereals production in 1990–2010 in Estonia, 1000 tonnes

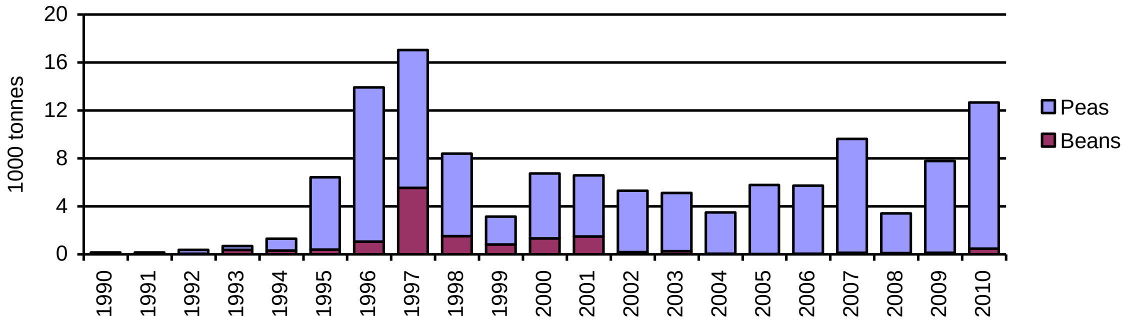

Figure 6.30. Pulse production in 1990–2010 in Estonia, 1000 tonnes

[95] IPCC 1997. Agriculture. Workbook. Table 4-17 – Summary of default values for parameters, pp 4.35.

[96] Since 2007 the activities to burn crop residues have been prohibited by a law (Põllumajandusministri määrus nr 57, 20.04.2007 and nr 20, 23.02.2011).

[97] IPCC 2000. Agriculture. Table 4-17 – Updated default emission factors to estimate direct N_2O emissions from agricultural soils, pp 4.60.

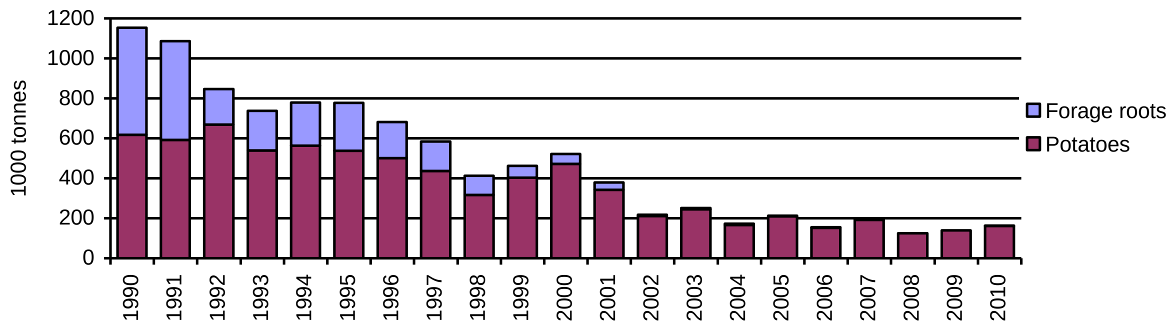

Figure 6.31. Tuber and root production in 1990–2010 in Estonia, 1000 tonnes

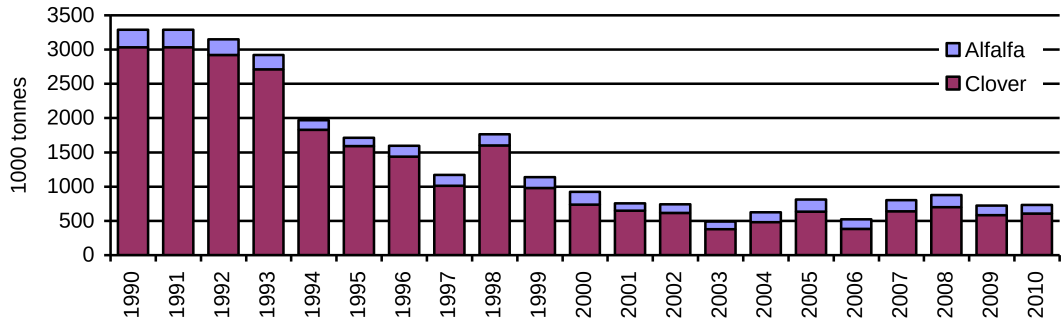

Figure 6.32. Clover and alfalfa production in 1990–2010 in Estonia, 1000 tonnes

The total N_2O emissions from crop residues left on agricultural land was 0.175 Gg in 2010 (Figure 6.33).

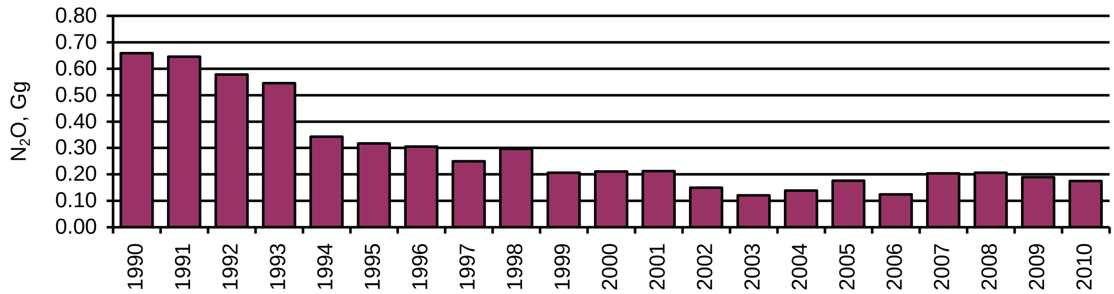

Figure 6.33. N_2O emissions from crop residues left on agricultural fields in 1990–2010 in Estonia, Gg

6.5.7. N_2O emissions from organic soils cultivation (CRF 4.D.1.5)

N_2O emissions occur as a result of cultivation of organic soils due to enhanced mineralization of old, N-rich organic matter. The rate of N-mineralization is determined by N-quality of histosols, management practice and climatic conditions (IPCC, 1997).

6.5.7.1. Methodology, data availability, data sources and emission factors

The *Tier 1* method was applied in order to estimate N_2O emissions from organic soils cultivation (IPCC, 1997).

$$N_2O_{direct} = F_{OS} \bullet EF_2 \bullet 44/28 \quad (6.28)$$

F_{OS} – area of cultivated organic soils, ha;

EF_2 – emission factor for organic soil mineralization due to cultivation, kg N_2O-N ha/year (Table 6.55).

Table 6.55. Factors used in the algorithm used to estimate N_2O emission from cultivated organic soils [98]

Factor	Unit
EF_2	8 kg N_2O-N/ha^{-yr}

6.5.7.2. Quantitative overview – N_2O emissions from organic soils cultivated in 2010

N_2O emissions from cultivation of organic soils were 0.264 Gg in 2010 in Estonia (Figure 6.34). The estimation was carried out based on the data received in the framework of National Forest Inventory (see chapter 7).

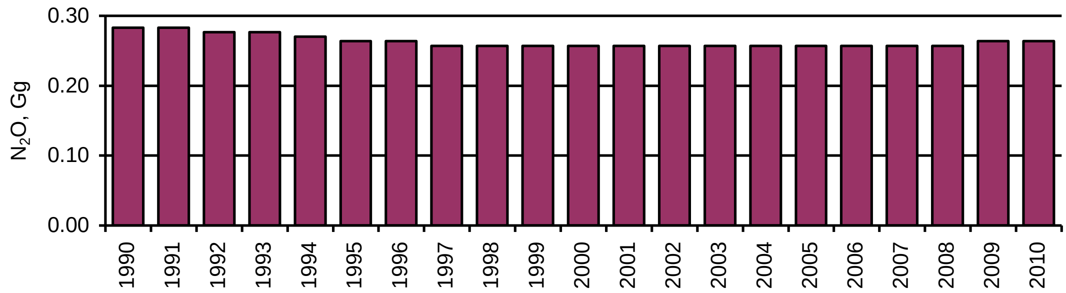

Figure 6.34. N_2O emissions from cultivation of organic soils in Estonia in 1990–2010, Gg

6.5.8. N_2O emissions from sewage sludge applied on agricultural soils (CRF 4.D.1.6)

Sludge from domestic wastewater treatment plants is used on agricultural land. Activity data on amounts of sludge recycled are collected by EEIC. The quantities of sewage sludge generated are demonstrated in Figure 6.35. The data of 1992–1993, 1994–1995 and 1998 were interpolated based on the total quantity of sludge generated. It was assumed that 13 per cent (a practice of several years) from the total amount of sludge was generated as sewage sludge. The data of 1990–1991 were extrapolated based on 5 per cent annual growth in amount of sewage sludge generation.

[98] IPCC 2000. Agriculture. Table 4.17 – Updated default factors to estimate direct N_2O emissions from agricultural soils, pp 4.60.

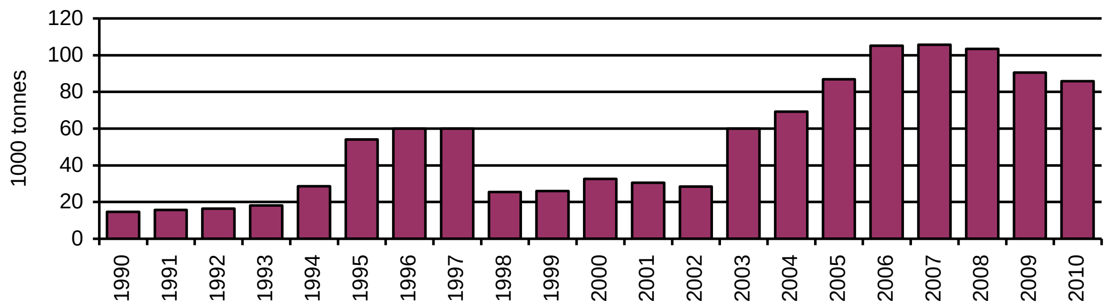

Figure 6.35. Sewage sludge generation in Estonia in 1990–2010, 1000 tonnes

The data in Table 6.56 illustrates the share of sludge used for improvement of environmental situation (R10) and treated biologically (R3) for compost. The data for years 1999–2010 were obtained from datasets of EEIC. It should be noted that EEIC does not collect information about usage of sewage sludge after biological treatment (R3). However, it was assumed that compost generated is applied onto agricultural fields in the year of treatment.

The quantities of sewage sludge treated according R10 category in 1990–1998 were extrapolated based on rough assumption – about 50 per cent of the total amount of generated sewage sludge were used for improvement of environmental situation (Table 6.56).

Since 2004, the quantity of sewage sludge treated biologically has increased, however the amounts of sewage sludge directly used for improvement of environmental situation has decreased.

Table 6.56. Amounts of municipal sludge application on agricultural land, tonnes[99]

Year	R3	R10
1990	-	*7 434*
1991	-	*7 825*
1992	-	*8 237*
1993	-	*9 081*
1994	-	*14 306*
1995	-	*27 073*
1996	-	*30 041*
1997	-	*30 028*
1998	-	*12 724*
1999	-	17 302
2000	-	26 489
2001	2 346	2 770
2002	20 278	11 385
2003	50 516	9 799
2004	66 902	1 025
2005	101 718	6 992
2006	108 377	12 285
2007	100 656	4 492
2008	72 271	18 948
2009	52 042	14 369

[99] R3 of the European Waste Catalogue (2002) – Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation process).
R10 of the European Waste Catalogue (2002) – Land treatment resulting in benefit to agriculture or ecological improvement.

Year	R3	R10
2010	71 174	20 843

6.5.8.1. Methodology, data availability and sources, emission factors

The *Tier 1* approach was employed in order to estimate N_2O emissions from sludge applied on agricultural land (IPCC, 1997).

$$F_{SL} = N_{FERT} \times (1 - Frac_{GASF})$$
(6.29)[100]

N_{FERT} - Total use of sludge applied on agricultural land in country, kg N/year;

$Frac_{GASF}$ – Fraction of total sludge nitrogen that is emitted as NO_x+NH_3, kg N/kg N.

$$N_2O_{direct} - N = F_{SL} \bullet EF \bullet 44/28_1 \quad (6.30)$$

EF – emission factor.

The emission factors used in the estimates are presented in Table 6.57.

Table 6.57. Parameters and factors used in the estimates

Factor	Value	
FracGASF[101]	0.10	kg NH_3-N + NOx-N/kg of sludge nitrogen applied
EF for F_{SL}	1.25%	
Sludge (sewage) N content[102]	5	% dry matter

6.5.8.2. Quantitative overview – N_2O emissions from sludge applied on agricultural land in 2010 (CRF 4.D.1.6)

The total N_2O emissions from sludge applied on agricultural land were 0.008 Gg in Estonia in 2010 (Figure 6.36).

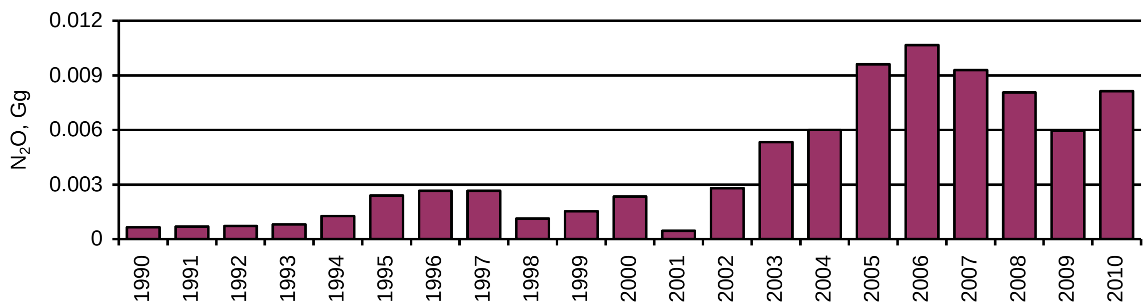

Figure 6.36. N_2O emissions from sludge applied on agricultural land in Estonia in 1990–2010, Gg

[100] IPCC 1997. Agriculture. Workbook. Equation1, pp 4.33.
[101] IPCC 1997. Agriculture. Reference Manual. Table 4-17- Summary of default values for parameters, pp. 4.35.
[102] CH_4 and N_2O Emissions from Waste Water Handling' background paper.

6.5.9. Uncertainties and time-series consistency

6.5.9.1. Synthetic fertilizers used (CRF 4.D.1.1)

The estimation of N_2O emissions from synthetic fertilizers used were carried out based on activity data and emission factors.

Investigations made into the estimates of uncertainties related to activity data (synthetic fertilizers applied on agricultural soils) are presented in (Rypdal and Winiwarter, 2001). The authors report uncertainties at ±5% in Austria, at ±5% in Norway, at ±10-50% in the Netherlands, at ±2% in the USA and at ±10% in Finland (Monni and Syri, 2003). No similar research has been carried out in Estonia, therefore the uncertainty of Finland was used in the estimates (Table 6.58).

Nitrogen emission factors have been used as IPCC default in the estimates of N_2O emissions. The IPCC gives an uncertainty of the factor of ±80%, the factor is 0.0125 with a range of 0.0025–0.0255 (IPCC, 1997).

6.5.9.2. Animal manure applied to soils (CRF 4.D.1.2)

The estimation of N_2O emissions from animal manure applied to soils was carried out based on activity data (amounts of nitrogen produced by livestock) and emission factors.

Uncertainties of N generated were described in the 'Manure Management' chapter above.

Nitrogen emission factor was taken as IPCC default. An uncertainty of the factors is given in the IPCC Guidelines (1997) at ±80% (Table 6.58) (IPCC, 1997).

6.5.9.3. N-fixing crops and crop residues (CRF 4.D.1.3 and CRF 4.D.1.4)

The estimation of N_2O emissions from N-fixing crops and crop residue is carried out based on activity data (crop production) and emission factors (N emission factor, crop residue ratios, nitrogen content in crops and fraction of residues left on fields).

Data on uncertainty of crop production (N-fixing and non-nitrogen fixing crops) in Estonia are not available, therefore the uncertainty of activity data was not estimated.

IPCC default nitrogen emission factor has been used in the estimates. IPCC gives an uncertainty of the factor at ±80% (Table 6.58) as the value of the factor is 0.0125 with a range of 0.0025–0.0255 (IPCC, 1997).

Table 6.58. Estimated values of uncertainties used in agriculture sector

Input	Uncertainties	References
Activity data		
Estonia's Livestock Population (cattle, swine, sheep, goats, horses, poultry)	± 10%	Rypdal and Winiwarter, 2001
Synthetic Fertilizers (applied to agricultural soils)	± 10%	Rypdal and Winiwarter, 2001
Emission factors		
Emission factor (synthetic fertilizers, animal manure, n-fixing crops and crop residues)	± 80%	Table 4-18 of the 1996 IPCC Guidelines, pp. 4.89
Fraction of synthetic N fertilizers that volatilizes as NH_3 and NO_x	± 30%	Monni and Syri, 2003
Fraction of animal manure N that volatilizes as NH_3 and NO_x	± 40%	Monni and Syri, 2003

6.5.10. Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.3.3.

The QA/QC plan for the agricultural sector includes the QC activities described in the IPCC GPG (IPCC 2000, Table 8.1). The activities are carried out every year during the inventory. The QC check list is used during the inventory.

6.5.11. Source-specific recalculations

There are several recalculations carried out in the 2012 submission:

(1) Animal manure applied on agricultural soils (CRF 4.D.1.2) – the amounts of manure applied on soils were recalculated due to the changes employed in the estimations of nitrogen excretion factors and because of the development of Estonian module on manure management system (Figure 6.37, Chapter 6.4.1.1);

(2) Synthetic fertilizers (CRF 4.D.1.1) – the data on amount of synthetic fertilizers applied on agricultural soils in 2003 were updated (Table 6.61);

(3) N-fixing crops (CRF 4.D.1.2) – The yields of clover and alfalfa were accounted for the entire time-series for the first time in the 2012 submission (Table 6.60);

(4) Crop residue (CRF 4.D.1.4) – The yields of clover and alfalfa were accounted for the entire time-series for the first time in the 2012 submission. In addition, the values of $Frac_{BURN}$ were updated for 2007–2009 because of new information retrieved regarding legislative prohibition established against burning of crop residues (Figure 6.38);

(5) Cultivation of organic soils (CRF 4.D.1.5) – the data on areas of organic soils cultivated were harmonized with the data reported under the LULUCF sector (Figure 6.39);

(6) Sewage sludge applied on agricultural lands (CRF 4.D.1.5) – the activity data on the amount of sewage sludge applied on soils were updated for 2009 (Table 6.61).

The total direct N_2O emissions from agricultural soils calculated in the 2011 and 2012 submissions are reported in Table 6.59.

Table 6.59. Direct N_2O emissions from agricultural soils in 1990–2009, Gg

Year	Reported N_2O emissions in the 2011 submission	Recalculated N_2Oemissions in the 2012 submission
1990	2.782	3.685
1991	2.722	3.592
1992	2.339	3.169
1993	1.663	2.476
1994	1.414	1.937
1995	1.239	1.681
1996	1.141	1.563
1997	1.253	1.467
1998	1.350	1.727
1999	1.182	1.356
2000	1.294	1.356
2001	1.151	1.277
2002	1.046	1.150
2003	1.198	1.183
2004	1.233	1.258

Year	Reported N_2O emissions in the 2011 submission	Recalculated N_2Oemissions in the 2012 submission
2005	1.188	1.259
2006	1.235	1.181
2007	1.335	1.371
2008	1.527	1.582
2009	1.401	1.387

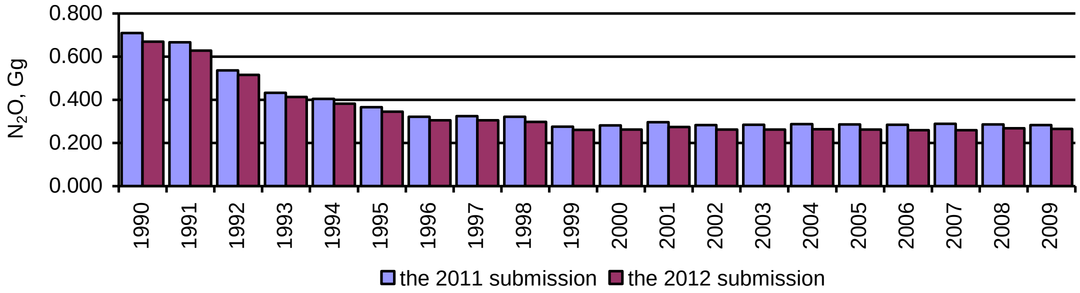

Figure 6.37. N_2O emissions from growing of animal manure in 1990–2009, Gg

Table 6.60. N_2O emissions from growing of N-fixing crops in 1990–2009, Gg

Year	Reported N_2O emissions in the 2011 submission	Recalculated N_2Oemissions in the 2012 submission
1990	0.0001	0.800
1991	0.0001	0.800
1992	0.0002	0.766
1993	0.0003	0.711
1994	0.0005	0.479
1995	0.0027	0.419
1996	0.0058	0.393
1997	0.0071	0.292
1998	0.0035	0.433
1999	0.0013	0.278
2000	0.0028	0.228
2001	0.0028	0.186
2002	0.0022	0.182
2003	0.0021	0.121
2004	0.0015	0.154
2005	0.0024	0.199
2006	0.0024	0.129
2007	0.0040	0.199
2008	0.0014	0.215
2009	0.0033	0.179

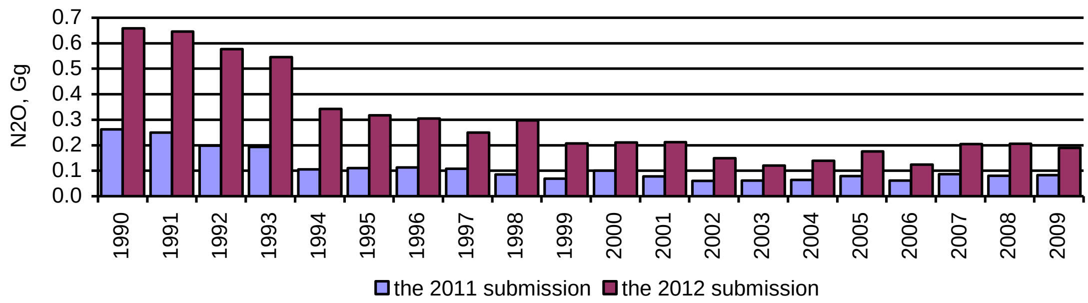

Figure 6.38. N_2O emissions from nitrogen input from crop residues in 1990–2009, Gg

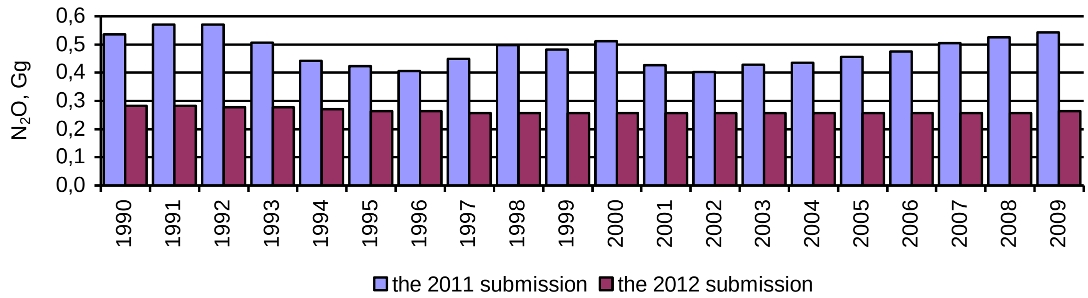

Figure 6.39. N_2O emissions from organic soils cultivation activities in 1990–2009, Gg

Table 6.61. N_2O emissions from synthetic fertilizers and sewage sludge application on agricultural soils, Gg

Year	Category	Reported N_2O emissions in the 2010 submission	Recalculated N_2Oemissions in the 2011 submission
2003	Synthetic fertilizers	0.416	0.411
2009	Sewage sludge	0.00587	0.00594

6.5.12. Source-specific planned improvements

Activity data and the algorithm used for the calculation are kept under consideration and will be updated necessarily.

The investigation of main flows of sewage and industrial sludge generated by main producers was planned in the 2011 previous submission. However, the research was not performed due to the lack of financial support. Estonia plans to carry out the abovementioned improvements in the next submissions.

In the framework of the further development of country-specific module on MMS, the fraction of livestock nitrogen excretion that volatilizes as NH_3 and NO_x ($Frac_{GASM}$) will be investigated to implement in the estimates.

6.5.13. N_2O emissions from pasture, range and paddock (CRF 4.D.2)

6.5.13.1. Methodology, data availability, data sources and emission factors

The method reported in Chapter 6.4.2. was used in order to estimate N_2O emissions from animal pasture, range and paddock.

6.5.13.2. Quantitative overview – N_2O emissions from pasture, range and paddock in 2010

The total N_2O emission from pasture, range and paddock made up 0.242 Gg in 2010. The emission decreased by 61 per cent compared to the base year due to decline in number of livestock population (Figure 6.40).

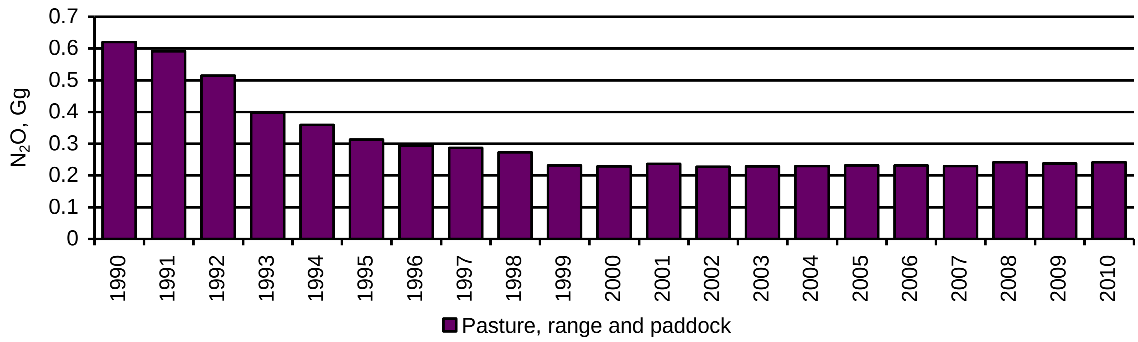

Figure 6.40. N_2O emissions from pasture, range and paddock in 1990–2010, Gg

6.5.13.3. Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.3.3

The QA/QC plan for the agricultural sector includes the QC activities described in the IPCC GPG (IPCC 2000, Table 8.1). The activities are carried out every year during the inventory. The QC check list is used during the inventory.

Activity data are checked annually for updating. Emission factors are compared with IPCC default and with emission factors of other countries.

6.5.13.4. Source-specific recalculations

There are several recalculations carried out in the 2012 submission, the list of recalculation performed is presented in Chapter 6.4.2.6. The results of the recalculations are reported in Table 6.62.

Table 6.62. N_2O emissions from pasture, range and paddock manure management in 1990–2009, Gg

Year	Reported N_2O emissions in the 2011 submission	Recalculated N_2Oemissions in the 2012 submission
1990	0.264	0.620
1991	0.255	0.591
1992	0.219	0.515
1993	0.162	0.397

Year	Reported N_2O emissions in the 2011 submission	Recalculated N_2Oemissions in the 2012 submission
1994	0.139	0.360
1995	0.122	0.313
1996	0.113	0.294
1997	0.110	0.287
1998	0.104	0.273
1999	0.091	0.232
2000	0.092	0.229
2001	0.097	0.237
2002	0.094	0.228
2003	0.095	0.229
2004	0.098	0.230
2005	0.102	0.232
2006	0.107	0.232
2007	0.110	0.230
2008	0.112	0.242
2009	0.111	0.238

6.5.13.5. Source-specific planned improvements

As it was mentioned in Chapter 6.4.1.4, the research continues to develop country-specific manure management system. The SE started a new cycle of agricultural survey in Estonia in 2010. The data on livestock population and manure management systems on village level will be finalized by the beginning of 2012. The results of the survey will be obtained from the SE. Hence, by the next submission, the data will be analyzed and used in the estimations. In addition, country-specific literature will be analyzed, together with data on structure of cattle population by herd size in the early of 1990th. The data will be interpolated between 1990th and 2000, and between 2000 and 2010. The results will be presented by the next submission.

6.6. Indirect emissions from agricultural soils (CRF 4.D.3)

Nitrous oxide is produced naturally in soils and aquatic systems through the microbial processes of nitrification and denitrification. A number of agricultural and other anthropogenic activities add nitrogen (N) to soils and aquatic systems, increasing the amount of N available for nitrification and denitrification, and ultimately the amount of N_2O emitted (IPCC, 2000).

6.6.1. Source category description

The total indirect N_2O emissions from agricultural soils were 0.761 Gg in 2010 (Figure 6.41). The emissions declined by 61 per cent compared to the base year by 2010 due to decrease in number of livestock population and synthetic and sludge application onto agricultural land.

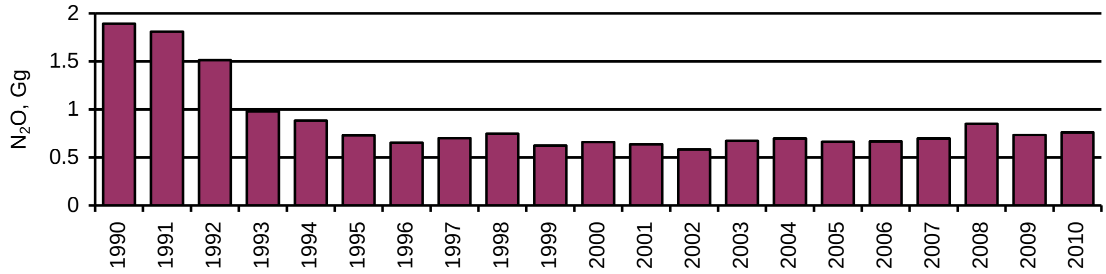

Figure 6.41. Indirect N_2O emissions from agricultural soils in Estonia in 1990–2010, Gg

6.6.2. Atmospheric deposition of NO_X and NH_4 (CRF 4.D.3.1)

Atmospheric deposition of nitrogen compounds such as nitrogen oxides (NO_x) and ammonium (NH_4) fertilizes soils and surface waters, which results in enhanced biogenic N_2O formation (IPCC, 2000).

6.6.2.1. Methodology, data availability, data sources and emission factors

The *Tier 1b* method was used to estimate emissions from the atmospheric deposition.

$$N_2O_{(G)} - N = \{(N_{FERT} \bullet Frac_{GASF}) + [\sum_T (N_{(T)} \bullet Nex_{(T)}) + N_{SEWSLUDGE}] \bullet Frac_{GASM})\} \bullet EF_4$$

(6.31)[103]

$N_2O_{(G)}$ – N_2O produced from atmospheric deposition of N, kg N/year;

N_{FERT} – Total amount of synthetic nitrogen fertilizer applied to soils, kg N/year;

$\sum_T(N_{(T)} \bullet Nex_{(T)})$ – total amount of animal manure nitrogen excreted in a country, kg N/year;

$N_{SEWSLUDGE}$ – Total sewage sludge nitrogen applied on agricultural soils, kg N/year;

$Frac_{GASF}$ – Fraction of synthetic N fertilizer that volatilises as NH_3 and NO_x, kg NH_3-N and NO_x-N/kg of N input (Table 6.63);

$Frac_{GASM}$ – 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 (Table 6.63);

EF_4 – Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces kg N_2O-N/kg NH_3-N and NO_x-N emitted (Table 6.63).

Table 6.63. Factors used in the algorithm of the estimation of atmospheric deposition

Factor	Value
$Frac_{GASF}$	0.1 kg NH_3-N + NO_x-N/kg of synthetic fertilizer nitrogen applied[104]
$Frac_{GASM}$	0.2 kg NH_3-N + NO_x-N/kg of nitrogen excreted by livestock[105]
EF_4	0.01 kg N_2O-N per kg NH_3-N and NO_x-N emitted[106]

[103] IPCC 2000. Agriculture. Equation 4.32, pp 4.70.
[104] IPCC 1997. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35.
[105] IPCC 1997. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35.

6.6.2.2. Quantitative overview – Atmospheric deposition of NO_x and NH_4 in 2010

The total N_2O emissions from atmospheric deposition were 0.124 Gg in 2010 in Estonia (Figure 6.42). The emissions decreased by 60 per cent by 2010 compared to the base year.

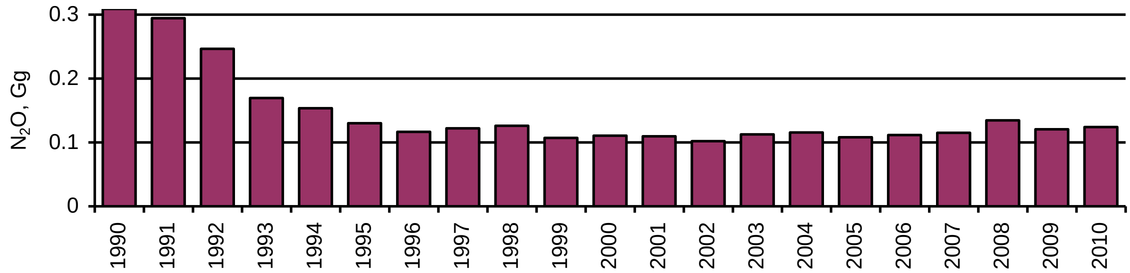

Figure 6.42. Atmospheric deposition of NO_x and NH_4 in 1990–2010, Gg

6.6.3. Leaching/run-off of applied or deposited nitrogen (CRF 4.D.3.2)

A large proportion of nitrogen is lost from agricultural soils through leaching and runoff. This nitrogen enters the groundwater, riparian areas and wetlands, rivers, and eventually the ocean, where it enhances biogenic production of N_2O (IPCC, 2000).

6.6.3.1. Methodology, data availability, data sources and emission factors

The *Tier 1b* method was is used to estimate emissions from the atmospheric deposition.

$$N_2O_{(L)} - N = [N_{FERT} + \sum_T (N_{(T)} \bullet Nex_{(T)}) + N_{SEWSLUDGE}] \bullet Frac_{LEACH} \bullet EF_5 \qquad (6.32)$$ [107]

N_{FERT} – Total amount of synthetic nitrogen fertilizer applied to soils, kg N/year;

$\sum_T(N_{(T)} \bullet Nex_{(T)})$ – Total amount of animal manure nitrogen excreted in a country, kg N/year;

$N_{SEWSLUDGE}$ – Total sewage sludge nitrogen applied on agricultural soils, kg N/year.

$Frac_{LEACH}$ – The amount of applied N that leaches or runs off, kg N/kg (Table 6.64);

Table 6.64. Factors used in the algorithm of the estimation of leaching/runoff

Factor	Value
$Frac_{LEACH}$	0.3 kg N/kg nitrogen of fertilizer or manure[108]
EF_5	0.025 kg N_2O-N per kg NH_3-N and NO_x-N emitted[109]

[106] IPCC 2000. Agriculture. Table 4-18 Deafult emission factors for estimating indirect N2O emissions from N used in agriculture. pp 4.73.
[107] IPCC 2000. Agriculture. Equation 4.34, pp. 4.71.
[108] IPCC 1997. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35.
[109] IPCC 2000. Agriculture. Table 4-18 –Default emission factors for estimating indirect N_2O emissions from N used in agriculture. pp 4.73.

6.6.3.2. Quantitative overview – Leaching/Run-off of applied or deposited nitrogen in 2010

The total N_2O emissions from leaching and run-off were 0.637 Gg in 2010 in Estonia (Figure 6.43). The emissions decreased by 60 per cent by 2010 in comparison with the base year.

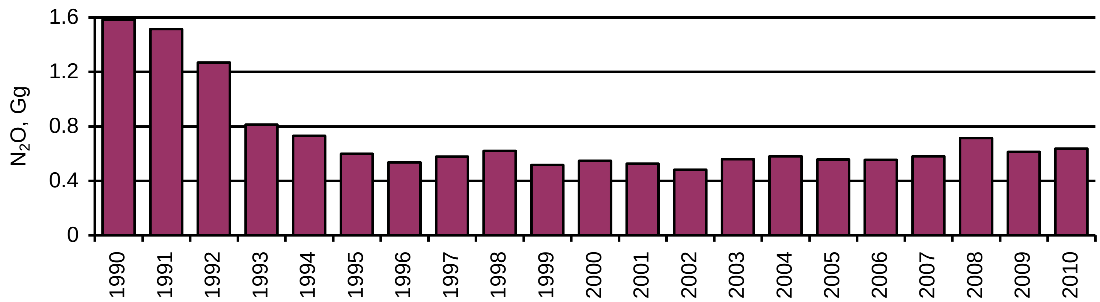

Figure 6.43. Leaching and run-off of NO_x and NH_4 in 1990–2010 in Estonia, Gg

6.6.4. Uncertainties and time-series consistency

6.6.4.1. Atmospheric Deposition (CRF 4.D.3.1)

The estimation of N_2O emissions from atmospheric deposition was carried out based on activity data (synthetic fertilizers and animal manure applied to soils) and emission factors (N emission factor, fraction of synthetic N fertilizers that volatilizes as NH_3 and NO_x and fraction of animal manure N that volatilizes as NH_3 and NO_x).

Uncertainties of fractions of synthetic fertilizers and animal manure that volatilize as NH_3 and NO_x were estimated by a Finnish expert (Monni *et al.*, 2003). These values were used in the estimates in order to calculate Estonia's uncertainties.

Nitrogen (N_2O) emission factor was used from (IPCC, 1997). IPCC Guidelines give the factor at 0.01 with a range 0.002–0.02, which means that the uncertainty of the factor is -80%...+100% (Table 6.65).

6.6.4.2. Nitrogen leaching and run-off (CRF 4.D.3.2)

The estimation of N_2O emissions from nitrogen leaching was carried out based on activity data (synthetic fertilizers and animal manure applied to soils) and emission factors (fraction of the fertilizer, manure nitrogen lost to leaching and surface run-off and N_2O emission factor).

Nitrogen (N_2O) emission factor is reported in (IPCC, 1997). The value of the factor is 0.025 with a range 0.002–0.12. The uncertainty of emission factor is -92%...+380% (Table 6.65).

Table 6.65. Estimated values of uncertainties used in agriculture sector

Input	Uncertainties	References
Activity data		
Estonia's livestock population (cattle, swine, sheep, goats, horses, poultry)	± 10%	Rypdal and Winiwarter, 2001
Synthetic fertilizers (applied to agricultural	± 5%	

Input	Uncertainties	References
soils)		Rypdal and Winiwarter, 2001
Emission factors		
Fraction of synthetic N fertilizers that volatilizes as NH_3 and NO_x	± 30%	Monni and Syri, 2003
Fraction of animal manure N that volatilizes as NH_3 and NO_x	± 40%	Monni and Syri, 2003
Emission factor (Atmospheric deposition)	-80%...+100%	Table 4-23 of the 1996 IPCC, pp. 4.105
Emission factor (N leaching and run-off)	-92%...+380%	Table 4-23 of the 1996 IPCC, pp. 4.105
Fraction of the fertilizer and manure nitrogen lost to leaching and surface run-off	-67%...167%	Table 4-24 of the 1996 IPCC, pp. 4.106
Emission factor (Nitrogen leaching and run-off)	-92%...380%	Table 4-23 of the 1996 IPCC, pp. 4.105

6.6.5. Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.3.3.

The QA/QC plan for the agricultural sector includes the QC activities described in the IPCC GPG (IPCC 2000, Table 8.1). The activities are carried out every year during the inventory. The QC check list is used during the inventory.

6.6.6. Source-specific recalculations

The recalculations in 'Indirect N_2O emissions from agricultural soils' category were performed due to the changes employed in the 'Manure management', 'Animal manure applied on agricultural soils' and 'Sewage sludge applied on agricultural soils' categories (Chapter 6.5.11).

The results of the recalculations completed and indirect N_2O emissions reported in the 2012 submission are provided in Table 6.66.

Table 6.66. Indirect N_2O emissions from agricultural soils in Estonia in 1990–2009, Gg

Year	Reported N_2O emissions in the 2011 submission	Recalculated N_2Oemissions in the 2012 submission
1990	1.762	1.893
1991	1.687	1.811
1992	1.394	1.515
1993	0.888	0.981
1994	0.799	0.883
1995	0.660	0.731
1996	0.581	0.652
1997	0.635	0.701
1998	0.689	0.746
1999	0.572	0.625
2000	0.612	0.659
2001	0.590	0.636
2002	0.539	0.583
2003	0.629	0.673
2004	0.655	0.696
2005	0.596	0.665
2006	0.631	0.667

Year	Reported N_2O emissions in the 2011 submission	Recalculated N_2Oemissions in the 2012 submission
2007	0.667	0.696
2008	0.805	0.850
2009	0.691	0.735

The indirect emissions occurred, which were calculated in the 2011 and 2012 submissions, are reported in Figure 6.44 and Figure 6.45.

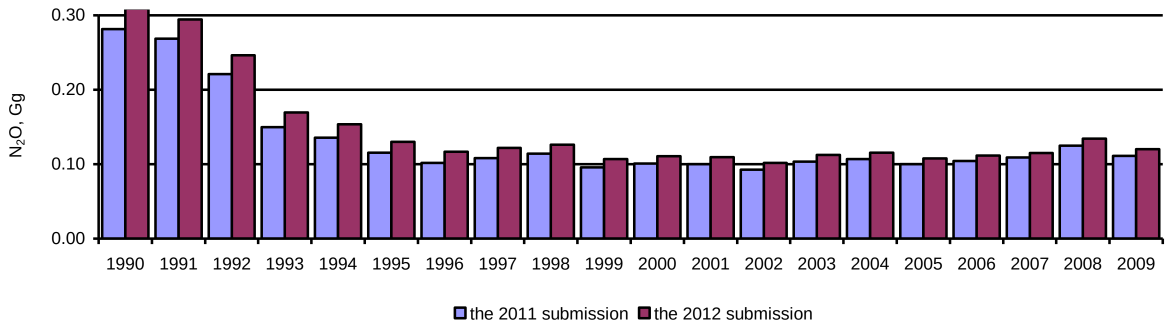

Figure 6.44. N_2O emissions from atmospheric deposition in 1990–2009 in Estonia, Gg

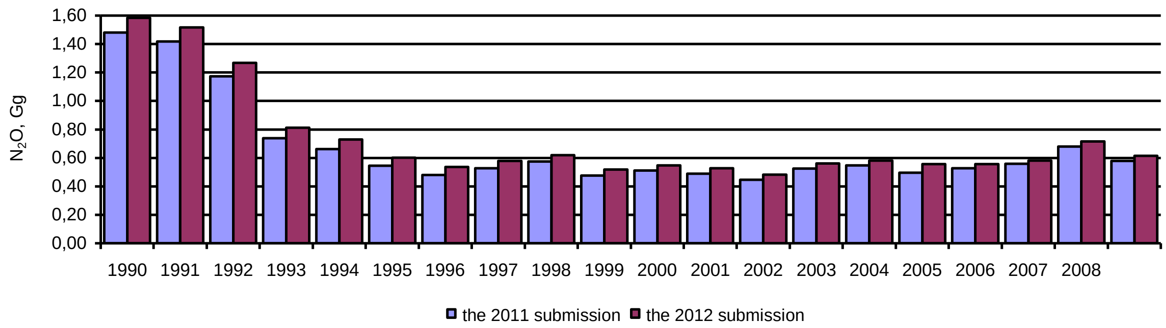

Figure 6.45. N_2O emissions due to nitrogen leaching and run-off in 1990–2009 in Estonia, Gg

6.6.7. Source-specific planned improvements

The activity data and the algorithm are kept under consideration and will be updated necessarily.

6.7. Field burning of agricultural residues (CRF 4.F)

The burning of agricultural residues is not considered a net source of CO_2 emissions because the carbon released to the atmosphere is reabsorbed during the next growing season, this burning is a source of net emissions of many trace gases including CH_4, N_2O and NO_x (IPCC, 2000).

The default value on the fraction of crop-residue burned was used in the estimates of emissions in Estonia in 1990–2006. Since, to date there are no reliable quantitative data developed yet. However, an opinion of expert on practice of crop residue burning was collected during the 2011 submission cycle. The opinion will be adjusted to quantitative data (i.e., to fraction of crop residue burned in 1990–2006) by the next submission. Since 2007, the burning of crop residues was prohibited by an Estonian law (Põllumajandusministri määrus nr 57, 20.04.2007 and nr 20, 23.02.2011), therefore GHG emissions for the reporting period of 2007–2010 are reported to be 'NO' in Estonia.

6.7.1. Methodology, data availability, data sources and emission factors

The detailed data on crop production is presented Figure 6.29–Figure 6.31. The data were obtained from SE. The remarkable inter-annual fluctuations in quantities of crops produced are caused by changes in sown area (Appendix A.3.3_VI) and by variations in weather conditions (Appendix A.3.3_VII).

The *Tier 1* of the Revised 1996 IPCC Guidelines (IPCC, 1997) was employed in the estimates:

$$DM_{BN} = Crop_{BN} \times RC_{RATIO} \times DM_{FRACTION} \tag{6.33}$$

DM_{BN} – Dry matter of crop residues burned in fields, Gg;

$Crop_{BN}$ – Quantity of crops, which produce residues burned in fields, Gg;

RC_{RATIO} – Residue-crop ratio for each type of crops;

$DM_{FRACTION}$ – Dry matter fraction of each crop residue, Gg DM/Gg FM.

$$TBB = DM_{BN} \times OX \tag{6.34}$$

TBB – Total biomass burned, Gg;

OX – Fraction of biomass oxidized for each crop type (default 0.9[110]).

$$C\_emission = TBB \times Cfraction \times Ratios\_for\_CH_4\_or\_CO \tag{6.35}$$

$$N\_emission = TBB \times Nfraction \times Ratios\_for\_N_2O\_or\_NO_X$$

C_emission – Emissions of carbon as methane and carbon monoxide (CO), Gg;

Cfraction – carbon content of each crop type, GgC/Gg DM;

Ratios for CH_4 or CO – Emissions ratios for CH_4 or CO (IPCC, 1997) [111];

N_emission – Emissions of carbon as nitrous oxide and nitrogen oxides (NO_x), Gg;

Nfraction – nitrogen content of each crop type, GgN/Gg DM;

Ratios for N_2O or NO_x – Emissions ratios for N_2O or NO_x (IPCC, 1997).

6.7.2. Emissions from field burning of agricultural residues in 1990–2006

CH_4 and N_2O emissions occurred due to the burning of crop residues in 1990–2006 are presented in Figure 6.46, Figure 6.47.

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[110] IPCC 1997. Agriculture. Workbook. pp. 4.30.

[111] IPCC 1997. Agriculture. Reference Manual. Table 4-16 Default emission rates for agricultural residue burning calculations, pp. 4.31.

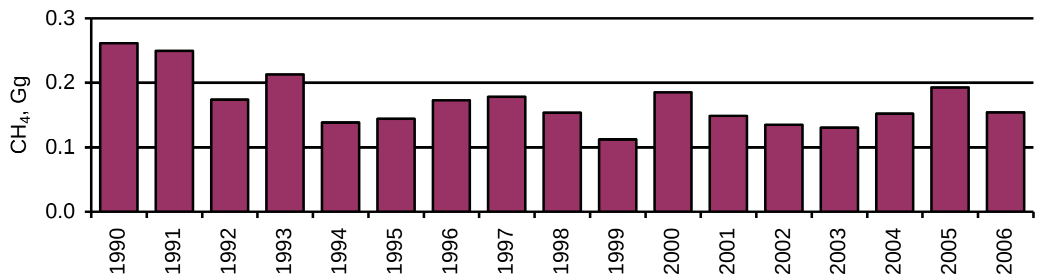

Figure 6.46. CH_4 emissions from field burning of agricultural residues in 1990–2006, Gg

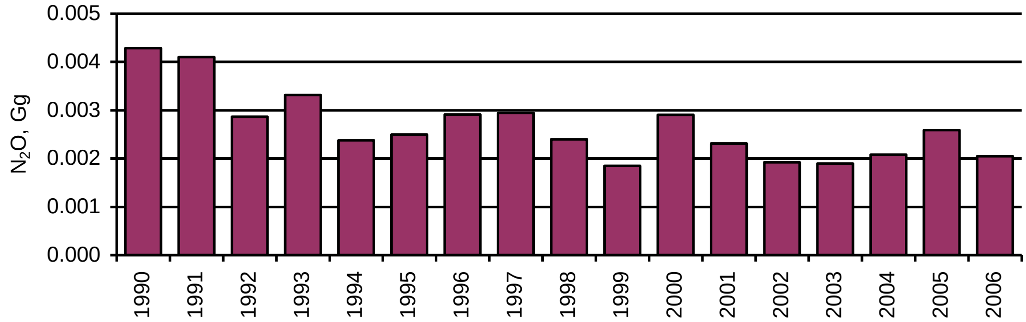

Figure 6.47. N_2O emissions from field burning of agricultural residues in 1990–2006, Gg

6.7.3. Uncertainties and time-series consistency

The estimation of N_2O and CH_4 emissions from agricultural residue burning was carried out based on activity data (crop residue left on fields) and emission factors is reported in the 1996 and 2000 IPCC Guidelines (Table 6.67).

Table 6.67. Estimated values of uncertainties used in the agriculture sector

Input	Uncertainties	References
Activity data		
Crop residue left on agricultural fields	± 20%	IPCC 2000. Agriculture. pp.4.20
Emission factors		
Default emission factor for CH_4	± 40%	Table 4-16 of the IPCC 1996 Guidelines, pp.4.31
Default emission factor for N_2O	± 29%	Table 4-16 of the IPCC 1996 Guidelines, pp.4.31

6.7.4. Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.3.3.

The QA/QC plan for the agricultural sector includes the QC activities described in the IPCC GPG (IPCC 2000, Table 8.1). The activities are carried out every year during the inventory. The QC check list is used during the inventory.

6.7.5. Source-specific recalculations

There is one recalculation carried out in the 2012 submission: (1) GHG emissions due to crop residue burning in 2007–2009 were reported to be 'NO' due to the update in activity data used (Estonian legalization on prohibition of crop residue burning was implemented) (Table 6.68).

Table 6.68. Emissions from the burning activities of crop residues in 2007–2009, Gg

Year	CH_4 emissions		N_2O emissions	
	2011[112]	2012	2011	2012
2007	0.222	NO	0.003	NO
2008	0.217	NO	0.003	NO
2009	0.218	NO	0.003	NO

6.7.6. Source-specific planned improvements

The fraction of crop residue burned will be developed in the next submissions.

[112] 2011 – the 2011 submission; 2012 – the 2012 submission.

7. LAND USE, LAND USE CHANGE AND FORESTRY (CRF 5)

7.1. Overview of the sector

7.1.1. Description and quantitative overview

The methodology used to calculate emissions and removals from Land Use, Land-Use Change and Forestry sector follows the IPCC Good Practice Guidance for LULUCF (IPCC, 2003). GPG-LULUCF suggests the use of six top-level land categories (Forest land, Cropland, Grassland, Wetlands, Settlements and Other land), devided into land remaining in the land-use category and land converted to another land use category. Since 2011 submission, the area of Estonia has been reported using *Approach 2* method that allows to track land-use transitions between categories.

In 2010, LULUCF sector acted as a CO_2 sink, resulting net carbon uptake about 3 758 Gg CO_2 equivalent (Figure 2.9), which means that total emissions arising from the sector are smaller than the total removals.

In the 2012 inventory submission Estonia reports emissions and removals in the following subsectors:

- Forest Land (CRF 5.A): emissions/removals from/by forest land in living biomass, dead wood and emissions from organic soils, in addition to abovementioned pools emissions from litter and mineral forest soils under forest land conversion to other land uses are reported;
- Cropland (CRF 5.B): emissions from cultivated organic soils, lime applied on agricultural soils, emissions/removals from/by orchards' living biomass were estimated for the first time in current submission;
- Grassland (CRF 5.C): emissions/removals from/by grassland in living biomass, dead wood and emissions from organic soils;
- Wetlands (CRF 5.D): CO_2 and N_2O emissions from peat extraction areas; loss of living biomass from forest land conversion to peatland was estimated for the first time in current submission;
- Settlements (CRF 5.E): emissions from Forest Land and Grassland conversion to Settlements in living biomass, dead wood and soil pools were estimated for the first time in current submission;
- Other land (CRF 5.F): emissions from loss of living biomass and dead wood after forest land conversion to Other land was estimated for the first time in current submission
- Non-CO_2 emissions from wildfires (CRF 5(V)) on Forest Land, Grassland and Wetland areas.

