GREENHOUSE GAS EMISSIONS IN ESTONIA 1990-2008

NATIONAL INVENTORY REPORT

to the UNFCCC secretariat

Common Reporting Formats (CRF)

1990-2008

Tallinn 2010

PREFACE

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

Part I. Description of the greenhouse gas emission inventory according to the UNFCCC reporting guidelines (FCCC/SBSTA/2004/8) containing description of the organization of the national greenhouse gas inventory, IPCC and other methods applied in calculation of the year 2008 emissions and exemptions to the previous inventories. A summarizing table of the emissions data for the years 1990-2008 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) and Estonian Environmental Research Centre (Ms Kristina Kaar, Ms Kristiina Nikkel and Ms Katri Saare) have made the inventory calculations, the description of the methodologies and other information included in the National Inventory Report. Climate and Ozone Bureau of Estonian Environment Information Centre (EEIC) co-ordinated the process of the inventory preparation.

The Ministry of the Environment is responsible for the 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

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.

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. A National Programme for the Reduction of Greenhouse Gas Emissions was compiled taking into consideration the Kyoto Protocol and the European Council Decision 93/389/EC from 24 June 1993 on the monitoring of greenhouse gas emissions in the EU (EÜT L 167, 09/07/1993 p 0031-0033). On 30 April 2004 the Estonian Government approved the National Programme for the Reduction of Greenhouse Gas Emissions for the years 2003-2012.

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 a Party to the Kyoto Protocol is required to report supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol, with the inventory submission due under the Convention, in accordance with paragraph 3(a) of decision 15/CMP.1. Part II of this report (Chapters 11-15) provides information on activities under Article 3, paragraph 3 (Afforestation, Reforestation, Deforestation), on accounting of Kyoto units, on changes in the national system and the national registry and information on the minimization of adverse impacts of climate change in accordance with Articles 3.14.

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

ES.2.1 GHG inventory

In 2008 the total emissions of GHGs, measured as CO_2-equivalents, were 10,523.76 Gg, and without CO_2 from LULUCF 20,253.58 Gg. From 1990 to 2008 the emissions decreased by 50.41 %. Table ES.1. shows the trends in the total emissions during the period 1990–2008. Figure ES.1. shows overall development of greenhouse gases in Estonia, in CO_2 equivalents (without CO_2 from LULUCF)

In 2008, the most important GHG in Estonia was carbon dioxide (CO_2), contributing 85.83 % to total national GHG emissions expressed in CO_2 equivalent, followed by methane (CH_4), 7.96 %, and nitrous oxide (N_2O), 5.56 %. Fluorocarbons (so-called "F gases") account for about 0.66 % of total emissions. The Energy sector accounted for 84.38 % of total GHG emissions, followed by Agriculture (7.14 %), Industrial Processes (5.14 %) and Waste (3.33 %).

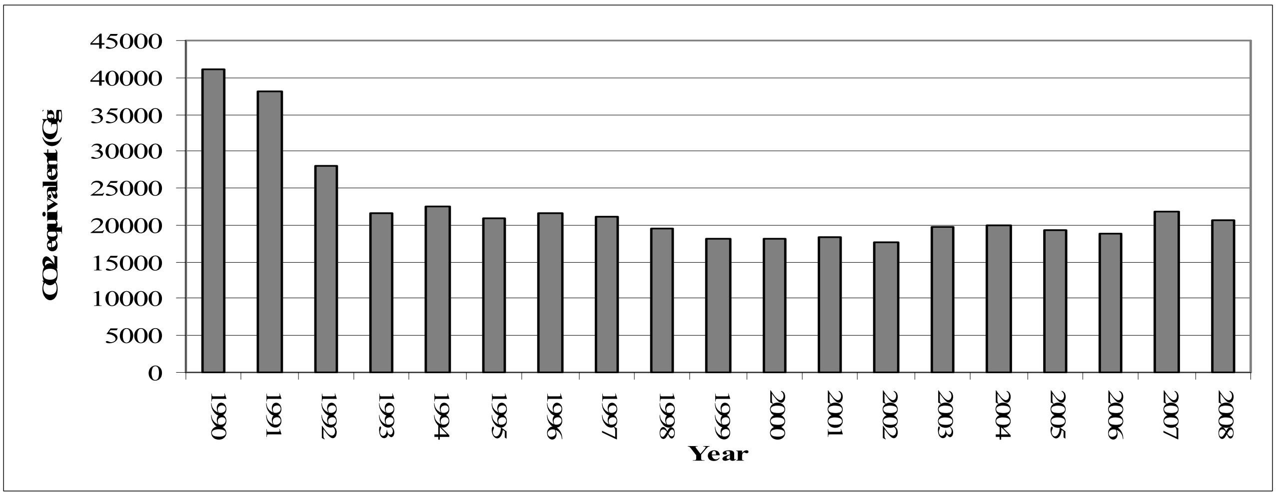

Figure ES.1. Overall development of greenhouse gases in Estonia, in CO_2 equivalents (without CO_2 from LULUCF)

Table ES.1. Greenhouse-gas emissions in Estonia-changes with regard to the base year

GREENHOUSE GAS EMISSIONS	**Base year (1990)**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
	CO2 equivalent (Gg)										
CO_2 emissions including net CO_2 from LULUCF	29,848.55	11,123.04	13,985.69	11,655.40	11,220.84	11,165.49	8,519.26	8,211.94	7,219.68	9,753.44	7,650.46
CO_2 emissions excluding net CO_2 from LULUCF	36,135.69	18,241.65	15,441.53	15,844.59	15,275.06	17,200.86	17,308.23	16,687.28	16,145.10	19,227.54	17,383.08
CH_4 emissions including CH_4 from LULUCF	2,728.32	1,605.93	1,655.55	1,708.70	1,577.49	1,607.94	1,687.98	1,664.63	1,676.12	1,645.90	1,613.37
CH_4 emissions excluding CH_4 from LULUCF	2,723.55	1,604.47	1,652.43	1,707.65	1,571.42	1,607.06	1,686.37	1,664.22	1,666.11	1,644.62	1,611.73
N_2O emissions including N_2O from LULUCF	1,985.26	998.94	1,022.65	868.53	911.11	918.15	1,034.30	941.99	964.89	1,042.05	1,126.47
N_2O emissions excluding N_2O from LULUCF	1,984.20	998.07	1,021.36	867.45	909.52	917.09	1,033.16	940.97	962.92	1,040.93	1,125.32
HFCs	NA,NO	25.68	70.13	86.14	87.28	92.71	105.49	118.82	135.66	140.78	132.08
PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.07	0.06	0.04
SF_6	NA,NO	3.22	2.73	1.74	1.43	1.31	1.08	1.08	1.15	0.97	1.35
Total (including LULUCF)	**34,562.13**	**13,756.81**	**16,736.75**	**14,320.51**	**13,798.15**	**13,785.61**	**11,348.11**	**10,938.45**	**9,997.58**	**12,583.19**	**10,523.76**
Total (excluding LULUCF)	**40,843.44**	**20,873.08**	**18,188.19**	**18,507.58**	**17,844.71**	**19,819.03**	**20,134.33**	**19,412.36**	**18,911.02**	**22,054.90**	**20,253.58**
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**Base year (1990)**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
	CO2 equivalent (Gg)										
1. Energy	36,076.54	18,075.56	15,334.81	15,755.11	15,318.65	17,233.69	17,277.46	16,641.08	16,057.06	18,970.20	17,090.81
2. Industrial Processes	1,034.39	672.29	698.01	736.22	535.48	594.51	753.27	797.00	858.79	1,036.77	1,040.88
3. Solvent and Other Product Use	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
4. Agriculture	3,052.52	1,478.30	1,298.27	1,271.52	1,181.54	1,263.21	1,289.95	1,272.85	1,291.74	1,350.00	1,447.07
5. Land Use, Land-Use Change and Forestry(5)	-6,281.31	-7,116.28	-1,451.44	-4,187.07	-4,046.56	-6,033.42	-8,786.22	-8,473.91	-8,913.44	-9,471.71	-9,729.83
6. Waste	680.00	646.93	857.10	744.73	809.05	727.62	813.65	701.42	703.43	697.93	674.82

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**	
	[Gg]	**[%]**	**[Gg]**	**[%]**	**[Gg]**	**[%]**	**[Gg]**	**[%]**	**[Gg]**	**[%]**	**[Gg]**	**[%]**
CO_2 emissions excluding net CO_2 from LULUCF	**36,135.69**	88,47	**18,241.65**	87,39	**15,441.53**	84,90	**16,687.28**	85,96	**19,227.54**	87,18	**17,383.08**	85,83
CH_4 emissions excluding CH_4 from LULUCF	**2,723.55**	6,67	**1,604.47**	7,69	**1,652.43**	9,09	**1,644.62**	8,57	**1,644.62**	7.46	**1,611.73**	7,96
N_2O emissions excluding N_2O from LULUCF	**1,984.20**	4,86	**998.07**	4,78	**1,021.36**	5,62	**940.97**	4,85	**1,040.93**	4,72	**1,125.32**	5,56
HFCs	**NA, NO**		**25.68**	0,123	**70.13**	0,386	**118.82**	0,612	**140.78**	0,638	**132.08**	0,652
PFCs	**NA, NO**		**NA, NO**		**NA, NO**		**NA, NO**		**0.06**	0,000	**0.04**	0,000
SF_6	**NA, NO**		**3.22**	0,015	**2.73**	0,015	**1.08**	0,006	**0.97**	0,004	**1.35**	0,007
Total (excluding LULUCF)	**40,843.44**		**20,873.08**		**18,188.19**		**19,412.36**		**22,054.90**		**20,253.58**	

ES.2.2 KP-LULUCF activities

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 paragraphs 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.

The LULUCF sector is a net sink of carbon during the entire period of reporting (Figure ES.2.) as the volume of forest biomass increment exceeds the total volume of forest harvested in Estonia. The changes in land use (from cropland to grassland) increased a capacity of carbon sequestration in this sector.

However, forest is a source of carbon within Kyoto Protocol land use, land use change and forestry (KP-LULUCF) sector (Figure ES.3.) carbon emitted from forest biomass deforested was higher than carbon sequestrated due to afforestation/reforestation activities implemented in Estonia. The sharp decrease in 2000 in the trend of net carbon emission from afforestation, reforestation and deforestation (ARD) activities was due to decline in areas of forest deforested (Table ES.3) (more detailed information is presented in Chapter 11).

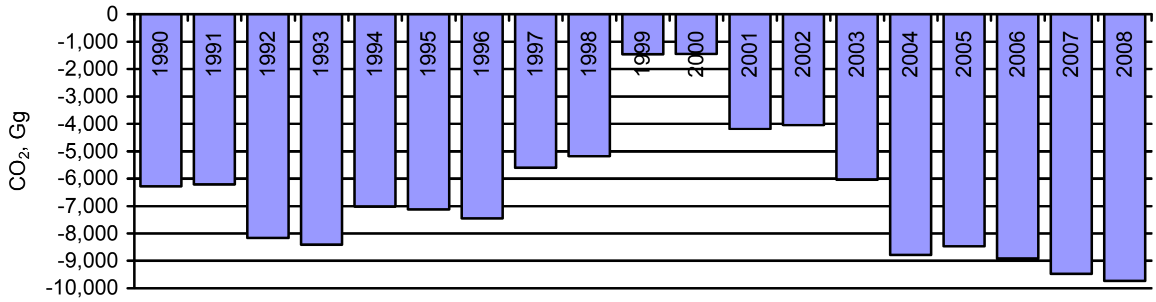

Figure ES.2. Net removal of CO_2 by Estonian LULUCF sector in 1990–2008, CO_2 Gg

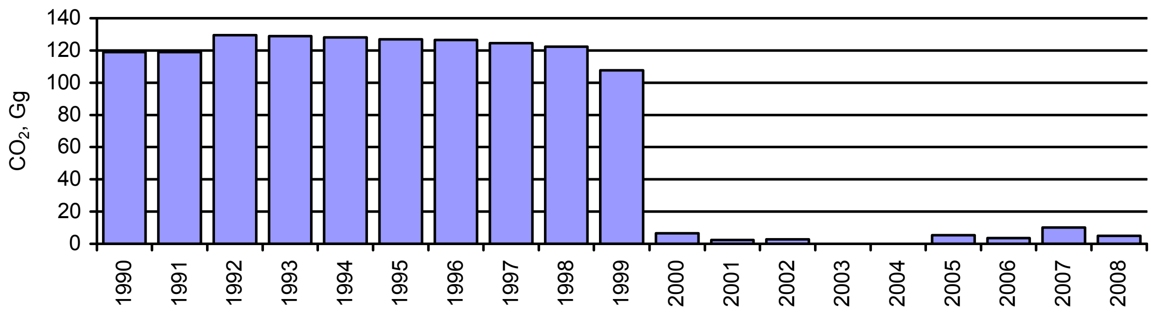

Figure ES.3. Net removal of CO_2 by Estonian KP-LULUCF sector in 1990–2008, CO_2 Gg

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

The greenhouse gas emissions and removals are divided into the following sectors according to the UNFCCC reporting guidelines on annual inventories (FCCC/SBSTA/2004/8): 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.4 shows the contributions of individual source and sink categories to total greenhouse gas emissions.

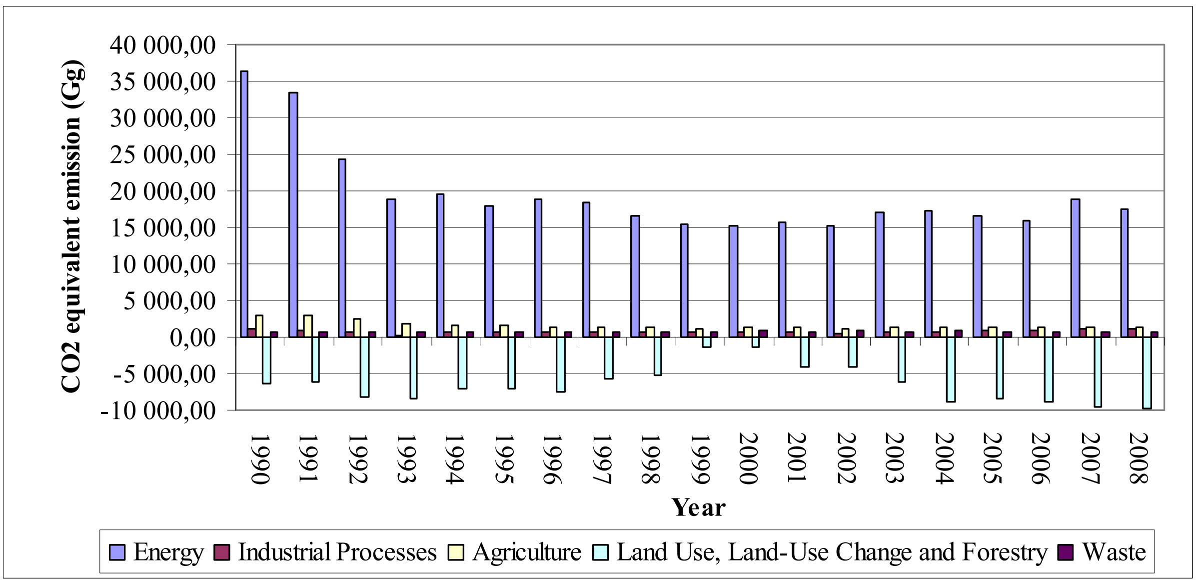

Figure ES.4. Greenhouse-gas emissions trends, by source groups, in CO_2 equivalents

The energy sector is the most significant source of greenhouse gas emissions in Estonia with an around 84% share of the total emissions in 2008. Since the base year, emissions have decreased by 52.63 %. 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 2008 the agriculture sector contributed 7.14 % of the total emissions. Since the base year emissions have decreased by 52.59 % , mostly due to the decreasing livestock population and the quantities of synthetic fertilizers and manure applied to agricultural fields.

In 2008 industrial greenhouse gas emissions contributed 5.14 % of the total greenhouse gas emissions in Estonia. Emissions have increased by 0.63 % between 1990 and 2008. 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 3.33 % of the total greenhouse gas emissions in 2008. The total emissions in CO_2 equivalent from the Waste sector decreased by 0.76 % compared to the base year: the emissions from solid waste land filled decreased by 14,3 % and emissions from waste composting processes increased about 100 fold – from 1.26 Gg to 121 Gg in 2008.

In 2008 the LULUCF sector acted as a CO_2 sink, totalling 9,729.83 Gg CO_2 equivalent. The LULUCF sector in Estonia has been a net sink during the whole reporting period 1990-2008 as the removals in the sector exceed the emissions. Reported net CO_2 removals in the LULUCF sector increased by 54.9 % between 1990 and 2008. The sharp decreases in 1999 and 2000 are explained by the sharp increase in the forest felling in these years. Land use has changed in recent decades.

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 20_{th} century.

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 20_{th} 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).

Over the last century the mean wind speed increased by 0.5-0.8 m/s. The increase of mean wind speed is characteristic mainly of the cold season (November to February). No significant change in wind speed is observed during the warm period (May–July).

Estonian tidal measurements over the period 1842–2005 suggest a mean sea level rise (adjusted to account for land uplift) of 1.5–2.1 mm/yr over the last century. The trend in Pärnu County (2.3–2.7 mm/yr) is greater than the estimated mean global sea level rise.

Increased air temperature has caused a decrease in the maximum discharge of spring floods and their earlier beginning. Before the 1960s the average beginning time of flood was the end of March or the beginning of April, whereas after the 1960s the floods have begun in February and for the last decade even in January. If the tendencies continue, Estonia can expect earlier and lower spring floods, smoothing the boundaries between the seasonality of river flow. More frequent flooding during winter may have an impact on the infrastructure, because the current structure was designed for past climate conditions with stable winters and higher spring floods.

As a result of climate change, groundwater recharge will increase by 5–75%, depending on the hydrogeological conditions of catchments. Groundwater recharge will be the most intensive in the heights of Upper Estonia, whereas toward the lowlands the incremental infiltration rate will be less intensive. The safe yield of wells tapping the upper aquifers will be augmented up to 20% on average in Upper Estonia. It will make the public water supply cheaper.

Changes in the climate will also have an effect on tourism in Estonia. Winter tourism (skiing as entertainment and as sport) will encounter difficulties with lack of snow. Estonia has old skiing traditions and in recent years Estonian ski-runners have obtained a good reputation. As a result, skiing is popular in Estonia, and interest in organising international top-level competitions has grown. Poor snow conditions may put these competitions at risk.

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 UN FCCC and in 2002, the Kyoto Protocol. In response to UNFCCC requirements Estonia has prepared the present emission National Inventory Report.

In 1994 an Interministerial Committee of Climate Change was created at the Estonian Government. The Chairman of this Committee is the Minister of the Environment and members are from key ministries, scientists as well as representatives of NGOs. This Committee deals with the problems connected with the implementation of UN FCCC, organises monitoring of emissions of GHG, national communications etc.

Single national entity with overall responsibility for the Estonian greenhouse gas inventory is the Estonian Ministry of the Environment. Financial resources are partly planned in the State Budget and partly applied from Environmental Investment Centre. Practical work is done 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, 2009 and 2010 inventories are produced in collaboration between the Ministry of the Environment, Estonian Environment Information Centre, Tallinn University of Technology and Estonian Environmental Research Centre (see Figure 1.1).

This report presents the national inventory of greenhouse gas emissions and removals from 1990 to 2008. 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 3.4.3). 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 2008. Chapters 3-8 give information of GHG emission trends from the base year 1990 to year 2007 for the following sectors: energy; industrial processes; agriculture; land use, land-use change and forestry; waste. Annex 1 contains the QC checklists; Annex 2 includes assessment of completeness. 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 and Chapter 16 information of implementation of flexible mechanisms of Kyoto Protocol. 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 includes additional information to be considered as part of the annual inventory submission and the supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol or other useful reference information. Annex 7 contains the mandatory uncertainty reporting table (table 6.1 of Good Practice Guidance 2000). Annex 8, 9, 10 and 11 contains additional information for the Energy, Agriculture, LULUCF and Industrial Processes sector.

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 a Party to the Kyoto Protocol is required to report supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol, with the inventory submission due under the Convention, in accordance with paragraph 3(a) of decision 15/CMP.1. Part II of this report (Chapters 11-15) provides information on activities under Article 3, paragraph 3 (Afforestation, Reforestation, Deforestation), on accounting of Kyoto units, on changes in the national system and the national registry and information on the minimization of adverse impacts of climate change in accordance with Articles 3.14.

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 paragraphs 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 the Estonian Ministry of the Environment (MoE). The inventory is produced in collaboration between the MoE, Estonian Environment Information Centre (EEIC), Tallinn University of Technology (TUT) and The Estonian Environmental Research Centre (EERC).

The MoE is responsible for:

- Coordinating the overall inventory preparation process;
- Approving the inventory before official submission to the UNFCCC;
- Concluding the formal agreements with inventory compilers annually by 1st of July (TUT, EERC);
- Coordinating the cooperative work between the inventory compilers and UNFCCC;
- 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;
- Coordinating the UNFCCC inventory reviews.

Climate and Ozone Bureau in EEIC is responsible for:

- Completing the National Inventory Report according to the parts submitted by the inventory compilers;
- Reporting the greenhouse gas inventory to the UNFCCC, including the National Inventory Report and CRF tables;
- Coordinating the QA/QC plan;
- 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 Tallinn University of Technology prepare the estimates for the Energy, Agriculture and LULUCF sectors. The EERC is responsible for the Waste sector and Industrial Processes sector together with the fluorinated gases estimates, which were prepared during the Twinning project EE05-IB-EN-01 “Enhancing the capacity to reduce the emissions of fluorinated greenhouse gases in Estonia” (twinning partner Germany). All experts collect activity data, 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; 2007, 19, 95), 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 §12 section 5 of the Statute of the Ministry of the Environment (RT I 23.12.2009, 63,412), the Ministry coordinates international cooperation and the implementation of international agreements in its jurisdiction and according to §36 section 4, the Climate and Radiation Department deals with ambient air, including climate change problems.

§2 section 1 subsection 3 of the Statute of the Climate and Radiation Department provides that the department shall develop international cooperation in its field, organize the fulfilment of obligations under the conventions and agreements, controls the fulfilment of obligations and intermediates the related information to Estonia. §2 section 2 subsection 5 of the mentioned Statute provides that the Ambient Air and Radiation Protection Bureau shall organize the fulfilment of obligations under the UNFCCC and IAEA conventions and obligations set to the European Union Parties in its field, controls the fulfilment of obligations, analyses the fulfilment process and intermediates the related information. §2 section 2 subsection 15 of the above Statute provides that the Ambient Air and Radiation Protection Bureau shall organise the required reports related to its field.

The Estonian Environment Information Centre works under the jurisdiction of the Ministry of the Environment and in accordance with its Statute (RTL 2004, 1, 3), the Climate and Ozone Bureau deals with climate change issues. Responsibilities of the Ministry of the Environment and of the Estonian Environment Information Centre concerning the greenhouse gas inventory are regulated by the Directive of the Minister of the Environment.

A co-operation agreement between the Ministry of the Environment and Tallinn University of Technology 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 the Estonian Environmental Research Centre and Tallinn University of Technology is done on annual bases.

The Statistical Office of 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. The official statistical surveys of the year 2007 are approved by Government of the Republic in Regulation No. 549 of 16 October 2006. According to the Regulation, data of carbon dioxide, methane, nitrous oxide, freons and sulphur hexafluoride emissions and carbon dioxide removals by ecosystems are collected during the survey "Greenhouse gases emissions and removals". The data on freons and sulphur hexafluoride are based on the survey "Using of Chemicals".

1.2.1.2. Institutional cooperation

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

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 an agreements with TUT and EERC. Through these agreements, the institutions are committed 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 the UNFCCC.

These institutions are in close contact with each other. Several cooperation meetings are held to discuss and agree on the methodological issues, problems that have arised and improvements that need to be implemented. As Estonia is a small country there is close contact between inventory experts (TUT, EERC) and inventory compiler (EEIC) 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.

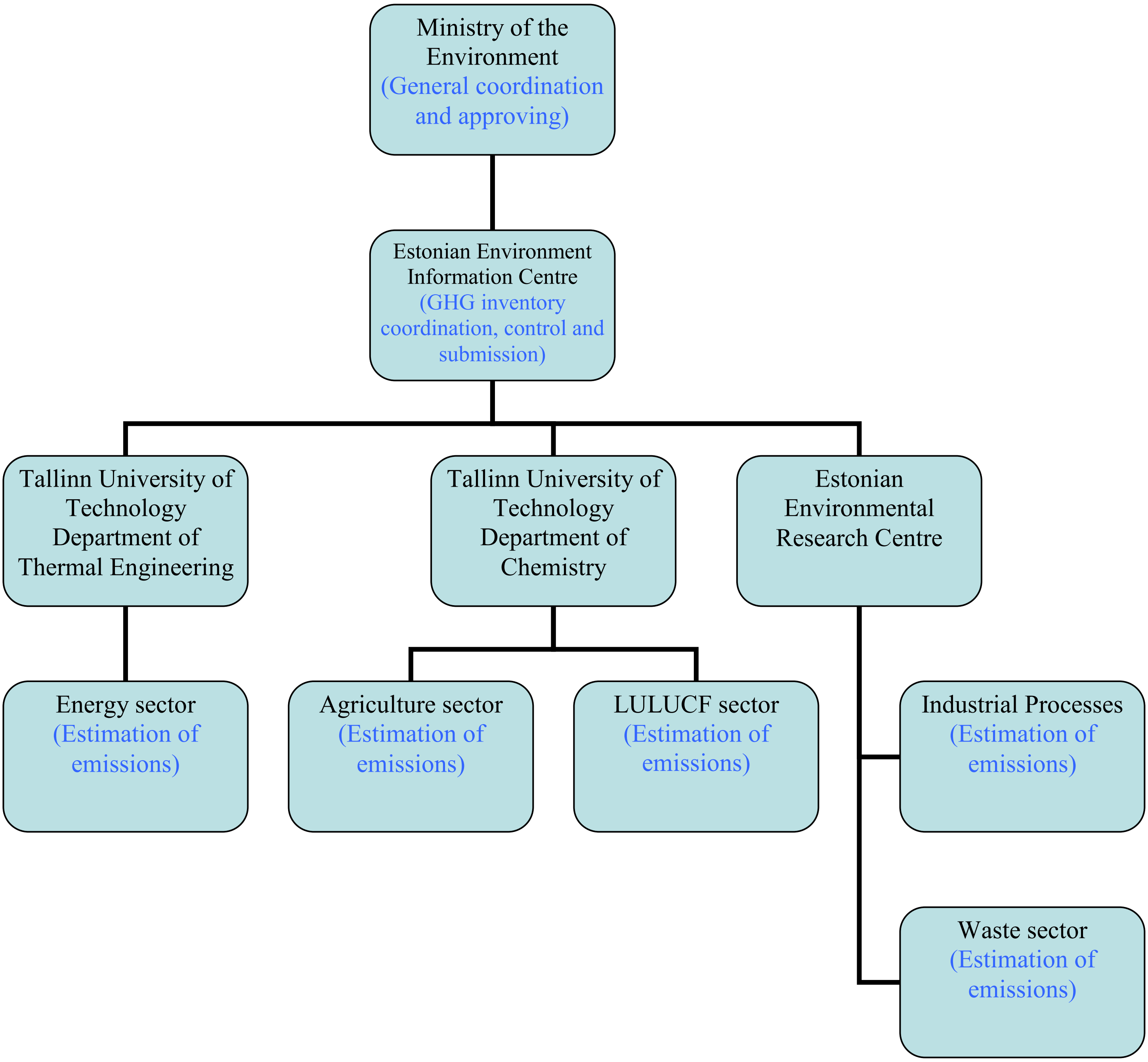

Figure 1.1. National System for GHG inventory in Estonia.

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.

EEIC in collaboration with the MoE has 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, EEIC, EERC 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

	Responsible	Deadline
Annual meeting: Will be discussed how the previous inventory cycle has been, what should be improved/changed; new contracts, etc	*All*	*May 15*
Agreement on the changes and adjustments to be made for the next year's reporting	All	July 1
Sectoral experts notify the EEIC 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	Sept. 15
Annual meeting: Sectoral experts notify the EEIC 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 EEIC give an overview of the new requirements, plans, etc	*All*	*Sept. 30*
Sectoral experts provide the XML files to the EEIC	TUT, EERC	Dec. 1
EEIC compiles the CRF tables and sends them to the sectoral experts for approval. QC checks are carried out and documented. CRF tables are also sent to the independent expert	EEIC	Dec. 7
EEIC performs the key category analysis and sends the results to the sectoral experts and independent expert	EEIC	Dec. 10
Sectoral experts provide the draft NIR to the EEIC. Prior to this the QC checks should be carried out and documented	TUT, EERC	Dec. 15
EEIC compiles the draft NIR according to the submitted sectoral parts and sends it to the sectoral experts,	EEIC	Dec. 21

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
EEIC performs QC of the NIR and sends the comments to the sectoral experts and independent expert for review	EEIC	Jan. 4
Sectoral experts send their comments and possible changes on the CRF tables according to the QA (performed by the independent expert) to EEIC and independent expert	TUT, EERC	Jan. 5
Sectoral experts send their comments and possible changes on the CRF tables according to the QC (performed by EEIC) to EEIC and independent expert	TUT, EERC	Jan. 8
Reporting to the EU (CRF tables and draft NIR)	MoE, EEIC	Jan. 15
The draft NIR along with the CRF tables is uploaded to the EEIC webpage for public review	EEIC	Jan. 18
Sectoral experts send the necessary data for uncertainty analysis to EEIC	TUT; EERC	Jan. 18
EEIC performs the uncertainty analysis and sends it to the sectoral experts and independent expert for approval	EEIC	Jan. 25
Independent expert carries out QA of the NIR and submits the results to the sectoral experts and EEIC	TUT	Febr. 2
MoE carries out QC of the CRF tables and NIR and submits the results to the EEIC	MoE	Febr. 8
EEIC submits the results of the Moe QC to the sectoral experts and independent expert	EEIC	Febr. 9
Sectoral experts send their comments and possible changes according to the QA/QC (performed by the MoE and independent expert) to EEIC and independent expert	TUT, EERC	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, EEIC	March 15
Answers to the EU initial check and if possible then corrections are made to the inventory	All	March 15-April 10
MoE approves the final inventory	MoE	April 10
Reporting to the UNFCCC	MoE, EEIC	April 15
NIR and CRF tables are uploaded to the EEIC webpage	EEIC	April 19

1.3. Inventory preparation

1.3.1. GHG inventory and KP-LULUCF inventory

The UNFCCC, the Kyoto Protocol and the EU's greenhouse gas monitoring mechanism require Estonia to submit annually a National Inventory Report (NIR) and Common Format (CRF) tables. The annual submission contains emission estimate for the second but last year, so that the 2010 submission contains estimates for the calendar year 2008.

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 the Estonian Ministry of Environment (MoE). The inventory is produced in collaboration between the MoE, Estonian Environment Information Centre (EEIC), Tallinn University of Technology (TUT) and The Estonian Environmental Research Centre (EERC).

In 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 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 and EERC are collecting data and prepare the estimates for the national inventory. The main sources of data are from official Estonian statistics (the Statistical Office of Estonia, Estonian Animal Recording Center) and from company's annual emission reports.

MoE has an agreement with the Estonian Statistical Office for receiving the statistical data; this agreement includes the data for the GHG inventory. The Statistical Office of 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.

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 the Statistical Office of Estonia.

The Statistical Office publishes:

1. Energy related data in the annual statistical bulletin *Energy Balance* in the end of September. The data received from the Statistical Office cover all fuels used in 6 main end-use sectors (Energy Industries, Manufacturing Industries, Transport, Agriculture, Residential and Commercial/Institutional).

2. Additionally TUT asks every year by special inquiry data on aviation bunkering because this data is not published (in the Energy Balance bulletin the data of aviation fuels is given in total and is not splitted into national and international use) and quantities of some industrial products which are not published (like production of pulp and paper, food and drink, etc) but are needed for implementation of GHG Inventory.

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

- AS Estonian Energy (data on oil shale consumption for pulverized combustion and for circulating fluidized bed combustion and oil shale gas data).

Industrial Processes

Activity data used in the estimates is obtained from the Statistical Office of Estonia, plants and in case of F-gases from national and international companies, associations, public institutions etc.

There are two sub-sectors in mineral industries:

- Cement industry and
- Lime industry

Data on clinker production (raw material for cement production) is received directly from the cement factory AS Kunda Nordic Cement.

Activity data on lime production is received from Statistics Estonia.

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

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, sport shoe soles). In those sub- sectors data is collected from national and international companies, associations, public institutions etc.

Agriculture

Activity data used in the estimates is obtained mainly from the Statistical Office of Estonia.

The Statistical Office opens the data annually by July–August. The data received from the Statistical Office are the following:

- number of livestock;
- crop yields;
- volume of N fertilizers applied on agricultural soils.

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

- Estonian Animal Recording Centre (fat content of milk and number of cows, which give birth);
- Scientific publications (a model of gross intake by pigs).

Waste

Activity data on solid waste generation and disposal used in calculating emissions are taken from an Estonian Environment Information Centre's yearbook (EEIC) published annually by September.

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

Quantity of methane recovered from landfills is taken from an "Energy Balance" yearbook published by the Estonian Statistical Office annually by September.

Activity data on wastewater treatment used in estimates are taken from an EEIC's annual report published by August.

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. EEIC 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 greenhouse gas inventories would be readily assessed in terms of quality. It is good practice to implement quality assurance/quality control (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, EEIC, TUT and EERC) 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. EEIC as the quality coordinator has an overall responsibility for coordinating and implementing the QA/QC plan. EEIC checks the QC reports of TUT and EERC 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 EEIC website www.keskkonnainfo.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 the 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) and IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry (IPCC 2003). 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	2006 IPCC methodology, revised 1996 IPCC methodology; IPCC good practice guidance	2006 IPCC methodology, revised 1996 IPCC methodology	Statistics Estonia (SE) and energy companies (AS Eesti Energia, AS Eesti Põlevkivi), Estonian Environment Information Centre
A. Fuel Combustion	T_1, T_2, T_3	D, CS, PC	Energy balances and Annual Yearbooks of Statistics Estonia; data of energy companies
A.1 Energy Industries	T_1, T_2, T_3	D, CS	Energy balances and Annual Yearbooks of Statistics Estonia; data of energy companies
A.2 Manufacturing Industries and Construction	T_1, T_2, T_3	D, CS, PC	Energy balances and Annual Yearbooks of Statistics Estonia; data of cement factory
A.3 Transport	T_1, T_2, T_3	D, CS	Energy balances and Annual Yearbooks of Statistics Estonia, Estonian Environment Information Centre
A.4 Other Sectors	T_1, T_2	D, CS	Energy balances and Annual Yearbooks of

			Statistics Estonia
A.5 Other	T_1, T_2	D, CS	Energy balances and Annual Yearbooks of Statistics Estonia
C. Fugitive Emissions	T_1, T_2	D; CS	Energy balances of Statistics Estonia
2. Industrial Processes	Revised 1996 IPCC methodology, 2006 IPCC methodology, IPCC good practice guidance	Revised 1996 IPCC methodology, 2006 IPCC methodology, IPCC good practice guidance	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
C. Consumption of halocarbons and SF_6	T_2, T_3	CS	National and international companies, associations, public institutions
4. Agriculture	1996 IPCC, 2000 IPCC	1996 IPCC, 2000 IPCC	Estonian statistics; IPCC default parameters
A. Enteric Fermentation	T_1; T_2	CS, D	Estonian statistics; IPCC default parameters
B. Manure Management	T_1	CS, D	Estonian statistics; IPCC default parameters
D. Agricultural Soils	T_1, $T1_b$	D	Estonian statistics; IPCC default parameters
F. Field Burning of Agricultural Residues	T_1	D	Estonian statistics; IPCC default parameters
5. LULUCF	1996 IPCC, 2003 LULUCF	1996 IPCC, 2003 LULUCF	
A. Forest land	T_1	D	Statistical Office of Estonia, Annual reports of Estonian Forest Protection and Silviculture
B. Croplands	T_1	D	Statistical Office of Estonia, Annual reports of Estonian Forest Protection and Silviculture
C. Grassland	T_1	D	Statistical Office of

			Estonia, Annual reports of Estonian Forest Protection and Silviculture
D. Wetlands	T_1	D	Statistical Office of Estonia, Annual reports of Estonian Forest Protection and Silviculture
E. Settlements	NE	NA	
6. Waste	Revised 1996 IPCC methodology, IPCC 2006	Revised 1996 IPCC methodology, IPCC 2006	
A. Solid Waste Disposal on Land	T_1 (the FOD method)	D	Estonian Environment Information Centre; Estonian Office of Statistics.
B. Domestic and commercial wastewater handling	T_1 (IPCC 1996)	D	Estonian Environment Information Centre; Estonian Office of Statistics.
B. Wastewater Handling (Human sewage)	T_1	D	Estonian Environment Information Centre; Estonian Office of Statistics.
C. Waste Incineration	T_1 NA 2008.a.	D	Estonian Environment Information Centre.
Biological treatment	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; NA- not applicable; D-IPCC default value
1996 IPCC – Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories
2000 IPCC– IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories
2003 LULUCF – Good Practice Guidance for Land Use, Land-Use Change and Forestry

1.4.2. KP-LULUCF inventory

A Tier 1 approach has been employed to estimate carbon removals/emissions related to ARD (afforestation /reforestation /deforestation) activities. The data on AR (afforestation /reforestation) areas were obtained from Estonian Office of Statistics, which reports the areas for each county of Estonia. Originally, these data are collected based on licence by Centre of Forest Protection and Silviculture. The data on deforestation areas in 1990–1999 were developed in the framework of a twinning project. The data on deforestation areas in 1999–2008 are collected in the process of National Forest Inventory (NFI), which was established in 1999 in Estonia.

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 2008), the trend of emissions (change between 1990 and 2008) 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	Energy Industries - Liquid Fuels	CO_2	yes	Level (1990), Trend	
1.A.1	Energy Industries - Solid Fuels	CO_2	yes	Level (1990, 2008), Trend	Level (1990, 2008), Trend
1.A.1	Energy Industries- Biomass	N2O	yes	Trend	
1.A.2	Manufacturing Industries and Constructions - Solid Fuels	CO2	yes	Level (1990, 2008)	Level (1990)
1.A.2	Manufacturing Industries and Constructions - Liquid Fuels	CO2	yes	Trend	
1.A.2	Manufacturing Industries and Constructions- Other Fuels	CO2	yes	Trend	
1.A.3.B	Road Transport - Liquid Fuels	CO2	yes	Level (1990, 2008), Trend	Level (1990)
1.B.2	Oil and Natural Gas	CH4	yes	Level (1990, 2008), Trend	Level (2008)
1.A.4	Other Sectors- Liquid Fuels	CO2	yes	Level (2008), Trend	Level (2008)
1.A.4	Other Sectors- Solid Fuels	CO2	yes	Trend	
1.A.4	Other Sectors- Gaseous Fuels	CO2	yes	Level (2008), Trend	Level (2008), Trend
1.A.4	Other Sectors- Biomass	CH4	yes	Trend	
1.A.5	Other	CO2	yes	Trend	
2.A.1.	Cement Production	CO2	yes	Level (1990, 2008), Trend	
2.B.1	Ammonia Production	CO2	yes	Level (2008), Trend	
2.F.1.2	Commercial Refrigeration	HFCs	yes	Trend	
2.F.1.4	Industrial Refrigeration	HFCs	yes	Trend	
4.A	Enteric Fermentation - Dairy Cattle	CH4	yes	Level (1990, 2008)	Level (1990, 2008)
4.A	Enteric Fermentation- Non-Dairy Cattle	CH4	yes	Level (1990, 2008), Trend	Level (1990)
4.B	Manure Management - Solis Storage and Dry Lot	N2O	yes	Level (1990, 2008), Trend	Level (1990)
4.B	Manure Management - Other AWMS	N2O	yes	Trend	
4.D.1.1	Direct Soil Emissions - Sunthetic Fertilizers	N2O	yes	Level (1990, 2008), Trend	Level (1990, 2008), Trend
4.D.1.2	Direct Soil Emissions - Animal Manure Applied to Soils	N2O	yes	Level (1990, 2008), Trend	Level (1990)
4.D.1.4	Direct Soil Emissions - Crop Residue	N2O	yes	Level (1990, 2008), Trend	Level (1990)
4.D.1.5	Direct Soil Emissions - Cultivation of Histosols	N2O	yes	Level (1990, 2008), Trend	Level (1990, 2008), Trend
4.D.3.1	Indirect Emissions - Atmospheric Deposition	N2O	yes	Level (1990)	
4.D.3.2	Indirect Emissions - Nitrogen Leaching and Run-off	N2O	yes	Level (1990, 2008), Trend	Level (1990, 2008), Trend
6.A	Solid Waste Disposal on Land	CH4	yes	Level (1990, 2008), Trend	Level (1990, 2008), Trend
6.B.2.2	Domestic and Commercial Wastewater - human sewage	CH4	yes	Trend	

6.C	Waste incineration	N2O	yes	Trend	
6.D	Biological Treatment	CH4	yes	Level (2008), Trend	
6.D	Biological Treatment	N2O	yes	Level (2008), Trend	
5.A	Carbon stock change (removals)	CO2	yes		Level (1990, 2008), Trend
5.A	Carbon stock change (emissions)	CO2	yes		Level (1990, 2008), Trend
5.A	Organic soils	CO2	yes		Level 1990, 2008), Trend
5.B	Cropland, Mineral soils	CO2	yes		Level (1990), Trend
5.B	Cropland, Organic soils	CO2	yes		Level (1990, 2008), Trend
5.C	Grassland, Mineral soils	CO2	yes		Level (2008), Trend
5.C	Grassland, Organic soils	CO2	yes		Level (2008), Trend

1.5.2. KP-LULUCF inventory

The key categories identified in UNFCCC inventory for the LULUCF sector were the result of a Tier 2 analysis. In order to identify key categories of the items under the Kyoto Protocol Article 3.3, the association between the LULUCF key categories and KP Article 3.3 should be carried out. However, the estimation of key categories of KP Article 3.3 has not been provided in this submission.

Since Estonia still is developing datasets required to report the complete greenhouse gas inventory in the LULUCF sector and the datasets developed for KP Article 3.3 are being built into the database of the whole LULUCF sector. A technology of remote sensing analysis are being employed to perform tasks set up (the first efforts were carried out within the twinning project with Finnish colleagues).

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, EEIC; TUT and EERC) 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 EEIC has an overall responsibility for QC of the data of the emission inventory. EEIC checks the QC reports of TUT and EERC. When EEIC 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 EEIC. The data compilation and reporting for source sectors are performed by TUT and EERC.

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 are carried out and individual source category checklists are produced. Also assessment of completeness is evaluated.

The sectoral experts send their xml files to the compiler (EEIC) who 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 is carried out to make sure that all the necessary data is filled. When

EEIC 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 EEIC 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 also sent to the compiler 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 IPCC guidelines. 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. It is also checked that all methodological changes, recalculations, trends in emission and removals are well explained.

Then the sectoral chapters are sent to the compiler 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 IPCC guidelines. The compiler also double checks the data in the NIR, so that it is consistent with those reported in the CRF.

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, Deputy Secretary General on Environmental Management 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 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 (EEIC) and the expert organizations are held whenever necessary.

MoE and EEIC, 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 designs 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 the EUs decision on a Mechanism for Monitoring Community greenhouse gas emissions, 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 2008 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, Agriculture, Waste and LULUCF sectors were carried out by Tiina Randla, assistant of Tallinn University of Technology, Institute of Chemistry, MSc.

Also public review was carried out. The draft NIR was uploaded to the EEIC website www.keskkonnainfo.ee where all interested parties have 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.

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 quality assurance/control 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. EEIC 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 EEIC 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 impoved archiving system was developed. The archiving system consist 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 will be archived according to the new 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.

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 exception relates to the reporting of emissions from Consumption of Halocarbons and SF_6 (CRF 2.F). 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.

In addition, industrial production data are commercially sensitive in a handful of cases, such as cement production, lime production and glass production. For these sectors, whilst emissions data are reported openly.

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

1.7.1. GHG inventory

The uncertainty estimates of the 2010 inventory has been done according to the Tier 1 method presented by the IPCC Good Practice Guidance 2000.

The uncertainty analysis reporting table is presented in Annex 7 and detailed information about uncertainty evaluation is described in the sectoral chapters.

1.7.2. KP-LULUCF inventory

Uncertainty rates related to activity data and emission factors employed in the estimates under Article 3.3 are presented in the LULUCF greenhouse gases inventory.

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: CO2, N2O CH4, F-gases (HFC, PFC and SF6), NMVOC, NOx, CO and SO2.

Assessment of completeness is presented in Annex 5.

1.8.2. KP-LULUCF inventory

Carbon removals due to afforested/reforested forest biomass increment and carbon emissions due to deforestation activities in Estonian forest were estimated in the 2010 submission.

Carbon fluxes related to litter, dead woods and organic soils were not estimated in this submission. Estonia still is developing datasets required to report the complete greenhouse gas inventory in the LULUCF sector and the datasets developed for KP Article 3.3, the research will be carried out to estimate omitting carbon pools. Technology of remote sensing analysis was being employed with Finnish colleagues to perform objectives set up (within the twinning project).

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 1990-2008.

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 and N_2O is 1990, and the base year for the emissions of fluorinated gases is 1995.

Total emissions of the six greenhouse gases in Estonia (excl. net emissions from the LULUCF) decreased steadily from 40,843.44 Gg CO_2 equivalent in 1990 to 20,253.58 Gg CO_2 equivalent, respectively (Figure 2.1.). From 1990 to 2008 the GHG emissions decreased by 50.41 %. This decrease was mainly caused by the transition from planned economy to market economy and the successful implementation of the necessary reforms.

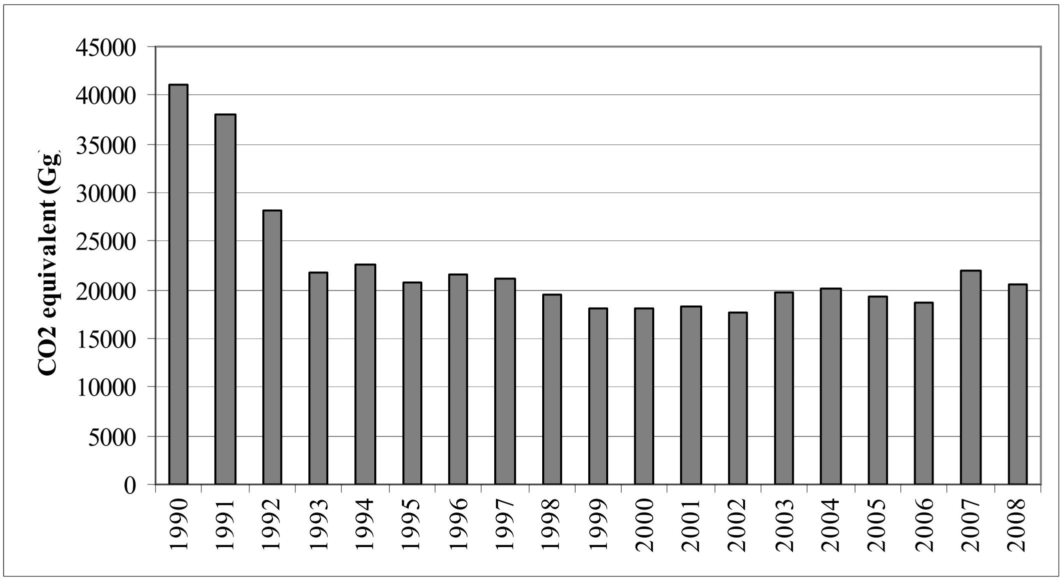

Figure 2.1. Overall development of greenhouse gases in Estonia, in CO_2 equivalents (without CO_2 from LULUCF)

2.2. Description and interpretation of emission trends by gas

In 2008, the most important GHG in Estonia was carbon dioxide (CO_2), contributing 85.83 % of the total GHG emissions (excl. LULUCF) expressed in CO_2 equivalent, followed by methane (CH_4), 7.96 % and nitrous oxide (N_2O), 5.56 %. Fluorinated gases (the so-called „F-gases") account for about 0.66 % of the total emissions (Figure 2.2).

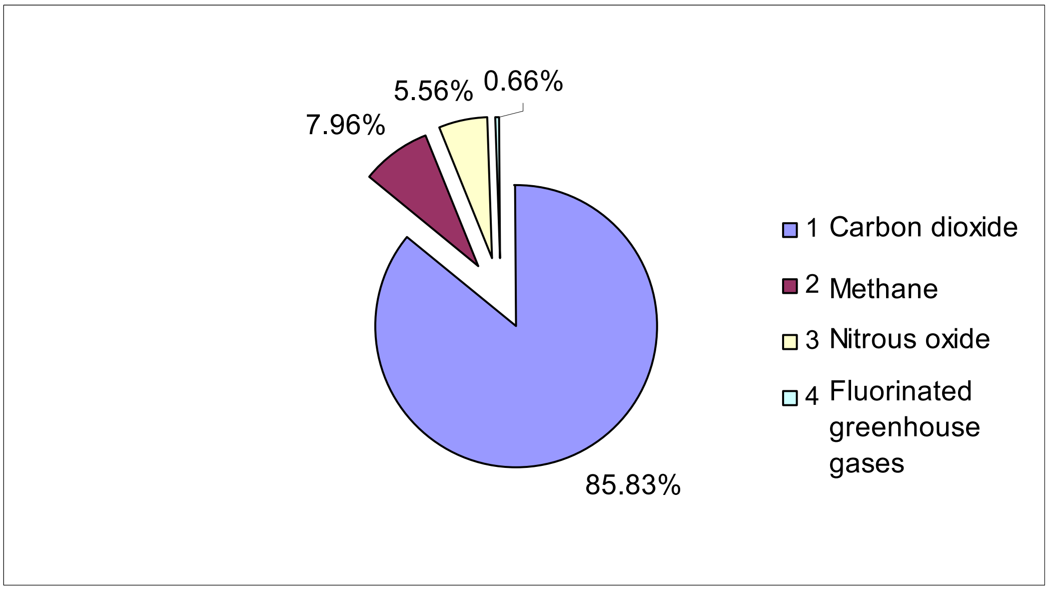

Figure 2.2. GHG emissions by gas in 2007.

Figure 2.3. shows GHG emission trends in 1990 to 2008. Emissions of CO_2 decreased by 51.89 % from 36,135.69 Gg in 1990 to 17,383.08 Gg in 2008, especially CO_2 emissions from

Energy sub-sector Public Electricity and Heat Production, which is the major source of CO_2 in Estonia.

Methane is the second most significant contributor to greenhouse gas emissions in Estonia after CO_2. Emissions of CH_4 decreased by 40.82 % from 2723.55 Gg CO_2 equivalent in 1990 to 1611.73 Gg CO_2 equivalent in 2008, especially from Energy sub-sector Fugitive Emissions from Fuels, which is the major source of CH_4 in Estonia.

Emissions of N_2O decreased by 43.29 % from 1984.20 Gg CO_2 equivalent in 1990 to 1125.32 Gg CO_2 equivalent in 2008, especially N_2O emissions from Agriculture sub-sector Agricultural Soils, which is the major source of N_2O in Estonia.

Emissions of the F-gases (HFCs, PFCs and SF_6) increased from 28,9 Gg CO_2 equivalent in 1995 to 133.47 Gg CO_2 equivalent in 2008, 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 two major decreases.