Estonia does not have sufficient country-specific activity data regarding litter and mineral soils to estimate related emissions correctly, therefore these pools are not reported in most of the subcategories under LULUCF sector. As an interim approach, Estonia used IEF-s related to litter and mineral soil pools from neighbouring countries (Sweden) in order not to underestimate emissions from accounted LULUCF activities (deforestation under KP), for consistency reasons, the same IEF-s were also implemented for estimating emissions in Forest Land conversion to other land uses under UNFCCC (Table 7.21, Chapters 7.4.2.3, 7.4.2.4). Estonia has taken steps to launch projects aimed to get country-specific data regarding omitted pools for future submissions.

Tier 2 approach of the IPCC Guidelines (LULUCF 2003) has been applied to estimate carbon flows associated with biomass change and biomass burning on land use categories (Table 7.1) for the whole time series. Carbon flows in organic soils have been estimated with default method, *Tier 1*. The estimates carried out have high rates of uncertainty, which is expected to be minimized during ongoing process of data collection.

Table 7.1. Methods and emission factors used to estimate the emissions/removals of GHG in the LULUCF sector of Estonia

Greenhouse gases source and sink categories	CO_2		CH_4		N_2O	
	Method Applied	EF	Method Applied	EF	Method Applied	EF
A. Forest land						
Forest Land remaining Forest Land	T1, T2	D	NA	NA	NA	NA
Biomass Burning	T2	D	T2	D	T2	D
Land converted to Forest Land	T1, T2	D	NA	NA	NA	NA
B. Cropland						
Cropland remaining Cropland	T1, T2	D	NA	NA	NA	NA
Land converted to Cropland	T1	D	NA	NA	NA	NA
C. Grassland						
Grassland remaining Grassland	T1, T2	D	NA	NA	NA	NA
Biomass Burning	T2	D	T2	D	T2	D
Land converted to Grassland	T1, T2	D	NA	NA	NA	NA
D. Wetlands						
Wetlands remaining Wetlands[113]	T1	D	NA	NA	NA	NA
Biomass Burning	T2	D	IE	NA	IE	NA
Land converted to Wetlands[114]	T2	D	NA	NA	NA	NA
Non-CO_2 emission from drainage of soils and wetlands (Peatland)	NA	NA	NA	NA	T1	D
E. Settlements						
Settlements remaining Settlements	NA	NA	NA	NA	NA	NA
Land converted to Settlements	T1, T2	D	NA	NA	NA	NA
F. Other land						
Other Land remaining Other Land	NA	NA	NA	NA	NA	NA
Land converted to Other Land	T1, T2	D	NA	NA	NA	NA

EF – Emission Factor, NE – not estimated, NA – not applicable, T1 – *Tier 1* method , T2 – *Tier 2* method, D –IPCC default

LULUCF sector inventory was carried out by Estonian Environment Information Centre (EEIC), department of the National Forest Inventory. Additionally, annual reports published by different institutions (EEIC, Estonian Land Board, Statistics Estonia (SE) etc. (see Table 7.2) have been used in the estimation of carbon fluxes related to the LULUCF sector.

[113] Organic soils managed for peat extraction.
[114] Forest land converted to Peatland.

Table 7.2. List of institutions (datasets) involved in the inventory of the LULUCF sector

References	Link	Abbreviation	Activity
Estonian Environment Information Centre	www.keskkonnainfo.ee	EEIC	- collecting and providing data of the National Forest Inventory; - collecting and providing data on land use categories (forest, cropland, grassland, wetlands, settlements, other lands); - collecting and providing data on forest biomass stock, increment, grassland stock, cropland living biomass, dead wood; - collecting and providing data on land use changes (including deforestation areas); - areas of peat extraction in 1990–2010
Estonian Rescue Service; State Forest Management Centre; Environmental Board	www.rescue.ee www.rmk.ee www.keskkonnaamet.ee	ERS; SFMC; EB	- collecting data on forest fires
Statistics Estonia	www.stat.ee	SE	- providing data on AR areas;
Estonian Land Board	www.maaamet.ee	ELB	- collecting and providing data on land areas by land use categories (Land Balances) for 1970–1990;

Figure 7.1 illustrates land use changes during the last four decades in Estonia. The area covered by forest has increased from 43.9% in 1970 to 49.8% in 2010 (increase of 270 thousand hectares). The increase has taken place mostly due to abandonment of grassland areas and overgrowing of wetlands. The area of grassland and wetlands decreased 433 and 67 thousand hectares respectively during the same period. The area of agricultural land – cropland increased until 1990s and started to decline after that due to the economical processes taking place in Estonian agricultural sector. Cropland area has been on a rising trend again since the last decade due to the increasing subsidies from government and the European Union. The area of settlements has been increasing constantly, about 29% during the period of last forty years.

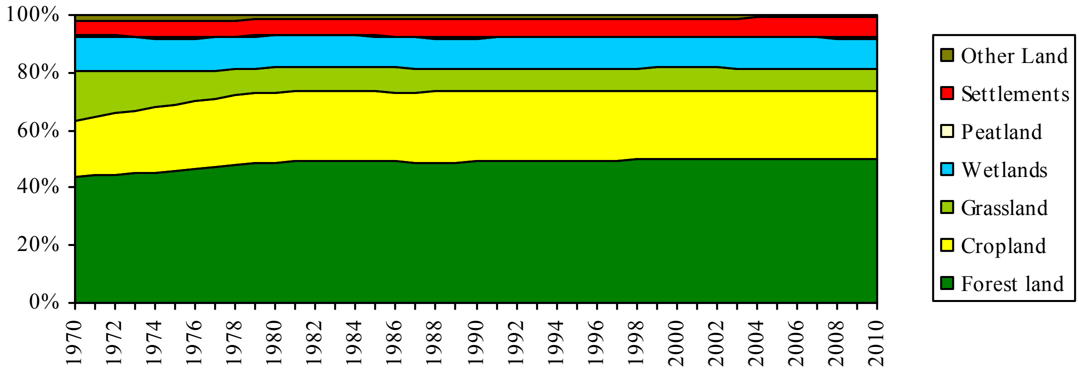

Figure 7.1. Land use in Estonia in 1970–2010, %

The areas of land use defined in accordance with the IPCC land use definitions are reported in Table 7.3. Peatland is a part of Wetlands and generally the area of Wetlands include both peatlands and inland water bodies if not stated otherwise. The total land area is Estonia's official land area, including all inland water bodies. The transition areas between all possible land-use categories were calculated on the bases of NFI field data. Since 2009 the land-use changes are assessed on each sample plot for the past 20 years.

All area estimates are being re-estimated annually due to the method used by National Forest Inventory (NFI). Sampling design of the Estonian NFI and the method of estimation of land use changes is described in Subchapter 7.1.3.

Table 7.3. The area of different land use classes in 1990–2010 (NFI), 1000 ha

	Forest land	**Cropland**	**Grassland**	**Wetlands**	**Peatland**	**Settlements**	**Other land**
1990	2 217.3	1 121.2	339.2	483.3	16.6	287.4	57.6
1991	2 222.0	1 118.6	338.7	483.3	16.6	286.9	56.6
1992	2 225.9	1 115.0	339.6	483.3	16.6	286.7	55.5
1993	2 232.9	1 111.0	338.6	482.7	16.6	286.4	54.5
1994	2 236.8	1 099.0	339.8	482.7	16.6	286.4	54.2
1995	2 241.1	1 099.0	345.3	481.4	16.6	286.0	53.2
1996	2 243.3	1 094.5	348.5	481.4	16.6	285.8	52.6
1997	2 244.5	1 091.9	350.4	481.4	16.6	285.8	52.1
1998	2 249.7	1 086.8	352.4	480.4	16.6	286.3	50.5
1999	2 252.9	1 085.2	352.8	479.9	16.6	285.8	49.5
2000	2 256.2	1 083.6	352.7	479.4	16.6	285.8	48.4
2001	2 256.7	1 080.6	355.7	479.4	16.6	285.8	47.9
2002	2 256.2	1 079.6	356.4	479.4	16.6	286.8	47.6
2003	2 257.0	1 077.1	356.1	479.4	16.6	288.9	47.6
2004	2 256.9	1 076.8	353.9	479.5	16.6	292.0	46.9
2005	2 258.7	1 075.7	353.8	479.5	16.6	292.5	45.8
2006	2 258.4	1 075.2	352.6	481.8	17.4	293.4	35.7
2007	2 256.8	1 077.3	347.2	480.8	18.6	296.8	43.8

	Forest land	Cropland	Grassland	Wetlands	Peatland	Settlements	Other land
2008	2 254.9	1 077.8	346.3	480.5	18.6	299.2	45.3
2009	2 254.5	1 078.3	346.3	480.5	18.6	299.7	44.8
2010	2 253.5	1 078.3	346.3	480.5	18.6	300.7	44.8

The net CO_2 emissions/removals of the Estonian LULUCF sector are presented in Figure 7.2. The main sink of CO_2 in Estonia is forest land, constituting over 90% of all LULUCF sector uptake (Figure 2.9). Emissions and uptake from forest land is predominantly determined by changes in forest growing stock. For 1990−1998, the data about growing stock of Forest Land has been interpolated, therefore only minor variability is detectable. In 1999 National Forest Inventory (NFI) was established and since then estimations are based on fieldwork data.

Due to the comparatively intensive use of forest resources, carbon flows derived from forest category have a major influence on the whole LULUCF sector's total carbon balance, being also the major cause of emissions in years 2000–2003. From 1999 to 2004, the rate of logging was more than twice as high as in the previous 10 years, which can be explained by the outcome of Land Reform and the economic boom taking place in the early 2000s. In 2002 and especially in 2006, extensive wildfires spread, having impact on the annual emissions of these years. Variation of estimates are also influenced by statistical fluctuation of activity data caused by random error of sampling.

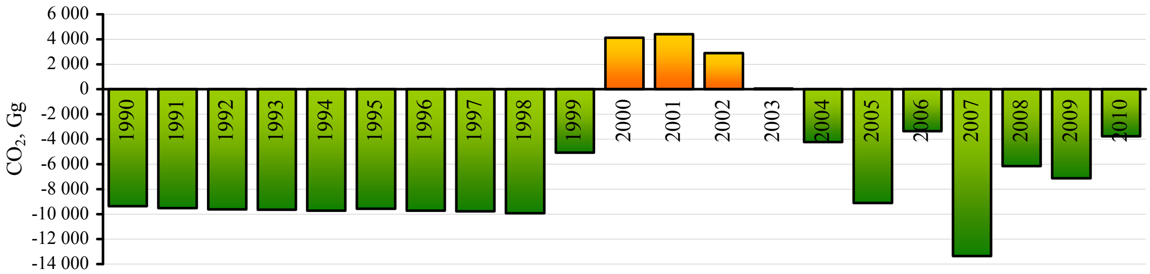

Figure 7.2. Annual change in emissions/removals of CO_2 from Estonian LULUCF sector in 1990−2010, CO_2 Gg

The total quantities of CH_4 and N_2O emitted are presented in Figure 7.3 and Figure 7.4. CH_4 emissions consist solely from emissions from forest, grassland and wetland wildfires. N_2O emissions comprise emissions from wildfires and emissions from peatland management.

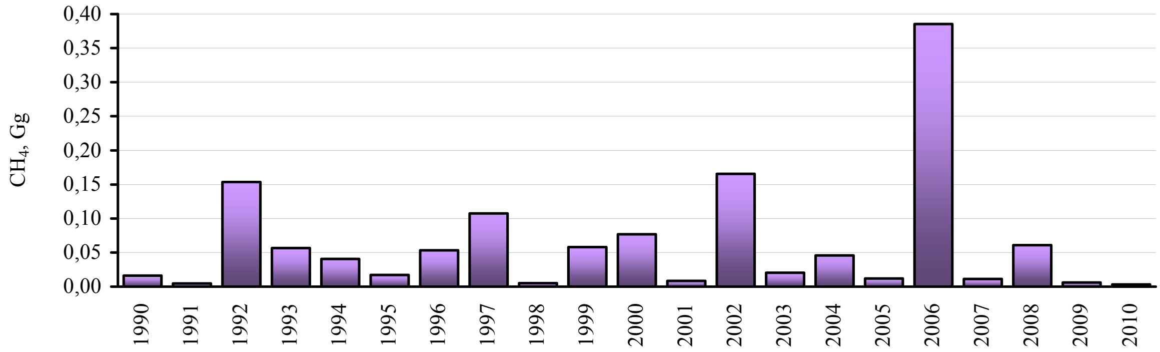

Figure 7.3. Emissions of CH_4 from the LULUCF sector in Estonia in 1990–2010, CH_4 Gg

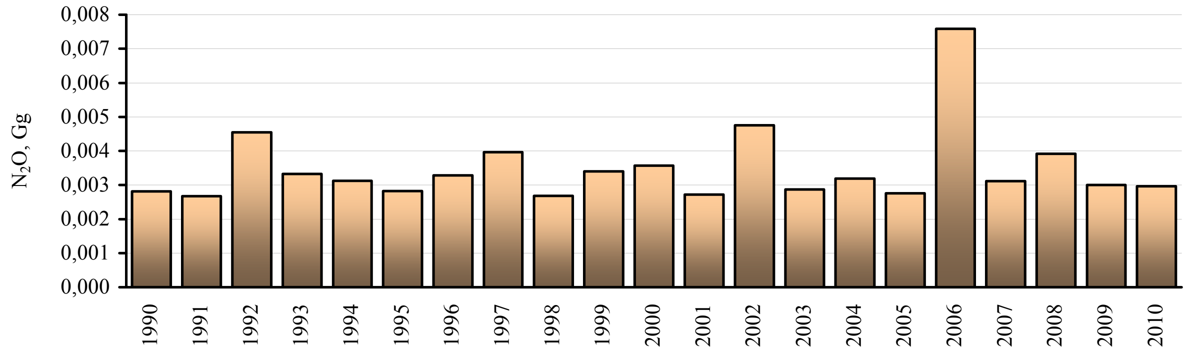

Figure 7.4. Emissions of N_2O from the LULUCF sector in Estonia in 1990–2010, N_2O Gg

Large interannual differences in emissions of non-CO_2 gases are caused mainly by the occurrence of wildfires (either wet or dry summer, years of extremes), see also biomass burning in Chapter 7.8.

7.1.2. Land areas and land-use categories used in the Estonian inventory

Land areas presented in the inventory reporting are consistent with the land-use categories given in the IPCC GPG-LULUCF (IPCC 2003). The area estimates for the land-use categories are based on the Estonian National Forest Inventory (NFI) carried out by the Estonian Environment Information Centre. The NFI is a sampling-based forest inventory that covers the whole country and all land-use classes. NFI also provides information on soils, division into mineral and organic soils as well as into undrained and drained land. The nationally classified NFI sample plots are reclassified into IPCC land-use categories. A short overview and sampling design of the NFI is described in Subchapter 7.1.3.

Table 7.4 gives an overview of land-use transitions between 31.12.1989 and 31.12.2010. Largest decrease in area has occurred among croplands, most of which have turned into grasslands due to ending of active management. Forest land areas have increased 1.8% during the last 21 years. This change is mostly a result of reallocation of grassland areas into forest land category, when the tree crown cover of grasslands exceeds 30% due to natural succession, the land is accounted as forest land.

Table 7.4. The land-use change matrix for IPCC land-use categories from 31.12.1989 to 31.12.2010 (1 000 ha)

	Initial						
Final	**Forest land**	**Cropland**	**Grass-land**	**Wetlands**	**Settle-ments**	**Other land**	**Final area**
Forest land	2 192.2	16.5	24.3	4.0	2.9	13.6	2 253.5
Cropland	0	1 067.6	10.7	0	0	0	1 078.3
Grassland	5.3	32.4	301.9	2.0	2.8	2.0	346.3
Wetlands	2.7	0	0	493.6	0	2.8	499.1
Settlements	9.6	5.1	2.2	0	283.3	0.5	300.7
Other land	3.1	1.0	0	0	0	40.7	44.8
Initial area	2 212.8	1 122.6	339.1	499.6	289.0	59.6	4 522.7
NET change	20.6	-54.9	37.2	-6.0	5.7	-18.9	
Change %	1.8	-3.9	2.1	-0.1	4.0	-24.8	

Implementation of IPCC land-use categories in the Estonian inventory is described below.

7.1.2.1. Forest land and definitions

Paragraph 1 of the definitions, modalities, rules and guidelines relating to land use, land-use change and forestry activities under the Kyoto Protocol, as contained in the Annex to decision 16/CMP.1 defines ‘forest’ as a minimum area of land of 0.05–1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10–30 per cent with trees with the potential to reach a minimum height of 2–5 meters at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high portion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10–30 per cent or tree height of 2–5 meters are also included as forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting, or natural causes (fires etc) but which are expected to revert to forest.

The definition of forest established by FAO (FRA 2005) is ‘land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use’.

Estonian Forest Act and the consequent definition of forest has been amended several times during the last 20 years. Since 2009 it stipulates forest land as land which meets at least one of the following requirements:

i) forest land use is included in land cadastre;

ii) has an area of 0.1 hectares of land, growing woody plants with a minimum height of 1.3 meters and the tree crown cover at least 30 percent.

However, it is practically very difficult to follow the requirement of forest use in cadastre in statistics for the whole country. It should be noted that approximately 13%

of forest land has not yet been entered in the cadastre. It also does not exist any international definition of forest based on registering forest land in the cadastre.

In addition, as the criterion of 1.3 m has caused some confusion in earlier reports, it should be noted that it is not 'the minimum tree height' in context of forest land definition. Actually, 1.3 m is criteria for counting unstocked forest area to stocked forest. The minimum tree height *in situ* by forest definition of the Forest Act is defined by tree species, stand's age and site index. Thus, there is not constant criteria for tree height in national definition.

For consistent statistical reasons, NFI has complied in general with the definition of forest, which was sustained in 1999. According to that, forest land is 'a land spanning 0.1 ha or more with tree crown cover (equivalent stocking level) of 30% or more with trees with the potential to reach a minimum height depending on the function of tree species, stand's age and site index. The latter criterion can be interpreted as 'stand productivity at least in Va yield class' (*id est* capability to produce as average of normal cutting cycle minimum 1 solid cubic metre per year per ha). Forest area includes temporary unstocked forest land (clear-cut areas, young regeneration areas, failed stands etc) that has enough potential to be a forest. It does not include land that is predominantly under agricultural or urban land use. According to the NFI definition of forest, estimates reported in national statistics and also in the UN/FAO Forest Resources Assessment (2005, 2010) procedure.

Starting from 2005, FRA 2005 forest criteria and OWL criteria were used in parallel with the national forest definition in the framework of the NFI. The aim was to present more precise and internationally comparable assessments in the future. Despite the fact the NFI could publish nowadays statistics in accordance with the forest definition of FRA, appropriate assessments are not published until now in international reports. Compared to the national definition, area of forest land is about 2% higher according to the FRA forest definition.

Due to the differences between definitions and that given in the decision 16/CMP.1, Estonia has established the 'definition of forest in the context of the Kyoto Protocol' in 2006 with the main parameters of forest definition reported in Table 7.5.

Table 7.5. Parameters for forest definition

Minimum tree crown cover	30%
Minimum land area	0.5 ha
Minimum tree height	2 m

The minimum tree crown cover (equivalent stocking level) criterion corresponds to the national definition of forest.

Since the NFI has been recording information on the forests, which remain in their surface area per hectare between 0.1 and 0.5 (since 2001 – due to the fact that criterion of 0.5 ha has been a minimum forest area in one of the earlier redaction of the Forest Act), there is available information that can be used to exclude these areas from LULUCF statistics. The same information is used for estimating forest area according to the FRA definition.

As mentioned above, there is no strict definition of the criterion of minimum tree height in the national definition of forest. For estimating forest area according to the FRA definition, the criterion 5 m of minimum tree height is used. As there is no forest-tree species that could reach the height of 2 m and not 5 m in the age of maturity, the criterion and data same as for counting forests according to the FRA definition can be used.

The total forest land should be considered as managed land in Estonia.[115] All the forests are managed in one way or another – the whole forest land in Estonia is or has been covered with forest management plans. In addition, protected forests are covered with the protection scheme.

7.1.2.2. Cropland

According to the definition used by the NFI, cropland is 'arable land, area where annual and perennial crops are growing (incl. fallow, orchards, short-term and long-term cultural grasslands and greenhouse areas)'. It does not include the built garden land size under 0.3 ha (that is included in Settlements).

Abandoned cropland is classified as cropland until it has not lost arable land features – changes in soil and vegetation have not taken place and the land is still usable as cropland without the implementation of specific treatments.

The national definition corresponds to the IPCC classification.

7.1.2.3. Grassland

According to the national definition, this category includes rangelands and pasture land that is not considered as cropland nor forest land: land with perennial grasses that is proper for mow and pasture, smaller fallows and former cultural grasslands that have lost arable land features, grassland from wild lands (– 'natural grassland'). Overgrown wooded pasture with canopy cover 30...50% is classified to grassland or forest, depending on the main land use purpose.

National land cover class 'bushes' (– area covered with natural or wildered cultivated bush and shrub species where canopy cover is over 50%) is defined as IPCC grassland[116].

7.1.2.4. Wetlands

Land permanently saturated by water and/or area's peat layer is at least 30 cm and minimum potential tree height does not accord to the Forest land term. It does include smaller bog holes.

The NFI wetland areas were defined as IPCC wetlands. In order to give a more detailed overview, peat extraction areas were excluded from wetland land-use category and reported separately in Table 7.3. The data used was taken from the NFI (for 1990–2010) and Land Balances (for 1970–1989).

[115] According to the ERT recommendation that Estonia provide supporting evidence to demonstrate that all forest land is managed.

[116] Area of bushes has been reported under 'Other lands' until the 2009 submission. It was recommended by the ERT to include areas of bushes to 'Grassland' category.

7.1.2.5. Settlements

The built-up areas, with roads, streets and squares, traffic and power lines, urban parks, industrial and manufacturing land, sports facilities, airports, legal waste down points, construction sites and buildings with up to 0.3 ha of garden yard, open cast areas (except peat extraction areas) were reported under settlement land use category (Table 7.3). The data on settlement areas were obtained from the NFI (for 1990–2010) and Land Balances (for 1970–1989).

7.1.2.6. Other land

Land areas that do not fall into any of the other five land-use categories. Consistent with the IPCC Guidelines, this land-use category is used to allow the total of identified land areas to match the national area.

7.1.3. National Forest Inventory

The estimation of emitted/removed quantities of carbon is carried out based on data received in the process of the NFI. Until the 1990s, the national estimation of forest resources was based on stand-wise forest inventories. Regular inventories, every 10 years, were carried out on most of the forest land: state forest districts as well as the forests of collective and state farms. After independence was regained in Estonia in 1991, the ownership reform program was started. Part of it was land reform. Land, which had been unlawfully expropriated, was to be returned to its initial owners or to their descendants. Borders of the state forests were restored accordingly to the year 1940, and the remaining land was left for privatisation. Changes were carried out in forest survey too. The planned economy, which had existed for 50 years, was replaced by a market economy resulting in intensive cutting of forests. As the land reform was not quick enough (and is still continuing today), a situation arose such that valid, current information was available only for one third of the Estonian forests. Intensified forest management together with the land reform created a need for new inventory methods.

The first National Forest Inventory covering the whole country commenced in 1999. With rather modest means the NFI is able to give a quite precise assessment of forest area, resources and cutting volume. The main objective of the NFI is to give a description of forests, but nowadays the NFI also gives information about subjects such as the distribution of land by land-use classes and the afforestation and growing stock of non-forest land etc.

Methodologically, the NFI is designed as an annual research effort, which using optimal methods, must ensure continuous updating of information and the forest database. A network of sample plots, covering the whole country, has been planned for five years with 20% or approximately 275 clusters (ca 4300 sample plots) measured each year, so that permanent plots will be re-measured every 5 years. Point estimates of parameters are calculated using data from the sample plots and form the basis for inferences to the entire population.

By 2001 the NFI assessments were used at the state level, as well as in compiling the strategic document "The Development Plan of Forestry until the Year 2010". Since that period the NFI has an important role in decision making on effective management of forests and future projections – in large-area forest management planning such as planning of cutting at the national level. At present, the actual themes of the NFI monitoring system include global carbon cycles and observation of features related to the protection of biological diversity.

The Estonian NFI covers all land use classes, including all forests and other wooded lands in all ownership groups, including protected areas. Assessments of the forest resource by the NFI have become the basis for national and international statistics in Estonia, such as the United Nations/FAO Forest Resources Assessment procedure, the Ministerial Conference on the Protection of Forests in Europe (MCPFE). The NFI also produces information on forest carbon pools and changes for the LULUCF reports of the United Nations Framework Convention on Climate Change.

The statistical design for the Estonian NFI is a systematic sample without pre-stratification. No remote sensing is applied. The network of sample plots covers the whole country and is planned as a five-year cycle. The sampling grid is designed to meet the accuracy requirements at national level. The sampling intensity is the same throughout the whole country. The sample (cluster) distribution is based on a national 5-km x 5-km quadrangle grid, determined by the L-EST co-ordinates system. Sample plots are organized into clusters to increase the efficiency of the survey. An observation unit is an individual field plot that is the centre of sample circles with defined radii. The method of sampling with partial replacement is used. Plots are divided into permanent clusters and temporary clusters that form 800 x 800 metre squares. All the permanent clusters (sample plots) are re-measured every 5 years. The sample plot radius depends on the assessed variables, as well as their values, for example, tree diameter. In addition to plots with the main radii of 10 m and 7 m, where land-use class is determined, plots of other radii are also used.

All population units have equal probability of selection into the sample. The result is point estimates of multiple population parameters based on the measurement data. Although all NFI estimates are based on sampling, they are not absolute. Therefore, each estimate of a general parameter is always accompanied with a sampling error.

More detailed information about sampling scheme, design and density of sampling is described in National Forest Inventories[117] (2010).

In order to collect data about land-use transitions, additional field studies started in 2009 in the framework of the NFI. This method follows the example of Finnish NFI. The fieldwork is ongoing (until 2014 or as long as needed). Collected data provides information on different land use classes (origins retrospectively 20 years), the year of changes and also soil type. During land category registration, "LULUCF former land category" is registered on every sample plot if land category has changed after base point (31.12.1989). Also the year of change is being estimated. All these observations are made directly in the field. In case of doubt, older maps and aerial photographs are used as supporting material to determine more accurately land use changes in time. Resulting data set is a matrix with the previous and the current land use classes in the timeline. During field study soil types (mineral/organic) are also estimated. All sample plots are assessed with soil type ‚mineral' or ‚organic'. In case the former land category type differs from current one, soil type is estimated by the former land category.

During field study following land categories (and subcategories) are registered by the NFI:

[117] pp.177-183; http://www.springer.com/life+sciences/forestry/book/978-90-481-3232-4.

M – forest (stocked forest land)
MM – unstocked forest land
MV – forest land (by GFRA 2005 definition)
OW – other wooded land (GFRA 2005 definition)
P – bushes
PM – arable land (excluding PK, PR)
PK – permanent crops
PR – long-term cultural grassland
RM – natural grassland
S – swamp, bog
SV – inland water bodies
A – settlements (excl. T, TR)
K – opencast pit (excl. KT)
KT – peat quarry
T – roads and railways
TR – lines, power lines etc.
KK – unusable mineral land
Y – other land

7.1.4. Key Categories

The key categories in LULUCF sector in 2010 are summarised in Table 7.6. The largest effect within the LULUCF sector on the overall inventory was attributed by Forest Land remaining Forest Land. LULUCF sector contributes 14.6% of the total inventory emissions in absolute values.

Table 7.6. Key categories in LULUCF sector (CRF 5) in 2010 (quantitative approach used, Tier 2)

IPCC source category	Gas	Identification criteria
5.A.1 Forest Land remaining Forest Land – living biomass	CO_2	Level (1990, 2010), Trend
5.A.1 Forest Land remaining Forest Land – net carbon stock change in organic soils	CO_2	Level (1990, 2010), Trend
5.A.1 Forest Land remaining Forest Land – deadwood	CO_2	Level (2010), Trend
5.A.2.1 Cropland converted to Forest Land – net carbon stock change in living biomass	CO_2	Level (2010), Trend
5.A.2.2 Grassland converted to Forest Land – net carbon stock change in living biomass	CO_2	Level (2010), Trend
5.A.2.4 Settlements converted to Forest Land – net carbon stock change in living biomass	CO_2	Trend
5.A.2.5 Other Land converted to Forest Land – net carbon stock in living biomass	CO_2	Level (2010), Trend
5.C.1 Grassland remaining Grassland – living biomass	CO_2	Trend
5.C.2 Land converted to Grassland – net carbon stock change in living biomass	CO_2	Level (2010), Trend
5.E.2.1 Forest Land converted to Settlements – living biomass	CO_2	Level (2010), Trend

7.2. Forest Land (CRF 5.A)

7.2.1. Source category description

Since 1970, forest area has been increasing in Estonia, mostly due to abandonment of grasslands and overgrowing of wetlands (Figure 7.5).

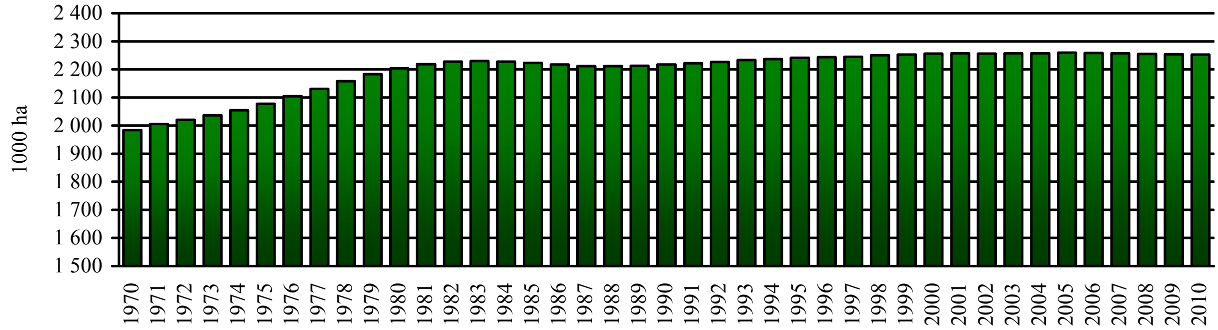

Figure 7.5. Forest land area in Estonia in 1970–2010, 1000 ha

Forest Land category constitutes over 90% of all LULUCF sector emissions/removals. The net removal from forest land was 4 013 Gg CO_2 eq. in 2010 (Figure 7.6). 2000−2003 the Forest Land category acted as a net source of CO_2 mainly due to extremely intensive harvesting. Estimations in Figure 7.6 include emissions and removals from living biomass, organic soils, dead wood and biomass burning pools.

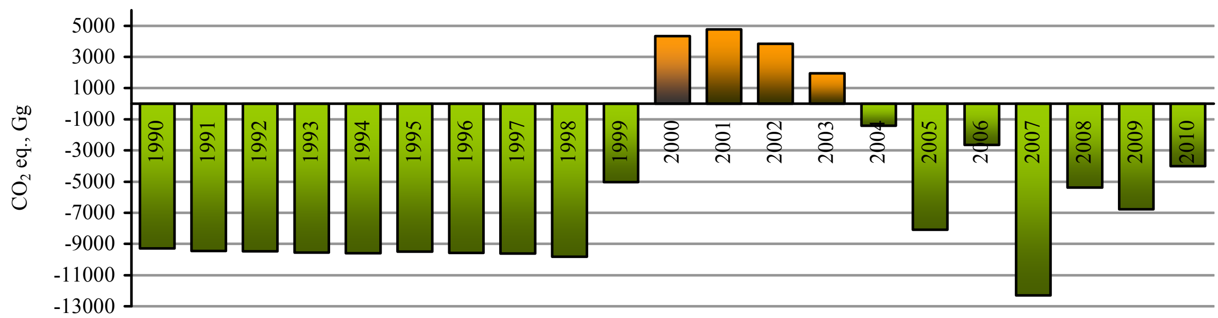

Figure 7.6. Annual net change in CO_2 removals (-)/emissions (+) from Forest Land category in 1990–2010, Gg CO_2 eq.

7.2.2. Methodological issues

Carbon stock change in category 5.A.1 Forest Land remaining Forest Land is given by the sum of changes in living biomass, dead organic matter and soils. The algorithm employed in order to estimate carbon flows related to 'Forest Land remaining Forest Land' is presented below:

Equation 7.1.[118]

$$\Delta C_{FF} = (\Delta C_{FF_{LB}} + \Delta C_{FF_{DOM}} + \Delta C_{FF_{Soils}})$$

Where:

ΔC_{FF} – annual change in carbon stocks from forest land remaining forest land, tC yr^{-1};
$\Delta C_{FF\ LB}$ – annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land remaining forest land, tC yr^{-1};
$\Delta C_{FF\ DOM}$ – annual change in carbon stocks in dead organic matter (includes dead wood and litter) in forest land remaining forest land, tC yr^{-1};
$\Delta C_{FF\ Soils}$ – annual change in carbon stocks in soils in forest land remaining forest land; tC yr^{-1}.

Equation 7.1 is also used for calculations in Land converted to Forest Land subsection.

7.2.2.1. Change in carbon stocks in living biomass

For estimating carbon stock changes in biomass under land remaining Forest Land category, *Tier 2* approach and *Method 2* – the stock change method (Equation 7.2) was used. NFI provides activity data of growing stock (biomass carbon stock) for the whole forest area for every single year. Biomass change is the difference between the biomass at year t_2 and year t_1.

It should be noted, that stock change method comprises also carbon loss from biomass burning, thus CO_2 emissions from burning are not presented separately, but included in general carbon stock change figures. However, CH_4 and N_2O emissions from biomass burning on forest areas have been estimated using Equation 7.11 (Chapter 7.8 Non-CO2 emissions from biomass burning (CRF 5 (V)).

Equation 7.2[119]

$$\Delta C_{FF_{LB}} = (C_{t_2} - C_{t_1})/(t_2 - t_1)$$

and

$$C = [V \bullet D \bullet BEF_2] \bullet (1 + R) \bullet CF$$

Where:

$\Delta C_{FF\ LB}$ – annual change in carbon stocks in living biomass (includes above- and belowground biomass), tonnes C yr^{-1};
C_{t2} – total carbon in biomass calculated at time t_2, tonnes C;
C_{t1} – total carbon in biomass calculated at time t_1, tonnes C;
V – merchantable volume, m^3 ha^{-1};
D – basic wood density, tonnes d.m. m^{-3} merchantable volume (Table 7.9);
BEF_2 – biomass expansion factor for conversion of volume to aboveground tree biomass, dimensionless (Table 7.7);
R – root-to-shoot ratio, dimensionless (Table 7.8);
CF – carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)$^{-1}$.

[118] GPG-LULUCF 2003, Equation 3.2.1., p 3.23.
[119] GPG-LULUCF 2003, Equation 3.2.3., p 3.24.

Equation 7.2 is also used for calculations of carbon stock changes in living biomass under land converted to Forest Land subsection with the exception that upper limit of BEF_2[120], average R[121] and average D[122] values are used (Table 7.7, Table 7.8, Table 7.9).

According to GPG-LULUCF 2003 and IPCC 2006 Vol. 4, Estonia is in between Boreal and Cold temperate climatic zone, however most recent reports (e.g. State of Europe's Forests, 2011) and the statement by national biologists is that Estonian forest vegetation is typical to boreal forests, thus input values from Boreal zone is selected for Forest Land category. Notice, that all other land use categories follow the default allocation by IPCC 2003.

Table 7.7. Default values of BEF_2[123]

	Land remaining Forest Land	Land converted to Forest Land
Forest type	BEF_2	upper limit BEF_2
Conifer	1.35	2.5
Broadleaf	1.30	

Table 7.8. Default values of root-to-shoot ratio R[124]

	Land remaining Forest Land		Land converted to Forest Land	
Forest type	Above-ground biomass, t/ha	Root-shoot ratio R	Above-ground biomass, t/ha	Root-shoot ratio average R
Conifer forest/plantation	50-150	0.32	< 50	0.44
Other broadleaf forest	75-150	0.26	< 75	

Table 7.9. Wood density of main tree species in Estonia, tonnes d.m. m^{-3} [125]

Tree species	Wood density
Pine	0.43[126]
Spruce	0.39[127]
Birch	0.51
Aspen	0.35
Common alder	0.45
Grey alder	0.45
Other	0.45
Average	0.44

[120] The upper BEF_2 value of 2.5 from the range 1.15-4.2 was chosen based on expert opinion (EEIC), since the upper limit of the range represents young forests.
[121] Average R value consists of the R values of tree species most common to Estonian forests (Table 7.9).
[122] Average D value consists of the D values of tree species most common to Estonian forests (Table 7.9).
[123] GPG-LULUCF 2003, Table 3A.1.10., p. 3.178.
[124] GPG-LULUCF 2003, Table 3A.1.8., p. 3.168.
[125] GPG-LULUCF 2003, Table 3A.1.9-1., p.3.171.
[126] B. Esping, Torkhandboken, 1977.
[127] B. Esping, Torkhandboken, 1977.

7.2.2.2. Annual change in carbon stock due to biomass changes in forest land

The forest area has increased 36 200 hectares by 2010 in comparison to the base year. The changes in forest area by main tree species are presented in Figure 7.7. As seen in Figure 7.7, approximately 50% of forest area is covered by conifers. The main parameters of Estonian forest in 2010 are presented in Table 7.10.

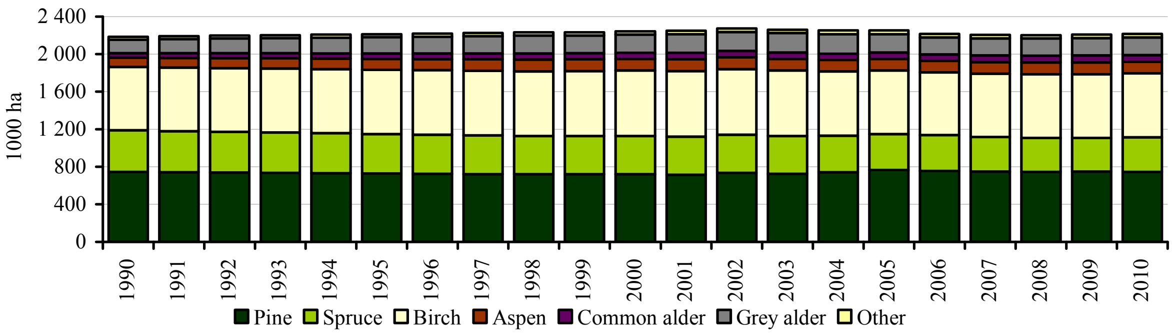

Figure 7.7. Forest area in Estonia in 1990–2010 by main tree species, 1000 ha

Table 7.10. General characteristics of Estonian forest area in 2010[128]

Main tree species	Area, 1000 ha	Relative error ± %	Growing stock, 1000 m^3	Relative error ± %	Increment, 1000 m^3 yr^{-1}
Pine	743.8	3.0	173 773	3.3	3 590
Spruce	369.5	4.4	80 693	5.0	2 758
Birch	680.7	3.1	120 546	3.6	3 203
Aspen	123.5	7.9	29 807	9.4	746
Common alder	70.6	10.6	16 273	11.8	342
Grey alder	186.6	6.4	30 914	7.2	1 351
Others	37.3	14.6	6 442	18.0	186
Total[129]	2 212.0	1.3	458 448	1.5	12 175

Data presented in Figure 7.8 characterizes carbon stock change in living biomass in land remaining Forest Land and land converted to Forest Land subcategories in 1990−2010. The estimation for 1990−1998 is based on interpolated data, since no exhaustive forest statistics were carried out during these years. National Forest Inventory that covers the whole country started at 1999. It should be also noted, that in Figure 7.8 the change in carbon stock, ie the difference in biomass between two subsequent years is presented. Even though the CSC of forest living biomass seems to be widely fluctuative, values shown in Figure 7.8 constitute only up to 2% from the total forest living biomass carbon stock.

From 1999 to 2003, the rate of harvesting volume was about twice as high than usual due to the economic boom in Estonia (see Table 7.11). In 2002 and especially in

[128] Eesti Metsad 2010, Adermann, V. (Forest statistics by NFI, 2012).
[129] The estimation is based on the national forest land definition, which is slightly different from the Kyoto definition, therefore the total area of forest land in current table differs 1.8% from the estimation shown in the land-use change matrix in Table 7.4.

2006, extensive forestfires spread, affecting also the emission estimates for these years.

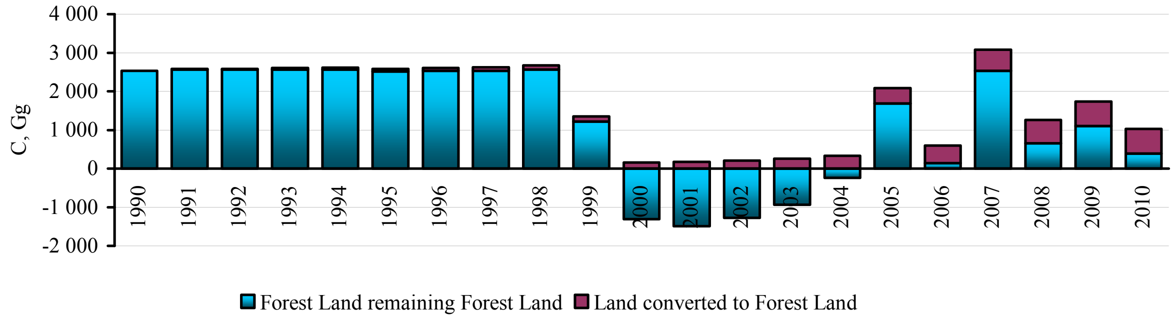

Figure 7.8. Carbon stock change in forest living biomass in Estonia in 1990–2010, Gg C

Data about forest fellings is estimated by NFI since 1999 (data starting point at 1998). SE collects forest harvesting data based on loggings planned (so called 'forest notices'). As the latter method underestimates cuttings during the 1990s, the data provided by SE for 1990 to 1997 are adjusted using the differences approach between the statistics of SE and the NFI. Data about total fellings during the last 21 years is presented in Table 7.11 and illustrated in Figure 7.9.

Table 7.11. Area and volume of forest biomass stock[130] harvested in 1990–2010

	Total felling area, 1000 ha	Harvested volume, 1000 m^3
1990	50.6	2 881.0
1991	58.8	4 288.9
1992	47.7	2 980.9
1993	57.6	3 382.6
1994	64.0	5 036.9
1995	63.5	5 533.7
1996	58.1	6 130.2
1997	65.5	8 947.1
1998	78.3	9 717.3
1999	80.1	12 517.0
2000	70.9	12 745.9
2001	77.2	11 973.5
2002	76.8	11 524.5
2003	63.7	9 716.9
2004	57.6	6 857.8
2005	58.8	6 316.4
2006	53.2	5 197.5
2007	45.8	5 223.3
2008	48.7	5 897.9
2009	51.2	6 058.8
2010	59.7	6 598.6

[130] Stem volume, over bark, without stump and branches, NFI.

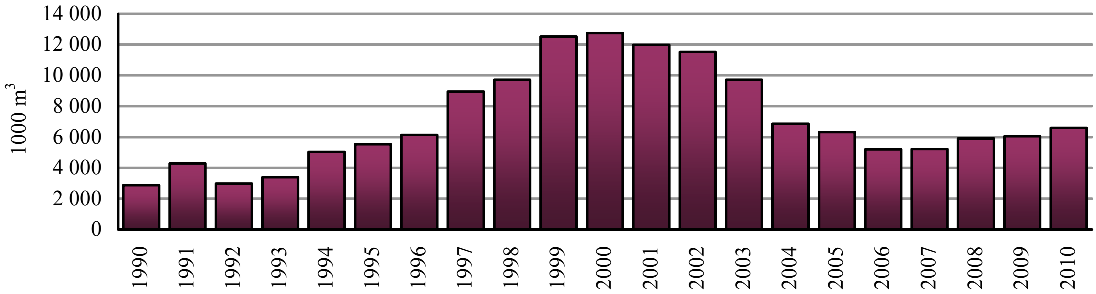

Figure 7.9. Harvested volume on forest land in Estonia in 1990–2010, 1000 m^3

7.2.2.3. CO_2 emissions/removals from/by dead wood

For estimating carbon stock changes in dead wood pool, *Tier 2* approach and the stock change method was used. NFI provides annually data about the volume of dead wood for the whole forest area (land remaining and transition to Forest Land). Dead wood stock change is the difference between biomass at year t_2 and year t_1 (Equation 7.3). Wood density of dead wood used to transform the volume of dead wood into tonnes of dry matter (B_t) is 0.266[131].

Equation 7.3[132]

$$\Delta C_{FF_{DW}} = \left[A \bullet \left(B_{t2} - B_{t1}\right)/T\right] \bullet CF$$

Where:

$\Delta C_{FF\ DW}$ – annual change in carbon stocks in dead wood in forest land remaining forest land, tonnes C yr^{-1};
A – area of managed forest land remaining forest land, ha;
B_{t1} – dead wood stock at t_1 for managed forets land remaining forest land, tonne d.m. ha^{-1};
B_{t2} – dead wood stock at t_2 (the previous time) for managed forets land remaining forest land, tonne d.m. ha^{-1};
$T=(t_2-t_1)$ – time period between time of the second stock estimate and the first stock estimate, yr;
CF – carbon fraction of dry matter (default = 0.5), tonnes C $(\text{tonne d.m.})^{-1}$.

Equation 7.3 is also used for calculations of dead wood stock change in land converted to Forest Land subsection.

7.2.2.4. CO_2 emissions/removals from/by litter

Estonia does not have sufficient data regarding litter to estimate related emissions correctly.

131 Journal of Forest Science, 56, 2010, (9) pp. 397-405. In the 2011 submission it was stated by mistake, that the value 0.266 is biomass expansion factor, instead it is dead wood density [t d.m./m^3].
132 GPG-LULUCF 2003, Equation 3.2.12., p 3.34.

7.2.2.5. CO_2 emissions/removals from/by mineral forest soils

Due to lack of more advanced methods, *Tier 1* approach was implemented with the assumption that carbon stock in mineral soil organic matter does not change, regardless of changes in forest management, types and disturbance regimes. This assumption is also supported by the latest publication by Uri et al.[133], that concluded the soil carbon pool remains stable irrespective of the stand age.

7.2.2.6. CO_2 emissions from drained organic forest soils

Tier 1 approach and Equation 7.4 was used for estimation of emissions from drained organic forest soils.

Equation 7.4[134]

$$\Delta C_{FF\ Organic} = A_{Drained} \bullet EF_{Drainage}$$

Where:

$\Delta C_{FF\ Organic}$ – CO_2 emissions from drained organic forest soils, tonnes C yr^{-1};
$A_{Drained}$ – area of drained organic forest soils, ha;
$EF_{Drainage}$ – emission factor for CO_2 from drained organic forest soils, tonnes C ha^{-1} yr^{-1} (Table 7.12).

Equation 7.4 is also used for calculations of organic forest soils emissions under land converted to Forest Land subsection.

Table 7.12. Default values for CO_2–C emission factor for drained organic soils in managed forests[135]

Biomes	Emission Factors (tonnes C ha^{-1} yr^{-1})	
	Value	Ranges
Boreal	0.16[136]	0.08–1.09

About 22% of all forest soils are organic soils, of which approximately 45% are drained according to NFI. Emissions from drained organic forest soils (Figure 7.10) have increased by 2% since 1990, that is also consistent with the increase in forest areas.

[133] Uri, V., Varik, M., Aosaar, J., Kanal, A., Kukumägi, M., Lõhmus, K. (2012). Biomass production and carbon sequestration in a fertile silver birch (*Betula pendula Roth*) forest chronosequence. Forest Ecology and Management, 267, pp. 117-126.
[134] GPG-LULUCF 2003, Equation 3.2.15, p. 3.42.
[135] GPG-LULUCF 2003, Table 3.2.3, p. 3.42.
[136] Despite ARR2010 and ARR 2011 recommendations, Estonia has not managed to develop country-specific EF values due to limited financial capacity for conducting necessary fieldwork and data analysis.

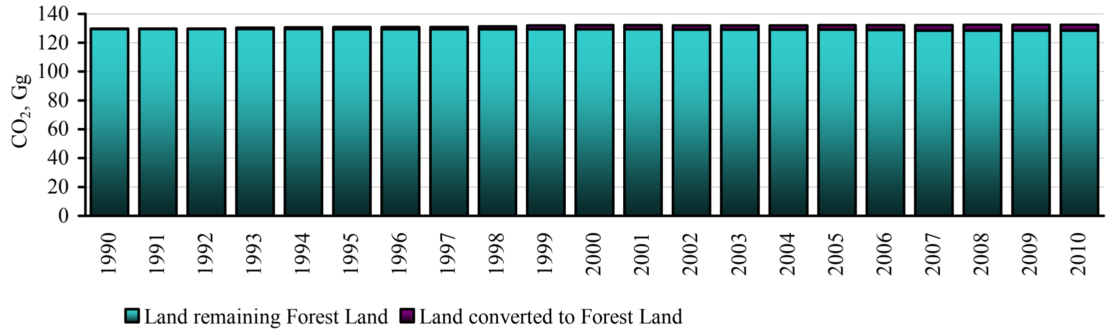

Figure 7.10. Emissions from drained organic forest soils in 1990–2010 in Estonia, Gg CO_2

7.2.3. Uncertainty and time-series consistency

CO_2 emissions/removals from forest biomass are estimated according to the LULUCF GPG (2003). Activity data is obtained from NFI, the emission factors used are from the LULUCF GPG (2003). Uncertainty rates of the activity data and the emission factors are presented in Table 7.13.

Table 7.13. Estimated values of uncertainties used in Forest Land (FL) category

IPCC Source Category	Uncertainties ± %		EF References
	Activity data[137]	Emission factors	
FL remaining FL – net carbon stock change in living biomass	2.26	46.95	LULUCF, 2003, p. 3.31
FL remaining FL – deadwood	2.60	30.07	LULUCF, 2003, p. 3.31, 5.17
FL remaining FL – net carbon stock change in organic soils	6.05	200.0	LULUCF 2003, Table 3.2.3, p. 3.42
CL converted to FL – deadwood	42.49	30.07	LULUCF 2003, p. 3.31, 5.17
CL converted to FL – net carbon stock change in living biomass	41.37	46.95	LULUCF 2003, p. 3.31
GL converted to FL – net carbon stock change in living biomass	44.71	46.95	LULUCF 2003, p. 3.31
GL converted to FL – net carbon stock change in organic soils	97.30	200.0	LULUCF 2003, Table 3.2.3, p. 3.42
GL converted to FL – deadwood	29.02	30.07	LULUCF, 2003, p. 3.31, 5.17
WL converted to FL – net carbon stock change in living biomass	86.34	46.95	LULUCF 2003, p. 3.31
WL converted to FL – net carbon stock change in organic soils	68.55	200.0	LULUCF 2003, Table 3.2.3, p. 3.42
WL converted to FL – deadwood	69.23	30.07	LULUCF 2003, p. 3.31, 5.17
SL converted to FL – net carbon stock change in living biomass	109.88	46.95	LULUCF, 2003, p. 3.31
SL converted to FL – net carbon stock change in organic soils	195.99	200.00	LULUCF 2003, Table 3.2.3, p. 3.42
SL converted to FL – deadwood	87.78	30.07	LULUCF 2003, p. 3.31, 5.17
OL converted to FL – deadwood	38.89	30.07	LULUCF 2003, p. 3.31, 5.17

[137] All activity data uncertainty estimates are obtained from NFI.

IPCC Source Category	Uncertainties ± %		EF References
	Activity data[137]	Emission factors	
OL converted to FL – net carbon stock change in living biomass	47.46	46.95	LULUCF 2003, p. 3.31

7.2.4. Source specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for LULUCF sector according to IPCC *Tier 1* method. The activities are carried out every year during the inventory. The QC check list is used during the inventory.