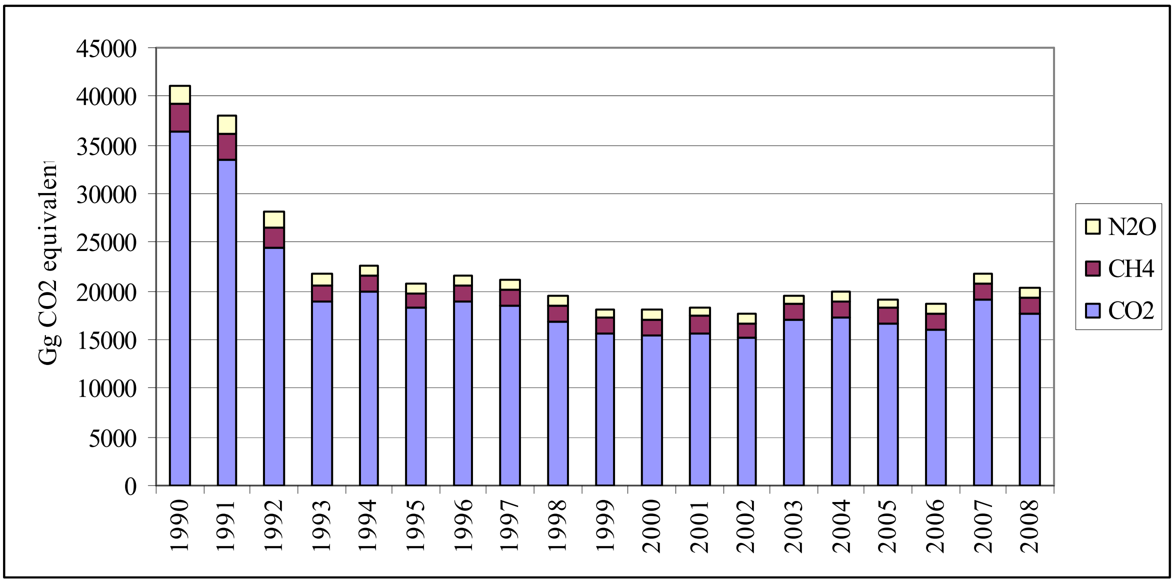

Figure 2.3. Greenhouse gas emission trends (CO_2 equivalent) in 1990 to 2008

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 2008 contributes 84.38 % of total greenhouse gas emissions (excl. LULUCF). The second largest sector is Agriculture, which accounted for 7.14 % of the total emissions in 2008. Emissions from Industrial Processes and Waste sectors accounted 5.14 % and 3.33 %, respectively of total emissions in 2008. Emissions of indirect gases are discussed in section 2.4.

Over the period 1990-2008, emissions from Energy sector decreased by 52.63 %, emissions from the Agriculture and Waste sectors decreased by 52.59 % and 0.76 %, respectively, and the Industrial Process sector increased 0.63 %. Reported net CO_2 removals on The Land-Use and Forestry sector increased by 54.9 % between 1990 and 2008. See Figure 2.4. Greenhouse gas emission trends, by source groups, in CO_2 equivalents.

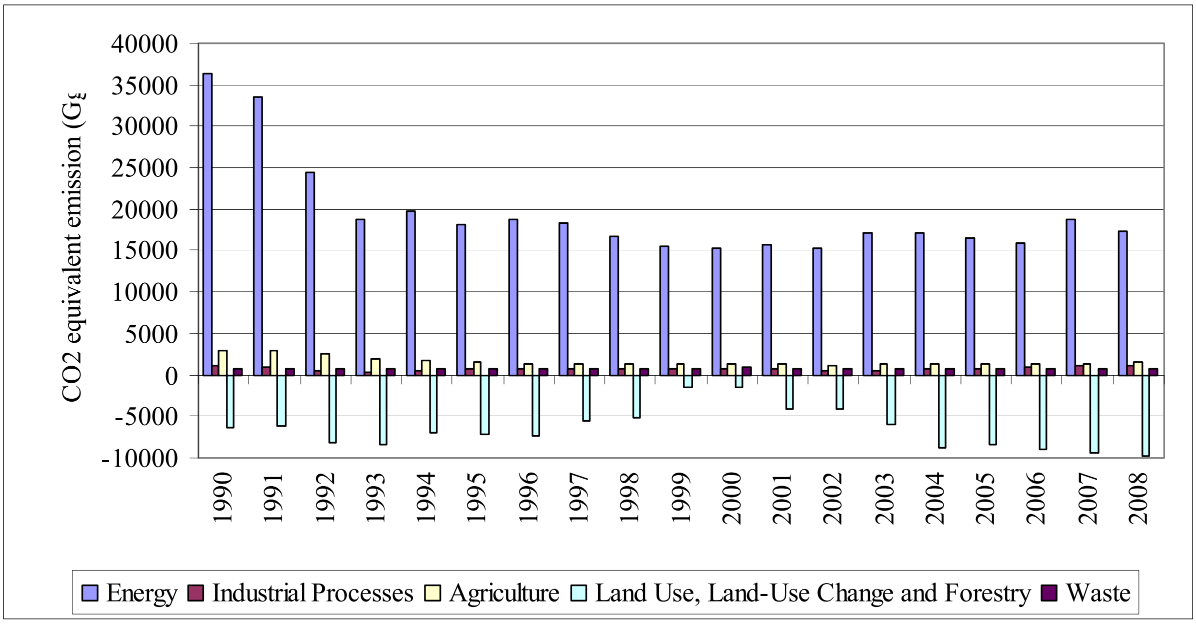

Figure 2.4. Greenhouse gas emission trends, by source groups, in CO_2 equivalents.

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: Energy Industries, Manufacturing Industries and Construction, Transport, Other Sectors, Fugitive emissions from fuels and Other. The share of emissions by category is presented in Figure 2.5.

Energy sector is the main source of GHG emissions in Estonia. In 2008, the Energy sector contributed 84.38 % of the total emissions. Most of the Energy sector emissions, 97.09 %, originated from Fuel Combustion (81.93 % of the total GHG emissions in 2008). 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 52.63 % (incl. Energy Industries- 55.83 %; Manufacturing Industries and Construction- 56.47 %; Transport- 7.38 %; Other Sector- 68.2 %; Other- 17.22% and Fugitive Emissions from Fuels- 37.2 %). 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.

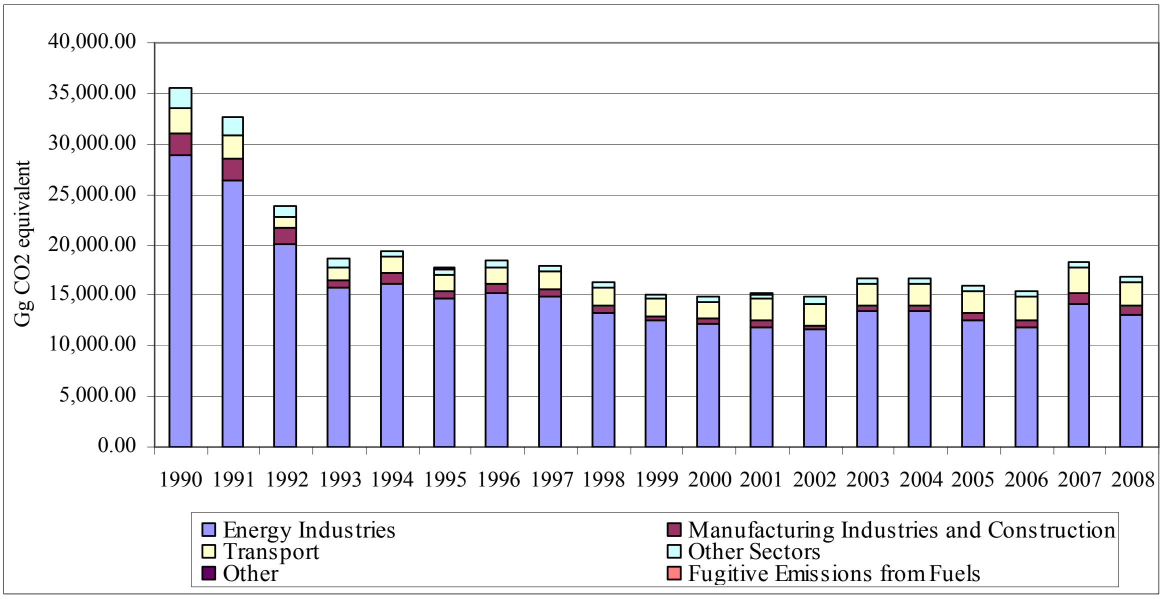

Figure 2.5. Trend in Emissions from Energy Sector 1990-2008

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 and Consumption of Halocarbons and SF_6. Under Mineral Products Estonia reports emissions from Cement Production and Lime and Glass Production. Emissions from Ammonia Productions 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. The share of emissions by category is presented in Figure 2.6.

In 2008 industrial GHG emissions contributed 5.14 % of the total GHG emissions in Estonia, totalling 1,040.88 Gg CO_2 equivalent. The most important GHG emissions from Industrial Processes in Estonia's inventory in 2008 are the CO_2 emissions from Cement Production, Ammonia Production and Lime Production with 2.98 %, 1.34 % and 0.13 %, respectively, and HFC emissions from Refrigeration and Air Conditioning Equipment with 0.66 % of the total GHG emissions in Estonia.

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. 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 AS Kunda Nordic Cement renovated its third kiln. The overall progressing of GHGs in the Industrial Processes sector in CO_2 equivalent is presented in Figure 2.6.

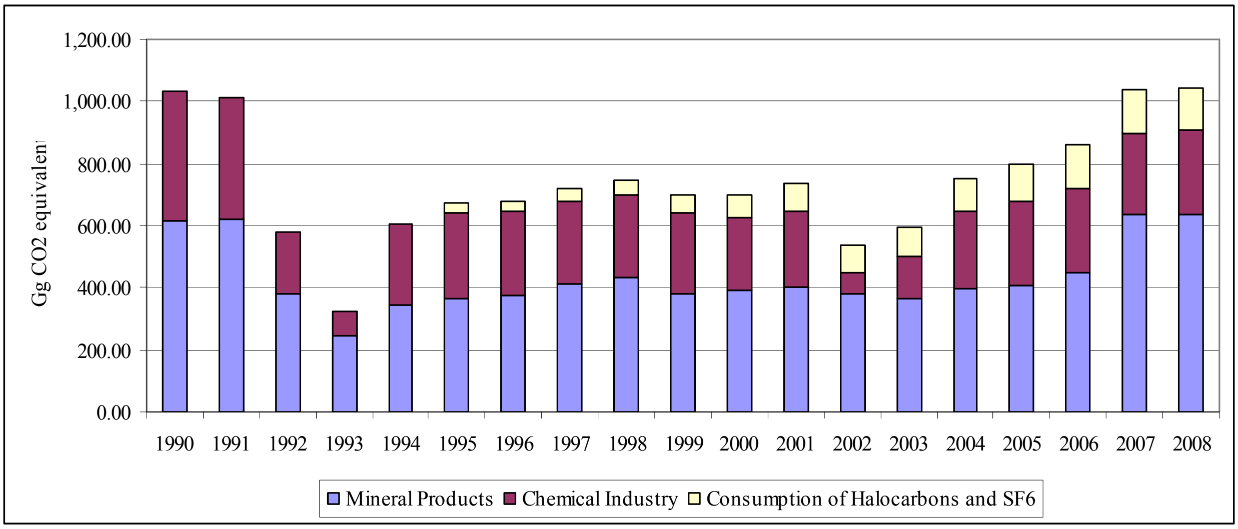

Figure 2.6. Trend in Emissions from Industrial Processes Sector 1990-2008

2.3.3. 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 to soils, N-Fixing Crops, Crop Residue, Cultivation of histosols. Indirect N_2O emissions include emissions from Atmospheric Deposition and Nitrogen Leaching and run-off. The share of emissions by category is presented in Figure 2.7.

In 2008 the Agriculture sector contributed 7.14 % of the total emissions, totalling 1,447.07 Gg CO_2 equivalent. Emissions from the Enteric Fermentation of livestock and Direct Emissions from Agricultural Soils contributed the main share of the total emissions from the

Agricultural sector. Emissions from Agricultural sector have declined 52.59 % compared to the base year, mostly due to the decreasing livestock population and the quantities of synthetic fertilizers and manure applied to agricultural fields. The overall progression of GHG in the Agriculture sector in CO_2 equivalent is presented in Figure 2.7.

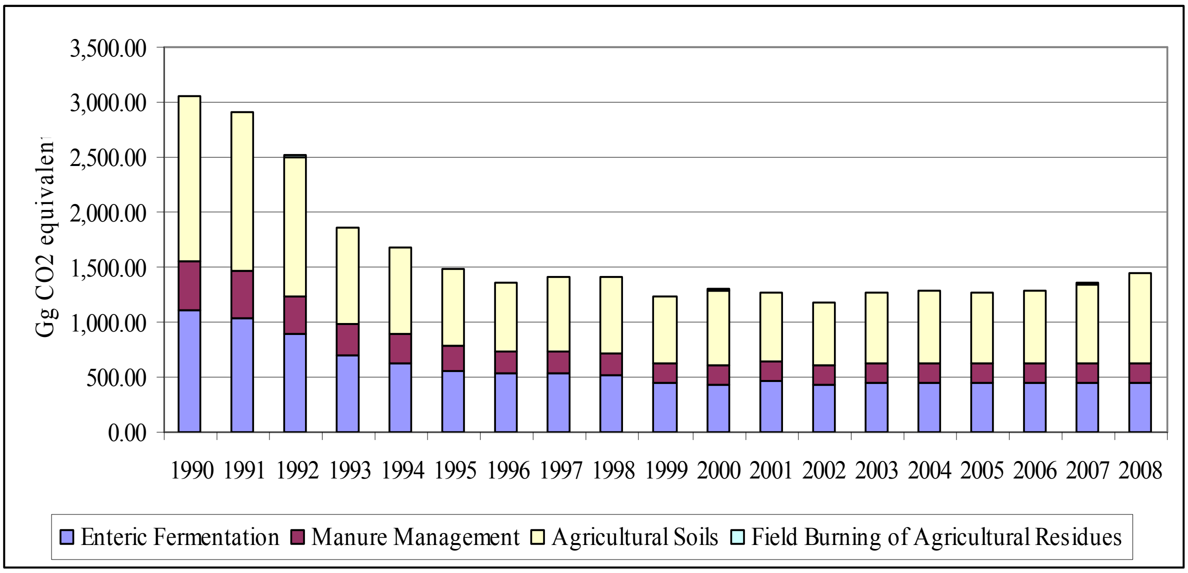

Figure 2.7. Trend in Emissions from Agriculture Sector 1990-2008

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

The LULUCF sector plays an important role in Estonian carbon cycle. Estonia ´s emissions from the LULUCF sector are divided into the following categories: Forest Land, Cropland, Grassland and Wetlands. The share of emissions by category is presented in Figure 2.8. In 2008 the LULUCF sector acted as a CO_2 sink, totalling 9,729.83 Gg CO_2 equivalent. The LULUCF sector in Estonia has been a net sink during the whole reporting period 1990-2008 as the removals in the sector exceed the emissions. The main sink of CO_2 in Estonia is Forest land. Reported net CO_2 removals in the LULUCF sector increased by 54.9 % between 1990 and 2008. The sharp decreases in 1999 and 2000 are explained by the sharp increase in the forest felling in these years. Land use has changed in recent decades.

Trend in Emissions from Land Use, Land- Use Change and Forestry Sector 1990 to 2008 is presented in Figure 2.8.

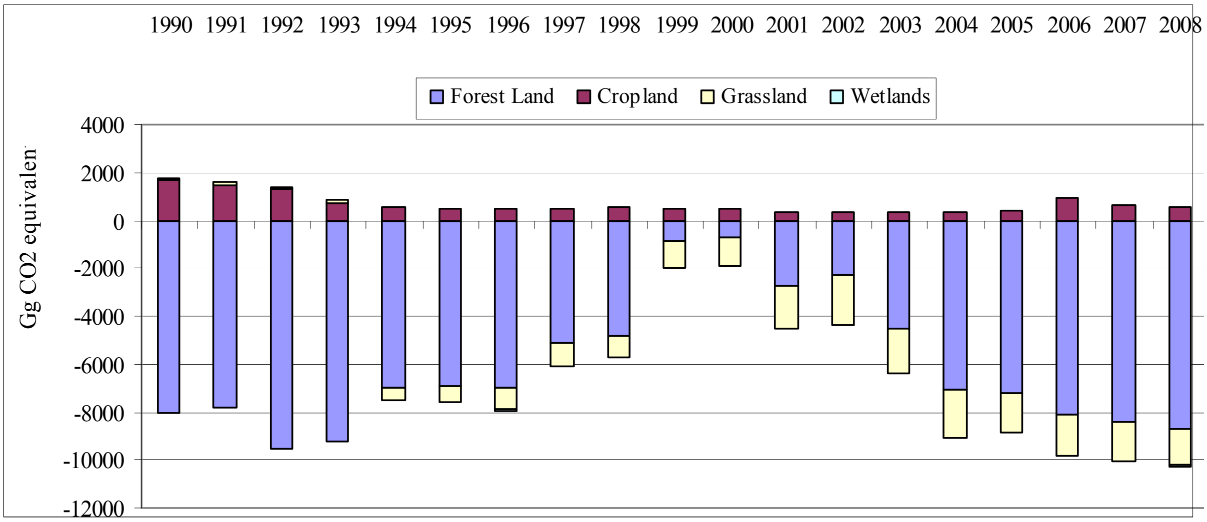

Figure 2.8. Trend in Emissions from Land Use, Land- Use Change and Forestry Sector 1990-2008

2.3.5. Trends in Waste (CRF 6)

Estonia´s emissions from Waste sector include emissions from Solid Waste Disposal on Land, Waste-water Handling, Waste Incineration and Other (Biological treatment). The share of emissions by category is presented in Figure 2.9.

In 2008 the Waste sector contributed 3.33 % of the total GHG emissions, totalling 674.82 Gg CO_2 equivalent. Solid Waste Disposal on Land contributed the most to the total emissions for the Waste sector in Estonia on 2008.

The total emissions in CO_2 equivalent from the Waste sector decreased by 0.76 % compared to the base year: the emissions from solid waste land filled decreased by 14,3 % and emissions from waste composting processes increased about 100 fold – from 1.26 Gg to 121 Gg in 2008.

There has been a sharp fluctuation in the quantities of GHG emissions from waste incineration in 2000, 2002, 2004, and 2008. The main reason for the augmentation is that, in 2000, 2002 and 2004 large amounts of inert and organic waste (incl. also textiles and wood) were burnt and in 2008 the sudden fallout took place, as no wastes were incinerated on land. The overall progression of GHGs in the Waste sector in CO_2 equivalent is presented in Figure 2.9.

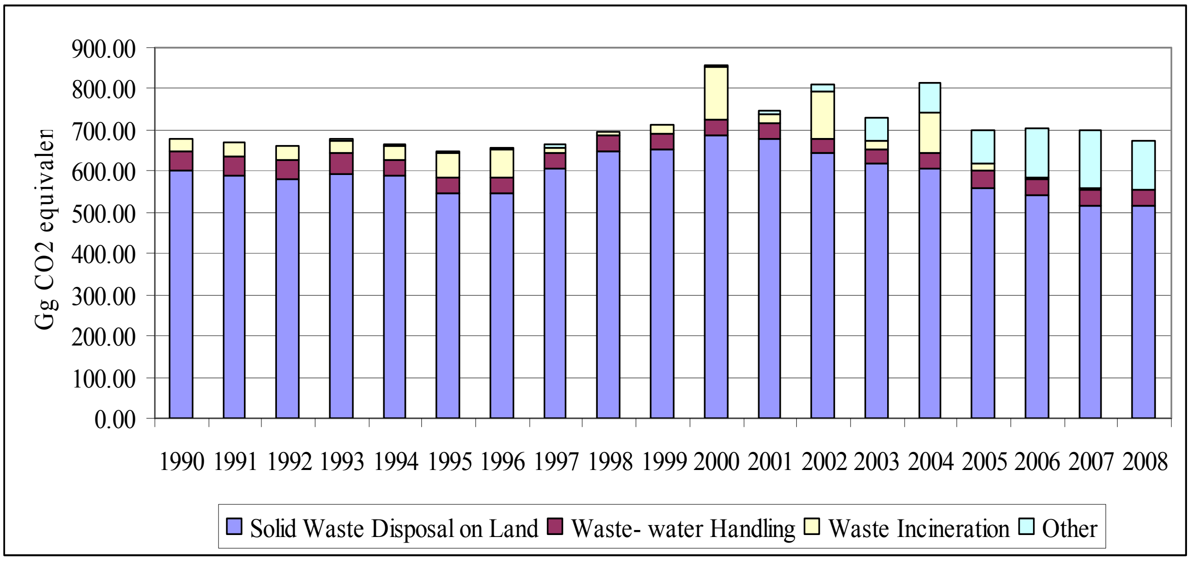

Figure 2.9. Trend in Emissions from Waste Sector 1990-2008

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 2008 are presented in Figure 2.10. Total NOx emissions decreased by 58.5 % from 79.95 Gg CO_2 equivalent in 1990 to 33.17 Gg CO_2 equivalent in 2008. Total CO emissions increased by 6.5 % from 62.66 Gg CO_2 equivalent in 1990 to 66.72 Gg CO_2 equivalent in 2008. Total NMVOC emissions decreased by 41.5 % from 44.00 Gg CO_2 equivalent in 1990 to 25.76 Gg CO_2 equivalent in 2008. Total SO_2 emissions decreased by 61.4 % from 167.09 Gg CO_2 equivalent in 1990 to 64.44 Gg CO_2 equivalent in 2008.

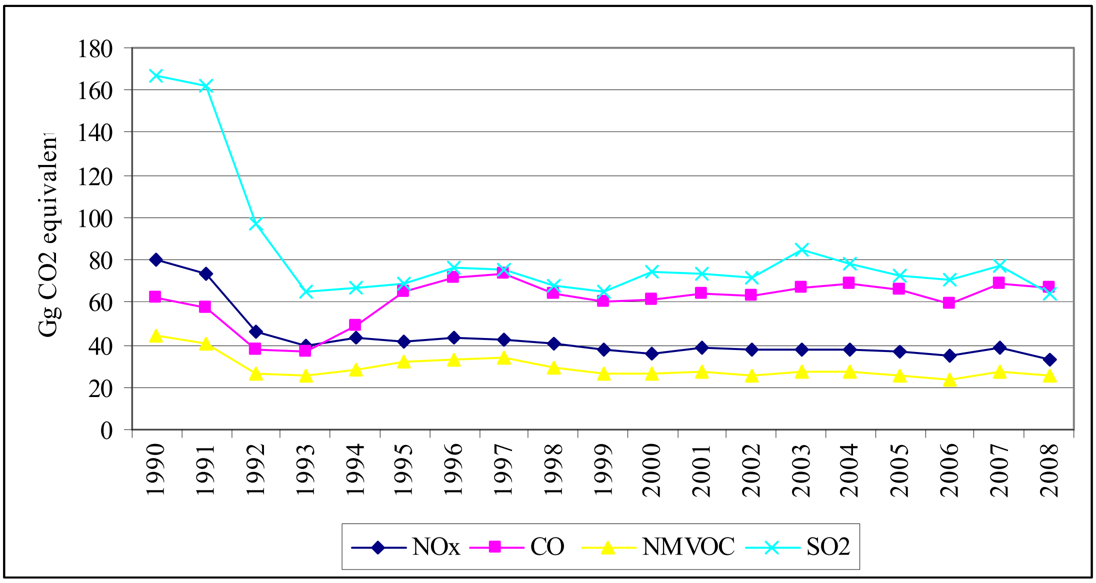

Figure 2.10. Emissions of NOx, CO, NMVOC and SO2 1990-2008 (Gg CO_2 equivalent)

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

Coverage of reporting of carbon pools and emission sources with regard to activities afforestation (A), reforestation (R) and deforestation (D) (under Article 3.3). The net emissions due to ARD activities are estimated to be 6,065.98 CO_2 Gg by 2008 in Estonia (Table 2.2)

Table. 2.1. Activity coverage and other information relating to activity under Article 3.3

Activity		Change in carbon pool reported					Greenhouse gas sources reported						
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning		
							N_2O	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O
Article 3.3 activities	AR	R	R	IE	NO	R	NO			NO	NO	NO	NO
	D	R	R	IE	IE	R			NO	NO	NO	NO	NO

Emissions and removals from KP-LULUCF activities are reported for the first time, thus trends are not yet available.

Table 2.2. Emissions and removals resulting from activities under Article 3.3 of Kyoto Protocol in 2008

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net CO_2 emissions/ removals	CH_4	N_2O	Net CO_2 equivalent emissions/removals
	(Gg)			
A. Article 3.3 activities				**6,065.98**
A.1. Afforestation and Reforestation	-533.52	NA	NA	-533.52
A.1.1. Units of land not harvested since the beginning of the commitment period	-533.52	NA	NA	-533.52
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	NA
A.2. Deforestation	6,599.51	NA	NA	6,599.51

3. ENERGY (CRF 1)

3.1. Overview of sector

Energy sector is the main source of greenhouse gas emissions in Estonia. In 2008, the energy sector contributed about 84.4% of total emissions, totalling 17.1 Tg CO_2 $_{eq}$ (Figure 3.1).

Energy-related CO_2 emissions vary much from year to year (Figure 3.4). The biggest decrease of emissions in 1993 compared to 1990 was caused by the transition from planned economy to market economy after Estonian reinstatement of independency in 1991. Compared with the base year 1990, the emissions in the energy sector in 2008 were about 53% lower (36.08 Tg CO_2 $_{eqv.}$ in 1990). The main contributors are the energy industry with approximately 56% decrease and transport with around 7.4% decrease in emissions relative to 1990. Emissions from manufacturing industries and construction have decreased 56.5%, other sectors 68%, other about 17% and fugitive emissions from fuels about 37.2% compared to 1990. The emissions from these source categories have only minor fluctuations during the recent years mainly following the economic trend, the structure of the energy supply and climatic conditions.

Most of the energy sector emissions – 97.1% originate from fuel combustion and only 2.9% 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 3.5).

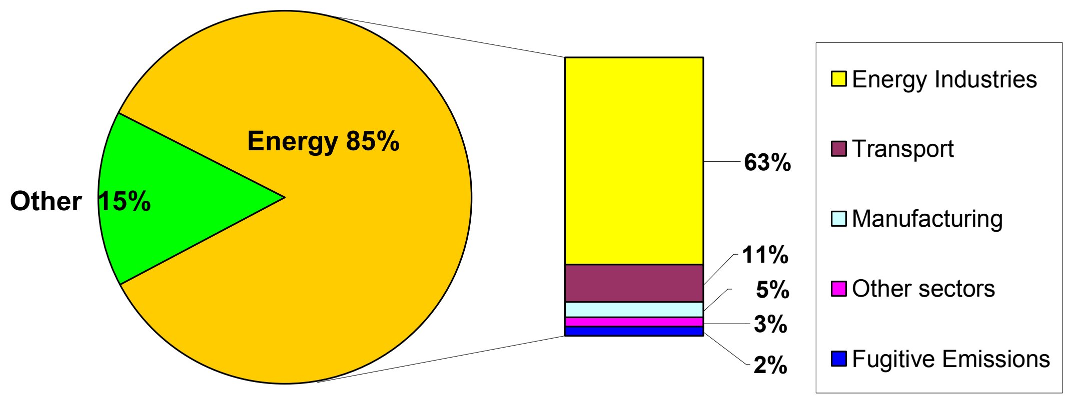

Figure 3.1 Emissions from the energy sector compared to the total emissions in 2008

The predominating part of primary energy utilized in Estonia is of domestic origin. Imported fuels (natural gas, fuel oils, coal, motor fuels and liquid gas) made up to 31% in the fuels utilized in 2008. The share of renewable energy in total consumption was about 11%, wood fuels formed the main part of it, the part of other sources remained on the level of 0.4%. From the energy of primary fuels (226 PJ) 44.2% was used for electricity production, 17.5% for heat production, 17% for the production of secondary fuels, about 2.2% as raw material in industry and 19% for immediate final consumption (the rest of the energy used for final consumption was converted energy)[1].

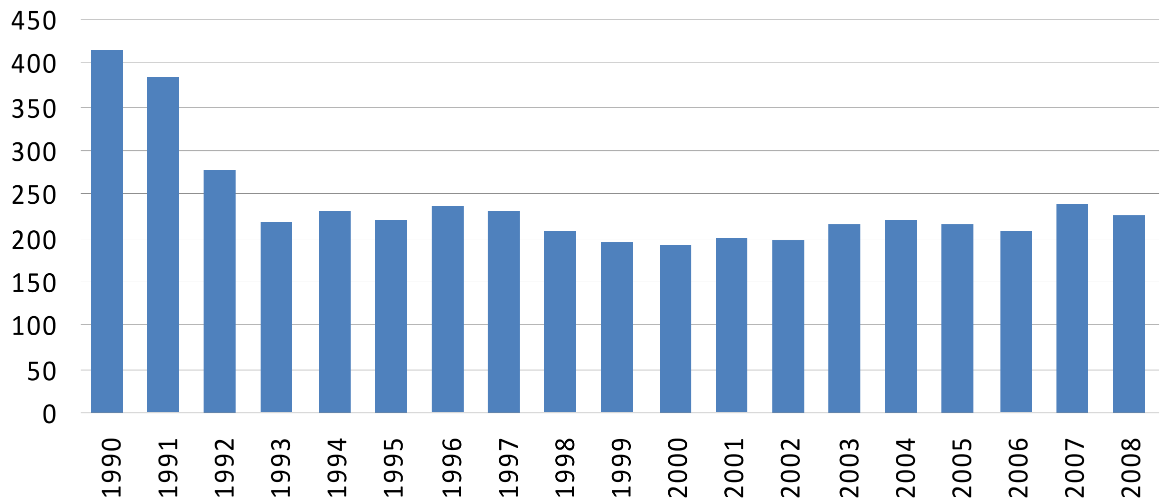

Figure 3.2 Development of Total Primary Energy Supply in Estonia in 1990 – 2008, TJ

The development of primary energy supply in Estonia is presented in the Figure 3.2. Estonia is situated among the first ten EU countries with the primary energy production per capita, exceeding the other Baltic States production about three times. In 2008 the primary energy production of Estonia decreased mainly due to the fall in oil shale production used as a fuel in electricity production. At the same time, the production of shale oil increased – since 2000, it has been increasing continuously. Compared to 2007, 2% more shale oil was produced. The structure of primary energy supply in 1990 and 2007 accordingly is presented in the Figure 3.3.

[1] Statistics Estonian. www.stat.ee

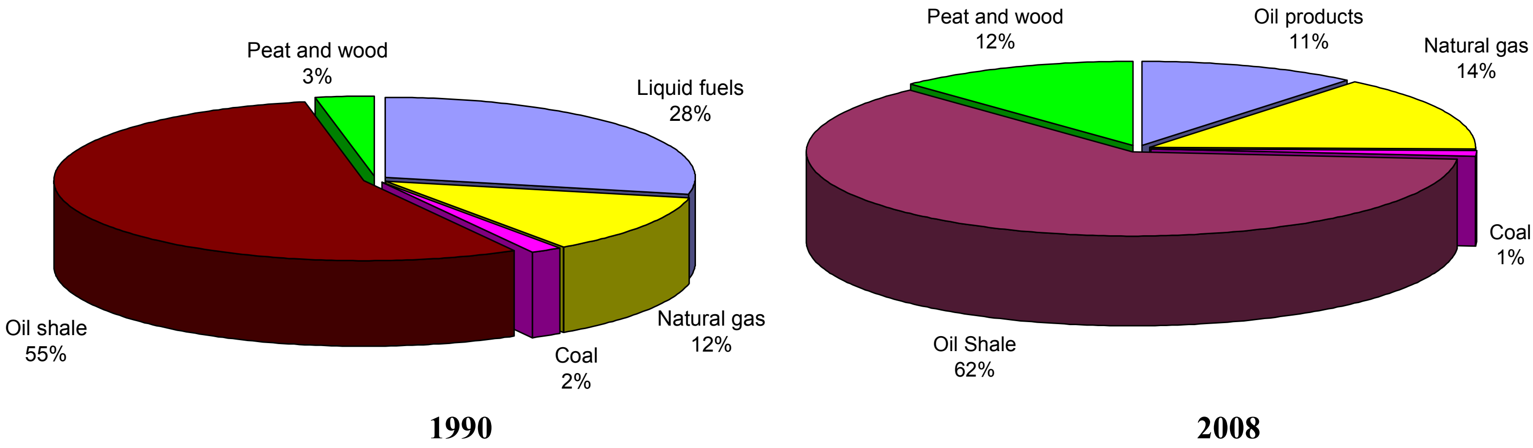

Figure 3.3 Structure of primary energy supply in Estonia in 1990 and 2008.

Analyzing the structure of primary energy supply in 2008 we can see that the share of oil shale has risen from 55% in 1990 up to about 62% in 2008. The shares of other local fuels – wood and peat – have significantly increased, accounting for 3% and 12%, respectively. From among imported fuels, the share of coal has continued to decline (to 1%). The share of oil products has fallen drastically, from 28% up to 11%. That of natural gas has slightly risen, from 12% to 14%.

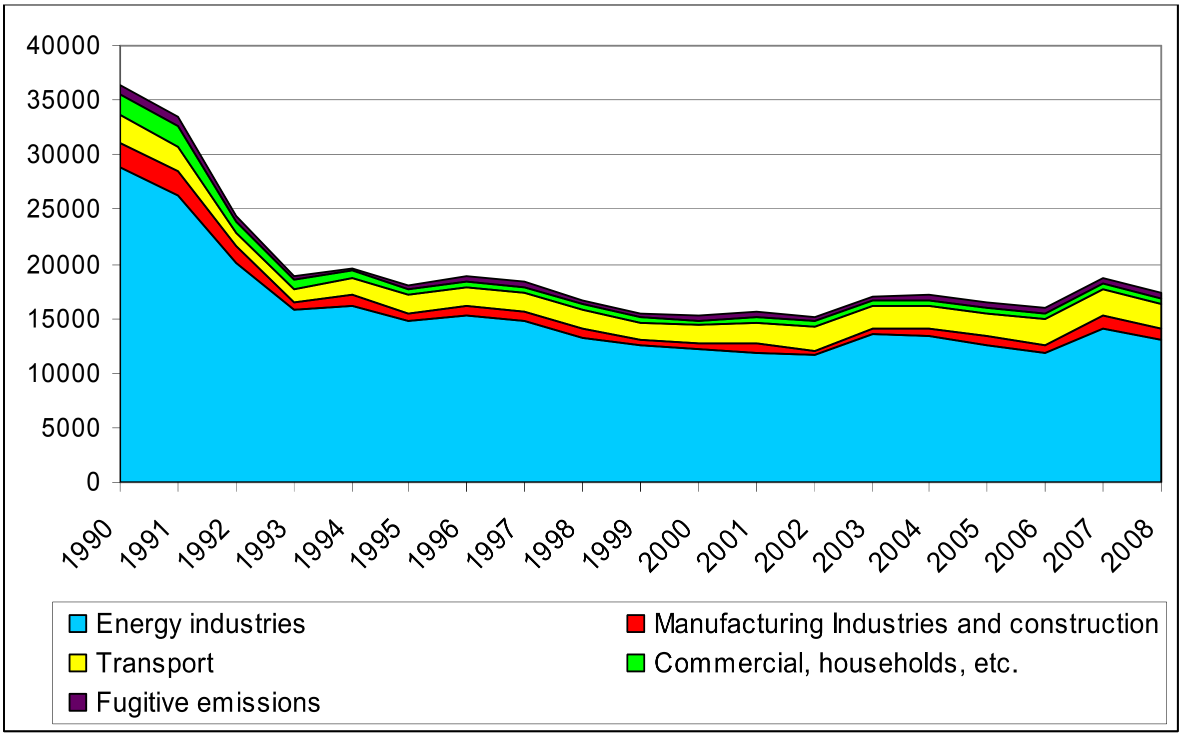

Figure 3.4. Emissions from the energy sector by subcategory in 1990-2008 (Gg $CO_{2\ eq}$.)

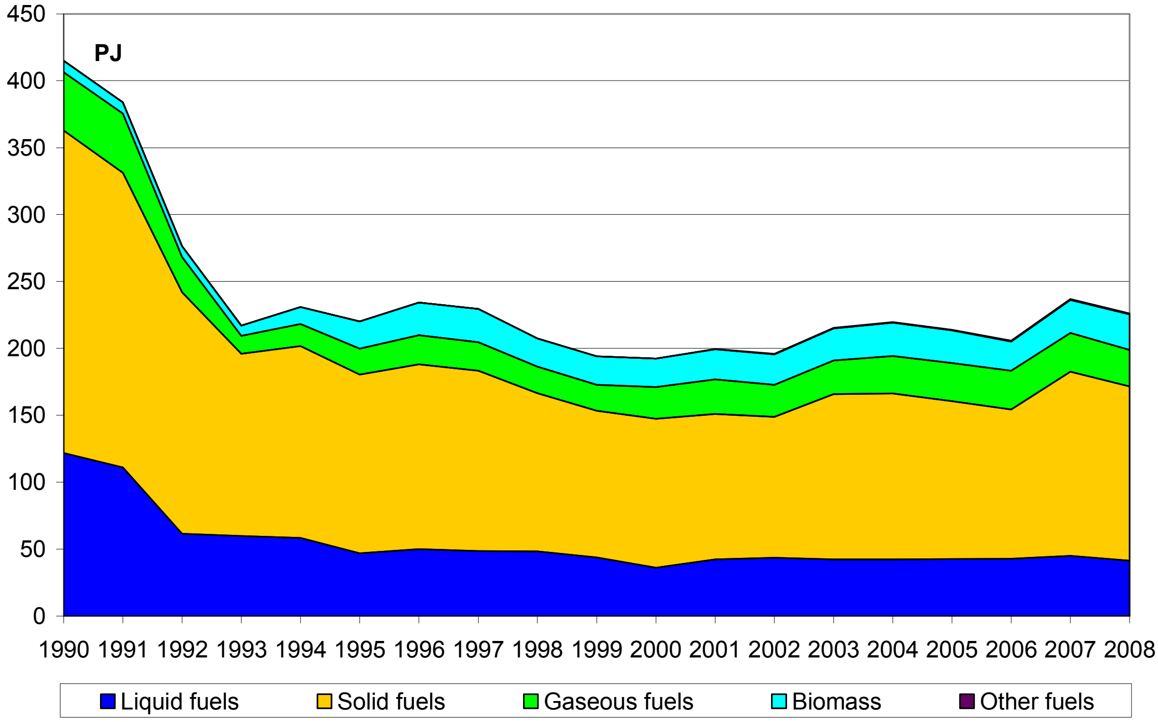

Figure 3.5. Consumption of fuels in 1990-2008, PJ

Table 3.1. Emissions from the energy sector in 1990–2008 by subcategory and gas (Tg, CO_2 eq)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
1. Energy	**36.08**	**33.14**	**24.28**	**18.86**	**19.74**	**18.08**	**18.87**	**18.38**	**16.73**	**15.50**	**15.33**	**15.76**	**15.32**	**17.23**	**17.28**	**16.64**	**16.06**	**18.97**	**17.09**
A. Fuel combustion	**35.28**	**32.35**	**23.82**	**18.64**	**19.41**	**17.70**	**18.45**	**17.98**	**16.35**	**15.13**	**14.91**	**15.30**	**14.93**	**16.81**	**16.78**	**16.13**	**15.53**	**18.45**	**16.59**
CO_2	35.10	32.18	23.71	18.55	19.33	17.60	18.34	17.86	16.24	15.03	14.82	15.20	14.82	16.70	16.66	16.01	15.42	18.33	16.48
CH_4	0.07	0.06	0.03	0.03	0.03	0.04	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
N_2O	0.11	0.11	0.07	0.06	0.06	0.06	0.07	0.07	0.06	0.05	0.05	0.06	0.07	0.07	0.07	0.08	0.08	0.08	0.08
B. Fugitive emissions, CH_4	**0.79**	**0.79**	**0.46**	**0.23**	**0.33**	**0.37**	**0.41**	**0.40**	**0.38**	**0.37**	**0.43**	**0.46**	**0.38**	**0.42**	**0.50**	**0.52**	**0.52**	**0.52**	**0.50**

The energy sector releases three greenhouse gases, carbon dioxide (CO_2) and small amounts of methane (CH_4) and nitrous oxide (N_2O). 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) (see Table 3.1).

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

Description

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)

Reported greenhouse gas 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
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	
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 (16.48 Tg) accounted for 96.4% of the energy sector's total emissions and 82% of total greenhouse gas emissions in 2008.

The portion of CH_4 emissions from fuel combustion in 2008 was about 3% and is mainly due to the incomplete combustion of wood fuels (small combustion). N_2O emissions from fuel combustion are relatively small - about 0.5%. N_2O emissions come mainly from energy industries and transport sectors (Table 3.3.).

The total primary energy supply decreased in 2008 by 8% compared with the previous year. In 2008, 70,4% of oil shale, 13.9% of natural gas, 6.9% of wood, 3.4% of oil shale gas; 1.9% of shale oil, 1.2% of peat and 2.3% of other fuels (gas/diesel oil, etc) was used in Estonia for electricity and heat production.

In 2008, the primary energy production decreased mainly due to the decrease of oil shale and electricity production. At the same time, electricity inland consumption increased from 7.18 TWh in 2007 to 7.43 % in 2008, but export has decreased by 8% compared to 2007. The production of shale oil also decreased — since 2000, it has been increasing continuously, but in 2008 compared to 2007, 3.5% less shale oil was produced. More than half of the production was exported — mainly to Netherlands, Finland, Denmark and Latvia.

Table 3.3. Emissions from fuel combustion in Estonia in 1990 - 2008 (Tg $CO_{2\ eqv}$)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
1.A Fuel combustion total	**35.28**	**32.35**	**23.82**	**18.64**	**19.41**	**17.70**	**18.45**	**17.98**	**16.35**	**15.13**	**14.91**	**15.30**	**14.93**	**16.81**	**16.78**	**16.13**	**15.53**	**18.45**	**16.59**
CO_2	35.10	32.18	23.71	18.55	19.33	17.60	18.34	17.86	16.24	15.03	14.82	15.20	14.82	16.70	16.66	16.01	15.42	18.33	16.48
1. Energy Industries	28.78	26.31	20.09	15.75	16.15	14.70	15.23	14.82	13.19	12.48	12.11	11.90	11.61	13.48	13.34	12.57	11.81	14.08	12.69
2. Manufacturing	2.26	2.15	1.54	0.69	1.00	0.79	0.89	0.81	0.79	0.47	0.57	0.71	0.47	0.52	0.65	0.70	0.70	1.16	0.98
3. Transport	2.45	2.23	1.15	1.27	1.59	1.55	1.62	1.72	1.78	1.66	1.65	1.96	2.08	1.99	2.04	2.12	2.32	2.44	2.28
4. Other Sectors	1.57	1.43	0.90	0.83	0.57	0.52	0.58	0.50	0.47	0.41	0.47	0.60	0.66	0.68	0.61	0.58	0.55	0.62	0.48
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	0.02	0.02	0.03	0.04	0.04	0.03	0.04
CH_4	0.07	0.06	0.03	0.03	0.03	0.04	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
N_2O	0.11	0.11	0.07	0.06	0.06	0.06	0.07	0.07	0.06	0.05	0.05	0.06	0.07	0.07	0.07	0.08	0.08	0.08	0.08

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 2008 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 1990 and 2008 Level Assessment (without LULUCF) (quantitative method used: Tier 2)

	IPCC Source Category	**Gas**	**Emissions 1990**	**Emissions 2008**
1.A.1	Energy Industries - Liquid Fuels	CO_2	4825.04	
1.A.1	Energy Industries - Solid Fuels	CO_2	21990.04	11253.54
1.A.3.B	Road Transport - Liquid Fuels	CO_2	2268	2139.53
1.A.2	Manufacturing Industries and Constructions - Solid Fuels	CO_2	1202.96	601.87
1.B.2	Oil and Natural Gas	CH_4	792.82	497.86
1.A.4.	Other Sectors - Liquid Fuels	CO_2		242.44
1.A.4.	Other Sectors - Gaseous Fuels	CO_2		193.2

Table 3.5 Key sources in the Energy sector in 2008, Trend Assessment (without LULUCF) (quantitative method used: Tier 2)

	IPCC Source Category	**Gas**	**Emissions 1990**	**Emissions 2008**
1.A.1	Energy Industries - Solid Fuels	CO_2	21990.04	11253.54
1.A.3.B	Road Transport - Liquid Fuels	CO2	2268	2139.53
1.B.2	Oil and Natural Gas	CH_4	792.82	497.86
1.A.1	Energy Industries - Liquid Fuels	CO_2	4825.04	355.29
1.A.4.	Other Sectors - Liquid Fuels	CO_2	1045.8	242.44
1.A.4.	Other Sectors - Gaseous Fuels	CO_2	137.89	193.2
1.A.2	Manufacturing Industries and Constructions - Liquid Fuels	CO_2	776.12	111.66
1.A.4.	Other Sectors - Solid Fuels	CO_2	389.65	46.92
1.A.2	Manufacturing Industries and Constructions -	CO2		41.95

	Other Fuels			
1.A.5	Other	CO2	43.61	36.14
1.A.4.	Other Sectors - Biomass	CH_4	6.23	17.19
1.A.1	Energy Industries - Biomass	N2O	3.03	12.07

Table 3.6 Key categories in Energy sector in 2008, Level Assessment (with LULUCF) (quantitative method used: Tier 2)

	IPCC Source Category	Gas	Emissions 1990	Emissions 2008
1.A.1	Energy Industries - Solid Fuels	CO_2	21990.04	11253.54
1.A.3.B	Road Transport - Liquid Fuels	CO_2	2268.00	
1.A.2	Manufacturing Industries and Constructions - Solid Fuels	CO_2	1202.96	
1.B.2	Oil and Natural Gas	CH_4		497.86
1.A.4.	Other Sectors - Liquid Fuels	CO_2		242.44
1.A.4.	Other Sectors - Gaseous Fuels	CO_2		193.2

Table 3.7 Key sources in Energy sector in 2008, Trend Assessment (without LULUCF) (quantitative method used: Tier 2)

	IPCC Source Category	Gas	Emissions 1990	Emissions 2008
1.A.1	Energy Industries - Solid Fuels	CO_2	21990.04	11253.54
1.A.4.	Other Sectors - Gaseous Fuels	CO2	137.89	193.2

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

3.2.1.1. 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). The emissions from energy industries by relevant subcategories and gases in 1990-2008 are presented in the Table 3.8. The Figure 3.6 presents the trend of GHG emissions from Energy Industries by relevant subcategories in 1990 to 2008.

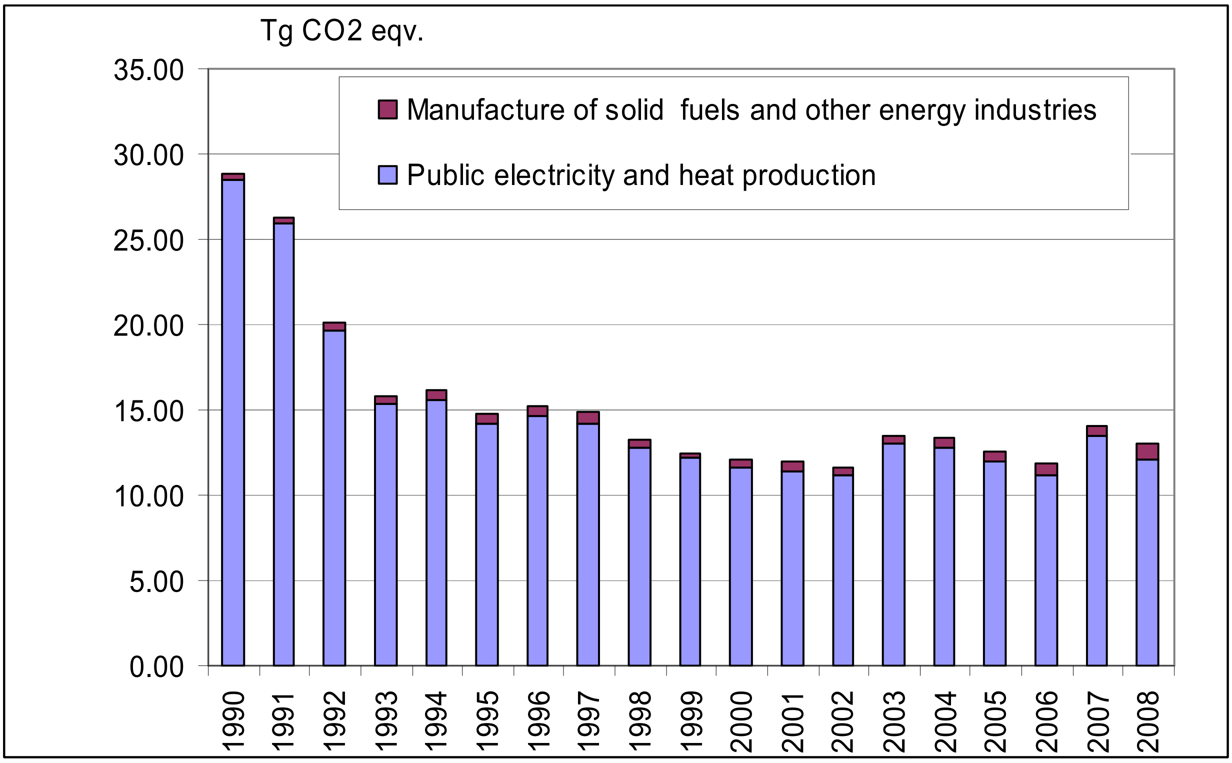

Figure 3.6. Trend of GHG emissions from Energy Industries by relevant subcategories in 1990-2008 (Tg $CO_{2\ eq}$)

In 2008, the production of electricity totalled 10,581 GWh – 13% less compared to 2007. The fall in electricity generation was caused by 16% smaller exports. Exports to Latvia decreased nearly two times compared to 2007. At the same time, the imports from Lithuania increased about four times.

Estonia has a long-time tradition for using hydro and wind power. Since 2005, electricity production from renewable energy sources has increased. In 2008 compared to 2007, the wind energy production increased 43% and hydro energy production nearly a third – both together still accounted for only 1.5% of the total electricity production. Estonia is on the average level among the EU states with the generation of electricity per capita (7.4 MWh per capita). In comparison with Baltic countries this indicator is the biggest. Due to natural hydro resources, Latvia and Lithuania have a significant advantage in the generation of hydro energy. In Latvia, hydro energy accounts for more than a half of electricity production.

Oil shale, natural gas, and shale oil serve as primary fuels for power plants. Compared to 2007, nearly a tenth less oil shale was used for electricity production. At the same time, the use of natural gas and shale oil did not change significantly. Power plants continued the application of combined heat and power (CHP) generation, which is cleaner in terms of the environment. Combined heat and power plants can be operated on the basis of different fuels, but at a stable thermal load. In 2008, there were 17 CHP-plants in Estonia which gave 9% of electricity and 30% of heat energy.

There were no great changes in heat production in 2003–2007, but in 2008 the production of heat decreased 9% due to warmer winter. Mainly natural gas, firewood and shale oil were used in heating plants. About half of generated heat is based using natural gas.

In 2008 compared to 2007, the imports of energy products have decreased about 10% – mainly due to the decrease in the imports of motor fuel. Imports of natural gas decreased about 6%.