7.2.5. Source-specific recalculations

Entire time series of activity data is being annually recalculated for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated to overall activity data.

Emissions from organic soils have been recalculated, since formerly all organic forest soils were accounted as drained due to lack of more accurate data, in current submission specified data about the proportion of drained soils among total organic forest soil areas was obtained from NFI.

According to ERT (ARR2011) recommendations, in current submission methodology, applied parameters and emission estimates are provided separately for Forest Land remaining Forest Land and land converted to Forest Land subcategories.

In current submission more accurate root-to-shoot ratio (R), BEF values and combustion factors were used (Table 7.14).

Table 7.14. Parameters used in Forest Land category recalculations

<table>
<tr><th>Parameter</th><th>Source</th><th colspan="2">2011 Submission</th><th colspan="2">2012 Submission</th></tr>
<tr><td>R conifer
FL remaining FL</td><td>Table 3A.1.8, LULUCF GPG 2003, p. 3.168</td><td>Aboveground biomass >150 t/ha</td><td>0.23</td><td>Aboveground biomass 50−150 t/ha</td><td>0.32</td></tr>
<tr><td>R broadleaf
FL remaining FL</td><td>Table 3A.1.8, LULUCF GPG 2003, p. 3.168</td><td>Aboveground biomass >150 t/ha</td><td>0.24</td><td>Aboveground biomass 75−150 t/ha</td><td>0.26</td></tr>
<tr><td rowspan="2">BEF
Land converted to FL</td><td rowspan="2">Table 3A.1.10, LULUCF GPG 2003, p. 3.178</td><td>BEF_1
Boreal conifers</td><td>1.15</td><td rowspan="2">BEF_2
upper limit of the range for boreal young forests</td><td rowspan="2">2.5</td></tr>
<tr><td>BEF_1
Boreal broadleaf</td><td>1.1</td></tr>
<tr><td>Combustion factor[138]</td><td>Table 3A.1.12, LULUCF GPG 2003, p. 3.179</td><td>All Boreal forest</td><td>0.34</td><td>Boreal forest, surface fire</td><td>0.15</td></tr>
</table>

[138] Estimates regarding forest biomass burning are presented in Chapter 7. 8 Non-CO_2 emissions from biomass burning (CRF 5 (V))

During internal QA/QC, it was found that more accurate R and BEF values can be used for estimating changes in Forest Land biomass carbon stocks. Root-shoot ratio (used for living biomass estimates, implementing stock change method, GPG-LULUCF 2003, Equation 3.2.3, p. 3.24) is dependent on rough aboveground biomass estimation, which was overestimated in previous submissions.

In previous submissions increment, i.e BEF_1 values were used instead of BEF_2 due to misinterpretation, since the annual growth in forest biomass (absolute) volume was regarded as biomass increment, instead it is growing stock under land converted to Forest Land, therefore corresponding BEF_2 values were used in the 2012 submission. The higher value 2.5 from range 1.15-4.2 (Boreal climatic zone, Table 3.A.1.10, p. 3.178) for BEF_2 was chosen based on expert opinion (EEIC) as the upper value of the range represents young forests or forests with low growing stock, which is typical for forests that have been recently converted to forests from other land uses and also under afforestation/reforestation (AR).

Also see Table 10.1 and Table 10.4–Table 10.6.

7.2.6. Source-specific planned improvements

A number of improvements are required to be carried out in order to guarantee complete, transparent and accurate GHG inventory in the ‘Forest Land’ subsection: forest land (Forest land remaining Forest land and land converted to Forest Land) areas, areas of mineral and organic soils under forest land will be revised annually. Updated data derived from the NFI for land-use changes will be used.

Carbon stock changes in mineral soils and litter have not been estimated due to lack of activity data. However, Estonian Environment Information Centre has initialized a project aimed to conduct fieldwork in order to obtain data about litter and mineral soil organic carbon stocks. Preliminary estimates are expected to be obtained by 2014. In addition, two analysis, aimed to find solutions to omitted pools and improve the quality of inventory, have been made recently:

1. Analysis of LULUCF Greenhouse Gas Inventory based on IPCC Guidelines and Submission Reports from 10 countries, Müürisepp, T., 2011
2. Report prepared under Contract No 4-1.1/209 12.09.2011 funded by Estonian Forestry Development Plan up to 2020, Švilponis, S., 2011.

7.3. Cropland (CRF 5.B)

7.3.1. Source category description

Total net CO_2 emissions from croplands is presented in Figure 7.11. Cropland source category includes emissions from organic soils, liming and carbon stock changes in living biomass, the latter was estimated for the first time in current submission. Nitrous oxide emissions from cultivated soils are reported under Agriculture sector, Chapter 6. Interannual emission fluctuations in Cropland category are mainly caused by changes in living biomass and varying liming intensity in different years.

Net CO_2 emissions from cropland were 103.2 Gg and 142.1 Gg, respectively in 2010 and 1990. The change has been mainly the result of reduction of liming and decrease in orchards biomass.

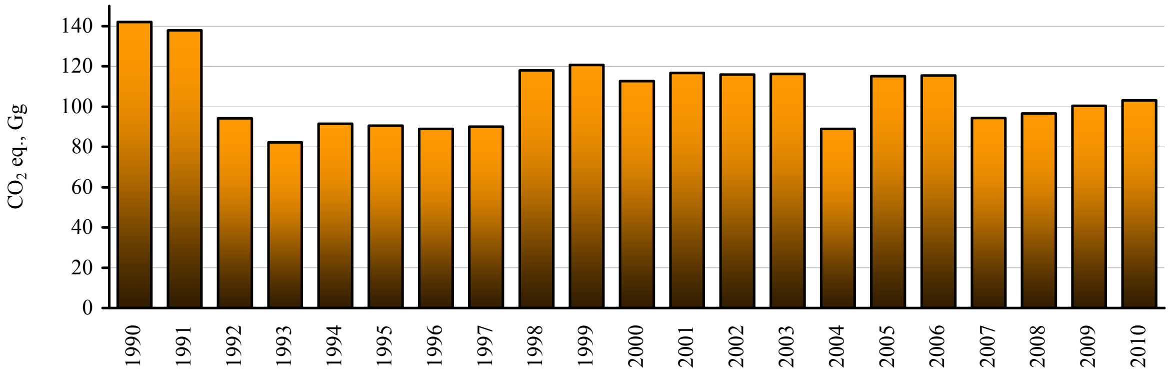

Figure 7.11. CO_2 emissions from Cropland category in 1990–2010, Gg CO_2 eq.

The area of Cropland (Figure 7.12) increased until the 1990s due to the propitious conditions in agricultural sector in Estonia. The biggest influence on the sector were the remarkable supports provided by early former Soviet Union, large market and raw material basis, also low market price for energy, which kept the agriculture artificially alive. After Estonia regained its independence in 1991, these beneficial conditions were abolished[139]. From 1991 until 2005, an overall downfall characterised Estonia's agriculture, caused by abandonment of arable lands due to reduced demand for local food products, caused by availability of cheap import goods as the result of opened markets and a significant rise in energy prices that decreased profits in the agricultural sector. As from 2005, the area of cropland has been increasing again due to increased investments and subsidiaries from the European Union to Estonian's agricultural sector, expansion of export opportunities and popularization of organic farming.

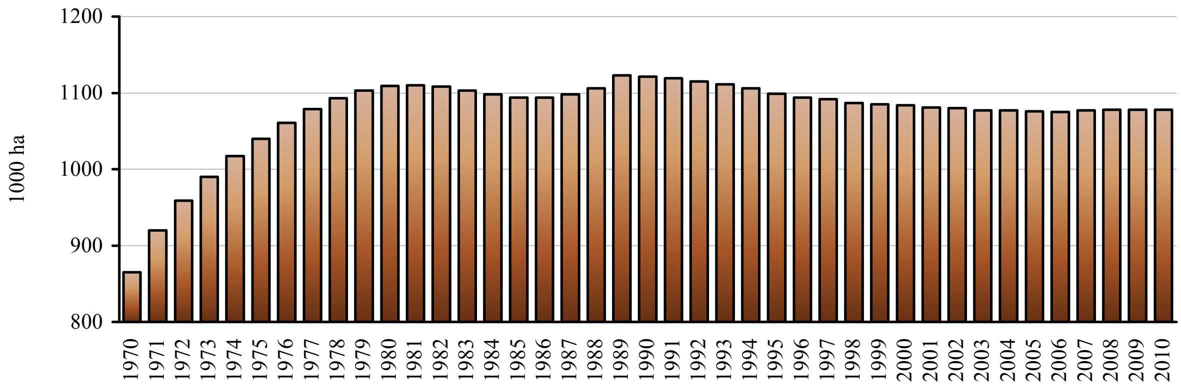

Figure 7.12. Cropland area in Estonia in 1970–2010, 1000 ha

Activity data used to estimate carbon fluxes related to cropland has been obtained from NFI (1990–2010) and SE (till 1990).

[139] Mäemets, M. (2006). An Outline of Agriculture in Estonia from the year 1990 until 2004, Bachelor's thesis, University of Tartu.

7.3.2. Methodological issues

7.3.2.1. Change in carbon stocks in living biomass

In 2012, Estonian Environment Information Centre launched a project in order to determine perennial woody crops biomass stock in croplands with the aim to provide data about orchards' growing stock, which can be used in cropland living biomass carbon stock estimations. Sample plots were randomly selected representing main market gardens and privately owned orchards in Estonia. Fieldwork included determining tree species, age, density per area and measuring individual tree components: tree height, diameter at different heights, height until beginning of the crown and crown length. Measured variables were used as input data in *Repola* [140] biomass function, that was implemented to estimate average above-, belowground and total biomass of orchards. The results are shown in Table 7.15.

Table 7.15. Average biomass stock on cropland orchards

	Living biomass stock, t d.m./ha
Total biomass	20.68
Aboveground	16.60
Belowground	4.07

Annual carbon stock change was calculated based on interannual area changes (Equation 7.5).

Equation 7.5

$$\Delta C_{CC_{LB}} = \left[B_{total} \bullet \left(A_{t2} - A_{t1}\right)\right] \bullet CF$$

Where:

$\Delta C_{CC\ LB}$ – annual change in cropland (CL remaining CL and land converted to CL) perennial woody crops carbon stock, tonnes C yr^{-1};
B_{total} – total average biomass stock of orchards, t d.m./ha (Table 7.15);
A_{t1} – orchards area in previous year, ha;
A_{t2} – orchards area in current year, ha;
CF – carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)$^{-1}$.

Activity data about area of orchards is obtained from Statistics Estonia. The area of orchards has declined constantly, from 9287 ha in 1990 to 4011 ha in 2010, thus the carbon stock in orchards has decreased as well as seen in Figure 7.13.

[140] Repola. J, Ojansuu, R. and Kukkola, M. (2007). Biomass functions for Scots pine, Norway spruce and birch in Finland, Working Papers of the Finnish Forest Research Institute, pp. 53

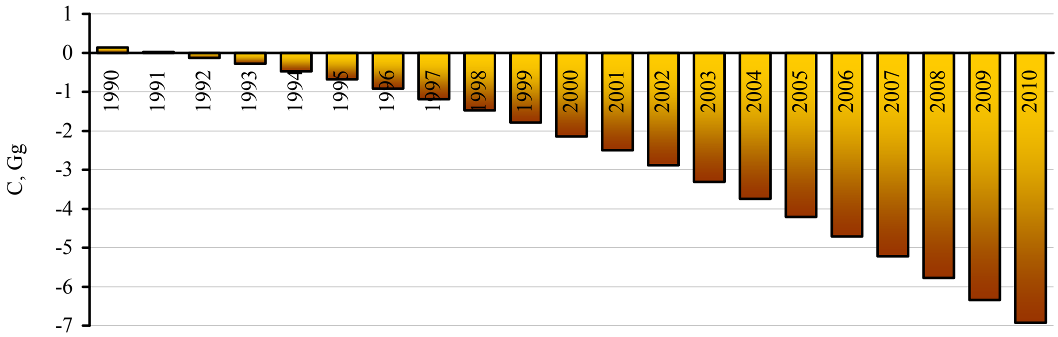

Figure 7.13. Annual change in cropland perennial woody crops (orchards) living biomass stock, Gg C

7.3.2.2. Mineral soils

Due to lack of data, carbon stock changes in mineral soils under Cropland category were not estimated in current submission.

7.3.2.3. Organic soils

The *Tier 1* method was applied in order to estimate CO_2 emissions from cultivated organic soils.

Equation 7.6[141]

$$\Delta C_{CCOrganic} = \sum_c (A \bullet EF)_c$$

Where:

$\Delta C_{CC\ Organic}$ – CO_2 emissions from cultivated organic soils in cropland remaining cropland, tonnes C yr^{-1};
A – land area of organic soils in climate type *c,* ha;
EF – emission factor for climate type *c* (Table 7.16), tonnes C ha^{-1} yr^{-1}.

The amount of carbon released is converted to CO_2 by multiplying with 44/12.

Equation 7.6 was also used for calculations of organic soil emissions in land converted to Cropland subsection.

Table 7.16. Annual emission factor (EF) for cultivated organic soils[142]

Climatic temperature regime	IPCC Guidelines default, tonnes C ha^{-1} yr^{-1}
Cold Temperate	1.0

Carbon emissions from cultivated organic soils are presented in Figure 7.14. Total net CO_2 emission from cropland organic soils was 77.1 Gg in 2010, this is 6.9% less

[141] GPG-LULUCF 2003, Equation 3.3.5, p. 3.79.
[142] GPG-LULUCF 2003, Table 3.3.5, p. 3.79.

compared to 1990. Decrease in emissions is the result of decline of the overall cropland area since 1990.

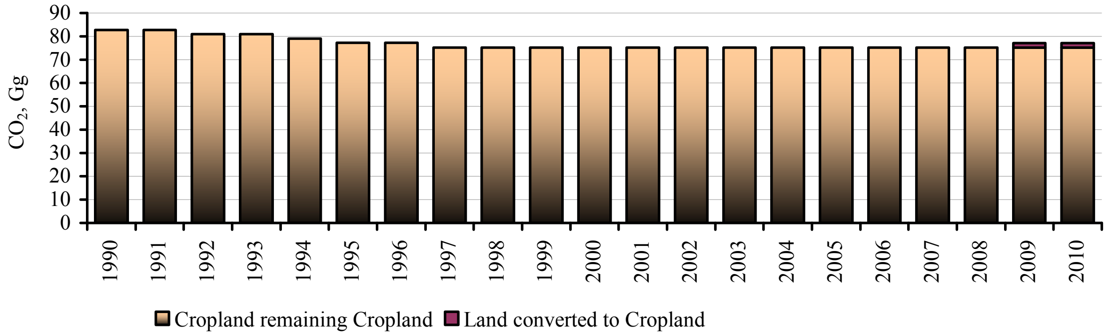

Figure 7.14. Carbon emissions from cultivated organic soils in 1990–2010, CO_2 Gg

7.3.2.4. CO_2 emissions from liming (CRF 5(IV))

The IPCC Guidelines include application of carbonate containing lime e.g. calcic limestone $CaCO_3$, or dolomite $CaMg(CO_3)_2$ to agricultural soils as a source of CO_2 emissions.

In Estonia, annual precipitation exceeds evapotranspiration, causing calcium and magnesium carbonates to leach out from the surface levels of soil by percolating water. As a result of the leaching carbonates, soil becomes deprived of calcium and magnesium. Over 22% of arable land soils in Estonia are calcium-deficient and acidificated. To eliminate calcium-deficiency in field soils, the quick-acting fine dusty limes are mainly used[143].

Tier 1 method (Equation 7.7) was used to estimate CO_2 emissions from liming of croplands. Activity data on agricultural land areas on which lime was applied to was obtained from Estonian Ministry of Agriculture. Data about liming is not implicit, since it is based on applied agricultural subsidies only and liming performed by landowner's own expence is left out from the statistics. However, the scope of liming carried out by landowner's own expence is considered to be marginal according to Estonian Ministry of Agriculture. Data about the average quantity of lime applied per one hectare (5 t/ha) was taken from a report published by Estonian Research Institute of Agriculture[144].

Equation 7.7[145]

$$\Delta C_{CC_{Lime}} = M_{Limestone} \bullet EF_{Limestone} + M_{Dolomite} \bullet EF_{Dolomite}$$

Where:

$\Delta C_{CC\ Lime}$ – annual C emissions from agricultural lime application, tonnes C yr^{-1};
M – annual amount of calcic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$), tonnes yr^{-1};

[143] Loide, V. (2010). Relieving the calcium deficiency of field soils by means of liming, Agronomy Research 8 (Special Issue II), pp. 415–420.
[144] Järvan, M. (2005). Põldude lupjamine, Eesti Maaviljeluse Instituut, Saku.
[145] GPG-LULUCF 2003, Equation 3.3.6., p. 3.80.

EF – emission factor, tonnes C (tonne limestone or dolomite)$^{-1}$; these are equivalent to carbonate carbon contents of the materials (12% for $CaCO_3$, 12.2% for $CaMg(CO_3)_2$).

Area of lime applied to has fluctuated widely over the years (Table 7.17). In 2004 and 2007 no liming occurred according to the Estonian Ministry of Agriculture.

Table 7.17. Lime application on agricultural lands in 1990-2010, ha

	Liming area, ha
1990	27 200
1991	25 080
1992	5840
1993	150
1994	4 840
1995	4 960
1996	3 780
1997	4 830
1998	16 965
1999	17 716
2000	13 473
2001	14 720
2002	13 731
2003	13 120
2004	0
2005	11 168
2006	10 440
2007	0
2008	100
2009	85
2010	330

Emissions from liming of croplands is illustrated in Figure 7.15. According to data obtained from the Ministry of Agriculture, no liming occurred in 2004 and 2007. Also, lime applied to croplands could not be separated into limestone and dolomite due to combined activity, thus the total emission from liming is reported.

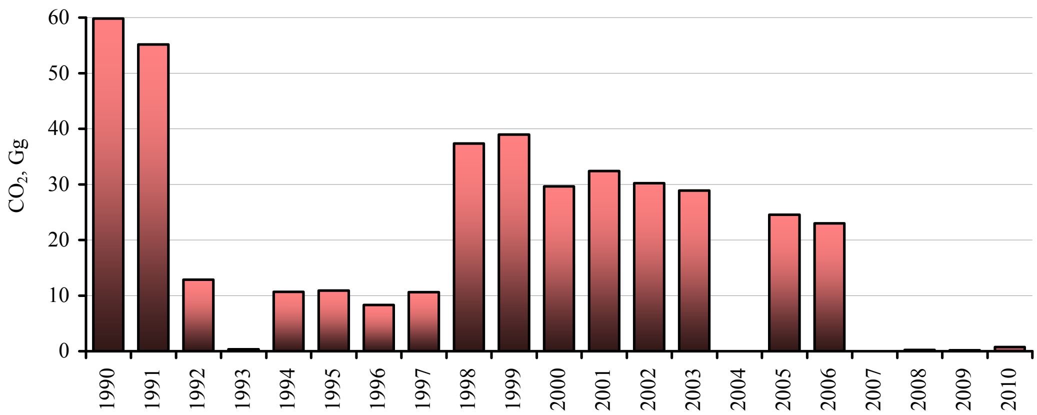

Figure 7.15. CO_2 emission from lime application on agricultural lands in 1990–2010, Gg CO_2

7.3.3. Uncertainty and time series consistency

CO_2 emissions from cropland living biomass, organic soils and liming are estimated according to the LULUCF GPG (2003). Activity data was obtained from Estonian NFI, national statistics and Ministry of Agriculture, emission factors were employed from the LULUCF GPG (2003). The uncertainty rates of activity data and the emission factors used are reported in Table 7.18.

Table 7.18. Estimated values of uncertainties in Cropland category

IPCC Source Category	Uncertainties ± %		EF References
	Activity data[146]	Emission factors	
Cropland – net carbon stock change in living biomass	32.42[147]		NFI, SE, Repola (2007)
Cropland remaining Cropland – net carbon stock change in organic soils	31.17	90.0	LULUCF 2003, Table 3.3.5, p. 3.79
Grassland converted to Cropland – net carbon stock change in organic soils	195.99	90.0	LULUCF 2003, Table 3.4.6, p. 3.118
Liming	29.15	NA	LULUCF 2003, p. 3.115

7.3.4. Source specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level is presented in Section 1.6.1.

The QC/QA plan for the LULUCF sector includes the QC activities described in the IPCC GPG. The activities are carried out every year during the inventory and the QC check list is used during the inventory.

Activity data are checked annually for updating. Emission factors are compared with IPCC default and with emission factors of other countries.

7.3.5. Source-specific recalculations

Entire time series of activity data is being annually recalculated for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated to overall activity data.

Carbon stock changes in Cropland living biomass was estimated for the first time in current submission.

Amount of lime applied to cropland has been recalculated due to an error made in previous submission during conversion of units.

Also see Table 10.1 and Table 10.4–Table 10.6.

[146] All activity data uncertainty estimates are obtained from NFI.
[147] Due to methodology used, a combined (activity data+ emission factors) uncertainty estimation is given

7.3.6. Source-specific planned improvements

Several improvements should be made in order to guarantee accurate and complete inventory in the future. Carbon stock changes in mineral soils were not estimated. Estonian Environment Information Centre has launched a project aimed to get country-specific data regarding croplands organic and mineral soil carbon stocks. Preliminary results are expected to be obtained by 2014.

7.4. Grassland (CRF 5.C)

7.4.1. Source category description

The spatial share of Grassland category is 7.7% of overall Estonian area, ranking grasslands to the fourth largest land-use category after Wetlands. By 2010, the area of grasslands had decreased 55% compared to 1970s (Figure 7.16) for two reasons: i) due to the abandonment of grazing lands (smaller units), and ii) development of the agricultural sector and cultivation of grasslands. Afforestation of grassland occurred at the same time, however, having a smaller impact on the area change.

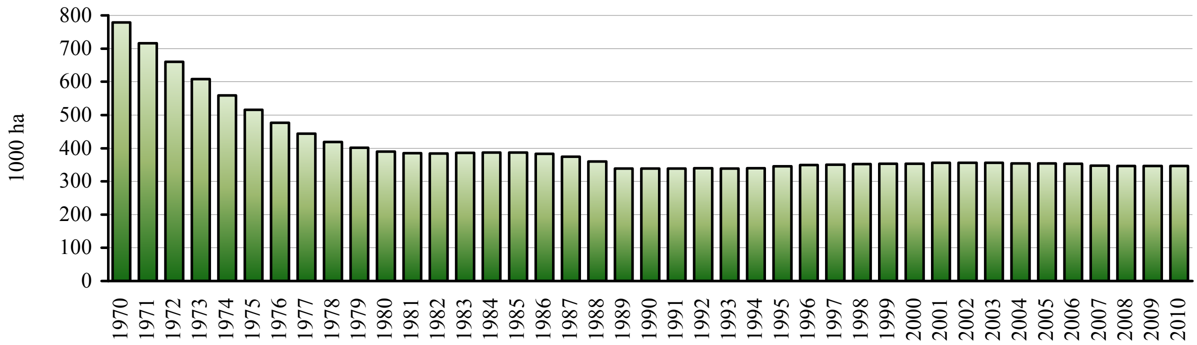

Figure 7.16. Grassland area in Estonia in 1970–2010, 1000 ha (SE, NFI)

Grassland category includes GHG emissions and removals from living biomass, organic soils and dead wood pools and emissions from biomass burning. In addition to abovementioned pools, emissions from mineral soil and litter pools have been estimated under Forest Land conversion to Grassland for the first time in current submission.

Grasslands have been a net sink of GHG-s throughout the accounting period (Figure 7.17).

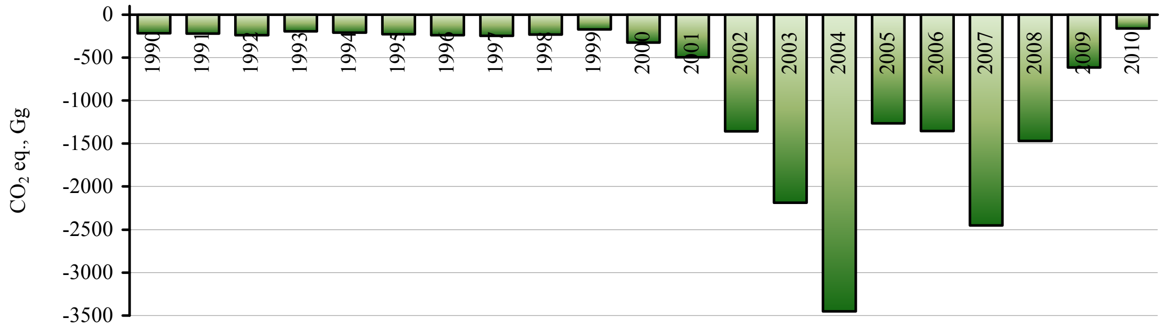

Figure 7.17. Annual net change of CO_2 removals from Grassland category in 1990−2010, Gg CO_2 eq.

7.4.2. Methodological issues

Carbon stock change in category 5.C Grassland remaining Grassland and land converted to Grassland is given by the sum of changes in living biomass, dead organic matter and soils (Equation 7.1).

7.4.2.1. Change in carbon stocks in living biomass

For estimating carbon stock changes in living biomass, *Tier 2* approach and *Method 2* – the stock change method was used. NFI provides annually updated data about the area and volume of growing stock of grasslands. Biomass change is the difference between the biomass at year t_2 and year t_1 (see Equation 7.2). Input parameters used for the calculations are presented in Table 7.9, Table 7.19 and Table 7.20.

Table 7.19. BEF_2 values used in Grassland category calculations

	Land remaining Grassland/ Land converted to Grassland
	BEF_2[148]
Conifers	2.5
Broadleaf	2.5

Table 7.20. Default values of root-to-shoot ratio R[149]

	Land remaining Grassland		Land converted to Grassland	
Forest type	Above-ground biomass, t/ha	Root-shoot ratio R	Above-ground biomass, t/ha	Root-shoot ratio average R
Conifer forest/plantation	< 50	0.46	< 50	0.44[150]
Other broadleaf forest	< 75	0.43	< 75	

[148] GPG-LULUCF 2003, Table 3A.1.10., p. 3.178, since there is low growing stock on grasslands, the upper BEF_2 value of 2.5 from the range 1.15-4.2 was used both for land remaining GL and land converted to GL based on expert opinion (EEIC).
[149] GPG-LULUCF 2003, Table 3A.1.8., p. 3.168.

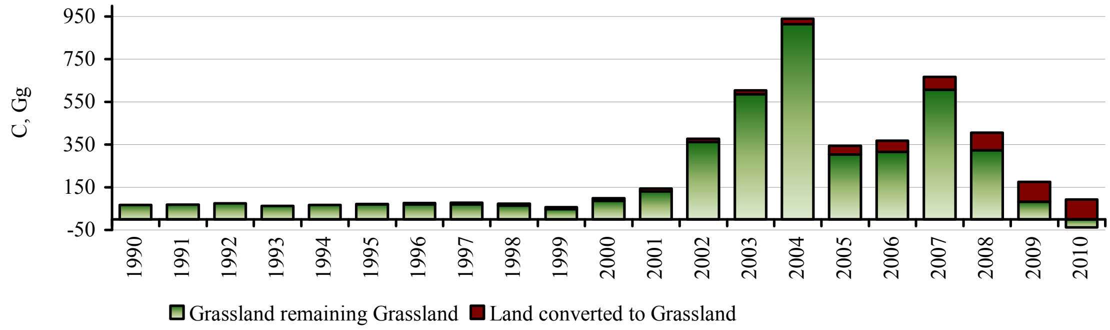

Figure 7.18 Carbon stock change in Grassland living biomass in 1990–2010, Gg C

Figure 7.18 illustrates annual change in living biomass carbon pool in Grassland remaining Grassland and land converted to Grassland subcategories. The area of land converted to Grasslands has increased steadily, thus the living biomass pool has enlarged in years as well. Sharp decline in the biomass of grasslands occurs in 2004/2005, when 2244 ha of grasslands shifted to forest land-use category, since grasslands were no longer actively managed and the tree crown cover exceeded 30%. Stock change method used for living biomass CSC calculations comprises also carbon loss from biomass burning. In 2002, 2006 and 2008 large-scale grassland fires spread in Estonia, having also impact on the overall grassland emission estimates. CH_4 and N_2O emissions from biomass burning on grassland areas are described in Chapter 7.8.

7.4.2.2. CO_2 emissions/removals from/by dead wood

For estimating carbon stock changes in dead wood, *Tier 2* approach was used. NFI estimates annually the volume of dead wood for the whole grassland area, data is provided for land remaining and land converted to Grassland subcategories. Dead wood stock change is the difference between biomass at year t_2 and year t_1 (Equation 7.3). Wood density of dead wood used to transform the volume of dead wood into tonnes of dry matter (B_t) is 0.266[151].

[150] Since the exact composition of tree species is not determined on land converted to Grassland, the average value of R and wood density (Table 7.9) was used for estimating living biomass emissions.
[151] Journal of Forest Science, 56, 2010, (9) pp. 397-405.

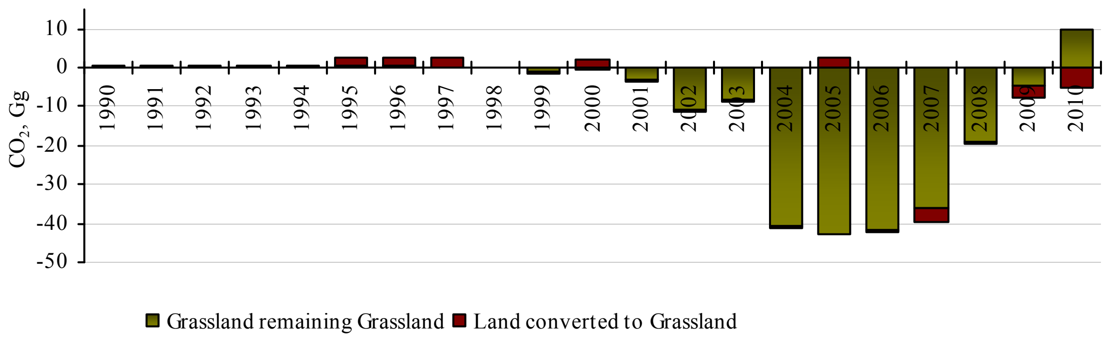

Figure 7.19. Annual change in net CO_2 removal (-)/emission (+) from Grassland dead wood pool[152] in 1990-2010

Figure 7.19 illustrates the uptake and emissions of CO_2 by dead wood pool in Grassland remaining Grassland and land converted to Grassland subcategories. The volume of dead wood has increased constantly until 2009, in 2010 dead wood biomass decreased in Grassland remaining Grassland subcategory, causing a slight emission of CO_2.

7.4.2.3. CO_2 emissions/removals from/by litter

Estonia does not have sufficient country-specific activity data regarding litter to estimate related emissions correctly.

In order to avoid underestimation of emissions and assure consistency between UNFCCC and Kyoto Protocol accounting, ERT (ARR2010) recommended Estonia to use implied emission factors (IEF-s) from neighbouring countries. As Forest Land conversion to Grassland is one of the deforestation activities under Article 3.3, Estonia decided to use average IEF values from Sweden[153] (Table 7.21) for calculating emissions from litter pool.

Annual area change is obtained from NFI.

Table 7.21. Implied emission factors used for litter and mineral soil emission estimates

Deforestation (KP)	Sweden[154] Net carbon stock change per area, Mg C ha^{-1}		
	2008	2009	Average
Litter	-1.250	-1.235	-1.243
Mineral soil	-1.207	-1.202	-1.204

152 Land converted to Grassland includes also emissions from FL conversion to GL litter pool (see subchapter 7.4.2.3)
153 Estonia considered using IEF-s from Latvia, Finland and Sweden as countries with the most similar climate conditions. Finland IEF-s were discarded for Finland uses Yasso model, which does not allow distinguish emissions from litter and mineral soil pools separately. Latvia's emission factors differed significantly from Swedish and Finnish factors. Therefore Sweden IEF-s were chosen as the most suitable and reliable data and for Estonia has the same geographical latitude with southern Sweden and similar climate conditions.
154 Reference: File: SWEDEN-2011-v2.1 (Resubmission of the 2011 CRF tables); Eionet (Sweden)

7.4.2.4. CO_2 emissions/removals from/by mineral soils

Due to the lack of data regarding mineral soil carbon stocks, estimation has not been carried out under Grassland remaining Grassland.

Emissions from mineral soil pool was estimated only under Forest Land conversion to Grassland in order to assure completeness and consistency between UNFCCC and KP (deforestation) reporting. Average IEF from Sweden was used (Table 7.21). More information can be found in previous subchapter.

7.4.2.5. CO_2 emissions from organic soils

The *Tier 1* approach is used in order to calculate CO_2 emissions from organic soils under grassland. The activity data about organic grassland areas are derived from NFI.

Equation 7.8[155]

$$\Delta C_{GGOrganic} = \sum_c (A \bullet EF)_c$$

Where:

$\Delta C_{GG\ Organic}$ – CO_2 emissions from cultivated organic soils in grassland remaining grassland, tonnes C yr^{-1};
A – land area of organic soils in climate type *c*, ha;
EF – emission factor for climate type *c*, tonnes C ha^{-1} yr^{-1} (Table 7.22).

Table 7.22. Annual emission factor (EF) for managed grassland organic soils[156]

Climatic temperature regime	IPCC Guidelines default, tonnes C ha^{-1} yr^{-1}
Cold Temperate	0.25

The amount of carbon released is converted to CO_2 by multiplying with 44/12.

Equation 7.8 was also used for calculations of organic soil emissions in land converted to Grassland subsection.

Carbon emissions from organic soils under Grassland remaining Grassland and land converted to Grassland subcategories are reported in Figure 7.20. Emissions from grassland soils have increased by 16.5% compared to the base year.

[155] GPG-LULUCF 2003, Equation 3.4.10., p. 3.114.
[156] GPG-LULUCF 2003, Table 3.4.6., p. 3.118.

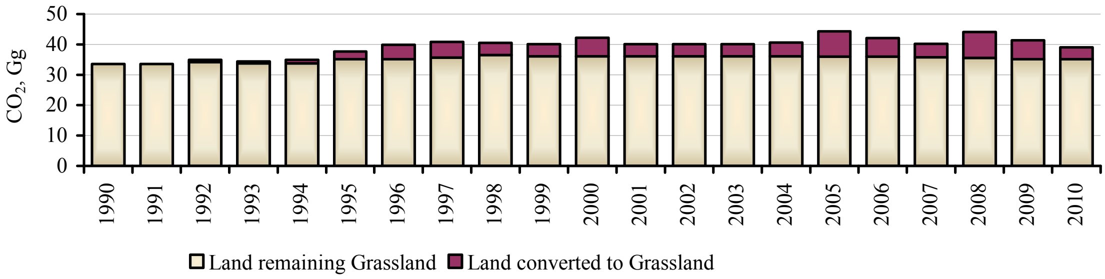

Figure 7.20. Annual change in emissions from grassland (organic) soils[157] in Estonia in 1990–2010, CO_2 Gg

7.4.3. Uncertainty and time series consistency

The estimates of carbon flows associated with Grassland land use category were carried out in accordance with the LULUCF GPG (2003). Activity data was employed from the NFI, the emission factors were taken from the LULUCF GPG (2003).

The uncertainty rates related to the activity data and the emission factors used in the estimates are presented in Table 7.23.

Table 7.23. Estimated values of uncertainties used in Grassland (GL) category

IPCC Source Category	Uncertainties ±%		EF References[158]
	Activity data	Emission factors	
GL remaining GL – net carbon stock change in organic soils	23.76	90.0	LULUCF 2003, Table 3.4.6, p. 3.118
GL remaining GL – living biomass	12.87	46.95	LULUCF 2003, p. 3.31
GL remaining GL – deadwood	26.19	30.07	LULUCF 2003, p. 3.31, 5.17
Land converted to Grassland – net carbon stock change in living biomass	33.98	46.95	LULUCF 2003, p. 3.31
Land converted to Grassland – net carbon stock change in organic soils	71.08	90.0	LULUCF 2003, Table 3.4.6, p. 3.118
Land converted to Grassland – deadwood	67.73	30.07	LULUCF 2003, p. 3.31, 5.17

7.4.4. Source specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QC/QA plan for the sector includes the QC activities described in the IPCC GPG (IPCC 2000, Table 8.1). The activities are carried out every year during the inventory. The QC check list is used during the inventory.

Activity data are checked annually for updating. Emission factors are compared with IPCC default and with emission factors of other countries.

[157] Land converted to Grassland includes also emissions from FL conversion to GL mineral soil pool (see subchapter 7.4.2.4)
[158] All activity data references are obtained from NFI.

7.4.5. Source-specific recalculations

Entire time series of activity data is being recalculated annually for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated to overall activity data. All emission pools are dependent on area, consequently estimates of living biomass, dead wood and organic soil emissions have been recalculated based on updated area estimates.

According to ERT recommendations, in current submission methodology, applied parameters and emission estimates are provided separately for Grassland remaining Grassland and Land converted to Grassland subcategories.

Dead wood estimates were calculated separately for the first time in current submission for Grassland remaining and land converted to Grassland subsections.

More accurate BEF values and combustion factors were used (Table 7.24).

Table 7.24. Parameters used in Grassland category recalculations

Parameter	Source	2011 Submission		2012 Submission	
BEF Land converted to GL	Table 3A.1.10, LULUCF GPG 2003, p. 3.178	BEF$_1$ Boreal conifers	1.15	BEF$_2$ upper value for boreal forest with low growing stock	2.5
		BEF$_1$ Boreal broadleaf	1.1		
Combustion factor[159]	Table 3A.1.12, LULUCF GPG 2003, p. 3.179	All Boreal forest	0.34	Boreal forest, surface fire	0.15

Emissions from litter and mineral soil pools under Forest Land conversion to Grassland were estimated for the first time in current submission. IEF-s from Sweden were used as an interim approach. Country-specific data is under development.

Also see Table 10.1 and Table 10.4–Table 10.6.

7.4.6. Source-specific planned improvements

Several improvements should be made in the next submissions in order to provide more accurate and complete GHG inventory: areas of grassland should be rechecked, carbon emissions/removals associated with dead organic matter (litter) and mineral soils should be estimated. The updated data derived from the NFI fieldwork for land-use changes will be used.

7.5. Wetlands (CRF 5.D)

7.5.1. Source category description

The area of Wetlands cover 11% of total Estonia's territory. Wetlands (including peatland and inland water bodies) decreased until the beginning of 1990s, since then

[159] Estimates regarding grassland biomass burning are presented in Chapter 7. 8 Non-CO_2 emissions from biomass burning (CRF 5 (V))

the area has remained stable (Figure 7.21). Decrease in wetlands area has taken place mostly due to drainage of bogs and mires for agricultural and forestry purposes. Carbon fluxes related to Wetlands land category have been estimated only for peat extraction areas.

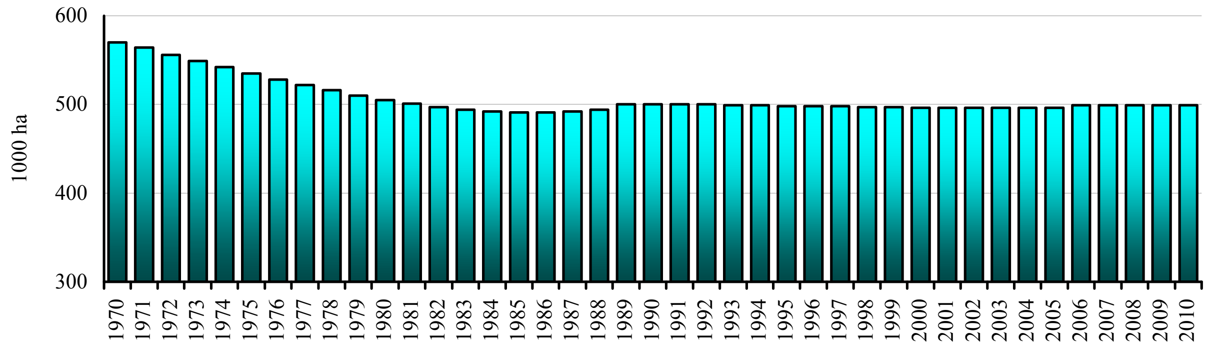

Figure 7.21. Area of Wetlands (including inland water bodies and peatland) in Estonia in 1970–2010, 1000 ha (SE, NFI)

In Estonia, peat is the third important indigenous fuel, after oil shale and wood. More detailed overview of usage of peat for energy production is given in under Energy sector (CRF 1), Chapter 3.

Activity data for the estimation of emissions related to peat extraction was obtained from NFI. In 2010, the total area of managed peat extractions fields was 18 579 ha (Table 7.25). Area of peat extraction fields grew rapidly in 2006 and 2007 as a result of exhaustion of old sites and opening new extraction fields due to the growing need for peat in energy sector and horticulture.

Table 7.25. Area of industrial peat production

Year	Peat extraction fields, 1000 ha
1990	16.64
1995	16.64
2000	16.64
2005	16.64
2006	17.41
2007	18.58
2008	18.58
2009	18.58
2010	18.58

7.5.2. Methodological issues

Tier 1 method was implemented in order to estimate CO_2 emissions from organic soils managed for peat extraction (Equation 7.9).

Equation 7.9[160]

$$\Delta C_{WWpeat\_Soil,extraction} = A_{peat\_Nrich} \bullet EF_{peat\_Nrich} + A_{peat\_Npoor} \bullet EF_{peat\_Npoor}$$

Where:

$\Delta C_{WW\ peat\ Soils,\ extraction}$ – CO_2 emission from organic soils managed for peat extraction expressed as carbon, tonnes C yr^{-1};
$A_{peat\ Nrich}$ – area of nutrient rich organic soils managed for peat extraction, ha;
$A_{peat\ Npoor}$ – area of nutrient poor organic soils managed for peat extraction, ha;
$EF_{peat\ Nrich}$ – emission factors for CO_2 from nutrient rich organic soils managed for peat extraction, tonnes C ha^{-1} yr^{-1};
$EF_{peat\ Npoor}$ – emission factors for CO_2 from nutrient poor organic soils managed for peat extraction, tonnes C ha^{-1} yr^{-1} (Table 7.26).

The amount of carbon released is converted to CO_2 by multiplying with 44/12.

Table 7.26. Emission factors for CO_2–C and N_2O–N for organic soils after drainage

Region / Peat Type	Emission Factor, tonnes CO_2–C ha^{-1} yr^{-1}	Emission Factor, kg N_2O–N ha^{-1} yr^{-1}
Nutrient Poor, EF_{Npoor}	0.2[161]	0.1[162]

CO_2 emissions directly associated with the change in soil carbon during peat extraction are showed in Figure 7.22. Emissions have increased by 11.7% compared to the base year due to the enlargement of peat extraction sites.

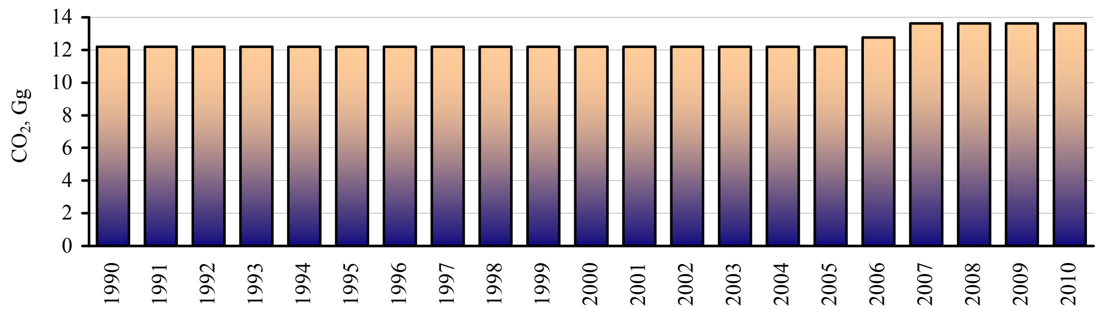

Figure 7.22. CO_2 emissions from peat extraction in 1990–2010, CO_2 Gg

Tier 1 method and Equation 7.10 were used for estimating of N_2O emissions from drained peatlands. Results are illustrated in Figure 7.23.

Equation 7.10[163]

$$\text{Direct } N_2O \text{ emissions}_{WWpeat} = \left(A_{peat\_Nrich} \bullet EF_{peat\_Nrich} + A_{peat\_Npoor} \bullet EF_{peat\_Npoor}\right) \bullet 44/28 \bullet 10^{-6}$$

160 GPG-LULUCF, 2003. Equation 3a.3.6, p.3.279.
161 GPG-LULUCF, 2003. Table 3a.3.2, p.3.280.
162 GPG-LULUCF, 2003, Table 3a.3.4, p. 3.284.
163 GPG-LULUCF, 2003, Equation 3a.3.7, p. 3.283.

Where:

N_2O emissions $_{WW\ peat}$ – emissions of N_2O, Gg N_2O yr^{-1};
$A_{peatNrich}$ – area of drained nutrient rich organic soils, ha;
$A_{peat\ Npoor}$ – area of nutrient poor organic soils, ha;
$EF_{peat\ Nrich}$ – emission factor for drained nutrient rich wetlands organic soils, kg N_2O–N ha^{-1} yr^{-1};
$EF_{peat\ Npoor}$ – emission factor for drained nutrient poor organic soils, kg N_2O–N ha^{-1} yr^{-1} (Table 7.26).

Figure 7.23. N_2O emission due to industrial peat extraction in 1990–2010, N_2O Gg

Emissions from loss of living biomass under Forest Land conversion to peatland were estimated using *Tier 2* approach and Equation 7.2. According to NFI, this kind of land-use transition took place in 2006 and 2007 when respectively 774 ha and 1 166 ha (Table 7.25) of forest land was converted to peat extraction sites. Annual CO_2 emissions from living biomass loss after land-use change were 99.85 Gg in 2006 and 150.40 Gg in 2007.

7.5.3. Uncertainty and time series consistency

The estimates of GHG flows were carried out based on the LULUCF GPG (2003). Activity data was obtained from NFI, the emission factors were taken from the LULUCF GPG (2003).

The uncertainty rates related to the activity data and the emission factors used in the estimates are presented in Table 7.27.

Table 7.27. Estimated values of uncertainties used in Wetlands category

IPCC Source Category	Uncertainties ±%		EF References[164]
	Activity data	Emission factors	
Wetlands remaining Wetlands – organic soils managed for peat extraction (CO_2)	29.81	315.0	LULUCF 2003, Table 3a.3.2 p. 3.280
Land converted to Wetlands/Peatland – living biomass (CO_2)	85.82	46.95	LULUCF 2003, p. 3.31
Land converted to Wetlands/Peatland – organic soils managed for peat extraction (N_2O)	87.63	300.0	LULUCF, 2003, Table 3a.3.4, p. 3.284

[164] All activity data references are obtained from NFI.

7.5.4. Source specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for LULUCF sector according to IPCC *Tier 1* method. The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in 1.6.1.

7.5.5. Source-specific recalculations

Entire time series of activity data is being annually recalculated for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated to overall activity data.

Emissions derived from loss of living biomass due to forest land conversion to peatland were estimated for the first time in current submission.

Also see Table 10.1 and Table 10.4–Table 10.6.

7.5.6. Source-specific planned improvements

Updated data derived from the NFI fieldwork for land-use changes will be used.

7.6. Settlements (CRF 5.E)

7.6.1. Source category description

Settlements, including all built-up areas, cover about 6.5% of Estonia's territory. The area of settlements has been increasing constantly in Estonia (Figure 7.24) mainly on behalf of forest lands (Table 7.4). Carbon flows related to Settlements remaining Settlements have not been calculated in current submission due to lack of detailed data about parks and gardens. Furthermore, it is not mandatory for Parties to prepare estimates for the category contained in appendix 3a.4 (Settlements remaining Settlements) of the IPCC good practice guidance for LULUC.

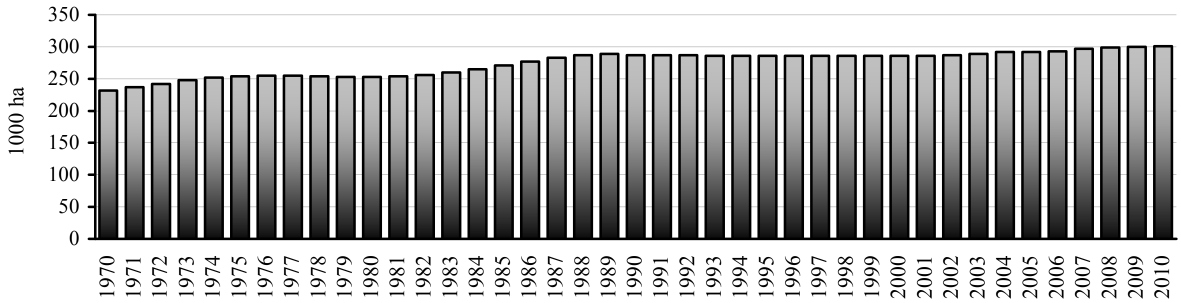

Figure 7.24. Area of Settlements in Estonia in 1970–2010, 1000 ha (SE, NFI)

7.6.2. Methodological issues

To ensure consistency between LULUCF and KP LULUCF sectors Estonia reports carbon stock changes under land converted to Settlements.

Based on available data from NFI, emission estimates were provided for living biomass, dead wood and organic soil pools under Forest Land conversion to Settlements and living biomass and dead wood pools under Grassland conversion to Settlements. Estonia does not have country-specific data regarding litter and mineral soil carbon pools, therefore ERT strongly recommended Estonia to use IEF-s from neighbouring countries as an interim approach, in order not to underestimate emissions from accounted LULUCF activities (with main emphasis on deforestation). For completeness and consistency reasons, the same IEF-s (Table 7.21) are also used for estimating emissions under land conversion to Settlements.

Equation 7.2 was used for calculating emissions from living biomass loss under both Forest land and Grassland conversion to Settlements. Same input parameters were used as in Forest Land remaining Forest Land and Grassland remaining Grassland calculations (Table 7.7−Table 7.9, Table 7.19, Table 7.20).

Equation 7.3 was used for calculating emissions from loss of dead wood stock after Forest Land and Grassland conversion to Settlements. Volume of dead wood stock was obtained from NFI and dead wood density of 0.266 (t d.m./m^3)[165] was used to transform the volume of dead wood into tonnes of dry matter.

Tier 1 approach and Equation 7.4 was implemented to report emissions from organic soils under Forest Land conversion to Settlements, only Grasslands organic soil emission factor of 0.25 (t C ha^{-1} yr^{-1}) was used, since the soil conditions of Settlements' greenery are most similar to Grasslands. Grassland conversion to Settlements has occurred only on mineral soils and Estonia does not have sufficient activity data to report estimations from mineral soils.

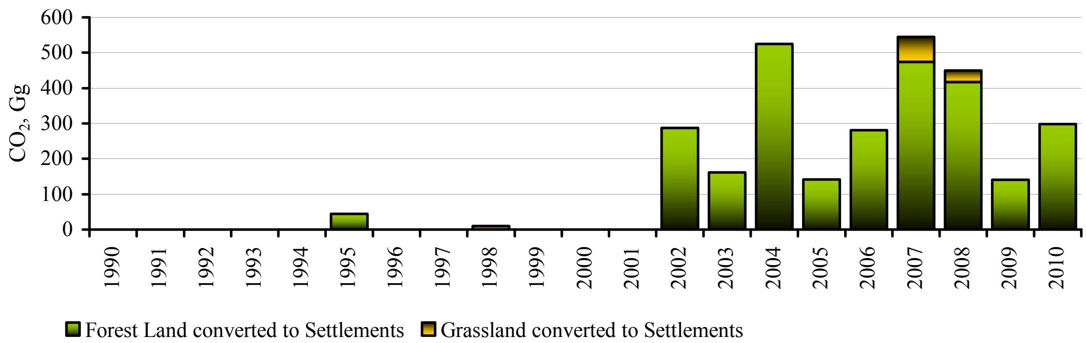

Figure 7.25. CO_2 emissions followed by Forest Land and Grassland conversion to Settlements in Estonia in 1990–2010, Gg

In Figure 7.25 total CO_2 emissions from Forest Land and Grassland conversion to Settlements have been shown. It should be noted that calculations are based on annual change of area (not cumulative). Figure 7.25 does not follow the trend of the whole Settlements area change in Figure 7.24, since conversion to Settlements has taken place on land use categories with different growing stock, e.g. no emissions occur after Other land transition to Settlements.