The emissions from manufacturing industries and construction by relevant subcategories and gases in 1990–2008 are presented in Table 3.9.

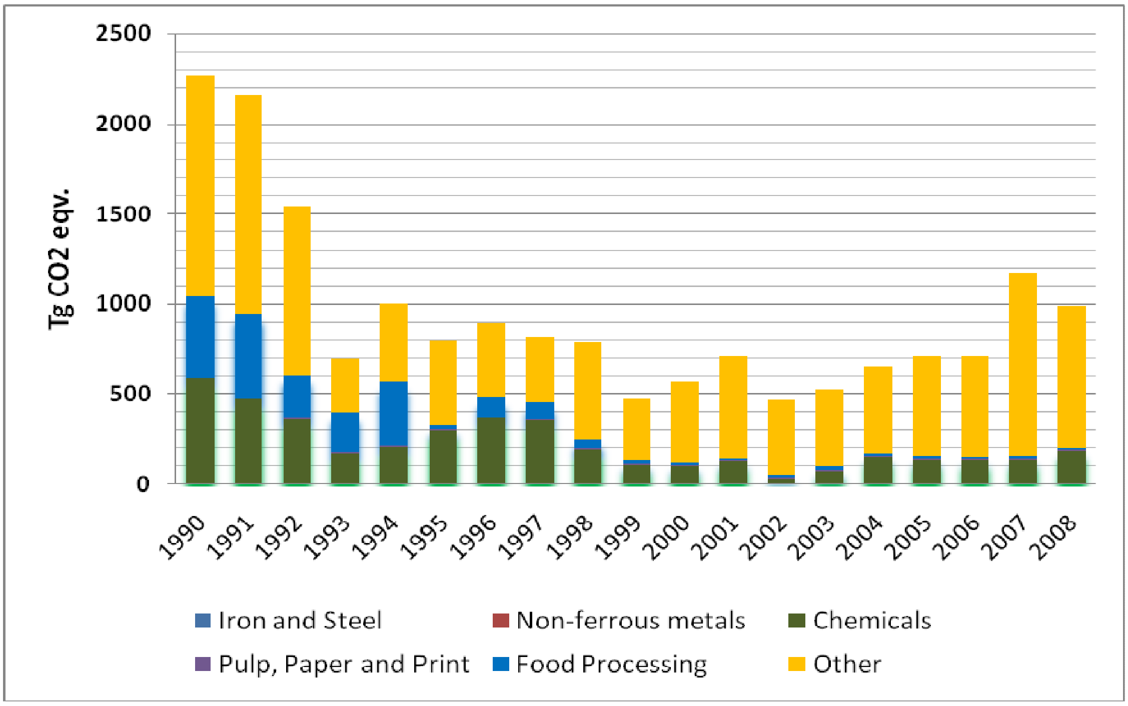

Figure 3.7 Trend of emissions GHG from manufacturing industries and construction by relevant subcategories in 1990-2008

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", Production of building materials, and "Other industry".

In 2008 production of industry decreased about 6.5% compared with 2007. At the same time in manufacturing industry, the production decreased 5% compared to 2007. During the first three quarters the decrease in manufacturing was mainly affected by price increase and insufficient demand in domestic market resulting from it. In the last quarter the decrease of demand in the external market resulting from world business depression had become obvious. The decrease in the production of manufacturing was mainly influenced by the production of branches holding the largest share, such as food, wood and building materials. The largest fall — 28% — was in the production of building materials, which is directly connected with the decline in the domestic construction market. The difficulties in the sales both in domestic and external markets affected continually wood manufacturing — the production of wood fell 19%. The decrease in the production of food was mainly influenced by the decrease in the production of beverages, primarily caused by a higher excise tax which increased in July, and by the price increase of raw materials in the world market. The production of food decreased 8%.

In 2008 compared to 2007, the production increased in the manufacture of metal products, chemical products, electrical machinery, radio- and communication equipment mainly due to the increase of export orders at the beginning of the year. The decrease of export orders at the end of the year turned to decline the branches of industry growing heretofore.

In December compared to the previous year, the production decreased in all branches of manufacturing. In December 2008 compared to November, the seasonally adjusted industrial production decreased 2%.

Table 3.8. The emissions from Energy Industries by relevant subcategories and gases in 1990-2008 (Tg, CO_2 eq.)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO_2 eq. 1. Energy industries	**28.80**	**26.33**	**20.11**	**15.76**	**16.17**	**14.72**	**15.27**	**14.84**	**13.21**	**12.50**	**12.13**	**11.92**	**11.63**	**13.50**	**13.37**	**12.61**	**11.84**	**14.11**	**12.72**
CO_2 a. Public Electricity and Heat Production	28.41	25.91	19.61	15.28	15.61	14.15	14.63	14.21	12.77	12.15	11.63	11.43	11.13	13.03	12.75	11.93	11.16	13.50	12.11
CO_2 c. Shale Oil Production	0.37	0.39	0.48	0.47	0.55	0.55	0.60	0.61	0.41	0.33	0.48	0.47	0.48	0.45	0.59	0.65	0.66	0.58	0.58
CH_4 1. Energy Industries (CO_2 eqv.)	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N_2O 1. Energy Industries (CO_2 eqv.)	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Table 3.9. The emissions from Manufacturing Industries and Construction by relevant subcategories and gases in 1990-2008 (Tg, CO_2 eq.)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO_2 eq.																			
2. Manufacturing Industries	**2.26**	**2.16**	**1.54**	**0.70**	**1.00**	**0.79**	**0.89**	**0.81**	**0.79**	**0.47**	**0.57**	**0.71**	**0.47**	**0.53**	**0.65**	**0.71**	**0.71**	**1.17**	**0.98**
a. Iron and Steel	0.003	0.000	0.000	0.000	0.004	0.003	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
b. Non-Ferrous Metals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.002	0.001	0.001	0.006	0.004
c: Chemicals	0.58	0.47	0.36	0.18	0.21	0.30	0.37	0.36	0.20	0.11	0.10	0.12	0.03	0.07	0.15	0.13	0.13	0.13	0.18
d. Pulp, Paper and Print	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.003	0.004	0.005	0.005	0.006
e. Food Processing, Beverages, etc	0.46	0.48	0.24	0.22	0.35	0.02	0.11	0.09	0.05	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01
f. Other	1.22	1.21	0.93	0.30	0.44	0.47	0.42	0.36	0.54	0.35	0.45	0.57	0.42	0.43	0.48	0.55	0.55	1.01	0.78
CH_4 2.Manufacturing Industries	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000
N_2O 2 Manufacturing Industries	0.004	0.004	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.002	0.003	0.003

3.2.1.2. Methodological issues

Methods

Emissions from fuel combustion are in general calculated by using the methodology of the IPCC 2006 Guidelines. Different tiers have been applied for different fuels and gases.

For some imported fuels Tier 1 approach has been applied. For domestic fuels – Oil Shale, Peat and fuels made from Oil Shale (Shale Oil, Oil Shale Semi-coke and Oil Shale Gas) Tier2 approach was used. Since 2004, when a new fluidised combustion technology for oil shale combustion was implemented - Tier 3 (a technology specific) method for CO_2 emission calculation was 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 (tC/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 $_{GHG,\ fuel}$	= <u>default</u> emission factor of a given GHG by type of fuel (tC/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 $_{fuel}$	= <u>country specific</u> emission factor of CO_2 by type of fuel (tC/TJ)
Oxidation Factor $_{fuel}$	= fuel specific oxidation factor

GREENHOUSE GAS EMISSIONS FROM STATIONARY COMBUSTION

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

Where:

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

Fuel consumption $_{fuel}$ = amount of fuel combusted (TJ)

Emission Factor $_{GHG,\ fuel}$ = country specific emission factor of a given GHG by type of fuel (tC/TJ).

Tier 3 for CO_2 emissions:

CO_2 EMISSIONS FROM STATIONARY COMBUSTION

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

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 (tC/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 (tC/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 new 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:

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

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:

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

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).

$$CEF_{oil\,shale\,CFB} = 10 \cdot (20.7 + 0.4 \cdot 17.7 \cdot 12/44)/8.4 = 26.94 \ tC/TJ$$

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 Ltd.* in Kohtla-Järve) and in ***Narva Power Plants 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. In Kohtla-Järve and Kiviõli vertical retorts and in the Narva PP 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. <u>Thermal processing of oil shale in vertical retorts takes place without any contact with the ambient atmosphere; therefore no pollutants are emitted.</u>

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^{o}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 <u>but partly emitted into atmosphere</u>. Dust is delivered to ash fields but partly back to the reactor.

Therefore, in 2008, 37.02 PJ of shale oil was consumed for shale oil production in total but only processing of 10.61 PJ of oil shale caused CO_2 emissions (see Table 3.10.).

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

Year	Oil shale for shale oil production	SHC Plant (Narva)	in vertical reactors (VKG)
1990	18.67	6.72	11.95
1991	19.89	7.16	12.73
1992	24.41	8.79	15.62
1993	23.85	8.59	15.26
1994	27.69	9.97	17.72
1995	27.70	9.97	17.73
1996	30.29	10.90	19.38
1997	30.85	11.11	19.74
1998	20.88	7.52	13.36
1999	16.44	5.92	10.52
2000	24.26	8.73	15.52
2001	25.67	8.58	17.10
2002	26.09	8.71	17.37
2003	29.03	8.27	20.75
2004	29.83	10.74	19.09
2005	31.73	11.74	19.99
2006	33.19	11.95	21.24
2007	33.24	10.50	22.73
2008	37.02	10.61	26.41

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 the calorific values and CO_2 emission factors of different oil shale gases are presented.

Table 3.11 Calorific values and CO_2 emission factors of different oil shale gases

Plant/technology	Calorific value, MJ/nm^3	Carbon Emission Factor, tC/TJ
Shale Oil Plant of Narva Power Plants		
Semi-coke gas (SHC -140[2] technology)	47.55	16.57

[2] SHC 140: solid heat carrier technology with oil yield 140 tons per hour

Viru Keemia Grupp AS (VKG), Kohtla-Järve		
Generator gas (vertical retort technology)	3.52	34.47

CO_2 emissions from the combustion of both oil shale gases are calculated separately and included into source-category CRF 1.A.1.a Public Electricity and Heat Production.

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 3.12 below. In order to improve the accuracy of the inventory, approximately some of the CO_2 factors were checked and updated for the current inventory.

Table 3.12 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)	45.53	GJ/t	17.2	63.1	0.99	D, IPCC 2006
Gasoline	43.99	GJ/t	19.91	73	0.99	CS, LT (Lithuania)
Jet Kerosene	43.0	GJ/t	19.5	71.5	0.99	D, IPCC 2006
Aviation Gasoline	43.0	GJ/t	19.5	71.5	0.99	D, IPCC 2006
Gasoil (light fuel oil)	42.26	GJ/t	20.2	74.1	0.99	CS, LT (Lithuania)
Gasoil (for non-road use)	42.26	GJ/t	20.2	74.1	0.99	CS, LT (Lithuania)
Shale Oil	39.22	GJ/t	21.1	77.4	0.99	CS, MoE 2006
Diesel Oil	42.26	GJ/t	20.2	74.1	0.99	CS, LT (Lithuania)
Residual Fuel Oil (heavy fuel oil)	40.15	GJ/t	21.1	77.4	0.99	D, IPCC 2006
Recycled Waste Oil		GJ/t	20.2	74	1	PS, Kunda Nordic Cement
Solid fuels						
Coal	27.2	GJ/t	26.8	98.3	0.98	D, IPCC 2006
Coke Oven Coke	29.3	GJ/t	29.18	107.0	0.98	D, IPCC 2006
Oil Shale $_{PC}$ *	8.87	GJ/t	27.85	102.1	0.98	CS, MoE 2006
Oil Shale $_{FBC}$ **	8.87	GJ/t	26.94	98.8	0.98	CS, MoE 2006
Milled Peat	8.7 – 12.0	GJ/t	28.9	106.0	0.98	CS, FI (Finland)
Sod Peat	8.7 – 12.0	GJ/t	27.82	102.0	0.98	CS, FI (Finland)
Peat Briquette	16.0	GJ/t	26.45	97.0	0.98	CS, FI (Finland)
Oil Shale Semi-coke	8.78	GJ/1000 m^3	15.45	56.7	0.995	CS, Martins, A., 2007
Oil Shale Generator Gas	3.52	GJ/1000 m^3		126.4	0.995	CS, Martins, A., 2007
Other Fossil based Waste (MSW)		GJ/t	21.8	80.0	1	PS, Kunda Nordic Cement
Plastic Waste		GJ/t	20.5	75	1	PS, Kunda Nordic Cement

Fuels	NCV average	Unit	CEF tC/TJ	CO_2 EF CO_2/TJ	Oxidation factor	Source
Gaseous fuels						
Natural Gas	33.6	GJ/1000 m^3	15.3		0.995	CS, FI (Finland)
Biomass fuels						
Solid Biomass (solid, includes e.g. firewood, bark, chips, sawdust and other industrial wood residues, pellets and briquettes)	6.13 – 16.92	GJ/m^3s	29.9		0.98	D, IPCC 2006
Black Liquors	10	GJ/t	29.9	109.6	0.98	D, IPCC1996
Biogas (landfill gas and biogas from wastewater treatment)	19.73	GJ/1000 m^3	14.89	56.1	0.995	D, IPCC2006

* Oil Shale PC - pulverised combustion of oil shale
** Oil Shale FBC - fluidised bed combustion of oil shale
*** D - IPCC default value; CS - country specific

Sources:
EE: expert estimation
Martins, A., 2007: Research of Ants Martins, Tallinn University of Technology (not published).
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).

The source of calorific values of different fuels is the Statistics Estonian (SE).

In the 2010 inventory submission Oil Shale Generator Gas and Oil Shale Semi-coke Gas are reported under solid not under gaseous fuels as in previous submissions, because these gases are made from solid fuel - Oil Shale.

Non-CO_2 Emission factors

CH_4 and N_2O emission factors for CRF 1.A.1 Energy Industries and CRF 1.A.2 Manufacturing Industries and Construction source categories are presented in the Table 3.13.

Table 3.13 CH_4 and N_2O emission factors by fuel, kg/TJ

Fuels	Energy Industry		Manufacturing Industry		Source
	CH4	N2O	CH4	N2O	
Liquid fuels					
LPG (Liquefied petrol Gas)	1	0. 1	1	0. 1	D, IPCC 2006
Gasoline	3	0. 6	2	0. 6	D, IPCC 2006
Jet Kerosene	3	0. 6	2	0. 6	D, IPCC 2006
Aviation Gasoline	3	0.6	2	0.6	D, IPCC 2006

Fuels	**Energy Industry**		**Manufacturing Industry**		**Source**
	CH4	**N2O**	**CH4**	**N2O**	
Gasoil (light fuel oil)	3	0.6	2	0.6	D, IPCC 2006
Gasoil (for non-road use)	3	0.6	2	0.6	D, IPCC 2006)
Shale Oil	3	0.6	2	0.6	CS, MoE 2006
Diesel Oil	3	0.6	2	0.6	D, IPCC 2006
Residual Fuel Oil (heavy fuel oil)	3	0.6	2	0.6	D, IPCC 2006
Recycled Waste Oil	3	0.6	2	0.6	D, IPCC 2006
Solid fuels					
Coal	1	1.5	1	1.5	D, IPCC 2006
Coke Oven Coke	1	1.5	1	1.5	D, IPCC 2006
Oil Shale $_{PC}$ *	0	0	1	1.5	CS, XXX/ D, IPCC 2006
Oil Shale $_{FBC}$ **	0	0.82	1	1.5	CS, XXX/ D, IPCC 2006
Milled Peat	30	4	30	4	D, IPCC 1996
Sod Peat	30	4	30	4	D, IPCC 1996
Peat Briquette	30	4	30	4	D, IPCC 1996
Oil Shale Semi-coke	1	0,1	1	0,1	D, IPCC 2006
Oil Shale Generator Gas	1	0.1	1	0.1	D, IPCC 2006
Other Fossil based Waste (MSW)	3	0.6	2	0.6	D, IPCC 2006
Plastic Waste	3	0.6	2	0.6	D, IPCC 2006
Gaseous fuels					
Natural Gas	0.1	0.1	0.1	0.1	CS, FI (Finland)
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, IPCC2006
Black Liquors	30	4	30	4	D, IPCC2006
Biogas (landfill gas and biogas from wastewater treatment)	1	0.1	1	0.1	D, IPCC2006

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 1996 IPCC Guidelines, but some emission factors and new data from national research were used as well. (See Table 3.14., Table 3.15. and Table 3.16.).

Table 3.14 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	
1. Manufacturing and Construction	300	150	200	100	110	300

Table 3.15 CO from fuel combustion (kg/TJ)

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

Table 3.16 NMVOC from fuel combustion (kg/TJ)

	Coal	*Natural Gas*	*Oil*	*Wood*	*Oil Shale**	*Peat/ Briquette*
Energy Industries	5	5	5	50		100
					60	
					50	
3. 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 the Statistics Estonia. Those data are also presented in the Database of the Statistics Estonian www.stat.ee and added to the *Estonian National Inventory Report 1990-2008* (see Annex 8). Some detailed data (i.e. technology specific oil shale and semi-coke gas consumption in Narva power plants and shale oil production by the Narva Shale Oil Plant) are obtained from the energy company Eesti Energia AS.

Fuel consumption in Energy Industries (CRF 1.A 1) and Manufacturing Industries and Construction (CRF 1.A 2) in 1990 - 2008 are presented in the Table 3.17 and on Figure 3.8 and Figure 3.9.

In the 2010 submission first time emissions from waste fuels: waste oils, plastics and other non-biomass Municipal Solis Waste (MSW) are calculated. Activity data are received from the Kunda cement factory, as these waste fuels are incinerated in the cement kilns of the factory.

In the current inventory submission biomass fuels include also data on gaseous biomass (landfill gas and waste water treatment (WWT) gas) and solid biomass includes data on black liquid used. The share of gaseous biomass is very small, only 0.8% of the biomass used by sectors 1.A.1 and 1.A.2 in 2008 (see Table 3.17).

As a new source (category 1.A.2.f/other fuels) activity data of waste fuels used are also first time taken into account in the 2010 submission. Waste fuels consist from fossil based fuels and biomass waste biomass based fuels (wood, paper, carton, etc). Fossil based waste fuels are: waste oils (including oil shale fusses), plastics and not biomass municipal solid waste. Today, there is only one factory in Estonia - Kunda Cement factory, where waste fuels can incinerate. In the future Estonia will build a special power plant for waste fuel incineration (see Table 3.17).

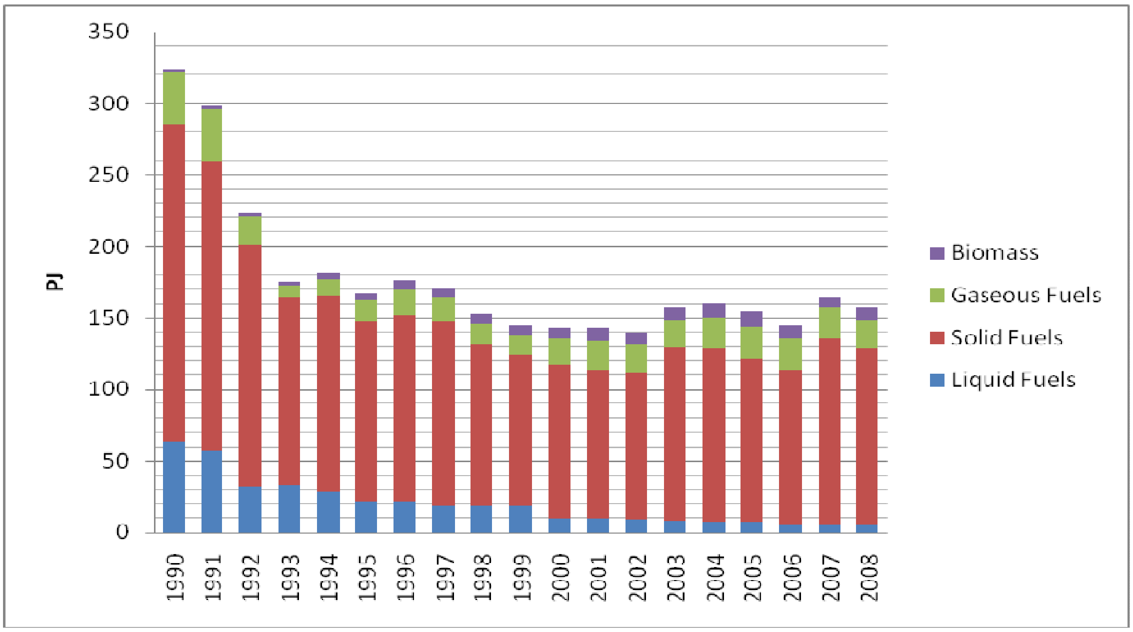

Figure 3.8 Trend of fuel consumption in Energy Industries, PJ

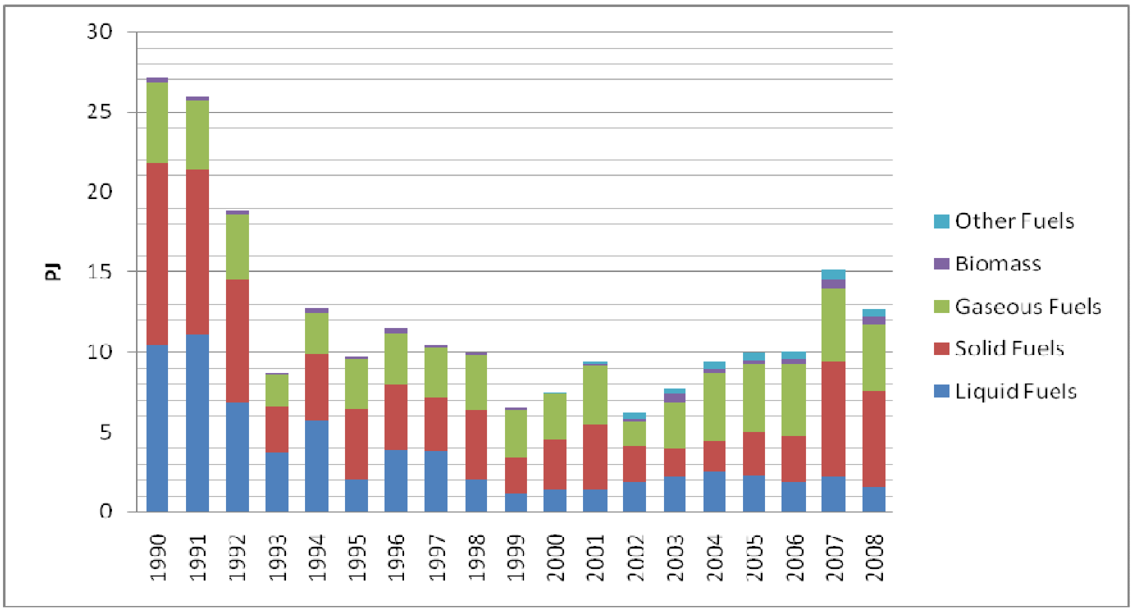

Figure 3.9. Trend of fuel consumption in Manufacturing Industries and Construction, PJ

Table 3.17 Fuel consumption in Energy Industries (CRF 1.A 1) and Manufacturing Industries and Construction (CRF 1.A 2) in 1990 - 2008 (PJ).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
Solid Fuels	222.33	202.52	168.80	130.64	137.72	126.55	130.92	129.13	112.33	105.65	106.93	103.99	102.19	120.98	120.89	114.24	107.77	130.04	117.90
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	19.66	19.47	21.65	21.91	21.99	21.24	19.77
Biomass																			
Solid	2.44	2.58	2.48	2.26	3.97	4.90	6.21	6.09	6.50	7.02	7.09	8.43	8.79	8.82	9.82	11.29	8.92	7.97	9.73
Gaseous	0	0	0	0	0.02	0.085	0.056	0.058	0.07	0.107	0.076	0.082	0.112	0.113	0.084	0.15	0.15357	0.176	0.082
1.A.2 Manufacturing Industries and Construction																			
Liquid Fuels	10.46	11.07	6.81	3.64	5.73	2.00	3.91	3.79	2.00	1.13	1.31	1.43	1.84	2.22	2.45	2.23	1.80	2.21	1.54
Solid Fuels	11.27	10.33	7.67	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
Gaseous Fuels	5.10	4.31	4.09	2.08	2.55	3.06	3.22	3.05	3.48	2.95	2.86	3.72	1.56	2.86	4.27	4.19	4.47	4.52	4.13
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	0.19	0.28	0.32	0.56	0.40
Other Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.01	0.13	0.35	0.39	0.47	0.51	0.55	0.61	0.56

3.2.1.3. Uncertainties and time series consistency

Uncertainty evaluation of CO_2 emission has been conducted for four fuel types used in Estonia in 2008: 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 (AS Metrosert, 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 2008 by using available estimates and the combination of available measured data;

Data has been obtained from database of Statistics of Estonia.[3]

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

[3] 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

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

Comparably large value of emission factor for type 'Other fuels' was used due to lack of more explicitly data. On the other hand. the contribution to total uncertainty of fuel combustion from this type is rather small, i.e. 0.8 %.

The relative uncertainty of CO_2 emission due to fuel combustion was 8.2% (see Table 3.18.). The largest uncertainty contribution of 30 % was caused by incomplete data of emission factor of other fuels. The uncertainty of CO_2 emission from the combustion of solid, liquid and gaseous fuels were: 10.8%, 2.5% and 3.9%, respectively.

Table 3.18. Estimated relative uncertainties of CO_2 emission due to fuel combustion in Estonia in 2008.

	Gas	Uncertainty of activity data, %	Uncertainty of emission factor, %	Combined relative uncertainty, %
1.A. Fuel Combustion		**2.5**	**7.8**	**8.2**
Liquid Fuels	CO_2	1.7	1.8	2.5
Solid Fuels	CO_2	3.3	10.3	10.8
Gaseous Fuels	CO_2	1.4	3.6	3.9
Other Fuels	CO_2	5	30	30.4

In estimation of uncertainties in greenhouse gases CH_4 and N_2O the IPCC[4] default values for activity data and emission factors: 5% and 25-75% were used, respectively (see Table 3.19).

Table 3.19. 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				

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

	CH_4	5%	50%	IPCC Good .... p. 2.41
	N_2O	3%	75%	IPCC Good .... p. 2.41
1.A.2. Manufacturing Industries and Constructions				
	CH_4	5%	50%	2006 IPCC. p. 2.41
	N_2O	3%	75%	2006 IPCC. p. 2.41
1.A.3. Transport				
	CH_4	5%	40%	IPCC Good .... p. 2.49
	N_2O	5%	50%	IPCC Good .... p. 2.49 „
1.A.4. Other Sectors				
	CH_4	5%	50%	IPCC Good .... Table 2.6. p. 2.41
	N_2O	5%	50%	IPCC Good .... Table 2.6. p. 2.41
1.B. FUGITIVE EMISSIONS from FUELS				
1.B.2.a Oil	CH_4	5%	25%	IPCC Good .... p. 2.92
1.B.2.b. Natural Gas	CH_4	5%	25%	IPCC Good .... p. 2.92
1.B.2.c. Venting	CH_4	5%	25%	IPCC Good .... p. 2.92

3.2.1.4. 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 the Statistic Estonia.

Fuel consumption data in natural units (in tons or thousand cubic meters, etc) and year average calorific value data of fuels are received from the Statistics Estonia 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 web site of the Statistics Estonia (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 yea 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 there are not very big. IEA uses 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 all heat produced by DH power plants and autoproducers is reported in Energy conversion sector. In national energy balance the part of heat produced by autoproducers and used by themselves (own consumption) is reported in the final consumption of fuels of the sector.

There is one more obstacle we can’t use IEA data – different deadlines. IEA data are available a year later of the NIR submission year.

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 2010 inventory submission some CO_2, CH_4 and N_2O emission factors of different fuels have been changed (see also chapters 3.2.1.5, 3.2.2.3; and 3.2.3.3).

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

3.2.1.5. Source-specific recalculations

1. Corrected activity data: Statistical Office of Estonia has a practice to correct statistical data of previous years. In current GHG submission practically all activity data (1990-2007) are over checked and updated if necessarily.

2. In the current GHG inventory submission CO_2 emissions from shale oil production are reported under CRF source category 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries. Shale oil is a liquid fuel made from solid fuel oil shale. In the previous submission emissions from shale production were incorrectly reported under 1.A.1.b.

3. In the current GHG inventory submission CO_2 emission factor of natural gas was updated. In the 2009 submission IPCC default value was used (15.3 tC/TJ). In the 2010 submission the Finnish CS CO_2 EF for natural gas (15.01 tC/TJ) was used, because Estonia, like Finland imports natural gas only from Russia (a recommendation of UN Country Review Team).

4. In the 2010 submission Lithuanian CS CO_2 EF for motor gasoline has been used. Estonia imports almost all motor gasoline from Lithuania (a recommendation of UN Country Review Team).

5. In the 2010 inventory submission N_2O emissions from oil shale fluidised bed combustion are estimated and reported in the CRF source – category 1.A.1.a (a recommendation of UN Country Review Team).

6. To the current inventory submission CH_4 and N_2O emissions from CRF 1.A.1.c (Shale oil production) are added. In previous inventory submissions these emissions were not reported (a recommendation of UN Country Review Team).

7. CO_2 emissions from the use of peat have been calculated separately for sod peat and milled peat. CO_2 EF for sod peat and peat briquette has been changed (see Table 3.20).

8. CH_4 and N_2O emissions from use of biomass have been increased because an additional biofuel – black liquor has been added (a recommendation of UN Country Review Team).

9. To the current inventory submission CH4 and N2O emissions from LPG are added. In previous inventory submissions these emissions were not reported (a recommendation of UN Country Review Team).

10. There is a new CRF source category Other Fuels added to the CRF 1.A.2.f. There are three different types of other fuels: technical waste oils, plastics and other fossil based waste fuels (SMW). Carbon emission factors used in calculation of CO_2 emissions are plant specific. The Kunda Nordic Cement factory belongs also to the Estonian ETS.

11. In the current GHG inventory submission a new carbon emission factor value 14.89 tC/TJ (IPCC 2006) was used for estimation of CO_2 emissions from Gas Biomass (landfill gas and WWT (waste water treatment gas) combustion (in the NIR 2009 CEF for biogas 15.3 tC/TJ was used).

12. In the current GHG inventory submission CH_4 and N_2O emissions from shale oil production are reported under CRF source category 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries. In the previous submission this emissions were failed.

13. In the 2010 submission the fuel use and resulting emissions from the ammonia production factory are included into CRF source category 1.A.2.c Chemical industries.

In the 2010 inventory submission following CO_2 emission factors have been changed (Table 3.20) (a recommendation of UN Country Review Team):

Table 3.20 New CO_2 EF used in 2010 inventory submission

	Old CEF, tC/TJ	**New CEF, tC/TJ**	**New CO_2 EF, tCO_2/TJ**	**Source**
Natural Gas	15.3	15.01	55	CS, Finnish
Coke Owen Coke	29.5	29.18	107	D, IPCC 2006
Casoline	18.9	19.91	73	CS, Lithuania
Biogas	15.3	14.89	56.1	D, IPCC 2006
Milled peat	28.9	28.9	106	CS, Finnish
Sod peat	28.9	27.82	102	CS, Finnish
Peat briquette	28.9	26.45	97	CS, Finnish

3.2.1.6. Source-specific planned improvements

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

3.2.2. Transport (CRF 1.A 3)

3.2.2.1. Source category description

In 2008, the greenhouse gas emissions from transport sector amounted to 23.16 Tg CO_2 equivalent. The share of the transport sector of the total greenhouse gas emissions was approximately 11.4% in 2008. In 1990 the share was 6.1%.

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.
1.A.3.c Railways	Railway transport operated by steam and diesel locomotives	
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 3.11 and in Table 3.22. In Figure 3.10 the emissions of the transport sector are given by gas.

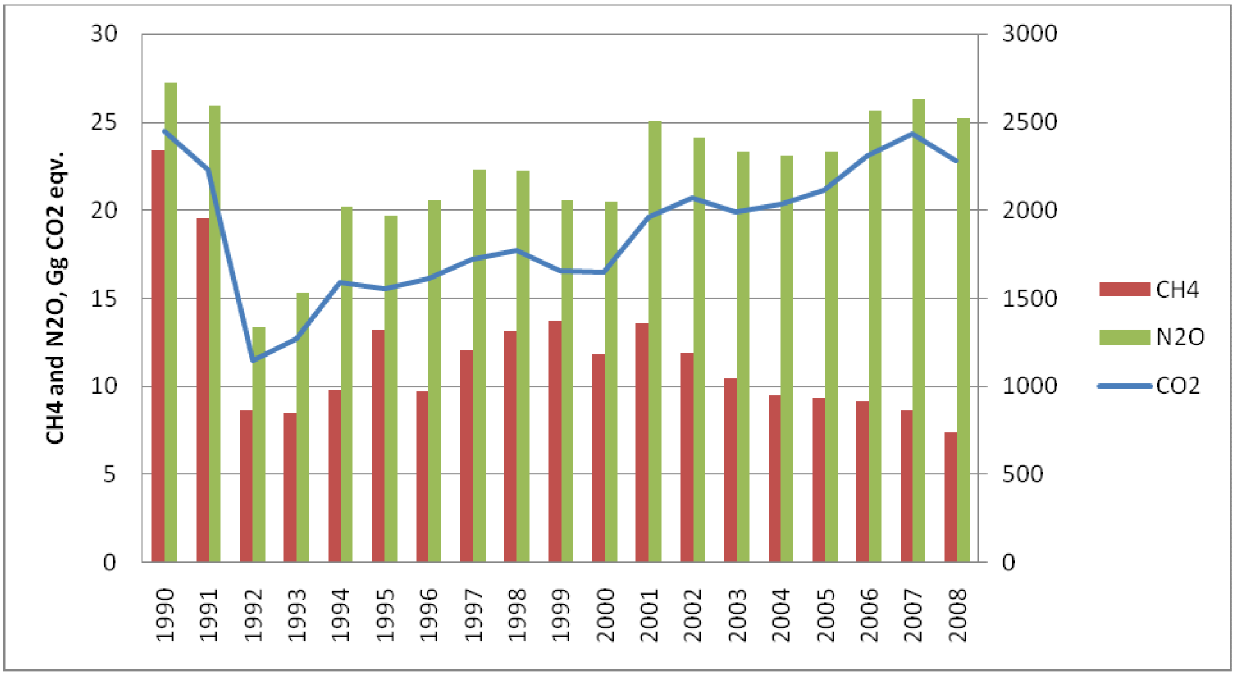

Figure 3.10 Emissions from transport sector by gas in 1990-2008, Gg CO_2 eq.

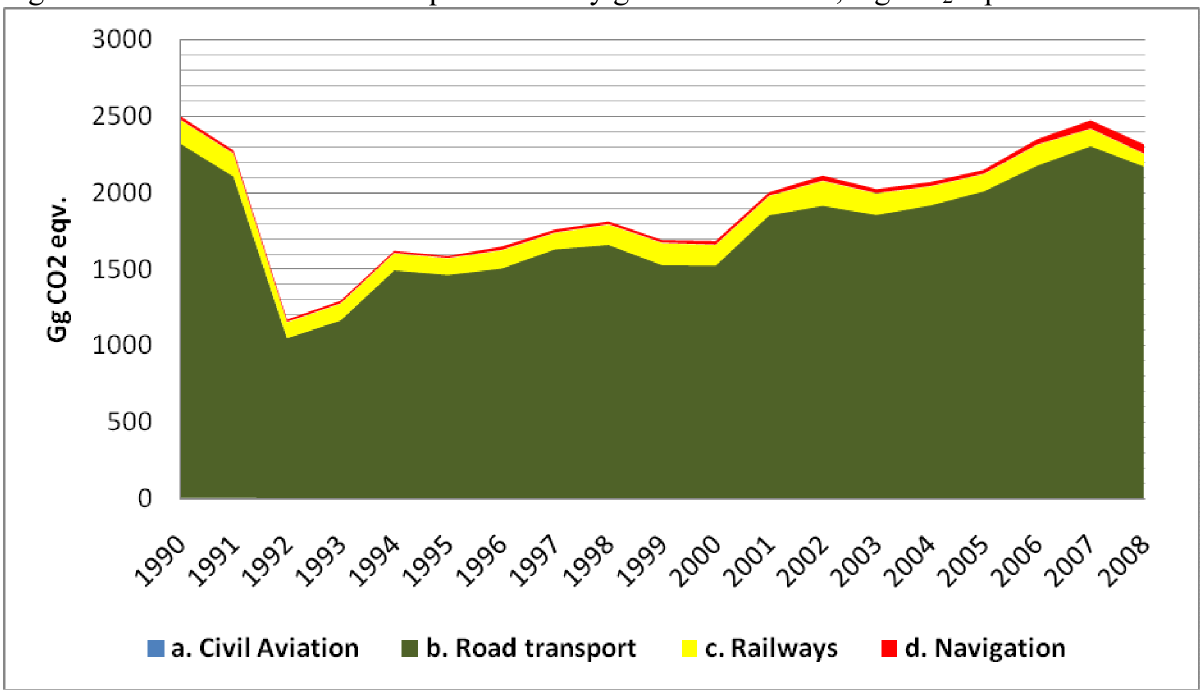

Figure 3.11 Emissions from transport by subcategory in 1990 – 2008, Gg $CO_{2\ eqv.}$

Table 3.22 Emissions from the transport sector in 1990–2008 by subcategories, Tg CO_2 eqv.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
3. Transport total, CO_2 eqv. CO_2	**2.50**	**2.27**	**1.17**	**1.29**	**1.62**	**1.59**	**1.65**	**1.76**	**1.81**	**1.69**	**1.68**	**2.00**	**2.11**	**2.02**	**2.07**	**2.15**	**2.35**	**2.47**	**2.32**
a. Civil Aviation	0.006	0.006	0.002	0.003	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.002	0.002	0.002	0.001	0.001	0.002
b. Road transport	2.27	2.06	1.03	1.14	1.46	1.43	1.47	1.60	1.62	1.49	1.49	1.81	1.88	1.82	1.88	1.98	2.14	2.27	2.14
c. Railways	0.15	0.15	0.10	0.11	0.11	0.11	0.12	0.11	0.13	0.14	0.14	0.13	0.16	0.14	0.12	0.11	0.14	0.11	0.08
d. Navigation	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.05	0.06
CH_4, CO_2 eqv.	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N_2O, CO_2 eqv.	0.03	0.03	0.01	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	0.03	0.03	0.03

Table 3.23 Fuel consumption in transportation sector in 1990-2008, PJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
a. Civil Aviation																			
Aviation Gasoline	0.08	0.08	0.03	0.04	0.03	0.04	0.03	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03
b. Road transport																			
Gasoline	21.41	19.26	9.02	9.50	12.31	10.53	11.56	12.85	12.34	11.80	11.85	14.13	12.97	12.43	11.98	12.24	13.31	13.97	13.90
Diesel Oil	9.50	8.79	4.97	6.06	7.55	9.00	8.58	8.95	9.86	8.61	8.52	10.67	12.70	12.45	13.76	14.76	15.98	17.06	15.34
LPG	0.14	0.09	0.03	0.00	0.17	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.002	0.01
c. Railways																			
Diesel Oil	1.95	1.84	1.36	1.41	1.45	1.43	1.54	1.41	1.78	1.96	1.84	1.70	2.20	1.91	1.69	1.53	1.85	1.53	1.12
Coal	0.12	0.14	0.05	0.05	0.06	0.04	0.06	0.04	0.01	0.00	0.01	0.01	0.00	NO	NO	NO	0.0004	NO	NO
d. Navigation																			
Diesel Oil	0.30	0.26	0.21	0.22	0.17	0.17	0.30	0.26	0.25	0.23	0.32	0.30	0.45	0.35	0.36	0.35	0.47	0.74	0.82

Road transportation is the most important emission source in transport sector covering over 93.8% of sector's emissions.

CO_2 emission trend decreased strongly after 1991. The reason of the decrease was the rapid increase of fuel prises after regaining independency in Estonian 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 2008 emissions from transportation sector decreased about 6% comparing with previous year. The reason for this decrease was the economic depression (Table 3.22).

3.2.2.2. Methodological issues

Estimation of emissions from mobile sources is a very complex undertaking that requires consideration of many parameters including transport class fuel consumed, operating characteristics, emission controls, maintenance procedures, fleet age etc.

Methods

Emissions can be estimated from either the fuel consumed (represented by fuel sold) or the distance travelled by the vehicles. In general, the first approach (fuel sold) is appropriate for CO_2 and the second (distance travelled by vehicle type and road type) is appropriate for CH_4 and N_2O.

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. For calculation of CH_4 and N_2O emissions the second approach has been used.

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:

CO_2 FROM ROAD TRANSPORT

$$Emission = \sum_a \left[Fuel_a \bullet EF_a \right]$$

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. natural gas. LPG etc).

The emission equation for Tier 3 is:

TIER 3 EMISSIONS OF CH_4 AND N_2O

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

Where:

Emission = emission or CH_4 or N_2O (kg)

$EF_{a.b.c.d}$ = emission factor (kg/km)

$Distance_{a.b.c.d}$ = distance travelled (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) (kg)

a = fuel type (e.g.. diesel. gasoline. natural gas. LPG)

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).

Activity data for calculation of CO_2 emissions from the Transport sector are received from the Statistics Estonian (www.stat.ee) and presented in the Table 3.23.

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. The emissions of road transportations was 2.17 Tg ($CO_{2\ eqv.}$) in 2008, it is about 94% of the transport sector emissions, 12.5% of the Energy sector and 10.6% of the total emissions. In 2008 the GHG emissions were about 6% lower than in 1990.

The trend of CO_2 emissions follows in general the fuel consumption trend in the road transportation sector (see Figure 3.12 and Table 3.23). 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 in 2008 a small decrease of emissions (about 6%) reflects the overall economic depression in Estonia.

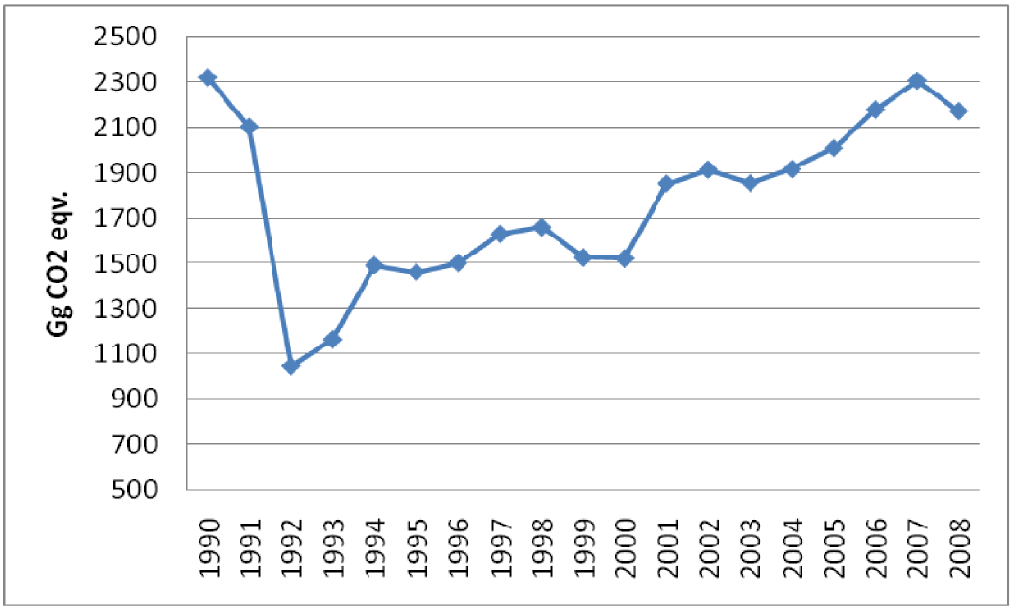

Figure 3.12 Emissions from the road transportation in 1990-2008, Gg $CO_{2\ eqv}$.

Methods

Emission estimations from road transportation are made using the IPCC 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 is also used for the calculation of SO2, CO, NOx and NMVOC emissions.

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

There has been a small amount of bioethanol and biodiesel blended in motor gasoline and diesel fuel in Estonia in recent years. In the present inventory these figures are included into total use of gasoline and diesel oil (as fossil origin). However, the share of non-fossil carbon is so small that it has no effect on total GHGs. The subject will be studied further in the future when there will be more significant amounts.

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. The calculation model COPERT IV is located in the Estonian Environment Information Centre.

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.

There has been a small amount of biofuels used in Estonia in resent years, but the share is very small, less than 0.3% and the biofuels are not separately reported in the national energy balance. Nevertheless, in the future Statistics Estonia plans to start report the biofuels consumption data separately from other motor fuels (but there are not included in the NIR 2010). However, the share of non-fossil carbon seems to be so small that it has no effect on total GHGs.

For obtaining activity data for CH_4 and N_2O emission calculations the Estonian Environment Information Centre has concluded a contract to the Estonian Motor Vehicle Registration Centre. Some of the data - number of vehicles in Estonia (in thousand vehicles**)** and road traffic kilometrage in Estonia (in million km/a) are presented in the tables 3.24 and 3.25.

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.

Table 3.24 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**

Source: Statistics Estonia:

Table 3.25 Road traffic kilometrage in Estonia (Million km/a)

	Cars	Vans	Lorries	Buses	MC and Mopeds	Vehicles total
1990	5601	658	213	1326	317	8115
1991	5376	610	197	1087	230	7500
1992	2725	303	113	513	83	3736
1993	3113	343	138	534	61	4188
1994	4197	462	176	602	43	5481
1995	3897	447	210	596	8	5157
1996	4202	485	196	608	10	5500
1997	4597	539	198	665	13	6012
1998	3440	422	212	722	10	4807
1999	4122	503	181	691	15	5511
2000	4065	506	173	708	16	5468
2001	5157	728	167	841	16	6910
2002	5096	836	174	887	17	7010
2003	5186	824	182	739	19	6950
2004	5226	923	180	781	33	7143
2005	5728	898	175	740	11	7552
2006	6441	951	170	748	19	8328
2007	6947	967	182	775	28	8899
2008	6863	947	171	769	30	8780

Source: Estonian Environment Information Centre

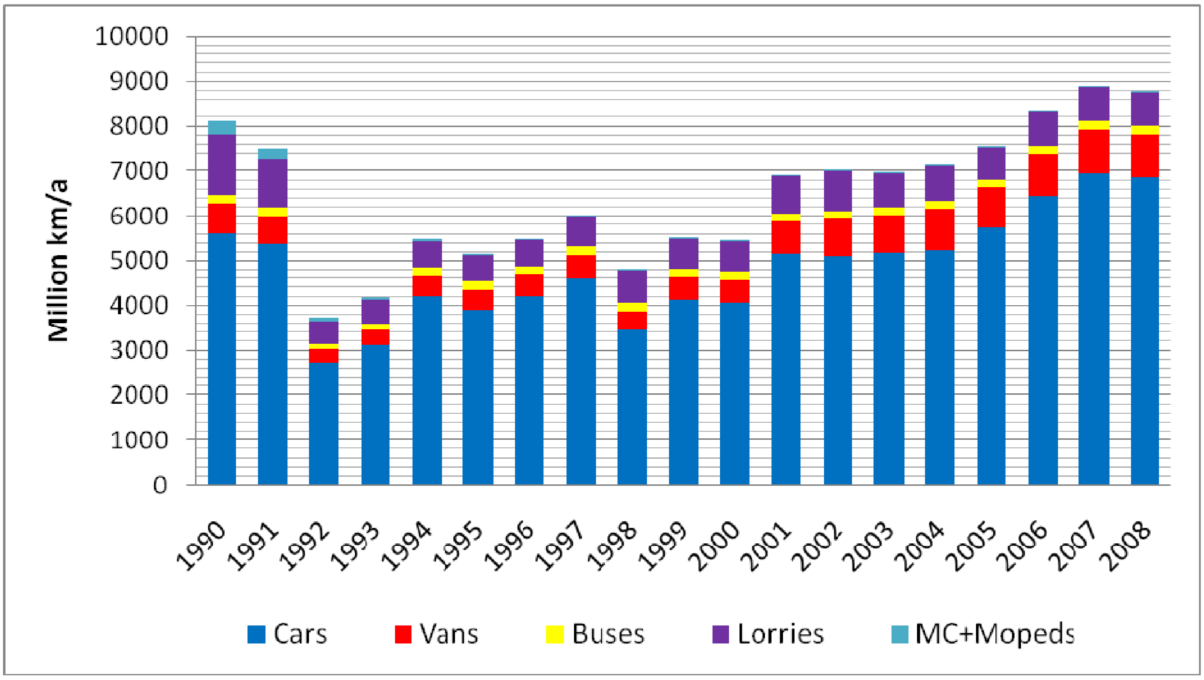

Figure 3.13 Road traffic kilometrage per vehicle in 1990-2008, Million km/a

Emission factors and other parameters

CO_2 emission factor for LPG is IPCC 2006 default value and EFs for gasoline and diesel oil are country specific and presented in the Table 3.26**.**

Table 3.26 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, tCO_2/TJ**	**Source**
LPG	45.53	17.2	0.99	63.1	D. IPCC2006
Gasoline	43.99	19.91	0.99	71.5	CS, Lithuania[5]
Diesel Oil	42.26	20.2	0.99	74.1	CS, Lithuania

Civil Aviation

The emissions from civil aviation (see Figure 3.14.) include all domestic civil aviation transport within Estonian flight information regions (mostly islands). 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 1.A.3 a (Table 3.23).

[5] Lithuanian NIR 1990-2007

The share of the civil aviation from the transport sector was only 0.1% and the amount of emissions was 2.04 Gg (CO_2 eqv.) in 2008. The corresponding figure was 5.76 Gg (CO_2 eqv.) in 1990. See Figure 3.14 and Table 3.22.

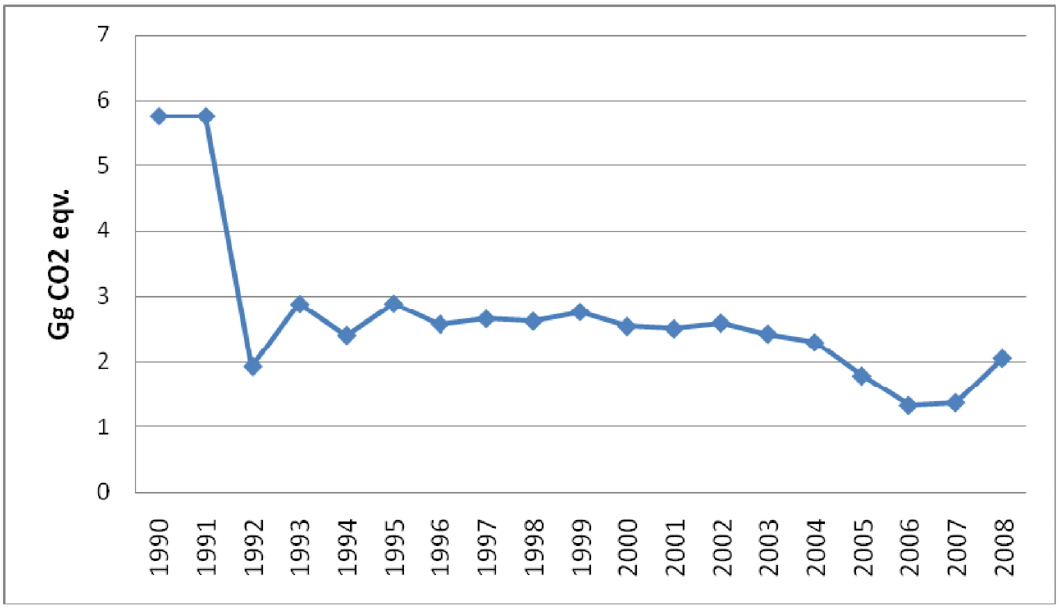

Figure 3.14 Emissions from civil aviation in 1990-2008, Gg CO_2 eqv.

Methods

For estimation of emissions from Civil Aviation the *Tier 2* approach was used. Operations of aircraft were divided into LTO (*Landing/Take-Off*)) 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. ***LTO Fuel Consumption = Number of LTOs * Fuel Consumption per LTO***
4. ***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 the Statistics Estonian 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 the Statistics Estonian. 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.

Emission factors and other parameters

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 IPCC Guidelines are presented in the Table 3.27.

Table 3.27 Emission factors used in the calculation of emissions from national aviation

	CO_2 tCO2/TJ	**CH_4** kg/TJ	**N_2O** kg/TJ	**NOx** kg/TJ	**CO** kg/TJ	**NMVOC** kg/TJ	**SO_2** kg/TJ
Cruise	72	0	2	240	47	2	23
LTO	75	22	3	126	2632	180	21

Railway

Railway transportation in Estonia is a small emission source in transport sector. The emissions of railway transportation were 83 Gg ($CO_{2eqv.}$) in 2008 it is only 3.6% of the sectors emissions. In 1990 the corresponding figure was 155 Gg ($CO_{2\ eqv.}$).

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. Besides, the rail passenger transport was disturbed due to capital repair of railways in 2008. 3% less passengers were carried by rail in domestic trips compared to 2007.

The rail transport is used mostly for transport of goods. The volume of goods transported decreased in 2008, 16% compared to 2007 (while volume of transit goods decreased by 29%).

Methods

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

Activity data

The activity data on fuel consumption used in railway transportation are obtained from the Statistics Estonian 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 1996 IPCC Guidelines are presented in the Table 3.28.

Table 3.28 Emission factors used in the calculation of emissions from railway transportation

Fuel	NCV average. GJ/t	GHG	EF	Oxidation factor	Source
Diesel Oil	42.26	CO_2	20.2 tC/TJ (74.1 tCO2/TJ)	0.99	IPCC2006
		CH_4	5 kg/TJ	5	IPCC2006
		N_2O	0.6 kg/TJ		IPCC2006
		NOx	929.6		EMEP/EEA
		CO	251.2		EMEP/EEA
		NMVOC	109.2		EMEP/EEA
		SO2	141.2		CS, EE
Coal	27.2	CO_2	26.8 tC/TJ (98.3 tCO_2/TJ)	0.98	IPCC2006
		CH_4	10 kg/TJ		IPCC2006
		N_2O	1.4 kg/TJ		IPCC2006
		NOx	200		EMEP/EEA
		CO	100		EMEP/EEA
		NMVOC	15		EMEP/EEA
		SO2	1028		CS, EE

Domestic Navigation

Domestic navigation includes the most important domestic waterway transport in Estonia: merchant ships, passenger ships, technical ships, pleasure and tour ships and other inland vessels.

Domestic navigation in Estonia is also a small emission source in transport sector. The emissions of domestic navigation were 60 Gg ($CO_{2\ eqv.}$) in 2008 it is only 2.6% of the sectors emissions. In 1990 the corresponding figure was 22 Gg ($CO_{2\ eqv.}$).

Methods

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

Activity data

The activity data on fuel consumption used in domestic navigation are obtained from the Statistics Estonian and presented in the Table 3.2.3.

Emission factors and other parameters

Emission factors of the CO_2, CH_4 and N_2O used in the calculation of emissions from domestic navigation are taken from the IPCC 2006 Guidelines are presented in the Table 3.29.

Table 3.29 Emission factors used in the calculation of emissions from domestic navigation

Fuel	NCV average. GJ/t	GHG	EF	Oxidation factor	Source
Diesel Oil	42.26	CO_2	20.2 tC/TJ	0.99	IPCC2006
		CH_4	5 kg/TJ		PCC2006
		N_2O	0.6kg/TJ		PCC2006
		NOx	1500 kg/TJ		IPCC1996
		CO	1000 kg/TJ		IPCC1996
		NMVOC	200 kg/TJ		IPCC1996
		SO2	141.2 kg/TJ		CS, EE

3.2.2.3. Source-specific recalculations

1. Recalculations in the Transport sector subcategory 1.A.3.a: Domestic Aviation/Aviation Gasoline are connected with activity data of the years 1997-2001 and 2003 corrected by Statistics Estonia (see Table 3.30).

Table 3.30 Aviation Gasoline consumption for Domestic Aviation, TJ

Year	Reported AD in NIR 1990-2007 (the 2009 submission)	New AD in NIR 1990-2008 (the 2010 submission)
1997	86.82	35.00
1998	117.67	35.00
1999	208.41	37.00
2000	91.17	34.00
2001	7.94	33.00
2003	13.86	32.00

2. In the 2010 inventory submission GHG emissions from LTO in the Transport sector subcategory 1.A.3.a: Domestic Aviation/Aviation are estimated and added to Cruise

emissions. In previous submission only emissions from fuel used for Cruise have been calculated.

3. Recalculations in the Transport sector subcategory 1.A.3.d: Domestic Navigation/Liquid fuels are connected with activity data of the years 1990-1994 corrected by Statistics Estonia (see Table 3.31 and Table 3.32).

Table 3.31. Diesel Oil for Domestic Navigation, TJ

Year	Reported AD in NIR 1990-2007 (the 2009 submission)	New AD in NIR 1990-2008 (the 2010 submission)
1990	1442	298.184
1991	1715	255.604
1992	2040	212.983
1993	4640	212.983
1994	2879	170.403

Table 3.32 Residual Fuel Oil for Domestic Aviation, TJ

Year	Reported AD in NIR 1990-2007 (the 2009 submission)	New AD in NIR 1990-2008 (the 2010 submission)
1990	6172	0
1991	7241	0
1992	3319	0
1993	3675	0
1994	2621	0

4. In the current inventory submission CRF source category 1.A.3.f Other Transportation has been removed and relevant emissions are reported under CRF 1.A.4.c Agriculture/Mobil.

5. In the previous 2009 inventory submission there was planned to use in the 2010 submission the Copert model also for CO_2 emission calculation from the road transportation but according to the recommendations of the Country Review Team (in September 2009) we still calculate CO_2 emissions by multiplying the amount of motor fuel sold (TJ) with emission factor of the fuel sold (IPCC Tier 2 method).

3.2.2.4. Source-specific planned improvements

Today, the share of biofuels used in transport sector is very small in Estonia (less than 0.3%) and the biofuels are not separately reported in the national energy balance. Nevertheless, Estonia Ministry of Environment will make a proposal to the Statistical Office to start collect and report bio fuel consumption data separately from other motor fuels in road transportation.

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

3.2.3.1. 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.

The emissions of the sub-category CRF 1.A.4 were 532 Gg $CO_{2\ eqv.}$ In 2008, it is about 3% of the energy sector's emissions and approximately 2.6% of total GHG emissions in Estonia. Corresponding emissions were 1672 Gg $CO_{2\ eqv}$ in 1990 (see Table 3.33).

Sub-category CRF 1.A.5 includes emissions from military use of fuels (see Table 3.34). In previous inventory submissions military fuels were included into Commercial/Institutional sector (CRF 1.A.4.a).

A new sub-category CRF 1.A.5 includes emissions from military use of fuels. In previous inventory submissions military fuels were included into Commercial/Institutional sector (CRF 1.A.4.a).

3.2.3.2. Methodological issues

Methods

Emissions from sub-category CRF 1.A.4 and CRF 1.A.5 are calculated by using the same methodology as for CRF 1.A.1 and 1.A.2 base on the IPCC 1996 and 2006 Guidelines.

Activity data

The activity data for source categories CRF 1.A 4 and CRF 1.A.5 are taken from the national energy statistics (see Annex 8) and presented in the Table 3.35 and Table 3.36. It covers fuel used in commercial/institutional and residential and agricultural/forestry/fisheries sectors.

The fuel consumption trends in 1990-2008 by main fuel groups of the Other sector are presented in the Figure 3.15.

In 2008, the fuel consumption of the Other sector has in total decreased by 21% compared to the year 1990. There have been big changes also in the structure of fuels. The consumption of liquid fuels has decreased by 33% and solid fuels about 22%, at the same time consumption of gaseous fuels and biomass has increased by 6% and 49% respectively compared to 1990.

Behind of this big increase in the use of biomass is mainly the residential sector. In the middle of nineties several different biofuels conversion projects started in Estonia, to replace imported fossil liquid fuels with local biomass. New buildings were often equipped with natural gas or electricity heating. Natural gas use is increased also in the Commercial/Institutional sector, especially in the last years.

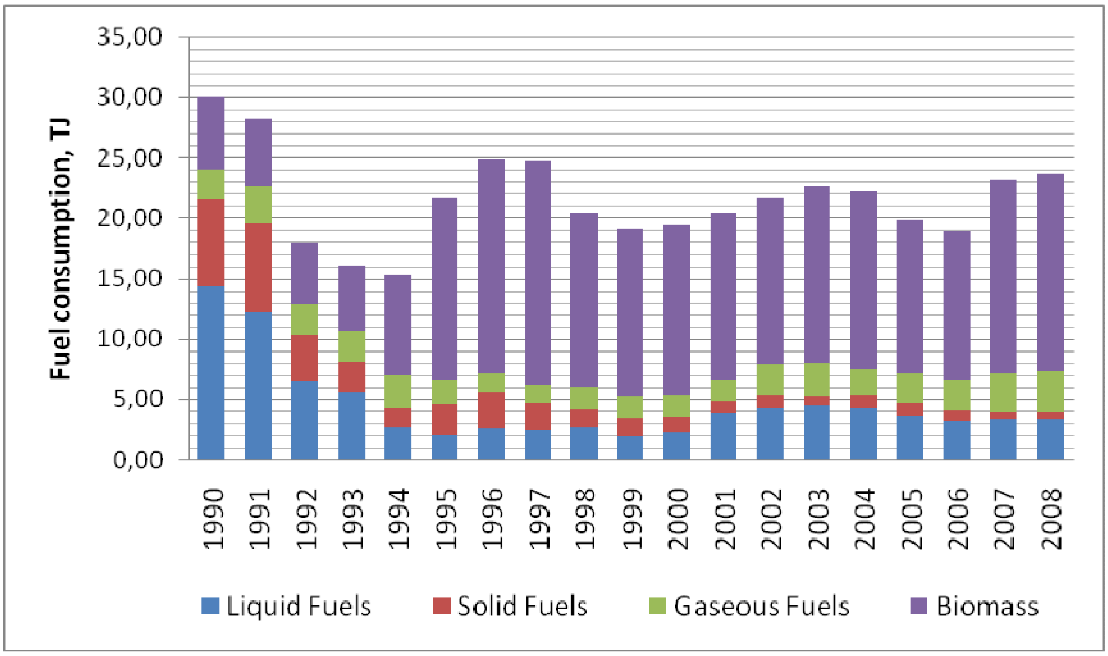

Figure 3.15 Fuel Consumption in the CRF categories 1.A.4 Other Sectors, TJ

Table 3.33 Emissions from Other Sectors (incl. Commercial/Institutional, Residential and Agriculture/Forestry/Fisheries) in 1990-2008, Tg $CO_{2\ esq.}$

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
4. Total Other Sectors	**1.67**	**1.53**	**0.96**	**0.88**	**0.61**	**0.57**	**0.64**	**0.55**	**0.52**	**0.45**	**0.51**	**0.63**	**0.71**	**0.73**	**0.66**	**0.62**	**0.60**	**0.67**	**0.53**
CO_2 4. Other Sectors	1.57	1.43	0.90	0.83	0.57	0.52	0.58	0.50	0.47	0.41	0.47	0.60	0.66	0.68	0.61	0.58	0.55	0.62	0.48
Commercial/Institutional	0.05	0.04	0.04	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.07	0.09	0.06	0.06	0.04	0.08	0.09
Residential	1.03	0.92	0.51	0.50	0.42	0.40	0.44	0.36	0.33	0.34	0.37	0.37	0.36	0.35	0.32	0.32	0.33	0.34	0.21
Agriculture/Forestry/ Fisheries	0.50	0.47	0.35	0.33	0.14	0.12	0.13	0.12	0.13	0.06	0.08	0.20	0.23	0.24	0.23	0.20	0.18	0.20	0.19
CH_4, CO_2 eqv	0.04	0.04	0.02	0.01	0.01	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N_2O, CO_2 eqv	0.06	0.06	0.04	0.04	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03

Table 3.34 Emissions from CRF 1.A.5 Other in 1990-2008, Gg $CO_{2\ eq.}$

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
5. Total Other	**44.43**	**54.43**	**34.85**	**11.03**	**11.19**	**29.32**	**16.56**	**13.95**	**19.84**	**20.50**	**20.28**	**22.21**	**18.17**	**22.36**	**31.47**	**38.94**	**36.03**	**35.22**	**36.78**
CO_2 5. Other																			
Mobile	43.61	53.44	34.24	10.83	10.99	28.80	16.27	13.70	19.48	20.13	19.92	21.81	17.82	21.95	30.91	38.26	35.41	34.61	36.14
CH_4, CO_2 eqv	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	0.04	0.04
N_2O, CO_2 eqv	0.77	0.93	0.56	0.19	0.18	0.48	0.27	0.23	0.33	0.35	0.34	0.38	0.33	0.39	0.53	0.64	0.59	0.57	0.60

Table 3.35 Fuel consumption in the CRF category 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**
1.A.4 (stationary)																			
Liquid Fuels	13.64	11.59	6.01	4.55	2.42	1.79	2.30	2.24	2.41	1.70	1.76	1.43	2.31	3.09	3.15	2.64	2.53	2.67	2.60
Solid Fuels	7.28	7.25	3.93	2.57	1.52	2.55	3.04	2.24	1.43	1.55	1.27	0.95	1.11	0.80	1.13	1.05	0.78	0.51	0.50
Gaseous Fuels	2.52	3.11	2.47	2.62	2.87	2.01	1.55	1.55	1.84	1.75	1.78	1.78	2.59	2.78	2.02	2.43	2.52	3.23	3.53
Biomass	5.94	5.62	5.10	5.33	8.29	15.21	17.71	18.49	14.41	14.01	14.12	13.90	13.83	14.57	14.79	12.74	12.47	16.06	16.37
1.A.4 (mobile)																			
Liquid Fuels	0.63	0.63	0.41	0.95	0.22	0.19	0.24	0.15	0.25	0.17	0.51	2.37	1.90	1.32	1.07	0.97	0.68	0.68	0.74

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

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
1.A.5 (mobile)																			
Liquid Fuels	0.60	0.73	0.47	0.15	0.15	0.39	0.22	0.19	0.27	0.28	0.27	0.30	0.24	0.30	0.42	0.52	0.48	0.47	0.49

Emission Factors

Emission factors used in the Other sector are presented in the Table 3.37. Both, IPCC and national (country specific) emission factors are used.

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

	CH_4	N_2O	NOx	CO	NMVOC	Source
Oil	10	2	100	20	5	IPCC1996
LPG	5	0.1	100	20	5	IPCC1996
Natural Gas	3	1	50	50	5	IPCC1996
Coal	300	4	100	200	200	IPCC1996
Oil Shale	1	1.5	110	87	60	CS, Procedure (2004)
Peat/Briquette	50	4	100	5000	600	IPCC1996
Wood (households)	200	2	100	2100	600	CS, FIN NIR 2008
Wood (agriculture and commercial)	50	2	100	2100	200	CS, FIN NIR 2008

Under the CRF source category 1.A.4.b Residential/liquid first time emissions from gardening machineries (lawn movers and tractors) are estimated. Activity data on motor fuels used in gardening machineries are received from the Estonian Environment Information Centre. Emission factors for gasoline and diesel oil used in gardening machines are presented in the Table 3.38.

Table 3.38 Emission factors of gasoline and diesel oil used in gardening machineries

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	Source
Motor Gasoline	19.91	120	2	180	79000	2500	EMEP/EEA Air Pollutant Emission Inventory Guidebook 2009
Diesel Oil	20.2	4	30	1100	530	230	EMEP/EEA Air Pollutant Emission Inventory Guidebook 2009

Under the CRF source category 1.A.4.c Agriculture/Mobile emissions from off-road agricultural transport are estimated. In the Table 3.39 emission factors of motor fuels used for off-road transportation and fishing and leisure boats are presented.

Table 3.39 Emission factors for agricultural off-road fuels, kg/TJ

	CO_2 (t C/TJ)	CH_4	N_2O	NOx	CO	NMVOC	Source
Motor Gasoline	19.91 CS	80 D	2 D	1200 D	1000 D	200 D	IPCC2006, Chapter 3, Table 3.3.1
Diesel Oil	20.2 CS	4.15 D	28.6 D	1200 D	1000 D	200 D	IPCC2006, Chapter 3, Table 3.3.1

Source: CS (Lithuanian NIR 1990-2007)

Under the CRF source category 1.A.5 Other/Mobile emissions from military fuel use are estimated. In the Table 3.40 emission factors of motor fuels used in military are presented.

Table 3.40 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	19.91 CS	3.8 D	5.7 D	600 D	8000 D	1500 D	IPCC2006, Chapter 3, Table 3.2.3
Diesel Oil	20.2 CS	3.9 D	3.9 D	800 D	8000 D	1500 D	IPCC2006, Chapter 3, Table 3.2.3

3.2.3.3. Source-specific recalculations

1. The main recalculations made in the sectors CRF 1.A.4. Other Sectors are connected with non–CO_2 emission (CH_4 and N_2O) factors change and CO_2 emission factor change for gasoline (Table 3.38 and Table 3.39). In the previous inventory submission non_CO_2 emissions from 1.A.4 were calculated using the same emission factors as in sectors 1.A.1 and 1.A.2. New CH_4, N_2O, NOx, CO, NMVOC and SO_2 EF are presented in the Table 3.37.
2. In the 2010 inventory submission a new source category has been added: emissions from gasoline and diesel oil used in gardening machines (in lawn movers and tractors).
3. . Emissions from off road agricultural transportation is reported under CRF source category 1.A.4.c Agriculture /Mobil. In the last (2009) inventory submission these

emissions were reported under CRF 1.A.3.e Other Transportation (a recommendation of the UN Country Review Team).

4. In the 2010 inventory submission a new CRF source category 1.A.5 Other is added. Under CRF 1.A.5 emissions from the use of liquid military transport fuels are reported

3.2.3.4. Source- specific planned improvements

During 2010, the final consumption of natural gas in 2002-2003 will be over checked by Statistics Estonia. In 2002-2003, there is a big derivation in the trend of gaseous fuels consumption in Commercial/Institutional sector. According to the information received from Statistics Estonia, the total final consumption figure is correct but break down by sectors should be corrected.

More detailed research is needed to separate military stationary fuels from the source category 1.A.4.b Commercial/Institutional**.**

There is planned to separate in the future agricultural mobile fuels, fishing boats used fuels and in off-road transportation used fuels. According to the information received from the Statistics Estonia amount of fishing boats used fuels is very small. Nevertheless, Estonia will ask Statistical Office to start report the fishing boats used fuels data separately from other agricultural mobile fuels.

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

3.3.1. Overview of the sector

Description

Under fugitive emissions from fuels Estonia reports CH_4 emissions from: oil and natural gas handling including the following activities:

- transmission and distribution of natural gas and oil products
- consumption of natural gas and
- CH_4 emissions from venting from oil production.

In 2008, fugitive emissions from natural gas and oil were 23.71 Gg CH_4 (497.86 Gg $CO_{2\ eq.}$).

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

In Estonia oil shale is mined for energy generation and shale oil production (see Table 3.41). There are no coal mines in Estonia.

Unlike coal mines there is no CH_4 emissions from Oil Shale mines as oil shale is located very close to the surface of the earth and the methane is a long time ago already emitted (Kattai, et all., 2000).

Table 3.41 Oil Shale production, Million tons

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Mt	22.49	19.61	18.85	14.92	14.53	13.31	14.74	14.38	12.46
1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
10.69	11.73	11.838	12.40	14.89	13.99	14.59	14.10	16.54	16.12

3.3.3. Oil and Natural Gas (CRF 1.B.2)

3.3.3.1. Source category description

Sources of fugitive emissions within oil and gas systems include releases during normal operation, such as emissions associated with venting, chronic leaks or discharge from process vents, 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.

3.3.3.2. Methodological issues

Methods

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

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

Activity data

The activity data for sub-category CRF 1.B.2 are taken from the annual energy statistics (see Annex 8).

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 3.42).

Table 3.42 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
Storage of oil products	200	kg CH_4/PJ	D
GAS			
Transmission and distribution of natural gas	458 000	kg CH_4/PJ	D
Other Leakage			
Non-residential gas consumed	279 500	kg CH_4/PJ	D
Residential gas consumed	139 500	kg CH_4/PJ	D
Venting from oil production			
Oil (Shale Oil)	4000	kg CH_4/PJ	D

3.3.3.3. Quantitative overview

Emissions of CH_4 from Oil and Gas activities are presented in the Table 3.43.

Table 3.43 CH_4 emissions from Oil and Gas activities, Gg $CO_{2\ eqv.}$

	1.B.2.A.3 Transport	1.B.2.A.4 Storage	1.B.2.A Total Oil	1.B.2.B.5 Other Leakage	1.B.2.B.3 Trans-mission	1.B.2.B Natural Gas	1.B.2.C Venting	1.B.2 Oil and Natural Gas	Fugitive emissions Gg CO_2 eq
1990	0.26	0.05	0.25	14.02	23.47	37.49	0.02	37.75	37.75
1991	0.14	0.03	0.13	13.98	23.53	37.51	0.02	37.65	37.65
1992	0.08	0.02	0.08	8.06	13.75	21.81	0.04	21.92	21.92
1993	0.08	0.02	0.08	3.80	6.82	10.62	0.04	10.74	10.74
1994	0.10	0.02	0.07	5.58	9.79	15.37	0.05	15.52	15.52
1995	0.10	0.02	0.09	6.54	11.17	17.71	0.05	17.85	17.85
1996	0.09	0.02	0.09	7.30	12.32	19.62	0.05	19.76	19.76
1997	0.12	0.02	0.11	7.09	11.97	19.06	0.06	19.24	19.24
1998	0.12	0.02	0.11	6.68	11.36	18.04	0.03	18.18	18.18
1999	0.13	0.03	0.12	6.51	11.06	17.56	0.02	17.71	17.71
2000	0.05	0.01	0.05	7.51	12.71	20.22	0.04	20.30	20.30
2001	0.06	0.01	0.05	8.09	13.65	21.74	0.04	21.83	21.83
2002	0.06	0.01	0.06	6.76	11.43	18.19	0.04	18.29	18.29
2003	0.06	0.01	0.05	7.48	12.60	20.08	0.05	20.18	20.18
2004	0.07	0.02	0.07	8.85	14.87	23.71	0.05	23.83	23.83
2005	0.06	0.01	0.06	9.10	15.33	24.43	0.05	24.54	24.54
2006	0.08	0.02	0.08	9.21	15.52	24.73	0.06	24.86	24.86
2007	0.12	0.02	0.11	9.14	15.44	24.58	0.07	24.76	24.76
2008	0.12	0.02	0.11	8.74	14.8	23.54	0.06	23.71	23.71

3.3.3.4. Uncertainty and time series' consistency

To estimate the uncertainties of this category the IPCC Tier2 method was used. Uncertainties of activity data (±5) 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 2008 was around ±0.43%.

3.3.3.5. Source-specific recalculations

The CRF source category 1.B.2.A.2 Oil Production is removed from the 2010 submission because CH_4 from the production of shale oil is already taken into account in the sub-category 1.A.1.c.

3.3.3.6. Source-specific planned improvements

In the nearest future it is planned to find country specific emission factors for fugitive CH_4 emissions from shale oil production.

3.4. Reference Approach

Reference approach (RA) is carried out using import, export, production and stock change data from the National Energy Balance published by Statistics of Estonia (www.stat.ee). In the 2008 inventory, the difference of CO_2 emissions between RA and Sectoral Approach (SA) was 1.54%, which is acceptable. However, differences in 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.

Recalculations made in the Reference Approach

- The main important recalculation was connected to feedstock fuels. In the previous GHG inventory submissions fuel amounts for feedstock were included into RA. In the 2010 inventory submission all fuel amounts for feedstock were taken off from the Apparent consumption of the Reference Approach.
- A new CS carbon emission factor has been used for motor gasoline – 19.91 tC/TJ (73 tCO_2/TJ). The old CEF for gasoline was an IPCC1996 default value, but as Estonia imports almost all motor gasoline from Lithuania (the petroleum refining company *JSC Mazeikiu Nafta* Lithuania) it is reasonable to use Lithuanian CS value for motor gasoline[6] (a recommendation of the 2009 Country Review Team).
- In the current GHG inventory submission different carbon emission factors are used for different peat fuels (a recommendation of the Finnish energy expert giving in the frame of the Light Twinning project carried out in May to September 2009). There are three different types of peat fuels used in Estonia: milled peat, sod peat and peat briquettes. In previous inventory submissions CEF 28.9 tC/TJ was used for all peat fuels. CEF for peat fuels are following: CEF milled peat = 28.9 tC/TJ. CEF sod peat = 27.82 tC/TJ and CEF peat briquette = 26.45 tC/TJ[7].
- A new country specific carbon emission factor has been used for natural gas – 15.01 tC/TJ (55 tCO_2/TJ). The old CEF for natural gas was an IPCC1996 default value (15.3 tC/TJ), but as Estonia imports all natural gas from Russia (like Finland) it is reasonable to use Finnish CS carbon emission factor value for natural gas[8] (a recommendation of the 2009 Country Review Team).

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[6] Source: Natinal Greenhouse Gas Emission Inventory Report 2008 of the Republic of Lithuania, www.unfccc.int

[7] Source: Greenhouse Gas Emission in Finland. National Inventory Report under the UNFCCC and the Kyoto Protocol 8 April Inventory Report 2008 , www.unfccc.int

- A new. IPCC 2006 carbon emission factor value 29.18 tC/TJ (107 tCO_2/TJ) was used for estimation of CO_2 emissions from coke oven coke combustion (in the NIR 2009 IPCC 1996 CEF for coke 29.5 tC/TJ was used).

3.5. International Bunkers

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

In 2008, GHG emissions from marine bunkers were 795.09 Gg CO_{2eqv} and from aviation bunker 86.3 Gg$CO_{2\ esq.}$

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 (see Figure 3.16).

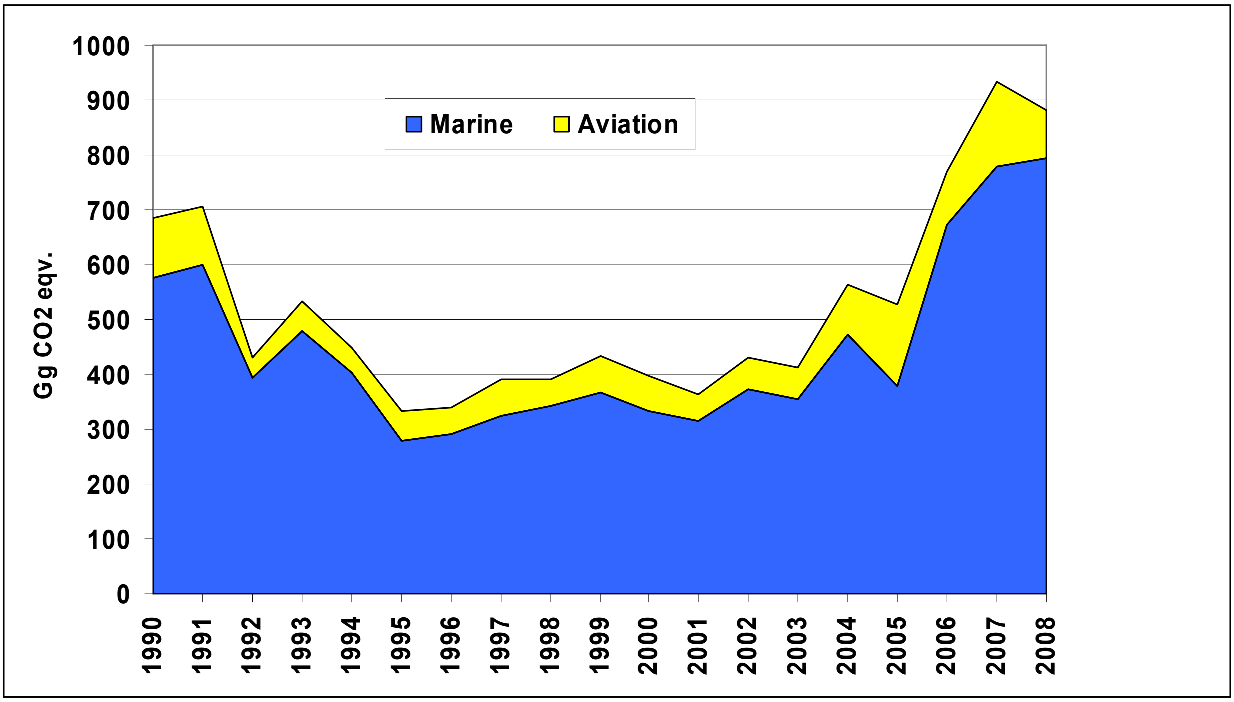


Figure 3.16 Emissions from international bunkers in 1990-2008, Gg $CO_{2\ eqv.}$

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

The emissions from the Aviation bunkering 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 2006 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.

Recalculations

Some corrections have been made in Activity Data – amounts of Jet Kerosene used in International Aviation are corrected (Table 3.44). The reason of these changes is manly connected with specification of the Jet Kerosene calorific value and also data processing mistakes.

Table 3.44 Jet Kerosene for International Aviation, TJ

	2009 submission (1990-2007)	2010 submission (1990-2008)
1997	855.18	907.00
1998	561.33	644.00
1999	740.59	912.00
2000	827.83	885.00
2001	680.06	655.00
2003	772.14	754.00

No uncertainty estimation for international bunkers has been carried out.

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 SF6 (CRF 2.F) and other production (CRF 2.D). Under Mineral products Estonia reports emissions from cement, lime and glass production. 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.

In 2009 emissions from CRF category 2.C.1 Iron and Steel Production were under investigation. Investigation was conducted by contacting companies dealing with iron and steel processing. According to the investigation, there is neither iron nor steel production from ore in Estonia. There is secondary metal and steel processing in Estonia (metal and steel casting). According to the companies dealing with metal and steel casting, CO_2 emissions from this process are only energy related and CO_2 from material does not occur.

Industrial greenhouse gas emissions contribute to about 5.14% of the total anthropogenic greenhouse gas emissions in Estonia (Figure 4.1). As outlined in the inventory for 2008 the most important greenhouse gas emissions from industrial processes in Estonia are the CO_2 emissions from the cement, ammonia and lime production with the 2.98%, 1.34% and 0.13% and HFC emissions from Refrigeration and Air Conditioning Equipment with the 0.61%. F-gas emissions comprised together about 0.66% of the total greenhouse gas 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. Sudden increase in the emissions in 2007 was mainly caused by increase of cement production.

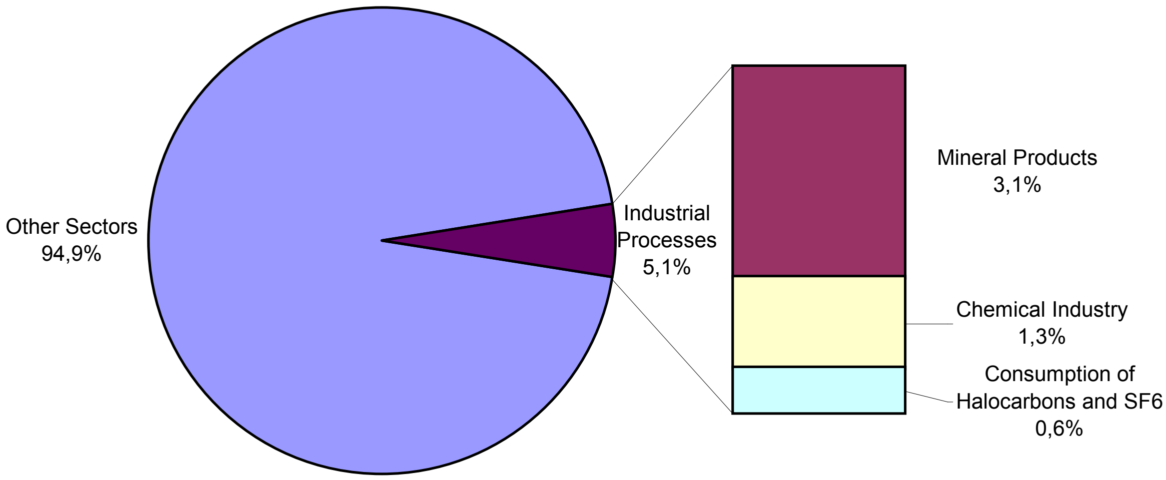


Figure 4.1. Emissions from industrial processes compared with total emissions in 2008.

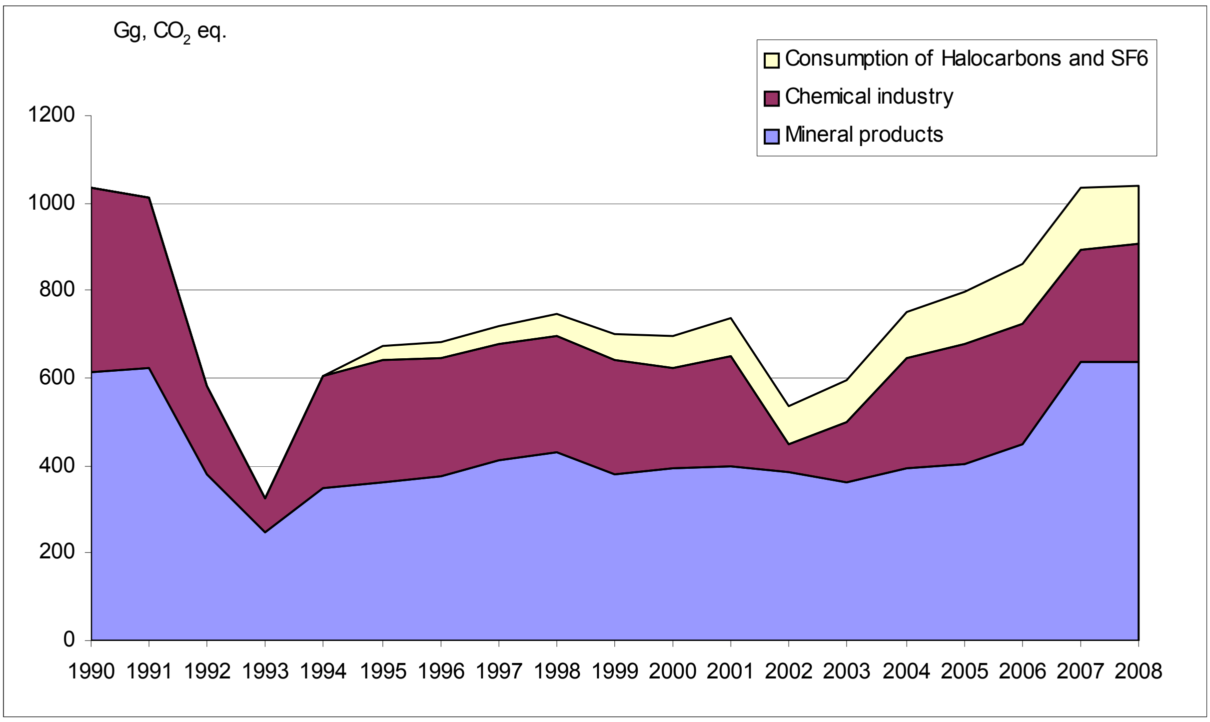


Figure 4.2. Emissions from industrial processes in Estonia in 1990-2008 (Gg CO_2 eqv.).

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

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2.A Mineral Products	614	622	380	246	346	363	377	414	431	382	394	400	383	364	396	405	450	635	637
2.B Chemical Industry	420	391	200	78.9	259	280	269	264	267	258	231	248	63.5	137	251	272	272	260	271
2.F Consumption of Halocarbons and SF6																			
HFCs	NO	NO	NO	0.03	0.05	25.7	30.9	36.7	46.3	56.1	70.1	86.1	87.3	92.7	105	119	136	141	132
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.07	0.06	0.04
SF_6	NO	NO	NO	NO	NO	3.22	3.51	3.0	2.99	3.01	2.73	1.74	1.43	1.31	1.08	1.08	1.15	0.97	1.35
Total	1 034	1 013	580	325	606	672	681	718	747	700	698	736	535	595	753	797	859	1 037	1 041

Key categories

Key categories in industrial processes in 2008 are summarised in Table 4.2. without LULUCF (there were no key categories with LULUCF) in accordance with IPCC Tier 2 method.

Table 4.2. Key categories in Industrial processes (CRF 2) in 2008 (without LULUCF).

IPCC code	IPCC source category	Gas	Identification criteria
2.A.1	Cement Production	CO_2	L, T
2.B.1	Ammonia Production	CO_2	L, T
2.F.1.2	Commercial Refrigeration	HFCs	T
2.F.1.4	Industrial Refrigeration	HFCs	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) and other (2.A.7) are reported. In the source category other (2.A.7), emissions from glass production are reported (2.A.7.1).

Emissions from using limestone and dolomite are presently under investigation, as it is believed that some quantity of limestone and dolomite is used to produce building materials (bricks, roof tiles etc). Investigation in this category started in 2009 and the results will be presented in 2011 Submission.

CO_2 emissions from mineral products have fluctuated since 1990 (Table 4.3.) having the lowest value in 1993 and after small increase in 1994 the trend of CO_2 emissions have stabilized (except a rise in 2007-2008). 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 is caused by increase of cement production (in 2007 AS Kunda Nordic Cement renovated third kiln).

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
2.A.1 Cement Production	483	479	315	228	330	348	361	396	404	361	374	380	356	335	365	373	414	597	603
2.A.2 Lime Production	131	143	65	16	14	13	12	12	20	15	13	13	18	20	22	24	27	28	25
2.A.7.1 Glass Production	NE	NE	0.2	1.7	2.5	2.9	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
Total	**614**	**622**	**380**	**246**	**346**	**363**	**377**	**414**	**431**	**382**	**394**	**400**	**383**	**364**	**396**	**405**	**450**	**635**	**637**

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- AS Kunda Nordic Cement. Standard wet process is used there to produce cement. The main raw materials in cement production are limestone, clay and gypsum. The clinker burning process takes place in three rotary kilns. Pulverised limestone is heated at temperature 1 450 ^{o}C with clay that is processed before (raw materials contain calcium, aluminum, ferrum and silica oxides). The mixture ingredients react forming intermediate product clinker. Depending on the type of cement, clinker is added to the gypsum. Also limestone, slag and fly ash are sometimes added, and then the mixture is pulverized to powder forming cement. Cement production process is very energy demanding process, where the most important fuels are oil, shale, coal and petrol coke. 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 (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:

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

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 4.4.).

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 - AS Kunda Nordic Cement – throughout the time series. Data on the cement kiln dust was also provided by the plant. Data on clinker production as well as CKD correction factors between 1990-2008 are presented in Table 4.4.

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

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.2.1.5. Source-specific recalculations

Emissions from cement production were recalculated throughout the time series due to more specific data over the emissions factors from plant. Also, in 2010 Submission method has been changed from country-specific (accordance with Tier 2) to good practice guidance method Tier 2. The change of method was recommended by UNFCCC Review Team and in the results of Twinning Light Project EE06-IB-TWP-ENV-06. Difference between 2009 Submission emissions and 2010 Submission emissions from cement production is brought out in Figure 4.3.

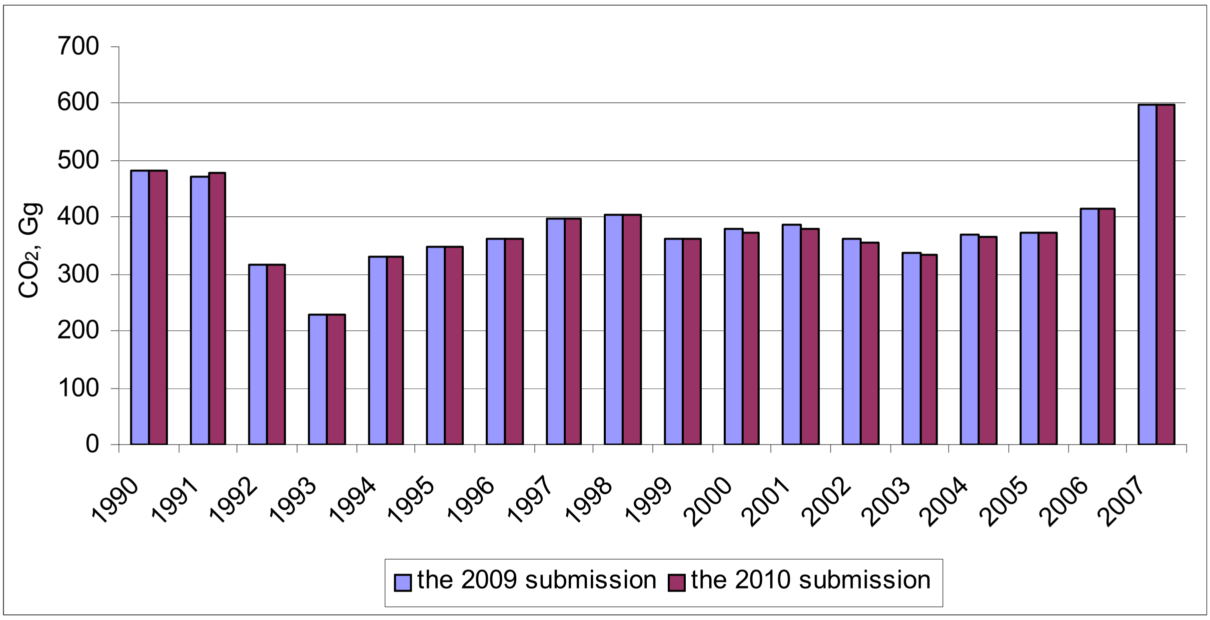


Figure 4.3. CO_2 emissions from cement production in 2009 Submission and in 2010 Submission.

4.2.1.6. Source-specific planned improvements

Estonia is planning to use EU-ETS data for verification from 2011 Submission as the recommendation of the UNFCCC review team.

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: AS Nordkalk and AS Limex.

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 AS Limex emission factor has been available since 1994 (production in AS Limex started in 1994). From AS Nordkalk 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 4.4.) 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 (1997-2008). 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 and taken partly from industrial statistics, 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 activity data took into account the uncertainty of plant-level data. Due to lack of knowledge activity data from 1990-1996 are partly taken from industrial statistics, this has also been taken into account in uncertainty estimations.

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

- From 1990-1996 default emission factor for quicklime has been used
- In case of one production plant emission factors from 1990-2004 are established as a mean value from emission factors in 2005-2008.

4.2.2.4. 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 QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.2.2.5. Source-specific recalculations

Emissions from lime production were recalculated throughout the time series. Emissions in 1990-1996 were recalculated due to applying plant specific emission factors to two production plants. Emissions in 1997-2007 were recalculated due to better activity data and plant specific emission factors available. Those recalculations were recommended by UNFCCC Review Team and in the results of Twinning Light Project EE06-IB-TWP-ENV-06. Difference between 2009 Submission emissions and 2010 Submission emissions from lime production is brought out in Figure 4.4.

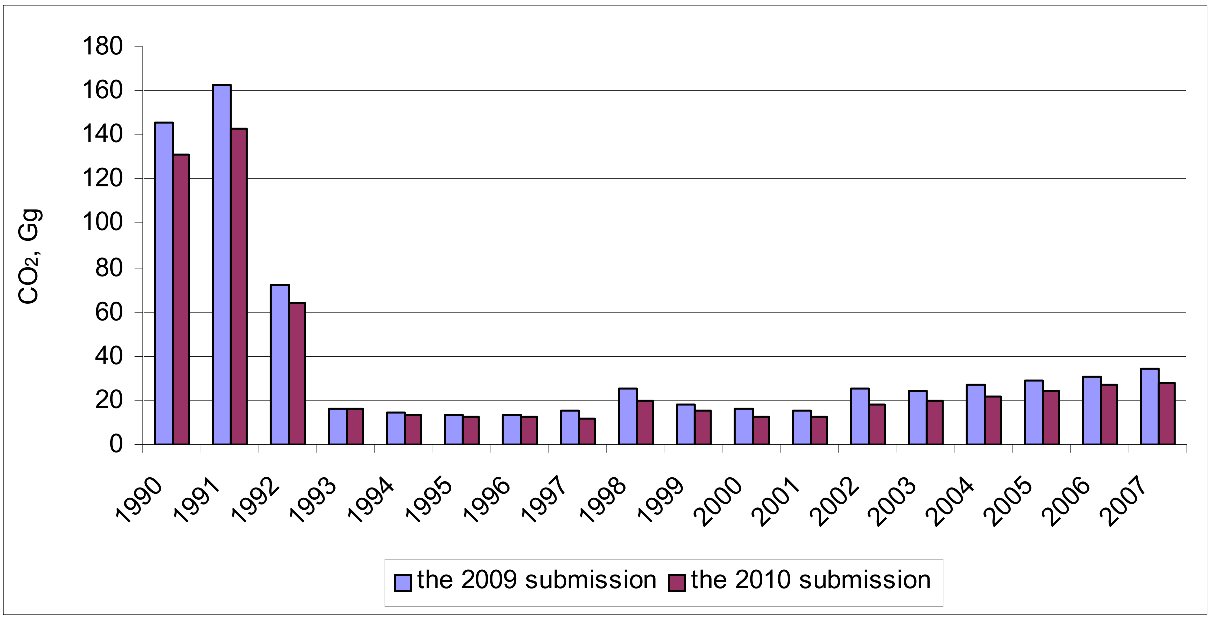


Figure 4.4. CO_2 emissions from lime production in 2009 Submission and in 2010 Submission.

4.2.2.6. Source-specific planned improvements

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

4.2.3. Glass Production

4.2.3.1. Source category description

This is the first year of reporting emissions from glass production. Emissions reported in 2010 Submission are calculated by using data from container glass production company- O-I Production Estonia AS. Investigation in this category started in 2009 and is still proceeding. As O-I Production Estonia AS (previously AS Järvakandi Klaas) started production in 1992, emissions from 1990-1991 are not estimated.

4.2.3.2. Methodological issues

METHODS

Process emissions in glass production are generated from limestone and soda ash use and they are calculated by multiplying emission factors with the amount of used carbonates. Activity data (1992-2008) is collected directly from glass producing company- O-I Production Estonia AS.

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.

Activity Data

The consumption of limestone and sodium carbonate has been used as activity data when calculating emissions from limestone and soda ash use. Activity data is collected directly from glass producing plant- O-I Production Estonia AS (Table 4.4.).

4.2.3.3. 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%.

4.2.3.4. 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 QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.2.3.5. Source-specific recalculations

As it was the first year of reporting emissions from glass production, data was recalculated from 1992-2007.

4.2.3.6. Source-specific planned improvements

To complete the investigation over time series.

Table 4.4. Activity data and emission factors for mineral products (Gg).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
$EF_{clinker}$, 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
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
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	42.2	43.4	39.5
IEF_{lime}, t/t	0.71	0.691	0.702	0.759	0.767	0.751	0.717	0.642	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.648	0.647	0.638	0.641
2.A.7.1																			
Limestone Consumption, kt	NE	NE	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
$EF_{default}$, t/t	NE	NE	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	NE	NE	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
$EF_{default}$, t/t	NE	NE	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

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 4.5). In Estonia there is only one ammonia production company- AS Nitrofert.

CO_2 emissions from ammonia production have decreased considerably since 1990, having the lowest values in 1993 and 2002. 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 relevant years there were reconstructions in AS Nitrofert that strongly affected production.

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 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 11).

According to the Tier 1a method:

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

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 4.5.).

Activity data

The annual ammonia production figures 1990-2008 have been obtained from the production plants and presented in Table 4.5.

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

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.3.1.5. Source-specific recalculations

CO_2 emissions from ammonia production were recalculated throughout time series. Previously the method used in calculating CO_2 ammonia production emissions did not take into account CO_2 from ammonia production that was used for carbamide (urea) production and CO_2 for sale. In 2010 submission, method Tier 1a was used, taking also into account CO_2 for urea production and CO_2 for sale. The change of method was recommended by UNFCCC Review Team and in the results of Twinning Light Project EE06-IB-TWP-ENV-06. Difference between 2009 Submission emissions and 2010 Submission emissions from ammonia production is brought out in Figure 4.5.

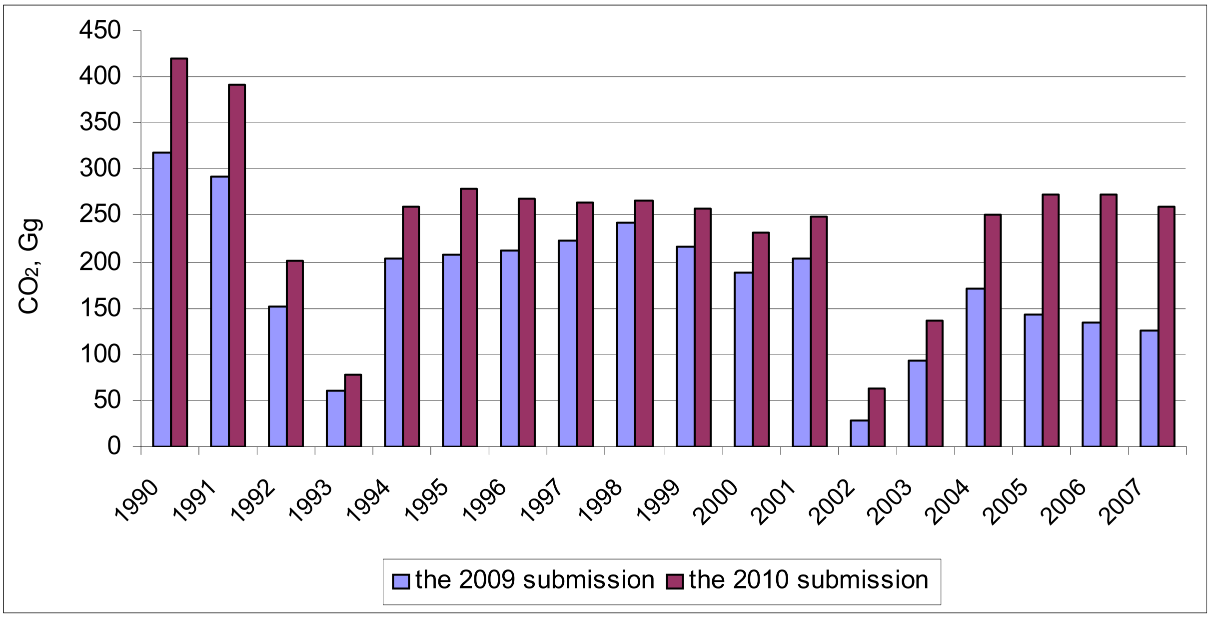


Figure 4.5. CO_2 emissions from ammonia production in 2009 Submission and in 2010 Submission.