[165] Journal of Forest Science, 56, 2010, (9) pp. 397-405.

7.6.3. Uncertainty and time series consistency

The estimates of GHG flows were carried out based on the LULUCF GPG (2003). Activity data was obtained from NFI, the emission factors were taken from the LULUCF GPG (2003).

The uncertainty rates related to the activity data and the emission factors used in the estimates are presented in Table 7.28.

Table 7.28. Estimated values of uncertainties used in land converted to Settlements category

IPCC Source Category	Uncertainties ±%		EF References
	Activity data[166]	Emission factors	
Forest Land converted to Settlements – living biomass	46.38	46.95	LULUCF, 2003, p. 3.31
Forest Land converted to Settlements – dead wood	50.23	30.07	LULUCF, 2003, p. 3.31, 5.17
Forest Land converted to Settlements – net carbon stock in soils	111.46	200.00	LULUCF 2003, Table 3.2.3, p. 3.42
Grassland converted to Settlements – living biomass	153.28	46.95	LULUCF, 2003, p. 3.31
Grassland converted to Settlements – dead wood	308.78	30.07	LULUCF, 2003, p. 3.31, 5.17

7.6.4. Source specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for LULUCF sector according to IPCC *Tier 1* method. The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in 1.6.1.

7.6.5. Source-specific recalculations

Entire time series of activity data is being annually recalculated for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated to overall activity data.

Emissions derived from Forest Land and Grassland conversion to Settlements were estimated for the first time in current submission.

Also see Table 10.1 and Table 10.4–Table 10.6.

7.6.6. Source-specific planned improvements

Updated data derived from the NFI fieldwork for land-use changes will be used.

[166] All activity data uncertainty estimates are obtained from NFI.

7.7. Other Land (CRF 5.F)

7.7.1. Source category description

Other land category includes all land that does not fall into the five previously described land-use categories.

According to IPCC Good Practice Guidance, it is not mandatory for Parties to present estimates for categories contained in Appendixes 3a.2, 3a.3 and 3a.4.

7.7.2. Methodological issues

ERT (ARR2011) recommended Estonia to provide emission estimates under Forest Land conversion to Other Land, in order not to underestimate emissions from accounted LULUCF activities (with main emphasis on deforestation) and for completeness and consistency reasons.

Carbon stock loss from living biomass and dead wood pools were estimated implementing Equation 7.2[167] and Equation 7.3 respectively, parameters for Forest Land remaining Forest Land were used. Average IEF-s from Sweden (Table 7.21) were used for estimating emissions from mineral soil and litter carbon stocks, since Estonia does not have country-specific data regarding these pools.

According to NFI, Forest Land conversion to Other Land took place only in 2006−2008. Net carbon stock changes/total emissions are shown in Table 7.29.

Table 7.29. Net carbon stock changes under Forest Land conversion to Other Land, Gg C

CRF 5.F.2.1	2006	2007	2008
Living biomass	-38.04	-154.49	-39.26
Dead organic matter (litter + dead wood)	-1.52	-6.34	-1.66
Soils (mineral)	-0.62	-2.47	-0.62
Total CO_2 emissions, Gg CO_2	147.31	598.75	152.30

7.7.3. Uncertainty and time series consistency

The estimates of GHG flows were carried out based on the LULUCF GPG (2003). Activity data was obtained from NFI, the emission factors were taken from the LULUCF GPG (2003).

The uncertainty rates related to the activity data and the emission factors used in the estimates are presented in Table 7.30.

[167] B_{t2} was assumed to be zero

Table 7.30. Estimated values of uncertainties used in Forest Land converted to Other Land category

IPCC Source Category	Uncertainties ±% Activity data[168]	Emission factors	EF References
Forest Land converted to Other land – living biomass	82.59	46.95	LULUCF, 2003, p. 3.31
Forest Land converted to Other land – dead wood	89.43	30.07	LULUCF, 2003, p. 3.31, 5.17
Forest Land converted to Other land – litter/mineral soil	79.99	NA[169]	NA

7.7.4. Source specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for LULUCF sector according to IPCC *Tier 1* method. The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in 1.6.1.

7.7.5. Source-specific recalculations

Entire time series of activity data is being annually recalculated for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated to overall activity data.

ERT recommended Estonia to give estimations regarding Forest Land conversion to Other Land, in order not to underestimate emissions from accounted LULUCF activities (with main emphasis on deforestation), therefore emissions derived from Forest Land conversion to Other Land were estimated for the first time in current submission.

Also see Table 10.1 and Table 10.4–Table 10.6.

7.7.6. Source-specific planned improvements

Updated data derived from the NFI fieldwork for land-use changes will be used.

7.8. Non-CO_2 emissions from biomass burning (CRF 5 (V))

This source category includes CH_4 and N_2O emissions from biomass burning on wooded lands due to wildfires. CO_2 emissions caused by wildfires are included in living biomass emission estimates due to stock change method used for calculations, thus CO_2 emissions are not reported under current category in order to avoid double accounting.

[168] All activity data uncertainty estimates are obtained from NFI.
[169] No uncertainty estimations are provided for FL to OL under mineral soils and litter pools, since IEF-s from Sweden were used in calculations and exact uncertainties regarding emssion factors are unknown, only activity data uncertainty (i.e area) is estimated by NFI

Controlled fires are not a common practice in Estonia, furthermore the standpoint of the public and the national authorities is opposed to prescribed burnings. For example, pursuant to the Forest Act, local administrations shall implement measures to prevent forestfires and according to the Estonian Fire Safety Act, it is forbidden to burn dead grass around the year.

7.8.1. Methodology, data availability and sources, emission factors

Tier 2 method and Equation 7.11 was used to estimate the emissions of non-CO_2 greenhouse gases. Country-specific activity data on areas damaged by fires (Figure 7.26) was obtained from Estonian Rescue Service, State Forest Management Centre and Environmental Board, average values for growing stock of forest land and grasslands were employed from the NFI database. The area and emissions from grassland and wetland fires has been presented together due to the combined statistical data available. It should be noted, that wetlands biomass comprises only a minor part of the combined data, therefore the estimation applies essentially for grasslands.

Equation 7.11[170]

$$L_{fire} = A \bullet B \bullet C \bullet D \bullet 10^{-6}$$

Where:

L_{fire} – quantity of GHG released due to fire, tonnes of GHG;
A – area burnt, ha;
B – mass of 'available' fuel, kg dry matter ha^{-1};
C – combustion efficiency (or fraction of the biomass combusted), dimensionless;
D – emission factor, g (kg dry matter.)$^{-1}$.

Parameters used for biomass burning emission calculations are shown in Table 7.31.

Table 7.31. Factors used for estimation of non-CO_2 greenhouse gas emissions from fires

	Combustion efficiency, C[171]	CH_4 Emission factor, D[172]	N_2O Emission factor, D[173]
Forest Land	0.15	9	0.11
Grassland and Wetlands	0.15	2	0.1

The total area of Estonian forests, grasslands and wetlands affected by wildfires is presented in Figure 7.26. Wide fluctuations are caused mainly by the weather conditions in different years (e.g. extremely hot and dry summers).

[170] GPG-LULUCF 2003, Equation 3.2.20, p. 3.49.
[171] GPG-LULUCF 2003, Table 3A.1.12, p. 3.179, Boreal forest, surface fire (expert opinion).
[172] GPG-LULUCF 2003, Table 3A.1.16, p. 3.185, Forest fires (Delmas *et al.* (1995)).
[173] GPG-LULUCF 2003, Table 3A.1.16, p. 3.185, Moist-infertile grassland (Scholes (1995)).

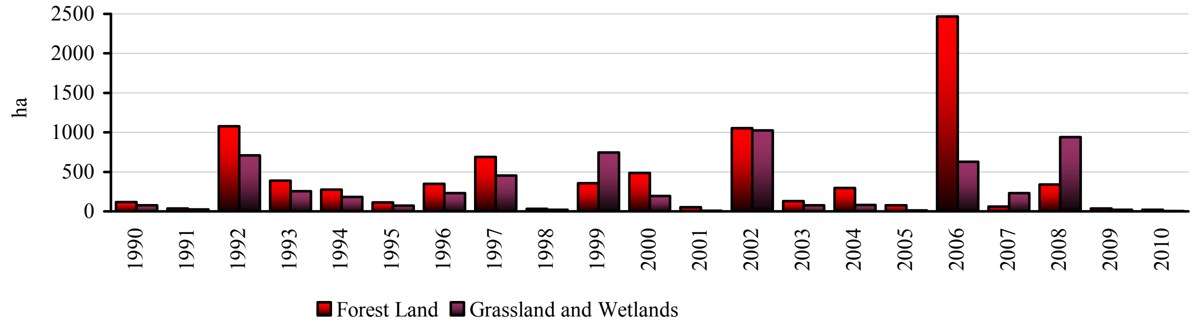

Figure 7.26. Annual area of forest land, grassland and wetlands affected by fires in 1990−2010, ha

Emissions of CH_4 and N_2O from land burnings are illustrated in Figure 7.27 and Figure 7.28. In 2010, only 4.1 hectares of grasslands/wetlands and 20.7 hectares of forest land was affected by fire. The total amount CH_4 and N_2O released after wildfires were 3.3 t and 0.04 t respectively. Non-CO_2 emissions from grassland wildfires are rather insignificant compared to forest land, since there is approximately 10 times less growing biomass on grasslands.

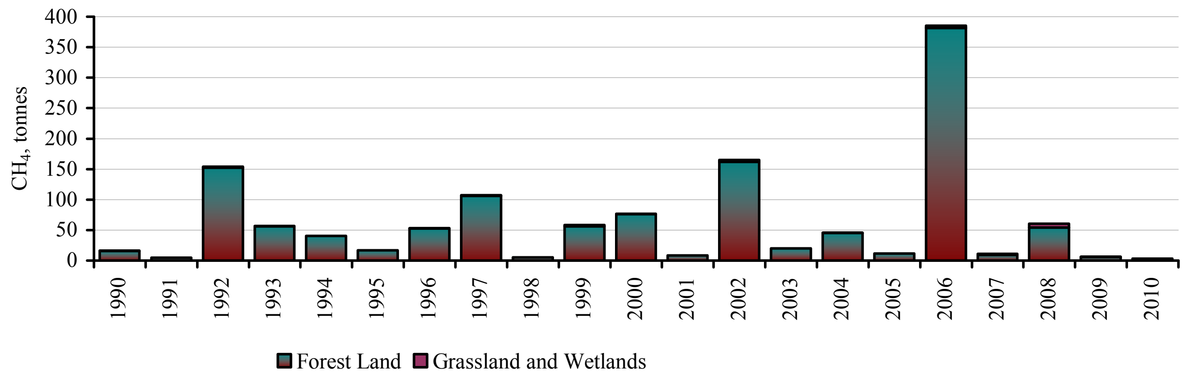

Figure 7.27. CH_4 emissions from wildfires in Estonia in 1990–2010, t

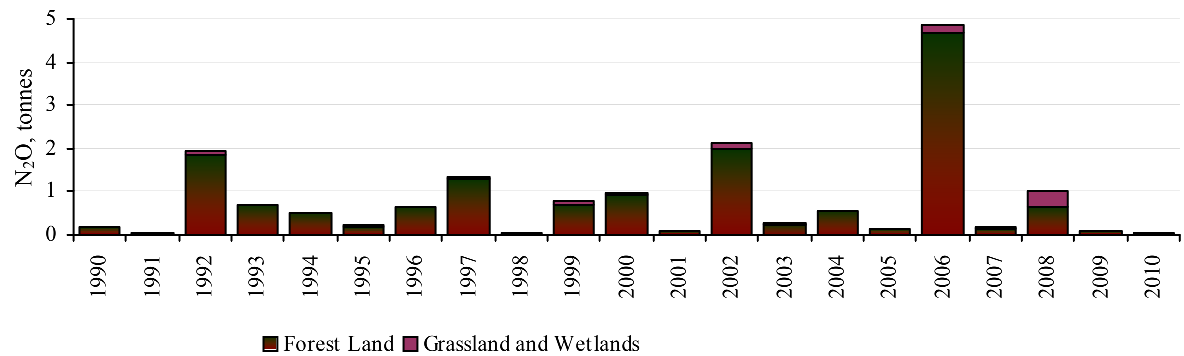

Figure 7.28. N_2O emissions from wildfires in Estonia in 1990–2010, t

7.8.2. Uncertainties and time series consistency

Uncertainty estimates of CH_4 and N_2O emissions from wildfires were carried out based LULUCF GPG (2003) guidelines. Activity data concerning area burnt was obtained from Estonian Rescue Service, State Forest Management Centre and Environmental Board, average values for growing stock of forest land and grasslands were employed from the NFI database. Emission factors were taken from the LULUCF GPG (2003). The uncertainty rates are shown in Table 7.32.

Table 7.32. Estimated values of uncertainties used in non-CO_2 emission estimates from biomass burning subsection

IPCC Source Category	Uncertainties ±%		EF References
	Activity data[174]	Emission factors	
Biomass burning (CH_4)	34.50	129.23	LULUCF 2003, p. 3.50; Table 3A.1.12, p. 3.179
Biomass burning (N_2O)	34.50	129.23	LULUCF 2003, p. 3.50; Table 3A.1.12, p. 3.179

7.8.3. Source specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for LULUCF sector according to IPCC *Tier 1* method. The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Chapter 1.6.

Activity data are checked annually for updating. Emission factors are compared with IPCC default and with emission factors of other countries.

7.8.4. Source-specific recalculations

Updated data of wildfires area were used. Instead of average boreal forest combustion factor more accurate value of boreal forest surface fire was used in current submission (Table 7.14). Due to more accurate R values used for biomass calculations (Table 7.14), the quantity of fuel burnt was re-estimated, therefore also new emission estimates for non-CO_2 emissions from fires were provided.

Also see Table 10.1 and Table 10.4–Table 10.6.

7.8.5. Source-specific planned improvements

Activity data will be updated.

[174] All activity data uncertainty estimates are obtained from NFI

8. WASTE (CRF 6)

8.1. Overview of the sector and methodology

In Estonia waste management policy bases on the EU legislation and national laws and acts, including National Waste Management Plan for years 2008–2013[175]. The main purpose of the national waste policy is to reduce the volume of the waste deposited in landfills, enlarge the potential of recoverable waste and minimize the hazardousness of wastes to the limit, where negative influence to the environment would be minimal. Waste management system in Estonia has been organized through four levels: national government, local governments, organization level and households.

Ministry of the Environment (MoE) in association with local governments and organizations coordinate realization of the waste policy, and organizing the supervision over the waste handling in the country.

The most important level concerning municipal waste management is related to local governments. According to the law, local authorities have a responsibility to organize the municipal waste handling and separate collection of wastes in their administrative territory, called as organized waste transport, because since 1st of January 2008 it is not allowed to deposit unsorted municipal wastes to the landfills.

According to the local waste handling regulations, in the level of households several activities have to be taken into consideration, as joining the organized waste transport system, sorting the wastes, collecting separately hazardous wastes, etc.

The Estonian inventory of GHG in waste sector covers CH_4 emissions from solid waste disposal sites including solid municipal and industrial waste, domestic and industrial sludge. The waste sector also covers GHG emissions from waste incineration (incl biogas burnt in a flare), biological treatment and wastewater handling including domestic, commercial and industrial wastewater. Emissions from wastewater handling basically do not occur in Estonia, as all wastewater is mostly treated using aerobic processes. However a small percentage of wastewater in wastewater treatment plants is treated using anaerobic processes.

Table 8.1 summarizes the data on approaches and emission factors employed for estimations of GHG emissions from each sub-sector of the waste sector. Due to lack of national research results to use country-specific emission factors, the IPCC default values are used. Relying on carried out decision trees, the Tier 1 and Tier 2 (The FOD) method is applied. The choice of activity data depends on used formulas to calculate emissions.

[175] Waste Management Plan, Riigi Jäätmekava 2008-2013.

Table 8.1. Methods and emission factors used for estimations of emissions from waste sector

	CO_2	CH_4	N_2O
Greenhouse gases source and sink categories	Method applied/EF	Method applied/EF	Method applied/EF
6. WASTE			
A. Solid Waste Disposal on Landfills		T2/D	
B. Wastewater Handling		T1/D	T1/D
B. Human Sewage			T1/D
C. Waste Incineration	T1/D		T1/D
D. Biological Treatment		T1/D	T1/D
D. Biogas Burnt In a Flare		T1/D	T1/D

T1 - *Tier 1* method, T2 - *Tier 2* method, D - IPCC default value.

8.1.1. References-sources of information

The inventory has carried out by researchers at Tallinn Environmental Research Centre (EERC). The main providers of activity data used in the estimates are Estonian Environment Information Centre (EEIC) and Statistics Estonia (SE).

Table 8.2. List of institutions (datasets) involved in the inventory for the waste sector

Reference	Link	Abbreviation	Activity/Data
Estonian Environmental Research Centre	www.klab.ee	EERC	- Activity data gathering - Estimation of emissions - Reporting
Statistics Estonia	www.stat.ee	SE	- Collection and reporting of data on product production in Estonia
Estonian Environment Information Centre -Waste Bureau -Water Bureau -Air Bureau	www.keskkonnainfo.ee	EEIC	- Collection of data on solid waste generation, disposal, and recovery, incl. waste incineration and biological treatment - Collection of data on waste water generation - Collection of data on methane recovery

8.1.2. Quantitative overview of the waste sector

In 2010 in Estonia CO_2 equivalent emissions from waste sector were 472.19 Gg. It made up 2.30% of the total GHG emission in 2010 (Figure 8.1). CH_4 emission from waste disposal, N_2O from human sewage and emissions (CH_4 and N_2O) from biological treatment are the most significant emissions of the waste sector in Estonia in 2010.

Due to recalculations in estimations (solid waste disposal on land, municipal sewage and domestic and commercial wastewater subcategories), the whole time series since 1990 was updated (Table 8.3).

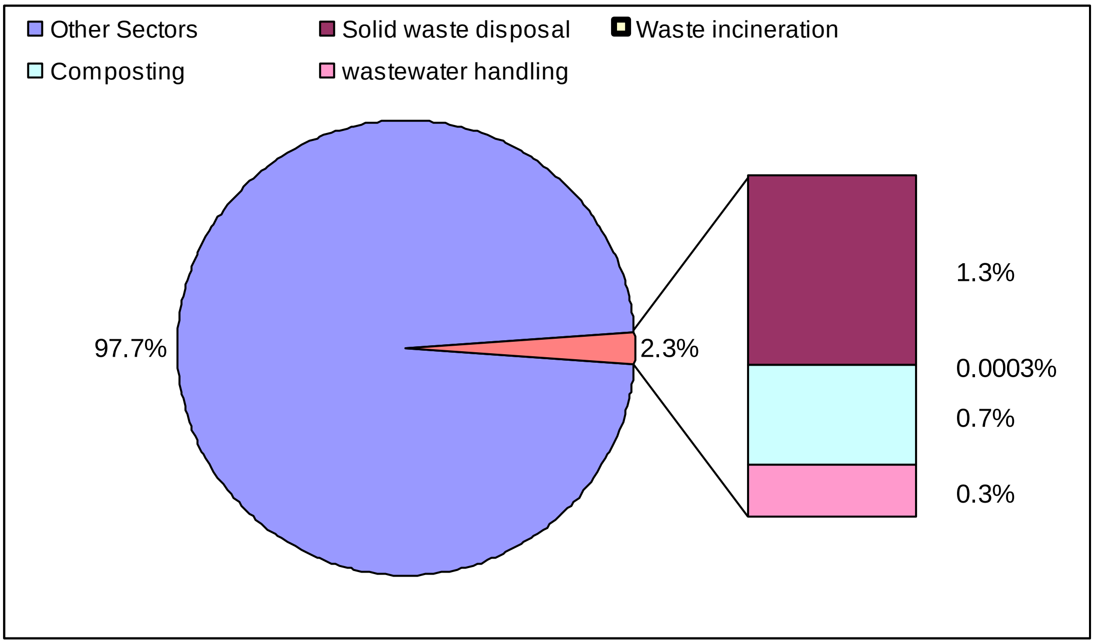

Figure 8.1. CO_2 equivalent emissions from the waste sector compared with the total GHG emissions in Estonia in 2010

The total CO_2 equivalent emission from the waste sector increased 23.9% in comparison with the base year: the emission from solid waste landfilled increased by 31% and emission from waste composting processes increased about 100 fold – from 1.26 Gg to 138.6 Gg in 2010 (Figure 8.2).

As seen from the table (Table 8.3) in 1995 GHG emissions from waste sector decreased, which is due to CH_4 emissions from paper and sludge waste from solid waste disposal on land in 1995 has decreased. There has been a sharp fluctuation in the quantities of N_2O emissions from waste incineration in 1999, 2000, 2008 and 2009. The main reason for the augmentation is that, in 1999 and 2000 large amounts of inert waste, nafta and oil waste and wood were burnt and in 2008 the sudden fallout took place, as no wastes were incinerated (D10 operation) without energy recovery.

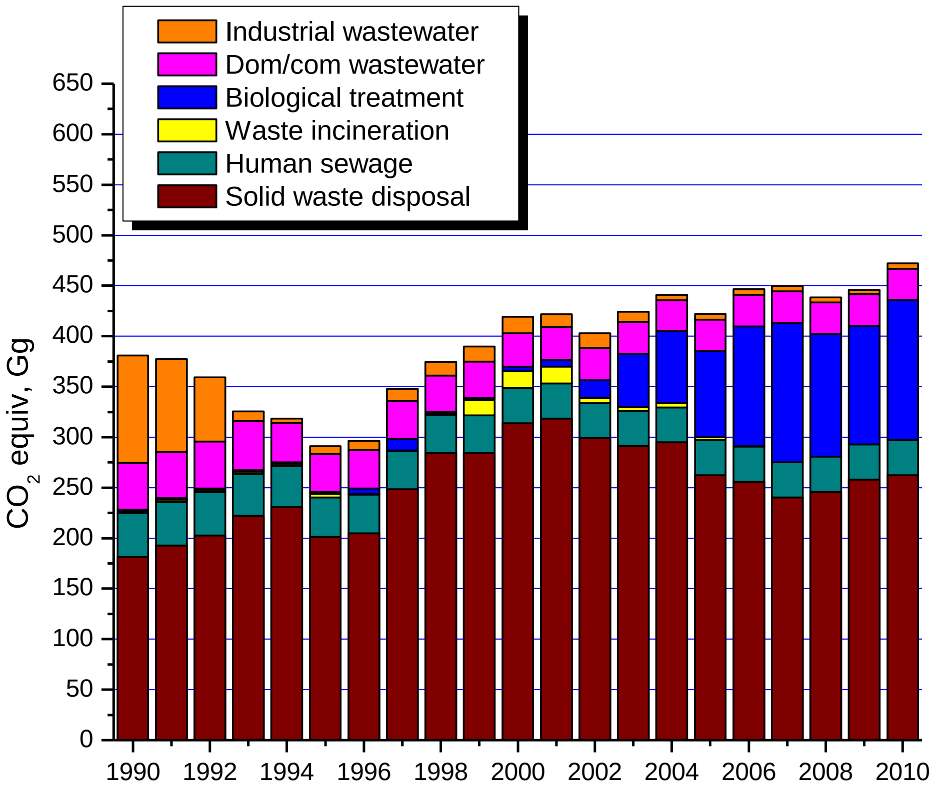

Figure 8.2. Trends of GHG emissions in the waste sector by source categories in 1990–2010**,** Gg CO_2 eq

Table 8.3. GHG emissions from waste sector in Estonia in 1990–2010, Gg

Year	Solid Waste Disposal	Waste Incineration		Biological Treatment		Wastewater Treatment				Total CO_2 equiv emissions
						Human sewage	Domestic and commercial wastewater		Industrial wastewater	
	CH_4	CO_2 [176]	N_2O	CH_4	N_2O	N_2O	CH_4	N_2O	CH_4	CO_2 equiv
1990	8.65	0.042	0.007	0.029	0.002	0.140	0.3870	0.1223	5.082	381.02
1991	9.18	0.042	0.007	0.030	0.002	0.140	0.3863	0.1221	4.379	377.39
1992	9.66	0.042	0.007	0.032	0.002	0.138	0.4256	0.1211	3.017	359.07
1993	10.58	0.042	0.007	0.033	0.002	0.135	0.5792	0.1177	0.449	325.42
1994	10.99	0.042	0.007	0.035	0.003	0.131	0.1617	0.1150	0.198	318.39
1995	9.59	0.049	0.011	0.037	0.003	0.126	0.1586	0.1105	0.375	291.00
1996	9.75	0.020	0.001	0.126	0.009	0.124	0.1951	0.1087	0.442	296.36
1997	11.83	0.035	0.001	0.262	0.020	0.123	0.1924	0.1073	0.584	348.02
1998	13.54	0.057	0.006	0.026	0.002	0.121	0.1525	0.1063	0.645	374.58
1999	13.53	0.041	0.050	0.043	0.003	0.120	0.1510	0.1052	0.717	389.73
2000	14.94	0.062	0.054	0.107	0.008	0.112	0.1127	0.0981	0.790	419.33
2001	15.17	0.045	0.054	0.143	0.011	0.112	0.1123	0.0977	0.608	421.68
2002	14.24	0.056	0.017	0.396	0.030	0.111	0.0745	0.0973	0.689	402.69
2003	13.88	0.051	0.013	1.192	0.089	0.111	0.0742	0.0969	0.483	424.24
2004	14.06	0.107	0.013	1.614	0.121	0.110	0.0370	0.0966	0.250	440.83
2005	12.50	0.060	0.009	1.920	0.144	0.113	0.0369	0.0985	0.267	421.94
2006	12.19	0.012	0.0004	2.682	0.201	0.112	0.0368	0.0983	0.268	446.52
2007	11.45	0.004	0.0002	3.119	0.234	0.112	0.0367	0.0981	0.255	449.82
2008	11.72	NO	NO	2.743	0.206	0.112	0.0367	0.0980	0.241	438.33
2009	12.29	0.00004	0.00002	2.655	0.199	0.112	0.0367	0.0979	0.210	445.92
2010	12.50	0.00005	0.00017	3.132	0.235	0.112	0.0367	0.0979	0.250	472.19

[176] As CO_2 emissions from waste incineration derived from biomass materials (e.g. paper, food waste, wooden material) are replaced by regrowth on an annual basis and are not considered net anthropogenic emissions (Revised 1996 IPCC Guidelines Reference Manual, Waste, pp 6.28).

8.1.3. Key categories

Waste key categories in 2010 (without LULUCF) calculated with the *Tier* 2 method[177] are:

6.A	Solid Waste Disposal on Land (CH_4)	L,T[178]
6.B.1	Industrial Wastewater (CH_4)	L
6.D	Biological Treatment (N_2O)	L
6.D	Biological Treatment (CH_4)	L

8.1.4. Uncertainty assessment

All calculated uncertainties of emission factors and activity data used are accordance with methodology used in emission estimations, derived from IPCC Guidelines. In the following table (Table 8.4) all categories comprised in uncertainty estimates are presented. As a recommendation by UNFCCC review team (2009) uncertainties in Waste Sector have been revised and presented under subcategories' descriptions. The combined uncertainties for activity data and emission factors used are calculated as follows[179]:

$$Utotal = \sqrt{U1^2 + U2^2 + \cdots Un^2}$$

The combined uncertainties related to the Waste Sector in 2010 are follows:

Table 8.4. The combined uncertainties related to waste sector (%)

Source category	Uncertainties %
6.A Solid Waste Disposal on Land	83.67
6.B.1 Industrial Wastewater	107.35
6.B.2 Domestic and Commercial Wastewater (anaerobic) (CH_4)	42.72
6.B.2 Domestic and Commercial Wastewater (anaerobic) (N_2O)	101.50
6.B.2.2 Domestic and Commercial Wastewater - human sewage	100.12
6.C Waste Incineration	100.12
6.D Biological Treatment (CH_4)	100.50
6.D Biological Treatment (N_2O)	100.50

8.1.5. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Waste sector according to IPCC *Tier 1* method. The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.

[177] GHG emissions/removals of LULUCF sector are not included.
[178] L-Level Assessment method; T-Trend Assessment method.
[179] IPCC GPG 2000. Chapter 6, pp 6.12.

8.2. Solid waste disposal on landfills (CRF 6.A)

8.2.1. Source category description

In 2010, there were 5 landfills (Jõelähtme, Uikala, Väätsa, Torma, Paikre) were municipal wastes were deposited. These landfills are conformed totally to environmental and technical requirements or standards and are capable to serve more than one county or service area (Figure 8.3)[180]. Due to rearrangements in waste management system, all landfills for not being in accordance with environmental requirements applied to landfills were closed in summer 2009. Also there are still several landfills in Estonia, which are closed but uncovered, all arrangements concerning covering, will be finished by the year 2013.

In the existing landfills, classified as managed solid wastes disposal sites, different kinds of activities of waste management are taking place: treatment and temporary storage of recoverable waste; separation of preliminarily separated waste, separation and destruction of wood; composting; collection of hazardous waste; separation of demolished constructional waste; etc.

In the last submission 13 solid waste disposal sites had been taken into account (Häädemeeste and Neemi were excluded).[181] These landfills were not included because in 2009 no municipal solid wastes were disposed there, in other 13 landfills wastes were disposed[182]. In the current report 5 solid waste disposal sites have been taken into account.

[180] Operating landfills in Estonia in 2008.
[181] http://www.keskkonnainfo.ee/failid/jaatmed/landfilled_2009.pdf.
[182] Explanation was added as a recommendation by the 2011 UNFCCC review team.

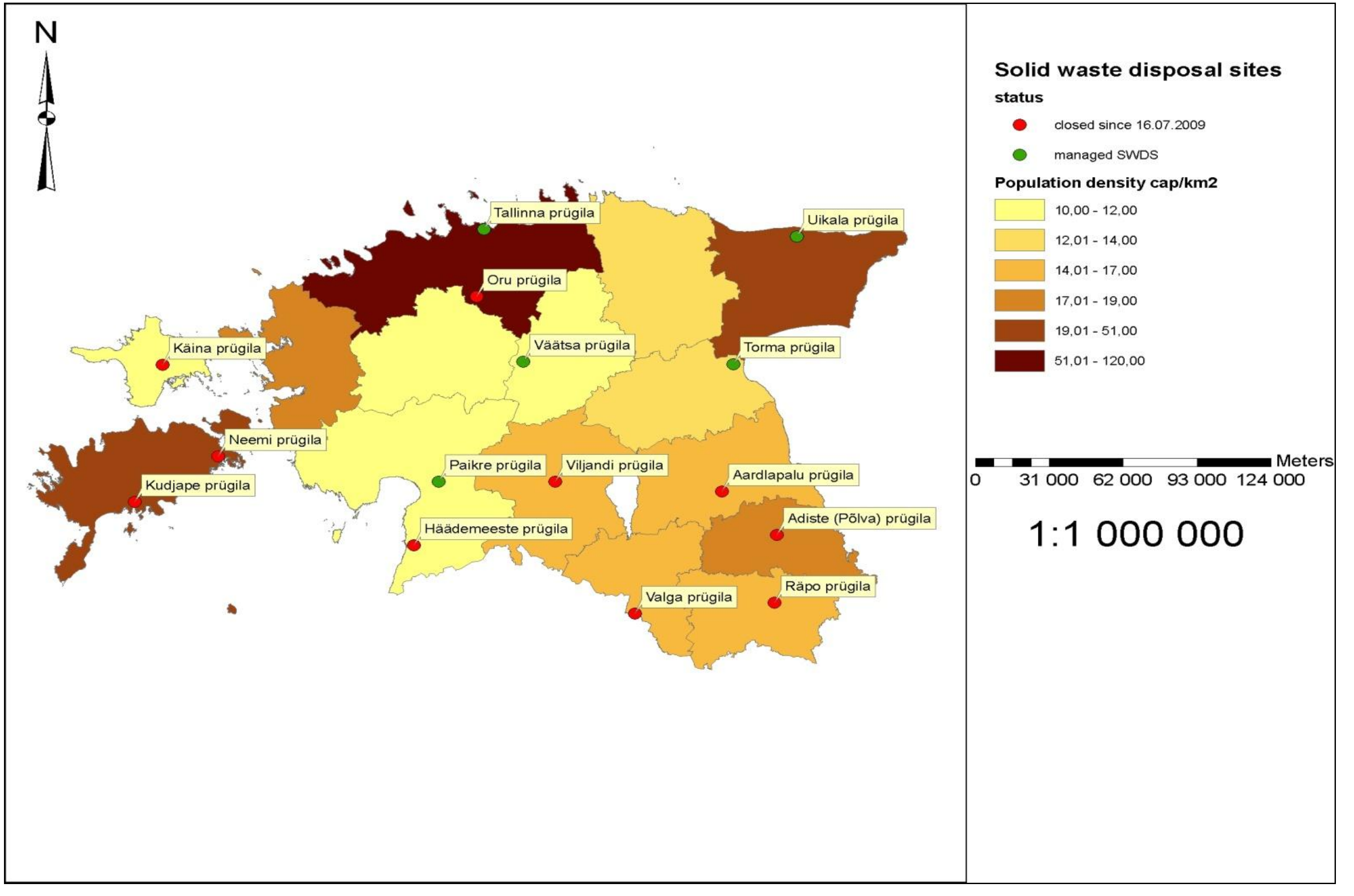

Figure 8.3. The map of Estonia's population, population density and operating landfills of municipal wastes in 2010

The annual trend of inert[183] and degradable waste generated in Estonia in 1990–2010 is presented in Figure 8.4. Since 1992 the EEIC has started to collect data in accordance with the Estonian waste classification (Estonian NIR, 2006), however in 1999 the adapted classification system was changed and the European Waste Catalogue was employed. The data for 1990–1991 were interpolated basing on the data of 1992–1998 (Estonian NIR, 2006). The forecast function of the Excel software was used to calculate the quantities of waste generated in the period 1990–1991. The calculations with Forecast function based on the Estonian GDP in 1990, 1991–1998 and quantities of waste generated in 1991–1998. Source of GDP is Statistics Estonia and source of data on waste generation in period 1992–1998 is Estonian Environment Information Centre.[184]

As seen from the Figure 8.4 the amount of inert and degradable waste generated in 2010 has increased appreciably compared with 2009. The quantity of waste generation in 2010 was about 19.5 mln tonnes, in contrast with 2009 it has risen 20% due to increase in consumption habits. The falloff in 2009 is probably related to economic downfall and decrease in consumption in the country. The proportion of degradable and inert waste generation is accordingly 9% and 91%.

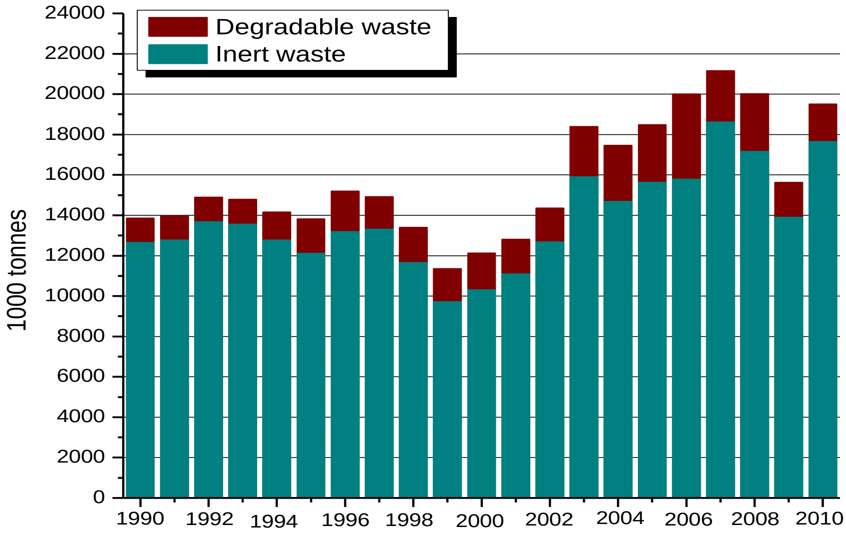

Figure 8.4. Amounts of waste generated in Estonia in 1990–2010, 1000 tonnes

As seen from the Figure 8.5 the quantity of DOC[185] generated has increased 2.5 times in 2010, compared with the base year. Although in comparison with the year 2009 the amount of DOC generated in 2010 has increased 19%, and the ratio of DOC landfilled to DOC generated has made fallout from 14% to 10.5%.

The reason why the amount of DOC generated has decreased in 2008 is mainly because the generation of industrial wood waste (in DOC tonnes) decreased about 31% compared with the year 2007 and therefore, the quantity of wastes in DOC tonnes reduced. The upturn in the

[183] Inert waste – non-biodegradable wastes e.g glass, metal, plastic, pottery, clinical waste and other inert waste (wastes from mineral excavation; inorganic chemical processes, etc.).
[184] Explanation about used interpolation method was added as a recommendation by 2011 UNFCCC review team.
[185] DOC-Degradable Organic Carbon.

ratio of DOC landfilled to DOC generated in 2008 is due to quantities of the solid municipal and industrial waste in DOC tonnes disposed into landfills enlarged. The reason why the amount of DOC generated has decreased in 2009 is mainly because the generation of municipal waste and industrial organic and wood waste (in DOC tonnes) decreased. The rise in 2010 in quantity of DOC generated is reasoned by increase in generation of industrial wood waste.

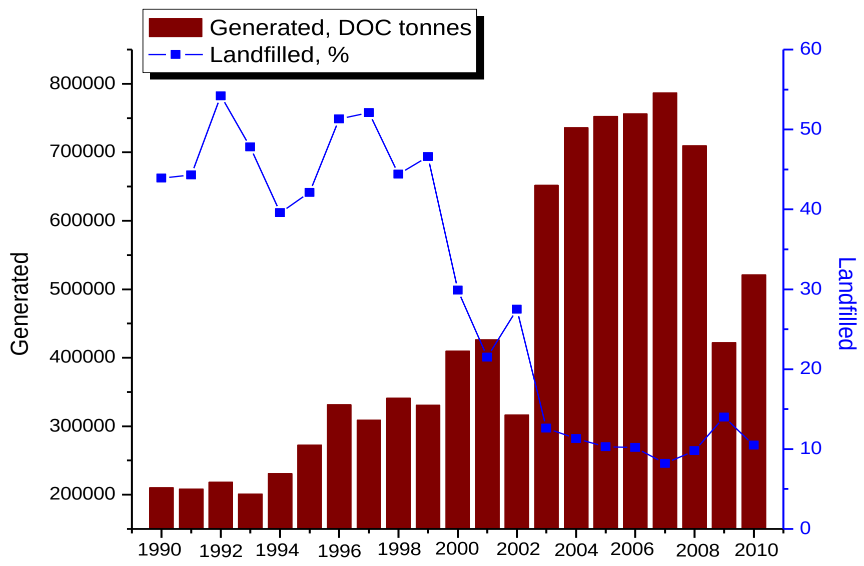

Figure 8.5. Quantity of DOC generated (tonnes) and ratio of DOC landfilled to DOC generated (%) in 1990–2010

Production of biogas

Biogas is a gas fuel obtained via anaerobic fermentation, which is comprised of 50–70% methane (CH_4), 30–40% carbon dioxide (CO_2) and other components such as N_2, O_2, NH_4, H_2S. A biogas station in landfills is provided with pre-preservation storage and mixing containers, biogas reactors, fermenting waste storage area, gas storage units, heating and power station for the use of gas.

In a production process first the biodegradable waste is directed from the mixing tanks to the biogas reactor, where an anaerobic process takes place with a temperature in the range of 35–42 ˚C. During the process biogas, which is comprised mainly of methane and carbon dioxide, is produced from organic substances in an oxygen poor environment. The gas is then directed to the gas storage tanks (at the head of the biogas reactor) and from there to the station, where biogas is transformed into heat and electricity.

The data on methane recovery in 2010 were obtained from EEIC Air bureau, as the landfills with the system of methane collection report their quantities of recovered methane directly to the Air bureau. Accordingly the summary amount of CH_4 recovered in 2010 was 1.63 Gg (Figure 8.6). During the UNFCCC review in 2011 occurred that not all landfills are recovering methane. In Väätsa landfill, which started to collect biogas in 2009, the gas is burnt in a flare. As a recommendation by the review team, the recalculation was made and the amount of CH_4 burnt in a flare was deducted. In last Submission the reported amount of methane recovery in 2009 was 4.07 Gg, the recalculated amount in 2009 is 1.9 Gg. CH_4 and

N_2O emission from biogas burnt in a flare is reported under biological treatment (6.D) sub category.

In the period 1995–2006[186] only one landfill in Estonia collected and recovered methane (Pääsküla landfill in Tallinn). The amount of reused CH_4 during this period fluctuates due to changes in the quantity of waste generation and percentage of organic waste in the total amount of waste generated. In 2007 Jõelähtme landfill started to collect methane, which causes increase in the total amount of reused CH_4. When characterizing the time series of the methane recovery (Figure 8.6), the amount of reused CH_4 has been the highest so far in 2007, because Jõelähtme landfill started to recover methane. The falloff since 2008 is related to quantities of organic wastes disposed, also the mode of the collecting devices and power of the collecting system.

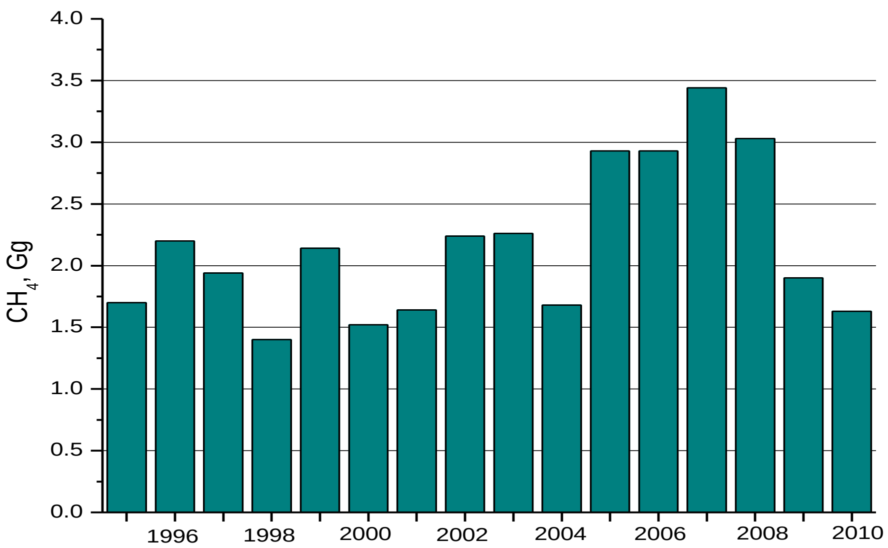

Figure 8.6. CH_4 recovered from landfills 1995-2010, Gg

8.2.2. Methodological issues

Activity data

Calculating emissions from solid waste disposal sites the total amount generated and the quantity of municipal waste generated in 2010 (collected from Estonian Environment Information Centre (EEIC) and amount of recovered methane (obtained from the EEIC Air bureau) are used as activity data.

In 2010 19.5 million tonnes of waste was generated in Estonia. About 80% of waste generated was produced by oil shale industry (wastes from mining and physical-chemical treatment, thermal processes, and other oil shale wastes[187]). The quantity of municipal waste generated in 2010 was about 440 466 tonnes (including municipal sludge), being 2.3% of the total amount of the waste generated. The total amount of waste disposed onto landfills was 11.7 millions tonnes, about 267 thousand tonnes of it comprised the municipal waste.

[186] Since 1995 CH_4 is collected and recovered in Estonia.
[187] wastes from the treatment of the oil shale and coal, e.g a pitch.

Municipal waste includes separately collected fractions – 23.5% of the total amount of municipal waste generated, garden and park wastes (5.8%) and other municipal wastes (incl. mixed municipal waste, waste from markets and street-cleaning residues, etc. – 77.4%). Compared to the year 2007 the amount of separately collected fractions has increased from 10% to 24% of the total quantity of municipal waste generated. The rise is explainable with a new requirements applied to the waste handling system, accordingly it is forbidden to deposit unsorted municipal waste to the landfills.

Methods

In order to estimate CH_4 emissions from solid waste disposal sites on landfills, the First Order Decay (the FOD) approach were employed, which is the IPCC Tier 2 method given in the IPCC Good Practice Guidance (IPCC 2000). Due to obtainable waste disposal activity data for the current inventory year and available waste disposal activity data for previous years, however country-specific key parameters are not available, the FOD method with default parameters and country-specific activity data were used.

$$CH_4\text{, Gg/year} = \sum_x [A \bullet k \bullet MSW_{T(W)} \bullet MSW_{F(X)} \bullet L_0(x) \bullet e^{-k(t-x)}] \quad (8.1)$$[188]

for x=initial year to t

t- year of inventory;
x- years for which input data should be added;
A- $(1-e^{-k})/k$ normalization factor which corrects the summation;
k- methane generation rate constant, 1/year;
$MSW_{T(W)}$ – total municipal solid waste (MSW) generated in year x, Gg/year;
$MSW_{F(X)}$ – fraction of MSW disposed at landfills in year x.

$L_0(x)$ – methane generation potential

$$L_0(x) = MCF_{(x)} \bullet DOC_{(X)} \bullet DOC_F \bullet F \bullet 16/12\text{, GgCH}_4\text{/Gg waste} \quad (8.2)$$

$MCF_{(x)}$ – methane correction factor in year x (fraction);
$DOC_{(X)}$ – degradable organic carbon (DOC) in year x (fraction), Gg C/Gg waste;
DOC_F – fraction of DOC degraded;
F – fraction by volume of CH_4 in landfill gas;
16/12 – conversion from C to CH_4.
Sum the obtained results for all years (x).

$$CH_4\text{, Gg/year} = [CH_4 \text{ generated in year } t - R(t)] \bullet (1 - OX) \quad (8.3)$$[189]

R(t) – recovered CH_4 in inventory year t, Gg/year;
OX – oxidation factor (fraction).

Emission factors

Emission factors (EFs) used in calculations of emissions from solid waste disposal sites are default emission factors from *IPCC 2000 Good Practice Guidance* and *IPCC 2006 Guidelines for National Greenhouse Gas Inventories*. The choices of the parameters are in full agreement with the information and data ranges given in the *Good Practice Guidance* (IPCC 2000).

[188] Equation 5.1 of the IPCC, 2000, pp 5.6.
[189] Equation 5.2 of the IPCC 2000, pp 5.7.

As no accurate analysis of DOC in different waste types achieved by sampling waste and measuring DOC in that waste have been made in Estonia, default DOC contents for FOD model are used in calculations (Table 8.5).

Table 8.5. Default DOC content of different waste types (wet basis)[190]

Waste group	DOC content
Municipal solid waste	
Food/Grease	0.15
Municipal	Table 8.7
Garden	0.2
Paper	0.4
Textile	0.24
Wood	0.43
Municipal sludge	0.05
Industrial waste	
Organic	0.15
Textile	0.24
Wood	0.43
Paper	0.4
Leather	0.39
Rubber	0.39
Industrial sludge	0.45

Table 8.6. Emission factors and parameters used in calculations

Factor/Parameter	Value	Reference
MCF	0.6/1	IPCC 2000, Waste, pp 5.9
DOCf	0.5	IPCC 2000, Waste, pp 5.9
F	0.5	IPCC 1996, Waste Reference Manual, pp 6.5
OX	0	IPCC 2000, Waste, pp 5.10
Methane generation rate constant		
k1=paper/textile waste	0.06	IPCC 2006, Waste, pp 3.17
k2=wood/rubber waste	0.03	IPCC 2006, Waste, pp 3.17
k3=organic/garden and park waste	0.1	IPCC 2006, Waste, pp 3.17
k4=food waste/sewage sludge	0.185	IPCC 2006, Waste, pp 3.17
k5=industrial waste	0.09	IPCC 2006, Waste, pp 3.17

Due to the earlier data on waste composition was not available; a waste composition analysis from the Netherlands was employed in earlier estimates of the FOD (for 1940–2000). However, since 2000, some research was carried out in Estonia, thus in order to estimate CH_4 emissions from solid waste landfilled, country-specific data was used since 2000. As a recommendation by UNFCCC review team (2011), waste composition data from Netherlands analysis for period 1940–2000 was replaced with country specific results from research made in Estonia in 2000 (Table 8.7).

[190] Table 2.4 and Table 2.5 of the 2006 IPCC Guidelines, pp 2.14-2.16.

On a subscription of the Ministry of the Environment a new research about waste composition of solid municipal waste (Eestis tekkinud olmejäätmete… 2008) was completed in 2008 and the new data was used to estimate methane emissions from the disposal of wastes since 2008 (Table 8.7).

During the review in 2011 Estonia presented calculation of country specific value for DOCf. The false abbrevation was used then by the inventory compiler, actual calculations was carried out about DOC content in mixed municipal waste (MSW), based on the waste composition data from Estonian analysis from 2008 and DOC content of different waste types (Table 8.8). To present country specific DOCf value, well-documented sampling and analysis on waste composition data is needed, in Estonia waste composition data has not been tested comprehensively. IPCC FOD model gives two options to calculate methane emissions from SWDS, the calculated DOC in mixed MSW can be used in *bulk waste option*. At present emissions are estimated using *waste composition option,* where default DOC contents in different waste types and country specific waste compositon data are used. As waste composition is relatively stable, both options give similar results.

Table 8.7. The waste composition of solid municipal waste, %

	1940-2000[191]	**2008-onward**[192]
Organic household waste and non-defined non separated waste	42.1	36.65
Paper and cardboard	25.3	17.53
Wood	3.3	0.44
Textiles	0.9	4.43

Table 8.8. DOC content of mixed municipal waste in Estonia in 1940–2010

	1940-2000	**2008-onward**
DOC content in MSW	0.201	0.156

8.2.3. Quantitative overview - CH_4 emissions from solid waste disposal (CRF 6.A)

In 2010 the total CH_4 emission from solid waste disposed onto landfills in Estonia was 12.5 Gg (Figure 8.7). The upturn trend of CH_4 emission emitted from disposal of different type of waste is presented in Table 8.9. As seen from the table, in 2010 the light decrease has taken place in the quantities of methane emitted from different types of biodegradable solid waste, except the emission from the garden and textile waste, which has risen. The driver for the decreasing trend in these emissions is the increasing amounts of landfill gas recovered and waste recycled.

[191] The data on waste composition of 2000 was taken from (Olmejäätmete koostise… 2000).
[192] The data on waste composition of 2008 was taken from (Eestis tekkinud olmejäätmete… 2008).

The amount of recovered landfill gas, waste recycled and unstable population which fluctuate during the time period affect also the implied emisson factor (IEF) of CH_4. The main reason to the unstable population is mostly migration to abroad, additional information about CH_4 recovery practices are described under 8.2.1 subcategory (Production of biogas).[193]

Generally it can be said, that CH_4 emission from organic and food waste, paper, sludge and emission from leather and rubber waste has decreased significantly during the last years, while emissions from garden and textiles waste have appreciably increased. CH_4 emission from the wood waste enlarged till the year 2006, in 2007 the trend fell into decay and then decreased slightly in 2010 (Table 8.9).

Table 8.9. Quantities of CH_4 emission and recovery from biodegradable solid waste disposed in landfills in 1990–2010, Gg

Year	Organic /Food	Garden	Paper	Wood	Textiles	Sludge	Leather/ Rubber	Recovery	Total CH_4 from SWDS
1990	3.66	0.080	3.63	0.72	0.11	0.063	0.070		8.65
1991	3.95	0.086	3.82	0.75	0.11	0.065	0.070		9.18
1992	4.18	0.090	4.00	0.79	0.12	0.067	0.070		9.66
1993	4.63	0.098	4.28	0.85	0.13	0.060	0.074		10.58
1994	4.82	0.103	4.47	0.88	0.13	0.050	0.074		10.99
1995	4.82	0.107	4.62	0.91	0.13	0.044	0.074	-1.7	9.59
1996	5.23	0.114	4.89	0.94	0.14	0.038	0.073	-2.2	9.75
1997	6.20	0.125	5.27	1.02	0.15	0.035	0.074	-1.94	11.83
1998	6.79	0.135	5.68	1.09	0.16	0.034	0.075	-1.4	13.54
1999	7.14	0.144	6.02	1.17	0.17	0.033	0.076	-2.14	13.53
2000	7.61	0.163	6.34	1.24	0.17	0.059	0.074	-1.52	14.94
2001	7.73	0.172	6.62	1.27	0.18	0.063	0.072	-1.64	15.17
2002	7.40	0.172	6.71	1.30	0.18	0.059	0.071	-2.24	14.24
2003	7.05	0.172	6.81	1.31	0.18	0.052	0.069	-2.26	13.88
2004	6.66	0.172	6.85	1.34	0.18	0.043	0.067	-1.68	14.06
2005	6.35	0.182	6.89	1.37	0.19	0.036	0.065	-2.93	12.50
2006	6.07	0.182	6.92	1.37	0.19	0.030	0.063	-2.93	12.19
2007	5.85	0.185	6.95	1.37	0.19	0.025	0.061	-3.44	11.45
2008	5.70	0.186	7.00	1.37	0.19	0.021	0.059	-3.03	11.72
2009	5.26	0.231	6.87	1.35	0.23	0.017	0.058	-1.90	12.29
2010	5.13	0.300	6.87	1.33	0.27	0.014	0.056	-1.63	12.50

[193] Answer to the ERT report 2011.

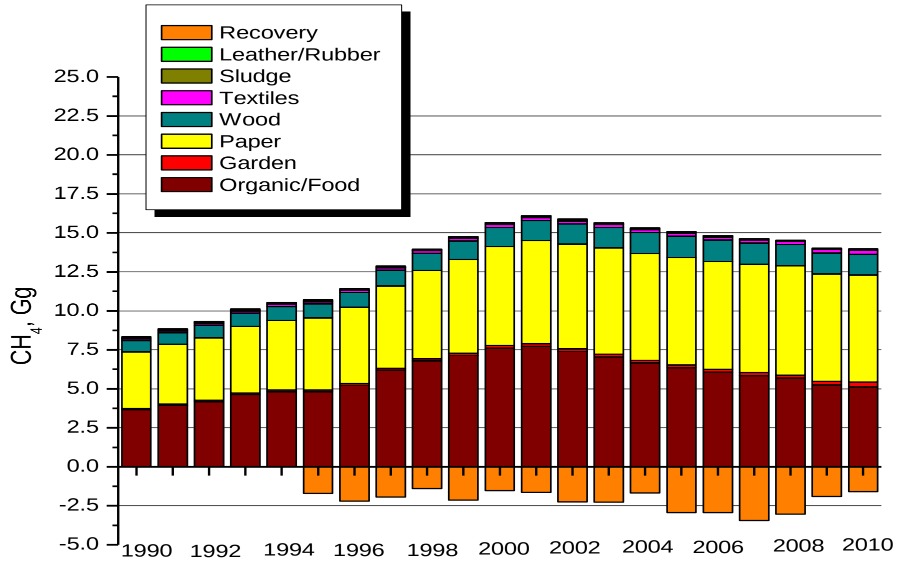

Figure 8.7. CH_4 emissions and recoveries from landfills in Estonia in 1990–2010, Gg

8.2.4. Source-specific recalculations

In 2012 Submission CH_4 emissions from solid waste disposed onto landfills were recalculated for whole time series (1990–2009) as a recommendation by UNFCCC review team (2009). Methane emissions were recalculated due to update in waste generation rate in period 1950–1990 and methane correction factor in period 1950–2010 based on reclassification of types of solid waste disposal sites. Also waste composition data from Netherlands analysis in period 1950–1999 was replaced with results from research made in Estonia in 2000[194].

The raport by the ERT in 2009 noted at first that FORECAST function used in calculations for annual waste generation rate resulted too high values and recommended to revise the values for entire time series and to use rate of 200 kg/cap/year[195] (Table 8.10). During the compiling the 2012 Submission discussion was held with experts in EEIC Waste bureau. It was decided that, as no research has been made to estimate historical waste generation considering historical production volumes, consumption habits, existing landfills, practices from neighbor countries, its complicated to value historical data. 200 kg/cap/year was used as historical waste generation rate as a recommendation by ERT.

Secondly used methane correction factor (MCF) of 1 implied that all landfills have been managed since 1940, which seems unlike. As no research has been made to classify solid waste disposal sites (SWDS) in IPCC categories, all landfills were categorized at first as *managed* by default. During the compiling the 2012 Submission, discussion was held between sector expert and experts in EEIC. It became evident that results of SWDS classification into IPCC site types bases on a distribution of waste disposals by mass between sites types not only on the number of working MSW landfills in the country. As the quantities of wastes distributed by mass between sites types need in FOD model are unknown, its complicated to

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[194] Historical data on waste disposal are necessary to estimate CH_4 emissons from landfills using the FOD method. Although ARR 2009 recommended to revise landfills data since 1940, the actual data is revised since 1950 due to the FOD model, which requires historical data as far back as 1950 (2006 IPCC, Waste, Chapter 3, pp 3.24).

[195] Gulayaev N. 1966. Municipal waste removing in cities. Moscow: Litriture for construction. P.16, table 6.

divide waste quantities between unmanaged shallow or deep landfills. It was decided to categorize all SWDS to *uncategorized* which correspond to MCF of 0.6. Since 2009 all landfills are categorized as *managed* because since then only managed landfills exist in Estonia and all municipal wastes are disposed there (Table 8.11).

Thirdly as a recommendation by the ERT in 2009 waste composition data from Netherlands analysis in period 1940–1999 was replaced with results from research made in Estonia in 2000 (Table 8.12).

In Table 8.13 recalculated CH_4 emissions due to update in waste generation rate, methane correction factor and waste composition data are presented for whole time series.

Table 8.10. Waste generation rate in period 1950–1989 in Estonia

	Reported Waste generation rate (kg/cap/yr) in 2011 Submission	Recalculated Waste generation rate (kg/cap/yr) in 2012 Submission
1950	410.5	200.0
1951	410.6	200.0
1952	410.7	200.0
1953	410.7	200.0
1954	410.8	200.0
1955	410.9	200.0
1956	411.0	200.0
1957	411.1	200.0
1958	411.2	200.0
1959	411.3	200.0
1960	411.4	200.0
1961	411.6	200.0
1962	411.8	200.0
1963	412.0	200.0
1964	412.2	200.0
1965	412.4	200.0
1966	412.6	200.0
1967	412.8	200.0
1968	413.0	200.0
1969	413.2	200.0
1970	413.4	200.0
1971	413.6	200.0
1972	413.8	200.0
1973	414.0	200.0
1974	414.2	200.0
1975	414.4	200.0
1976	416.7	200.0
1977	418.7	200.0
1978	421.0	200.0
1979	424.9	200.0
1980	429.0	200.0
1981	433.9	200.0
1982	437.1	200.0
1983	441.0	200.0

1984	445.3	200.0
1985	446.5	200.0
1986	450.0	200.0
1987	452.0	200.0
1988	455.4	200.0
1989	459.5	200.0
1990	340.5[196]	

Table 8.11. Methane correction factor (MCF) in period 1990–2010 in Estonia

	Reported MCF in 2011 Sumbission	Recalculated MCF in 2012 Submission
1990	1.0	0.6
1991	1.0	0.6
1992	1.0	0.6
1993	1.0	0.6
1994	1.0	0.6
1995	1.0	0.6
1996	1.0	0.6
1997	1.0	0.6
1998	1.0	0.6
1999	1.0	0.6
2000	1.0	0.6
2001	1.0	0.6
2002	1.0	0.6
2003	1.0	0.6
2004	1.0	0.6
2005	1.0	0.6
2006	1.0	0.6
2007	1.0	0.6
2008	1.0	0.6
2009	1.0	1.0
2010		1.0

Table 8.12. Waste composition data in period 1940–1999 in Estonia

Type of waste	Reported waste composition data (%) in 2011 Submission					Recalculated waste composition data (%) in 2012 Submission
	1940-1957	1958-1970	1971-1979	1980-1989	1990-1999	1940-1999[197]
Food	64	56	52	53	52	42
Garden	0	0	0	0	0	1
Paper	22	20	26	21	25	25
Wood	0	0	3	3	3	3

196 The increase in waste generation rate since 1990 is due to use in country specific waste generation and urban population, before 1990 no country specific data on waste generation was available, so recommended 200 kg/cap/yr value was used instead of interpolated data with FORECAST model.
197 The data on waste composition of 2008 was taken from (Eestis tekkinud olmejäätmete… 2008).

Textile	2	1	2	2	2	1
Plastics, other inert	12	23	17	21	18	28
Total, %	**100**	**100**	**100**	**100**	**100**	**100**

Table 8.13. CH_4 emissions from solid waste disposal sites in Estonia in 1990–2010, Gg

Year	Reported CH_4 emission (Gg) from SWDS in 2011 Submission	Recalculated CH_4 emission (Gg) from SWDS in 2012 Submission
1990	28.57	8.65
1991	28.03	9.18
1992	27.60	9.66
1993	28.15	10.58
1994	27.95	10.99
1995	25.95	9.59
1996	25.96	9.75
1997	28.81	11.83
1998	30.92	13.54
1999	31.05	13.53
2000	32.67	14.94
2001	32.38	15.17
2002	30.59	14.24
2003	29.44	13.88
2004	28.86	14.06
2005	26.69	12.50
2006	25.81	12.19
2007	24.59	11.45
2008	24.48	11.72
2009	22.29	12.29
2010		12.50

8.2.5. Uncertainties and time series consistency

The estimations of CH_4 emission from municipal waste disposal is carried out based on activity data and emission factors (methane correction factor-MCF, degradable organic carbon-DOC, fraction of DOC, fraction of CH_4 in landfill gas-F).

Uncertainties of default emission factors and activity data used in the estimations are derived accordingly to methodology from IPCC Good Practice Guidance. Values are presented in Table 8.14.[198]

The combined uncertainty rates related to solid waste disposal waste sub-category are reported in Chapter 8.1.4.

[198] In some cases (methane recovery, waste composition) 2006 IPCC is used for uncertainties, as in GPG 2000, no values were available for these parameters.

Table 8.14. Estimated uncertainties of parameters used in the waste sector calculations

Input	Uncertainties	References
Activity data		
Total municipal solid waste	± 10%	2000 IPCC, Waste, Table 5.2, pp 5.12
Total uncertainty of waste composition	± 10%	2006 IPCC, Waste, Table 3.5, pp 3.27
Methane recovery (R)	± 10%	2006 IPCC, Waste, Table 3.5, pp 3.27
Emission factors		
Degradable Organic Carbon (DOC)	-50,±20%	2000 IPCC, Waste, Table 5.2, pp 5.12
Fraction of DOC Dissimilated	-30%, +0	2000 IPCC, Waste, Table 5.2, pp 5.12
Methane correction factor		
=1.0	-10%...0%	2000 IPCC, Waste, Table 5.2, pp 5.12
=0.6	-50%…60%	2000 IPCC, Waste, Table 5.2, pp 5.12
Fraction of CH_4 in Landfill Gas	-0%, +20%	2000 IPCC, Waste, Table 5.2, pp 5.12
Methane generation rate constant (k)	40%	2000 IPCC, Waste, Table 5.2, pp 5.12

8.2.6. Source specific planned improvements

The activity data are kept under consideration and will be updated necessarily.

8.3. Wastewater handling (CRF 6.B)

8.3.1. Source category description

Wastewater can be source of CH_4 and N_2O when treated or disposed anaerobically, CO_2 emissions from wastewater treatment are not considered as greenhouse gases, for being biogenic origin. The most common wastewater treatment methods in developed countries, including Estonia, are centralized aerobic wastewater treatment plants, where treatment can be classified as primary, secondary, and tertiary treatment.

In Estonia (e.g. Paljassaare wastewater plant in Tallinn) domestic and industrial wastewater is treated as follows:

At first wastewater from households and commercial institutions is collected by drains to the main pumping station, where primary mechanical clearance in taking place. After that the wastewater is canalized to the wastewater treatment plant, where physical barriers remove larger solids from water and also greases, oils and sand are removed. During the secondary treatment coagulants are added and settled organic particulates are removed. Tertiary/biological treatment includes biodegradation by microorganisms in aerobic environment, and activated sludge processes with effluent of phosphor and nitrogen. Biogas, diverged in anaerobic stabilization process of sludge, is reused in several wastewater treatment processes, and in heating up the buildings situated in the plant's territory. Cleaned water is canalized into the sea, situated 3 km far from the coast by the piping system, which ends 26 m depth at the sea. The similar wastewater treatment is used also in Pärnu and Narva.

Sludge treatment

The sludge separated in several processes of cleaning the wastewater is treated as follows:

At first, the sludge is pumped to the sludge treatment plant, where it is fermentated in the methane tanks and dehydrated in centrifuges. In the anaerobic process the significant amount of biogas (including plenty of methane) is emitted, which is reused by canalizing it back to the biological treatment section, or it is used as the fuel, to generate the heat.

The sludge dehydrated and mixed with supporting substances is either composted or landfilled. The result of the sludge composted is used as a fertilizer. The emissions of CH_4 from domestic and industrial sludge were not carried out as the amount sludge was added to the total amount of waste transferred to landfills.

The total amount of wastewater generated in 2010 was 1.8 billion m^3, from which 1.5 billion m^3 was used as cooling water for the production of energy and therefore no water treatment was needed. 359.5 million m^3 of the total amount of wastewater generated needed to be handled, the quantity of wastewater, which was actually treated, using mostly aerobic treatment, was about 358.1 million m^3. As seen from the Figure 8.8, the decrease has taken place in the amounts of wastewater treated in Estonia in 1990-2010, which is likely caused by the quantities of used water decrease due to the consequence of saving (water meters in households, water saving in technological processes) and due to the a large number of closed industries.

Wastewater generation by type and economic sectors in Estonia in 2010 are presented in Table 8.15 and Table 8.16.

Table 8.15. Wastewater generation by type, 1000 m^3

Year	Total	Cooling Water	Total wastewater, exp cooling water	Mining water	Sewage	Rainfall water
2010	1 750 113.8	1 496 321.1	261 579.9	120 449.3	116 999.4	16 344

Table 8.16. Wastewater generation by economic sectors in Estonia, 1000 m^3

Year	Energy	Cooling/industry	Other	Agriculture	Domestic	Industry
2010	4 995.9	1 502 151.6	6 651.8	4 475.9	39 424.2	25 623.6

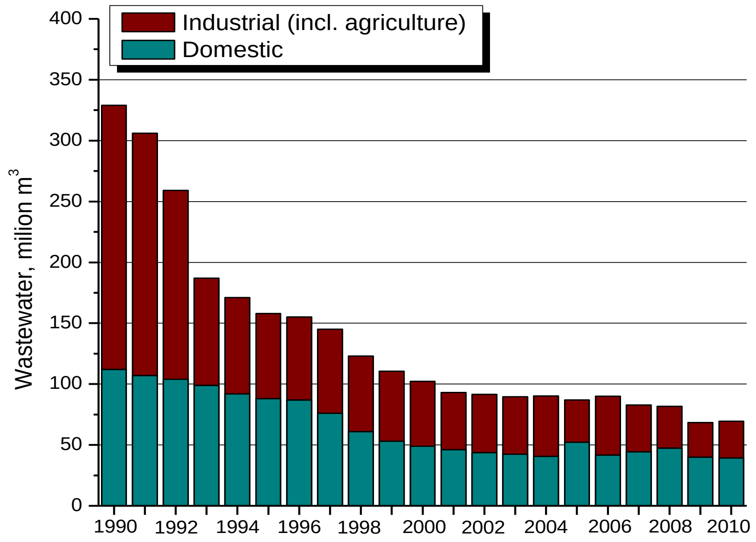

Figure 8.8. Amounts of wastewater treated in Estonia in 1990–2010, million m^3

8.3.2. Methodological issues

Activity data

The quantities of domestic and industrial wastewater generation and treatment were obtained from the datasets of the EEIC Water Bureau. The data on the population of Estonia and the amount of products produced (for equation 8.6) were derived from the SE. The amount of products produced have been used for activity data, when calculating CH_4 emissions from industrial wastewater handling. The data on the population of Estonia have been used for activity data of the CH_4 and N_2O emissions from domestic/commercial wastewater handling.

Emission factors and other parameters

Emission factors and parameters for domestic/commercial and industrial wastewaters are IPCC default values and are presented in Table 8.17.

Methodology

Estimating the emissions from domestic and industrial wastewater in anaerobic conditions, *Tier 1* method from IPCC 1996 was used. Due to country-specific parameters are not available, the IPCC Tier 1 method and default parameters was used.

$$CH_4 \text{ Emissions} = (\text{Total Organic Waste} \bullet \text{Emission Factor}) - \text{Methane Recovery} \quad (8.4)$$[199]

Domestic wastewater (CH_4):

$$TOW_{dom} = P \bullet D_{dom} \quad (8.5)$$[200]

TOW_{dom} - Total domestic/commercial organic wastewater in kg BOD/year;
TOS_{dom} – Total domestic/commercial organic sludge in kg BOD/year;
P – Population in 1000 persons;

[199] IPCC 1996, Waste, pp. 6.22, equation 12.
[200] IPCC 1996, Waste. pp 6.18, equation 6.

D_{dom} – Domestic/commercial degradable organic component in kg BOD/1000 persons/year;

Industrial wastewater (CH_4):

$$TOW_{ind} \text{ (kg COD/year)} = W \bullet O \bullet D_{ind} \bullet (1\text{-}DS_{ind}) \quad (8.6)$$[201]

TOW_{ind} – Total industrial organic wastewater in kg COD/year;
TOS_{ind} – Total industrial organic sludge in kg Cod/year;
W – Wastewater consumed in m^3/tonne of product;
O – Total output by selected industry in tonnes/year;
D_{ind} – Industrial degradable organic component in kg COD/m3 wastewater;
DS_{ind} – Fraction of industrial degradable organic component removed as sludge.

$$EF_i = B_0 \bullet \sum (WS_{ix} \bullet MCF_x) \quad (8.7)$$[202]

EF_i – emission factor (kg CH_4/kg DC) for wastewater type
B_{0i} – maximum methane producing capacity (kg CH_4/kg DC) for wastewater type I
WS_{ix} – fraction of wastewater type i treated using wastewater handling system x
MCF_x – methane conversion factors of each wastewater system x

Estimating methane emission from industrial wastewater, total industrial output (products in tonnes per year) was calculated based on the main industry types producing wastewater in Estonia (food/beverage, paper/pulp, paints, fertilizers, soap/detergents). As activity data for 1990-1994 was insufficient, total industrial output for years 1990–1994 was calculated based on the wastewater output data derived from CRF Reporter and default Wastewater generation rates.[203] Multiplying total industrial output and default industrial wastewater data (GPG 2000, pp 5.22, Table 5.4) total organic wastewater from specific industrial source was found. Net methane emission from industrial wastewater handling was calculated based on the default emission factors and quantities of total organic wastewater derived from industrial source.

Estimating the N_2O emissions from domestic wastewater, *Tier 1* method from IPCC 2006 was used.

Domestic wastewater (N_2O):

$$N_2O \text{ Emissions} = N_{EFFLUENT} \bullet EF_{EFFLUENT} \bullet 44 / 28 \quad (8.8)$$[204]

N_2O emissions = N_2O emissions in inventory year, kg N_2O/year
$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments, kg N/year
$EF_{EFFLUENT}$ = emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N
The factor 44/28 is the conversion of kg N_2O-N into kg N_2O

$$N_{EFFLUENT} = P \bullet Protein \bullet F_{NPR} \bullet F_{NON-CON} \bullet F_{IND-COM} - N_{SLUDGE} \quad (8.9)$$[205]

$N_{EFFLUENT}$ = total annual amount of nitrogen in the wastewater effluent, kg N/year
P = human population
Protein = annual per capita protein consumption, kg/person/year

201 IPCC 1996, Waste. pp 6.19, equation 8.
202 IPCC 1996, Waste. pp 6.21, equation 10.
203 IPCC 2000. Waste. Table 5.4, pp 5.22.
204 IPCC 2006. Waste, pp. 6.25, equation 6.7.
205 IPCC 2006. Waste, pp. 6.25, equation 6.8.

F_{NPR} = fraction of nitrogen in protein, kg N/kg protein
$F_{NON-CON}$ = factor for non-consumed protein added to the wastewater
$F_{IND-COM}$ = factor for industrial and commercial co-discharged protein into the sewer system
N_{SLUDGE} = nitrogen removed with sludge, kg N/year

Table 8.17. Emission factors and parameters used in the calculations of wastewater treatment

Factor/parameter	Value	Reference
Domestic wastewater (CH_4)		
D_{dom} (kg BOD/1000 persons/ year)	18.250	IPCC 1996, Waste. pp 6.23, Table 6-5
COD (kg COD/m^3)	Variable	IPCC 2000, Waste Chapter, Table 5.4, pp 5.22
WS_{ix}	0.01	Estonian NIR 2006,Table 6.14
Domestic wastewater (N_2O)		
$EF_{EFFLUENT}$	0.005	IPCC 2006,Waste, pp 6.25
F_{NPR}	0.16	IPCC 2006,Waste, pp 6.25
$F_{NON-CON}$	1.4	IPCC 2006,Waste, pp 6.25
$F_{IND-COM}$	1.25	IPCC 2006,Waste, pp 6.25
N_{SLUDGE}	0	IPCC 2006,Waste, pp 6.25
Industrial wastewater		
B_0 (kg CH_4/Kg BOD)	0.25	IPCC 1996, Waste. pp 6.20
WS		
-Domestic	Variable	Estonian NIR 2006, Waste Chapter, Table 6.14
-Industrial	Variable	Estonian NIR 2004, Waste Chapter, Table 6.15
MCF	0.6	Estonian NIR 2006, Waste Chapter, Table 6.14, 6.15
WS_{ix}	0.01	Estonian NIR 2006,Table 6.14

8.3.3. Quantitative overview – CH_4 and N_2O emissions from domestic/ commercial (w/o human sewage) and industrial wastewater handling

In 2010 the total amount of CH_4 emission from domestic and commercial wastewater handling was 0.0367 Gg (Figure 8.9). So far, the quantity of CH_4 emission has been the highest in 1993, as the amount of wastewater treated by the anaerobical handling system was the greatest. As seen from the figure, the trend of CH_4 emission from domestic and commercial wastewater has stabilizised since 2004 because the fraction of the anaerobical treatment in wastewater handling system has decreased, as wastewater is mostly treated using aerobic treatment.

In 2010 the total amount of N_2O emission from domestic and commercial wastewater handling was 0.098 Gg (Figure 8.10). As seen from the figure, since 1990 until 2010, the emissions have declined slightly due to decrease in human population. In addition fluctuation in time series is related to changes in per capita protein consumption, which has been lowest between 2000 to 2004 – 32.485 kg/cap/yr and highest in the first decade of the period – 35.405 kg/cap/yr.

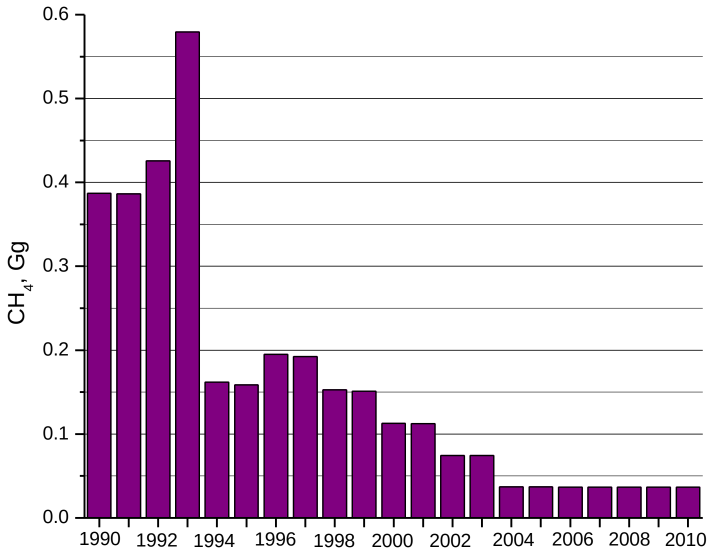

Figure 8.9. CH_4 emissions from domestic/commercial wastewater handling in 1990–2010, Gg

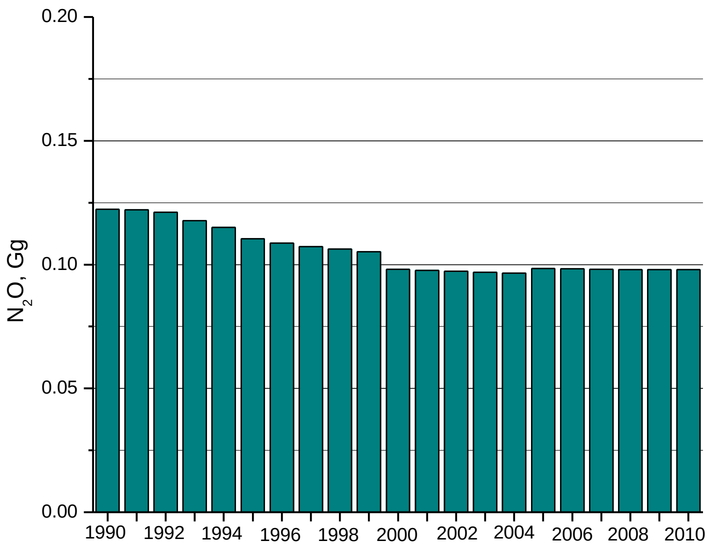

Figure 8.10. N_2O emissions from domestic/commercial wastewater handling in 1990–2010, Gg

In 2010 the total amount of CH_4 emission from industrial wastewater handling was 0.250 Gg (Figure 8.11). As seen from the figure in period 1990–1993 quantities of the CH_4 emissions decreased, which is due to the collapse of The Soviet Union market, that caused Estonia's pulp and paper industry breakdown and a large number of closed industries (in 1991 Maardu chemical combine stop working). The increase in the quantities of the methane emissions from industrial wastewater the period 1995–2000 is related to the increase in the production output of pulp and paper industries and the increase of the fraction of wastewater treated by the anaerobical handling system.

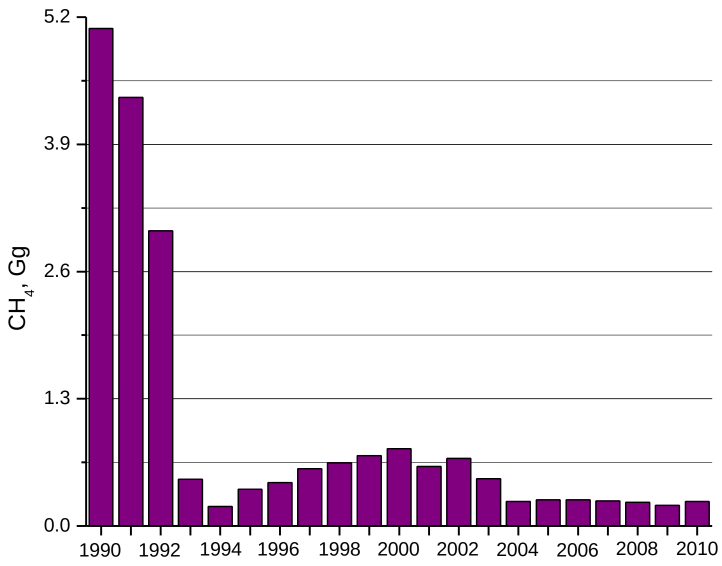

Figure 8.11. CH_4 emissions from industrial wastewater handling in 1990–2010, Gg

8.3.4. Source-specific recalculations

Under industrial wastewater handling CH_4 emission in 2009 was recalculated because data of total industrial output in 2009 was updated due to activity data of production and wastewater output was corrected in databases of Estonian Statistics in 2011 (Table 8.18).

According to the recommendation of European Commission N_2O emission from UNFCCC CRF 6.B.2.1 subcategory was estimated for the first time in 2011 Submission. In 2012 Submission emissions are recalculated for whole time series due to update in per capita protein consumption in period 1990–2009 (Table 8.19).

Table 8.18. Total industrial output and CH_4 emissions from industrial wastewater handling in 2009

Industry type	Total industrial output (t/year) (the 2010 submission)	Reported emissions of CH_4 in 2009, Gg (the 2010 submission)	Total industrial output (t/year) (the 2011 submission)	Recalculated emissions of CH_4 in 2009,Gg (the 2011 submission)
Paints	21 400	0.207	21 300	0.210
Fertilizers	0		9 400	
Food and beverage	972 025		977 955	

Table 8.19. N_2O emissions from Domestic and commercial wastewater handling in Estonia in 1990–2010, Gg

Year	Reported per capita protein consumption 2011 Submission	Reported N_2O emission from Domestic/commercial Wastewater in 2011 Submission	Updated per capita protein consumption 2012 Submission	Recalculated N_2O emission from Domestic/commercial Wastewater in 2012 Submission
	2009	2009	2010	2010
1990	32.85	0.1135	35.405	0.1223
1991	32.85	0.1133	35.405	0.1221
1992	32.85	0.1124	35.405	0.1211
1993	32.85	0.1092	35.405	0.1177
1994	32.85	0.1067	35.405	0.1150
1995	32.85	0.1047	34.675	0.1105
1996	32.85	0.1030	34.675	0.1087
1997	32.85	0.1016	34.675	0.1073
1998	32.85	0.1007	34.675	0.1063
1999	32.85	0.0997	34.675	0.1052
2000	32.85	0.0992	32.485	0.0981
2001	32.85	0.0988	32.485	0.0977
2002	32.85	0.0984	32.485	0.0973
2003	32.85	0.0980	32.485	0.0969
2004	36.87	0.1096	32.485	0.0966
2005	36.87	0.1093	33.215	0.0985
2006	36.87	0.1091	33.215	0.0983
2007	36.87	0.1089	33.215	0.0981
2008	36.87	0.1088	33.215	0.0980
2009	36.87	0.1087	33.215	0.0979
2010			33.215	0.0979

8.3.5. Uncertainty and time series consistency

The estimation of CH_4 emissions from wastewater handling is carried out taking into account activity data (industrial production, human population) and emission factors. Default uncertainty ranges for domestic and industrial wastewater are presented in Table 8.20[206].

The estimation of N_2O emissions from domestic wastewater is carried out based on 2006 IPCC Guidelines. Uncertainties of default emission factors and activity data used in the estimations are derived accordingly to methodology from 2006 IPCC Guidelines. The combined uncertainty rates related to wastewater handling sub category are reported in Chapter 8.1.4.

Table 8.20. Default uncertainty ranges for domestic and industrial wastewater

Input	Uncertainties	References
Domestic wastewater (CH_4)		
Human Population	±5%	IPCC GPG 2000, pp 5.19,

[206] Although IPCC 1996 Guidelines are used to calculate CH_4 emissions, IPCC GPG values for uncertainties are used, as in 1996 Guidelines the uncertainties are unavailable.

		table 5.3
BOD/person	±30%	IPCC GPG 2000, pp 5.19, table 5.3
Maximum Methane Producing Capacity (B_o)	±30%	IPCC GPG 2000, pp 5.19, table 5.3
Industrial wastewater (CH_4)		
Industrial Production	±25	IPCC GPG 2000, pp 5.23, table 5.5
Wastewater /unit production COD/unit wastewater	-50%, + 100%	IPCC GPG 2000, pp 5.23, table 5.5
Maximum Methane Producing Capacity (B_o)	±30%	IPCC GPG 2000, pp 5.23, table 5.5
Domestic wastewater (N_2O)		
$E_{EFLUENT}$	±98%	IPCC 2006, pp 6.27, table 6.11
Population	±10%	IPCC 2006, pp 6.27, table 6.11
Protein consumption	±10%	IPCC 2006, pp 6.27, table 6.11
F_{NPR}	±7%	IPCC 2006, pp 6.27, table 6.11
$F_{NON\text{-}CON}$	-29%, +7%	IPCC 2006, pp 6.27, table 6.11
FIND-COM	±20%	IPCC 2006, pp 6.27, table 6.11

8.3.6. Source specific planned improvements

The activity data are kept under consideration and will be updated necessarily.

8.4. N_2O emission from human consumption followed by municipal sewage treatment (CRF 6.B.2.2)

8.4.1. Source category description

Human consumption of food results in the production of sewage, that can be processed in septic systems or wastewater treatment facilities, and may then seep into underground systems, be disposed or directly on land, or be discharged into a water source (e.g. rivers and estuaries (IPCC 2000).

8.4.2. Methodological issues

Activity data

The data on population of Estonia was used as activity data and was obtained from the dataset of the SE. The annual per capita protein consumption was used from FAO statistical databases and was updated for whole time series in 2012 Submission as a recommendation by UNFCCC review team 2009.

Methodology

The default IPCC (the *Tier 1*) method was used to estimate emissions from the atmospheric deposition. Due to country-specific EF values are not available, the IPCC Tier 1 method and mix of country-specific (the national population) and other available data (protein consumption) and default EF was used.

$$N_2O - N = PROTEIN \bullet Nr_{PEOLPE} \bullet Frac_{NPR} \bullet EF_6 \quad (8.10)$$ [207]

PROTEIN – the annual per capita protein consumption, kg protein/person-year;
Nr_{PEOLPE} – the national population;
$Frac_{NPR}$ – the fraction of protein that is nitrogen, kg N/kg of protein.

Emission factors

Emission factors used in the calculations are default emission factors from IPCC 1996 and IPCC 2000 Agriculture chapter.

Table 8.21. Factors used in the algorithm of human consumption followed by municipal sewage treatment

Factor	Value
$Frac_{NPR}$	0.16 kg N/kg of protein[208]
EF_6	0.01 kg N_2O-N/ kg N discharged sewage effluent[209]

8.4.3. Quantitative overview – Human consumption followed by municipal sewage treatment

The total N_2O emission from human sewage in Estonia in 2010 was 0.112 Gg (Figure 8.12). Since 1990 until 2010, the emissions have declined slightly due to decreasing population. In addition fluctuation in time series is related to changes in per capita protein consumption, which has been lowest between 2000 to 2004 – 32.485 kg/cap/yr and highest in the first decade of the period – 35.405 kg/cap/yr.

[207] IPCC 2000. Agriculture. Equation 4.39, pp. 4.72.
[208] IPCC 1996. Agriculture. Reference manual. Table 4-24 – Default values of parameters for indirect emissions. pp. 4.106.
[209] IPCC 1996. Agriculture. Workbook. Table 4-18 – Default emission factors for estimating indirect N2O emissions from N used in agriculture. pp. 4.73.

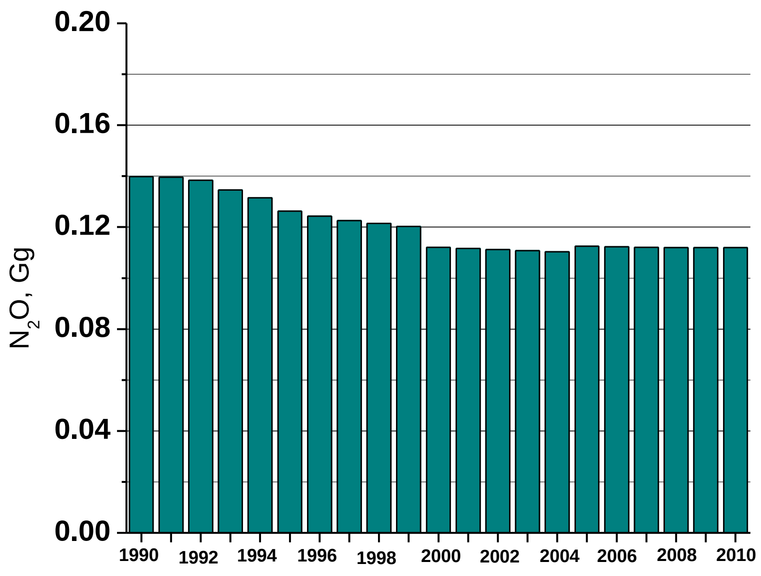

Figure 8.12. N_2O emissions from human sewage in Estonia in 1990–2010, Gg

8.4.4. Source specific recalculations

N_2O emissions from human sewage were recalculated for whole time series due to update in per capita protein consumption from FAO databases (Table 8.22).

Table 8.22. N_2O emissions from human sewage in 1990–2010 in Estonia, Gg

Year	Reported per capita protein consumption (kg/per/yr) 2011 Submission	Reported N_2O emission (Gg) from Sewage Sludge in 2011 Submission	Updated per capita protein consumption (kg/per/yr) 2012 Submission	Recalculated N_2O emission (Gg) from Sewage Sludge in 2012 Submission
	2009	2009	2010	2010
1990	32.85	0.130	35.405	0.140
1991	32.85	0.129	35.405	0.140
1992	32.85	0.128	35.405	0.138
1993	32.85	0.125	35.405	0.135
1994	32.85	0.122	35.405	0.131
1995	32.85	0.120	34.675	0.126
1996	32.85	0.118	34.675	0.124
1997	32.85	0.116	34.675	0.123
1998	32.85	0.115	34.675	0.121
1999	32.85	0.114	34.675	0.120
2000	32.85	0.113	32.485	0.112
2001	32.85	0.113	32.485	0.112
2002	32.85	0.112	32.485	0.111
2003	32.85	0.112	32.485	0.111
2004	36.87	0.125	32.485	0.110
2005	36.87	0.125	33.215	0.113
2006	36.87	0.125	33.215	0.112

2007	36.87	0.124	33.215	0.112
2008	36.87	0.124	33.215	0.112
2009	36.87	0.124	33.215	0.112
2010			33.215	0.112

8.4.5. Uncertainty and time-series consistency

The data on protein consumption per capita were plotted from FAO databases; the uncertainty of this parameter is not recorded. The uncertainty in number of population was described in the Domestic and Commercial Wastewater chapter.

The nitrogen (N_2O) emission factor is presented in the IPCC 1997. The IPCC gives an uncertainty of the factor –80%…100%, as a value of the factor is 0.01 with a range of 0.002-0.02.

The combined uncertainty rates related to human sewage sub category are reported in Chapter 8.1.4.

Table 8.23. Estimated values of uncertainties used in waste sector

Input	Uncertainties	References
Activity data Population	±5%	IPCC, 2000. Waste, pp. 5.19
Emission factor Emission factor (human sewage)	-80%…100%	IPCC GPG 2000. Agriculture, pp 4.75

8.4.6. Source specific planned improvements

The activity data are kept under consideration and will be updated necessarily.

8.5. Waste incineration (CRF 6.C)

8.5.1. Source category description

Waste incineration is defined as the high temperature combustion of solid and liquid waste in controlled incineration facilities. Types of waste incinerated include municipal solid waste, industrial waste, sewage sludge, and hazardous and clinical waste. Relevant greenhouse gases emitted in the processes of incineration and open burning of waste include carbon dioxide, methane and nitrous oxide. In this chapter emissions of CO_2 and N_2O are covered.

In Estonia there are several enterprises, where waste incineration system is used to generate fuel and energy to keep equipment in work. Mostly hazardous wastes e.g solvents, paint and petroleum, are burnt in “Kunda Nordic Tsement AS” factory, which produces constructional cements and crused limestone, and factory of constructional materials “Maxit Estonia” in Pärnu County. Also one of the Estonians biggest hazardous wastes handling company “Epler & Lorenz AS” has a waste incineration system with a purpose to incinerate hazardous waste.

According to Estonian National Waste Management Plan for years’ 2008–2013 one possible scenario to improve waste management system, points out the idea that extra two waste incineration plants should be planned with a purpose to generate heat and energy, and reduce the amount of municipal wastes deposited on to landfills.

8.5.2. Methodological issues

Activity data

Under Waste Sector emissions from waste incineration without energy recovery are reported. The activity data on amounts of waste incinerated is collected and reported by the EEIC. The data on 1990–1994 was interpolated basing on rough assumptions.

In 2010 the quantity of waste from waste incineration without energy recovery was 21 tonnes (Table 8.24). In 2008 the quantity of waste from waste incineration without energy recovery didn't occurred in Estonia, as all wastes were combusted to generate fuel or energy. As waste incineration with energy recovery is part of the energy sector, the data and emissions will be reported under the energy sector.

Table 8.24. Amounts of waste incinerated in Estonia in 1990–2010, tonnes[210]

Year	Inert waste	Leather and Rubber	Municipal Waste	Petroleum-products and Oils	Organic Waste	Paper	Plastic	Sludge	Textiles	Wood	Total
1990[211]	41	6	12	165	27	117	10	1	22	0	402
1991	41	6	12	164	27	117	10	1	22	0	401
1992	41	6	12	163	27	117	10	1	22	0	401
1993	41	6	12	164	27	117	10	1	22	0	402
1994	41	6	12	167	27	117	10	1	22	0	404
1995	41	15	23	292	15	389	5	2	61	0	847
1996		2	14	149	24	35	4		25	0	253
1997		4	2	90	55	40	12		2	0	206
1998	41	5	8	135	14	7	19		0	90	319
1999	122			145		16	10			4 643	4 940
2000	466		3	2	41	2	5			815	1 341
2001	436			2	482	19		13		3	961
2002	125			124	15	10			135	272	696
2003	86			203	3	3		1	130	122	566
2004	87			25	1	2			321		481
2005	63			106	0	2			176	10	366
2006					0				40		41
2007									14	7	21
2008											0
2009						2					2
2010						3				18	21

[210] D10 operation of the waste disposal activities – Incineration on land.
[211] The data of 1990-1994 was interpolated.

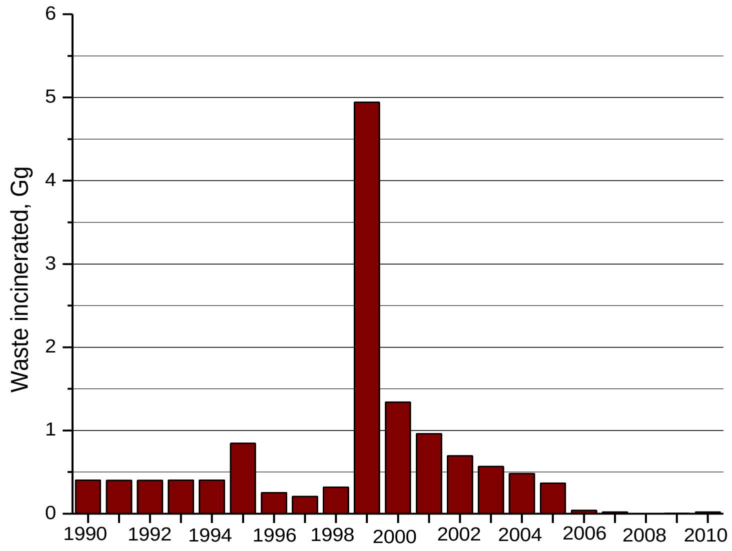

Figure 8.13. Amounts of waste incinerated without energy recovery in Estonia in 1990–2010, Gg

As seen from the previous figure there has been a sharp increase in the amounts of waste incinerated in 1995 and 1999–2000. The remarkable fluctuation of quantities is due to the large amounts of waste from paper, wood, inert, petroleum-products and oils were incinerated in these years. Generally the trend of waste incineration has decreased through the years since 2000 and has reached 21 tonnes in 2010, as more and more waste is recycled, composted or incinerated with the purpose to generate energy and the amount of waste appropriate for combustion without energy recovery is therefore minimized.

Methods

IPCC 2006 Tier 1 approach was employed in order to estimate CO_2 emissions from solid waste burnt in controlled incineration facilities (IPCC, 2006). CO_2 emission estimate based on the total amount of waste combusted. Due to emission factors are IPCC default values, Tier 1 method was used.

$$CO_2 \text{ emissions, Gg/year} = \sum_i (SW_i \bullet dm_i \bullet CF_i \bullet FCF_i \bullet OF_i) \bullet 44/12 \quad (8.11)$$[212]

CO_2 emissions - CO_2 emissions in inventory year ,Gg/year;
SW_i – total amount of solid waste of type *i* (wet weight) incinerated, Gg/year;
dm_i – dry matter content in waste (wet weight) incinerated, (fraction);
CF_i – fraction of carbon in the dry matter (total carbon content), (fraction);
FCF_i – fraction of fossil carbon in the total carbon, (fraction);
OF_i – oxidation factor (fraction)
type of waste incinerated specified as follows:

MSW: municipal solid waste
ISW: industrial solid waste
SS: sewage sludge
HW: hazardous waste
CW: clinical waste, others (that must be specified)

[212] IPCC 2006, Waste. Chapter 5, pp. 5.7, equation 5.1.

Emission factors

Emission factors (EFs) used in calculations of emissions from waste incineration are default emission factors from *IPCC 2006 Guidelines for National Greenhouse Gas Inventories* (Table 8.25).

Table 8.25. Default dry matter content, total carbon content and fossil carbon content of different waste components[213],[214],[215]

Waste component	Dry matter content in % of wet weight	Total carbon content in % of dry matter	Fossil carbon fraction in % of total carbon
Municipal waste			
Paper/cardboard	90	46	1
Textiles	80	50	20
Food waste	40	38	-
Wood	85	50	-
Garden and park waste	40	49	0
Rubber and Leather	84	67	20
Plastics	100	75	100
Other, inert waste	90	3	100
Industrial waste			
Food, beverages and tobacco	40	15	-
Textile	80	40	16
Wood and wood products	85	43	-
Pulp and paper	90	41	1
Petroleum products, Solvents			
Plastics	0	80	80
Rubber	84	56	17
Hazardous waste	10-90	NA	5-50
Clinical waste	65	40	25

In order to estimate N_2O emissions from solid waste burnt in controlled facilities *Tier 1* approach was employed (IPCC, 2006). N_2O emission estimate based on the waste input to the incineration. Due to emission factors are IPCC default values, Tier 1 method was used.

$$N_2O \text{ emissions, Gg/year} = \sum_i (IW_i \bullet EF_i) \bullet 10^{-6} \quad (8.12)$$ [216]

N_2O emissions - N_2O emissions in inventory year, Gg/year;
IW_i – amount of incinerated waste of type *i*, Gg/year;
EF_i – N_2O emission factor for waste of type *i*, kg N_2O/Gg of waste;
10^{-6} – conversion to gigagram;
i – category or type of waste incinerated specified as follows:

MSW: municipal solid waste
ISW: industrial solid waste
SS: sewage sludge
HW: hazardous waste

[213] Table 2.4 of the 2006 IPCC Guidelines, pp. 2.14.
[214] Table 2.5 of the 2006 IPCC Guidelines, pp. 2.16.
[215] Table 2.6 of the 2006 IPCC Guidelines, pp. 2.16.
[216] IPCC 2006, Chapter 5, pp. 5.14, equation 5.5.

CW: clinical waste, others (that must be specified)

Emission factors

Emission factors (EFs) used in calculations of emissions from waste incineration are default emission factors from *IPCC 2000 Good Practice Guidance* and *IPCC 2006 Guidelines for National Greenhouse Gas Inventories* (Table 8.26).

Table 8.26. N_2O emission factors for incineration of waste[217]

Waste category	Emission factor, g N_2O/t waste incinerated	Weight basis
MSW	8[218]	Wet basis
Industrial waste	100	Wet basis
Sludge (except sewage sludge)	450	Wet basis
Sewage sludge	900	Wet basis

8.5.3. Quantitative overview - CO_2 and N_2O emissions from solid waste incineration

In 2010 CO_2 emission from waste incineration without energy recovery was 0.000046 Gg and N_2O emission from waste incineration without energy recovery was 0.000168 Gg (Figure 8.14).

In 2008 no CO_2 and N_2O emissions emitted from solid waste incineration without energy recovery, as all wastes were burnt with a purpose to generate energy, emissions from waste incineration with energy recovery will be reported under energy sector.

The sharp increases in CO_2 and N_2O emissions in 1995 was due to large amounts of paper, petroleum-products and oils waste was incinerated, the increase in 2000–2001 was due to large amounts of wood and inert waste was incinerated The Figure 8.14 shows that the trend of the GHG emissions from incineration has been decreasing after the sharp upturn in 2004, it is because the quantities of the wastes used in combustion has been reduced.

As a large fraction of the carbon in waste combusted (e.g., paper, food waste, wood) is derived from biomass raw materials which are replaced by regrowth on an annual bases, these emissions should not be considered net anthropogenic CO_2 emissions in the IPCC Methodology. These CO_2 emissions are reported as an information item under Waste Sector. CO_2 emissions from oxidation during incineration of carbon in waste of fossil origin (e.g., plastics, rubber, liquid solvents, waste oils) are considered net emissions and are included in the national estimations under Energy Sector[219].

[217] Table 5.5 of the 2006 IPCC Guidelines, Chapter 5, pp. 5.21.
[218] An experience of Germany.
[219] 2006 IPCC, Chapter 5, Waste, pp 5.5.

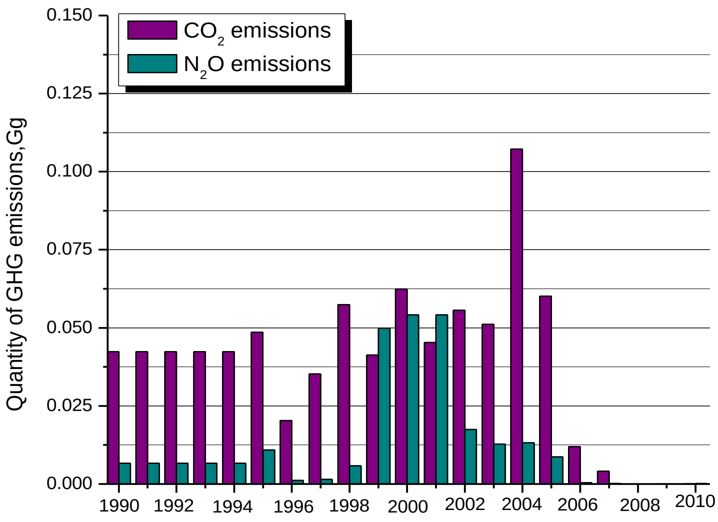

Figure 8.14. CO_2 and N_2O emissions from waste incineration without energy recovery in Estonia in 1990–2010, Gg

8.5.4. Source-specific recalculations

No source specific recalculations were made in 2012 Submission.

8.5.5. Uncertainties and time series consistency

The estimation of GHG emissions from waste combustion is carried out taking into account the activity data (amount of waste burnt) and emission factors. Uncertainties of default emission factors and activity data used in the estimations are derived accordingly to methodology from 2006 IPCC Guidelines. Values employed in the estimates are presented in Table 8.27.

The combined uncertainty rates related to waste incineration sub-category are reported in Chapter 8.1.4.

Table 8.27. Estimated values of uncertainties used in 'Waste Incineration' category of the Waste sector

Input	Uncertainties	References
Activity data		
Amounts of waste incinerated	±5%	IPCC 2006, Waste, pp. 5.24
Emission Factors		
Total carbon content:		
Paper/cardboard	±9%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Textiles	-50%…0%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Food waste	-47%…+32%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Wood	±8%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Garden and park waste	-8%…+8%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Plastics	-11%…+13%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Other, inert waste	-100%…+30%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Hazardous waste	±82%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Fossil carbon fraction:		
Paper/cardboard	-100%…+400%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Textiles	-100%…+150%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Plastics	-5%…0%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Other, inert waste	-50%…0%	IPCC 2006, Waste, Table 2.4, pp. 2.14
Hazardous waste	±82%	IPCC 2006, Waste, Table 2.4, pp. 2.14

8.5.6. Source specific planned improvements

The activity data are kept under consideration and will be updated necessarily.

8.6. Biological treatment (Composting) of waste (CRF 6.D)

8.6.1. Source category description

Many advantages attend to biological treatment, like reduced volume in the waste material, stabilization of the waste, destruction of waste material and production of biogas for energy use. Composting of solid organic wastes, such as food waste, garden and park waste and sludge is an aerobic process with bacteria, where the large fraction of degradable organic carbon (DOC) in the waste material is converted into carbon dioxide. As CO_2 is formed during the aerobic conditions of composting with an inflow of oxygen, the emissions are not carried out for being biogenic origin. CH_4 is formed in anaerobic sections of the compost, but it is also oxidized to a large extent in the aerobic sections of the compost. The process of composting can also produce emissions of N_2O. In the current chapter the emissions of CH_4 and N_2O are covered.