4.3.1.6. Source-specific planned improvements

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

Table 4.5. Activity data, emission factors and CO_2 emissions from ammonia production in 1990-2008.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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
$EF_{ammonia}$, t/t	1.429	1.446	1.431	1.434	1.44	1.391	1.325	1.282	1.266	1.294	1.308	1.356	1.349	1.389	1.243	1.28	1.285	1.289	1.293
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
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
CO_2 sold for food industry, Gg	2.753	2.675	1.365	0.228	0.446	1.658	1.761	2.139	2.316	2.639	4.158	6.828	1.891	3.198	6.05	6.05	7.07	7.104	7.766

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. 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 the Statistics Estonia “Industry” and of the years 1995-2008 from the electronic database on the web site 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

The amount of produced food and drink was corrected for year 1992, 1995-2007. Those recalculations were due to corrections in meat production data. The emissions from pulp and paper were corrected for years 1992, 1993, 1999-2007.

4.4.4. Source-specific planned improvements

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

4.5. Consumption of Halocarbons and SF6 (CRF 2.F)

In 2008, greenhouse gas emissions under the category CRF 2.F emissions of Consumption of Halocarbons and SF_6 amounted to 133.466 Gg CO_2 equivalent, which is about 0.66% 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), SF_6 emissions from electrical and other electrical equipment (CRF 2.F.8 and 2.F.9) and PFC emissions from sport shoe soles (CRF 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 4.6. and Figure 4.6.), especially HFC emissions from refrigeration and air-conditioning equipment, which is the major source of halocarbons in Estonia (see Figure 4.7.). 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 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 4.6. Actual emissions of HFCs, PFCs and SF_6, 1995-2008 (CO_2 equivalent Gg).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
HFCs	NO	NO	NO	0.03	0.05	25.68	30.89	36.7	46.33	56.14	70.13	86.14	87.28	92.71	105.49	118.82	135.66	140.78	132.08
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.07	0.06	0.04
SF_6	NO	NO	NO	NO	NO	3.22	3.51	3.0	2.99	3.01	2.73	1.74	1.43	1.31	1.08	1.08	1.15	0.97	1.35
Total	NO	NO	NO	0.03	0.05	28.9	34.4	39.7	49.32	59.15	72.86	87.88	88.71	94.02	106.57	119.89	136.89	141.8	133.47

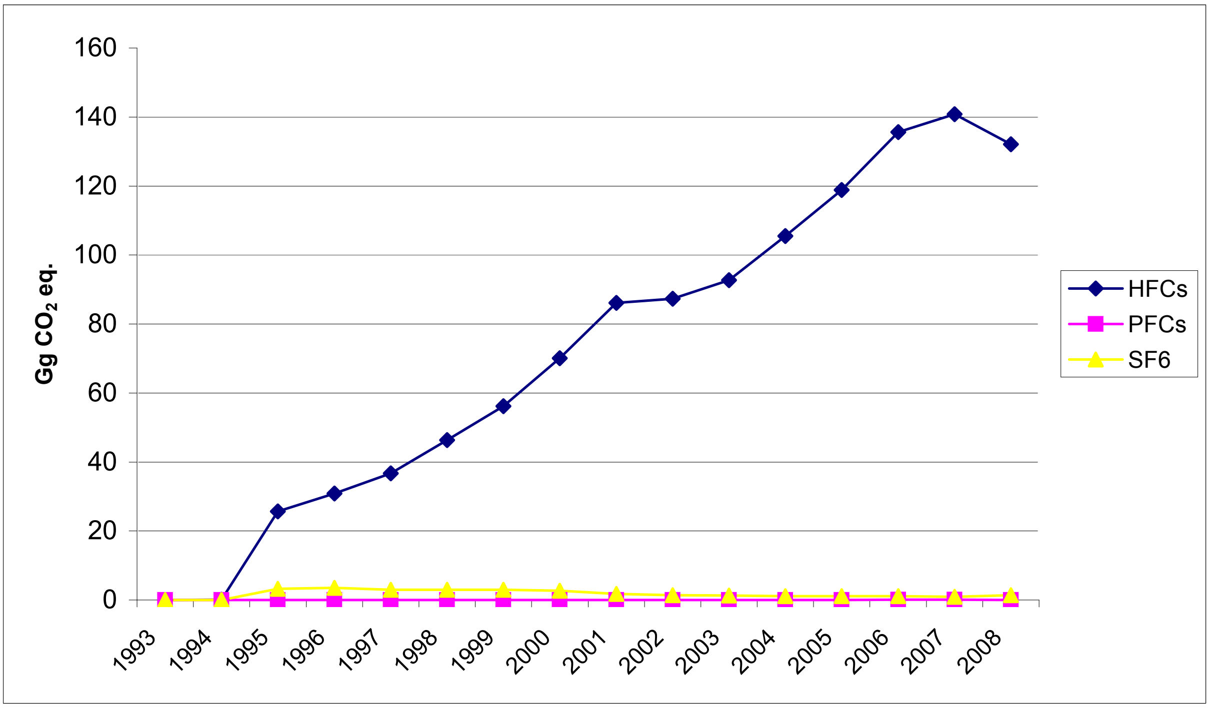


Figure 4.6. Actual emissions of HFCs, PFCs and SF_6, 1995-2008 (Gg CO_2 eq.).

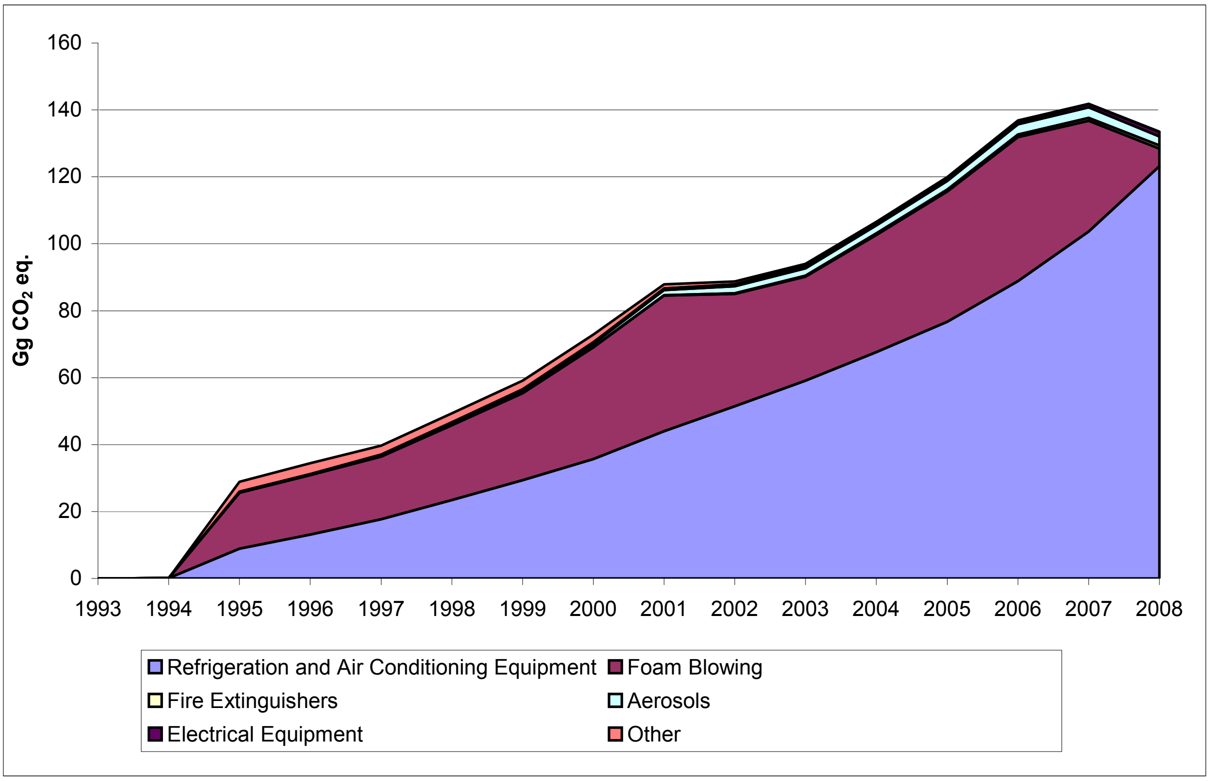


Figure 4.7. Actual emissions of F-gases by subcategory, 1993-2008 (Gg CO_2 eq.).

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.

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 92.3% of the Estonian F-gas emissions (123.149 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 imported (new and second hand). To some degree HFC-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. Today only a small part of imported new domestic refrigeration equipment operates with HFC-134a (1% according to Estonian experts). The share of HFC-134a in the Estonian stock of fridges/freezers is (depending on imports from different manufacturers) bigger and is estimated 12.5%.

4.5.1.1.2. Methodological issues

In 2008 Estonia had – according to the statistical office – about 584,000 households with 587,600 refrigerators. The number of newly imported fridges/freezers in 2008 is estimated at 66,000, about 5% of which are freezers (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 57,158 (12.5% without new equipment in 2007-2008) à 150 g HFC-134a refrigerant, in total 8,574 kg HFC-134a. In newly imported/bought systems in 2007, 2008 – annually 130,340 units – some 1% contains HFC-134a, in total 196 kg HFC-134a. Lifetime of domestic refrigeration equipment in Estonia is calculated by industry at not less than 15 years.

Emission factors: EES Ringlus reports that in 2008 about 5% of 24,900 fridges (1,245 units) collected for recycling contained HFC-134a as refrigerant with a loss of 25-30% of the original charge. The annual operating emission rate is, following this information, 2%/year (EF_{op}). This country specific emission factor is higher than the IPCC 2006 guidelines default value of max. 0.5%/year.

The number of refrigerators decommissioned per annum can be calculated (based on 15 years lifetime) at 39,170 from which 24,900 are collected by the recycling companies and sent for treatment to foreign countries (mostly Finland); remaining 14,270 are disposed without refrigerant recovery. If we assume (i) that 5% of these 14,270 non-collected refrigerators contain HFC-134a, and (ii) that in each of them 70% of the original 150 gram charge is left (30% already emitted), the disposal HFC-134a emissions are 75 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 HFC-134a
- Country specific operating emission factor: 2%

The total 2008 amount of HFC-134a emissions is 0.2504 tons (stock emissions: 175 kg, end-of-life emissions: 75 kg) representing 325.5 tons 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 quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.1.5. Source-specific recalculations

No source-specific recalculations have been done.

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 report 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 HFC-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 HFC-134a.
- Stand alone or plug-in equipment (mostly vending machines for shops, filling stations etc., on average 250 g HFC-134a/device).

The commercial refrigeration sector is dominated by the refrigerants R-404A, which make 89.5% of the 2008 HFC stock (mostly used in supermarket systems) and HFC-134a (about 10%, mainly used in vending machines and small shops). Other HFC refrigerants (R-407C, R-410A or the HFC-152a containing mixture R-401A) are only of less importance.

In general Estonian refrigeration equipment 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 2008 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 3,250 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. Seven service companies provided the activity data (stock, new installations in 2008, refilling data) on the HFC refrigerant consumption of their clients in the supermarket sector. Four service companies provided only 2007 stock data and new installations had to be added by their estimations. The 2008 stock data compilation from the service companies was 51.832 tons HFC. R-404A stock had to be completed in two cases by assessment of the stock summing 2008 stock of R-404A 57.474 tons and total HFC stock 57.822 tons. This assessment was based on the refilling data provided by the two service companies. 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. Thus 10% was added resulting in a total amount of 63.604 tons of HFC for the 2008 stock of supermarkets.

Small shops: Seven service companies (five 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%). In two cases 2008 new installations had to be added by service company's estimations. In this sub sector also a 10% surcharge was added resulting in a total stock of 6.543 tons HFC.

Restaurants etc.: The companies installing and servicing refrigeration equipment for restaurants, canteens and similar institutions did not provide stock data. The respective 2006 stock was estimated based on a number of 3,250 possible clients with on average 0.75 kg refrigerant quantity resulting in about 2.4 tons HFC-refrigerant. The number of new installations in 2007, 2008 was added based on data from companies active in this field. In 2008 the companies sold new equipment with 222 kg refrigerants. The percentage of HFC-134a is estimated by Estonian experts at about 2/3 (1.931 tons), the percentage of R-404A with about 1/3 (0.944 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 HFC-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.

Emissions: The service companies were asked for 2008 stock data and refilling data of their clients. In supermarket sub sector R-404A refilling ratio from companies who reported refilling data and stock data is about 14%. Normally emissions are higher than the refilling ratio. A certain fraction of emissions is never replenished by refilling. On the other hand Estonian database is still too small to allow more detailed emission rate calculation. 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).

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. 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 2008 amounts to 11.124 tons (11.11 tons R-404A and 0.013 tons HFC-134a). The manufacturing emissions from this filling are 55.618 kg. The HFC stock amounts to 76.772 tons (68.722 tons R-404A, 7.641 tons HFC-134a and small amounts of R-407C, HFC-152a and R-410A). The stock emissions are in total 11.009 tons. The biggest part of them is R-404A (10.303 tons) and HFC-134a (0.645 tons), the emissions of the other HFC are only 61 kg. As the first filling of HFC-134a took place in 1993, then according to 15 years of lifetime, first disposal emissions occurred in 2008. The amount of fluid remained at products at decommissioning amounts to 0.211 tons of HFC-134a. The disposal emissions are in total 0.105 tons of HFC-134a.

The CO_2 equivalent of all 2008 HFC emissions is 34.815 Gg (34,815 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 quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.2.5. Source-specific recalculations

Emissions from commercial refrigeration were recalculated in case of HFC-134a from 1993-2005, in case of R-404A from 1995-2005 and in case of R-407C from 1997-2005. Those years represent the years of starting using those refrigerants. Previously German percentages of the years 1995-2005 were used. In 2010 submission emissions were calculated as a steady increase (every year the same quantity of new equipment) as it is believed that it is more appropriate method for Estonia. There is no backdating information based on real usage of F-gases available in Estonia.

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

4.5.1.3.1.1 Source category description

By 31.12.2008, 1,283 refrigerated vans and trucks and 967 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.

4.5.1.3.1.2 Methodological issues

The Estonian Motor Vehicle Registration Centre provided a list of all refrigerated vehicles registered at the end of 2008, 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).

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 HFC-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%. 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.

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 2008 quantity of HFCs filled in empty units of refrigerated vehicles in Estonia amounts to 125.5 kg HFC-134a and 1,584 kg R-404A, the “manufacturing” emissions on these first fills are 1.3 kg HFC-134a and 15.8 kg 404A. The HFC stock in refrigerated vehicles amounts to 787.9 kg HFC-134a and 15,992 kg R-404A; the stock emissions are 236.4 kg HFC-134a and 4,251 kg R-404A. The CO_2 equivalent of all 2008 HFC emissions is about 12,532 tons (12.532 Gg).

4.5.1.3.1.3 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 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 2008 (± 1%), b) refrigerant charges (± 6%) and c) refrigerant split into HFC-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%.

4.5.1.3.1.4 Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.3.1.5 Source-specific recalculations

No source-specific recalculations have been done.

4.5.1.3.1.6 Source-specific planned improvements

In the future, attempts should be made to determine more precisely the share of second hand imports with empty refrigeration units.

Time series starting from base year 1990 will be established.

4.5.1.3.2. Reefer Containers

4.5.1.3.2.1. 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% (0.097%), so that it is responsible of 0.097% of HFC stock and HFC emissions of the worldwide reefer container fleet.

4.5.1.3.2.2. 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 HFC-134a and R-404A (80% to 20%).

The emissions of HFC-134a and R-404A are calculated by means of emission factors. The operating emission factor is 10%[9], the disposal emission factor is 30%. (Manufacturing emissions are not distributed by world trade shares but are estimated in the (few) countries of container manufacturing).

Information about the 2008 share of Estonia in the world trade (both export and import) was given by the Statistical Office.

From 2008 onwards, the annual updating of the worldwide data does no longer rely on the German inventory. 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 2008 HFC stock emissions from reefer containers attributable to Estonia are 408.2 kg HFC-134a (530.66 t CO_2 eqv.) and 49.6 kg R-404A (161.7 t CO_2 eqv.). The 2008 emissions from the decomissioning of reefer containers attributable to Estonia are 20.5 kg HFC-134a (26.6 t CO_2 eqv.). The total is 718.95 t or 0.719 Gg CO_2 equivalent.

4.5.1.3.2.3. 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 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%).

[9] UNEP, 2002 Report of the Refrigeration, Air Conditioning and Heat pumps technical options committee 2002 Assessment, Nairobi, January 2003, p. 92.

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%.

Time series 1995-2005 were established in 2008.

4.5.1.3.2.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.3.2.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.1.3.2.6. Source-specific improvements

Time series starting from base year 1990 will be established.

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. 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 94.6%. Other HFC refrigerants (HFC-134a, R-402A, R-407C, R-507A or the HFC-152a containing mixture R-401A) 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.vt.agri.ee) because companies wishing to handle foodstuff must be approved by the VTA. Approved enterprises: Fish industry - more than 60 plants with chilling/freezing equipment; meat industry - 120 plants; dairy industry – 38 plants.

Nine service companies provided the activity data (stock, new installations in 2008, refilling data) on the HFC consumption of their industrial clients. Three service companies provided only 2007 stock data and new installations had to be added by their estimations. In two cases the service companies could not report on 2008 stock data. These data had to be completed by our assessment. (The assessment is based on the refilling data provided by the service companies, and the 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 21.496 tons (48.318 tons, reported and assessed). About two thirds of the estimated HFC stock amount is attributable to one big service company who could not provide stock data for 2008 but only 2006-2008 newly installed systems. Better stock data from this company will significantly enhance the overall quality of the stock data in the future.

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.

Emissions: The service companies and the industrial companies surveyed by questionnaires were asked for 2008 stock and refilling data. Complete stock and refilling data for R-404A are available for 20 individual companies in the fish, meat, milk, and beverage industry, with an R-404A stock of 8.556 tons. The refilling ratio of the individual companies range from 0 to 34%. The average refilling rate is 7.2%. As refilling ratio from service companies was higher (about 25%) and as there is no longer research over refilling ratios, ratio used in 2006-2007 was adapted (14%).

As in the case of industrial refrigeration the emission factor (EF_{op}) for the stock is country specific, i.e. is based on the year 2008 average refilling ratio in the industry, with 14%. This emission factor is in the range of the IPCC guidelines 2006 (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. The EF_{disp} (disposal loss factor) is estimated at a value of 50%.

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 2008 amounts to 4.823 tons (2.414 tons HFC-143a, 2.088 tons HFC-125, 0.279 tons HFC-134a and 0.041 tons of HFC-32). The manufacturing emissions from filling are 24.12 kg. The HFC stock amounts to 48.318 tons (23.999 tons HFC-143a, 20.821 tons HFC-125, 3.166 tons HFC-134a, 0.331 tons HFC-32 and small amount of HFC-152a). The stock emissions total 6.765 tons. The biggest parts of them are HFC-143a (3.36 tons), HFC-125 (2.915 tons) and HFC-134a (443 kg); the emissions of the other HFCs are only 46.53 kg. As the first filling of HFC-134a took place in 1993, then according to 15 years of lifetime, first disposal emissions occurred in 2008. The amount of fluid remained at products at decommissioning amounts to 0.016 tons of HFC-134a. The disposal emissions are in total 0.008 tons of HFC-134a.

The CO_2 equivalent of all 2008 HFC emissions is 21.623 Gg (21,623 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 two activity data “Filled in new manufactured products” and “HFC stock in operating systems” is estimated ± >25% (26%). This high value mainly results from the high share of estimations in the determination of total HFC stock. The UN of the activity data “Remained in products at decommissioning” is estimated ± 20% (0.2).

The combination of this value with the UN of the respective emission factors (± 15%) results in the UN of both manufacturing and operating HFC emissions of ± 30%.

4.5.1.4.4. Source-specific QA/QC and verification

The data for this report was partly collected within the framework of the Twinning Project EE2005/IB/EN/01.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.4.5. Source-specific recalculations

Emissions from industrial refrigeration were recalculated in case of HFC-134a from 1993-2005, in case of R-404A from 1995-2005 and in case of R-407C from 1997-2005. Those years represent the years of starting using those refrigerants. Previously German percentages of the years 1995-2005 were used. In 2010 submission emissions were calculated as a steady increase (every year the same quantity of new equipment) as it is believed that it is more appropriate method for Estonia. There is no backdating information based on real usage of F-gases available in Estonia.

4.5.1.4.6. Source-specific planned improvements

More detailed research of refilling ratios.

4.5.1.5. Stationary Air Conditioning

4.5.1.5.1. Heat Pumps

4.5.1.5.1.1. 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 R-407C, air heat pumps with R-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.

4.5.1.5.1.2. Methodological issues

The leading expert of the Estonian Heat Pump Association provided information on heat pumps in Estonia in cooperation with the three biggest suppliers of heat pumps in the country. 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. 30,258 systems in 2008 (5,059 ground, 25,040 air and 159 other heat pumps), about one-third of them were installed in 2008 (11,580). According to the experts 11 ground and 20 air HP went for decommissioning in 2008. 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%, for operating systems (EF_{op}) of 2.5% and for disposal (EF_{disp}) of 30.0%.

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 210 kg R-407C, the manufacturing emissions 4.2 kg R-407C. The 2008 operating stock amounts to 10,436 kg R-407C (ground and other HP) and 25,040 kg R-410A (air HP). The 2008 operating emissions total 260.9 kg R-407C and 626 kg R-410A. The amount of fluid remained in HP at decommissioning was 22 kg R-407C and 20 kg R-410A. The 2008 disposal emissions in total 6.6 kg R-407C and 6 kg R-410A.

All global warming emissions together amount to 1504.678 t CO_2 equivalent (1.505 Gg).

4.5.1.5.1.3. 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 activity data HFC consumption and HFC stock is estimated at ± 9%. The emission factors are estimated ± 5%. The combination of the UN of the stock/consumption with the UN of the emission factors results in the UN of the HFC emissions of ± 10.3%.

4.5.1.5.1.4. 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 QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.5.1.5. Source-specific recalculations

Emissions from heat pumps were recalculated from 1998 – 2004 due to better data available from Estonian Heat Pump Association.

4.5.1.5.1.6. 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

4.5.1.5.2.1. 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 R-407C and R-410A.

4.5.1.5.2.2. Methodological issues

The 2008 newly installed systems, the total 2008 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 2008 the following numbers of operating systems: 525 chillers, 3,800 ventilation systems and 34,500 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.

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).

The operating stock amounts to 82.895 t HFC-134a, 37.752 t HFC-32 and 39.637 t HFC-125. Operating emissions: 3.724 t HFC-134a, 2.159 t HFC-32, 2.289 t HFC-125.

All global warming emissions together amount to 12.690 Gg CO_2 equivalent (12,690 t CO_2 equivalent).

4.5.1.5.2.3. 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 A/C 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).

4.5.1.5.2.4. Source-specific QA/QC and verification

The data for this report was partly collected within the framework of the Twinning Project EE2005/IB/EN/01.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.5.2.5. Source-specific recalculations

Emissions from stationary and room air-conditioning were recalculated from 1995-2005. In Estonia usage of room air-conditioning equipment with R-407C started in 1998, with R-410A in 2000. Usage of stationary air-conditioning equipment with HFC-134a started in 1995, with R-407C in 1997. Previously German percentages of the years 1995-2005 were used. In 2010 submission emissions were calculated as a steady increase (every year the same quantity of new equipment) as it is believed that it is more appropriate method for Estonia. There is no backdating information based on real usage of F-gases available in Estonia.

4.5.1.5.2.6. Source-specific planned improvements

The emission factors of split systems and chillers estimated by the national sector experts are deemed by far too low compared with values discussed in other countries. They should be reviewed in the next years.

4.5.1.6. Mobile Air Conditioning

4.5.1.6.1. Passenger Cars

4.5.1.6.1.1. Source category description

In 2008, there were about 543,000 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 325,800 vehicles of the Estonian passenger cars have been manufactured from 1994 onwards approx. 60% 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%.

4.5.1.6.1.2. Methodological issues

The Estonian Motor Vehicle Registration Centre provided a list of all passenger cars registered at the end of 2008, 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[10], which the authors of this study claim to be representative of EU countries.

Method according to IPCC Guidelines 2006: Tier 2a with Europe specific determination of EF.

- Country-specific average refrigerant charge: 625 grams.
- Emission factor: 10%.
- 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 130.814 tons in the year 2008. The HFC-134a emissions from the Estonian passenger car fleet in 2008 total 13, 081 kg (10%), the CO_2 equivalent of which is 17,006 tons.

The amount of HFC-134a in the passenger cars MACs disposed in 2008 was estimated 10, 063 kg. Disposal emissions from the Estonian passenger car fleet in 2008 total 5,031 kg (EF=50%), the CO_2 equivalent of which is 6,541 tons.

The CO_2 equivalent of all 2008 HFC emissions is 23,547 tons (23.547 Gg).

[10] Öko-Recherche/Ecofys (Winfried Schwarz and Jochen Harnisch): Establishing the leakage rates of mobile air conditioners (B4-3040/2002/337136/MAR/C1). For the European Commission (DG Environment), April 2003.

4.5.1.6.1.3. 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.

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%.

Time series 1995-2005 were established in 2008.

4.5.1.6.1.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.6.1.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.1.6.1.6. Source-specific planned improvements

Time series starting from base year 1990 will be established.

4.5.1.6.2. Trucks

4.5.1.6.2.1. Source category description

In 2008, there were about 77,900 trucks of the weight classes (according to 2002/16/EC) N1, N2, and N3 in traffic register of Estonia, 61% 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.

4.5.1.6.2.2. Methodological issues

The Estonian Motor Vehicle Registration Centre provided a list of all trucks registered at the end of 2008, 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[11]: weight class N1: 10%; weight classes N2 and N3: 15%.
- 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 19,844 kg in the year 2008. The HFC-134a emissions from the Estonian truck fleet in 2008 total 2,574 kg (13%), the CO_2 equivalent of which is 3,347 tons.

The amount of HFC-134a in the truck MACs disposed in 2008 was estimated 1,527 kg. Disposal emissions from the Estonian truck fleet in 2008 total 763.2 kg (EF=50%), the CO_2 equivalent of which is 992.2 tons.

The CO_2 equivalent of all 2008 HFC emissions is 4,339 tons (4.339 Gg).

4.5.1.6.2.3. 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.

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%.

[11] Öko-Recherche (Winfried Schwarz): Establishing the leakage rates of mobile air conditioners in heavy duty vehicles (070501/2005/422963/MAR/C1). Part I trucks, and part II buses, For the European Commission (DG Environment), February 2007.

Time series 1995-2005 were established in 2008.

4.5.1.6.2.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.6.2.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.1.6.2.6. Source-specific planned improvements

Time series starting from base year 1990 will be established.

4.5.1.6.3. Buses

4.5.1.6.3.1. Source category description

In 2008, about 3,150 buses were operated in Estonia, 1,550 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.

4.5.1.6.3.2. Methodological issues

The Estonian Motor Vehicle Registration Centre provided a list of all buses registered at the end of 2008 (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 (see the 2007 bus study for the European Commission[12]) 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.[13]

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.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.

[12] Öko-Recherche (Winfried Schwarz): Establishing the leakage rates of mobile air conditioners in heavy duty vehicles (070501/2005/422963/MAR/C1). Part I trucks, and part II buses, For the European Commission (DG Environment), February 2007.

[13] 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 total HFC-134a stock in bus MACs in Estonia amounts to 8,330 kg in the year 2008. The HFC-134a emissions from the Estonian bus fleet in 2008 total 1,269 kg (15.2%), the CO_2 equivalent of which is about 1,650 tons.

The amount of HFC-134a in the bus MACs disposed in 2008 was estimated 555.3 kg. Disposal emissions from the Estonian bus fleet in 2008 total 277.7 kg (EF=50%), the CO_2 equivalent of which is 361 tons.

The CO_2 equivalent of all 2008 HFC emissions is 2,011 tons (2.011 Gg).

4.5.1.6.3.3. 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.

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%.

Time series 1995-2005 were established in 2008.

4.5.1.6.3.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.6.3.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.1.6.3.6. Source-specific planned improvements

Time series starting from base year 1990 will be established.

4.5.1.6.4. Ships

4.5.1.6.4.1. 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. In Estonia, 36 ships with air-conditioning are registered. Refrigerants in use are HCFC-22, R-407C (mixture), R-404A (mixture) and HFC-134a as the new standard refrigerant[14]. By far most HFC-refrigerants are used for air-conditioning (HFC-134a); only a small part is used for provision cooling (HFC-134a, R-404A, R-407C). The cooling ad freezing systems of the Estonian deep-sea freezer trawlers operate without HFC (refrigerants: R-22 and ammonia).

4.5.1.6.4.2. 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,

[14] Winfried Schwarz (Öko-Recherche) and Jan-Martin Rhiemeier (Ecofys), The analysis of the emissions of fluorinated greenhouse gases from refrigeration and air conditioning equipment used in the transport sector other than road transport and options for reducing these emissions: Maritime, Rail, and Aircraft Sector. Prepared for the European Commission (07010401/2006/445124/MAR/C4), November 2007.

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 2008 were provided directly by the ship owners. The estimation of the stock emissions is based on direct measurement (refilling data 2008).

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific HFC refrigerant stock: 6,932 kg HFC-134a; 417.6 kg R-404A and 50 kg R-407C.
- Country-specific stock emissions (refills), EF = 30%: 2,080 kg HFC-134a; 125.3 kg R-404A and 15 kg R-407C.

The CO_2 equivalent of the stock emissions (all HFC together) is 3,135 tons (3.135 Gg).

4.5.1.6.4.3. 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.

Time series 1995-2005 were established in 2008.

4.5.1.6.4.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.6.4.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.1.6.4.6. Source-specific planned improvements

Data on tugboats >100 GT and Estonian naval ships will be collected.

Time series starting from base year 1990 will be established.

4.5.1.6.5. Railcars

4.5.1.6.5.1. Source category description

In 2008, there were 34 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 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. 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.

4.5.1.6.5.2. 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 34 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: all types of railcars 30 kg/a of R-401A (4.5 kg of HFC-152a).
- Country-specific emission factors: calculation based on annual losses of R-401A (200 kg) and the amount of refrigerant stock leads to the implied emission factor of 0.1961 for all types of railcars.

The total HFC-152a stock in railcar MACs in Estonia amounts to 153 kg in the year 2008. The HFC-152a emissions from the Estonian railcars in 2008 total 30 kg (19.6%), the CO_2 equivalent of which is 4,200 kg based on the GWP 140 of HFC-152a.

There were 95 trams in Estonia, newer ones of these are potentially air-conditioned. However, according to the only Estonian operator (TTTK) none of the vehicles is equipped with a MAC.

4.5.1.6.5.3. 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.

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%.

Time series 1995-2005 were established in 2008.

4.5.1.6.5.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.6.5.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.1.6.5.6. Source-specific planned improvements

Time series starting from base year 1990 will be established.

4.5.1.6.6. Wheel Tractors and Mobile Machinery

4.5.1.6.6.1. 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. Thus only 15% of the 33,000 operating agricultural machines, 32% of the 5,000 construction machines, and 20% of the 1,100 other mobile machines in use in Estonia are potentially air conditioned, in 2008. 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.

4.5.1.6.6.2. Methodological issues

The Estonian Motor Vehicle Registration Centre published in the yearbook of 2008 the number of wheel tractors and mobile machinery registered in the end of 2008. The vehicles were classified according to the production years into 4 categories of up to 2 years, 3 to 5 years, 6 to 10 years, and over 10 years old machines. Official data about air conditioning of the vehicles were not available.

The main seller of agricultural and construction machines on the Estonian market (Mecro) was interviewed about the relevant MAC data in 2007. It shows that 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%; combine harvesters, construction machines, forestry and roadwork machines 25%.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.

In 2008, the total HFC-134a stock in tractor and mobile machinery MACs in Estonia amounts to 12,488 kg in the year 2008. The HFC-134a emissions from the entire Estonian fleet total 2,697 kg (21.6%) the CO_2 equivalent of which is about 3,506 tons (3.506 Gg).

The amount of HFC-134a in the tractor/mobile machinery MACs disposed in 2008 was estimated 960.6 kg. Disposal emissions from the Estonian fleet in 2008 total 480.3 kg (EF=50%), the CO_2 equivalent of which is 624.4 tons.

The CO_2 equivalent of all 2008 HFC emissions is 4,130 tons (4.130 Gg).

4.5.1.6.6.3. 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.

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%.

Time series 1995-2005 were established in 2008.

4.5.1.6.6.4. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.1.6.6.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.1.6.6.6. Source-specific planned improvements

Time series starting from base year 1990 will be established.

4.5.2. Foam Blowing

4.5.2.1. PU Insulation Panels

4.5.2.1.1. Source category description

In 2008 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%.[15]

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).

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{op}: 0,5%.

The 2008 Estonian HFC-134a bank in PU insulation panels amounts to 15.23 tons, the annual use-phase emissions are 0.076 tons (98.97 tons or 0.099 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.

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%.

Time series 1998-2005 were established in 2008.

4.5.2.1.4. Source-specific QA/QC and verification

[15] 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 data for this report was collected by the expert of Estonian Environmental Research Centre.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

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. 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.

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.

In 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.[16] 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%.
- 2008 domestic consumption: 278 kg HFC-365mfc, 22 kg 227ea and 20 kg HFC-134a.

Manufacturing emissions: 55.6 kg HFC-365mfc, 4.4 kg HFC-227ea and 4 kg HFC-134a (EF = 20%), altogether 67.5 t CO_2 equivalent.

In 2008 the stock constituted of 276.3 kg HFC-365mfc, 34.9 kg HFC-227ea and 31.8 kg HFC-134a. Stock emissions: 2.8 kg HFC-365mfc, 0.4 kg HFC-227ea and 0.3 kg HFC-134a, altogether 3.9 t CO_2 equivalent.

[16] 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).

Total global warming emissions: 71.4 t CO_2 equivalent (0.071 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%.

A time series from 1995 to 2005 cannot be established because 2006 is the first year of HFC use in this application.

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.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.2.2.5. Source-specific recalculations

No source-specific recalculations have been done.

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 2008, one company in Estonia used HFC-365mfc and HFC-227ea for manufacturing of a very small amount of PU integral skin products.

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 2008 consumption of HFC-365mfc was provided by the manufacturer of integral skin products in Estonia.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{manu}: 100%.
- 2008 consumption and manufacturing emissions of HFC-365mfc: 28 kg. Since the blowing agent always contains small amount of HFC-227ea to reduce the flammability of the substance this amount of the add-on was estimated to be 2.1 kg. Emissions total 31 tons CO_2 equivalent (0.031 Gg).

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.

A time series from 1995 to 2005 cannot be established because 2006 is the first year of HFC use in this application.

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.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

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.

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}: 0.66%.
- 2008 HFC-134a bank: 8.6 tons.
- 2008 use-phase emissions: 56.5 kg (0.66%) which is 73.4 t (0.073 Gg) CO_2 equivalent.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

4.5.2.4.2. 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%

Time series 2001-2005 were established in 2008.

4.5.2.4.3. Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.2.4.4. Source-specific recalculations

No source-specific recalculations have been done.

4.5.2.4.5. 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 as of 2008 both Estonian producers have now 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.

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 2008” is equated to the HFC content of OFC cans sold to the Estonian market and used in 2008. Hence only emissions from manufacturing and use (= stock) are entered in the CRF table, no emissions from disposal. The 2008 HFC-consumption was in total 817.7 t.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{manu}: 1.7%.
- Country specific EF_{op}: 100%.
- Manufacturing emissions: 14.04 tons HFC-152a or1,966 t CO_2 equivalent.
- Stock = use-phase emissions: 21.9 HFC-152a or 3,063 t CO_2 equivalent.

The HFC emissions from manufacturing and from stock total to 5,028 t or 5.028 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.

Time series 1995-2005 were established in 2008.

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.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.2.5.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.2.5.6. Source-specific planned improvements

Time series starting from base year 1990 will be established.

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 0.74% of the Estonian F-gas emissions (0.989 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 2008 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 2008 quantity of F-gases in installed fire fighting systems amounted to 16.806 t (13.271 t HFC-227ea, 0.567 t HFC-23 and 3.227 t R-866, the latter containing 8% CO_2 in mixture with HFC-134a and HFC-125). The emissions from this stock are calculated 2 percent: 11.33 kg HFC-23, 6.45 kg HFC-125, 52.91 kg HFC-134a and 265.43 kg HFC-227ea. The CO_2 equivalent of all 2008 HFC emissions is about 989.16 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 partly collected within the framework of the Twinning Project EE2005/IB/EN/01.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.3.5. Source-specific recalculations

No source-specific recalculations have been done.

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 2008 (production + import - export) is the stock of the same year 2008. (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.

In 2008 MDIs (asthma/COPD) with HFC-134a as propellant were sold to Estonian market by seven 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 2008 domestic consumption of HFC-134a was 1.3 tons (manufacturing emissions: 25.8 kg), of which 1.03 tons were sold to the domestic market, resulting in use-phase emissions of the same amount.
- Anti-Asthma MDIs: The 2008 domestic market was 1,952 kg, with the same quantity of emissions.

Overall emissions: 1.98 tons HFC-134a or 2,572 tons CO_2 equivalent (2.572 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%.

Time series 1995-2005 were established in 2008.

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.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.4.1.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.4.1.6. Source-specific planned improvements

Time series starting from base year 1990 will be established.

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 of signal horns provided data on his HFC-134a consumption for signal horns sold to the Estonian market in 2008; manufacturers from US and Germany submitted the respective data on solvent and cleaning sprays sold to Estonia. The number of cans for all purposes with HFC charge between 11 and 90 g/can sold in Estonia in 2008 was 2,089; the HFC-134a charge totalled 48.7 kg (average charge 23.3 g/can).

As in MDIs, the HFC-consumption for general aerosols in 2008 is equated to emission in the same year 2008 (EF_{op} 100%). The very small amount of emissions from manufacturing (3%) in case of the signal horns is calculated separately.

Method according to IPCC guidelines 2006: Tier 2a with country specific EF.

- Country specific EF_{manu}: 3%.
- Country specific EF_{op}: 100%.
- Country specific charge of aerosol cans: 23.3 g

The 2008 domestic consumption of HFC-134a for producing novelty aerosols was 41.5 kg (manufacturing emissions: 0.83 kg). 25.2 kg were sold to the domestic market, resulting in use-phase emissions of the same amount. The 2008 of HFC-134a stock emissions from general and novelty aerosols is 89.2 kg.

Overall emissions: 49.5 kg HFC-134a or 64.4 tons CO_2 equivalent (0.064 Gg).

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%.

Time series 1995-2005 were established in 2008.

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.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.4.2.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.4.2.6. Source-specific planned improvements

Time series starting from base year 1990 will be established.

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 1988 (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

Of the seven Estonian companies of electrical power distribution data, five companies 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 2.3 kg. The respective stock amounts to 7,494 kg (HV) and 2,910 kg (MV). Stock emissions: 36.4 kg (HV), 2.2 kg (MV). Total: 38.6 kg.

Total global warming emissions: 978 t CO_2 equivalent (0.978 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%.

Time series 1995-2005 were established in 2008.

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.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.5.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.5.6. Source-specific planned improvements

The data of the two missing operators shall be collected.

Time series starting from base year 1990 will be established.

4.5.6. Other

Under this category PFC emissions from sport shoes with gas cushion as well as emissions of SF_6 from radiotherapy devices are reported. This is very small category, which is responsible of about 0.07% Estonian F-gas emissions (0.09 Gg CO_2-equivalent).

4.5.6.1. Other Electrical Equipment

Under "Other Electrical Equipment" Estonia reports emissions of SF_6 from radiotherapy devices. This is very small group, which is responsible of about 0.04% Estonian F-gas emissions (0.051 Gg CO_2 equivalent).

4.5.6.1.1. Source-category description

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 and much elder system the EF_{op} was calculated at 30% a year, bases on the operator's experience from the last four years. The smaller equipment went to decommissioning at the end of 2008. The country specific EF_{op} deduced from this information is 11.2%. The discussion with the operator resulted in emission factor for disposal (EF_{disp}) of 4.0%.

Method according to IPCC guidelines 2006: Tier 2a with country specific EF.

- Country specific EF_{op}: 11.2%;
- Country specific EF_{disp}: 4%.

The 2008 stock of SF_6 totals 18.9 kg, the 2008 operating emissions 2.11 kg and the 2008 disposal emissions 0.03 kg.

Global warming emissions: 51.165 t CO_2 equivalent (0.051 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 partly collected within the framework of the Twinning Project EE2005/IB/EN/01.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.6.1.5. Source-specific recalculations

In 2010 submission disposal emissions from other electrical equipment were recalculated for year 1998. Previously no disposal emissions were reported.

4.5.6.1.6. Source-specific planned improvements

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

4.5.6.2. Sport Shoe Soles

Under this title PFC emissions from sport shoes with gas cushion are reported. This is very small group, which is responsible of about 0.03% Estonian F-gas emissions (0.038 Gg CO_2 equivalent).

4.5.6.2.1. Source-category description

Sport shoes using soles with SF_6-gas cushions were introduced to the European market in the early 1990's. From 2003 to 2005 SF_6 was replaced by PFC-218 (perfluoropropane). Footwear with SF_6/PFC-cushions has not been manufactured in Estonia but was imported. 100 percent of the F-gases in the soles are emitted at the end-of-life of the shoes. The lifetime is calculated at three years.

4.5.6.2.2. Methodological issues

Data on the Estonian market of sport shoes with PFC gas cushion were provided by the manufacturer. New footwear on the Estonian market has been clear of SF_6 from July 2003 onwards; final disposal emissions occurred in 2006; PFC-stock, PFC quantity for disposal/PFC disposal emissions have been calculated for 2004-2006, and 2006-2009, respectively.

The method follows IPCC guidelines 2006 (Emissions in year t = Sales in year t-3).

- EF_{disp}: 100% (IPCC GL).

The total 2008 quantity of PFC-218 in footwear at decommissioning (end of life emission) amounts to 5.5 kg. The CO_2 equivalent emissions are 38.49 t CO_2 equivalent (0.038 Gg).

4.5.6.2.3. 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 "sales in year 2004" and "emissions in 2007" can be estimated comparably low (± 10%).

4.5.6.2.4. Source-specific QA/QC and verification

The data for this report was collected within the framework of the Twinning Project EE2005/IB/EN/01.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.6.1.

The QA/QC plan for the industrial processes 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 checklist is used during the inventory.

4.5.6.2.5. Source-specific recalculations

No source-specific recalculations have been done.

4.5.6.2.6. Source-specific planned improvements

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

5. SOLVENTS AND OTHER PRODUCT USE (CRF 3)

Sector Solvents and Other Product Use (CRF 3) is presently under investigation. Primary examination started in the middle of 2009 during Twinning Light Project EE06-IB-TWP-ENV-06 “Improving the Quality of Estonia’s National greenhouse Gas Inventory”. Results of the investigation will be presented in the next submissions.

6. AGRICULTURE (CRF 4)

6.1. Overview of the sector

6.1.1. Description and quantitative overview

The total greenhouse gas emissions reported in the agricultural sector of Estonia were 1,447Gg CO_2 equivalents in 2008. The sector contributed about 7.1%[17] to the total GHG emissions in Estonia (Figure 6.1).

Agricultural GHG emissions in Estonia consist of CH_4 emissions from enteric fermentation of domestic livestock (for 14 sub-categories of livestock) and CH_4 end N_2O emissions from manure management systems, and 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; from cropping of N-fixing crops; emissions from crop residues and cultivation of organic soils. Indirect N_2O emissions include emissions from atmospheric deposition, leaching and run-off.

Enteric fermentation of livestock and direct emissions from agricultural soils contributed to the main share to the total emissions from the agricultural sector (Figure 6.1).

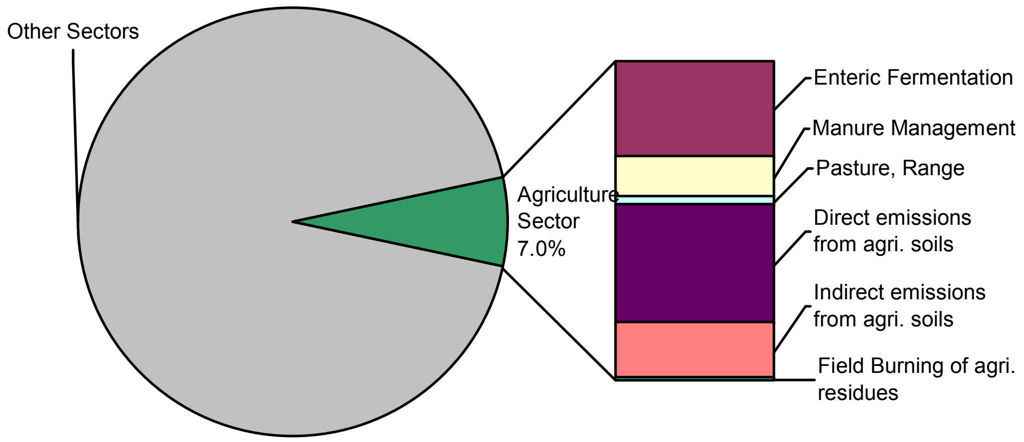


Figure 6.1. Emissions from agriculture compared to total GHG emissions in 2008, Gg

CO_2-equiv emissions from the agricultural sector have declined 53 per cent compared with the base year, mostly due to decreasing livestock population and to quantities of synthetic fertilizers and manure applied on agricultural fields (Figure 6.2, Table 6.1).

[17] GHG emissions related to LULUCF sector are not included.

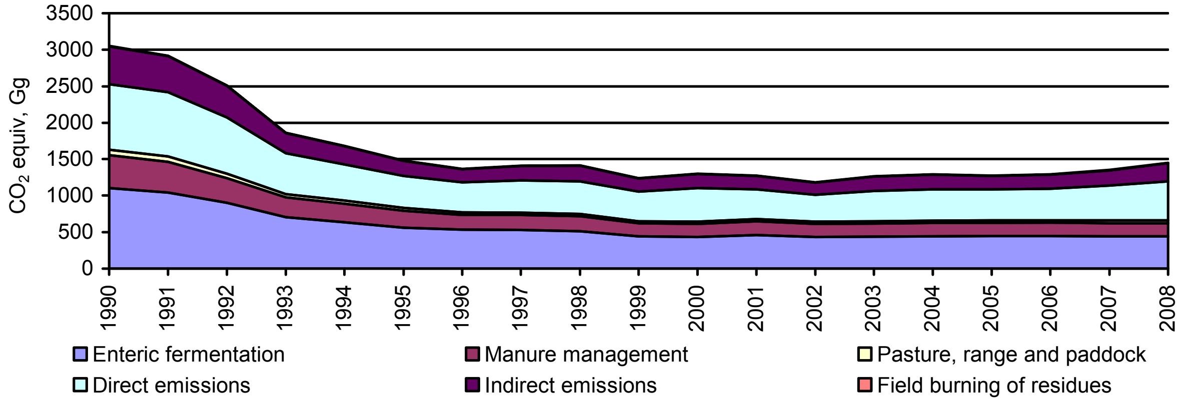


Figure 6.2. Trend in agricultural emissions by source categories in 1990–2008, CO_2-equiv Gg

Table 6.1. Estonia's agricultural greenhouse gases emissions by sources in 1990–2008, Gg

Year	Enteric fermentation	Manure management		Agricultural soils		Field burning of agricultural residues		Total GHG emissions		Total CO_2 equiv emissions
				Direct	Indirect					
	CH_4	CH_4	N_2O[18]	N_2O	N_2O	CH_4	N_2O	CH_4	N_2O	CO_2 equiv
1990	52.44	6.99	1.22	2.91	1.66	0.26	0.004	59.69	5.80	3,052.5
1991	49.60	6.51	1.15	2.85	1.59	0.25	0.004	56.36	5.60	2,918.6
1992	42.85	5.07	0.94	2.50	1.39	0.17	0.003	48.09	4.84	2,509.6
1993	33.46	4.04	0.76	1.80	0.89	0.21	0.003	37.71	3.44	1,859.2
1994	30.14	3.90	0.70	1.61	0.80	0.14	0.002	34.17	3.10	1,678.7
1995	26.68	3.58	0.63	1.42	0.66	0.14	0.002	30.41	2.71	1,478.3
1996	25.44	3.00	0.55	1.33	0.58	0.17	0.003	28.61	2.47	1,364.9
1997	25.16	3.03	0.56	1.43	0.63	0.18	0.003	28.37	2.63	1,410.0
1998	24.43	3.05	0.55	1.44	0.69	0.15	0.002	27.63	2.68	1,411.4
1999	21.04	2.70	0.49	1.31	0.58	0.11	0.002	23.85	2.38	1,237.2
2000	20.72	2.71	0.49	1.49	0.61	0.19	0.003	23.62	2.59	1,298.3
2001	21.82	2.90	0.51	1.32	0.59	0.15	0.002	24.87	2.42	1,271.5
2002	20.59	2.80	0.49	1.19	0.54	0.14	0.002	23.52	2.22	1,181.5
2003	20.86	2.80	0.49	1.35	0.63	0.13	0.002	23.79	2.46	1,263.2
2004	21.07	2.80	0.50	1.38	0.65	0.15	0.002	24.02	2.53	1,289.9
2005	21.25	2.79	0.50	1.37	0.59	0.19	0.003	24.24	2.46	1,272.9
2006	21.34	2.78	0.50	1.39	0.63	0.15	0.002	24.27	2.52	1,291.7
2007	20.98	2.88	0.51	1.54	0.67	0.22	0.003	24.08	2.72	1,350.0
2008	21.03	2.82	0.51	1.72	0.80	0.22	0.003	24.07	3.04	1,447.1

Other emissions related to Estonia's agriculture are reported in the land use, land use change and forestry (LULUCF) and the Energy sector (Figure 6.3.) – CO_2 emissions from land use change in the agriculture are estimated and reported in the LULUCF sector; GHG emissions from fuel consumption for different purposes in the agriculture are estimated in the Energy sector.

[18] N_2O emissions emitted during livestock pasturing (4.D.2 of the CRF reporter) are included into the total

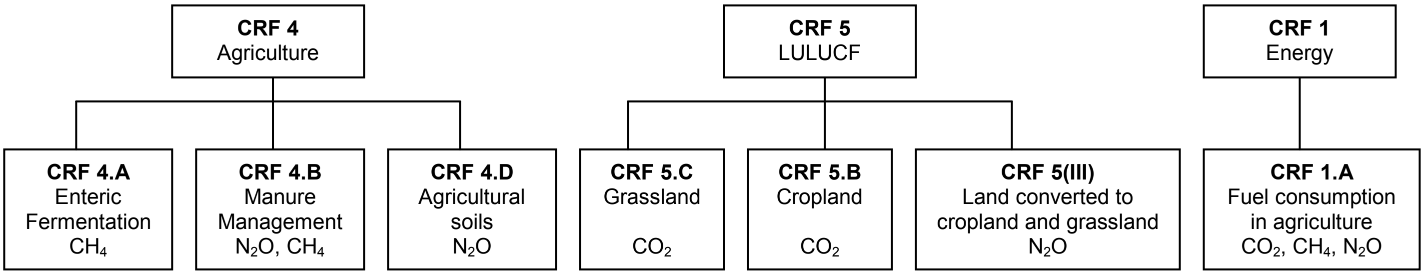


Figure 6.3. Emissions from agricultural sources and their reporting categories in the national greenhouse gas inventory

6.1.2. Source category description and methodology

A *tier 1* and a *tier 2* approach is implemented to estimate GHG emissions from the agriculture sector in Estonia. A list of method and emission factor employed 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 have been carried out to improve quality of the inventory in the agriculture sector:

1. activity data on country-specific weight of dairy cattle were implemented (4.A. Enteric fermentation and 4.B. Manure management);
2. emissions from enteric fermentation and manure management of fur animals were estimated for the first time in the 2010 submission (4.A. Enteric fermentation and 4.B. Manure management);
3. activity data on sewage sludge applied on agricultural soils were updated (4.D.1. Direct soil emissions)
4. activity data on quantities of crops burned were updated (4.F. Field burning of agricultural residues).