8.6.2. Methodological issues

Activity data

The quantities of waste composted in 2010 are used as activity data. The data is provided by EEIC. In 2010 783 038 tonnes of wastes were treated biologically (composted) in Estonia; it made up 6.7% of the total amount of waste disposed. Compared with the year 2009 the amount of wastes composted has increased, as large amounts of paper and wood waste have been composted (Table 8.28).

Inert and petroleum product wastes consist of oils and stone, waste from the oil shale industry, and plastic waste were not taken into account in the estimates of emissions from waste composting processes.

Table 8.28. Amounts of waste used for composting in Estonia in 1990–2010, tonnes[220]

Year	Leather and Rubber	Municipal Waste	Organic Waste	Paper	Sludge	Textiles	Wood	Total
1990	n.d.[221]	n.d.	3 751	364	127	144	2 753	7 139
1991	n.d.	n.d.	3 948	383	127	144	2 898	7 500
1992	n.d.	n.d.	4 156	404	127	144	3 050	7 881
1993	n.d.	n.d.	4 375	425	127	144	3 211	8 282
1994	n.d.	n.d.	4 605	447	127	144	3 380	8 703
1995	1	1	4 847	471	127	366	3 558	9 371
1996	3		30 481	846		59	133	31 522
1997	11		62 341	890	102	72	1 993	65 409
1998	61		4 340	565	78	80	1 494	6 618
1999			6 226	600	220	319	3 480	10 845
2000			22 073	830	120	419	3 277	26 719
2001			20 241	775	12 168		2 498	35 682
2002			20 992	694	6 104	54	71 109	98 953
2003		84	130 504	2 988	35 904	83	128 339	297 902
2004		3 752	110 599	3 657	55 062	344	229 993	403 407
2005		1 210	184 907	5 032	68 527	52	220 197	479 925
2006		54	176 229	6 564	84 575	109	402 866	670 397
2007		39	147 632	5 757	161 147	34	465 204	779 813
2008		2 207	222 052	4 950	131 472	12	325 014	685 707
2009		10 172	202 866	2 226	144 666	0	303 696	663 626
2010		10 141	168 088	3 917	146 718	0	454 174	783 038

[220] The data of 1990-1995 were interpolated basing on rough assumptions made.
[221] n.d not determined.

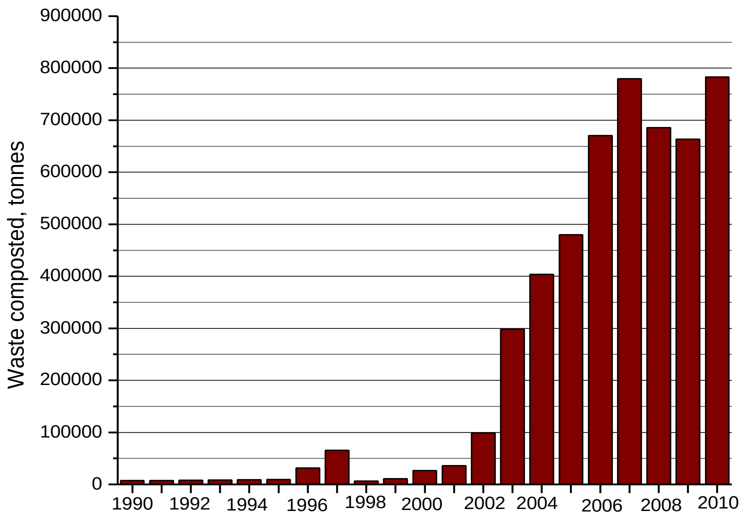

Figure 8.15. Amounts of organic waste used in biological treatment in Estonia in 1990–2010, tonnes

As seen from the previous figure (Figure 8.15) the amounts of organic waste used in biological treatment have been marginal in the first decade of the period and started to enlarge sharply since 2000 and have increased hundredfold – from 7 139 tonnes in 1990 to 783 038 tonnes in 2010. The increase in 1996–1997 is caused by large quantities of wastes from manures are reported under composting activities. The volume of wastes for composting have enlarged significantly in recent years due to obligations stated with Waste Act in 2004[222], where percentage limitation of quantities of organic wastes disposed in landfills is enacted by time periods.

Methods

In order to estimate emissions from biological treatment of solid waste *Tier 1* approach was used (IPCC, 2006), due to emission factors are IPCC default values.

$$CH_4, Gg = \sum_i (M_i \bullet EF_i) \bullet 10^{-3} - R \quad (8.13)$$ [223]

CH_4 emissions – total CH_4 emissions in inventory year, Gg CH_4;
M_i – mass of organic waste treated by biological treatment type *i*, Gg;
EF – emission factor for treatment *i*, g CH_4/kg waste treated;
R – total amount of CH_4 recovered in inventory year, Gg CH_4;
i – composting or anaerobic digestion.

$$N_2O, Gg = \sum_i (M_i \bullet EF_i) \bullet 10^{-3} \quad (8.14)$$ [224]

N_2O emissions – total N_2O emissions in inventory year, Gg N_2O;
M_i – mass of organic waste treated by biological treatment type *i*, Gg;
EF – emission factor for treatment i, g N_2O/kg waste treated;
i– composting or anaerobic digestion.

[222] Estonian Waste Act
[223] IPCC 2006, Chapter 4, equation 4.1, pp. 4.5.
[224] IPCC 2006, Chapter 4, equation 4.2, pp. 4.5.

Emission factors

Emission factors (EFs) used in calculations of emissions from biological treatment of wastes are default emission factors from *IPCC 2006 Guidelines for National Greenhouse Gas Inventories* (Table 8.29).

Table 8.29. Default emission factor for CH_4 and N_2O emissions from biological treatment of waste[225]

Type of biological treatment	CH_4 emission factor (g CH_4/kg waste treated)	N_2O emission factor (g N_2O/kg waste treated)
Composting	4	0.3

8.6.3. Quantitative overview - CH_4 and N_2O emissions from biological treatment of waste

N_2O emissions from biological treatment of waste were 0.23 Gg and CH_4 emissions 3.13 Gg in 2010 (Figure 8.16). As seen from the figure the emissions of CH_4 and N_2O follow the same trend as the amount of waste biologically treated changes. The sharp upturn in the quantities of CH_4 emissions since 2002 is due to the large amount of wood, sludge and organic waste that were composted in these years. In 2008 and 2009 CH_4 and N_2O emissions have decreased due to reduction in consumption. Compared with the year 2009, the GHG emissions in 2010 have increased due to the amount of paper and wood waste treated using composting process has increased.

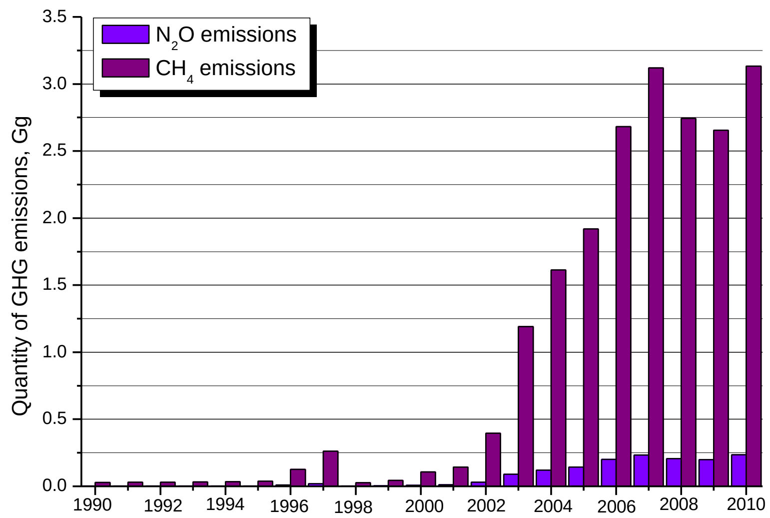

Figure 8.16. CH_4 and N_2O emissions from biological treatment in Estonia in 1990–2010, Gg

8.6.4. Uncertainties and time series consistency

The estimation of GHG emissions from biological waste treatment is carried out taking into account activity data (quantities of waste composted) and emission factors. Uncertainties of

225 IPCC 2006, Chapter 4, Table 4.1, pp. 4.6, on a wet basis.

default emission factors and activity data used in the estimations are derived accordingly to methodology from 2006 IPCC Guidelines. Values employed in the estimates are presented in Table 8.30.

The combined uncertainty rates related to biological treatment sub-category are reported in Chapter 8.1.4.

Table 8.30. Estimated values of uncertainties used in Composting category of the Waste Sector

Input	Uncertainties	References
Activity data		
Managed Waste Disposal on Land	±10%	2006 IPCC, Waste, Table 3.5 pp. 3.27
Emission factors		
Emission factor for treatment (CH_4)	-99%...+100%	2006 IPCC, Waste, Chapter 4, pp. 4.6
Emission factor for treatment (N_2O)	-80%...+100%	2006 IPCC, Waste, Chapter 4, pp. 4.6

8.6.5. Source specific planned improvements

The activity data are kept under consideration and will be updated necessarily.

8.7. Biogas burnt in a flare (CRF 6.D)

8.7.1. Source category description

During the UNFCCC review 2011 it appeared that CH_4 recovery reported under Waste Sector differ about 50% from amount of CH_4 consisting in biogas reported under Energy Sector. During the UNFCCC review it occurred that not all landfills are recovering methane. In Väätsa landfill, which started to collect biogas in 2009, the gas is burnt in a flare. As a recommendation by ERT 2011 Estonia estimated N_2O and CH_4 emissions from biogas which is not recovered but collected and burnt in a flare. Recommended by ERT these emissions are reported under category Waste Other (6.D)

8.7.2. Methodological issues

Activity data

Calculating emissions from biogas burnt in a flare the quantities of biogas burnt is used as activity data. The data is derived from EEIC Air bureau.

As seen from a Table 8.31, 2 landfills in Estonia - Väätsa and Paikre landfills burn biogas in a flare but not recover methane. Time-series begin in 2009 when Väätsa landfill started to collect methane. In addition in 2010 Paikre landfill started to collect and flare methane as well (Table 8.31).

Table 8.31. Amount of biogas burned in a flare in 2009–2010

Company	2009	2010
Väätsa Prügila AS	5 500	5 500
Paikre OÜ		17.13
Total (m^3)	550 000	5 517.130
Total (TJ)	0.11000	0.11034

Methodology

IPCC 1996 Guidelines using *Tier 1* method of multiplying the amount of flared gas and energy stationary combustion default emission factors of CH_4 and N_2O was applied to estimate GHG emissions.

N_2O, CH_4 = EF ● Activity (8.15)[226]

EF = emission factor (kg/TJ)
Activity = energy input (TJ)

Emission factors and parameters

Emission factors (EFs) used in calculations of emissions from biogas burnt in a flare are default emission factors from *IPCC 1996 Revised Guidelines*. Other parameters from Table 8.32 are plant specific.

Table 8.32. Emission factors and parameters used in calculations of biogas burnt in a flare

NCV (MJ/nm3) of biogas		
Company	2009	2010
Väätsa Prügila AS	20	20
Paikre OÜ		20
Emission factors (kg/TJ)[227]		
N_2O	CH_4	
0.1	5	

8.7.3. Quantitative overview – CH_4 and N_2O emissions from biogas burnt in a flare

The total amount of CH_4 emission in 2010 was 0.000552 Gg and N_2O emission 0.000011 Gg. As seen from the table above (Table 8.33), the emissions are marginal compared other greenhouse gas emissions from Waste Sector.

Table 8.33. CH_4 and N_2O emissions from biogas burnt in a flare (Gg)

	2009	2010
CH_4 emissions	0.000550	0.000552
N_2O emissions	0.000011	0.000011

[226] IPCC 1996, Energy, pp 1.35, pp 1.36.
[227] IPCC 1996, Energy, pp 1.35, pp 1.36.

8.7.4. Uncertainties and time series consistency

The estimation of GHG emissions from biogas burnt in a flare is carried out taking into account activity data (quantities of biogas burnt) and emission factors. Uncertainties of default emission factors and activity data used in the estimations are derived from IPCC GPG 2000 under Energy Sector, pp. 2.92. Accordingly uncertainty for activity data is noted as 5% and uncertainty for emission factor 25%.

8.7.5. Source specific planned improvements

The activity data are kept under consideration and will be updated necessarily.

9. OTHER

Estonia does not report any emissions under the Other sector.

10. RECALCULATIONS AND IMPROVEMENTS

10.1. Explanations and justifications for recalculations

10.1.1. GHG inventory

Explanations and justifications for the recalculations performed for this submission are given in Table 10.1.

Table 10.1. Recalculations made for the 2012 inventory submission by the CRF category and their implications

SECTOR	SOURCE	RECALCULATION
ENERGY	Energy Industries (CRF 1.A.1), Manufacturing Industries and Construction (1.A.2), Transport (1.A.3), Other Sectors (1.A.4) and Other (1.A.5)	In the 2011 submission Lithuanian country specific CEF of gasoline (19.91 tC/TJ) was used. In the current submission the Lithuanian revised CS CEF of gasoline (19.9 tC/TJ) was implemented. In the 2011 submission Finnish country specific CEF of natural gas was used (15.01 tC/TJ). In the current submission Russian CS CEF of natural gas (15.07 tC/TJ) was implemented because Estonia uses Russian natural gas and the NCV of the natural gas is the same (ERT 2011 recommendation).
	Energy Industries (CRF 1.A.1), Manufacturing Industries and Construction (1.A.2),	In the CRF source categories 1.A.1.a Electricity and Heat Production/Solid Fuels and 1.A.2.f Manufacturing Industries and Construction/Other carbon emission factors of generator gas were revised. There was a mistake in CEF calculations (carbon mole ratio of ethene (C_2H_4) was wrong). The recalculated CEF value of the VKG oil plant generator gas is now 53.43 tC/TJ and Kiviõli oil plant generator gas 50.03 tC/TJ of the (2011 submission 47.81 and 42.16 tC/TJ accordingly). In the CRF source category 1.A.1.a Electricity and Heat Production/Solid Fuels oxidation factor of peat was revised. In the 2011 submission the oxidation factor value 0.97 has been used, but according to the Revised 1996 IPCC Guideline (Vol. 2, Energy, p.1.8, table 1-4) oxidation factor of peat in Energy Industries is 0.99. In CRF source categories 1.A.1.a Electricity and Heat Production/Solid Fuels and Biomass the following activity data have been revised: in 2006, oil shale for pulverized combustion 62164.82 TJ (instead 64259 TJ in 2011); in 2003, wood: 8936 TJ and in 2009: 10444 TJ (instead 8823 and 10430 TJ respectively in 2011). These AD have been corrected in national energy balances by Statistics Estonia. In the CRF source category 1.A.2.c Chemicals/Solid fuels CH_4 EF of generator gas was revised. In the 2012 submission CH_4 EF value 5 kg/TJ was used instead 1 kg/TJ in 2011. In the CRF source category 1.A.2.f Other/Biomass activity data on solid biomass waste of the years 2005-2009 (MSW biomass fraction) was revised (by Estonian Environment Centre waste department). In the CRF source category 1.A.2.f Other activity data on biomass fuels on 2008 were corrected due the revised activity data by Estonian Statistics The correct Biomass consumption amount in 2008 was 327 TJ instead 362 TJ reported in 2011 submission. In the CRF source category 1.A.2.f Other/Other Fuels CH_4 and

		N_2O emission factors of waste fuels were revised of the years 2004-2009 (ERT 2011 recommendation). In the current submission CH_4 EF value 30 kg/TJ and N_2O EF value 4 kg/TJ (IPCC1996) of other fuels were used (in 2011 submission 1 kg/TJ and 2 kg/TJ, respectively). In the CRF source category 1.A.2.c Chemicals/Liquid fuels total sum on 1997 was invalid. The correct number is 1568 TJ (instead 1602 TJ in 2011). In the CRF source category 1.A.2.f Other activity data on oil shale consumption in 1992 were revised. The correct number is 4455 TJ (instead 5178 TJ in 2011).
	Transport (CRF 1.A.3)	Activity data on aviation gasoline are updated. In 2011, the Statistics Estonia revised and specified the old data on fuel consumption for national aviation. AD of the CRF source category 1.A.3.a is now in line with IEA data. CH_4 and N_2O emission from the use of gasoline and diesel oil in road transportation (1.A.3.b) have been changed due to implementation of the new version of the calculation model Copert IV. CO_2 emissions (2005-2009) from the use of gasoline and diesel oil in road transportation (1.A.3.b) have been changed due to change of methodology. In 2012 submission first time biofuels where calculated separately from fossil fuels. Amounts of biofuels are taken off from amounts of fossil gasoline and fossil diesel oil. Activity data on LPG (1992, 1993), gasoline (1995, 2007–2009) and diesel oil (1994-1999 and 2005-2009) are updated. There are different reasons for this update: gasoline activity data of the years 2008 and 2009 and diesel oil data of the years 2005-2009 changed because the amounts of biofuels were taken off from the total amount and are reported separately in the 1.A.3.b/Biomass. All other changes in AD are connected with revised AD by SE or by incorrect updating of AD in previous year.
	Transport (CRF 1.A.3) and Other Sector (CRF 1.A.4)	In the National Energy Balance some amounts of Aviation Gasoline were allocated under Commercial /Institutional sector: 1TJ (in 1993); 9 TJ (in 1006); 13 TJ (in 1997); 15 TJ (2004) and 4 TJ (in 2008). In the current submission these amounts and corresponding emissions are reported under CRF sub-category 1.A.3.a National Aviation.
	Other Sector (CRF 1.A.4)	In the 2011 national submission Estonia used Finnish carbon emission factor (CEF=15.01 tC/TJ) of natural gas. In the current submission Estonia uses Russian CEF (15.07 tC/TJ) because all natural gas is imported from Russia and the calorific value of natural gas is the same (ERT 2011 reccommendation). In the current inventory submission CH_4 and N_2O emission factors of all fuels used in CRF 1.A.4 are taken from the Revised 1996 IPCC Guideline. In the previous submission IPCC 2006 CH_4 and N_2O emission factors were used (ERT 2011 reccommendation) (see NIR Table 3.3 and 3.38). The following changes in activity data were made in the sub-sectors of the category 1.A.4: 1.A.4.a. Peat briquette (1997) 5 TJ (8 TJ in 2011); peat (1999) 0 TJ (1 TJ in 2011); Biomass total (1992) 404 TJ (109 TJ in 2011), in 2006, 76.634 TJ (75.634 in 2011); wood (1993) 109 TJ (18 TJ in 2011). 1.A.4.b. Biomass total (2003) 14400 TJ (14290 TJ in 2011); milled peat (2007) 0 TJ (3 TJ in 2011). 1.A.4.c. Shale oil (2008) 54 TJ (o TJ in 2011). AD of the years 2007-2010 have been revised and corrected by SE in 2010, AD on wood consumption in 1993 was inserted

		from energy balance to calculation tables wrongly.
	Oil and Natural Gas (CRF 1.B.2)	CRF source-category 1.B.2.b 5 Other Leakage (including other leakage at industrial plants and power plants and in residential and commercial sectors) has been removed from the 2012 inventory submission because that emissions from natural gas distribution cover emissions of other leakage at residential and commercial sectors and in industrial plants and power stations. CH_4 emission factor for natural gas distribution was changed according to the Review Team (2011) recommendations (in 2012 submission the CH_4 emissions factor for natural gas distribution 165016 kg CH_4/PJ was used, in 2011 submission – 458000 kg CH_4/PJ).
	Feedstock and Non-Energy Use of Fuels (CRF 1.AD.5)	In the 2011 national submission carbon stored from non-energy consumption of natural gas, bitumen and lubricants was not reported in line with Revised 1996 IPCC Guidelines. In the current inventory submission data in the CRF table 1.AD.5 are reported correctly.
INDUSTRIAL PROCESSES	Lime Production (CRF 2.A.2)	CO_2 emissions from lime production were corrected for year 2006. Recalculation was made due to mistake in production data of one company.
	Bricks and Tiles Production (CRF 2.A.7.2a)	Activity data in 1992–2010 was recalculated due to data about bricks production was included by two plants.
	Food and Drink (CRF 2.D.2)	NMVOC emissions from food and drink were corrected for the year 2009. The recalculation in 2009 was due to corrections in food and drink production data. Every year Statistical Office of Estonia gives out initial data and they have a practice to correct statistical data for previous years.
	Domestic Refrigeration (CRF 2.IIA. F.1.1)	The leakage rate of domestic refrigerators was reviewed as the recommendation of the UNFCCC review team. According to the new information received from EES Ringlus, the average refrigerant loss of the fridges collected for recycling is 6% of the original charge. Based on 15 years lifetime, the annual operating emission rate is 0.4%/year (EF_{op}). Emissions from stock were recalculated accordingly from 1995–2009. Also, investigation was carried out over time series. The results indicated that refrigerant HFC-134a was introduced by the industry at the end of 1993. As there is no backdating information available about Estonia, the German percentages of the years 1993-1994 were applied to Estonia. According to lifetime of domestic refrigerators, disposal emissions did not occur before 2006.
	Refrigerated Vehicles (sub sector under 2.IIA.F.1.3 Transport Refrigeration)	The investigation over time series was made. Emissions were estimated for years 1993–1994 due to HFCs (HFC-134a and R404A) have been used since 1993 as refrigerants in refrigerated vehicles. Activity data in 2009 was recalculated due to more detailed data from service companies for refrigerated vehicles was available.
	Reefer Containers (sub sector under 2.IIA.F.1.3 Transport Refrigeration)	The investigation over time series was made. Emissions were estimated for years 1993–1994 due to HFCs have been used since 1993 as refrigerants in reefer containers. HFC-134a has been the most commonly used refrigerant since 1993. R404A has been used since 1997. According to product lifetime of 14 years, first decommissioning emissions of R-134a occurred in 2007. R-134a emissions were recalculated in 1995–2005 and 2007–2008 due to more detailed data for reefer containers was available.
	Passenger Cars (sub sector under 2.IIA.F.1.6 Mobile Air-Conditioning)	The investigation over time series was made. Emissions were estimated for year 1994 due to in Western Europe systematic air-conditioning of passenger cars with the refrigerant HFC-134a started in 1994.

		According to product lifetime of 13 years, first decommissioning emissions of R-134a occurred in 2007.
	Trucks (sub sector under 2.IIA.F.1.6 Mobile Air-Conditioning)	The investigation over time series was made. Emissions were estimated for year 1994 due to in Western Europe systematic air-conditioning of trucks with the refrigerant HFC-134a started in 1994/95. According to product lifetime of 13 years, first decommissioning emissions of R-134a occurred in 2007.
	Buses (sub sector under 2.IIA.F.1.6 Mobile Air-Conditioning)	The investigation over time series was made. Emissions were estimated for years 1992–1994 due to in Estonia air-conditioning of buses with the refrigerant HFC-134a started in 1992. According to product lifetime of 13 years, first decommissioning emissions of R-134a occurred in 2005.
	Ships (sub sector under 2.IIA.F.1.6 Mobile Air-Conditioning)	Activity data in years 2006–2009 were recalculated due to more data about ship air-conditioning was available from Estonian ferryboat companies and data about air-conditioning systems on Estonian naval ships was available from Ministry of Defence.
	Spray and Injection PU Foam (sub sector under 2.IIA.F.2.1 Hard Foam)	Activity data in year 2009 was recalculated due to more detailed data about spray and injection PU foam manufacturing was available from production company.
	One Component PU Foam (sub sector under 2.IIA.F.2.1 Hard Foam)	The investigation over time series was made. Emissions were estimated for years 1992–1994 due to production of OCF with HFC-134a as propellant started in 1992 in Estonia.
	Fire Extinguishers (CRF 2.F.3)	In the 2012 Submission, activity data was corrected for year 2009. Recalculation was made due to more data was available from companies dealing with fire protecting systems.
	General and Novelty Aerosols (CRF 2.IIA.F.4.2)	Activity data in year 1997 and 1998 was recalculated due to entry mistake.
	Electrical Equipment (CRF 2.F.8)	The investigation over time series was made. Emissions were estimated for years 1991–1994 due to high voltage equipment was installed in Estonia first in 1991.
	Other Electrical Equipment (sub sector under 2.F.9 Other)	The investigation over time-series was made. Emissions were estimated for years 1999–2003. Time serie starts in 1995 because SF_6 containing radiotherapy devices have been used in Estonia since 1995.
SOLVENT AND OTHER PRODUCT USE	Paint Application (CRF 3.A), Degreasing and Dry Cleaning (CRF 3.B) and Other product use (sub sector under 3.D.5 Other)	NMVOC and indirect CO_2 emissions from paint application were corrected for the years 2001–2002, 2004, 2009, from degreasing and dry cleaning for the year 2006 and from other product use for the year 2009. All recalculations were due to updates in activity data in databases of Statistics Estonia.
	N_2O from Aerosol Cans (CRF 3.D.3)	As it was the first year of reporting N_2O emissions from aerosol cans, N_2O emissions from Aerosol Cans were recalculated from 2007–2009.
AGRICULTURE	CH_4 emissions from enteric fermentation of livestock (CRF 4.A)	There are several recalculations carried out in the 2012 submission. Enteric fermentation of cattle: (1) Values of feed digestibility were updated – country-specific values were used in the estimates; (2) Values of daily weight gain for dairy cattle and mature female cattle were updated – country-specific values were used in the estimates; (3) Classification of feeding situation of dairy cattle was updated – 'Pasture' was selected as the main feeding situation for dairy cattle; (4) An omission made in the process of using the equation (6.8) was corrected. Enteric fermentation of swine: (1) The calculation algorithm of gross energy intake by swine was corrected – the formula used to estimate gross energy intake was interpreted incorrectly in the previous submissions. Since, the formula was used a basis to estimate gross energy intake instead of energy intake for maintenance and growth. However, in the present submission, the correction was implemented, the values of feed digestibility were used to calculate gross energy intake and CH_4 EFs and the total CH_4 emissions from swine enteric fermentation were re-estimated.

	CH_4 emissions from manure management (CRF 4.B)	There are several recalculations carried out in the 2012 submission. Cattle manure management: (1) Values of feed digestibility were updated – country-specific values were used in the estimates; (2) Values of daily weight gain for dairy cattle and mature female cattle were updated – country-specific values were used in the estimates; (3) Classification of feeding situation of dairy cattle was updated – 'Pasture' was selected as the main feeding situation for dairy cattle; (4) An omission made in the process of using the equation (6.8) was corrected; (5) Estonian country-specific module on manure management system was developed. Swine manure management: (1) The calculation algorithm of gross energy intake by swine was corrected – the formula used to estimate gross energy intake was interpreted incorrectly in the previous submission. Since, the formula was used a basis to estimate gross energy intake instead of energy intake for maintenance and growth. However, in the present submission, the correction was implemented, the values of feed digestibility were used to calculate gross energy intake and CH_4 EFs and the total CH_4 emissions from swine enteric fermentation were re-estimated; (2) Estonian country-specific module on manure management system was developed.
	N_2O emissions from manure management (CRF 4.B)	There are several recalculations carried out in the 2012 submission, in 'N_2O emissions from manure management system' sub-section: The initial parameters used to estimate gross energy intake were recalculated (for cattle): (1) Values of feed digestibility were updated – country-specific values were used in the estimates; (2) Values of daily weight gain for dairy cattle and mature female cattle were updated – country-specific values were used in the estimates; (3) Classification of feeding situation of dairy cattle was updated – 'Pasture' was selected as the main feeding situation; (4) An omission made in the process of using the equation (6.8) was corrected. Nitrogen excretion rates were recalculated: (8) Nitrogen excretion rates for cattle livestock were recalculated based on nitrogen balance; (9) Nitrogen excretion rates for swine livestock were used from country-specific literature; The module on MMS usage was changed: (10) Estonian country-specific manure management systems were developed for all categories of livestock.
	N_2O emissions from agriculture soils (CRF 4.D)	There are several recalculations carried out in the 2012 submission: (1) Animal manure applied on agricultural soils (CRF 4.D.1.2) – the amounts of manure applied on soils were recalculated due to the changes employed in the estimations of nitrogen excretion factors and because of the development of Estonian module on manure management system; (2) N-fixing crops (CRF 4.D.1.2) – The yields of clover and alfalfa were accounted for the entire time-series for the first time in the 2012 submission; (3) Crop residue (CRF 4.D.1.4) – The yields of clover and alfalfa were accounted for the entire time-series for the first time in the 2012 submission. In addition, the values of $Frac_{BURN}$ were updated for 2007–2009 because of new information retrieved regarding legislative prohibition established against burning of crop residues; (4) Cultivation of organic soils (CRF 4.D.1.5) – the data on areas of organic soils cultivated were harmonized with the data reported under the LULUCF sector; (5) Sewage sludge applied on agricultural lands (CRF 4.D.1.5) – the activity data on the amount of sewage sludge applied on soils were updated for 2009. The recalculations in 'Indirect N_2O emissions from agricultural soils' category were performed due to the changes employed in the 'Manure management', 'Animal manure applied on agricultural soils' and 'Sewage sludge applied on agricultural

		soils' categories.
LULUCF	Forest Land (CRF 5.A)	All area estimates are being updated annually, since new data about land-use transitions is collected every year and new estimates will be integrated to overall activity data. Due to new area estimates, living biomass stock, dead wood stock and area of organic and mineral soils are re-estimated annually by NFI as well. More accurate combustion efficiency value and quantity of fuel burnt were used in the estimation of forest fires. More accurate root-to-shoot (R) ratios and BEF values were used in the calculations. Formerly all organic soils in forest land were accounted as drained due to lack of more accurate activity data, in the 2012 submission, specified data about areas of drained organic forest soils were obtained from NFI.
	Cropland (CRF 5.B)	All estimates of total area of Cropland and area of organic and mineral soils have been updated by NFI. Living biomass emission estimates were provided in current submission for the first time due to new data available. Total amount of lime applied (Table 5.B.1 in CRF Reporter) has been re-estimated due to mistakes made in the calculations in previous years.
	Grassland (CRF 5.C)	All estimates of area, living biomass stock, dead wood stock and area of organic and mineral soils have been updated by NFI. For the first time dead wood estimates were calculated separately for Grassland remaining and land converted to Grassland subsections. More accurate combustion efficiency and BEF values were used.
	Wetlands (CRF 5.D)	All estimates of total area of Wetlands and area of Peatland have been updated by NFI. Emissions from living biomass in land converted to peatland subsection were estimated for the first time.
	Settlements (CRF 5.E)	All area estimates have been updated by NFI. In current submission emissions derived from land conversion to Settlements were estimated for the first time.
	Other land (CRF 5.F)	All area estimates have been updated by NFI. Forest Land conversion to Other land was estimated for the first time.
WASTE	Solid waste disposal on land (CRF 6.A)	Emissions for whole time series (1990-2009) were recalculated due to update in waste generation rate in period 1940-1990 and reclassification SWDS types. Also waste composition data in period 1940-1999 have been replaced with results from research made in Estonia in 2000.
	Wastewater handling (CRF 6.B)	Under industrial wastewater handling CH_4 emission in 2009 was recalculated because data of total industrial output in 2009 was updated due to activity data of production and wastewater output was corrected in databases of Estonian Statistics in 2011. According to the recommendation of European Commission N_2O emission from UNFCCC CRF 6.B.2.1 subcategory was estimated for the first time in 2011 Submission. In 2012 Submission emissions are recalculated for whole time series due to update in per capita protein consumption in period 1990-2009. N_2O emissions from human sewage (CFR 6.B.2.2) were recalculated for whole time series due to update in per capita protein consumption from FAO databases.

10.1.2. KP-LULUCF inventory

Entire time series of activity data was recalculated for ARD activities. In previous submissions, all reforested areas were accounted, in current submission this mistake has been corrected and estimation of reforested areas corresponds to the Marrakesh Accord limitations[228]. For AR activities, recalculations have been made containing the specified increment, depending on the age of the stand.

Deforestation areas have been updated according to new data obtained and to somewhat different method used for D area estimation in the 2012 submission. In the previous submission, the area of deforestation was estimated by aggregating data from NFI and data obtained from land transition assessment. In current submission, area of deforestation is derived directly from land-use transition assessment.

Carbon stock changes in above- and below-ground biomass on AR areas were re-calculated, due to the availability of more accurate BEF and root-to-shoot (R) values (Table 10.2). See Chapter 7.2.5.

Estonia does not have country-specific data regarding litter and mineral soil carbon stocks, therefore these pools have been omitted in previous submissions. ERT (ARR2010) strongly recommended Estonia to use IEF-s from neighbouring countries as an interim approach, in order not to underestimate emissions from accounted LULUCF activities (with main emphasis on deforestation). Estonia considered using IEF-s from Latvia, Finland and Sweden as countries with the most similar climate conditions. Finland IEF-s were discarded for Finland uses Yasso model, which does not allow distinguishing emissions from litter and mineral soil pools separately. Latvia's emission factors differed significantly from Swedish and Finnish factors. Therefore Sweden IEF-s (Table 7.21) were chosen as the most suitable and reliable data and for Estonia has the same geographical latitude with southern Sweden and similar climate conditions. For completeness and consistency reasons, the same IEF-s have been used for estimating emissions under deforestation (KP) and Forest Land conversion to other land uses under UNFCCC reporting.

Table 10.2. Parameters used in AR category recalculations

Parameter	Source	2011 Submission		2012 Submission	
BEF	Table 3A.1.10, LULUCF GPG 2003, p. 3.178	Average BEF_1 for Boreal forests	1.125	Upper BEF_2 value for young Boreal forests[229]	2.5
R	Table 3A.1.8, LULUCF GPG 2003, p. 3.168	Average R value for Conifer forest (50−150 t/ha) and Other broadleaf forest (75−150 t/ha)	0.29	Average R value for Conifer forest (<50 t/ha) and Other broadleaf forest (<75 t/ha) [230]	0.44

[228] Paragraph 1 of the Annex to draft decision -/CMP.1 (Land use, land-use change and forestry) contained in document FCCC/CP/2001/13/Add.1, p.58

[229] BEF_2 value used for AR living biomass estimations is the same as used under UNFCCC reporting land conversion to Forest Land

[230] R value used for AR living biomass estimations is the same as used under UNFCCC reporting land conversion to Forest Land

Emissions from organic soils have been recalculated, since formerly all organic forest soils were accounted as drained due to lack of more accurate data, in current submission specified data about the proportion of drained soils among total organic forest soil areas was obtained from NFI.

In the 2012 submission, emissions from AR area burning were calculated for the first time.

10.2. Implications for emission levels

10.2.1. GHG inventory

For the national total CO_2 equivalent emissions without Land-Use, Land-Use Change and Forestry, the general impact of the improvements and recalculations performed is small and the changes for the whole time-series are between -2.89% (2006) and -0.09% (1993). Therefore, the implications of the recalculations on the level and on the trend, 1990–2009, of this national total are small (Table 10.3).

For the national total CO_2 equivalent emissions with Land-Use, Land-Use Change and Forestry, the general impact of the recalculations is larger. The differences vary between -31.46% (2008) and 7.13% (2004), (Table 10.3).

Table 10.3. Recalculation performed in year 2012 for 1990–2009. Differences in % between this submission and the April 2011 submission for Estonia

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total CO_2 equivalent emissions with LULUCF	2.26	-4.84	-3.14	-2.79	-3.68	-2.61	-6.30	-4.90	-13.71	-7.49
Total CO_2 equivalent without LULUCF	-0.92	-1.05	-0.78	-0.09	-0.73	-0.96	-1.00	-1.43	-1.72	-2.69

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total CO_2 equivalent emissions with LULUCF	-1.53	-1.38	-0.39	-7.13	7.13	-8.57	-12.94	-1.31	-31.46	-3.71
Total CO_2 equivalent without LULUCF	-2.74	-2.59	-2.24	-2.36	-2.52	-2.45	-2.89	-2.15	-2.17	-1.60

10.2.2. KP-LULUCF inventory

See section 10.1.2.

10.3. Implications for emission trends, including time series consistency

10.3.1. GHG inventory

It is a high general priority in the considerations leading to recalculations back to 1990 to have and preserve the consistency of the activity data and emissions time-series. As a consequence activity data, emissions factors and methodologies are carefully chosen to represent the emissions for the time-series correctly. Often considerations regarding the consistency of the time-series have led to recalculations for single years when activity data and/or emissions factors have been changed or corrected. Furthermore, when new source are considered, activity data and emissions are as far as possible introduced to the inventories for the whole time-series based on preferably the same methodology.

The implication of the recalculations is further shown in Table 10.4–Table 10.6.

Table 10.4. Recalculation for CO_2 performed in year 2012 for 1990–2009. Differences in CO_2 equivalent (Gg) between this and the April 2011 submission for Estonia

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total National Emissions and Removals		**1 246.70**	**-885.88**	**-261.08**	**-190.17**	**-185.06**	**41.73**	**-393.94**	**-92.88**	**-1 033.17**	**-478.30**	**242.96**
1. Energy		**168.59**	**146.13**	**52.18**	**109.21**	**109.14**	**124.95**	**122.82**	**118.14**	**62.65**	**-24.63**	**67.96**
1.A.	Fuel Combustion Activities	168.59	146.13	52.18	109.21	109.14	124.95	122.82	118.14	62.65	-24.63	67.96
1.A.1.	Energy Industries	103.17	91.45	90.13	91.78	95.02	96.65	103.68	101.30	52.55	-24.37	67.37
1.A.2.	Manufacturing Industries and Construction	65.67	54.75	-42.07	14.73	13.87	26.18	19.76	18.11	11.25	0.65	0.64
1.A.3.	Transport	-0.77	-0.74	3.60	2.22	-0.38	1.68	-0.31	-0.29	-1.06	-1.18	-0.43
1.A.4.	Other Sectors	0.52	0.66	0.52	0.49	0.62	0.43	-0.30	-0.99	-0.09	0.28	0.38
1.A.5.	Other	-0.00	-0.00		-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
2. Industrial Processes				**0.01**	**0.03**	**0.05**	**0.05**	**0.03**	**0.01**	**0.01**	**0.01**	**0.01**
2.A.	Mineral Products			0.01	0.03	0.05	0.05	0.03	0.01	0.01	0.01	0.01
3. Solvent and Other Product Use												
5. Land Use, Land-Use Change and Forestry		**1 078.11**	**-1 032.01**	**-313.27**	**-299.42**	**-294.25**	**-83.27**	**-516.79**	**-211.03**	**-1 095.83**	**-453.68**	**174.98**
5.A.	Forest Land	1 052.95	-1 044.88	-376.98	-380.30	-405.21	-254.36	-601.80	-376.34	-1 322.59	-576.90	45.48
5.B.	Cropland	-28.22	-27.81	-29.13	-25.18	-26.31	-24.03	-19.78	-20.84	-19.42	-18.28	-16.99
5.C.	Grassland	33.14	18.25	68.37	79.55	108.71	120.40	72.14	151.47	199.15	101.33	106.94
5.D.	Wetlands	20.24	22.43	24.47	26.51	28.56	30.60	32.64	34.69	36.73	40.17	39.56
5.E.	Settlements						44.12			10.29		
5.F.	Other Land											

		2001	2002	2003	2004	2005	2006	2007	2008	2009
Total National Emissions and Removals		**237.46**	**518.85**	**-901.34**	**1 596.43**	**-315.16**	**-1 413.90**	**516.23**	**-5 456.52**	**4.50**
1. Energy		**76.43**	**82.35**	**82.14**	**86.65**	**103.42**	**81.24**	**97.87**	**87.53**	**88.57**
1.A.	Fuel Combustion Activities	76.43	82.35	82.14	86.65	103.42	81.24	97.87	87.53	88.57
1.A.1.	Energy Industries	75.82	81.94	85.03	85.45	86.63	91.61	106.66	100.88	103.24
1.A.2.	Manufacturing Industries and Construction	0.75	0.40	-2.91	1.11	-0.04	-7.02	-7.08	-4.69	-9.54
1.A.3.	Transport	-0.52	-0.48	-0.46	0.68	16.31	-3.92	-2.14	7.62	-5.87

1.A.4.	Other Sectors	0.38	0.49	0.47	-0.59	0.52	0.58	0.39	4.62	0.75
1.A.5.	Other	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.03	-20.90	-0.00
2. Industrial Processes		**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**-0.58**	**0.01**	**0.01**	**0.00**
2.A.	Mineral Products	0.01	0.01	0.01	0.01	0.01	-0.58	0.01	0.01	0.00
3. Solvent and Other Product Use		**0.01**	**-0.01**		**0.01**		**0.00**			**0.89**
5. Land Use, Land-Use Change and Forestry		**161.00**	**436.49**	**-983.49**	**1 509.75**	**-418.59**	**-1 494.56**	**418.35**	**-5 544.07**	**-84.97**
5.A.	Forest Land	106.90	-118.30	-1 527.74	384.04	-1 462.61	-2 447.31	-1 409.99	-5 765.82	-596.76
5.B.	Cropland	-15.66	-14.26	-12.71	-11.08	-9.41	-7.55	-5.69	-4.19	-3.60
5.C.	Grassland	33.36	244.79	363.35	581.49	883.43	403.50	515.67	-397.50	353.94
5.D.	Wetlands	36.41	37.32	32.45	30.86	28.90	128.30	174.60	21.68	21.02
5.E.	Settlements		286.94	161.15	524.44	141.10	281.19	545.02	449.45	140.44
5.F.	Other Land						147.31	598.75	152.30	

Table 10.5. Recalculation for CH_4 performed year 2012 for 1990–2009. Differences in CO_2 equivalent (Gg) between this and the April 2011 submission for Estonia

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total National Emissions and Removals		**-970.90**	**-950.63**	**-706.96**	**-507.22**	**-557.30**	**-544.07**	**-568.69**	**-588.45**	**-581.16**	**-617.54**	**-638.99**
1. Energy		**-576.84**	**-578.81**	**-324.45**	**-141.72**	**-204.39**	**-206.61**	**-225.10**	**-211.98**	**-216.44**	**-211.04**	**-253.58**
1.A.	Fuel Combustion Activities	33.10	31.04	29.57	29.82	44.50	80.85	93.83	97.95	76.57	74.29	74.85
1.A.1.	Energy Industries		0.06		0.13	0.17	0.18	0.08	0.06	0.04	0.01	0.02
1.A.2.	Manufacturing Industries and Construction	0.33	0.27	-0.00	0.07	0.07	0.13	0.10	0.10	0.05		
1.A.3.	Transport	1.62	1.19	0.89	0.95	0.65	0.63	0.63	0.67	0.77	0.67	0.65
1.A.4.	Other Sectors	31.15	29.52	28.69	28.67	43.61	79.91	93.02	97.12	75.70	73.61	74.18
1.A.5.	Other											
1.B.	Fugitive Emissions from Fuels	-609.94	-609.85	-354.03	-171.54	-248.89	-287.46	-318.93	-309.94	-293.01	-285.33	-328.44
1.B.2.	Oil and Natural Gas	-609.94	-609.85	-354.03	-171.54	-248.89	-287.46	-318.93	-309.94	-293.01	-285.33	-328.44
4. Agriculture		**27.40**	**24.93**	**25.49**	**15.37**	**11.84**	**9.84**	**8.64**	**4.62**	**1.57**	**1.43**	**-0.69**
4.A.	Enteric Fermentation	54.47	50.24	43.10	28.52	26.04	22.88	18.00	14.12	11.28	10.35	8.15

4.B.	Manure Management	-27.07	-25.31	-17.60	-13.15	-14.20	-13.03	-9.36	-9.50	-9.71	-8.92	-8.85
4.F	Field Burning of Agricultural Residues											
5. Land Use, Land-Use Change and Forestry		**-3.09**	**-0.97**	**-31.30**	**-11.85**	**-8.72**	**-3.70**	**-11.97**	**-24.60**	**-1.20**	**-40.08**	**-12.41**
5.A.	Forest Land	-0.34	-0.10	-3.25	-1.20	-0.87	-0.36	-1.15	-2.32	-0.11	-1.23	-1.67
5.C.	Grassland	-2.76	-0.87	-28.04	-10.64	-7.85	-3.34	-10.82	-22.28	-1.09	-38.85	-10.75
6. Waste		**-418.36**	**-395.79**	**-376.71**	**-369.02**	**-356.03**	**-343.60**	**-340.27**	**-356.49**	**-365.10**	**-367.86**	**-372.30**
6.A.	Solid Waste Disposal on Land	-418.36	-395.79	-376.71	-369.02	-356.03	-343.60	-340.27	-356.49	-365.10	-367.86	-372.30
6.B.	Waste-water Handling											

		2001	2002	2003	2004	2005	2006	2007	2008	2009
Total National Emissions and Removals		**-648.57**	**-640.91**	**-582.93**	**-631.13**	**-632.70**	**-713.51**	**-634.63**	**-716.77**	**-389.36**
1. Energy		**-279.58**	**-222.12**	**-248.43**	**-307.07**	**-329.44**	**-335.66**	**-314.21**	**-294.74**	**-163.85**
1.A.	Fuel Combustion Activities	73.71	73.45	77.99	78.48	67.66	66.33	85.26	87.74	93.91
1.A.1.	Energy Industries	0.02	0.03	0.04	0.03	0.02	0.05	0.04	0.03	0.04
1.A.2.	Manufacturing Industries and Construction	-0.00	-0.00		0.07	0.02	-0.02	-0.02	0.03	-0.01
1.A.3.	Transport	0.70	0.75	0.68	0.68	0.66	0.72	0.80	1.62	2.51
1.A.4.	Other Sectors	72.99	72.67	77.26	77.70	66.95	65.58	84.44	86.09	91.37
1.A.5.	Other							0.00	-0.02	
1.B.	Fugitive Emissions from Fuels	-353.29	-295.56	-326.42	-385.55	-397.10	-401.99	-399.48	-382.48	-257.75
1.B.2.	Oil and Natural Gas	-353.29	-295.56	-326.42	-385.55	-397.10	-401.99	-399.48	-382.48	-257.75
4. Agriculture		**-7.00**	**-2.97**	**-0.97**	**-3.46**	**-3.93**	**-5.19**	**-10.73**	**-11.50**	**-12.20**
4.A.	Enteric Fermentation	3.65	7.40	9.65	6.94	6.66	5.31	5.68	4.53	4.14
4.B.	Manure Management	-10.65	-10.37	-10.62	-10.40	-10.59	-10.49	-11.74	-11.48	-11.75
4.F	Field Burning of Agricultural Residues							-4.67	-4.55	-4.59
5. Land Use, Land-Use Change and Forestry		**-0.60**	**-72.59**	**-6.79**	**-9.64**	**-1.43**	**-86.71**	**-33.74**	**-142.43**	**-3.46**
5.A.	Forest Land	-0.19	-3.47	-0.42	-0.91	-0.23	-7.35	-0.19	-1.03	-0.12
5.C.	Grassland	-0.42	-69.12	-6.37	-8.72	-1.20	-79.37	-33.55	-141.40	-3.34
6. Waste		**-361.38**	**-343.24**	**-326.74**	**-310.96**	**-297.89**	**-285.95**	**-275.95**	**-268.10**	**-209.86**
6.A	Solid Waste Disposal on Land	-361.38	-343.24	-326.74	-310.96	-297.89	-285.95	-275.95	-268.10	-209.93

6.B.	Waste-water Handling									0.07

Table 10.6. Recalculation for N_2O performed year 2012 for 1990–2009. Differences in CO_2 equivalent (Gg) between this and the April 2011 submission for Estonia

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total National Emissions and Removals		**419.35**	**403.71**	**368.50**	**340.94**	**250.76**	**217.42**	**214.31**	**133.32**	**184.35**	**87.36**	**64.94**
1. Energy		**4.21**	**4.21**	**5.12**	**5.65**	**12.04**	**19.78**	**25.05**	**22.83**	**18.56**	**17.91**	**20.87**
1.A.	Fuel Combustion Activities	4.21	4.21	5.12	5.65	12.04	19.78	25.05	22.83	18.56	17.91	20.87
1.A.1.	Energy Industries		-0.00								-0.01	
1.A.2.	Manufacturing Industries and Construction	2.60	2.46	1.91	0.90	1.48	1.34	1.27	0.94	1.55	0.89	0.93
1.A.3.	Transport	2.83	2.40	1.46	2.98	6.68	9.82	13.68	11.25	9.12	9.37	12.36
1.A.4.	Other Sectors	-1.21	-0.65	1.75	1.76	3.88	8.61	10.11	10.64	7.89	7.66	7.58
1.A.5.	Other											
3. Solvent and Other Product Use												
4. Agriculture		**411.09**	**394.16**	**378.86**	**337.86**	**239.43**	**196.72**	**194.20**	**124.29**	**163.71**	**95.71**	**54.04**
4.B.	Manure Management	-19.34	-18.01	-7.56	-15.90	-17.41	-21.55	-14.75	-17.41	-23.09	-18.26	-22.39
4.D.	Agricultural Soils (4)	430.43	412.17	386.42	353.77	256.84	218.27	208.95	141.70	186.80	113.97	76.44
4.F	Field Burning of Agricultural Residues											
5. Land Use, Land-Use Change and Forestry		**-1.82**	**-0.53**	**-21.29**	**-8.21**	**-6.23**	**-2.94**	**-8.74**	**-17.55**	**-1.64**	**-29.94**	**-9.24**
5.A.	Forest Land	-0.06	-0.02	-0.59	-0.22	-0.16	-0.07	-0.21	-0.42	-0.02	-0.22	-0.30
5.C.	Grassland	-2.03	-0.64	-20.70	-7.86	-5.79	-2.46	-7.99	-16.45	-0.80	-28.67	-7.93
5.D.	Wetlands	0.28	0.13	-0.00	-0.14	-0.28	-0.41	-0.55	-0.68	-0.82	-1.05	-1.01
6. Waste		**5.86**	**5.85**	**5.81**	**5.64**	**5.51**	**3.86**	**3.80**	**3.75**	**3.72**	**3.68**	**-0.73**
6.B.	Waste-water Handling	5.86	5.85	5.81	5.64	5.51	3.86	3.80	3.75	3.72	3.68	-0.73

		2001	2002	2003	2004	2005	2006	2007	2008	2009
Total National Emissions and Removals		**102.38**	**45.03**	**31.93**	**31.95**	**59.69**	**-50.76**	**6.28**	**-53.41**	**29.74**
1. Energy		**33.09**	**32.39**	**9.61**	**10.01**	**8.86**	**8.16**	**9.58**	**9.35**	**12.07**

1.A.	Fuel Combustion Activities	33.09	32.39	9.61	10.01	8.86	8.16	9.58	9.35	12.07
1.A.1.	Energy Industries				-0.00	-0.08	0.53	-0.00	0.00	0.02
1.A.2.	Manufacturing Industries and Construction	0.86	0.73	0.58	0.79	1.03	0.72	1.71	1.04	0.62
1.A.3.	Transport	25.52	24.93	1.45	1.55	1.42	0.39	-0.65	0.05	1.98
1.A.4.	Other Sectors	6.71	6.73	7.57	7.68	6.49	6.51	8.52	8.60	9.45
1.A.5.	Other							0.00	-0.34	
3. Solvent and Other Product Use								**0.00**	**0.00**	**0.00**
4. Agriculture		**71.16**	**65.86**	**28.36**	**37.64**	**59.25**	**8.36**	**28.46**	**48.58**	**26.90**
4.B.	Manure Management	-25.74	-21.72	-20.09	-24.06	-24.46	-24.76	-27.61	-21.76	-20.91
4.D.	Agricultural Soils (4)	96.90	87.58	48.44	61.69	83.71	33.13	56.97	71.19	48.69
4.F	Field Burning of Agricultural Residues							-0.91	-0.85	-0.88
5. Land Use, Land-Use Change and Forestry		**-1.14**	**-52.50**	**-5.31**	**-7.03**	**-1.22**	**-60.10**	**-24.59**	**-104.18**	**-2.08**
5.A.	Forest Land	-0.03	-0.63	-0.08	-0.17	-0.04	-1.33	-0.03	-0.19	-0.02
5.C.	Grassland	-0.31	-51.02	-4.70	-6.44	-0.88	-58.58	-24.76	-104.36	-2.47
5.D.	Wetlands	-0.80	-0.86	-0.53	-0.43	-0.30	-0.19	0.20	0.37	0.41
6. Waste		**-0.73**	**-0.73**	**-0.72**	**-8.66**	**-7.20**	**-7.18**	**-7.17**	**-7.16**	**-7.16**
6.B.	Waste-water Handling	-0.73	-0.73	-0.72	-8.66	-7.20	-7.18	-7.17	-7.16	-7.16

10.3.2. KP-LULUCF inventory

See Chapter 10.1.2. KP–LULUCF inventory.