Agricultural key categories in 2008 estimated in accordance with IPCC Tier 2 method are presented in Table 6.2.

Table 6.2. Methods and emissions factors used for estimations of emissions from agriculture

	CH_4		N_2O		Key category	
	Method Applied	Emission Factor	Method Applied	Emission Factor	LULUCF sector is not included	LULUCF sector is included
I. Enteric Fermentation						
1. Cattle						
a. Cows, bulls and heifers (2 years and over)						
Dairy cattle	T2	IPCC, CS			L[19], T	L
Non-dairy cattle					L, T	
…Mature females	T1	IPCC, CS				
…Mature males	T1	IPCC, CS				
b. Bovine animals (ages between 1 and 2 years)	T1	IPCC, CS				
c. Calves (less than 1 year old)	T1	IPCC				
2. Swine						
a. Piglets, live weight less than 20 kg	T2	IPCC, CS				
b. Young pigs, live weight 20 - <50 kg	T2	IPCC, CS				
c. Fattening pigs, live weight						
50 - <80 kg	T2	IPCC, CS				
80 - <110 kg	T2	IPCC, CS				
110 kg or more	T2	IPCC, CS				
d. Breeding pigs, live weight 50 kg and more	T2	IPCC, CS				
3. Sheep	T1	IPCC				
4. Goats	T1	IPCC				
5. Horses	T1	IPCC				
6. Poultry	NE	NA				
7. Fur farming	T1	IPCC				
II. Manure Management						
1. Cattle						
a. Cows, bulls and heifers (2 years and over)						
Dairy cattle	T1	IPCC, CS				
Non-Dairy Cattle						
Mature females	T1	IPCC, CS				
Mature males	T1	IPCC, CS				
b. Bovine animals (ages between 1 and 2 years)	T1	IPCC, CS				
c. Calves (less than 1 year old)	T1	IPCC				
2. Swine						
a. Piglets, live weight less than 20 kg	T1	IPCC, CS				
b. Young pigs, live weight 20 - <50 kg	T1	IPCC, CS				
c. Fattening pigs, live weight						
50 - <80 kg	T1	IPCC, CS				
80 - <110 kg	T1	IPCC, CS				
110 kg or more	T1	IPCC, CS				
d. Breeding pigs, live weight 50 kg and more	T1	IPCC, CS				
3. Sheep	T1	IPCC				
4. Goats	T1	IPCC				

[19] L – Level assessment;
T – Trend assessment

	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	IPCC				
6. Poultry	T1	IPCC				
7. Fur farming	T1	IPCC				
II. Manure Management						
Anaerobic lagoon			T1	IPCC		
Liquid system			T1	IPCC		
Daily spread			T1	IPCC		
Solid storage and Dry lot			T1	IPCC	L, T	
Other animal waste management systems			T1	IPCC	T	
III. Rice Cultivation	NO					
IV. Agricultural soil						
1. Direct soil emissions						
a. Synthetic fertilizers			T1	IPCC	L, T	L
b. Animal waste applied to soils			T1	IPCC	L, T	
c. N-fixing crops			T1b	IPCC		
d. Crop residues			T1b	IPCC	L, T	
e. Cultivation of histosols			T1	IPCC	L, T	L, T
f. Sewage sludge			T1	IPCC		
2. Animal production			T1	IPCC		
3. Indirect emissions						
a. Atmospheric deposition			T1b	IPCC		
b. Leaching and run-off			T1	IPCC	L, T	L, T
V. Prescribed burning of savannas	NO					
VI. Field burning of agricultural residues	T1	IPCC	T1	IPCC		

T1 –Tier 1; T – Tier 2; IPCC – IPCC default factors; CS – Country specific; NO – not occurring

6.1.3. References – sources of information

The estimations were carried out based on approaches presented in the 1996 Revised IPCC Guidelines (IPCC 1997) and the IPCC Good Practice Guidance (IPCC 2000).

Activity data were obtained from Estonian National Statistics, emission factors were taken mostly from the IPCC Guidelines (IPCC 1997, 2000).

A 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

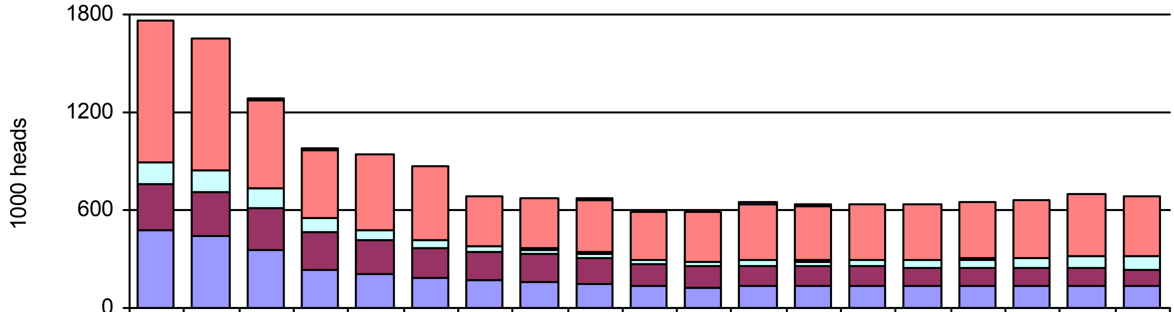
References	Link	Abbreviation	Data
Tallinn University of Technology	www.ttu.ee	TUT	- activity data gathering; - estimation of emissions; - reporting (the CRF tables, the NIR).
Statistics Estonia – Agricultural Statistics	www.stat.ee	ESO	- collection and reporting of data on livestock population, quantities of crop produced and amounts of fertilizers applied on fields.
Estonian Animal Recording Centre	www.jkkeskus.ee	EARC	- collection and reporting of data on milk production, fat content in milk, and percentage of cows that give birth. - dairy cattle population by dairy-cattle breed.
Estonian Environment Information Centre	www.keskkonnainfo.ee	EEIC	- providing with CORINE land cover map. - collection and reporting of data on amounts of sludge used for improvement of environment (on agricultural fields)

6.1.4. Livestock characterization

Livestock population decreased in comparison with the base year: the total number of swine decreased by 58 per cent, horses – by 40 per cent and poultry – by 73 per cent. The number of dairy cattle decreased by 64 per cent: from 280.7 thousand heads to 100.4 thousand heads, the number of non-dairy cattle decreased from 477 thousand heads in 1990 to137.5 thousand heads in 2008. The number of sheep decreased by 44 per cent and the number of goats increased from 0.9 thousand heads to 3.6 thousand heads from 1990 to 2008 (Figure 6.4, Figure 6.5 and Figure 6.6). The decline in the livestock population was caused by economical reasons due to reintegration of former soviet union, as Estonia was left with a large excess 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 (The rural economy of Estonia).

The population of fur animals decreased remarkably by 1999 compared to 1990 due to lack of supply 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. (Fur farming in

Estonia). Since 2000, the number of fur animals has started slightly to increase. Nowadays about 99 per cent of the production of Estonian fur farming is exported (The rural economy of Estonia).



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Horses	8.6	7.8	6.6	5.2	5	4.6	4.2	4.2	3.9	3.9	4.2	5.5	5	6	5.1	4.8	4.9	5.3	5.2
Swine	860	799	541	424	460	449	298	306	326	286	300	345	341	345	340	346.5	345.8	379	364.9
Goats	0.9	0.9	1.1	1.1	1.5	1.7	1.6	1.7	2.1	2.7	3.2	3.6	3.9	3.5	2.9	2.8	3.3	4	3.6
Sheep	139.8	141.9	123.1	82.2	60	48.2	37.6	33.9	28.7	28.2	29	28.8	29.9	30.8	38.8	49.6	62.7	72.4	78.2
Dairy cattle	281	264	253	227	211	185	172	168	159	138	131	129	116	117	117	112.8	108.4	103	100.4
Non-dairy cattle	477	444	361	237	208	185	171	158	149	129	122	132	138	140	133	136.7	136.4	137.9	137.5

Figure 6.4. Population of livestock in Estonia from 1990–2008, 1000 heads

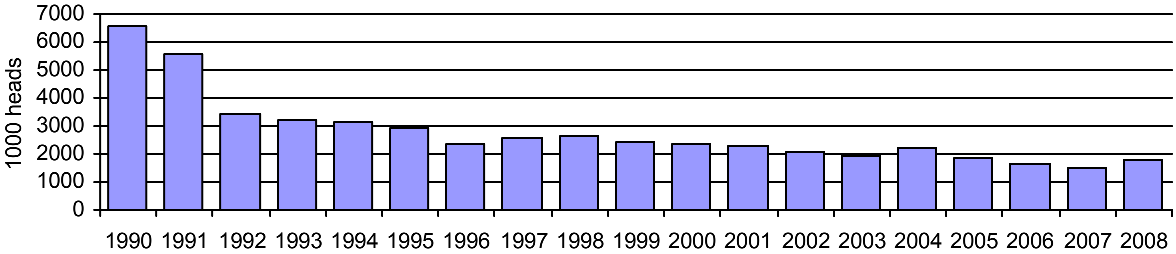


Figure 6.5. Population of poultry in Estonia from 1990 to 2008, 1000 heads

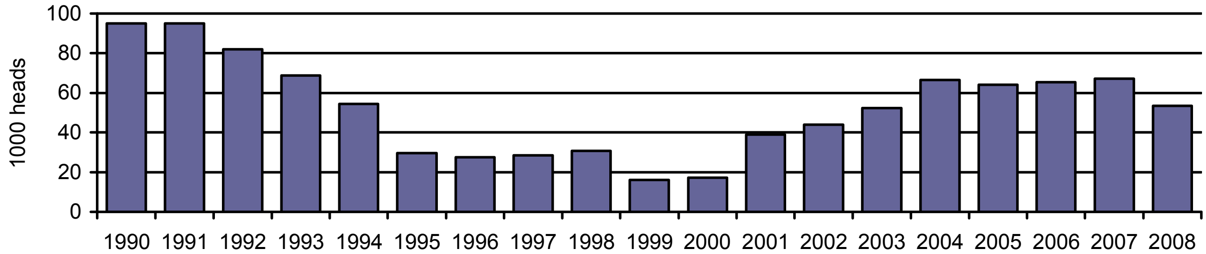
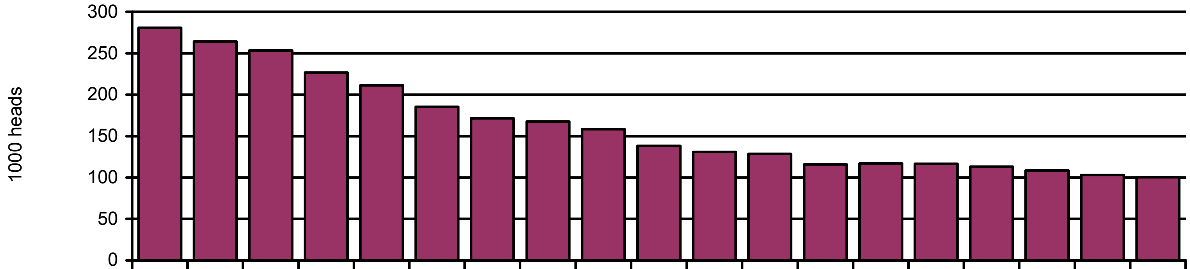


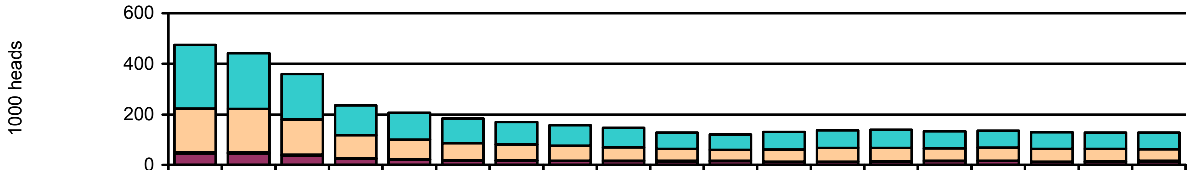
Figure 6.6. Population of fur animals in Estonia from 1990 to 2008, 1000 heads[20]

[20] The data on fur animal population in 1994-2008 were obtained from ESO datasets; in 1991 – from (Fur farming in Estonia) and the data for years 1990, 1992-1993 were interpolated/extrapolated.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Dairy-Cattle	280.7	264.3	253.4	226.7	211.4	185.4	171.6	167.7	158.6	138.4	131	128.6	115.6	116.8	116.5	112.8	108.4	103	100.4

Figure 6.7. Population of dairy cattle in Estonia in 1990–2008, 1000 heads



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Calves	251.9	220	178.8	116.9	105.8	97	89.1	80.4	77.1	64.3	61.1	69.9	70	72.3	66.3	67.2	66	64.5	65.6
Bovine Animals	172.1	171.1	139.4	91.7	77.9	67.3	63	59.3	54.7	48.5	44.8	48.8	55.1	52.8	51	51.9	51.6	51.5	47
Mature Males	4.2	4.1	3.4	2.2	1.9	1.6	1.5	1.4	1.3	1.6	1.2	1.2	1.1	0.8	1.3	0.8	1.7	1.8	2.2
Mature Females	47	46.7	38.1	25	21.3	18.4	17.2	16.2	14.9	14.5	14.7	12	12.1	14.5	14.7	16.8	11.1	11.6	14.5

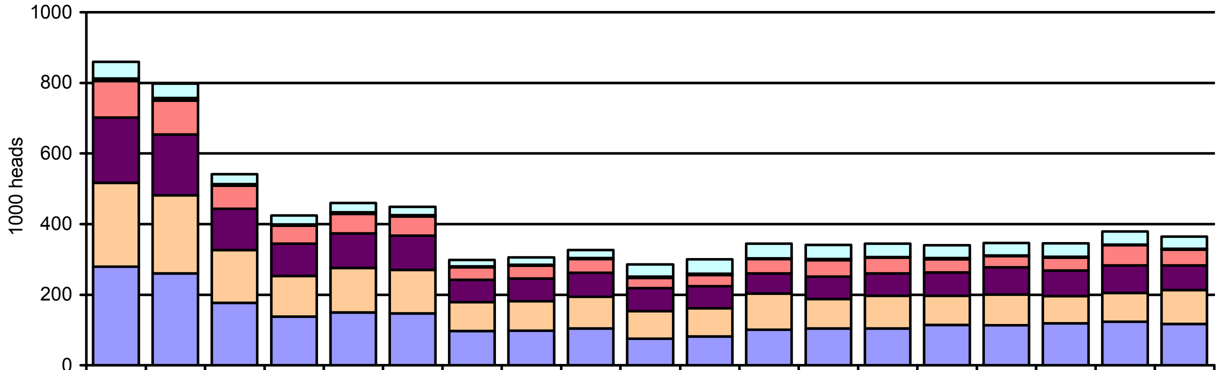
Figure 6.8. Population of non-dairy cattle in Estonia in 1990–2008, 1000 heads[21]

The data on number of mature non-dairy cattle population was collected and reported by ESO according to two methodologies employed: for 1990–1998, livestock population data were reported for two sub-categories (bovine animals and mature males) and for 1999–2007, the population of three sub-categories of non-dairy mature cattle was reported by ESO (bovine animals, mature males and females). In order to guarantee the consistency in the activity data used, the data of 1990–1998 were updated basing on assumptions in the 2009 submission (the activity recommended by the ERT), the results are illustrated in Figure 6.7.

The activity data on swine population in 1990–1998 were updated in the 2009 submission (the activity recommended by the ETR). The number of swine population for 1990–1998 was broken down and reported for three sub-categories of swine (breeding sows, fattening pigs and young swine) and for 1999–2007 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). Based on assumptions, the activity data on

[21] DC – Dairy Cattle;
MF – Bulls (1 year and over);
MM – Heifers (1 year and over);
B – Bovine animals (aged between 1 and 2 years);
C – Calves (under 1 year old);
MF, MM and B cattle category is reported under 'Mature non-dairy cattle' in the CRF reporter and C cattle category is under 'Young cattle'

swine population in 1990–1998 were recalculated for six sub-categories instead of three reported (Figure 6.9).



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Br	47.1	41.5	27.7	25.3	26.6	23.4	17.6	21.3	22.6	33.8	40.5	41.6	39.8	37.9	35.9	35.6	38.4	36.5	34.7
P110m	7.6	7	4.8	3.7	4	4	2.6	2.6	2.8	3.8	3.2	1.7	3.6	1.8	3.3	1.5	2.4	2.6	2.6
P110	103.2	96.1	65.2	50.6	55	54	35.6	36.2	38.6	29	32	40.8	45.8	44.6	37.8	31.7	36.5	56.3	44.2
P80	185	172.3	116.8	90.8	98.6	96.8	63.9	64.9	69.1	66	63.8	57	64.7	64.3	65.5	77.2	72.8	78.5	70.1
P50	237.5	221.3	150	116.6	126.6	124.3	82.1	83.3	88.8	77.9	79.5	103.6	82.8	91.9	83.9	87.2	76.9	81.8	96.2
P20	279.6	260.4	176.6	137.2	149	146.3	96.6	98	104.5	75.2	81.2	100.3	104.1	104.1	113.7	113.3	118.8	123.3	117.1

Figure 6.9**.** Population of pigs in Estonia in 1990–2008, 1000 heads[22]

The activity data used in the estimations in the 2010 submission differ from those reported in FAO statistic dataset due to different methods of data reporting (Table 6.4). In the framework of FAO datasets, the data on livestock population is reported according the following methodology – total live animal numbers have to be considered for the year ending 30 September (e.g. 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 ESO, total live animal numbers have to be considered for the year ending 31 December.

The ESO data have been used in the estimates of the 2010 submission.

Table 6.4. The number of livestock population in Estonia in 1992–2008, in accordance with ESO and FAO datasets, 1000 heads

Year	Cattle		Pigs		Sheep		Goats		Horses		Poultry	
	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO
1992	614.0	708.3	541	798.6	123.1	141.9	1.1		6.6	7.8	3,418.1	5,538
1993	464.0	614.6	424	541.1	82.2	124.2	1.1		5.2	6.6	3,236.1	3,418

[22] P20 - Piglets, live weight less than 20 kg;
P50 - Young pigs, live weight 20–<50 kg;
P80 – Pigs, live weight 50–<80 kg;
P110 – Pigs, live weight 80–<110 kg;
P100m – Pigs, live weight 110 kg or more;
Br - Breeding sows;

Year	Cattle		Pigs		Sheep		Goats		Horses		Poultry	
	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO
1994	419.0	463.2	460	424.3	60	83.3	1.5		5.0	5.2	3,129.7	3,226
1995	370.0	419.5	449	459.8	48.2	61.5	1.7		4.6	5.0	2,911.3	3,130
1996	343.0	370.4	298	448.8	37.6	49.8	1.6		4.2	4.6	2,324.9	2,911
1997	326.0	343.0	306	298.4	33.9	39.2	1.7		4.2	4.2	2,602	2,325
1998	308.0	325.6	326	306.3	28.7	33.9	2.1	1.7	3.9	4.2	2,635.7	2,602
1999	267.0	307.5	286	326.4	28.2	28.7	2.7	2.1	3.9	3.9	2,461.8	2,636
2000	253.0	267.3	300	285.7	29	28.2	3.2	2.7	4.2	3.9	2,366.4	2,414
2001	261.0	252.8	345	300.2	28.8	29	3.6	3.2	5.5	4.2	2,294.9	2,318
2002	254.0	260.5	341	345.0	29.9	28.8	3.9	3.6	5.0	5.5	2,096.3	2,249
2003	257.0	253.9	345	340.8	30.8	29.9	3.5	3.9	6.0	5.3	1,945.2	2,070
2004	250.0	257.2	340	344.6	38.8	30.8	2.9	3.5	5.1	5.8	2,183	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	240.9	244.8	379	345.8	72.4	62.7	4.0	3.3	5.3	4.9	1,477.6	1,638
2008	237.9	242.0	364.9	379.0	78.2	72.4	3.6	4.0	5.2	5.3	1,757.3	1,478

6.2. CH_4 emissions from enteric fermentation

6.2.1. Source category description

Methane is emitted as a by-product of the livestock digestive process, in which microbes resident in the animal's digestive system ferment the feed consumed by the animal. This fermentation process is also known as enteric fermentation. The CH_4 is then eructated or exhaled by the animal. Within livestock, ruminant livestock (cattle, buffalo, sheep, and goats) are the primary source of emissions (Gibbs *et al.*, 2000). Pigs are non-ruminant animals and convert a smaller proportion of feed intake into methane than ruminants.

CO_2-equiv emissions from enteric fermentation of livestock made up 33 per cent from the total CO_2-equiv emissions of the agricultural sector in Estonia in 2008. CH_4 emissions of 2008 are 59.9 per cent lower than the emission of the base year due especially to decreasing number of livestock (Table 6.5, Figure 6.10).

Table 6.5. CH_4 emissions from enteric fermentation by animal type in 1990–2008 in Estonia, Gg

Year	Cattle	Pigs	Sheep	Goats	Horses	Poultry	Fur farming	Total, CH_4, Gg
1990	50.47	0.68	1.12	0.005	0.15	NE	0.010	52.44
1991	47.68	0.63	1.14	0.005	0.14	NE	0.010	49.60
1992	41.30	0.43	0.98	0.006	0.12	NE	0.008	42.85
1993	32.36	0.34	0.66	0.006	0.09	NE	0.007	33.46
1994	29.19	0.37	0.48	0.008	0.09	NE	0.006	30.14
1995	25.85	0.36	0.39	0.009	0.08	NE	0.003	26.68
1996	24.81	0.24	0.30	0.008	0.08	NE	0.003	25.44
1997	24.56	0.24	0.27	0.009	0.08	NE	0.003	25.16

Year	Cattle	Pigs	Sheep	Goats	Horses	Poultry	Fur farming	Total, CH_4, Gg
1998	23.86	0.26	0.23	0.011	0.07	NE	0.003	24.43
1999	20.49	0.24	0.23	0.014	0.07	NE	0.002	21.04
2000	20.14	0.25	0.23	0.016	0.08	NE	0.002	20.72
2001	21.19	0.28	0.23	0.018	0.10	NE	0.004	21.82
2002	19.95	0.28	0.24	0.020	0.10	NE	0.004	20.59
2003	20.20	0.28	0.25	0.018	0.10	NE	0.005	20.86
2004	20.38	0.27	0.31	0.015	0.09	NE	0.007	21.07
2005	20.47	0.28	0.40	0.014	0.09	NE	0.006	21.25
2006	20.45	0.28	0.50	0.017	0.09	NE	0.007	21.34
2007	19.96	0.31	0.58	0.020	0.10	NE	0.007	20.98
2008	20.00	0.29	0.63	0.018	0.09	NE	0.005	21.03
%, 2008	95.1	1.4	3.0	0.1	0.4	NE	0.02	100.00

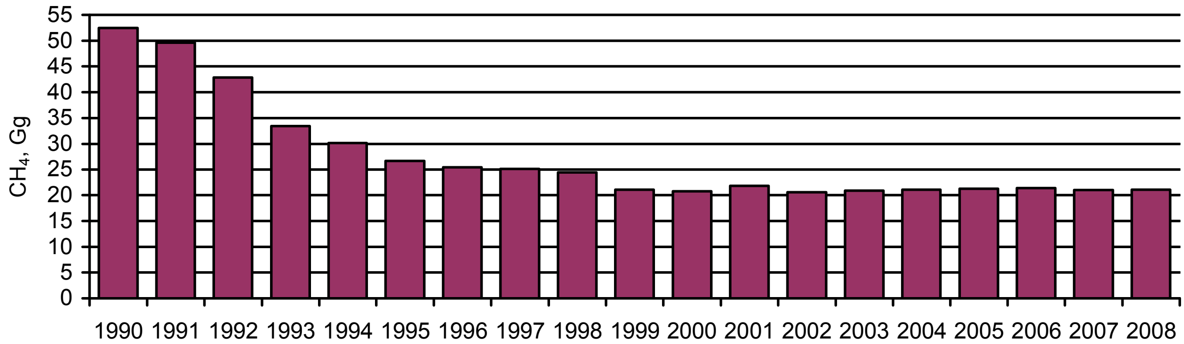


Figure 6.10. CH_4 emissions from Estonia's livestock enteric fermentation in 1990–2008, Gg

6.2.2. Cattle

6.2.2.1. Methodology, data availability, data sources and emission factors

The *Tier 2* method (IPCC 1997) was used to estimate CH_4 emissions from enteric fermentation of the main cattle livestock sub-categories (presented by ESO). A disaggregation on county level of Estonia was applied (Table 6.6). Counties of Estonia are presented in Figure 6.11.

Table 6.6. Symbols used in the algorithm for cattle

County	Cattle categories
i1- Harju	j1- Dairy cattle
i2- Hiiu	j2- Mature females
i3- Ida-Viru	j3- Mature males
i4- Jõgeva	j4- Bovine cattle
i5- Järva	j5- Calves (less than 1 year old)
i6- Lääne	
i7- Lääne-Viru	
i8- Põlva	
i9- Pärnu	
i10- Rapla	
i11- Saare	

County	Cattle categories
i12- Tartu i13- Valga i14- Viljandi i15- Võru	

Figure 6.11. Administrative boundaries of Estonia's counties (Estonian Land Board)

Net energy for maintenance – Net energy required by the animal to keep the animals in energy equilibrium

$$NE_{mji}\,(MJ/day) = C_{f\,ji} \times (weight\_in\_kg_{ij})^{0.75} \qquad (6.1)^{23}$$

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;

Cf – Coefficient for calculating NE_m (Table 6.7);

Table 6.7. C_f coefficient[24]

Animal Category	C_{fi}
Cattle (non-lactating)	0.322
Cattle (lactating)	0.335

[23] IPCC 2000, Agriculture, Equation 4.1, pp 4.13.
[24] IPCC 2000, Agriculture, Table 4-4 – Coefficient for calculating NEm, pp. 4.15

Net energy for activity for animals

$$NE_{aji} = C_a \times NE_{mji}\text{\_for\_cattle} \quad (6.2)^{25}$$

NE_{aji} - Net energy intake by *j* category of cattle in *i* county, MJ/head/day;

C_a - Coefficient corresponding to animal's feeding situation;

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[26]

Situation	Definition	C_a
Stall	Animals are confined to a small area with the result that they expend very little or no energy to acquire feed.	0
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

$$NE_{gji}(\text{MJ/day}) = 4.18 \times \left\{(0.035 W_{ji}^{0.75} \times WG_{ji}^{1.119}) + WG_{ji}\right\} \quad (6.3)^{27}$$

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

$$NE_{l_i}(\text{MJ/day}) = \text{kg\_of\_milk/day}_i \times (1.47 + 0.40 \times \text{Fat}_i) \quad (6.4)^{28}$$

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

$$NE_{pregnancy}(\text{MJ/281} - \text{day\_period}) = 28 \times \text{calf\_birth\_weight\_in\_kg} \quad (6.5)^{29}$$

$$\text{Calf\_birth\_weight\_(kg)} = 0.266 \times (\text{cow\_weight\_in\_kg})^{0.79} \quad (6.6)$$

Ratio of net energy available in a diet for maintenance to digestible energy consumed

[25] IPCC 2000, Agriculture, Equation 4.2a, pp. 4.12.
[26] IPCC 2000, Table 4.5 – Activity coefficients corresponding to animal's feeding situation, pp. 4.15.
[27] IPCC 1997, Agriculture, Reference Manual, Equation 3, pp. 4.18.
[28] IPCC 2000, Agriculture, Equation 4.5a, pp. 4.17.
[29] IPCC 1997, Agriculture, Reference Manual, Equation 6, pp. 4.19.

$$NE/DE_{ji} = 1.123 - (4.092 \times 10^{-3} \times DE_{ji}\%) + (1.126 \times 10^{-5} \times (DE_{ji}\%)^2) - 25.4/DE_{ji}\% \quad (6.7)$$ [30]

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;

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

$$NE_g/DE_{ji} = 1.164 - (5.160 \times 10^{-3} \times DE_{ji}\%) + (1.308 \times 10^{-5} \times (DE_{ji}\%)^2) - 37.4/DE_{ji}\% \quad (6.8)$$ [31]

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

$$GE = \frac{(NE_{m\,ji} + NE_{feedji} + NE_{lji} + NE_{workji} + NE_{pregnancyji}) \times \left(\frac{100}{DE_{ji}\%}\right)}{(NE/DE)_{ji} + (NE_{gji}/\{NE_g/DE\}_{ji})} \quad (6.9)$$ [32]

GE – Gross energy 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[33], 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

$$E = [GE \times Y_m \times (365 days/yr)] / [55.65 MJ / CH_4\ kg] \quad (6.10)$$ [34]

[30] IPCC 2000, Agriculture, Equation 4.9, pp. 4.19.
[31] IPCC 1997, Agriculture, Reference Manual, Equation 10, pp. 4.19.
[32] IPCC 1997, Reference Manual, Equation 16, pp. 4.21.
[33] Net energy for work was not calculated

E – Methane emission 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;

Table 6.9. Average milk yield per cow, fat content and percentage of cows that gave birth in 2008

County	Average milk yield per cow, kg/day	Fat content[35], %	Percentage of cows that gave birth in 2008, %
Estonian average	18.58	4.12	89.2
Harju	17.52	4.14	85.6
Hiiu	12.73	4.34	57.6
Ida-Viru	16.58	4.08	87.5
Jõgeva	19.50	4.18	90.9
Järva	19.63	4.08	94.3
Lääne	17.25	4.24	90.3
Lääne-Viru	19.44	4.02	91.0
Põlva	20.72	4.09	93.7
Pärnu	18.22	4.16	90.0
Rapla	18.62	4.00	90.7
Saare	16.01	4.17	83.8
Tartu	21.59	4.08	91.3
Valga	16.03	4.25	82.2
Viljandi	17.00	4.21	87.0
Võru	17.31	4.21	76.4

The main sources of data used in the algorithm to estimate the methane emission factor from enteric fermentation by sub-categories of cattle:

Weight, kg – data on weight of dairy-cattle were obtained based on the data of EARC and an expert judgment on weight of mail categories of dairy-cattle in Estonia (Table 6.10)

Feeding situation – data were obtained from databases (tables) reported by the IPCC[14]

Milk production per day, kg/day – a source of data is ESO (Table 6.10, Figure 6.13).

Fat content of milk, % - the data were taken from EARC (Table 6.10, Figure 6.13).

Percentage of cows that give birth in a year, % – the data were employed from EARC (Table 6.10, Figure 6.13).

Feed digestibility, % - data were used from databases presented by IPCC[14] .

[34] IPCC 2000, Agriculture, Equation 4.14, pp. 4.26.
[35] www.jkkeskus.ee/pages/sta/2005/ka2005.htm

Table 6.10. Weight [kg/head] (see Appendix A_II), average milk yield [kg/head/yr] per cow and fat content of milk [%] in 1990–2008

Year	Weight of dairy-cattle, kg	Fat content of milk, %	Milk yield per cow, kg/head/yr	Percentage of cows that gave birth, %
1990[36]	575.0	4.14	10.87	80.0
1991	576.0	4.14	10.87	80.0
1992	577.2	4.07	9.67	80.0
1993	578.8	4.10	9.10	80.0
1994	579.7	4.12	9.47	80.0
1995	580.2	4.20	9.83	80.0
1996	580.8	4.34	10.44	95.8
1997	581.6	4.32	12.28	94.9
1998	582.6	4.26	12.21	97.1
1999	583.8	4.23	11.43	81.3
2000	584.5	4.29	12.77	76.9
2001	585.3	4.31	14.55	76.3
2002	585.9	4.29	14.08	82.8
2003	586.2	4.31	14.33	81.3
2004	585.8	4.27	15.33	81.7
2005	585.7	4.21	16.13	84.0
2006	586.1	4.17	17.22	92.2
2007	586.4	4.15	17.76	88.4
2008	586.8	4.12	18.58	89.2

Table 6.11. CH_4 emission factor from enteric fermentation of cattle in 2008, kg CH_4/head/year

	Emission factors for enteric fermentation, kg CH_4/head/yr				
		Non-dairy cattle			
County	Dairy cattle	Mature males	Mature females	Bovine animals	Calves
Harju	128.0	67.7	59.0	62.7	34.4
Hiiu	108.5	67.7	59.0	62.7	34.4
Ida-Viru	123.7	67.7	59.0	62.7	34.4
Jõgeva	136.8	67.7	59.0	62.7	34.4
Järva	136.4	67.7	59.0	62.7	34.4
Lääne	128.0	67.7	59.0	62.7	34.4
Lääne-Viru	134.9	67.7	59.0	62.7	34.4
Põlva	140.9	67.7	59.0	62.7	34.4
Pärnu	131.3	67.7	59.0	62.7	34.4
Rapla	131.4	67.7	59.0	62.7	34.4
Saare	122.0	67.7	59.0	62.7	34.4
Tartu	144.3	67.7	59.0	62.7	34.4
Valga	122.7	67.7	59.0	62.7	34.4
Viljandi	126.6	67.7	59.0	62.7	34.4
Võru	127.4	67.7	59.0	62.7	34.4

The implied emission factor (IEF) for dairy-cattle is presented in Figure 6.12. The IEF of dairy cattle is continuing to grow since 1995 mostly due to increase in milk production by

[36] The values of 1991

cow and fat content of milk. The country-specific IEF is higher than IPCC default for Eastern and Western European dairy-cattle (Figure 6.12), mostly due to high rate of milk production.

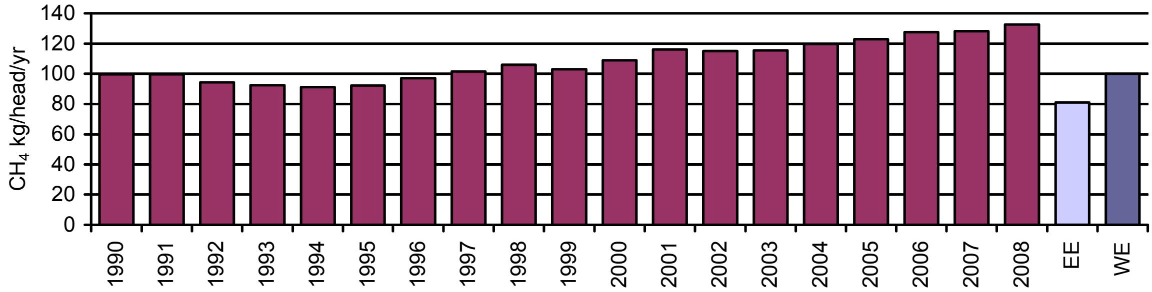


Figure 6.12. Implied enteric fermentation emission factor of dairy cattle in 1990–2008, CH_4 kg/head/yr[37]

6.2.2.2. Quantitative overview – CH_4 emissions from enteric fermentation of cattle in 2008

The total CH_4 emissions from enteric fermentation of cattle were 20.00Gg in 2008. Dairy cattle livestock was a main contributor to the total CH_4 emissions from cattle enteric fermentation in Estonia in 2008 (Table 6.12). The breakdown of CH_4 emissions from cattle enteric fermentation by counties of Estonia is presented in Figure 6.13.–6.14.

Table 6.12. CH_4 emissions from enteric fermentation of cattle in 1990–2008 in Estonia[6], Gg

	Cattle				
Year	DC	MF	MM	B	C
1990	27.96	2.77	0.28	10.78	8.67
1991	26.35	2.76	0.28	10.72	7.57
1992	23.94	2.25	0.23	8.73	6.16
1993	20.95	1.48	0.15	5.75	4.02
1994	19.28	1.26	0.13	4.88	3.64
1995	17.10	1.08	0.11	4.22	3.34
1996	16.68	1.01	0.10	3.95	3.07
1997	17.02	0.96	0.10	3.71	2.77
1998	16.80	0.88	0.09	3.43	2.65
1999	14.27	0.86	0.11	3.04	2.21
2000	14.28	0.87	0.08	2.81	2.10
2001	14.94	0.71	0.08	3.06	2.41
2002	13.30	0.71	0.07	3.45	2.41
2003	13.49	0.86	0.05	3.31	2.49
2004	13.94	0.87	0.09	3.20	2.28
2005	13.86	0.99	0.05	3.25	2.31
2006	13.82	1.01	0.12	3.23	2.27
2007	13.21	1.19	0.12	3.23	2.22
2008	13.30	1.34	0.15	2.95	2.26

[37] EE – Eastern European Enteric Fermentation emission factor for dairy cattle; average milk production of 2,550 kg/head/yr.
WE – Western European Enteric Fermentation emission factor for dairy cattle; average milk production of 4,200 kg/head/yr. (Table 4-4 – Enteric fermentation emission factors for cattle. 1996 IPCC, Agriculture, Reference Manual).

Year	Cattle				
	DC	MF	MM	B	C
%, 2008	66.5	6.7	0.7	14.7	11.3

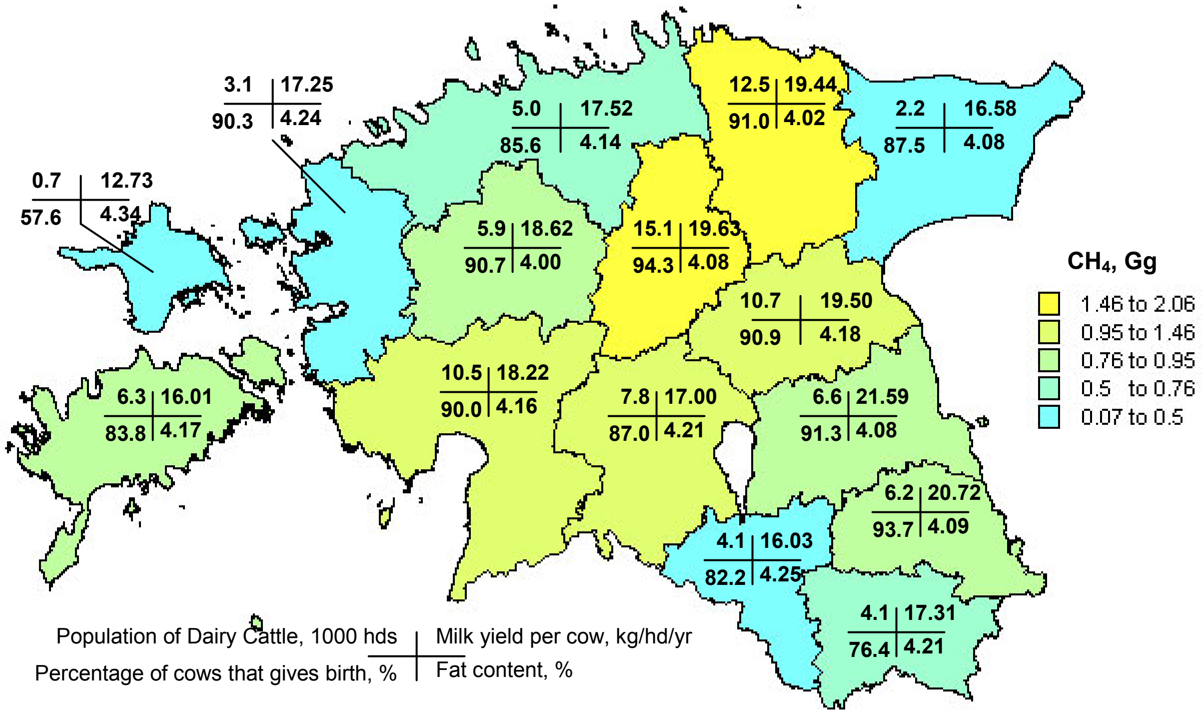


Figure 6.13. CH_4 emissions from dairy cattle enteric fermentation, CH_4 Gg (see Figure 6.11)

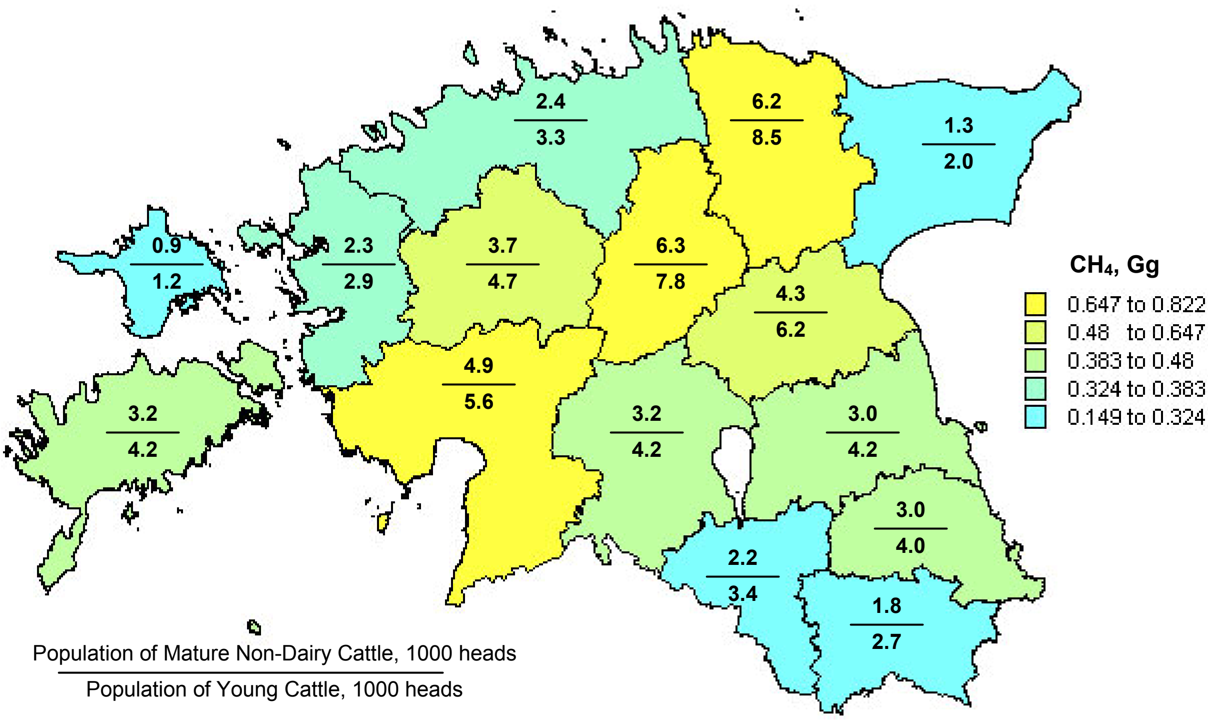


Figure 6.14. CH_4 emissions from non-dairy cattle enteric fermentation, CH_4 Gg (see Figure 6.11)

6.2.3. Pigs

6.2.3.1. Methodology, data availability, data sources and emission factors

A *Tier 2* was used for the estimation of CH_4 emissions from enteric fermentation of pigs. The estimation was carried out for the main sub-categories of pigs break down by weight of animals (Table 6.13), feed digestibility, methane conversion factor were taken from the revised 1996 IPCC Guidelines (IPCC 1997).

Table 6.13. Symbols used in the algorithm for swine

County	Swine categories
i1- Harju	j1- Piglets, live weight less than 20 kg
i2- Hiiu	j2- Young pigs, live weight20–<50 kg
i3- Ida-Viru	j3- Pigs, with live weight 50–<80 kg
i4- Jõgeva	j4- Pigs, with live weight 80–<110 kg
i5- Järva	j5- Pigs, with live weight 110 kg or more
i6- Lääne	j6- Breeding pigs, live weight 50 kg or more
i7- Lääne-Viru	
i8- Põlva	
i9- Pärnu	
i10- Rapla	
i11- Saare	
i12- Tartu	
i13- Valga	
i14- Viljandi	
i15- Võru	

Gross energy intake by swine

$$E_{ji} = 2.0 \times w_{ji}^{0.63} \qquad (6.11)^{38}$$

GE – Gross energy intake by *j* category of swine in *i* county, MJ/head/day;

w – Live weight of *j* category in *i* county, kg;

Methane emission factor from livestock category

$$E = \left[GE \times Y_m \times (365 days/yr)\right] / \left[55.65 MJ / CH_4\ kg\right] \qquad (6.12)^{39}$$

E – Methane emissions from enteric fermentation, kg CH_4 / year;

GE – Gross energy intake, MJ/head/day;

[38] Oll *et al.*, 1991; Turnpenny *et al.*, 2001.

[39] 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;

The implied emission factor for swine enteric fermentation for the entire time-series is presented in Figure 6.15. The data in Table 6.14 demonstrates CH_4 emission factor for each category of pigs and the emission factor for developed countries recommended by the revised 1996 IPCC guidelines (IPCC 1997).

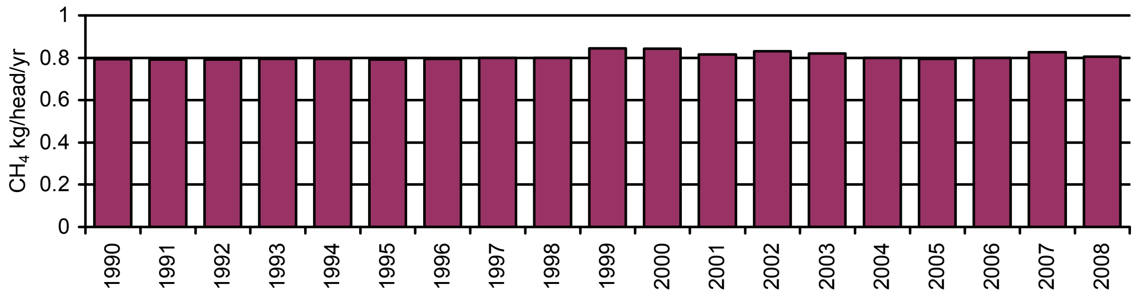


Figure 6.15. Average swine enteric fermentation emission factor, CH_4 kg/head/year

Table 6.14. Enteric fermentation methane emission factors for pigs, kg CH_4/head/year

Swine category	Emission factor, kg CH_4/head/year	
	used in the estimation	IPCC[40]
Total		1.5
Piglets, live weight less than 20 kg	0.3	
Young pigs, live weight 20–<50 kg	0.7	
Fattening pigs		
…live weight 50–<80 kg	1.1	
…live weight 80–<110 kg	1.4	
…live weight 110 kg or more	1.5	
Breeding pigs, live weight 50 kg or more	1.2	

6.2.3.2. *Quantitative overview – CH_4 emissions from enteric fermentation of pigs in 2008*

The total CH_4 emissions from swine enteric fermentation were 0.29Gg in 2008. The emissions have decreased by 57 per cent since the base year due to decline in population of pigs (Table 6.15, Figure 6.16).

Table 6.15. CH_4 emissions from enteric fermentation of pigs in 1990–2008 in Estonia[7], Gg

Year	Swine					
	P20	P50	P80	P110	P100m	Br
1990	0.0939	0.1756	0.2020	0.1431	0.0115	0.0563
1991	0.0874	0.1636	0.1881	0.1332	0.0107	0.0496
1992	0.0593	0.1109	0.1276	0.0904	0.0073	0.0331

[40] IPCC 1997. Agriculture. Reference Manual. Table 4-3 – Enteric Fermentation Emission Factors. pp. 4.10

Year	Swine					
	P20	P50	P80	P110	P100m	Br
1993	0.0461	0.0862	0.0991	0.0702	0.0056	0.0302
1994	0.0500	0.0936	0.1076	0.0762	0.0061	0.0318
1995	0.0491	0.0919	0.1057	0.0749	0.0060	0.0280
1996	0.0324	0.0607	0.0698	0.0494	0.0040	0.0210
1997	0.0329	0.0616	0.0708	0.0502	0.0040	0.0254
1998	0.0351	0.0656	0.0755	0.0535	0.0043	0.0270
1999	0.0252	0.0576	0.0721	0.0402	0.0058	0.0404
2000	0.0273	0.0588	0.0697	0.0444	0.0049	0.0484
2001	0.0337	0.0766	0.0622	0.0566	0.0026	0.0497
2002	0.0350	0.0612	0.0706	0.0635	0.0055	0.0476
2003	0.0350	0.0679	0.0702	0.0618	0.0027	0.0453
2004	0.0382	0.0620	0.0715	0.0524	0.0050	0.0429
2005	0.0380	0.0645	0.0843	0.0440	0.0023	0.0425
2006	0.0399	0.0568	0.0795	0.0506	0.0037	0.0459
2007	0.0414	0.0605	0.0857	0.0781	0.0040	0.0436
2008	0.0393	0.0711	0.0765	0.0613	0.0040	0.0415
%, 2008	13.4	24.2	26.1	20.9	1.3	14.1

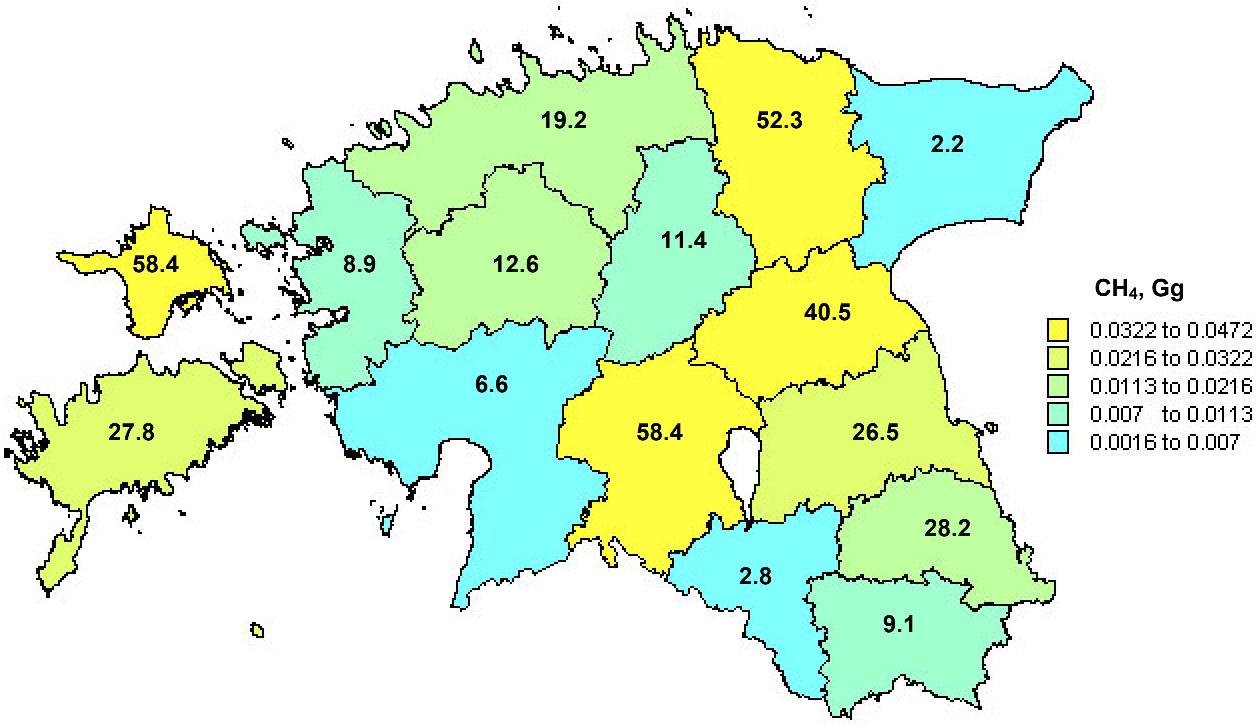


Figure 6.16. Population of pigs and CH_4 emissions from pig enteric fermentation by counties of Estonia in 2008, 1000 heads, Gg (see also Figure 6.11)[41]

6.2.4. Other livestock

6.2.4.1. Methodology, data availability, data sources and emission factors

The algorithm based on a *Tier 1* (IPCC 1997) and is presented below by the formula (6.13).