10.4. Recalculations, including in response to the review response, and planned improvements to the inventory

10.4.1. GHG inventory

Table 10.7 summarises the sectoral improvement needs for the forthcoming inventories recognised by the Estonian experts responsible for the calculations. More detailed information about planned improvements can be found under the sectoral chapters.

Table 10.7. Sector-specific improvement needs of Estonia´s national greenhouse gas inventory

SECTOR	SOURCE	IMPROVEMENTS
ENERGY	CO_2 from gasoline combustion (CRF 1.A.1, 1.A.2, 1.A.3, 1.A.4, 1.A.5)	It is planned to find country specific carbon emission factor for gasoline. Ministry of the Environment is going to launch special study in 2012 to estimate CS emission factors in key categories. The finances were applied from the Environmental Investment Centre and decision for financing was received in the end of 2011.
INDUSTRIAL PROCESSES		No source-specific improvements are under active consideration at the moment.
SOLVENT AND OTHER PRODUCT USE		No source-specific improvements are under active consideration at the moment.
AGRICULTURE	CH_4 emissions from enteric fermentation (CRF 4.A)	CH_4 emissions from enteric fermentation of calves fed on milk (less than 6 months old) were calculated and reported in the 2012 submission, in spite of the fact that CH_4 conversion rate of milk-fed calves is zero. Since, Estonian national statistics (SE) has reported data on the total population of calves less than one year old (i.e., population of calves less than 6 months old is reported together with calves older than 6 months). Hence, there is a need for further data adjustment, which allows to determine population of calves fed on milk (less than 6 months old) from the total population number of calves (less than 1 year old). The adjustment will be performed by the next submission. The consultations with personals of SE will be hold. The data on weight, daily weight gain, digestibility of feed etc. of calves less than 6 months old and aged between 6 months and one year will be employed from scientific literature and additional consultations with agricultural experts will be established. In addition, the adjusted data on calves population and parameters needed in the process of the estimation of emissions from enteric fermentation will be applied also to estimate nitrogen excretion rates for these categories of calves. The planned activity allows to improve inventory of nitrogen generated by calves and stored to manure management systems. The parameters (weight, daily weight gain etc.) used to estimate emission factors for enteric fermentation of non-dairy cattle will be investigated from country-specific literature as well.
	CH_4 emissions from manure management (CRF 4.B)	The research continues to develop country-specific manure management system. The SE started a new cycle of agricultural survey in Estonia in 2010. The data on livestock population and manure management systems on village level will be finalized by the beginning of 2012. The results of the survey will be obtained from SE, in addition the information on grazing practice organic holdings will be studied as well. Hence, by the next submission, the data will be analyzed and used in the estimations. In addition, country-specific literature will be analyzed, together with the data on structure of cattle population by herd size in the early of 1990th. The data will be interpolated between 1990th and 2000, and between 2000 and 2010. The data on biogas recovery practice and volumes of biogas recovered in Estonia will be investigated by the next submission. The results will be presented by the next submission.
	N_2O emissions from manure management (CRF	The research continues to develop country-specific manure management system. The SE started a new cycle of agricultural survey in Estonia in 2010. The data on livestock population and manure management systems

	4.B)	on village level will be finalized by the beginning of 2012. The results of the survey will be obtained from SE, in addition the information on grazing practice organic holdings will be studied as well. Hence, by the next submission, the data will be analyzed and used in the estimations. In addition, country-specific literature will be analyzed, together with the data on structure of cattle population by herd size in the early of 1990th. The data will be interpolated between 1990th and 2000, and between 2000 and 2010. The data on biogas recovery practice and volumes of biogas recovered in Estonia will be investigated by the next submission. The results will be presented by the next submission. In addition, the adjusted data on calves population and parameters needed in the process of the estimation of emissions from enteric fermentation will be applied to estimate nitrogen excretion rates for these categories of calves. The planned activity allows to improve inventory of nitrogen generated by calves and stored to manure management systems.
	Direct emissions from agricultural soils (CRF 4.D.1)	Activity data and the algorithm used for the calculation are kept under consideration and will be updated necessarily. The investigation of main flows of sewage and industrial sludge generated by main producers was planned in the 2011 previous submission. However, the research was not performed due to the lack of financial support. Estonia plans to carry out the abovementioned improvements in the next submissions. In the framework of the further development of country-specific module on MMS, the fraction of livestock nitrogen excretion that volatilizes as NH_3 and NO_x ($Frac_{GASM}$) will be investigated to implement in the estimates.
	N_2O emissions from pasture, range and paddock (CRF 4.D.2)	As it was mentioned in Chapter 6.4.1.4, the research continues to develop country-specific manure management system. SE started a new cycle of agricultural survey in Estonia in 2010. The data on livestock population and manure management systems on village level will be finalized by the beginning of 2012. The results of the survey will be obtained from SE. Hence, by the next submission, the data will be analyzed and used in the estimations. In addition, country-specific literature will be analyzed, together with data on structure of cattle population by herd size in the early of 1990th. The data will be interpolated between 1990th and 2000, and between 2000 and 2010. The results will be presented by the next submission.
	Indirect emissions from agricultural soil (CRF 4.D.3)	The activity data and the algorithm are kept under consideration and will be updated necessarily.
	Field burning of agricultural residues (CRF 4.F)	The fraction of crop residue burned will be developed in the next submissions.
LULUCF	All sectors	Areas of all land use and land-use change categories will be updated annually according to new data obtained from NFI fieldwork.
	Carbon stock change in forest mineral soils and litter pools (CRF 5.A)	Estonian Environment Information Centre has initialized a project aimed to conduct fieldwork in order to obtain data about litter and mineral soil organic carbon stock in forests. Preliminary results are expected to be obtained by 2014.
	Carbon stock change in soils (CRF 5.B)	Estonia has launched a project with the aim to obtain data about cropland mineral soil carbon pool and emissions factor for organic soils, preliminary results are expected to be obtained by 2014.
	Carbon stock change in grassland mineral soils and litter pool (CRF 5.C)	Estonia is exploring options to get country-specific data for future submissions.
WASTE	All sectors	The activity data are kept under consideration and will be updated necessarily.

Table 10.8 summarises Estonia´s responses to the review of the initial report under the Kyoto Protocol.

Table 10.8. 2011 Estonia National GHG Inventory Centralized Review response

Category	Comment	Estonia's response	Where in NIR 2012	Future plans
General (Completeness)	The ERT noted that the reporting is incomplete for a number of LULUCF categories and pools for which reporting is mandatory and methodologies exist in the IPCC *Good Practice Guidance for Land Use, Land-Use Change and Forestry*. The ERT recommends that, in its next annual submission, Estonia report estimates of the categories not yet addressed in order to further improve the completeness and accuracy of its inventory. Furthermore, the ERT reiterates the encouragement of the previous review report that Estonia report potential emissions of fluorinated gases (F-gases).	Estonia has launched a project aimed to get country-specific activity data regarding forest land litter pool and carbon stock changes in mineral soils, emission estimates and carbon stock changes in cropland mineral and organic soils. Preliminary results are expected to be obtained by 2014. Cropland living biomass carbon stock estimates are provided in the current submission for the first time due to new data obtained. According to ERT recommendations (ARR2010), Estonia will use implied emission factors (IEF) from neighbouring countries (Sweden) for major omitted pools (mineral soil, litter). Estonia has estimated actual emissions of F-gases therefore we do not find it rational to estimate also potential emissions.	Section 7.2.2.4 CO_2 emissions/removals from/by litter (Forest Land) Section 7.2.2.5 CO_2 emissions/removals from/by mineral forest soils Section 7.2.6 Source-specific planned improvements (Forest Land) Section 7.3.2.1 Change in carbon stocks in living biomass (Cropland) Section 7.3.6 Source-specific planned improvements (Cropland)	
General (Key categories)	Estonia has identified all activities under Article 3, paragraph 3 of the Kyoto Protocol as key categories. The result of the analysis is presented in the KP-LULUCF CRF table NIR-3. However, the rationale for the identification of the activities as key categories is not presented in the comments column of KP-LULUCF CRF table NIR-3 or in the NIR. The ERT recommends that Estonia improve the transparency of its reporting by providing a description of the analysis in the NIR and comments in the CRF tables.	The basis for assessment of key categories under Article 3.3 of the Kyoto Protocol is the same as the assessment made for the UNFCCC inventory. Quantitative Tier 2 method is used.	Section 11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4	
General (Key categories)	The previous review report recommended that Estonia use the results of its key category analysis as a driving force for setting priorities for improving the quality of the inventory. In the NIR 2011, Estonia states that this action has been added to the inventory improvement plan and it will be carried out when more financial support is available. However, the ERT reiterates the recommendation from the previous review report because the results of the key category analysis are fundamental for setting the priorities for using available resources.	Source category-specific quality assurance of the NIR and the CRF tables using Tier 2 quality control elements was carried out in key categories in the 2012 submission.	Section 1.6.1.2	

General (Uncertainties)	Estonia has provided a tier 1 uncertainty analysis in its 2011 annual submission including and excluding LULUCF. However, the results of the analysis are not presented in the main part of the NIR (chapter 1.7); only a reference to the tables contained in annex 7 of the NIR is provided. Furthermore, the ERT notes that the values presented in the last line of both tables in the annex are not correct, leading to a potential misunderstanding of the results. The ERT recommends that Estonia correct the uncertainty calculation in its next annual submission and present the results in the NIR.	The results of uncertainty analysis are are presented in the main part of the NIR in the 2012 submission. The uncertainty calculation tables (Table 6.1) are corrected in the 2012 submission.	Section 1.7. General uncertainty evaluation, including data on the overall uncertainty for the inventory totals	
General (Uncertainties)	Estonia did not include explanations for the differences in the uncertainty estimates when the results are compared with the previous submissions. The ERT reiterates the recommendation of the previous review report that Estonia include explanations for such changes in the uncertainty estimates in its next annual submission. The ERT also reiterates the recommendation that Estonia include uncertainty estimates for the KP-LULUCF activities.	Explanations for the differences in the uncertainty estimates when the results are compared with the previous submission are included in the 2012 submission. KP-LULUCF Article 3.3 activities uncertainty estimates are included in the 2012 submission.	Sector specific chapters Section 11.3.1.5. Uncertainty estimates	
General (Uncertainties)	The ERT noted that the selected uncertainty values for each category are not always well explained or justified. In response to a recommendation of the previous review report, Estonia stated in the NIR that it is planning to carry out a project in order to improve the uncertainties but that the timeline is not yet established. The ERT reiterates the recommendation of previous review reports that, in its next annual submission, Estonia improve the justification of the uncertainty values used.	Source category-specific quality assurance of the NIR and the CRF tables using Tier 2 quality control elements was carried out in key categories in the 2012 submission. This included review of uncertainty estimates and available documentation. As a result, estimates and justifications of the values used have been improved in the 2012 submission.	Sector specific chapters	
General (Verificaction and QA/QC approaches)	The ERT noted some inconsistencies between the NIR and CRF tables and the use of notation keys (see paras. 35, 36, 44, and 92) and it recommends that Estonia improve the quality control and verification procedures to prevent such errors.	Estonia has improved the QA/QC and verification procedures to prevent inconsistencies between the NIR and CRF tables and the use of notation keys.		

Energy	The NIR is not sufficiently transparent in terms of the driving forces behind the trends in emissions and implied emission factors (IEFs) for all subcategories. The ERT recommends that Estonia include more detailed information for all key categories in the NIR of its next annual submission; for example, by including graphs or diagrams to demonstrate the different fuel types contributing to a specific subcategory over the time series.	In the 2012 inventory submission Estonia updated the NIR 1990–2010 with the figures and also provides explanations on driving forces behind the trends of emissions in all key categories.	Energy industries: section 3.2.5, Figure 3.7; Manufacturing Industries and Construction: pages 67-73, Figures 3.9–3.15; Other sectors: section 3.2.7, Figures 3.25–3.28	
Energy	The ERT noted that the notation keys have not been used consistently for all categories in the energy sector; for example, for iron and steel (liquid fuel, biomass and other fuels) and agriculture, forestry and fisheries (solid fuels) CO_2 emissions have been reported as "not applicable" ("NA"), whereas the AD have been reported as "not occurring" ("NO"). The ERT encourages Estonia to review its use of notation keys in all CRF tables in its next annual submission in order to ensure that all notation keys are consistently used.	Estonia has reviewed the use of notation keys in all CRF tables in the 2012 annual submission. The notation keys are consistently used for all categories.	All CRF tables, 1.Energy	
Energy	The ERT also noted that there are a number of areas in the NIR where incorrect references were used; for example, NIR table 3.29 should refer to the Revised 1996 IPCC Guidelines rather than the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (hereinafter referred to as the 2006 IPCC Guidelines), and inconsistent EFs were included in comparison with those tables in the CRF reported. The ERT recommends that Estonia improve the internal QA/QC procedures and report on these in its next annual inventory submission.	Estonia has reviewed the use of references of EFs in all categories and made appropriate corrections.	Tables 3.31, 3.32 and 3.37	

Energy	During the review, the ERT identified a number of areas in the 2011 inventory submission where EFs have been adopted from the 2006 IPCC Guidelines rather than the Revised 1996 IPCC Guidelines or the IPCC good practice guidance, without providing any justification. In response to questions raised by the ERT during the review, Estonia provided some justifications, mainly explaining that the EFs from the 2006 IPCC Guidelines reflect the results of latest research and thus lead to more accurate estimates. The ERT considered that these explanations were not sufficient and/or not sufficiently documented to justify the use of the 2006 IPCC Guidelines default EFs. In response to the list of potential problems and further questions from the ERT, Estonia reverted to using the EFs from the Revised 1996 IPCC Guidelines and recalculated the emissions of all categories in the energy sector for the whole time series. The ERT recommends that Estonia update the NIR, of its next annual submission, with the revised EFs providing explanations for the recalculation.	In the 2012 inventory submission Estonia updated the NIR 1990–2010 with the revised EF-s and also provides explanations of recalculations.	Sections 3.2.5.5, 3.2.6.6, 3.2.7.3 and 3.3.2.5	
Energy	The ERT noted that Estonia replaced IPCC default EFs with EFs from other countries for some categories in the 2011 annual submission; for example, the CO2 EF for peat (milled, sod and briquettes) in fuel combustion, which was adopted from Finland, and the CO2 EF for gasoline, diesel and gas oil from Lithuania in road transportation. However, no explanation is provided in the NIR that these EFs better reflect the national circumstances of Estonia. In response to questions raised during the review, Estonia has provided references from Finnish energy experts from the Estonian-Finnish Twinning project that was carried out in 2008 which provide justification for the CO2 EFs it has used for sod peat and peat briquettes. The ERT recommends that Estonia include these references for the justification of these EFs and provide more detailed documentation in its next annual submission.	Estonia included in the NIR 2012 explanations about the logic behind the adopted CEFs of milled peat (= IPCC default value), sod peat and peat briquette from Finland and gasoline, diesel oil (= IPCC default value) and gas oil (= IPCC default value) carbon EFs from Lithuania.	After the Table 3.13	

Energy	During the review, Estonia explained that all oil products mentioned above are not exclusively imported from Lithuania. The ERT recommends that the Party revise its CO2 EFs for gasoline, diesel and gas oil and develop country-specific values, for example by taking into account the share of oil products from other countries in order to develop country-specific EFs.	The following text is added into NIR 2012: The ERT (2011) recommended Estonia not to use the Lithuanian CO_2 emission factor for gasoline as a CS one but elaborate the Estonian own EF for gasoline using the weighted average method of country specific emission factors from main importer countries. This is a large work and needs gasoline import data by countries which are not available in the electronic database of Statistics Estonia and have to be requested by special order from the statistical office. In the current submission Estonia still decided to use Lithuanian CO_2 EF of gasoline because according to the rough estimation made by ERT (on gasoline import data 2009) the value of Lithuanian CO_2 EF of gasoline is more close to Estonia's one.	Pages 83–84	
Energy	Estonia adopted the CO_2 EF for natural gas from Finland, using the same carbon EF of 15.01 t C/TJ, but a lower net calorific value (NCV) for natural gas (33.6 GJ/1000 m3) than Finland (36 GJ/1000 m3). The ERT noted that the resulting IEF (54.76 t/TJ) is lower than the IPCC default value (56.1 t/TJ). The NIR does not provide any explanation why the carbon EF of Finland better reflects the national circumstances of Estonia. Also, Finland is not a natural gas producer and imports natural gas from the Russian Federation, as does Estonia. The ERT strongly recommends that Estonia justify or revise the use of EFs that are different to the IPCC default values in its next annual submission. In addition, the ERT recommends that Estonia develop country-specific CO_2 EFs for natural gas, for example by obtaining NCV and composition of natural gas from the national gas companies and report all necessary background information to document these EFs in future inventory submissions.	In the 2012 inventory Estonia uses the carbon EF for natural gas of the Russian Federation, because Estonia imports natural gas only from Russia and the NCV of the natural gas is the same. In the nearest future Estonia still plans to develop country-specific CEF for natural gas (depends from the financial possibilities of the MoE).	Table 3.13 of the NIR	

Energy (Reference and sectoral approaches)	The difference in the estimate of CO_2 emissions calculated using the reference and sectoral approaches is 2.00 per cent in 2009. The difference is larger at the beginning of the time series, ranging between 1.77 and 6.58 per cent. The NIR includes brief explanations on the comparison. The difference is mainly attributed to the fact that Estonia has not completed the reference approach in line with the Revised 1996 IPCC Guidelines. In spite of the recommendations in the previous review report, Estonia has still not included several fuels in the CRF tables of the 2011 annual submissions (e.g. bitumen in the reference approach table 1.A(b) was reported as NO but in table 1.A(d) 1,348.39 TJ of bitumen was reported as feedstock and non-energy use.) Further, in table 1.A(c) the fuel consumption values for gaseous fuels were identical in the two approaches in 2009; however, this should not be the case when the sectoral approach is compared with the reference approach (which includes fuel use for feedstocks and non-energy purposes), because natural gas is used as a feedstock in Estonia. The ERT recommends that Estonia complete tables 1.A(b), 1.A(c), 1.A(d) according to the Revised 1996 IPCC Guidelines in its next annual submission.	In the 2012 inventory submission Estonia has completed the reference approach tables in line with the Revised 1996 IPCC Guidelines.	CRF Table 1.A(b), 1.A(c) and 1.A(d)	
Energy (Reference and sectoral approaches)	Estonia has provided information of the CO_2 comparison between the reference and sectoral approaches and the relevant information on the national energy balance in the 2011 NIR. The ERT recommends that Estonia include a national energy balance sheet in its next annual inventory submission.	In the 2012 submission Estonia included the national energy balance sheet in Annex 4 of the NIR.	NIR Annex 4	
Energy (Reference and sectoral approaches)	The information in the NIR on net calorific values and carbon EFs for several fuel types are different from the values reported in CRF table 1.A(b). Also the NCV for gasoline in CRF table 1.A(b) is 1,000 times smaller than the value reported to the International Energy Agency (IEA). The ERT recommends that Estonia develops appropriate QC procedures in order to avoid those errors and report on their implementation in its next annual submission.	The problem of 1000 time smaller NCV and CEFs of some liquid fuels in RA was caused by Reporter error. Estonia informed the Help Desk about the error and Help Desk sent us a new version of the Reporter. Today, the error is eliminated.	CRF Table 1.A(b)	

Energy (International bunker fuels)	Previous review reports have recommended that Estonia improve the explanations of the split between domestic and international aviation and navigation. The 2011 NIR states that data comes from Statistics Estonia, and that the surveys conducted require information to be provided as to whether fuel is used for domestic or international transport, in accordance with the IPCC criteria. However, in the NIR there is no information regarding the source of information for the number of landing/take-off (LTO) cycles. During the review Estonia provided the time series for the number of LTO cycles divided into domestic and international flights and more information on the methodology use for deriving the emission estimates. The ERT recommends that Estonia include this information in its next annual submission.	Estonia has included information on LTO cycles divided into domestic and international flights and also information on the methodology used in the 2012 submission.	NIR pages 100–101	
Energy (Key categoris - Stationary combustion: solid fuels - CO2)	In response to the list of potential problems and further questions from the ERT, Estonia provided an up-to-date carbon balance for all three individual shale oil production plants based on each specific thermal processing operation. Hence, Estonia has revised carbon EFs of semi-coke gas and both types of generator gases which arise from these operations. This updated information has resulted in revised estimates for all categories under the energy sector and in particular the categories electricity and heat production/solid fuel, chemical industry and other – carbon stored with black ash and semi-coke. The ERT commends Estonia for its effort to resolve this issue in such short period of time and recommends that Estonia include the descriptions and revised carbon EFs spreadsheet in its next annual submission.	Estonia has included descriptions and revised carbon EFs of semi-coke and generator gas, semi-coke and carbon stored with semi-coke to NIR 2012.	Carbon EFs: NIR 2012, Table 3.13 and in Annex 2; Carbon stored in Annex 2 of the NIR 2012	

Energy (Key categoris - Stationary combustion: solid fuels - CO_2)	The ERT further noted that, in its submission of revised estimates, Estonia also updated the NCV of oil shale to a value which is inconsistent with that provided by Statistics Estonia in the energy balance. Estonia explained that Statistics Estonia uses an annual average NCV for enriched oil shale which is obtained from one oil shale mining company. The Party explained that this value is not applicable to the plants that produce shale oil and that the updated NCVs were collected directly from those plants. Furthermore, Estonia's MoE and the inventory experts have begun discussions with Statistics Estonia to adjust national statistics data by using plant-specific NCVs for oil shale instead of the average value of enriched oil shale. The ERT encourages Estonia to continue this dialogue in order to ensure consistency and provide explanations in its next annual submission, if the NCVs reported in the inventory are not consistent with those in the energy balance of Statistics Estonia.	In the NIR 2012 Estonia continues use of plant specific net calorific values of oil shale used in oil plants. The Statistics Estonia still works with updating of data collection forms and a new updated data on NCV will be implemented only in 2013.	Table 3.13 of the NIR	
Energy (Key categories - Fugitive emissions: oil - CH_4)	Estonia reports CH_4 emissions from transport and storage of oil products using default EFs from the Revised 1996 IPCC Guidelines. However, these factors refer to crude oil. The ERT encourages Estonia to review the appropriateness of adopting these EFs, and document the decision-making process regarding these EFs in its next annual submission.	In the NIR 2011 CH_4 EF value for oil product storage 200 kgCH_4/PJ was used. In the 2012 submission the value of CH_4 EF 135 kg CH_4/PJ was implemented. In the IPCC 1996 Revised Guideline Table 1-58 of the value of CH_4 EF in range 20-250 has given. Estonia implemented the average value of the EF. The CRF category 1.B.2 is not key category in Estonia.	Table 3.41 of the NIR	
Energy (Non-key categories - Road transportation: liquid fuels - CH_4 and N_2O)	Estonia reports emissions of CH_4 and N_2O using the IPCC tier III COPERT IV model. However, the NIR does not provide any information on how the effects of emission control technology and operation conditions are incorporated into the tier III emission calculations. During the review, Estonia provided further documentation of the calculation methodology. The ERT recommends Estonia to include the documentation in its next annual inventory submission to improve the transparency.	The description of used CH_4 and N_2O emission calculation methodology in 1A3b is included into the NIR 2012.	Section 3.2.6.3 Methods	

Energy (Non-key categories - Fugitive emissions: natural gas - CO2)	In the CRF tables, CH_4 emissions from natural gas transmission have been provided but CO_2 emissions from this category were reported as "NO". The ERT noted that this is not in line with the IPCC good practice guidance, which provides a tier 1 methodology and a default EF for estimating CO_2 emissions from natural gas transmission and the ERT recommended that Estonia provide an estimate for this source. In response to the list of potential problems and further questions from the ERT, Estonia stated that there is no transmission of natural gas in Estonia, only distribution and, as there are no compressor stations in Estonia, no fugitive CO_2 emissions occur. The ERT recommends that Estonia correct the reporting in the CRF and include this explanation in the NIR of its next annual submission.	Estonia has corrected the reporting of fugitive CH_4 emissions from the use of natural gas in the CRF tables and also included corresponding explanations into the NIR 2012.	Section 3.3.2	
Industrial processes and solvent and other product use	Estonia reports potential emissions of HFCs, PFCs and SF6 as "not estimated" ("NE"). The ERT reiterates the encouragement of the previous review report that Estonia provide estimates of potential emissions for these gases.	Estonia has estimated actual emissions therefore we do not find it rational to estimate also potential emissions.	NIR: no changes	

Industrial processes and solvent and other product use (Key categories - Consumption of halocarbons and SF6 - HFCs)	The ERT recommends that Estonia provide in its next annual submission a justification of the use of the methodology described in the 2006 IPCC Guidelines and provide a comparison of used methods and EFs with the IPCC good practice guidance. The ERT reiterates the concern expressed in the previous review report that the EF for product life factor (PLF), given as 2 per cent for household refrigeration is high compared with the default IPCC good practice guidance range of 0.1–0.5 per cent and country-specific values reported by other countries (mostly between 0.01 per cent and 0.5 per cent). The ERT reiterates the recommendation of the previous review report that Estonia review the leakage rate of these refrigerators and further justify its use of the EF or apply a default PLF value or a revised country-specific PLF and recalculate the emissions, as applicable, noting that the review of leakage rates for household refrigerators is mentioned under the planned improvements for the 2012 annual submission. The ERT also reiterates the recommendation that Estonia improve the transparency of its reporting by including in the NIR more information about the development of the PLF for commercial refrigeration and for different types of vehicles that incorporate air-conditioning equipment.	The use of the methodology described in the 2006 IPCC Guidelines is justified and used methods and EFs are compared with the IPCC good practice guidance in the 2012 submission. The leakage rate of household refrigerators is reviewed and its use is justified in the 2012 submission. More information about the development of the PLF for commercial refrigeration is included in the NIR 2011 (also included in NIR 2012). More information about the development of the PLF for different types of vehicles that have mobile air conditioning are included in the 2012 submission.	Section 4.5 Consumption of Halocarbons and SF_6 (page 155). Consumption of Halocarbons and SF6, Methodological issues (4.5.1.1.2 - 4.5.4.2.2). NIR section 4.5.1.1.2 and 4.5.1.1.5 (Domestic refrigeration). NIR section 4.5.1.2.2 (Commercial refrigeration). NIR section 4.5.1.6.1 Methodological issues (Passenger cars)	

Industrial processes and solvent and other product use (Non-key categories - Soda ash use - CO2)	In response to the list of potential problems and further questions from the ERT, Estonia informed the ERT about investigations that were carried out to identify further uses of soda ash in Estonia. These investigations identified further soda ash use in processes of electrolyte neutralization and Estonia provided revised emission estimates for CO_2 emissions from soda ash use in the electrolyte neutralization process for the entire time series and the ERT agreed with these estimates. The ERT recommends that Estonia transparently document the methodologies, EFs and AD used for the calculations in the NIR of its next annual submission. The ERT also recommends that Estonia ensure completeness for this category in future submissions, by monitoring any potential uses, and report on these activities in its next annual submission. This could be done by applying appropriate QA/QC procedures, for example by comparing the sum of specific soda ash uses included in the inventory with statistical data on production, import and export (national or international (e.g. Eurostat)).	Methodologies, EFs and AD used for the calculations are documented in the 2012 submission. A complete quality assurance and quality control was carried out for Industrial Processes sector (also soda ash use) according to IPCC Tier 1 method in the 2012 submission.	Section 4.2.3	
Agriculture (Key categories - Enteric fermentation - CH4)	The ERT noted that the characterization data for non-dairy cattle provided in the NIR is insufficient as very little information was provided on animal characteristics and production. The ERT recommends that Estonia provide further information on the characterizations applied to non-dairy cattle.	The NIR includes the data on population of non-dairy cattle, their weight, feeding situation, digestibility of feed etc.	Annex 3, Table 6.23 of the NIR	

Agriculture (Key categories - Enteric fermentation - CH4)	The ERT considers that, for swine, the approach used by Estonia is appropriate. However, the ERT recommends that the Party provide further documentation to improve transparency to show which gross energy (GE) intake and methane conversion rate (Ym) values were used. Developed and developing country values are provided for each in table A-4 of the Revised 1996 IPCC Guidelines, but it is not clear what values have been applied to each of the age/weight classes of swine defined by Estonia. The ERT recommends that Estonia provide the additional information, as suggested above, in order to enhance transparency. While the IEF for swine as shown in the CRF tables (0.8 kg/head/year) is the lowest of any reporting Party, Estonia has given a reasonable explanation as to why the IEF is lower than the IPCC default value of 1.5 kg/head/year for developed countries and 1.0 kg/head/year for developing countries. Given that the IPCC default EF is based upon certain assumptions of population age and size structure in order to be able to apply it to the entire population across a wide range of countries, it is reasonable that the IEF for Estonia is lower than the IPCC default, since Estonia estimated its EFs by age/size class and developed EFs specifically for those age/size classes. The ERT recommends that Estonia enhance the transparency of the NIR by providing the GE and Ym values applied to each of the age/weight classes of swine and justify the use of the lower IEF.	The data on weight, GE by each category of swine were specified and presented in the NIR.	Table 6.14, page 216	
Agriculture (Key categories - Enteric fermentation - CH4)	In the CRF tables, Estonia reports only calves under the young cattle subcategory, with bovine cattle (aged 1 to 2) reported in the mature animal subcategory, which is not in accordance with the IPCC good practice guidance. The ERT also noted that the calves were not excluded from the enteric fermentation calculations for the period when they are exclusively milk fed. The ERT reiterates the recommendation of the 2010 review report that Estonia report bovine cattle in the young cattle subcategory, because they are growing animals, and apply a Ym of zero to calves for the period when they are milk fed.	The detailed information on GHG emissions occurred from each category of cattle livestock were described in the NIR. However, the 2012 submission does not include the re-structured emissions in the CRF tables. Since, in the framework of the 2012 submission, a lot of efforts were put to develop country-specific MMS, which, in its turn, triggered the recalculations in CH_4 and N_2O MMS sub-sections.		The recommendation will be taken in the next submission.

Land use, land-use change and forestry	The ERT notes that the LULUCF sector of the inventory is not complete, with emissions/removals for many subcategories and pools reported as “NE” and with inconsistent use of notation keys for some aspects of the time series without clear explanation (e.g. IE, NO for 1990–1994 and IE for 1995–2009 for carbon stock change in dead organic matter in land converted to grassland). In the 2011 submission Estonia provided for the first time estimates of carbon stock changes in grassland converted to cropland (organic soils) and land converted to grassland (living biomass and organic soils). Estonia does not estimate emissions/removals from forestland converted to wetlands, land converted to settlements, except wetlands converted to settlements, and forest land converted to other land and cropland converted to other land. For the subcategories that are reported, the following pools are not estimated: living biomass for cropland remaining cropland and wetlands remaining wetlands; dead organic matter for cropland remaining cropland and wetlands remaining wetlands; and mineral soils for cropland remaining cropland and grassland converted to cropland, and grassland except wetlands converted to grassland. The ERT commends Estonia for the improvements made to its inventory, but reiterates the recommendation of the previous review report that Estonia improve the completeness of the LULUCF estimates.	Estonia has reviewed the use of notation keys in all CRF tables in the 2012 annual submission. Inconsistencies have been eliminated. Estonia has reported in the 2012 submission estimates under Forest Land conversion to Peatland (Wetland), Forest Land converted to Settlements (living biomass, dead organic matter, soils), Grassland converted to Settlements (living biomass, dead wood), Forest Land converted to Other Land (living biomass, dead wood). Estonia does not report emissions under Wetland conversion to Settlements, since that kind of land use transformation has not taken place, also no estimates for Cropland conversion to Other Land. Estonia reports emissions/removals under Cropland remaining Cropland and land converted to Cropland living biomass pool for the first time in the 2012 submission. Mineral soil carbon pool estimates are currently under development for Forest Land and Cropland categories.	Section 7.3.2.1 Change in carbon stocks in living biomass (Cropland) Section 7.5.2 Methodological issues (FL to Peatland, living biomass) Section 7.6.2 Methodological issues (FL to SL, GL to SL) Section 7.7.2 Methodological issues (FL to Other Land)	

Land use, land-use change and forestry	Estonia uses NFI data for estimating the areas of land categories and land-use changes. The NFI covering the whole country starting from 1999 uses systematic sampling with a 5 x 5 km quadrangle grid, and is implemented every year, measuring one fifth of the permanent sampling plots. All permanent plots are measured once in every five years. Before 1999, stand-wise forest inventories were implemented. Estonia started an additional field study in 2009 in the framework of the NFI to specifically assess land use and land-use changes over the past 20 years and estimate soil types (mineral/organic). However, the ERT notes that the Party did not provide detailed methods used to identify the exact year when land use change occurred on each sampling plot, when using the data of NFI where each permanent plot is measured.	Land use change matrix was established as described in NIR 7.1.3. In addition to land category registration, "LULUCF former land category" is registered on every sample plot if land category has changed after base point (31.12.1989). Also the year of change has been estimated. All these observations are primary made directly in the field. In case of doubt, older maps and aerial photographs were used as supporting material to determine more accurately land use and changes in time. Resulting data set is a matrix with the previous and the current land use classes in the timeline.	Section 7.1.3 National Forest Inventory	
Land use, land-use change and forestry	For the LULUCF subcategories reported, Estonia generally applies tier 1 methods for estimating emissions/removals, using country-specific AD and default EFs and parameters from the IPCC good practice guidance for LULUCF. The ERT reiterates the recommendation from the previous review report that Estonia develop country-specific EFs and parameters where possible.	Estonia implements Tier 2 method for all living biomass, dead wood and biomass burning estimates. Tier 1 is used for calculating emissions from organic soils and liming. Estonia is also exploring options to develop country-specific emission factors.		
Land use, land-use change and forestry	The ERT considers that the reporting in the LULUCF sector is not transparent but has improved since the last review. Estonia included transparent descriptions of the methods and EFs used to estimate emissions and removals (essentially default values from the IPCC good practice guidance for LULUCF). However, Estonia did not provide information on the methodology for estimating carbon stock changes in any land converted to other land in the NIR. The ERT strongly recommends that the Party provide the information on the methodology used for estimating carbon stock changes in any land converted to other land. The information on the AD including the data source and estimation method is sometimes not provided transparently or explained clearly. The ERT reiterates the recommendation from the previous review report that Estonia clearly present the AD used in the NIR.	In the 2012 submission carbon stock changes, methodology and used parameters/emission factors are provided separately for land remaining in the same land use and land converted to other land use. All activity data sources are noted in the current national report, the majority of AD is obtained from NFI.	Section 7.1.1 Description and quantitative overview 7.2 Forest Land (CRF 5.A) 7.3 Cropland (CRF 5.B) 7.4 Grassland (CRF 5.C) 7.5 Wetlands (CRF 5.D) 7.6 Settlements (CRF 5.E) 7.7 Other Land (CRF 5.F)	

Land use, land-use change and forestry (Key categories - Forest land remaining forest land - CO_2)	In its 2011 submission, and for the first time, Estonia estimates the change in carbon stock in living biomass by using the stock change method with default parameter values from the IPCC good practice guidance for LULUCF (except for wood density of pine and birch) and uses NFI for estimates of the area of forest land. The ERT recommends that Estonia develop country-specific parameter values for future annual submissions.	Estonia is exploring options to develop country-specific emission factors.		
Land use, land-use change and forestry (Key categories - Forest land remaining forest land - CO_2)	Carbon stock changes in living biomass fluctuate considerably between 1990 and 2008, from losses of 1,339.21 Gg C in 2001 to gains of 2,579.66 Gg C in 2007. During the review, Estonia explained that the difference in the carbon stock change between two successive years is small compared with the total growing stock, and is lower than the sampling error of the growing stock estimates. In its NIR, the Party also reports that the significant change of harvest volumes and extensive impact of wildfires affects the emission estimates. However, the ERT considers that the level of harvest volumes and wildfires cannot explain the large fluctuations, and that the method using NFI data largely contribute to the fluctuations. The ERT strongly recommends that Estonia explore ways to reduce fluctuations due to the estimation method, for example by using the NFI dataset for the specific year and that for five years previously to compare the data of the same sampling plots.	There has been considerable fluctuation in carbon stock of living biomass between 1990 and 2008 in Estonia. It is impossible to undo actual changes that have taken place. Losses in the years 1999-2004 have been caused by intense logging activity (due to land reform and economic factors) during this period when cutting intensity was three times higher than in 1990-1995 and twice as much as nowadays. In general, Estonia still holds the opinion although CSC in consecutive years varies, it does not differ in absolute terms more than sampling error of the stock estimates (less than 2%) and therefore does not consider the need to further smooth the data. A better visual (smaller variation) for time series estimation degrades the overall data accuracy. Estonia uses interpolated data for 1990-1998 (period before NFI) and NFI data (5-year averages) since 1999. The method using NFI data certainly affects the fluctuation but is also the most accurate. Estonia recognizes that there might be some fluctuations in the years 2005-2007, acknowledges the problem and will give it special attention.	Section 7.1.3 National Forest Inventory Table 7.11 Area and volume of forest biomass harvested in 1990-2010 Figure 7.9 Harvested volume on forest land in Estonia in 1990-2010	

Land use, land-use change and forestry (Key categories - Forest land remaining forest land - CO2)	In order to calculate the carbon stock change in deadwood Estonia uses a countryspecific value, 0.266, for the biomass expansion factor to convert the merchantable volume to aboveground biomass (BEF2), and Estonia cites an article in an international journal (Journal of Forest Science, 56, 2010, (9) pp.397–405) as a reference for this value. However, by definition, this value should be larger than 1.0; and the rationale for the difference was not clearly provided in the NIR or during the review. The ERT recommends that, in its next annual submission, Estonia provide the rationale for the use of this value or explore the possibility that there might be a different definition in the original reference in accordance with the IPCC good practice guidance for LULUCF. Otherwise, the Party is recommended to use country specific BEF2 which is more accurate than the default IPCC value if appropriate, or the default IPCC value.	By mistake it was written in the 2011 NIR that value 0.266 is biomass expansion factor, instead it is dead wood density (tonnes/m3), used for converting the volume of dead wood (data obtained from NFI) into tonnes of dry matter.	Section 7.2.2.3 CO_2 emissions/removals from/by dead wood (Forest Land)	

Land use, land-use change and forestry (Key categories - Forest land remaining forest land - CO2)	In the NIR, Estonia did not provide transparent information on the data source for estimating areas of forest land remaining forest land under organic soils. During the review, Estonia explained that the data of NFI which survey soil types were mainly used to estimate the areas for the NIR 2011, and that supplementary data from the additional field study which started in 2009 were used for estimating emissions in the years 1990–1998. Forest data provided by Statistics Estonia were used to some extent, but data from the European programme CORINE (Coordination of information on the environment), which had been used for the previous submission, were not used any more. The ERT recommends that Estonia provide the information on the data sources used for estimating emissions from organic soils in its next submission. In addition, Estonia continues to use the default IPCC CO2 EF (0.16 t C/ha/year) for drained organic soils in managed forests for boreal forests, which may not be suitable for Estonia since Estonia is situated in cold temperate wet zone according to Genetic climate zone map in IPCC good practice guidance LULUCF (Figure 3.13) and the default IPCC CO2 EF for temperate forest (0.68 t C/ha/year) is larger than that for boreal forest, as indicated in the previous review report. During the review, Estonia indicated that the development of a country-specific EF is still in progress. The ERT reiterates the recommendation of the previous review report that Estonia reassess the appropriateness of the default EF or replace it with country-specific data in its next annual submission.	The area of organic forest soils is obtained from NFI only. According to GPG-LULUCF 2003 and IPCC 2006 Vol. 4, Estonia is in between Boreal and Cold temperate climatic zone, however most recent reports (e.g. State of Europe's Forests, 2011) and the statement by national biologists is that Estonian forest vegetation is typical to boreal forests, thus input values from Boreal zone is selected. Notice, that all other land use categories follow the default allocation by IPCC 2003. Despite ERT recommendations, Estonia has not managed to give country-specific EF values due to limited financial capacity for conducting necessary fieldwork and data analysis	Section 7.2.2.6 CO_2 emissions from drained organic forest soils	

Land use, land-use change and forestry (Key categories - Forest land remaining forest land - CO2)	Estonia reports CO_2 emissions from biomass burning under forest land remaining forest land by wildfires in CRF table 5(V) as 2.03 Gg in 2009. However, the Party uses the stock change method to estimate carbon stock change in living biomass, which usually includes CO_2 emissions from biomass burning. During the review, Estonia recognized that the estimates are double counted, and included revised estimates with its submission of 17 October 2011 where CO_2 emissions from biomass burning are now included in carbon stock change in living biomass and CO2 emissions from biomass burning under forest land remaining forest land by wildfires in CRF table 5(V) is reported as "IE". The ERT agrees with the revised estimates, and recommends that the Party provide a description of this in the NIR, reflecting the correction, in its next annual submission.	Explanations regarding the methodology of living biomass carbon stock and biomass burning and the linkage between these pools are included in the 2012 submission.	Section 7.2.2.1 Change in carbon stocks in living biomass Section 7.8 Non-CO_2 emissions from biomass burning (CRF 5 (V))	
Land use, land-use change and forestry (Key categories - Land converted to forest land - CO2)	In its 2011 submission, Estonia for the first time estimates the area and CO_2 emissions from land converted to forest land as 54.43 kha and 693.86 Gg CO_2. The ERT commends Estonia for estimating the area and emissions from this category. However, Estonia did not provide the methodology for these calculations in the NIR. The ERT strongly recommends that the Party provide detailed information on the methodology including equations and parameters in accordance with the IPCC good practice guidance for LULUCF in the NIR of its next annual submission.	Estonia has provided methodology and estimates separately for Forest Land remaining Forest Land and land converted to Forest Land in its 2012 submission.	Section 7.2.2.2 Annual change in carbon stock due to biomass changes in forest land Section 7.2.2.3 CO_2 emissions/removals from/by dead wood Section 7.2.2.6 CO_2 emissions from drained organic forest soils	
Land use, land-use change and forestry (Key categories - Cropland remaining cropland - CO2)	Estonia did not report the carbon stock change in living biomass from 1990 to 2009 in its 2011 submission, even though the Party reported the carbon stock change in living biomass in orchards in its 2010 submission. Estonia explained that the data on area of orchards are inappropriate, but that the carbon stock change is estimated to be a very small sink. The ERT recommends that the Party collect more reliable area data on orchards and estimate the carbon stock change in living biomass.	Estonia has provided estimates for cropland living biomass in its 2012 submission due to new data obtained.	Section 7.3.2.1 Change in carbon stocks in living biomass (Cropland)	

Land use, land-use change and forestry (Key categories - Cropland remaining cropland - CO2)	Estonia reported that the amount of limestone applied to cropland in 2009 was 0.43 Mg/year but that the amounts of dolomite applied to cropland and of limestone and dolomite for grassland were reported as "NE". During the review, in response to questions raised by the ERT, the Party explained that the data correspond to the total limestone and dolomite applied to croplands, although mainly limestone is applied, and that lime is not added to grassland in Estonia. The ERT recommends that the Party provide this detailed information in the NIR and use the correct notation keys in its next annual submission. In addition, the IEF of 120 (Mg CO_2-C/Mg) in the CRF tables is different from the IPCC default factor of 0.12 (t C/t $CaCO_3$ or t $CaMg(CO_3)_2$), which is reported by the Party in the NIR. The ERT notes that it seems that the difference is due to the mistreatment of units. The ERT recommends that the Party check the calculation for this category, and provide corrected values with a clear explanation in its next annual submission, and also enhance the QC check procedures.	The use of notation keys has been revised and corrected. The total annual amount of limed applied is 1000 times greater than reported in 2011 due to a mistake made when converting units, therefore also IEF value was incorrect in the CRF table. This mistake has been corrected in the 2012 submission.	Section 7.3.2.4 CO_2 emissions from liming (CRF 5(IV)) Section 7.3.5 Source-specific recalculations	
Land use, land-use change and forestry (Key categories - Grassland remaining grassland - CO2)	Estonia uses 2.5 as the biomass expansion factor for the conversion of merchantable volume to aboveground biomass (BEF2) for change in living biomass. In its NIR, a value of 0.25 was reported, but during the review, Estonia explained that 2.5, the default value from the IPCC good practice guidance for LULUCF, is the correct value. There is no methodology provided in the IPCC good practice guidance for LULUCF for estimating carbon stock change in deadwood, and Estonia uses the same methodology here as it used for the category forest land remaining forest land. However, the Party did not provide a detailed explanation of why this methodology is used for grassland remaining grassland. In particular, for BEF2 for carbon stock change in deadwood Estonia uses a country-specific value, 0.266. This is not only an abnormal value (see para. 82 above), but also different from the value used for living biomass, which could result in overestimate of the carbon stock change in dead wood. The ERT recommends that Estonia provide the detailed explanation for the use of this methodology in the NIR of its 2012 annual submission.	NFI provides annually data about the volume of dead wood under grasslands, therefore stock change method is used for estimation of carbon stock changes in this pool. 0.266 is not BEF2 as stated by mistake in the 2011 submission, instead it is dead wood density used for conversion of the volume of dead wood into tonnes of dry matter.	Section 7.4.2.2 CO_2 emissions/removals from/by dead wood (Grassland)	

Land use, land-use change and forestry (Key categories - Grassland remaining grassland - CO2)	The ERT noted that the area of organic soils in grassland remaining grassland is reported constant during the periods 1990–1993 (40.69 kha), 1995–1999 (39.20 kha), 2000–2005 (38.45 kha), and 2006–2008 (38.24 kha), and the ERT noted that this pattern of the time-series might derive from the data collection method. However, the Party did not provide an explanation of the constant area estimates in the NIR. The ERT recommends that Estonia provide the explanation on the trend of area change, including the method of area estimation and data sources, and explore the way to improve time-series consistency of areas in the NIR of its 2012 annual submission.	During its annual fieldwork when determining land use (and soil type), NFI has not detected land use change on its sample plots, therefore the area is reported constant for some periods. The case, when the overall grassland area has changed but area of organic soils has remained the same can be explained by the fact that the majority of grasslands are on mineral soils and it is highly likely when grasslands are converted to other land uses, it happens on mineral soil, so the area of organic grassland soils stays the same.	Section 7.4.2.5 CO_2 emissions from organic soils (Grassland)	
Land use, land-use change and forestry (Key categories - Land converted to grassland - CO2)	In its 2011 submission, Estonia estimates for the first time the area and CO2 emissions from land converted to grassland as 6.08 kha and 45.18 Gg CO2 respectively. The ERT commends Estonia for estimating emissions from this category. However, Estonia did not provide the methodology for these calculations in the NIR. The Party reported the carbon stock change in dead organic matter as “IE”, “NO” between 1990 and 1994 and “IE” between 1995 and 2009; and also reported the carbon stock change in soils as “NO” and “NE” for the whole time series. However, no detailed explanation was provided in the NIR. The ERT strongly recommends that the Party provide, in the NIR of its 2012 annual submission, detailed information on the methodology used, including equations and parameters in accordance with the IPCC good practice guidance for LULUCF and on the rationale of the use of these notation keys.	In the 2012 submission, Estonia has improved time series consistency and reports carbon stock changes in living biomass, dead wood and organic soils due to new data obtained from NFI. Methodologies and parameters implied are provided in the NIR 2012. Use of notation keys has been revised.	Section 7.4.2.1 Change in carbon stocks in living biomass Section 7.4.2.2 CO_2 emissions/removals from/by dead wood Section 7.4.2.5 CO_2 emissions from organic soils	

Waste (Key categories - Solid waste disposal on land - CH4)	Estonia uses the ‘Forecast’ function of the Excel software to calculate amounts of municipal solid waste generated in the period 1940–1989 based on data from the period 1990-2009. The ERT notes that the formula recalculates all previous values when a new value for the most recent year is available, in an automatic manner without a detailed assessment of the appropriate use of the projection function. In addition, it was noted in previous review reports that the approach used results in a very high waste generation rate of 415 kg/person/year for 1940 while relevant methodological studies recommend a waste generation rate of 200 kg/person/year.5 The ERT reiterates the recommendation of the previous review report that the Party revise the waste generation rate for the entire time series in order to reflect actual economic growth and consumption patterns in Estonia since 1940.	Estonia revised the waste generation rate for the entire time series in the 2012 submission. During the compilation of the 2012 submission discussion was held with experts in EEIC Waste bureau. It was decided that, as no research has been made to estimate historical waste generation considering historical production volumes, consumption habits, existing landfills, practices from neighbor countries, its complicated to value historical data. 200 kg/cap/year was used as historical waste generation rate as a recommendation by ERT.	Sections 8.2.2, 8.2.4	
Waste (Key categories - Solid waste disposal on land - CH4)	The ERT noted considerable fluctuations of the CH4 IEFs: the 2009 value (0.090 t/t MSW) is 43.2 per cent higher than the 1990 value (0.063 t/t MSW), but the minimum value occurs in 1996 (0.027 t/t MSW). In response to questions raised by the ERT during the review, the Party explained that these fluctuations are the result of the implementation of CH4 recovery practices starting in 1995 and the unstable population rate in the country. The ERT recommends that the Party include additional information in the NIR of its next annual submission regarding CH4 recovery practices and the unstable population rate in the country in order to improve the transparency.	The amount of recovered landfill gas, waste recycled and unstable population which fluctuate during the time period affect also the implied emisson factor (IEF) of CH4. The main reason to the unstable population is mostly migration to abroad, additional information about CH4 recovery practices are described under 8.2.1 subcategory (Production of biogas).	Sections 8.2.1, 8.2.3	
Waste (Key categories - Solid waste disposal on land - CH4)	The DOC value for the period 1940–2000 was derived from an analysis of waste composition from the Netherlands and there is no justification in the NIR to indicate why these data reflect Estonian conditions. The ERT reiterates the recommendations from previous review reports that the Party use the country-specific composition of waste and document any recalculations in its next annual submission. The ERT encourages the Party to compare new values with data from neighbouring Baltic countries.	In the 2012 submission waste composition data from Netherlands analysis in period 1940–2000 was replaced with results from research made in Estonia in 2000, as a recommendation by the ERT in 2009.	Sections 8.2.2, 8.2.4	

Waste (Key categories - Solid waste disposal on land - CH4)	Estonia used a methane correction factor (MCF) of 1.0 and an oxidation factor of 0 for the entire period, which implies that all SWDS are categorized as managed. The rationale for this assumption is not provided in the NIR, and the ERT considers that it is unlikely that this assumption is correct, at least for the beginning of the time series. Moreover, 10 out of 15 SWDS were closed in 2009, probably due to non-conformity with the requirements of managed SWDS. The Party explained that no research or investigation has been made by the inventory compilers responsible for the waste sector to categorize and classify SWDS. The ERT reiterates the recommendations from the previous review report that Estonia justifies or changes the assumption that all SWDS are managed for the entire time series and modify the values for DOC and the MCF accordingly.	As no research has been made to classify solid waste disposal sites (SWDS) in IPCC categories, all landfills were categorized at first as managed by default. During the compiling the 2012 Submission, discussion was held between sector expert and experts in EEIC. It became evident that results of SWDS classification into IPCC site types bases on a distribution of waste disposals by mass between sites types not only on the number of working MSW landfills in the country. As the quantities of wastes distributed by mass between sites types need in FOD model are unknown, its complicated to divide waste quantities between unmanaged shallow or deep landfills. It was decided to categorize all SWDS to uncategorized which correspond to MCF of 0.6. Since 2009 all landfills are categorized as managed because since then only managed landfills exist in Estonia and all municipal wastes are disposed there.	Sections 8.2.2, 8.2.4	
Waste (Key categories - Other (waste) - CH4 and N2O)	Estonia used the tier 1 method from the 2006 IPCC Guidelines and default EFs to estimate emissions from waste incineration. For the year 2009, Estonia reported a CH4 recovery of 4.07 Gg in CRF table 6.A. During the review, the ERT identified that 0.12 PJ of biogas was used in the energy sector, which corresponds to 2.04 Gg CH4. In response to questions raised during the review, Estonia provided further information to the ERT, which acknowledged that the discrepancy was associated with one landfill site (of the four existing in Estonia) that captured and flared the biogas in 2009. However, Estonia does not provide emission estimates of the amount of CH4 and N2O emissions from the flaring activity. In response to the list of potential problems and further questions from the ERT, Estonia submitted estimates for the year 2009 for CH4 and N2O emissions from biogas burned in flares, which resulted in an increase of 0.55 Mg of CH4 and 0.011 Mg of N2O emissions. The ERT recommends that Estonia report detailed information on the composition of incinerated waste and the methods and parameters used to estimate CH4 and N2O emissions in its next annual submission in order to improve the transparency.	The information and estimation of emissions from biogas burnt in a flare in period 2009 - 2010 has been included in the 2012 submission.	Section 8.7	

Waste (Key categories - Other (waste) - CH4 and N2O)	The ERT noted that there are inter-annual fluctuations in the CH4 emissions from biological treatment between 1995 and 2003 ranging between –90 and 239 percent. The Party explained that fluctuations in the CH4 and N2O emissions are due to variations in the composition and amount of organic waste throughout the years. The ERT recommends that the Party include additional information in the NIR of its next annual submission regarding the composition and amount of organic waste in order to improve the transparency.	Additional information has been included in the 2012 submission.	Section 8.6.3	
Article 3.3	Deforestation areas have been estimated from a database based on the NFI, with aerial photographs to identify land use and land-use change at the end of 1989. The ERT strongly recommends that Estonia provide detailed information on the data used for estimating the afforestation and reforestation areas, and revise it so that is in accordance with its definition of forest, e.g. by using the NFI data with supporting material including aerial photographs which are currently used for the area estimation of land converted to forest land under the Convention and of deforestation under the Kyoto Protocol. The ERT also reiterates the strong recommendation from the previous review report that, in its next annual submission, Estonia provide information to demonstrate complete land coverage on afforestation, reforestation and deforestation in accordance with the requirements of paragraph 20 of the annex to decision 16/CMP.1.	AR area data is obtained from Statistics Estonia (SE). The statistics cover the whole country, since 1991 (assessment in 1990 found by extrapolation). The method is an accounting made according to special forest notices gathered by environment agencies over time. The supplementary spatial information has been included in the above mentioned forest notices gathered by environment agencies. AR areas in Estonia may be slightly overestimated due to the fact that SE data on forests were collected according to the definition of forest under the Estonian Forest Act. According to NFI estimates, forest area between 0.1-0.5 ha constitutes 0.35% (about 28 ha per year) of total forest area, that is a negligible figure. D areas are monitored using NFI land use transfers based on field measurements using sample plots (according to KP forest criteria), additionally with aerial photographs to control land use changes. If a plot is converted from one land use category to another, it can be detected. Thus, the "Spatial assessment unit" will be a sample plot. Each plot has an identification code and a registered geographical position. The same “Spatial assessment unit” has consistently been used in both the UNFCCC and the KP-reporting.	Section 11.1.1 Definition of forest and any other criteria	

Article 3.3	The area of afforestation and reforestation are reported separately in the NIR, which is unusual among reporting Parties, because it is difficult to identify land that has not been forested for a period of at least 50 years. The ERT encourages Estonia to provide information on the method used to identify land which is under afforestation and under reforestation, or report the areas of afforestation and reforestation together, which is in line with the IPCC good practice guidance for LULUCF, and to clearly demonstrate that the areas were non-forested land at the end of 1989.	Estonia will report the areas of afforestation and reforestation together in the future.	Table 11.6. Afforestation/reforestation (AR) and deforestation (D) activities, ha (NFI & SE, 2011)	
Article 3.3	The ERT notes that Estonia does not report on litter and that the Party assumes that carbon stocks in mineral soils do not change, regardless of changes in forest management, types and disturbance regimes, what is especially unusual for deforestation. In its NIR, the Party states that it recognizes the importance of carrying out additional studies and that it explores options to obtain country-specific data regarding litter and soil organic matter for further submissions. According to its NIR, Estonia is planning to use data from countries with similar circumstances and conditions to estimate emissions/removals from the omitted carbon pools and to report those emissions/removals in its 2012 annual submission. The ERT reiterates the strong recommendation of the previous review report that Estonia provide data on these omitted pools, or otherwise provide sufficient verifiable information, as required in paragraph 6(e) of the annex to decision 15/CMP.1, which demonstrates that these pools are not a net source, and, as an interim approach, use data from countries with similar circumstances and conditions in its next annual submission.	As an interim approach, Estonia is using Sweden IEF-s in the 2012 submission for estimating emissions from litter and mineral soil under deforestation areas.	Section 11.3.1.1 Description of the methodologies and the underlying assumptions used	

Article 3.3	Estonia does not estimate emissions from biomass burning with the explanation that the AD did not allow for separate allocation to afforestation, reforestation and deforestation and other forest areas. The ERT considers that this might result in an underestimate of emissions. The ERT strongly recommends that the Party provide emissions from biomass burning from areas under afforestation, reforestation and deforestation, or demonstrate that there is no biomass burning from areas under afforestation, reforestation and deforestation.	In its 2012 submission, Estonia has provided emission estimates from biomass burning from areas under afforestation and reforestation.	Section 11.3.1.1 Description of the methodologies and the underlying assumptions used	
Article 3.3	The Party does not provide any specific uncertainty analysis or QA/QC procedure applied for the KP-LULUCF activities. The ERT reiterates the recommendation from the previous review report that Estonia implement such measures in its next annual submission.	The same QA/QC procedures and uncertainty analysis was applied for the KP-LULUCF activities as under UNFCCC reporting.	Section 1.3.3 Quality assurance/quality control (QA/QC) procedures and extensive review of GHG inventory Section 11.3.1.5 Uncertainty estimates	
Article 3.3 (Afforestation and reforestation - CO2)	In its 2011 submission, Estonia for the first time applied specific annual growth volumes taking into account the stand age of forest instead of using constant annual growth volumes. The Party has provided the values used for biomass expansion factor, density and root-to-shoot ratio to convert to biomass, but has not provided the reference to these values. The ERT commends Estonia for the use of annual growth volumes, but recommends that the Party provide the reference to these values in its next annual submission.	References for implied parameters have been reported in the 2012 submission.	Section 11.3.1.1 Description of the methodologies and the underlying assumptions used	

Article 3.3 (Afforestation and reforestation - CO2)	Estonia does not estimate carbon stock change in deadwood, explaining that the accumulation of dead wood was assumed to be marginal. The ERT recommends that the Party provide further information, as required in paragraph 6(e) of the annex to decision 15/CMP.1, which demonstrates that these pools are not a net source, in accordance with section 4.2.3.1 of the IPCC good practice guidance for LULUCF. In table 5(KP-I)A.1.1 of its original 2011 submission, Estonia reports a positive value for carbon stock change in organic soils (2.87 Gg C in 2009), which would indicate that this pool was a sink. During the review, in response to questions raised by the ERT, Estonia explained that the value was reported with the opposite sign due to a confusion regarding the interpretation of the notes in the CRF reporter. In its submission of 17 October 2011, the Party resubmitted new CRF tables, where the values of carbon stock change in organic soils were corrected. The ERT recommends that the Party provide the description of the correction in its next annual submission.	Dead wood pool under AR areas is considered to be negligible, since previous land use did not have perennial woody biomass, no large-scale disturbances have occurred on AR areas and the natural mortality rate of young stands is very low. DW=NO assumption is also supported by JRC `Not a source` decision tree - Reasoning based on sound knowledge of likely system responses for AR. Further explanations are provided in NIR 2012. Description of the correction of carbon stock change in organic soils are provided in NIR 2012.	Section 11.3.1.1 Description of the methodologies and the underlying assumptions used Section 11.3.1.4 Changes in data and methods since the previous submission (recalculations)	
National registry	The Party is encouraged to select, implement and report, in the next annual submission, changes made in its registry database, infrastructure and or procedures to support a user authentication mechanism as suggested by the ITL Administrator's Change Advisory Board.	Additional information regarding 2-factor authentication is given in Annex 4 of SIAR	SIAR Annex 4	
Minimization of adverse impacts in accordance with Article 3, paragraph 14, of the Kyoto Protocol	The ERT recommends that the Party, in its next annual submission, report any change(s) in its information provided under Article 3, paragraph 14, in accordance with chapter I.H of the annex to decision 15/CMP.1.	Estonia has reported the changes in information.	Chapter 15	

10.4.2. KP-LULUCF inventory

Planned improvements in KP LULUCF sector include following:

- improving the accuracy of D areas using updated data from fieldwork;
- assessments of the AR sites in the framework of the NFI;
- estimation of omitted carbon pools (litter, mineral soil).

Estonian Environment Information Centre has initialized a project aimed to conduct fieldwork in order to obtain data about litter and mineral soil organic carbon stocks. Preliminary estimates are expected to be obtained by 2014. In addition, two analysis, aimed to find solutions to omitted pools and improve the quality of inventory, have been made recently:

1. Analysis of LULUCF Greenhouse Gas Inventory based on IPCC Guidelines and Submission Reports from 10 countries, Müürisepp, T., 2011
2. Report prepared under Contract No 4-1.1/209 12.09.2011 funded by Estonian Forestry Development Plan up to 2020, Švilponis, S., 2011.

Estonia will use implied emission factors from neighbouring countries (Sweden) as an interim approach, in order to avoid underestimation of emissions.

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

11. KP-LULUCF

11.1. General information

Under Article 3, paragraph 3, of the Kyoto Protocol (KP), Estonia reports emissions and removals from afforestation (A), reforestation (R) and deforestation (D). The estimates for emissions and removals are prepared and reported consistent with the IPCC GPG LULUCF 2003 and Decisions 15/CMP.1 and 16/CMP.1 of the KP.

In 2010, net removals from Article 3.3 activities were 47.06 Gg CO_2 eq. Uptake from afforestation and reforestation activities including emissions from biomass burning was estimated at 346.72 Gg CO_2 eq., whereas deforestation resulted in a net emission of 299.66 Gg CO_2 eq. Area subject to AR was 22 982 ha by the end of the third year of the commitment period. The area deforested since 1 January 1990 had reached to 20 633 hectares in the end of 2010 (Table ES.3.). The rate of deforestation has fluctuated widely over the years, causing substantial variations in interannual CO_2 emissions. The most important activities under deforestation have been conversion of forest land to built-up land and infrastructure.

11.1.1. Definition of forest and any other criteria

Paragraph 1 of the definitions, modalities, rules and guidelines relating to land use, land-use change and forestry activities under the Kyoto Protocol, as contained in the Annex to decision 16/CMP.1 defines 'forest' as "a minimum area of land of 0.05–1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10–30 per cent with trees with the potential to reach a minimum height of 2–5 meters at maturity *in situ*. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high portion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10–30 per cent or tree height of 2–5 meters are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest."

The definition of forest established by FAO (GFRA 2005) fits within the Kyoto's – 'land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use'.

The Estonian Forest Act and the consequent definition of forest has been amended several times during the last 20 years. The last one stipulates forest land as land which meets at least one of the following requirements:

i) forest land use is included in land cadastre;

ii) has an area of 0.1 hectares of land, growing woody plants with a minimum height of 1.3 meters and the tree crown cover at least 30 percent.

This approach is possible if there is the case of a specific part of the forest. However, it is practically very difficult to follow the requirement of forest use in cadastre in statistics for the whole country. Should also be noted that up to 13% of forest land has not yet been registered in the cadastre. Also, there is no international definition of forest based on registering forest land in the cadastre.

In addition, as the criterion of 1.3 m has caused some confusion in earlier reports, it should be noted that it is not 'the minimum tree height' in context of forest land definition. Actually, 1.3 m is criteria for counting unstocked forest area to stocked forest. The minimum potential tree height *in situ* by meaning of the Forest Act is defined by tree species, stand's age and site index. Thus, there is not constant criteria for tree height in national definition.

For consistent statistical reasons, Estonian National Forest Inventory (NFI) has complied in general with the definition of forest, which was sustained in 1999. According to that, forest land is 'a land spanning 0.1 ha or more with tree crown cover (equivalent stocking level) of 30% or more with trees with the potential to reach a minimum height depending on the function of tree species, stand's age and site index. The latter criterion can be interpreted as stand productivity at least in 'Va yield class'. Forest area includes temporary unstocked forest land (clear-cut areas, young regeneration areas, failed stands etc) that has enough potential to be a forest. It does not include land that is predominantly under agricultural or urban land use. According to the NFI's definition of forest, estimates reported in national statistics and also in the UN/FAO Forest Resources Assessment (2005, 2010) procedure.

Starting from 2005, FRA 2005 forest criteria and OWL criteria were used in parallel with the national forest definition in the framework of the NFI. The aim was to present more precise and internationally comparable assessments in the future. Despite the fact the NFI could publish nowadays statistics in accordance with the forest definition of FRA, appropriate assessments are not published until now in international reports. Compared to the national definition, area of forest land is about 2% higher according to the FRA forest definition.

Due to the differences between definitions and that given in the decision 16/CMP.1, under the KP Estonia has defined forest as a land with the main parameters of forest definition reported in Table 11.1. These criteria are also used under UNFCCC reporting for the LULUCF sector.

Table 11.1. Elected parameters for forest definition

Minimum tree crown cover	30%
Minimum land area	0.5 ha
Minimum tree height	2 m

Compared to national definitions, the minimum tree crown cover (equivalent stocking level) criterion corresponds to the national definition of forest.

Since the NFI has been recording information on forests, which remain in their surface area per hectare between 0.1 and 0.5 (due to the fact that criterion of 0.5 ha has been a minimum forest area in one of the earlier redaction of the Forest Act), there is information available that is used to exclude these areas (sample-plots) from LULUCF statistics. The proportion of sample plots under 0.5 ha in forests is 0.35%. The same information is used for estimating forest area according to the FRA definition.

As mentioned above, there is no strict definition of the criterion of minimum tree height in the national definition of forest. For estimating forest area according to the FRA definition, the criterion 5 m of minimum tree height is used. As there is no forest-tree species that could reach the height of 2 m and not 5 m in the age of maturity in Estonia, the criterion and data same as for counting forests according to the FRA definition can be used.

The total forest land in Estonia is or has been covered with forest management plans. In addition, protected forests are covered with the protection scheme. Thus, the total forest land in Estonia is managed forest – managed in one way or another.

11.1.2. Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

Estonia has elected to account the activities under article 3.3 (afforestation, reforestation and deforestation) for the first commitment period stated in the report "Report to facilitate the estimation of Estonia's assigned amount under the Kyoto Protocol, 2007".

Estonia has not elected to account the activities under article 3.4 for the first commitment period.

11.1.3. Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

Estonia started to make efforts to monitor, estimate and to report carbon flows related to afforestation (A), reforestation (R) and deforestation (D) activities for the first time in the 2010 submission. All forests fulfilling the definition of forest, as given above, are considered as managed forests.

Afforestation/reforestation (AR) areas (Table 11.7) have been obtained from Statistics Estonia (SE)[231], which reports the areas for each county of Estonia. Originally, this data was collected by Centre of Forest Protection and Silviculture, since 2010 by Estonian Environment Information Centre (EEIC).

ERT has rightly observed that the area of AR may be overestimated due to the fact that SE data on forests are collected according to the definition of forest under the Estonian Forest Act, which is inconsistent with the forest definition parameters chosen by Estonia for reporting under the KP, because the forest parameters include a minimum area of 0.1 ha. The ERT recommends that Estonia provide information to demonstrate the appropriateness of SE data and their consistency with the forest definition parameters as chosen by the Party under the KP for AR activities.

According to NFI estimates, these areas constitute 0.35% of the total forest area. Thus, the average annual overestimated area could be about 28 ha per year. Despite the fact the area is small, Estonia is looking ways to solve the problem.

During 1990-2004, large agricultural areas were abandoned in Estonia. A part of them were overgrown by forest trees. However, the activity can not be defined as direct human-induced and therefore these areas were not taken into account for afforestation reporting.

Data about deforestation areas has been acquired from NFI database. This database contains sample plot data, stand-level and tree data. To collect specific land use change data, additional field study started in 2009 in the framework of the NFI. In this submission new datasets are used for land use change, including deforestation activities. The land use at the end of 1989

[231] *http://pub.stat.ee/px-web.2001/I_Databas/Economy/12Forestry/12Forestry.asp.*

for each sample plot has been derived from the information of land use and land-use changes assessed in the field using aerial photographs as supporting material if necessary. The time series for D activities were established from data using the same principles and definitions for forest and D activities. NFI will continue to monitor forest and other land-use categories during the first commitment period (or as long as needed).

The forests, other land use and land-use changes will be monitored every year in the whole country. Sampling design of the Estonian NFI and the method for estimating land use changes is described in Subchapter 7.1.3. More detailed information about sampling scheme, design and density is described in National Forest Inventories (2010)[232].

11.1.4. 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.

Not applicable.

11.2. Land-related information

Estonia implements the *Reporting Method 1* for lands subject to Article 3.3 activities. The area of Estonia is not divided into regions because it is relatively small and homogeneous in terms of ecological conditions. *Approach 1* is used for representing the land areas. Area of AR activities has been identified in stand-level, data is gained from SE. Data for deforestation and other land use and land-use changes were obtained by the National Forest Inventory. NFI is a sampling based inventory system that covers all land-use categories. Sampling unit for area estimation is a point. Plots that contain different land categories or stands of distinctly different parameters are divided into sections accordingly to the detailed regulation. The latter ones counted in estimations with its area weighted to full-size sample plot.

11.2.1. Spatial assessment unit used for determining the area of the units of land under Article 3.3

The spatial assessment unit to determine the area of units of land under Article 3.3 is 0.5 ha, which is the same as the minimum area of forest.

11.2.2. Methodology used to develop the land transition matrix

A *Tier 1* approach is employed to estimate areas of land use change in the LULUCF sector inventory. National Forest Inventory database includes information on the IPCC land use and land-use change category for each sample plot. The annual land-use change areas were calculated for 1990–2010. Land transition matrix was developed by adding and subtracting land under conversion to and from land-use category areas (Table 7.4).

11.2.3. Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

The area of Estonia is not divided into geographical regions. Since the spatial assessment unit defined is Estonia's national territory, the geographical location of the boundaries of the areas that encompass units of land subject to ARD is that of the entire country.

[232] p.177-183; *http://www.springer.com/life+sciences/forestry/book/978-90-481-3232-4.*

11.3. Activity-specific information

11.3.1. Methods for carbon stock change and GHG emission and removal estimates

11.3.1.1. Description of the methodologies and the underlying assumptions used

Carbon stock changes in living biomass

Afforestation and reforestation sites were classified according to the identified land-use change. Biomass increment on AR areas (Table 11.2) was obtained by assuming that the mean increment per area unit of a certain age of forest (derived from NFI data) is the same as in the land converted to Forest Land subcategory under UNFCCC reporting. This mean increment was multiplied by the AR area estimate to obtain the estimation of growing stock.

Dead wood and growing stock data under deforestation was obtained from NFI and was assumed to be the same as used under Forest Land remaining Forest Land subcategory estimations. For more detailed description about estimation of forest living biomass see Chapter 7.2.2.1.

Equation 7.2 was used for estimating living biomass carbon stock change on both AR and D areas. Parameters used are shown in Table 11.3.

Table 11.2. Average annual increment by occurrence of forest, $m^3\ ha^{-1}\ yr^{-1}$

Year	Increment	Year	Increment
1990	3.45	2001	1.55
1991	3.28	2002	1.38
1992	3.10	2003	1.21
1993	2.93	2004	1.03
1994	2.76	2005	0.86
1995	2.59	2006	0.69
1996	2.41	2007	0.52
1997	2.24	2008	0.34
1998	2.07	2009	0.17
1999	1.90	2010	0.00
2000	1.72		

Table 11.3. Parameters used in emission/removals estimations from ARD activities

	AR	D
BEF_2	2.5[233]	1.33[234]
R (root-shoot ratio)	0.44[235]	0.29[236]
D (wood density)[237]	0.44	0.44

[233] Same BEF_2 value as used under UNFCCC land converted to Forest Land, Table 7.7
[234] Average BEF_2 value used under UNFCCC FL remaining FL, Table 7.7
[235] R for AR activities is average R value from Table 7.8 Land converted to Forest Land.
[236] R for D activities is the average R value from Table 7.8 Forest Land remainig Forest Land.
[237] Table 7.9 in Section 7.2.2.1.

Carbon stock changes in mineral and organic soils

Emissions from organic forest soils were calculated similarly as those under UNFCCC, using Equation 7.4 and parameters showed in Table 11.4. For AR areas the same emission factor was used as under Forest Land remaining Forest Land. For deforestation areas, EF of Grassland's organic soils were used, due to the fact that deforestation is mainly the conversion of forest land to settlements and soil conditions of Settlements' greenery is most similar to Grasslands (see also Chapter 7.6.2, land converted to Settlements).

Table 11.4. EF used in ARD organic soil emission estimations

Biomes	Emission Factors (tonnes C ha^{-1} yr^{-1})	
	AR	D
Boreal	0.16	0.25

Estonia does not have sufficient data regarding mineral soil pool to estimate related emissions correctly. Therefore IEF-s from Sweden (Table 7.21, see Chapter 10.1.2) were used as interim approach.

Carbon stock changes in litter and dead wood

Dead wood pool is considered to be negligible on AR areas, since previous land use did not have perennial woody biomass, no large-scale disturbances have occurred on AR areas and the natural mortality rate of young stands is very low. Therefore it is highly unlikely, that dead wood and litter pools are sources on AR areas. The assumption is also supported by JRC \`Not a source\` decision tree − Reasoning based on sound knowledge of likely system responses for AR.

Emissions derived from removal of dead wood pool after deforestation were calculated based on NFI dead wood estimates. Methodology and parameters used for the estimation of dead wood carbon stock changes on deforested areas correspond to the UNFCCC Forest Land remaining Forest Land reporting (see Chapter 7.2.2.3), only it is assumed that all dead wood biomass will be lost after deforestation.

Estonia does not have sufficient data regarding litter pool to estimate related emissions correctly. Therefore IEF-s from Sweden (Table 7.21, see Chapter 10.1.2) were used as interim approach.

Biomass burning

According to ERT (ARR2011) recommendations, emissions from biomass burning on AR areas were estimated for the first time in current submission. The same methodology was implemented as described in UNFCCC reporting Section 7.8. Equation 7.11 and parameters indicated in Table 11.5 were used. Data regarding forest growing stock (biomass burnt) was obtained from NFI. For combustion efficiency, a higher value than the one used under Forest Land (CRF 5.A) was chosen based on expert opinion, since compared to mature forests young trees are more affected by forest fires.

Table 11.5. Parameters used for biomass burning estimation on AR areas

	Combustion efficiency [238]	CO_2 emission factor [239]	CH_4 emission factor [240]	N_2O emission factor [241]
AR	0.76	1580	9	0.11

Instant oxidation is assumed for biomass estimates under deforestation, therefore its is reported that burning does not occur under D areas.

Other GHG emissions

Emissions from N fertilization and from lime applications are not estimated, since they do not occur.

11.3.1.2. Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

Estonia does not have sufficient data regarding mineral soil organic matter and litter to estimate related emissions correctly. The current data available about the carbon fluxes in forest soils is fragmentary and have largely site- and study-specific character to support broad generalisation. Consequently, it is difficult to provide a reliably estimation of the yearly changes of carbon pools in forest soils.

It is important to carry out additional studies aimed to investigate the direction of carbon stock changes in forest soils associated with forest type, management activities (rotation length, harvest practices), site preparation activities (soil scarification) and other disturbances (such as forest fires) which affect more or less soil organic carbon pool. It is also important to carry out studies about the yearly quantity and quality of forest litter in extensive scale to obtain important parameters for modelling of carbon fluxes in forest soils. Estonian Environment Information Centre has initialized a project aimed to conduct fieldwork in order to obtain data about forest litter pool and mineral soil organic carbon stocks. Preliminary estimates are expected to be obtained by 2014. In addition, two analysis, aimed to find solutions to omitted pools and improve the quality of inventory, have been made recently:

1. Analysis of LULUCF Greenhouse Gas Inventory based on IPCC Guidelines and Submission Reports from 10 countries, Müürisepp, T., 2011
2. Report prepared under Contract No 4-1.1/209 12.09.2011 funded by Estonian Forestry Development Plan up to 2020, Švilponis, S., 2011.

As an interim approach, Estonia used IEF-s from Sweden for estimating emissions from litter and mineral soil under deforestation activities.

[238] GPG-LULUCF 2003, Table 3A.1.12, p. 3.179, upper limit of All Boreal Forest, NFI expert opinion, EEIC.
[239] GPG-LULUCF 2003, Table 3A.1.16, p. 3.185, Forest fires (Delmas *et al.* (1995)).
[240] GPG-LULUCF 2003, Table 3A.1.16, p. 3.185, Forest fires (Delmas *et al.* (1995)).
[241] GPG-LULUCF 2003, Table 3A.1.16, p. 3.185, Forest fires (Delmas *et al.* (1995)).

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

Indirect and natural GHG emissions/removals have not been factored out.

11.3.1.4. Changes in data and methods since the previous submission (recalculations)

Entire time series of activity data was recalculated for ARD activities. In previous submissions, all reforested areas were accounted, in current submission this mistake has been corrected and estimation of reforested areas corresponds to the Marrakesh Accord limitations[242]. For AR activities, recalculations have been made containing the specified increment, depending on the age of the stand.

Deforestation areas have been updated according to new data obtained and to somewhat different method used for D area estimation in the 2012 submission. In the previous submission, the area of deforestation was estimated by aggregating data from NFI and data obtained from land transition assessment. In current submission, area of deforestation is derived directly from land-use transition assessment.

Carbon stock changes in above- and below-ground biomass on AR areas were re-calculated, due to the availability of more accurate BEF and root-to-shoot (R) values (Table 10.2).

Estonia does not have country-specific data regarding litter and mineral soil carbon stocks, therefore these pools have been omitted in previous submissions. ERT (ARR2010) strongly recommended Estonia to use IEF-s from neighbouring countries as an interim approach, in order not to underestimate emissions from accounted LULUCF activities (with main emphasis on deforestation). Estonia considered using IEF-s from Latvia, Finland and Sweden as countries with the most similar climate conditions. Finland IEF-s were discarded for Finland uses Yasso model, which does not allow distinguishing emissions from litter and mineral soil pools separately. Latvia's emission factors differed significantly from Swedish and Finnish factors. Therefore Sweden IEF-s (Table 7.21) were chosen as the most suitable and reliable data and for Estonia has the same geographical latitude with southern Sweden and similar climate conditions. For completeness and consistency reasons, the same IEF-s have been used for estimating emissions under deforestation (KP) and Forest Land conversion to other land uses under UNFCCC reporting.

Emissions from organic soils have been recalculated, since formerly all organic forest soils were accounted as drained due to lack of more accurate data, in current submission specified data about the proportion of drained soils among total organic forest soil areas was obtained from NFI. In addition, in the 2011 submission, carbon stock changes in organic soils were reported with an incorrect sign (a remark made by ARR2011), this mistake has been corrected in current submission and organic soils are regarded as sources under deforestation throughout the accounting period.

In the 2012 submission, emissions from AR area burning were calculated for the first time.

[242] Paragraph 1 of the Annex to draft decision -/CMP.1 (Land use, land-use change and forestry) contained in document FCCC/CP/2001/13/Add.1, p.58

11.3.1.5. Uncertainty estimates

Tier 1 was implemented for estimating uncertainty rates related to activity data and emission factors employed in the estimates under Article 3.3. activities. The methodology for uncertainty estimation will be further developed.

Table 11.6. Estimated values of uncertainties under ARD activities

IPCC Source Category	Uncertainties ±%		EF References
	Activity data[243]	Emission factors	
Afforestation/reforestation – living biomass	6.29	46.95	LULUCF, 2003, p. 3.31
Afforestation/reforestation – organic soils	3.99	200.0	LULUCF 2003, Table 3.2.3, p. 3.42
Deforestation – living biomass	31.23	46.95	LULUCF, 2003, p. 3.31
Deforestation – dead wood	33.83	30.07	LULUCF, 2003, p. 3.31, 5.17
Deforestation – litter	30.24	NA244	NA
Deforestation – organic soils	61.66	200.00	LULUCF 2003, Table 3.2.3, p. 3.42
Deforestation – mineral soils	34.75	NA	NA

11.3.1.6. Information on other methodological issues

The NFI measures one fifth of the sample plots of one inventory cycle during one year. When describing rare events, NFI estimates have the disadvantage fluctuations from year to year when using the data from one year. In current submission, NFI field data from 2009 and 2010 was used to assess the changes in land-use data in 1990s. To improve the accuracy of the estimates, several years data should be used.

Collection of assessments of the AR sites is under development (in addition to official statistics, SE, which has its own disadvantages) in the framework of the NFI. The argument for applying NFI data is that it is the only continuous inventory and monitoring system in Estonia that covers all land uses and gives reliable estimates for the land use areas and tree growth.

11.3.1.7. The year of the onset of an activity, if after 2008

The year of the onset of an activity is 2008.

11.4. Article 3.3

Estonia reports all emissions by sources and removals by sinks from AR activities under Category A.1.1 Afforestation/Reforestation: units of land not harvested. Forests afforested or reforested since 1990 have not reached the regeneration age by the first commitment period.

[243] All activity data uncertainty estimates are obtained from NFI.
[244] No uncertainty estimations are provided for Deforestation under mineral soils and litter pools, since IEF-s from Sweden were used in calculations and exact uncertainties regarding emission factors are unknown, only activity data uncertainty (i.e area) is estimated by NFI

According to guidance for good silviculture, the rotation time varies from 30 to 120 years depending on the tree species and site index of a forest.

The areas of Article 3.3 activities are estimated as described in Section 11.2.2. – the cumulative sum of areas afforested/reforested and deforested since 1990.

11.4.1. Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

The activity data about afforested/reforested and deforested areas is presented in Table 11.7. The reported AR activities are directly human induced since those activities are based on decisions not to continue the previous activities but the forest management activities. Planting of new forest is the main human-induced reforestation activity directed towards increasing of forest area in Estonia. Afforestation activities have been implemented on agricultural lands and quarries worked out.

Changes in deforested areas were detected on NFI sample plots. The land-use category in the end of 1989 was assessed during field measurements, in addition aerial photos were used where necessary. Since the land-use category just before 1 January 1990 was fixed, the reported land-use changes have occurred after that. Occurrence of not directly human-induced changes resulting in deforestation are practically non-existent in Estonia.

Table 11.7. Afforestation/reforestation (AR) and deforestation (D) activities, ha (NFI & SE, 2011)

Year	Afforestation/ Reforestation[245]	Deforestation
1990	7 394.1	564.7
1991	4 758.5	0.0
1992	1 584.1	0.0
1993	1 337.9	0.0
1994	1 169.2	0.0
1995	220.8	662.7
1996	253.8	495.2
1997	359.0	499.5
1998	437.1	0.0
1999	399.2	0.0
2000	450.2	496.1
2001	618.7	0.0
2002	444.9	1 009.3
2003	561.3	571.1
2004	392.3	2 182.1
2005	847.8	1 499.7
2006	1 193.4	2 770.2
2007	28.6	4 934.8
2008	221.8	2 958.0
2009	148.2	984.9
2010	160.7	1 004.5
Total	22 981.6	20 632.7

[245] According to Marrakesh Accord limitations: Paragraph 1 of the Annex to draft decision -/CMP.1 (Land use, Land-use change and Forestry) contained in document FCCC/CP/2001/13/Add.1, p.58.

11.4.2. Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

According to Estonian legislation land category change by human is allowed only with orders from local authorities and/or environmental minister. This must be preceded by the reassignment of the land (eg commercial, residential or transport land), which is reflected both in the Land Cadastre and Land Registry. When a NFI sample plot is located in a clear-cut area, the surveyor assesses whether the cutting has been done for regeneration purpose or for land-use change. Clear signs of a land-use change can be seen in the surrounding and location of the area; also the data from Land Cadastre and Land Registry is checked.

According to the Forest Act, forest owner is obliged to implement reforestation techniques to the extent that within five years after logging or forest death ensures a renewed forest. Re-establishment of a forest usually starts within 2 years after the harvesting.

11.4.3. Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

Clear-cut forest areas, which have not classified as Deforestation, were classified as temporarily unstocked forest.

11.5. Article 3.4

Not applicable.

11.6. Other information

Estonian Forestry Development Plan up to 2020 was approved by the Parliament on 15 February 2011. The main aim of the Forestry Development Plan is to ensure sustainable forest management.

At present, land reform in Estonia is nearing the end and no special measures regarding afforestation, reforestation and deforestations are foreseen. Therefore current trends are expected to continue and activities under Article 3.3 are expected to be a small sink during the first commitment period.

11.6.1. Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

The basis for assessment of key categories under Article 3.3 of the KP is the same as the assessment made for the UNFCCC inventory. Key category analysis for KP-LULUCF was performed according to Chapter 5.4.4 of the IPCC Good Practice Guidance for LULUCF (IPCC 2003).

According to the IPCC GPG for LULUCF the key categories for Kyoto Protocol activities can be derived from the identified key categories in the UNFCCC inventory as follows: Whenever a category is identified as key in the UNFCCC inventory, the associated activity under the Kyoto Protocol can be considered as key in reporting under the Kyoto Protocol. According to this approach, all of the categories under Articles 3.3 of the Kyoto Protocol (afforestation and reforestation, deforestation) can be regarded as key categories.

11.7. Information relating to Article 6

No projects in this sector under Article 6 are implemented in Estonia.

12. INFORMATION ON ACCOUNTING OF KYOTO UNITS

12.1. Background information

Standard Electronic Format report (hereinafter as SEF) information corresponds to the requirements of decisions 14/CMP.1 and 15/CMP.1. Information required under Decision 15/CMP.1 paragraph 11 is displayed as required by UNFCCC ITL Administrators' "Standard Independent Assessment Report. Reporting Requirements and Guidance for Registries v4.7" in "SEF_EE_2012_1_15-46-53 9-1-2012.xls". The SEF report for 2011 has been submitted to the UNFCCC Secretariat electronically and the contents of the report can also be found as Annex 6 of this document. SEF tables are included in Estonian NIR submission for the fourth time (please see SEF_EE_2012_1_15-46-53 9-1-2012). The SEF tables include information about AAU, ERU, CER, t-CER, l-CER and RMU in Estonian national registry (hereinafter as NR) standing 31st of December 2011. Also the SEF includes information on transfers of the units during the year 2011.

12.2. Summary of information reported in the SEF tables

The total number of AAU units in the NR at the beginning of the year 2011 was 149 967 364. In the end of the year the total balance of AAUs was 101 775 558 distributed as following: 101 775 558 AAU units and 13 448 ERU units were in the Party holding account; 4 278 459 units in the entity holding accounts; 210 000 units in the other cancellation account and 38 013 117 units in the retirement account. The number of ERUs in NR corresponded to 13 448 (in the party holding account). The units of CERs in the NR corresponded to 957 (in entity holding accounts).

Estonian NR did not contain any RMUs, t-CERs or neither l-CERs nor any units were on the Article 3.3/3.4 Net-Source Cancellation accounts and in t-CER and l-CER Replacement accounts. SEF report is also included in Estonian Standard Independent Assessment Report (hereinafter as SIAR) 2011 report as Appendix 1 (as SIAR Report R-1).

12.3. Discrepancies and notifications

Information about discrepant transactions is included in SIAR report Appendixes 2 and 3. No discrepancies and no notifications occurred in 2011.

12.4. Publicly accessible information

Due to the updates on the publicly available information web page in year 2011, information referred in Decision 13/CMP.1; II Registry requirements; E. Publicly accessible information in paragraphs 45-48 are as following via user interface of the MoE www.envir.ee/ 1170489 (please select *„Avalikkusele kättesaadavad aruanded vastavalt Kyoto protokolli artiklile 7 / Publicly available information according to Kyoto Protocol article 7"*):

- account information (information on paragraph 45 of annex to the decision 13/CMP.1);

- JI projects in Estonia (information on paragraph 46 of annex to the decision 13/CMP.1);
- information about unit holdings and transactions (information on paragraph 47 of annex to the decision 13/CMP.1);
- information about Entities Authorized to Hold Units (information on paragraph 48 of annex to the decision 13/CMP.1).

Information regarding the NR is publicly available to users via MoE web page http://www.envir.ee/register.

This information is currently available at:

1) Paragraph 45 of annex to the decision 13/CMP.1 (account information). This information is available to users via user interface of the MoE http://www.envir.ee/1170489 and via CITL http://ec.europa.eu/environment/ets/. Selecting from left hand menu "Accounts" - "Search" - selecting Estonia;

2) Paragraph 46 of annex to the decision 13/CMP.1 (information of JI projects in Estonia). This information is available to users via user interface of the web page of the Ministry of the Environment http://www.envir.ee/1155464;

3) Paragraph 47 of annex to the decision 13/CMP.1 (information about unit holdings and transactions). Following information is publicly accessible via user interface of the CITL http://ec.europa.eu/environment/ets. Selecting from left hand menu "Transactions" - "Search" - selecting Estonia and other relevant parameters displayed in the search field. In accordance with the annex XVI of the EC regulation (No 2216/2004 of 21 Dec. 2004) "the information for each completed transaction relevant for the registries system for year X shall be displayed from 15 January onwards of year X+5".

4) Paragraph 48 of annex to the decision 13/CMP.1 (information about Entities Authorized to hold units under its responsibility). The Decision 280/2004/EC of the European Parliament and of the Council requires EU Member States to provide information on the legal entities authorized to participate in the mechanism under Articles 6, 12 and 17 of the Kyoto Protocol in the NIR. According to the Estonian national legislation (The Ambient Air Protection Act) §117) the Ministry of the Environment as competent authority is authorized to trade with AAUs, RMUs, ERUs and CERs. Installations falling under the scope of the Directive 2003/87/EC are authorized to use ERUs and CERs for compliance according to the percentage set out in National Allocation Plan for 2008-2012. This information is available to users via user interface of the web page of the Ministry of the Environment http://www.envir.ee/1170489.

Public information required by Commission regulation (EC) No 920/2010 (in addition to the above-mentioned public information):

1) Installation and permit details - information about installations and permit details is available to users via user interface of MoE http://www.envir.ee/orb.aw/class=file/action=preview/id=1172349/KP+2008-2012+ja+aastad_alloc+ja+VE.pdf and CITL http://ec.europa.eu/environment/ets/ selecting from left hand menu "Operator Holding Accounts" - "Search" - selecting Estonia;

2) Information about verified emissions, surrenders and compliance status of installations - information about verified emissions, surrenders and compliance status of installations is available to users via user interface of the MoE web page at http://www.envir.ee/cp1 (selecting „Ülevaade kauplemisperioodil 2008-2012 eraldatud LHÜ-de, tõendatud KHG

heitkoguste ja tagastatatud LHÜ-de kohta on leitav siit„) and from the interface of the CITL http://ec.europa.eu/environment/ets/ selecting from left hand menu "Allocation/Compliance" - "Search" - selecting Estonia;

3) National allocation plan for Estonia - information on national allocation plan for Estonia is available via user interface of the MoE web page at http://www.envir.ee/cp1 (selecting from headline „*Eesti riiklik kasvuhoonegaaside lubatud heitkoguse jaotuskava aastatel 2008-2012*" last three headings in English) and via CITL web page http://ec.europa.eu/environment/ets/ selecting from left hand menu "NAP-info" - "Search" - selecting Estonia.

12.5. Calculation of the commitment period reserve (CPR)

The commitment period reserve can be calculated in accordance with decision 11/CMP.1 as 90% of the proposed assigned amount or 100% of its most recently reviewed inventory times five, whichever is lowest.

Estonia has interpreted the "most recently reviewed inventory" the inventory for the year 2010. This would mean that five times the emissions from the total inventory of 2010 will be lower, than 90% of the assigned amount. This would give an estimated commitment period reserve of **102 583 811 tonnes CO_2 equivalents.**

20 516 762,206 x 5 = 102 583 811 t $CO_{2\ eq}$

12.6. KP-LULUCF accounting

The results of accounting procedure for the activities under Articles 3.3 of the Kyoto Protocol are presented in Table 12.1.

Net removals from Article 3.3 activities were 47.06 Gg CO_2 eq. in 2010.

Table 12.1. Calculation of accounting quantities for activities under Article 3, paragraphs 3 and 4

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	BY(5)	Net emissions/removals(1)				Accounting Parameters(7)	Accounting Quantity (8)
		2008	2009	2010	Total(6)		
	(Gg CO_2 equivalent)						
A. Article 3.3 activities							
A.1. Afforestation and Reforestation							-974,57
A.1.1. Units of land not harvested since the beginning of the commitment period(2)		-303,03	-324,82	-346,72	-974,57		-974,57
A.1.2. Units of land harvested since the beginning of the commitment period(2)							NA,NO
Total Estonia		NA,NO	NA,NO	NA,NO	NA,NO		NA,NO
A.2. Deforestation		869,52	292,94	299,66	1 462,13		1 462,13
B. Article 3.4 activities							

B.1. Forest Management (if elected)		NA	NA	NA	NA		NA
3.3 offset[(3)]						487,55	NA
FM cap[(4)]						1 833,33	NA
B.2. Cropland Management (if elected)	NA	NA	NA	NA	NA	NA	NA
B.3. Grazing Land Management (if elected)	NA	NA	NA	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA	NA	NA	NA

13. INFORMATION ON CHANGES IN NATIONAL SYSTEM

There have been no changes in Estonia's National Inventory System since last submission. The overview of the allocation of responsibilities is shown in Figure 1.1.

14. INFORMATION ON CHANGES IN NATIONAL REGISTRY

Information on changes is national system is presented in following table (Table 14.1).

Table 14.1. Information on changes in national registry

Reporting Item	Contents
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	Ms. Getlyn Makke Ministry of the Environment Climate and Radiation department Narva mnt 7A, Tallinn 15172 Tel +372 6260 753 E-mail: getlyn.makke@envir.ee or khgregister@envir.ee No changes occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(b) Change of cooperation arrangement	Estonian NR is not a part of any consolidated registry system. However, the VPN connection to the ITL is shared with several countries using the same tunnel. No change occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database or the capacity of national registry	Estonian NR system is based on CR software (since October 2009). CR software uses an Oracle 9i relation database dedicated data model for supporting the registry operations. No change occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change of conformance to technical standards	No change occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change of discrepancies procedures	No change occurred during the reported period.

Reporting Item	Contents
15/CMP.1 annex II.E paragraph 32.(f) Change of security	Estonia has implemented 2-factor authentication system for registry users and Transaction Authentication Number for performing transactions (using Estonian ID-card system). In Estonia ID-card is compulsory for all residents (Law on personal identification documents: Feb, 1999 and Digital Signature Act: March, 2000). It contains: digital signature, encryption, personal data file, certificate for authentication and certificate for digital signature. Two keys issued for ID-card can be used for authentication where the key on the ID card can be read only with the PIN.
15/CMP.1 annex II.E paragraph 32.(g) Change of list of publicly available information	Changes have occurred due to the updates on the publicly available information web page in year 2011. Detailed information is available in SIAR 2011 report Part I.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	http://khgregister.envir.ee Change on the web address - instead of HTTPS the HTTP is valid since 2011.
15/CMP.1 annex II.E paragraph 32.(i) Change of data integrity measure	No change occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change of test results	No change occurred during the reported period.
The previous Annual Review recommendations	Recommendations by ERT in year 2011 report Ref nr P2.4.2.1 and recommendation Ref 2.3.6 „*The Party is encouraged to select, implement and report, in the next submission, changes made in its registry database, infrastructure and or procedures to support a user authentication mechanism as suggested by the ITL Administrators Change Advisory Board*“.

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

Estonia has provided information on minimization of adverse impacts in accordance with Article 3, paragraph 14 in its previous national inventory reports under the Kyoto Protocol. The information is provided in accordance with the guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol (Decision 15/CMP.1, Section H.).

The changes since previous inventory submission include following:

- inclusion of information regarding fast start financing,
- update of information regarding inclusion of aviation.

15.1. Information on how Estonia is striving, under Article 3, paragraph 14, of the Kyoto Protocol, to implement the commitments mentioned in Article 3, paragraph 1, of the Kyoto Protocol in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention

European Union (EU) has agreed a forward-looking political agenda to achieve its core energy objectives of sustainability, competitiveness and security of supply, by reducing greenhouse gas emissions by 20%, increasing the share of renewables in the energy consumption to 20% and improving energy efficiency by 20%, all of it by 2020.

Two major EU Directives, the Directive on the promotion of the use of renewable energy (Directive 2009/28/EC) and as well as the extension of the EU emission trading scheme to the aviation sector (Directive 2008/101/EC) are more related with potential impacts on third countries.

Inclusion of aviation in the EU Emission Trading Scheme

Aviation contributes to global climate change, and its contribution is increasing. Even though there has been significant improvement in aircraft technology and operational efficiency this has not been enough to neutralise the effect of increased traffic, and the growth in emissions is likely to continue in the decades to come. Aircraft operators from developing countries will be affected to the extent they operate on routes covered by the EU Emissions Trading Scheme.

At the moment Estonia is Administrative Member State for one aircraft operator from developing country – Zambezi Airlines of Zimbabwe. They had only one EU related flight in the year 2010 and do not plan to fly to the EU from 2011 onwards. Aircraft operators from developing countries will be affected to the extent they operate on routes covered by the EU Emission Trading Scheme. In terms of the economic impacts, aircraft operators with higher market share on the routes covered will have to pay larger proportion of the compliance costs.

Promotion of renewable energy

The Directive on renewable energy (Directive 2009/28/EC), a part of the EU's climate and energy package, sets ambitious targets for all Member States including Estonia. In November 2010, the Government approved the National Renewable Energy Action Plan up to 2020. One of the objectives of the plan is to increase the share of renewable energy to at least 25% in gross final consumption of energy.

According to the plan, the share of electricity produced from renewable sources must grow to over 15% of consumption in ten years. Inland transport, the aim is to achieve that 10% of the used energy sources would be renewable energy.

Estonia supports regional and international development measures, encourages the exchange of best practices in production of energy from renewable sources between regional and international development initiatives and promotes the use of structural funding. For promoting the use of biomass and bio-energy, the Government approved in January 2007 the Development Plan 2007–2013 for Enhancing the Use of Biomass and Bioenergy. The objective of the plan is to create favourable conditions for the development of biomass and bio-energy production.

Co-operation projects with developing countries

One of the priorities of developing co-operation in Estonia as stated in the Development Plan for Estonian Development co-operation and humanitarian aid 2006–2010 is supporting sustainable development and achieving internationally set environmental standards in developing countries.

Under this priority Estonia funds and implements bilateral development co-operation projects for supporting the development of environmental protection institutions, in particular in the field of water resource management and forestry.

Other method of supporting developing countries is through support of international environmental organisations - European and Mediterranean Plant Protection Organisation, International Atomic Energy Agency, International Plant Genetic Resources Institute, International Seed Testing Association, World Meteorological Organisation, Multilateral Fund for the Implementation of the Montreal Protocol, United Nations Framework Convention on Climate Change – in their activities in supporting environmentally friendly development in developing countries.

Fast start finance projects

The Copenhagen Accord notes developed countries’ commitment to providing developing countries with fast start finance approaching USD 30 billion for the 2010-2012 period, for enhanced action on mitigation (including Reducing Emissions from Deforestation and Forest Degradation, REDD), adaptation, technology development and transfer and capacity building. Fast start finance will support immediate action on climate change and kick start mitigation and adaptation efforts in developing countries.

<u>Climate change mainstreaming in Bhutan</u>

In 2011 Estonia contributed 796972 EUR to the co-financing action in Bhutan named "Global Climate Change Alliance- Climate Change Adaptation in the Renwable Natural Resources Sector". Co-financing is in cooperation with European Commission and total cost of the project is 4 396 972 EUR. The overall objective of the GCCA programme is to enhance resilience of Bhutan´s rural households to the effects of climate change. The specific objectibe is to ensure climate change readiness of the Renewable Natural Resources sector in Bhutan by mainstreaming climate change into the sector and ensuring steps are taken towards increasingly addressing climate change adaptation at multi-sectoral level. The expected results of the proposed programme are the development of a Renewable Natural Resources- Climate Change Adaptation Action Plan as well as the establishment of an institutional framework allowing a mutli-sectoral approch to climate change adaptation. Required activities to achieve the expected results and objectives cover among others a thorough and consultative planning exercise, a realistic budgeting exercise for all planned actions, an assessment and determination of the responsibility of each stakeholder and the establishment of a formal coordination mechanism for the planning and implementation of climate change adaptation measures.

The Global Climate Change Alliance (GCCA) is an initiative set up by the European Commission to strengthen dialogue and cooperation on climate change between the European Union and the developing countries that are most vulnerable, in particular the least developed countries (LDCs) and small island developing states (SIDS). It was launched in 2007. Through the GCCA the EU provides technical and financial support in five priority areas: mainstreaming climate change into poverty reduction strategies; adaptation; reducing emissions from deforestation and forest degradation (REDD+); enhancing participation in the Clean Development Mechanism; and disaster risk reduction.

15.2. Information on how Estonia gives priority, in implementing the commitments under Article 3, paragraph 14, to specific actions

Estonia reports activities that are related to the actions specified in the subparagraphs (a) to (f) of paragraph 24 of the reporting requirements in the Annex to decision 15/CMP.1.
a) 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

Several fiscal measures have been introduced in Estonia to support sustainable energy consumption and reduce GHG emissions. For example excise duties on fuels and pollution charges. Current tax rates are stipulated in the *Alcohol, Tobacco, Fuel and Electricity Excise Duty Act*. The Environmental Charges Act (enforced in 2006) obliges the owners of combustion equipment to pay pollution charges for several pollutant emissions (e.g. sulphur dioxide, nitrogen oxides, etc.). At present, the CO_2 charge has to be paid by all enterprises producing heat in the scope of *District Heating Act* (includes distribution and sales of heat) excluding the ones firing biomass, peat or waste.

Estonia as a Member State of the EU has to comply with the EU requirements (Directive 2003/96/EC) for the taxation of fuels and energy. Estonia has been granted some transitional time for the introduction of relevant taxes. Regarding shale oil (oil produced from oil shale), Estonia was eligible to apply a transitional period until 1 January 2010 for adjusting the national level of taxation on shale oil used for district heating purposes to the EU minimum level of taxation. Nevertheless, Estonia had already introduced the tax on shale oil. The tax exemption for natural gas (methane) is permitted by Directive 2003/96/EC, which allows an exemption on natural gas in those Member States where the share of natural gas in energy end-use was less than 15% in 2000. The exemption applies for a maximum of ten years after the directive’s entry into force or until the national share of natural gas in energy end-use reaches 25%, whichever comes first. Actually, Estonia imposed excise duty on natural gas on 1 January 2008 already.

More information about tax system and fiscal measures is presented in Estonia's Fifth National Communication under the UNFCCC and Kyoto Protocol.

b) Removing subsidies associated with the use of environmentally unsound and unsafe Technologies

No subsidies for environmentally unsound and unsafe technologies have been implemented. Estonia's tax system is presented shortly above (Paragraph 24a) and through this tax system Estonia promotes sustainable production and technologies. For instance according to the Environmental Charges Act (enforced in 2006) the CO_2/t pollution charge doubled between 2006 and 2009.

c) Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end

Estonia does not have any support activities in this field.

d) 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

Estonia has done research for enhancing technologies that emit less GHGs but at the moment there is no cooperation with developing countries in this field.

e) 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

Estonia´s development policy supports low carbon and sustainable development but at the moment there is no cooperation with developing countries in this field.

f) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies

Estonia has contributed 1,000,000 EUR over the years 2008-2010 to the Neighbourhood Investment Facility Trust Fund. Trust Fund supports strengthening of infrastructure interconnections between the EU and its neighbours in the areas of transport and energy, addressing common environmental concerns and supports other relevant activities. Estonia earmarked its contribution to the Eastern region of European Neighbourhood and Partnership Instrument (including Georgia and Republic of Moldova). Estonia is planning to contribute at least 1,000,000 EUR over the years 2011-2013 to the Neighbourhood Investment Facility Trust Fund and as for the previous period, the contribution will be earmarked to the Eastern region of European Neighbourhood and Partnership Instrument.

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