[41] The number of pig population of Hiiu and Viljandi Counties was calculated.

$$CH_4 \text{ Emissions} = EF_{ji} \times \text{population}_{ji} / (10^6 \text{ kg/Gg}) \quad (6.13)$$[42]

CH_4 Emissions$_{ji}$ – 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;

The emissions factors (for developed countries) were used in the process of the estimation of CH_4 emissions from sheep, goats and horses (Table 6.16). The emission factor for fur animals was provided by a Finnish expert in the Agriculture sector[43].

Table 6.16. Enteric fermentation methane emission factors, kg CH_4/head/year[44]

Enteric Fermentation	Emission Factor, kg CH_4/head/yr
Sheep	8
Goats	5
Horses	18
Poultry	Not estimated
Fur animals	0.1[45]

6.2.4.2. Quantitative overview – CH_4 emissions from enteric fermentation of other livestock in 2008

The total CH_4 emissions from enteric fermentation of other livestock were 0.74Gg in 2008. The emissions of CH_4 declined by 42 per cent by 2008 in comparison with the base year due to decreasing number of other livestock population (Table 6.17).

Table 6.17. CH_4 emissions from enteric fermentation of other livestock in 1990–2008 in Estonia, Gg

	Other livestock			
Year	Sheep	Goats	Horses	Fur animals
1990	1.118	0.005	0.155	0.0095
1991	1.135	0.005	0.140	0.0095
1992	0.985	0.006	0.119	0.0082

[42] IPCC 2000. Agriculture. Equation 4.12, pp. 4.25.
[43] Sanna Pitkänen, personal communication
[44] IPCC 1997. Agriculture. Reference Manual. Table 4-3 Enteric Fermentation Emission Factors (default values for developed countries) pp. 4.10
[45] For fur animals the Norwegian emission factor was used (0.1 kg/animal/yr). 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.

Year	Other livestock			
	Sheep	Goats	Horses	Fur animals
1993	0.658	0.006	0.094	0.0069
1994	0.480	0.008	0.090	0.0056
1995	0.386	0.009	0.083	0.0029
1996	0.301	0.008	0.076	0.0028
1997	0.271	0.009	0.076	0.0028
1998	0.230	0.011	0.070	0.0031
1999	0.226	0.014	0.070	0.0016
2000	0.232	0.016	0.076	0.0017
2001	0.230	0.018	0.099	0.0037
2002	0.239	0.020	0.095	0.0044
2003	0.246	0.018	0.104	0.0052
2004	0.310	0.015	0.092	0.0067
2005	0.397	0.014	0.086	0.0064
2006	0.501	0.017	0.088	0.0065
2007	0.572	0.020	0.095	0.0067
2008	0.626	0.018	0.094	0.0053

6.2.5. Uncertainties and time-series consistency

The estimations of CH_4 emissions from enteric fermentation of cattle are carried out based on the *Tier 2* approach based on Estonian activity data and default factors taken from the IPCC Guidelines (1997, 2000). The *Tier 1* method is used to estimate CH_4 emissions from other livestock: swine, goats, horses, sheep and fur animals.

Uncertainties in activity data are not calculated in Estonia. The data were obtained from (Rypdal K., *at al.*, 2001), where the uncertainties in 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 taken in order to calculate uncertainties in emissions from enteric fermentation of livestock (Table 6.18). 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, all parameters were used as IPCC defaults, excluding milk production per cow and milk fat content. The uncertainty rate was taken as ±50% (Table 6.18) (IPCC 2000).

The estimations of CH_4 emissions from enteric fermentation of swine were estimated based on sub-categories of pigs. Almost all IPCC default parameters were used in the estimates (excl. weight). According to these, the uncertainties of the estimations are taken as ±50% (Table 6.18) (IPCC 2000).

Table 6.18. Estimated values of uncertainties used in agriculture sector (CH_4 emissions from enteric fermentation)

Input	Uncertainties	References
Activity data		
Estonia's livestock population (cattle, swine, sheep, goats, horses, poultry and fur animals)	± 10%	Rypdal K., et al., 2001
Emission factors		
Enteric fermentation (CH_4) (cattle, swine, fur farming)	± 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

6.2.6. Source-specific QC/QA 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 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.

6.2.7. Source-specific recalculations

There is one recalculation that was carried out in the 2010 submission: weight of mature dairy-cattle was updated for the entire time-series, a country specific value (Appendix A_IV) was used in the estimates instead of IPCC default. The results of the recalculation are reported in Figure 6.17 and in Table 6.19.

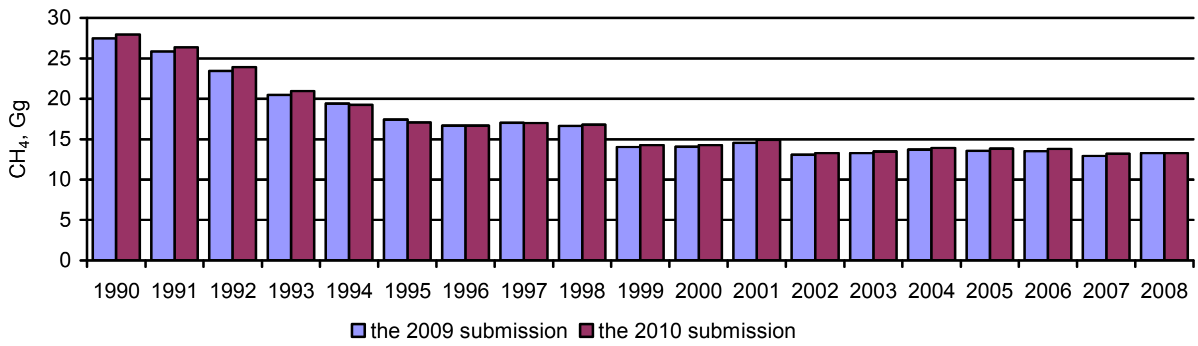


Figure 6.17. CH_4 emissions from enteric fermentation of dairy cattle in 1990–2008, Gg

Table 6.19. Reported and recalculated CH_4 emissions from enteric fermentation of dairy cattle in 1990–2008, Gg

	Reported emissions of CH_4 in the 2009 submission	Recalculated emissions of CH_4 (the 2010 submission)
1990	27.46	27.96
1991	25.85	26.35
1992	23.44	23.94
1993	20.48	20.95
1994	19.44	19.28
1995	17.44	17.10
1996	16.68	16.68
1997	17.05	17.02
1998	16.65	16.80
1999	14.04	14.27
2000	14.08	14.28
2001	14.55	14.94
2002	13.09	13.30
2003	13.32	13.49
2004	13.73	13.94
2005	13.58	13.86
2006	13.53	13.82
2007	12.94	13.21
2008		13.30

6.2.8. Source-specific planned improvements

The activity data are kept under consideration and will be updated necessarily.

6.3. CH_4 emissions from manure management

6.3.1. Source category description

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.

Methane emissions (recalculated to CO_{2equiv}) from manure management comprised 4.5 per cent from the total agricultural emissions in Estonia.

Table 6.20. CH_4 emissions from manure management in 1990–2008 in Estonia, Gg

Year	Cattle	Swine	Sheep	Goats	Horses	Poultry	Fur animals	Total
1990	3.74	2.68	0.0266	0.0001	0.012	0.510	0.0126	6.982
1991	3.54	2.49	0.0270	0.0001	0.011	0.432	0.0126	6.506
1992	3.08	1.68	0.0234	0.0001	0.009	0.267	0.0109	5.068
1993	2.43	1.33	0.0156	0.0001	0.007	0.252	0.0092	4.036
1994	2.19	1.44	0.0114	0.0002	0.007	0.244	0.0075	3.898
1995	1.94	1.40	0.0092	0.0002	0.006	0.227	0.0039	3.584
1996	1.86	0.93	0.0071	0.0002	0.006	0.181	0.0037	2.995
1997	1.85	0.96	0.0064	0.0002	0.006	0.203	0.0038	3.032
1998	1.80	1.03	0.0055	0.0003	0.005	0.206	0.0041	3.045
1999	1.54	0.95	0.0054	0.0003	0.005	0.192	0.0021	2.698
2000	1.52	1.00	0.0055	0.0004	0.006	0.185	0.0023	2.714
2001	1.60	1.11	0.0055	0.0004	0.008	0.179	0.0049	2.901
2002	1.50	1.11	0.0057	0.0005	0.007	0.164	0.0059	2.797
2003	1.52	1.11	0.0059	0.0004	0.008	0.152	0.0070	2.803
2004	1.53	1.07	0.0074	0.0003	0.007	0.170	0.0089	2.797
2005	1.54	1.08	0.0094	0.0003	0.007	0.147	0.0085	2.795
2006	1.54	1.09	0.0119	0.0004	0.007	0.128	0.0087	2.780
2007	1.50	1.23	0.0138	0.0005	0.007	0.115	0.0089	2.876
2008	1.50	1.15	0.0149	0.0004	0.007	0.137	0.0071	2.822
%, 2008	53.2	40.8	0.5	0.0	0.3	4.9	0.3	100

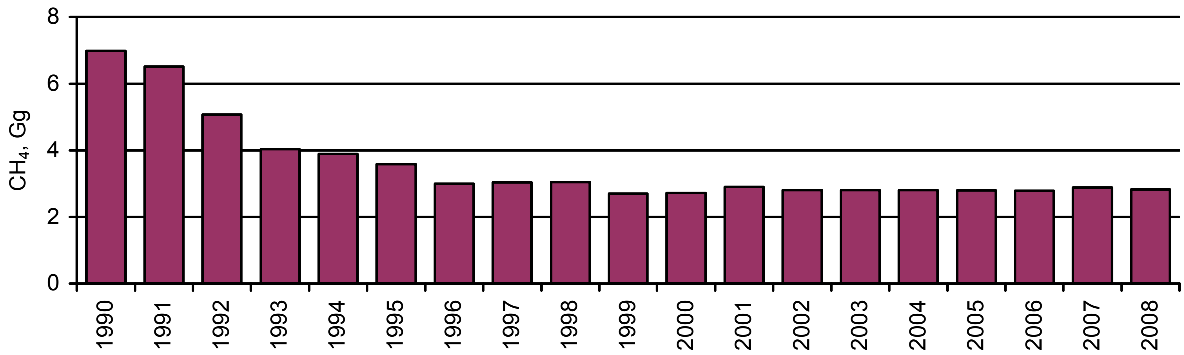


Figure 6.18. CH_4 emissions from Estonia's livestock manure management in 1990–2008, Gg

6.3.2. Cattle

6.3.2.1. Methodology, data availability, data sources and emission factors

CH_4 production from manure of dairy cattle, non-dairy cattle was estimated based on the algorithm presented in the IPCC (2000) using specific country data and IPCC default factors.

CH_4 emissions from manure management

$$CH_4\_Emissions_{ji} = Emission\_Factor_{ji} \times Population_{ji} / (10^6 \, kg/Gg) \qquad (6.14)$$ [46]

CH_4 $Emissions_{ji}$ – Methane emissions from manure management of *j* category of cattle in *i* county, Gg CH_4/yr;

Emission $Factor_{ji}$ – Methane emission factor for *j* category of cattle in *i* county, kgCH_4/head/yr;

$Population_{ji}$ – The number of head in *j* category of cattle in *i* county, heads;

Emission factor from manure management

$$EF_{ji} = VS_{ji} \times 365\_days/yr \times B_{oji} \times 0.67 kg/m^3 \times \sum_{nK} MCF_{nk} \times MS\%_{jiK} \qquad (6.15)$$ [47]

EF_{ji} - Annual methane emission factor for *j* category of cattle in *i* county, kg;

VS_{ji} - Daily VS excreted 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 6.21);

MCF_{ik} - CH_4 conversion factors for each manure management system *n* by climate region *k* (Table 6.22);

MS_{ijk} - Fraction of animal species/category *j*'s manure handled using manure system *n* in *i* country in climate region *k* (Table 6.22);

Volatile solid excretion rates

$$VS_{ji} \; (kg \; dm/day) = \frac{GE_{ii}}{18.45} \times (1 - \frac{DE_{ji}\%}{100\%}) \times (1 - \frac{ASH\%}{100\%}) \qquad (6.16)$$ [48]

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 6.21);

ASH – Ash content of the manure as a percentage, % (i.e., 8%);

Table 6.21. Parameters used in the estimates[49]

[46] IPCC 2000. Agriculture. Equation 4.15, pp. 4.30.
[47] IPCC 2000. Agriculture. Equation 4.17, pp. 4.34.
[48] IPCC 2000. Agriculture. Equation 4.16, pp. 4.30.

	Feeding	Digestibility of Feed, %	CH_4 Conversion	Bo (m^3 CH_4/kg VS)
Cows, bulls and heifers (2 years and over)				
...Dairy cattle	Stall Fed	60	6%	0.24
...Non-dairy cattle:				
…...Mature females	Pasture/Range	60	6.5%	0.17
…...Mature males	Pasture/Range	60	6.5%	0.17
Bovine animals (aged between 1 and 2 years)	Pasture/Range	60	6%	0.17
Calves (less than 1 year old)	Pasture/Range	65	6%	0.17

Table 6.22. Manure management system usage (%, Eastern Europe manure management system) and methane conversion factor (MCFs)[50]

	Lagoon	Liquid/ Slurry Solid	Solid Storage	Dry lot	Pasture / Range	Daily Spread	Digester	Burned for Fuel	Other
	Manure Management System Usage (%)[51]								
Dairy Cattle	0	18	68	0	13	1	0	0	0
Non-dairy Cattle	0	28	0	0	26	0	0	0	46
	Methane Conversion Factors (MCFs)[52]								
MCF	90%	10%	1%	1%	1%	0.1%	10.0%	7.5%	1%

Basing on the algorithm presented in this chapter, CH_4 emission factor was estimated as follows (Table 6.23)

Table 6.23. Manure management emission factors for cattle, kg CH_4/head/year

	Dairy cattle	Mature non-dairy cattle	Calves
1990	7.74	4.52	2.23
1991	7.74	4.52	2.23
1992	7.34	4.52	2.23
1993	7.18	4.52	2.23
1994	7.08	4.52	2.23
1995	7.16	4.52	2.23
1996	7.55	4.52	2.23
1997	7.88	4.52	2.23
1998	8.23	4.52	2.23
1999	8.01	4.51	2.23
2000	8.47	4.50	2.23
2001	9.02	4.53	2.23
2002	8.94	4.54	2.23
2003	8.97	4.52	2.23
2004	9.30	4.51	2.23
2005	9.54	4.50	2.23
2006	9.90	4.50	2.23

[49] Table A-1 and Table A-2 of the 1996 Revised IPCC Guidelines. Agriculture. Reference Manual. pp. 4.31
[50] Table B-3 (Eastern Europe) of the 1996 Revised IPCC Guidelines. Agriculture. Reference Manual. pp. 4.43
[51] For Dairy Cattle – IPCC 1997. Agriculture. Reference Manual. Table B-3 – Manure Management Emission Derivation for Dairy Cattle. pp. 4.43
For Non-Dairy Cattle – IPCC 1997. Agriculture. Reference Manual. B-4 – Manure Management Emission Derivation for Non-Dairy Cattle. pp. 4.44
[52] IPCC 2000. Agriculture. Table 4-10 – MCF Values for Manure Management System (for cool climate). pp 4.37

	Dairy cattle	Mature non-dairy cattle	Calves
2007	9.96	4.48	2.23
2008	10.29	4.46	2.23
IPCC default for Eastern Europe	6.0	4.0[53]	

6.3.2.2. Quantitative overview – CH_4 emissions from cattle manure management in 2008

The total CH_4 emissions from cattle manure management were 1.50Gg in Estonia in 2008, the emissions declined by 59 per cent by 2008 in comparison with the base year (Table 6.24).

Table 6.24. CH_4 emissions from cattle manure management activities in 1990–2008 in Estonia[6], Gg

	Cattle				
Year	DC	MF	MM	B	C
1990	2.172	0.168	0.018	0.736	0.563
1991	2.047	0.167	0.018	0.732	0.492
1992	1.859	0.136	0.014	0.596	0.399
1993	1.628	0.089	0.009	0.392	0.261
1994	1.498	0.086	0.009	0.362	0.236
1995	1.328	0.074	0.008	0.313	0.217
1996	1.296	0.069	0.007	0.293	0.199
1997	1.322	0.065	0.007	0.276	0.180
1998	1.305	0.060	0.006	0.254	0.172
1999	1.109	0.059	0.007	0.225	0.144
2000	1.109	0.059	0.006	0.208	0.137
2001	1.160	0.048	0.006	0.227	0.156
2002	1.033	0.049	0.005	0.256	0.156
2003	1.048	0.059	0.004	0.245	0.162
2004	1.083	0.059	0.006	0.237	0.148
2005	1.077	0.068	0.004	0.241	0.150
2006	1.073	0.069	0.008	0.240	0.147
2007	1.026	0.081	0.008	0.239	0.144
2008	1.033	0.092	0.010	0.218	0.147
%, 2008	68.9	6.1	0.7	14.6	9.8

6.3.3. Pigs

6.3.3.1. Methodology, data availability, data sources and emission factors

Methane production from the manure of swine by sub-categories was estimated employing the algorithm described in Chapter 6.2.2.1.

53 Manure management emission factor for non-dairy cattle (Table 4-6 – Manure management emission factor. Agriculture, Reference Manual. p.4.13)

Methane conversion factor and the system of manure management usage (%) for cattle manure storage are presented in Table 6.25. The factors (DE, B_o) used in the estimates were obtained from IPCC tables on default factors (Table 6.26). Estimated emission factors are reported in Table 6.27.

Table 6.25. Manure management system usage (%, Eastern European manure management system) and methane conversion factor (MCFs)

	Lagoon	Liquid/ Slurry Solid	Solid Storage	Dry lot	Pit < 1 month	Pit > 1 month	Daily Spread	Digester	Other
	Manure Management System Usage (%)[54]								
Swine	8	0	39	14	19	19	0	0	1
	Methane Conversion Factors (MCFs)[55]								
Swine	90%	39%	1%	1%	5%	10%	0.1%	10%	1%

Table 6.26. Parameter used in the estimates

	Feed Digestibility (DE) %	Feed Intake kg/day	VS kg/h/d	Bo (m^3 CH_4/kg VS)	Methane Conversion Factor (%)
Piglets, live weight less than 20 kg	75%	0.5	0.113	0.45	0.6%
Young pigs, live weight 20–<50 kg	75%	1.0	0.249	0.45	0.6%
Fattening pigs					
…live weight 50–<80 kg	75%	1.5	0.368	0.45	0.6%
…live weight 80–<110 kg	75%	1.9	0.468	0.45	0.6%
…live weight 110 kg or more	75%	2.1	0.513	0.45	0.6%
Breeding pigs, live weight 50 kg or more	75%	1.6	0.403	0.45	0.6%

Table 6.27. Methane emission factors from swine manure management systems, kg CH_4/head/year

Category of Swine	Emission factor, kg CH_4/head/yr	IPCC default for Eastern Europe[56]
Estonian average	3.25	4.0
Piglets, live weight less than 20 kg	1.32	
Young pigs, live weight20–<50 kg	2.91	
Fattening pigs		
...live weight 50–<80 kg	4.29	
...live weight 80–<110 kg	4.45	
...live weight 110 kg or more	5.98	
Breeding pigs, live weight 50 kg or more	4.70	

Implied CH_4 emission factor for pig manure management system are reported in Figure 6.19.

[54] IPCC 1997. Agriculture. Reference Manual. Table B-6 – Manure Management Emission Derivation for Swine. pp. 4.46

[55] IPCC 2000. Agriculture. Table 4-10 – MCF Values for Manure Management System (for cool climate). pp 4.37

[56] Manure management emission factor for swine (Table 4-6 – Manure management emission factor. Agriculture, Reference Manual. p.4.13)

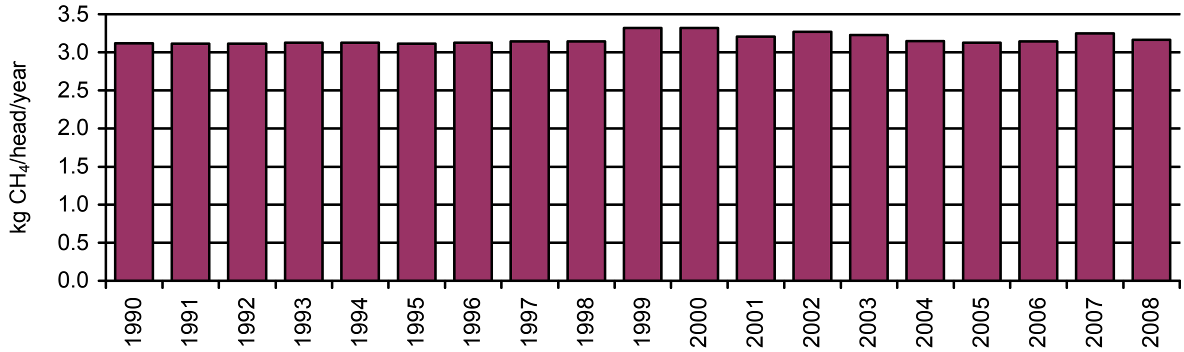


Figure 6.19. Implied CH_4 emission factor for pig manure management system in 1990–2008, kgCH_4/head/year

6.3.3.2. Quantitative overview – CH_4 emissions from pig manure management in 2008

The total CH_4 emissions from swine manure management were 1.15Gg in Estonia in 2008. The emissions decreased by 57% by 2008 in comparison with the base year due to decreasing number of swine population (Table 6.28).

Table 6.28. CH_4 emissions from swine manure management activities in 1990–2008 in Estonia, Gg

	Swine					
Year	P20	P50/YS	P80	P110	P100m	Br
1990	0.369	0.691	0.794	0.563	0.045	0.221
1991	0.344	0.643	0.740	0.524	0.042	0.195
1992	0.233	0.436	0.502	0.355	0.029	0.130
1993	0.181	0.339	0.390	0.276	0.022	0.119
1994	0.197	0.368	0.423	0.300	0.024	0.125
1995	0.193	0.361	0.416	0.294	0.024	0.110
1996	0.128	0.239	0.274	0.194	0.016	0.083
1997	0.129	0.242	0.278	0.197	0.016	0.100
1998	0.138	0.258	0.297	0.210	0.017	0.106
1999	0.099	0.226	0.283	0.158	0.023	0.159
2000	0.107	0.231	0.274	0.174	0.019	0.190
2001	0.132	0.301	0.245	0.222	0.010	0.195
2002	0.137	0.241	0.278	0.250	0.022	0.187
2003	0.137	0.267	0.276	0.243	0.011	0.178
2004	0.150	0.244	0.281	0.206	0.020	0.169
2005	0.150	0.253	0.331	0.173	0.009	0.167
2006	0.157	0.224	0.313	0.199	0.014	0.180
2007	0.163	0.238	0.337	0.307	0.016	0.171
2008	0.155	0.280	0.301	0.241	0.016	0.163
%, 2008	13.4	24.2	26.1	20.9	1.3	14.1

6.3.4. Other livestock

6.3.4.1. Methodology, data availability, data sources and emission factors

CH_4 emissions from manure management for other livestock were calculated in accordance with formula (6.14) using activity data on the population of livestock and IPCC factors (IPCC 1997). Methane emission factors for categories of livestock were taken from the IPCC Guidelines (1997) (Table 6.29).

Table 6.29. Methane emission factors for other livestock from manure management, kg CH_4/head/year[57]

Category of livestock	Emission Factor, kg CH_4/head/yr
Sheep	0.19
Goats	0.12
Horses	1.4
Poultry	0.078
Fur animals[58]	
…Foxes and Raccoon	2.34
…Minks	1.305

6.3.4.2. Quantitative overview – CH_4 emissions from other livestock manure management in 2008

The total CH_4 emissions from other livestock manure management system were 0.17Gg in Estonia in 2008 (Figure 6.20). The emissions declined by 70 per cent by 2008 in comparison with the base year due to decreasing number of other livestock population.

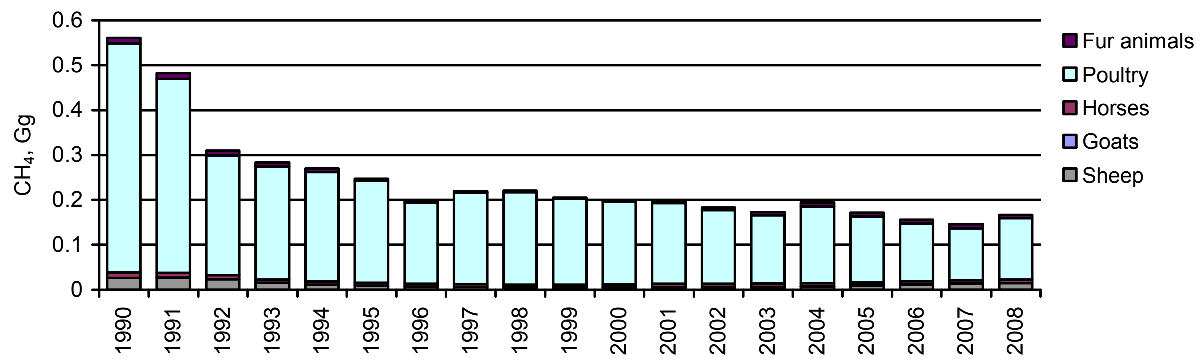


Figure 6.20. CH_4 emissions from other livestock manure management in 1990–2008, Gg

[57] IPCC 1997. Agriculture. Reference Manual. Table 4-5 manure management emission factors (developed countries, cool climate region). pp. 4-12.
[58] The values of manure management factor for fur animals was provided by an Finish expert in the Agriculture sector.

6.3.5. Uncertainties and time-series consistency

CH_4 emissions from manure management are 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), and the value of uncertainties is ±20% (Table 6.30). This factor has been used in the estimates.

Emission factors for cattle and swine are 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 6.30), the factor was developed based on the experience of other countries. Rypdal 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 K., *at al.*, 2001) and ±30% in Finland (Monni S., *et al.*, 2003).

N_2O emissions from livestock manure management are calculated based on activity data (livestock population), nitrogen excretion factors (Nex, kg/head/yr) and N emission factor related to manure management system.

An uncertainty of Nex (by categories of livestock) is presented in IPCC Guidelines (IPCC 1997), where the value is the same for all categories of livestock – ±25% (Table 6.30).

IPCC reports nitrogen emission factors for all systems of manure management used in Estonia's estimates of N_2O emissions from animal manure. Uncertainties of the factors are estimated at -50%...+100% (Table 6.30).

Table 6.30. Estimated values of uncertainties used in agriculture sector (manure management)

Input	Uncertainties	References
Activity data		
Estonia's livestock population (cattle, swine, sheep, goats, horses, poultry and fur animals)	± 10%	Rypdal K., *et al.*, 2001
Emission factors		

Input	Uncertainties	References
Manure management (CH_4) (cattle, swine)	± 25%	Rypdal K., *et al.*, 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

6.3.6. Source-specific QC/QA 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 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.

6.3.7. Source-specific recalculations

There is one recalculation carried out in the 2010 submission: weight of mature dairy-cattle was updated for the entire time-series. A country specific value (Appendix A_IV) was used in the estimates instead of IPCC default. The results of the recalculation are reported in Figure 6.21 and in Table 6.31.

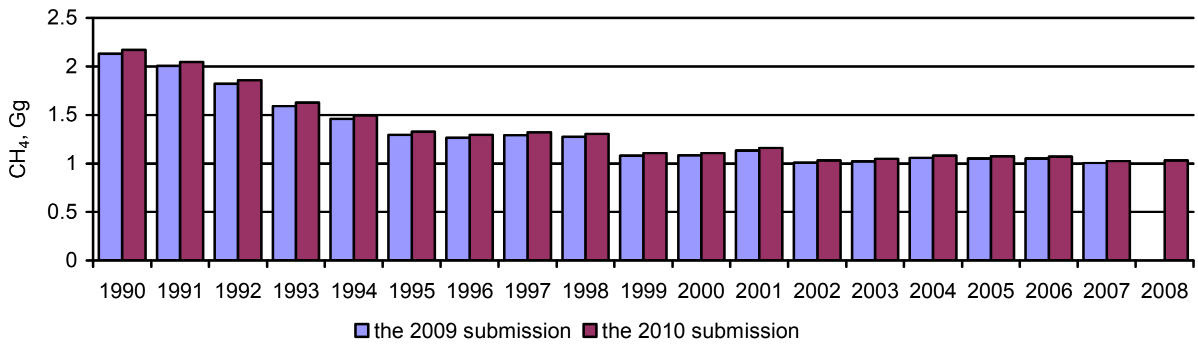


Figure 6.21. CH_4 emissions from enteric fermentation of dairy cattle in 1990–2008, Gg

Table 6.31. Reported and recalculated CH_4 emissions from enteric fermentation of dairy cattle in 1990–2008, Gg

	Reported emissions of CH_4 in the 2009 submission	Recalculated emissions of CH_4 (the 2010 submission)
1990	2.133	2.172
1991	2.008	2.047
1992	1.821	1.859
1993	1.591	1.628
1994	1.462	1.498
1995	1.296	1.328
1996	1.266	1.296
1997	1.292	1.322
1998	1.276	1.305
1999	1.082	1.109
2000	1.084	1.109
2001	1.135	1.160
2002	1.010	1.033
2003	1.024	1.048
2004	1.060	1.083
2005	1.054	1.077
2006	1.051	1.073
2007	1.005	1.026
2008		1.033

6.3.8. Source-specific planned improvements

A dataset on country-specific manure management system will be developed in the next submissions. The data on types of manure management system were collected by ESO in 2001 (see Appendix_V), the next cycle of data collection will take place in 2010. Estonian manure management system will be developed based on these two datasets. The data for years of 2002–2009 will be interpolated and module on manure management system for years of 1990–2000 will be extrapolated taking into consideration agricultural expert opinions.

6.4. N_2O emissions from manure management

6.4.1. 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).

N_2O emissions from manure management made up 9.0% from the total agricultural emissions in Estonia in 2008. N_2O emissions from animal manure stored of the base year is 2.5 fold higher than 2008 emissions (Table 6.32., Figure 6.22).

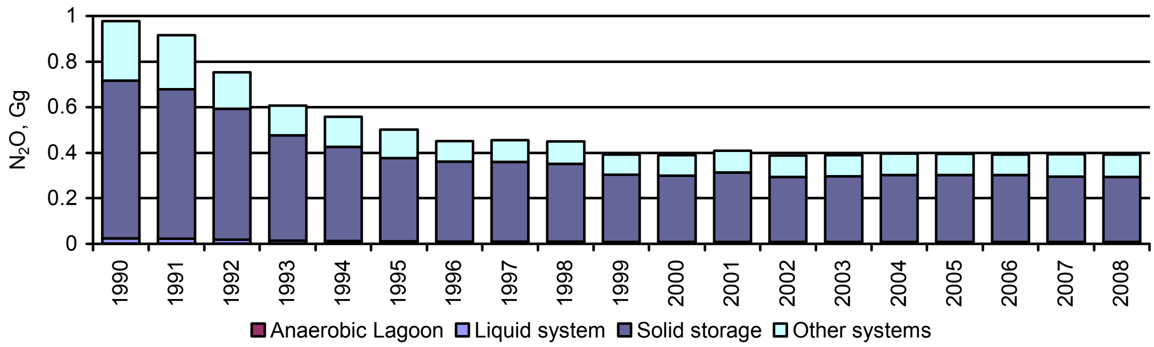


Figure 6.22. N_2O emissions from Estonia's manure management systems in 1990–2008, Gg.

Table 6.32. N_2O emissions from Estonia's manure management systems in 1990–2008, Gg

Year	Anaerobic lagoon	Liquid system	Solid storage	Other system
1990	0.0018	0.0222	0.6942	0.2609
1991	0.0018	0.0208	0.6583	0.2367
1992	0.0014	0.0166	0.5763	0.1596
1993	0.0009	0.0127	0.4637	0.1306
1994	0.0008	0.0118	0.4135	0.1326
1995	0.0007	0.0107	0.3652	0.1260
1996	0.0007	0.0094	0.3519	0.0899
1997	0.0006	0.0093	0.3510	0.0946
1998	0.0006	0.0092	0.3422	0.0979
1999	0.0005	0.0081	0.2942	0.0903
2000	0.0005	0.0080	0.2906	0.0914
2001	0.0005	0.0085	0.3047	0.0964
2002	0.0006	0.0083	0.2842	0.0950
2003	0.0006	0.0083	0.2877	0.0929
2004	0.0005	0.0083	0.2931	0.0948
2005	0.0005	0.0083	0.2932	0.0930
2006	0.0006	0.0082	0.2927	0.0917
2007	0.0006	0.0084	0.2850	0.0999
2008	0.0006	0.0083	0.2847	0.0995

6.4.2. Cattle

6.4.2.1. Methodology, data availability, data sources and emission factors

The key methodology used for the estimation of N_2O emissions from manure management was a *Tier 1* method (IPCC 1997).

$$(N_2O-N)_{(mm)} = \sum_{(S)}\{[\sum_{(T)} N_{(T)} \bullet Nex_{(T)} \bullet MS_{(T,S)}] \bullet EF_{3(S)}\} \qquad (6.17)^{59}$$

$(N_2O\text{-}N)_{(mm)}$ – 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*;

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:

$$N_2O_{(mm)} = (N_2O-N)_{(mm)} \bullet 44/28 \qquad (6.18)$$

The data on population of livestock by categories were obtained from database of the ESO (Appendix A_I). The percentage of manure production per animal waste management systems and emission factors for N_2O from manure management (Table 6.34) is used from the reports of IPCC (1997). An example of the estimation of nitrogen excretion factor for dairy cattle is presented in Appendix_VI.

Table 6.33. Average N excretion factors used in the estimates, kg N/head/year

Year	Dairy Cattle	Mature Non-dairy cattle	Young cattle
1990	76.12	46.19	17.24
1991	76.18	46.19	17.24
1992	72.18	46.19	17.24
1993	70.63	46.19	17.24
1994	68.33	46.19	17.24

[59] IPCC 2000. Agriculture. Equation 4.18. pp. 4.42

Year	Dairy Cattle	Mature Non-dairy cattle	Young cattle
1995	69.19	46.19	17.24
1996	72.85	46.19	17.24
1997	76.02	46.19	17.24
1998	79.35	46.19	17.24
1999	77.68	46.46	17.24
2000	82.16	45.99	17.24
2001	87.10	46.29	17.24
2002	86.36	46.39	17.24
2003	86.64	46.17	17.24
2004	89.82	46.13	17.24
2005	92.15	45.99	17.24
2006	95.50	45.98	17.24
2007	96.15	45.79	17.24
2008	99.50	45.53	17.24

Table 6.34. Percentage of manure production per animal waste management systems, %[60] and default emission factors for N_2O from manure management [61]

Type of Animal	Anaerobic lagoon	Liquid system	Daily spread	Solid storage and Dry lot	Pasture Range and Paddock	Other System
Non-dairy cattle	0	19	1	67	13	0
Dairy cattle	8	39	0	52	0	1
EF_3 (kg N_2O-N/kg Nitrogen excreted)	0.001	0.001	0.0	0.02	0.02[62]	0.001[63]

6.4.2.2. Quantitative overview – Nitrogen excretion by cattle livestock in 2008

The total quantity of nitrogen generated by cattle was 14,395 tonnes in Estonia in 2008. The allocation of nitrogen excreted among different types of manure management system is presented in Table 6.35.

Table 6.35. The allocation of the quantity of nitrogen (in manure) excreted by cattle among different types of manure management system, tonnes N/year

Year	Anaerobic lagoon	Liquid system	Daily spread	Solid storage and dry lot	Pasture range and paddock	Other AWMS
1990	1,172	9,774	214	21,935	2,778	147
1991	1,123	9,302	201	20,791	2,617	140
1992	915	7,934	183	18,200	2,378	114
1993	601	5,972	160	14,634	2,082	75
1994	519	5,277	144	13,055	1,878	65
1995	456	4,662	128	11,561	1,668	57
1996	425	4,446	125	11,137	1,625	53

[60] IPCC 1997. Agriculture. Reference Manual. Table 4-7 –Default values for percentage of manure N production in different animal waste management systems in different world regions (Default values for Eastern Europe were used). pp 4-11
[61] IPCC 2000. Agriculture. Table 4.12 – Default emission factors for N_2O from manure management. pp 4.43
[62] The factors were used in the 'Animal waste applied to soils and excreted on pasture' chapter
[63] Cattle and Swine Deep Litter from IPCC 2000. Agriculture. Table 4.13 – Default emission factors for N_2O from manure management system not specified in the IPCC. pp 4.44

Year	Anaerobic lagoon	Liquid system	Daily spread	Solid storage and dry lot	Pasture range and paddock	Other AWMS
1997	395	4,348	127	11,109	1,657	49
1998	369	4,188	126	10,828	1,636	46
1999	327	3,636	108	9,328	1,398	41
2000	308	3,544	108	9,210	1,399	38
2001	326	3,717	112	9,624	1,456	41
2002	350	3,603	100	8,964	1,298	44
2003	351	3,635	101	9,064	1,316	44
2004	339	3,639	105	9,212	1,360	42
2005	348	3,673	104	9,229	1,351	44
2006	350	3,673	104	9,211	1,346	44
2007	358	3,626	99	8,962	1,287	45
2008	352	3,616	100	8,984	1,299	44

6.4.3. Pigs

6.4.3.1. Methodology, data availability, data sources and emission factors

The activity data were obtained from national statistics, method used in the estimation was employed from the IPCC Guidelines. Nitrogen excretion factor was estimated using the algorithm presented in Box 2 (Appendix A_VI), the factor was calculated for each swine sub-category. The implied nitrogen excreted factor is demonstrated in Figure 6.23.

Table 6.36. Percentage of manure production per animal waste management systems, %[64] and default emission factors for N_2O from manure management [65]

Type of Animal	Anaerobic Lagoon	Liquid System	Daily Spread	Solid Storage and Dry lot	Pasture Range and Paddock	Other System
Swine	0	29	0	0	0	44
EF_3 (kg N_2O-N/kg Nitrogen excreted)	0.001	0.001	0.0	0.02	0.02[66]	0.02[67]

[64] IPCC 1997. Agriculture. Reference Manual. Table 4-7 –Default values for percentage of manure N production in different animal waste management systems in different world regions (Default values for Eastern Europe were used). pp 4.11
[65] IPCC 2000. Agriculture. Table 4.12 – Default emission factors for N_2O from manure management. pp 4.43
[66] The factors were used in the 'Animal waste applied to soils and excreted on pasture' chapter
[67] Cattle and Swine Deep Litter from IPCC 2000. Agriculture. Table 4.13 – Default emission factors for N_2O from manure management system not specified in the IPCC. pp 4.44

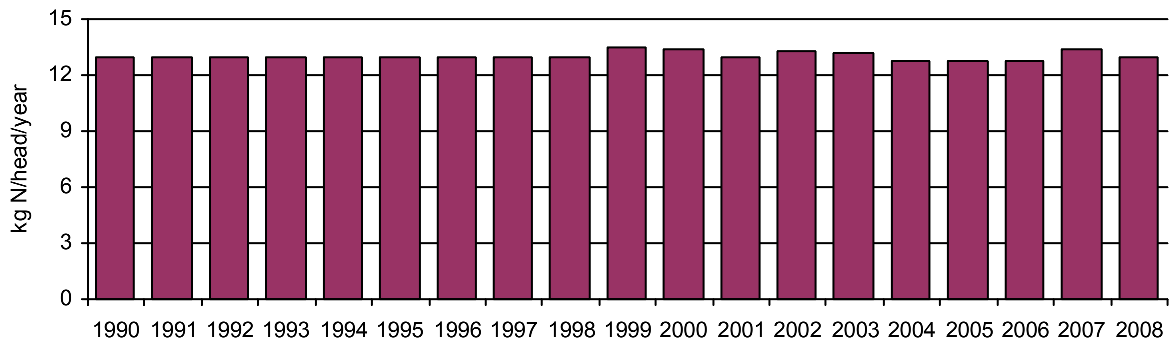


Figure 6.23. Implied swine nitrogen excretion factor reported in the CRF for 1990–2008, kg N/head/year

6.4.3.2. Quantitative overview – Nitrogen excretion by swine livestock in 2008

The total quantity of nitrogen generated by pigs was 4,720 tonnes in Estonia in 2008. The allocation of nitrogen excreted among different types of manure management system is presented in Table 6.37.

Table 6.37. The allocation of the quantity of nitrogen (in manure) excreted by pigs among different types of manure management system, tonnes N/year

Year	Liquid system	Pasture range and paddock	Other AWMS
1990	3,232	3,009	4,904
1991	3,000	2,793	4,552
1992	2,033	1,893	3,084
1993	1,596	1,486	2,422
1994	1,729	1,610	2,623
1995	1,686	1,570	2,558
1996	1,122	1,045	1,703
1997	1,154	1,074	1,751
1998	1,230	1,145	1,866
1999	1,120	1,043	1,700
2000	1,168	1,087	1,772
2001	1,293	1,204	1,962
2002	1,316	1,225	1,997
2003	1,313	1,223	1,992
2004	1,263	1,175	1,916
2005	1,280	1,191	1,941
2006	1,282	1,194	1,946
2007	1,471	1,370	2,232
2008	1,369	1,274	2,077

6.4.4. Other livestock

6.4.4.1. Methodology, data availability, data sources and emission factors

The activity data on other livestock population were taken from national statistics, a module of manure management system, emission factors (Table 6.39) and nitrogen excretion factors (Table 6.38) were obtained from the Revised 1996 IPCC Guidelines (IPCC 1997).

Table 6.38. Nitrogen excretion factors per head of animal, kg N/head/year

Animal category	Nitrogen Excretion factor, kg N/head/year
Poultry	0.6
Sheep	16
Horses, Goats	25
Fur farming[68]	
…Foxes and Raccoon	2.3
…Minks	1.3

Table 6.39. Percentage of manure production per animal waste management systems, %[69] and default emission factors for N_2O from manure management [70]

Type of Animal	Anaerobic lagoon	Liquid system	Daily spread	Solid storage and Dry lot	Pasture, range and paddock	Other system
Poultry	0	28	0	0	1	71
Sheep	0	0	0	0	73	27
Other animals	0	0	0	0	92	8
EF_3 (kg N_2O-N/kg Nitrogen excreted)	0.001	0.001	0.0	0.02	0.02[71]	0.02[72]

It was assumed that only solid storage and dry lot manure management system is applied for fur animals in Estonia for the entire time-series.

6.4.4.2. Quantitative overview – Nitrogen excretion by other livestock in 2008

The total quantity of nitrogen generated by other livestock was 2,602 tonnes in 2008. The breakdown of the quantity of nitrogen excreted among types of manure management is reported in Table 6.40.

[68] The values of emission factors from manure management of fur animals was provided by an Finish expert in the Agriculture sector

[69] IPCC 1997. Agriculture. Reference Manual. Table 4-7 –Default values for percentage of manure N production in different animal waste management systems in different world regions (Default values for Eastern Europe were used). pp 4-11

[70] IPCC 2000. Agriculture. Table 4.12 – Default emission factors for N_2O from manure management. pp 4.43

[71] The factors were used in the 'Animal waste applied to soils and excreted on pasture' chapter

[72] Cattle and Swine Deep Litter from (IPCC 2000) Agriculture. Table 4.13 – Default emission factors for N_2O from manure management system not specified in the IPCC. pp 4.44

Table 6.40. The allocation of the quantity of nitrogen (in manure) excreted by other livestock among different types of manure management system, tonnes N/year

Year	Sheep	Goats	Horses	Poultry	Fur farming
1990	2,237	23	215	3,922	153
1991	2,270	23	195	3,323	153
1992	1,970	28	165	2,051	136
1993	1,315	28	130	1,936	119
1994	960	38	125	1,878	103
1995	771	43	115	1,747	61
1996	602	40	105	1,395	60
1997	542	43	105	1,561	59
1998	459	53	98	1,581	62
1999	451	68	98	1,477	33
2000	464	80	105	1,420	36
2001	461	90	138	1,377	71
2002	478	98	133	1,258	78
2003	493	88	145	1,167	92
2004	621	73	128	1,310	116
2005	794	70	120	1,127	102
2006	1,003	83	123	983	105
2007	1,158	100	133	887	108
2008	1,251	90	130	1,054	77

6.4.5. Source-specific QC/QA 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 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.

6.4.6. Source-specific recalculations

There are two recalculations carried out in the 2010 submission in 'N_2O emissions from manure management system' sub-section: (1) weight of mature dairy-cattle was updated for the entire time-series, a country specific value (Appendix A_IV) was used in the estimates instead of IPCC default; (2) the quantities of nitrogen excreted by fur animals were estimated for the first time in the 2010 submission. The results of the recalculations are reported in Figures 6.24–6.25 and in Tables 6.41–6.42.

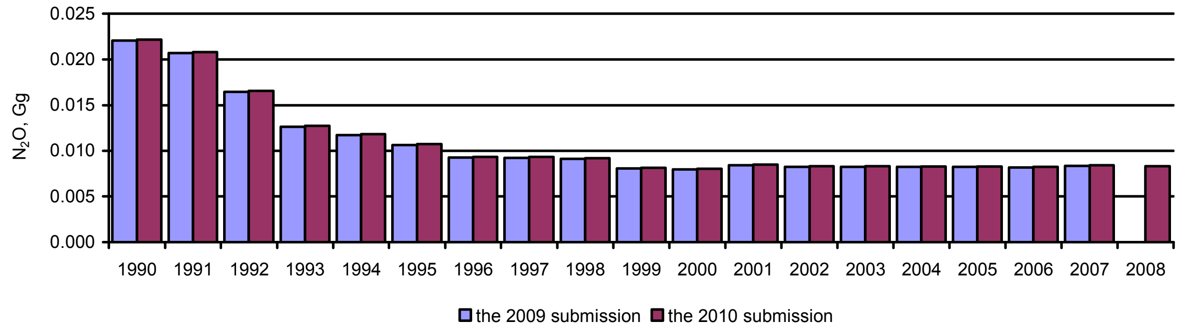


Figure 6.24. N_2O emissions from liquid manure management systems in 1990–2008, Gg

Table 6.41. N_2O emissions from liquid manure management in 1990–2008, Gg

Year	Reported emissions of N_2O (the 2009 submission)	Recalculated emissions of N_2O in 1990–2008 (the 2010 submission)
1990	0.0220	0.0222
1991	0.0207	0.0208
1992	0.0165	0.0166
1993	0.0126	0.0127
1994	0.0117	0.0118
1995	0.0107	0.0107
1996	0.0093	0.0094
1997	0.0092	0.0093
1998	0.0091	0.0092
1999	0.0080	0.0081
2000	0.0080	0.0080
2001	0.0084	0.0085
2002	0.0082	0.0083
2003	0.0082	0.0083
2004	0.0082	0.0083
2005	0.0082	0.0083
2006	0.0082	0.0082
2007	0.0083	0.0084
2008		0.0083

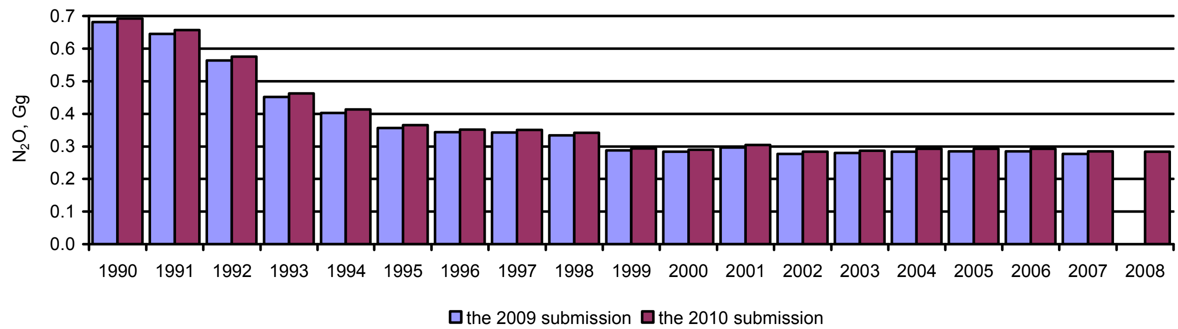


Figure 6.25. N_2O emissions from solid storage manure management systems in 1990–2008, Gg

Table 6.42. N_2O emissions from solid storage manure management in 1990–2008, Gg

Year	Reported emissions of N_2O (the 2009 submission)	Recalculated emissions of N_2O in 1990–2008 (the 2010 submission)
1990	0.681	0.694
1991	0.645	0.658
1992	0.564	0.576
1993	0.452	0.464
1994	0.403	0.414
1995	0.357	0.365
1996	0.344	0.352
1997	0.343	0.351
1998	0.334	0.342
1999	0.288	0.294
2000	0.284	0.291
2001	0.297	0.305
2002	0.277	0.284
2003	0.280	0.288
2004	0.285	0.293
2005	0.285	0.293
2006	0.285	0.293
2007	0.277	0.285
2008		0.285

6.4.7. Source-specific planned improvements

A dataset on country-specific manure management system will be developed in the next submissions. The data on types of manure management system were collected by ESO in 2001 (see Appendix_V), the next cycle of data collection will take place in 2010. Estonian manure management system will be developed based on these two datasets. The data for years of 2002–2009 will be interpolated and module on manure management system for years of 1990–2000 will be extrapolated taking into consideration agricultural expert opinions.

6.5. N_2O emissions from pasture, range and paddock (CRF 4.D.2)

6.5.1. Methodology, data availability, data sources and emission factors

The method reported in Chapter 6.3 was used in order to estimate N_2O emissions from animal pasture, range and paddock.

6.5.2. Quantitative overview – N_2O emissions from pasture, range and paddock in 2008

The N_2O emissions from pasture, range and paddock made up 0.12 Gg in 2008. The emissions decreased by 52 per cent compared to the base year (Figure 6.26) due to decline in number of livestock population (Figure 6.4–6.8).

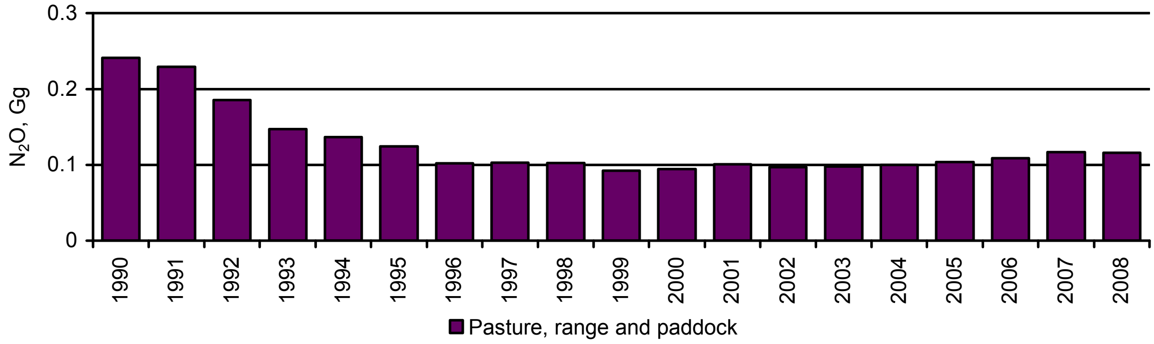


Figure 6.26. N_2O emissions from pasture, range and paddock, Gg

6.5.3. Source-specific QC/QA 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 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.

6.5.4. Uncertainties and time-series consistency

Uncertainty rates in the estimates of N_2O emissions from manure management systems are reported in Chapter 6.3.5.

6.5.5. Source-specific recalculations

There is one recalculation carried out in the 2010 submission: weight of mature dairy-cattle was updated for the entire time-series, a country specific value (Appendix A_IV) was used in the estimates instead of IPCC default. The results of the recalculation are reported in Table 6.43.

Table 6.43. N_2O emissions from pasture, range and paddock manure management in 1990–2008, Gg

Year	Reported emissions of N_2O (the 2009 submission)	Recalculated emissions of N_2O in 1990–2008 (the 2010 submission)
1990	0.2397	0.2413
1991	0.2279	0.2295
1992	0.1841	0.1856
1993	0.1460	0.1475
1994	0.1355	0.1369
1995	0.1233	0.1245
1996	0.1012	0.1023
1997	0.1019	0.1031
1998	0.1016	0.1028
1999	0.0912	0.0923
2000	0.0936	0.0946
2001	0.1002	0.1012
2002	0.0964	0.0973
2003	0.0972	0.0982
2004	0.0992	0.1001
2005	0.1031	0.1040
2006	0.1082	0.1091
2007	0.1163	0.1171
2008		0.1163

6.5.6. Source-specific planned improvements

A dataset on country-specific manure management system will be developed in the next submissions. The data on types of manure management system were collected by ESO in 2001 (see Appendix A_V), the next cycle of data collection will take place in 2010. Estonian manure management system will be developed based on these two datasets. The data for years of 2002–2009 will be interpolated and module on manure management system for years of 1990–2000 will be extrapolated taking into consideration agricultural expert opinions.

6.6. Direct emissions from agricultural soils

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 (N) available for nitrification and the amount of N_2O emitted (IPCC 2000).

The following agricultural activities exert influence on N flows in agricultural soils:

- Synthesis fertilizers;
- Animal excreta nitrogen used as fertilizer;
- Biological nitrogen fixation;
- Crop residue;
- Cultivation of high organic content soils;
- Sewage sludge application on agricultural soils;

6.6.1. Source category description

The total direct N_2O emissions from agricultural soils were 1.72Gg in Estonia in 2008 (Figure 6.27).

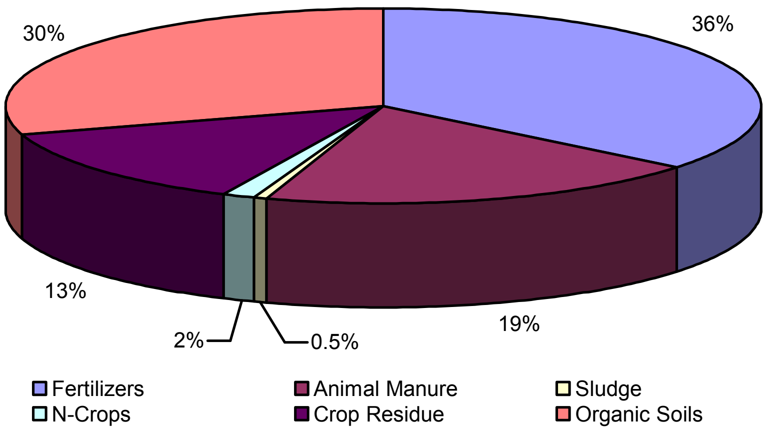


Figure 6.27. Direct N_2O emissions from agricultural soils in Estonia in 2008, Gg

Table 6.44. Direct N_2O emissions from agricultural soils in Estonia in 1990–2008, Gg

Year	Synthetic fertilizers	Animal manure	Sludge applied	N-fixing crops	Crop residue	Organic soils	Total
1990	1.141	0.822	0.0007	0.0003	0.41	0.537	2.914
1991	1.111	0.773	0.0007	0.0003	0.40	0.570	2.852
1992	1.032	0.629	0.0007	0.0005	0.28	0.559	2.502
1993	0.529	0.499	0.0008	0.0009	0.28	0.491	1.798
1994	0.461	0.460	0.0013	0.0009	0.25	0.428	1.605
1995	0.334	0.415	0.0024	0.0053	0.26	0.407	1.420
1996	0.293	0.366	0.0027	0.0117	0.27	0.388	1.328
1997	0.362	0.367	0.0027	0.0144	0.26	0.429	1.432
1998	0.441	0.363	0.0011	0.0070	0.15	0.474	1.439
1999	0.352	0.319	0.0015	0.0026	0.18	0.459	1.310
2000	0.396	0.318	0.0023	0.0056	0.26	0.512	1.490
2001	0.347	0.335	0.0005	0.0055	0.20	0.428	1.316
2002	0.295	0.321	0.0028	0.0043	0.17	0.403	1.193
2003	0.416	0.322	0.0053	0.0043	0.17	0.429	1.345
2004	0.439	0.326	0.0060	0.0028	0.18	0.429	1.381
2005	0.355	0.327	0.0096	0.0049	0.22	0.450	1.368
2006	0.400	0.329	0.0107	0.0047	0.18	0.465	1.388

Year	Synthetic fertilizers	Animal manure	Sludge applied	N-fixing crops	Crop residue	Organic soils	Total
2007	0.442	0.335	0.0093	0.0081	0.25	0.498	1.543
2008	0.626	0.333	0.0081	0.0028	0.23	0.519	1.721

6.6.2. Activity data employed

The activity data on synthetic fertilizers applied on agricultural fields, crop production in Estonia were taken from the datasets of the ESO. The data on amounts of sludge used on arable lands were used from the EEIC. The data on areas of histosols cultivated in Estonia were estimated merging two map-datasets: CORINE cover maps (scale 1:100 000) and Estonian soil map (scale 1: 10 000).

6.6.3. N_2O emissions from synthetic fertilizer nitrogen applied to soils (CRF 4.D.1.1)

The emissions of N_2O are estimated from annual synthetic nitrogen applied to soils.

6.6.3.1. Methodology, data availability, data sources and emission factors

The algorithm reported in IPCC (2000) was used for the estimation of nitrogen input into agricultural soils adjusted for volatilization.

$$F_{SN} = N_{FERT} \times (1 - Frac_{GASF}) \qquad (6.19)^{73}$$

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;
N_2O emissions into the atmosphere from using of synthetic nitrogen was calculated based on the formula (6.20).

$$N_2O_{direct} - N = F_{SN} \bullet EF \bullet 44/28_1 \qquad (6.20)$$

Table 6.45. IPCC default factors used in the estimation

Factors	Value
EF_1 for F_{SN}	1.25%[74]
$Frac_{GASF}$	0.1 kg NH_3-N + NO_x-N/kg of synthetic fertilizer nitrogen applied[75]

[73] IPCC 1997. Agriculture. Workbook. Equation 1, pp. 4.33.
[74] IPCC 2000. Agriculture. Table 4-17. Updated default emission factors to estimate direct N_2O emissions from agricultural soils, pp. 4.60

6.6.3.2. Quantitative overview – N_2O emissions from synthetic fertilizers applied to soils in 2008

The total N_2O emissions from synthetic fertilizers applied onto agricultural soils were 0.626 Gg in Estonia in 2008 (Figure 6.29). The emissions declined by 45 per cent by 2008 in comparison with the base year due to the decrease in amounts of synthetic fertilizers applied to agricultural fields, mostly on fields sown with cereals and forage crops (Figure 6.28, Appendix A_VII).

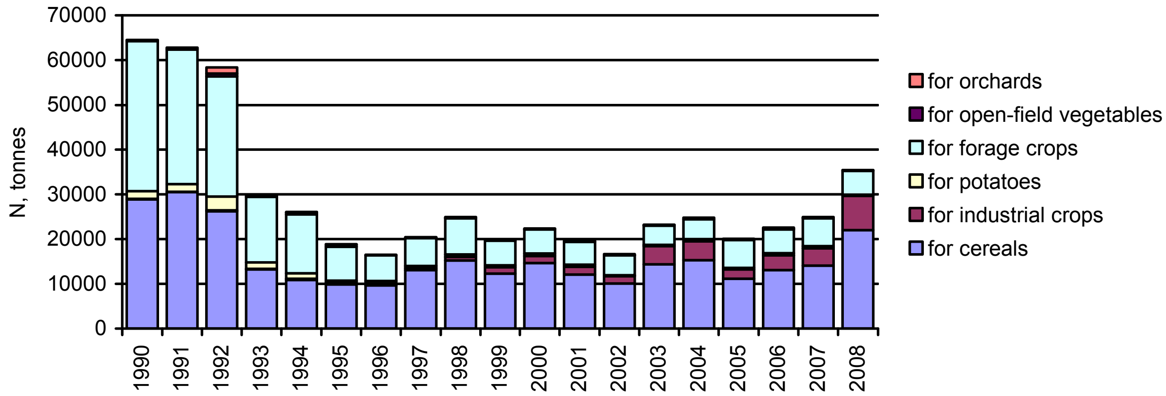


Figure 6.28. Quantity of synthetic fertilizers applied to agricultural soils in 1990–2008 in Estonia, 1000 tonnes (ESO).

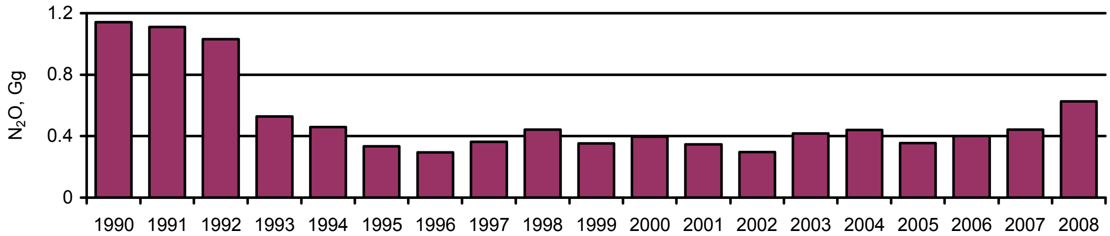


Figure 6.29. N_2O emissions from synthetic fertilizers applied to agricultural soils in 1990–2008 in Estonia, Gg.

6.6.4. N_2O emissions from animal manure applied to soils (CRF 4.D.1.2)

N_2O occurs from agricultural soil through manure application to fields as organic fertilizer.

6.6.4.1. Methodology, data availability, data sources and emission factors

N_2O emissions into the atmosphere from animal waste applied to agricultural fields as organic fertilizer were estimated according to the algorithm suggested by IPCC (1997).

[75] IPCC 1997. Agriculture. Reference Manual. Table 4-17 Summary of default values for parameters, 1996, pp. 4.35

$$N_2O_{direct} - N = F_{AW} \bullet EF_1 \qquad (6.21)$$

$$F_{AW} = (Nex \bullet (1 - Frac_{FUEL} + Frac_{GRAZ} + Frac_{GASM})) \qquad (6.22)$$[76]

$$Nex = \sum [N_{(T)} \times Nex_{(T)}] \qquad (6.23)$$

$$Nex_{(AWMS)} = \sum [N_{(T)} \times Nex_{(T)} \times AWMS_{(T)}] \qquad (6.24)$$

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/yr;

$AWMS_{(T)}$ – Fraction of $Nex_{(T)}$ that is produced in the different distinguished animal waste management systems in country;

$Frac_{FUEL}$ – Fraction of livestock nitrogen excretion contained in excrements burned for fuel, kg N/kg N totally excreted;

$Frac_{GRAZ}$ – Fraction of livestock nitrogen excreted and deposited onto soil during grazing, kg N/kg N excreted;

$Frac_{GASM}$ – Fraction of total nitrogen excretion that is emitted as NOx or NH_3, kg N/kg N;

$N_{(T)}$ – Number of animals per type of animal in country;

Nex – Total nitrogen excretion by animals in country, kg N/yr;

$Nex_{(T)}$ – Nitrogen excretion per Type of animal in country, kg/yr;

$Nex_{(AWMS)}$ – Nitrogen excretion per Animal Waste Management System, kg/yr;

Nitrogen excretion generated per type of animals and per animals waste management system was estimated in 'N_2O emissions from manure management' chapter.

IPCC default factors were used to estimate nitrogen input to agricultural soils (Table 6.46).

Table 6.46. IPCC default factors used in the estimation of N_2O emissions from animal waste applied to soils

Factor	Value
$Frac_{FUEL}$	0.0 kg N/kg nitrogen excreted[77]
$Frac_{GRAZ}$	see Tables 6.34, 6.36 (Pasture, range and paddock)
$Frac_{GASM}$	0.2 kg NH_3-N + NO_x-N/kg of nitrogen excreted by livestock[45]

[76] IPCC 1997. Agriculture. Workbook. Equations 2-4, pp 4.33.
[77] IPCC 1997. Agriculture. Workbook. Table 4-17 – Summary of default values for parameters. pp 4.35.

6.6.4.2. Quantitative overview – N_2O emissions from Animal manure applied to soils in 2008

The total N_2O emissions from animal manure applied on agricultural soils were 0.333Gg in Estonia in 2008 (Figure 6.30). The emissions decreased by 60 per cent by 2008 compared to the base year, due to the decline in the number of livestock population.

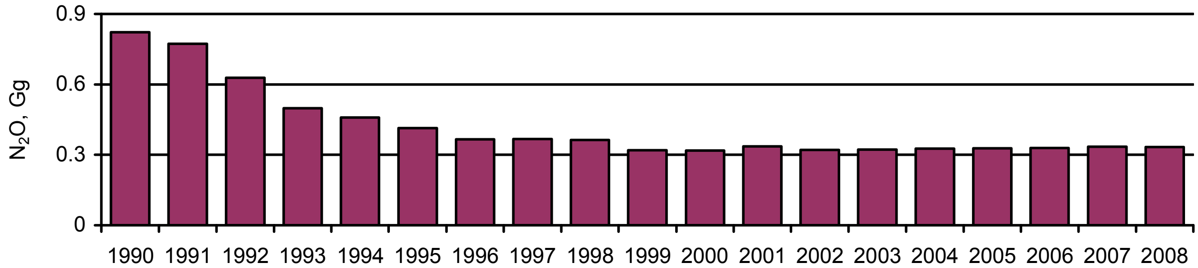


Figure 6.30. N_2O emissions from animal manure applied to agricultural soils in 1990–2008 in Estonia, Gg

6.6.5. Nitrogen input in N-fixing crops (CRF 4.D.1.3)

The amount of nitrogen fixed by N-fixing crops cultivated annually (IPCC 2000).

6.6.5.1. Methodology, data availability, data sources and emission factors

The *Tier 1* method (IPCC 1997) was used to estimate emissions from N fixing crops and pastures.

$$F_{BN} = \sum_i [Crop_{BF} \bullet (1 + Res_{BF_i} / Crop_{BF_i}) \bullet Frac_{DM_i} \bullet Frac_{NCRBF_i}] \quad (6.25)^{78}$$

$Crop_{BF}$ – Production of pulses + soybeans in country, kg dry biomass/yr;

$Res_{BFi}/Crop_{BFi}$ – 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 the ESO (Table 6.48, Appendix A_IX). IPCC default factor was used in the estimation (Table 6.47). The factor for conversion of the crop production from fresh matter (FM) to dry matter (DM) was obtained from Jonas M., *et al.*, 2001.

[78] IPCC 2000. Agriculture. Equation 4.26, pp. 4.57.

Annual N_2O emissions from N-fixing crops was calculated using the formula (6.26) (a *Tier 1*, IPCC 1997)

$$N_2O_{direct} = F_{BN} \bullet EF_1 \bullet 44/28 \quad (6.26)$$

EF_1 – IPCC default factor for N-fixing crops (Table 6.47);

Table 6.47. Factors used in the algorithm of the estimation

Factor	Value
$Frac_{NCRBF}$[79]	0.03 kg N/kg of Dry Matter
Conversion factor from FM to DM[80]	0.87 t DM / t FM
Grain-to-Straw ratio for Legumes[48]	1.525
EF_1 for F_{BN}	1.25%

6.6.5.2. Quantitative overview – N_2O emissions from growing of N-fixing crops in 2008

The total production of legumes in Estonia was 3,309 tonnes in 2008 (Table 6.48) that equals 142,998 kg N.

Table 6.48. Production of legumes in Estonia in 2008 (ESO)

County	Harvest, tonnes	Total production, t DM	N_2O emissions, Gg
Harju	40	58	0.0000
Hiiu	23	33	0.0000
Ida-Viru	9	13	0.0000
Jõgeva	4	6	0.0000
Järva	85	122	0.0001
Lääne	47	68	0.0000
Lääne-Viru	448	645	0.0004
Põlva	132	190	0.0001
Pärnu	339	488	0.0003
Rapla	72	104	0.0001
Saare	94	135	0.0001
Tartu	678	977	0.0006
Valga	485	699	0.0004
Viljandi	681	981	0.0006
Võru	172	248	0.0001
Whole country	3,309	4,767	0.0028

The total N_2O emissions from growing of N-fixing crops were 0.0028Gg in Estonia in 2008 (Figure 6.31). The contribution of the emissions to the total direct emissions from agricultural crops in negligible.

[79] IPCC 1997. Agriculture. Workbook. Table 4-17 – Summary of default values for parameters. pp 4.35
[80] Jonas *et al.*, 2001

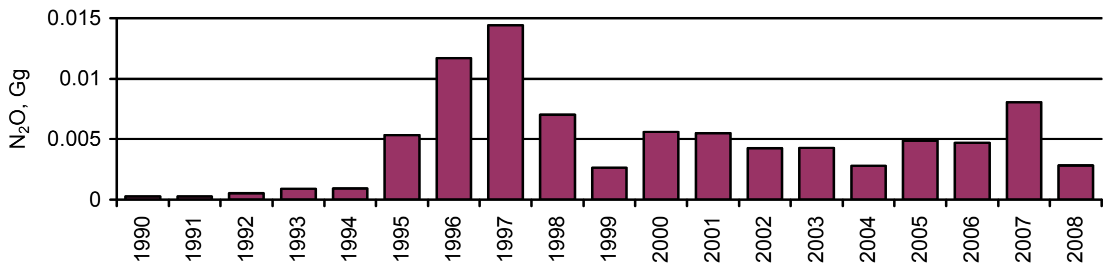


Figure 6.31. N_2O emissions from growing of N-fixing crops in 1990–2008 in Estonia, Gg

The N_2O emissions from growing of N-fixing crops considerably changes from one reporting year to another. The total sown area of N-fixing crops is presented in Figure 6.32. The remarkable changes in the sown area were in 1995–1997 and 1997–1999, since 1999 the total sown area is changing slightly. However, the inter-annual changes in quantity of N-fixing crops produced are considerable, as crops are vulnerable to weather conditions (precipitation, weather etc.). In 1998–1999, 2004 and in 2008 high variation in precipitation occurred (see Appendix A_IX) and this caused the decline in N-fixing crop production.

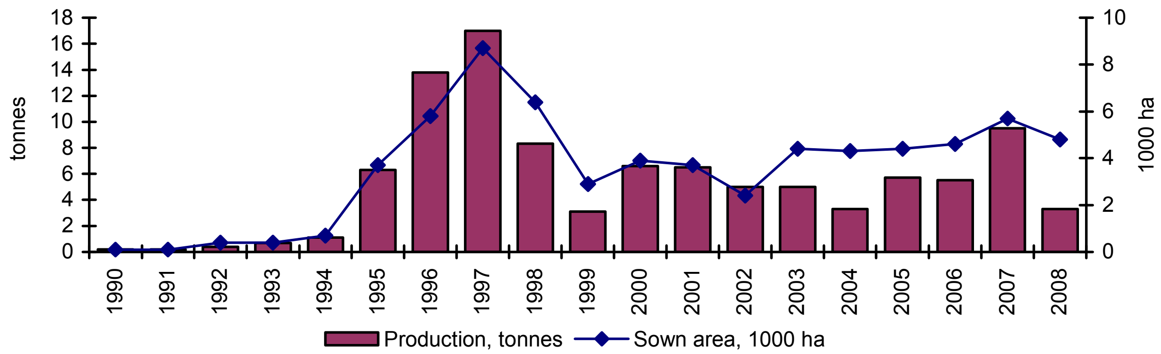


Figure 6.32. Production of N-fixing crops [tonnes] and sown area [1000 ha] in 1990–2008 in Estonia (ESO) (see Appendix A_IX)

6.6.6. N_2O emissions from nitrogen input from crop-residue (CRF 4.D.1.4)

The amount of nitrogen returned to soils annually through the incorporation of crop residues.

6.6.6.1. Methodology, data availability, data sources and emission factors

The default IPCC *Tier 1* method was used for the estimation emissions from crop residues returned to the soil.

$$F_{CF} = \sum_i (Crop_{O_i} \bullet Res_{O_i}/Crop_{O_i} \bullet Frac_{DM_i} \bullet Frac_{NCRO_i}) \bullet (1 - Frac_{BURN_i} - Frac_{FUEL\text{-}CR_i} - Frac_{CNST\text{-}CR_i} - Frac_{FOD_i}) + \sum_j Crop_{O_j} \bullet Res_{O_j}/Crop_{O_j} \bullet Frac_{DM_j} \bullet Frac_{NCRO_j}) \bullet (1 - Frac_{BURN_j} - Frac_{FUEL\text{-}CR_j} - Frac_{CNST\text{-}CR_j} - Frac_{FODj} \quad (6.27)$$[81]

$Crop_{BF}$ - Production of pulses + soybeans in country, kg dry biomass/yr;

$Crop_0$ – Production of non-N-fixing crops in country, kg dry biomass/yr;

$Res_O/Crop_O$ and $Res_{BF}/Crop_{BF}$ – residue to crop product mass ratio (Table 6.50, the factor obtained from (Jonas M., *et al*, 2001) were used in the estimation);

$Frac_{NCRBF}$ – 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 was calculated using the formula (6.28) (a *Tier 1* method of IPCC 1997).

$$N_2O_{direct} = F_{CR} \bullet EF_1 \bullet 44/28 \quad (6.28)$$

Table 6.49. Conversion factors from fresh matter (FM) to dry matter and grain-to-straw conversion ratio for main types of crops

	FM to DM conversion factor	Grain to straw ratio
Cereals	0.85	1.2
Legumes	0.87	1.5
Potatoes	0.45	0.6
Fodder roots	0.45	0.6
Industrial crops	0.56	2.5

Table 6.50. Factors used in the algorithm of the estimation of N_2O emissions from crop residues[82]

Factor	Unit
$Frac_{NCRBF}$	0.03 kg N/kg of Dry Matter
$Frac_{NCR0}$	0.015 kg N/kg of Dry Matter
$Frac_R$	0.45 kg N/kg crop-N
$Frac_{BURN}$	0.10, kg N/kg crop-N (for developed countries)
EF_1 for F_{CF}	1.25%[83]

[81] IPCC 2000. Agriculture. Equation 4.29. pp. 4.59
[82] IPCC 1997. Agriculture. Workbook. Table 4-17 – Summary of default values for parameters. pp 4.35.
[83] IPCC 2000. Agriculture. Table 4-17 – Updated default emission factors to estimate direct N_2O emissions from agricultural soils. pp 4.60.

6.6.6.2. *Quantitative overview – N_2O emissions from crop-residues in 2008*

In 2008, the production of cereals was 863 thousand tonnes, industrial crops – 111 thousand tonnes, potatoes – 125 thousand tonnes and legumes and fodder roots – 3.3 and 0.4 thousand tonnes respectively. The production of crops decreased by almost 50 per cent by 2008 compared to the base year (Figure 6.33). The inter-annual changes in crop production are explained by decline in the total sown area (Figure 6.34) and by weather conditions (Appendix A_X).

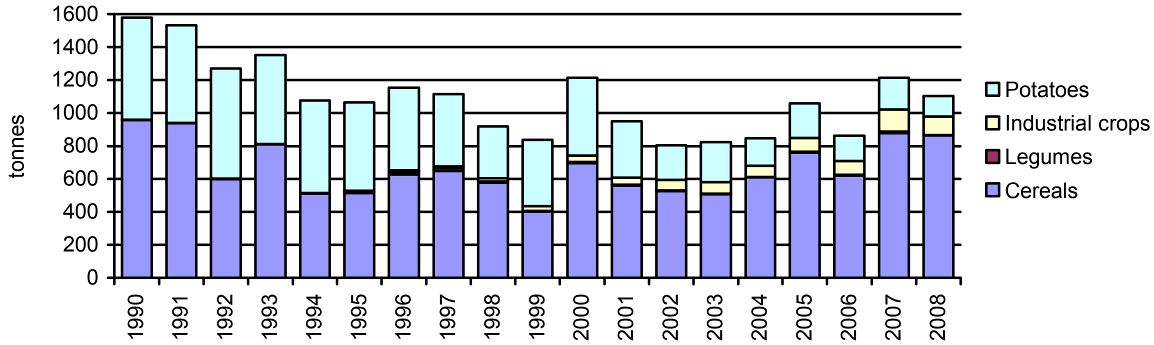


Figure 6.33. Crop production by main type of crops in Estonia in 1990–2008, tonnes (ESO)

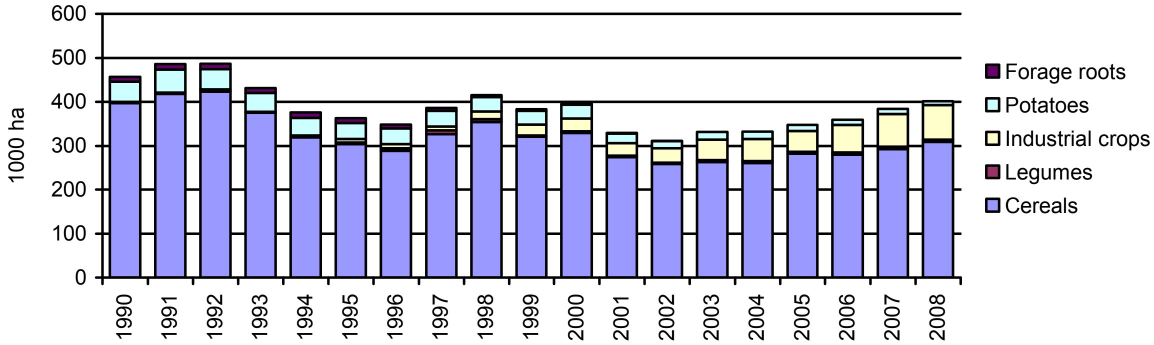


Figure 6.34. Sown area of main types of crops, 1000 ha (ESO)

The quantity of crop harvested in each county of Estonia in 2008 is reported in Table 6.51.

Table 6.51. Crop harvest in Estonia in 2008, DM tonnes (with residues)

County	Cereals	Legumes	Potatoes	Fodder roots	Industrial crops
Harju	75,539	58	19,202	0	5,270
Hiiu	6,097	33	4,745	8	468
Ida-Viru	35,134	13	6,148	24	1,497
Jõgeva	129,943	6	12,630	17	8,985
Järva	131,149	122	8,110	0	7,109
Lääne	36,420	68	7,485	2	3,876
Lääne-Viru	206,887	645	11,190	0	15,094
Põlva	90,719	190	9,698	61	5,982
Pärnu	78,722	488	9,971	88	5,699
Rapla	66,823	104	12,234	77	3,993
Saare	22,988	135	5,763	70	1,256

County	Cereals	Legumes	Potatoes	Fodder roots	Industrial crops
Tartu	189,794	977	12,814	26	12,574
Valga	64,254	699	4,709	19	3,165
Viljandi	149,799	981	7,815	82	10,092
Võru	56,819	248	17,756	44	2,233
Whole country	1,341,084	4,767	150,270	518	87,291

The total N_2O emissions from crop residues left on agricultural land was 0.23 Gg in 2008 (Figure 6.35).

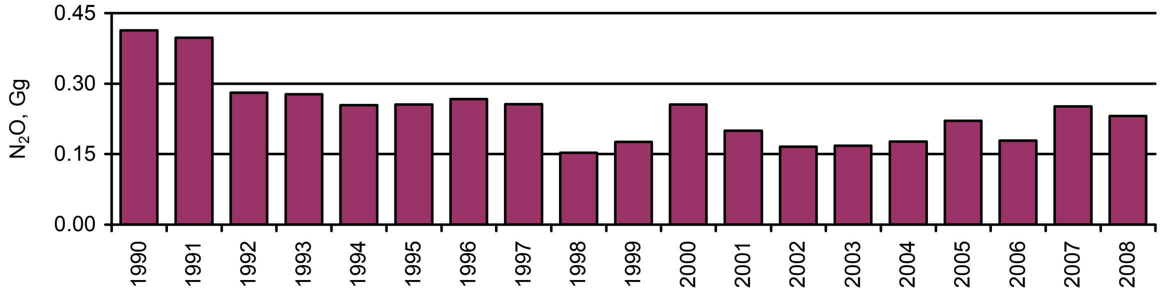


Figure 6.35. N_2O emissions from crop residues left on agricultural fields in 1990–2008 in Estonia, Gg

6.6.7. N_2O emissions from Organic Soils Cultivation (CRF 4.D.1.5)

Large 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).

6.6.7.1. 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).

$$N_2O_{direct} = F_{OS} \bullet EF_2 \bullet 44/28 \qquad (6.29)$$

F_{OS} – area of cultivated organic soils, ha;

EF_2 – emission factor for organic soil mineralization due to cultivation, kg N_2O-N ha/yr (Table 6.52);

Table 6.52. Factors used in the algorithm of the estimation of N_2O emissions from cultivated organic soils[84]

Factor	Unit
EF_2	8 kg N_2O-N/ha^{-yr}

6.6.7.2. *Quantitative overview – N_2O emissions from organic soils cultivated in 2008*

The N_2O emissions from cultivation of organic soils were 0.52 Gg in 2008 in Estonia. The estimation was carried out basing on the data received from combination (the interpolation method was employed) of data from CORINE maps (1990, 2000), Estonian soil map and the data on arable land from ESO (see Appendix A_XI).

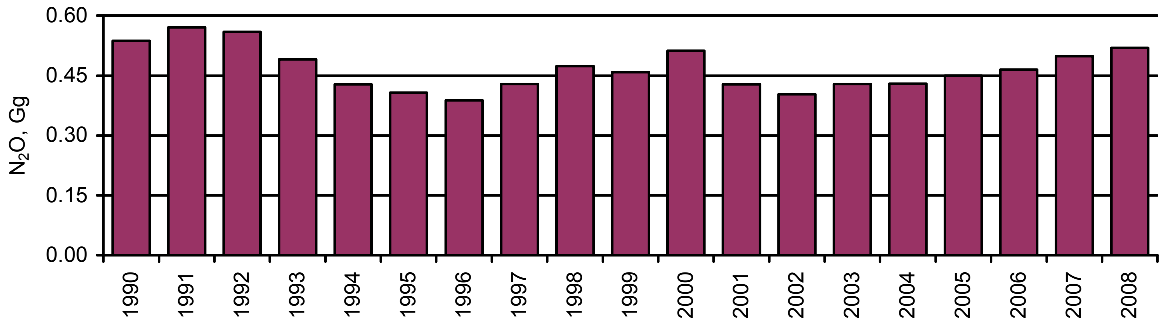


Figure 6.36. N_2O emissions from cultivation of organic soils in Estonia in 1990–2008, Gg

6.6.8. 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. The activity data on amounts of sludge recycled are collected by EEIC. The quantities of sewage sludge generated are demonstrated in Figure 6.37. 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.

[84] IPCC 2000. Agriculture. Table 4.17 – Updated default factors to estimate direct N_2O emissions from agricultural soils, pp 4.60

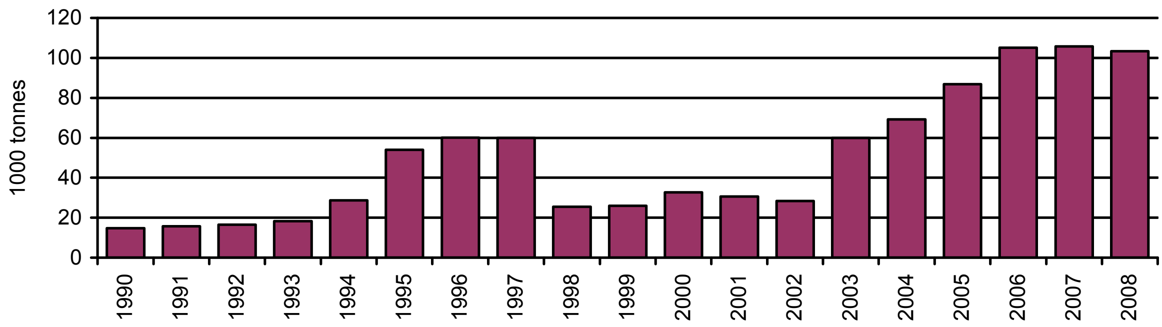


Figure 6.37. Sewage sludge generation in Estonia in 1990–2008, thousand tonnes (EEIC)

The data in Table 6.53 illustrates the share of sludge used for improvement of environmental situation (R10) and quantities of treated biologically (R3), for compost. The data for years 1999–2008 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 6.53).

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 6.53).

Table 6.53. Amounts of municipal sludge application on agricultural land, tonnes (see Appendix A_VIII, where quantities of sludge treated are reported by code of European Waste Catalogue, 2002)[85]

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*

[85] 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
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

6.6.8.1. 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).

$$F_{SL} = N_{FERT} \times (1 - Frac_{GASF}) \qquad (6.30)^{86}$$

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;

$$N_2O_{direct} - N = F_{SL} \bullet EF \bullet 44/28_1 \qquad (6.31)$$

EF – emission factor.

The emission factors used in the estimates are presented in Table 6.54.

Table 6.54. Parameters and factors used in the estimates

Factors	Value	
FracGASF	0.10[87]	kg NH_3-N + NOx-N/kg of sludge nitrogen applied
EF for F_{SL}	1.25%	
Sludge (sewage) N content	5[88]	% dry matter

6.6.8.2. Quantitative overview – N_2O emissions from sludge applied on agricultural land (CRF 4.D.1.6)

The total N_2O emissions from sludge applied on agricultural land were 0.008Gg in 2008 (Figure 6.38).

[86] IPCC 1997. Agriculture. Workbook. Equation1, pp 4.33
[87] IPCC 1997. Agriculture. Reference Manual. Table 4-17- Summary of default values for parameters, pp. 4.35
[88] ‘CH_4 and N_2O Emissions from Waste Water Handling’ background paper

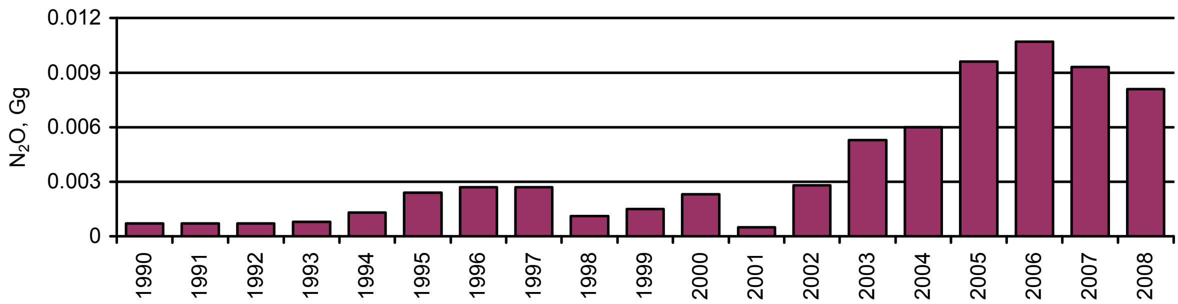


Figure 6.38. Emissions of N_2O from sludge applied on agricultural land in Estonia in 1990–2008, Gg

6.6.9. Uncertainties and time-series consistency

6.6.9.1. Synthetic fertilizers used (CRF 4.D.1.1)

The estimation of N_2O emissions from synthetic fertilizers used is 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 K., *at al.*, 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 S., *et al.*, 2003). No similar research has been done in Estonia, therefore the uncertainty of Finland was used in the estimates (Table 6.55).

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).

6.6.9.2. Animal manure applied to soils (CRF 4.D.1.2)

The estimation of N_2O emissions from animal manure applied to soils is 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 6.55) (IPCC 1997).

6.6.9.3. 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 6.55) as the value of the factor is 0.0125 with a range of 0.0025–0.0255 (IPCC 1997).

Table 6.55. 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 K., *et al.*, 2001
Synthetic fertilizers (applied to agricultural soils)	± 10%	Rypdal K., *et al.*, 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 S., *et al.*, 2003
Fraction of animal manure N that volatilizes as NH_3 and NO_x	± 40%	Monni S., *et al.*, 2003

6.6.10. Source-specific QC/QA 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 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.

6.6.11. Source-specific recalculations

There is one recalculation carried out in 'Animal manure applied to agricultural soils' sub-sector was carried out in the 2010 submission: weight of mature dairy-cattle was updated for the entire time-series (Appendix A_IV), a country specific value was used in the estimates instead of IPCC default. The results of the recalculation are reported in Table 6.56.

Table 6.56. N_2O emissions from animal manure applied to agricultural sols in 1990–2008, Gg

Year	Reported emissions of N_2O (the 2009 submission)	Recalculated emissions of N_2O in 1990–2008 (the 2010 submission)
1990	0.815	0.822
1991	0.765	0.773
1992	0.622	0.629
1993	0.491	0.499
1994	0.453	0.460
1995	0.409	0.415
1996	0.361	0.366
1997	0.362	0.367
1998	0.358	0.363
1999	0.315	0.319
2000	0.313	0.318
2001	0.330	0.335
2002	0.316	0.321
2003	0.317	0.322
2004	0.321	0.326
2005	0.323	0.327
2006	0.324	0.329
2007	0.330	0.335
2008		0.333

There is one recalculation carried out in 'N_2O emissions from sewage sludge applied onto agricultural soils' sub-section in the 2010 submission (Table 6.57): activity data on amounts of sewage sludge applied onto soils were updated. In the 2009 submission, the quantities of industrial and sewage sludge treated under R10 category were taken into the estimates, quantity of sewage sludge treated under R3 category were not considered. In the 2010 submission, the amounts of sewage sludge treated under R3 and R10 categories were employed in the estimates and quantities of industrial sludge were excluded from the estimates.

Table 6.57. N_2O emissions from sewage sludge applied to agricultural sols in 1990–2008, Gg

Year	Reported emissions of N_2O (the 2009 submission)	Recalculated emissions of N_2O in 1990–2008 (the 2010 submission)

Year	Reported emissions of N_2O (the 2009 submission)	Recalculated emissions of N_2O in 1990–2008 (the 2010 submission)
1990	0.004	0.0007
1991	0.005	0.0007
1992	0.001	0.0007
1993	0.008	0.0008
1994	0.008	0.0013
1995	0.012	0.0024
1996	0.014	0.0027
1997	0.010	0.0027
1998	0.014	0.0011
1999	0.015	0.0015
2000	0.025	0.0023
2001	0.017	0.0005
2002	0.016	0.0028
2003	0.021	0.0053
2004	0.001	0.0060
2005	0.001	0.0096
2006	0.002	0.0107
2007	0.001	0.0093
2008		0.0081

6.6.12. Source-specific planned improvements

The activity data are kept under consideration and will be updated necessarily. Special attention will be paid to activity data employed in 'Sewage sludge applied on agricultural soils', the investigation of main flows of sludge generated by main producers will be carried out in the next submissions.

6.7. Indirect emissions from agricultural soils

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).

The IPCC provides methods to estimate N_2O emissions from:

- Leaching and runoff of N that is applied to, or deposited on, soils;
- Formation of N_2O in the atmosphere from NH_3 emissions originating from anthropogenic activities;

6.7.1. Source category description

The total indirect N_2O emissions from agricultural soils were 0.80 Gg in 2008 (Table 6.58). The emissions declined by 2 fold by 2008 due to decreasing number of livestock population and synthetic and sludge application onto agricultural land.

Table 6.58. Indirect N_2O emissions from agricultural soils in Estonia in 1990–2008, Gg

Year	Atmospheric Deposition	Leaching and Run-off	Total, N_2O Gg
1990	0.270	1.394	1.664
1991	0.257	1.336	1.593
1992	0.221	1.172	1.393
1993	0.149	0.737	0.887
1994	0.135	0.662	0.797
1995	0.115	0.544	0.659
1996	0.101	0.478	0.580
1997	0.108	0.526	0.633
1998	0.114	0.574	0.687
1999	0.097	0.481	0.578
2000	0.101	0.510	0.611
2001	0.099	0.488	0.588
2002	0.092	0.445	0.538
2003	0.103	0.525	0.628
2004	0.106	0.548	0.654
2005	0.100	0.495	0.595
2006	0.104	0.526	0.630
2007	0.109	0.558	0.667
2008	0.125	0.679	0.804

6.7.2. Atmospheric deposition of NOx and NH4 (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).

6.7.2.1. Methodology, data availability, data sources and emission factors

The default IPCC *Tier 1* method was is used to estimate emissions from the atmospheric deposition.

$$N_2O_{(G)} - N = [(N_{FERT} \bullet Frac_{GASF}) + (\sum_T (N_{(T)} \bullet Nex_{(T)}) \bullet Frac_{GASM})] \bullet EF_4 \qquad (6.32)^{89}$$

$N_2O_{(G)}$ – N_2O produced from atmospheric deposition of N, kg N/yr;

[89] IPCC 2000. Agriculture. Equation 4.31, pp 4.68.

N_{FERT} – Total amount of synthetic nitrogen fertilizer applied to soils, kg N/yr;

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

$Frac_{GASF}$ – Fraction of synthetic N fertilizer that volatilises as NH_3 and NO_x, kg NH_3-N and NO_x-N/kg of N input;

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

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 6.59. 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[90]
$Frac_{GASM}$	0.2 kg NH_3-N + NO_x-N/kg of nitrogen excreted by livestock[91]
EF_4	0.01 kg N_2O-N per kg NH_3-N and NO_x-N emitted

6.7.2.2. Quantitative overview – Atmospheric deposition of NO_x and NH_4 in 2008

The N_2O emissions from atmospheric deposition were 0.124 Gg in 2008 in Estonia (Figure 6.39). The emissions decreased by 54 per cent by 2008 compared to the base year.

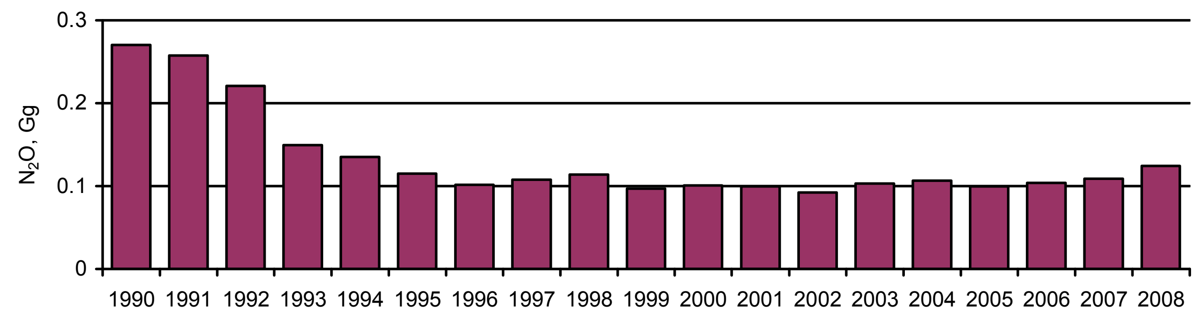


Figure 6.39. Emissions of N_2O due to atmospheric deposition in 1990–2008, Gg

6.7.3. 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).

[90] IPCC 1997. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35
[91] IPCC 1997. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35

6.7.3.1. Methodology, data availability, data sources and emission factors

The default IPCC *Tier 1* method was is used to estimate emissions from the atmospheric deposition.

$$N_2O_{(L)} - N = [N_{FERT} + \sum_T (N_{(T)} \bullet Nex_{(T)})] \bullet Frac_{LEACH} \bullet EF_5 \quad (6.33)$$ [92]

N_{FERT} – Total amount of synthetic nitrogen fertilizer applied to soils, kg N/yr;

$\sum_T(N_{(T)} \bullet Nex_{(T)})$ – Total amount of animal manure nitrogen excreted in a country, kg N/yr;

$Frac_{LEACH}$ – The amount of applied N that leaches or runs off, kg N/kg (Table 6.60);

Table 6.60. 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[93]
EF_5	0.025 kg N_2O-N per kg NH_3-N and NO_x-N emitted[94]

6.7.3.2. Quantitative overview – Leaching/Run-off of applied or deposited nitrogen in 2008

The N_2O emissions from leaching and run-of were 0.68 Gg in 2008 in Estonia (Figure 6.40). The emissions decreased by 51 per cent by 2008 in comparison with the base year.

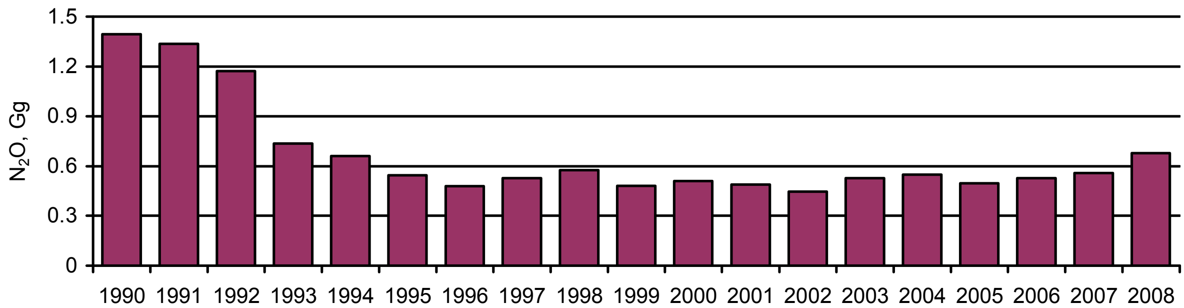


Figure 6.40. Emissions of N_2O due to leaching and run-off in 1990–2008 in Estonia, Gg

6.7.4. Uncertainties and time-series consistency

6.7.4.1. Atmospheric Deposition (CRF 4.D.3.1)

The estimation of N_2O emissions from atmospheric deposition is carried out based on activity data (synthetic fertilizers and animal manure applied to soils) and emission factors (N

[92] IPCC 2000. Agriculture. Equation 4.34, pp. 4.71
[93] IPCC 1997. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35
[94] IPCC 2000. Agriculture. Table 4-18 –Default emission factors for estimating indirect N_2O emissions from N used in agriculture. pp 4.73

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 S., *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 6.61).

6.7.4.2. Nitrogen leaching and run-off (CRF 4.D.3.2)

The estimation of N_2O emissions from nitrogen leaching is 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 the 1996 IPCC Guidelines (IPCC, 1997). The value of the factor is 0.025 with a range 0.002–0.12. The uncertainty of the emission factor is -92%...+380% (Table 6.61).

Table 6.61. 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 K., *et al.*, 2001
Synthetic fertilizers (applied to agricultural soils)	± 5%	Rypdal K., *et al.*, 2001
Emission factors		
Fraction of synthetic N fertilizers that volatilizes as NH_3 and NO_x	± 30%	Monni S., *et al.*, 2003
Fraction of animal manure N that volatilizes as NH_3 and NO_x	± 40%	Monni S., *et al.*, 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

6.7.5. Source-specific QC/QA 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 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.

6.7.6. Source-specific recalculations

There is one recalculation carried out in the ‘Atmospheric deposition of NO_x and NH_4’ category of the 2010 submission: activity data on weight of dairy-cattle and on amounts of sewage sludge applied on agricultural soils were updated (Figure 6.41, Table 6.62).

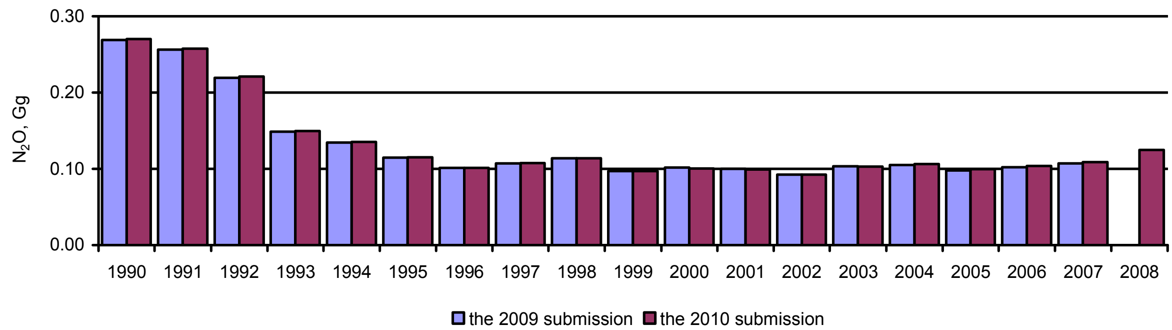


Figure 6.41. N_2O emissions from atmospheric deposition in 1990–2008 in Estonia, Gg

Table 6.62. N_2O emissions from atmospheric deposition in Estonia in 1990–2008, Gg

Year	Reported emissions of N_2O in 1990–2008 (the 2009 submission)	Recalculated emissions of N_2O (the 2010 submission)
1990	0.269	0.270
1991	0.256	0.257
1992	0.219	0.221
1993	0.149	0.149
1994	0.135	0.135
1995	0.115	0.115
1996	0.101	0.101
1997	0.107	0.108
1998	0.114	0.114
1999	0.097	0.097
2000	0.102	0.101
2001	0.100	0.099
2002	0.092	0.092
2003	0.103	0.103
2004	0.105	0.106

Year	Reported emissions of N_2O in 1990–2008 (the 2009 submission)	Recalculated emissions of N_2O (the 2010 submission)
2005	0.098	0.100
2006	0.102	0.104
2007	0.107	0.109
2008		0.125

There is one recalculation carried out in the 'Nitrogen leaching and run-off' category of the 2010 submission: activity data on weight of dairy-cattle and on amounts of sewage sludge applied on agricultural soils were updated (Figure 6.42, Table 6.63).

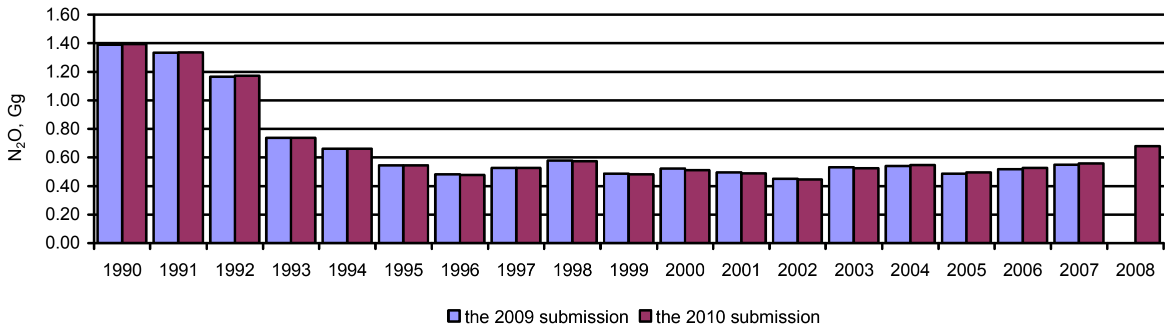


Figure 6.42. N_2O emissions due to nitrogen leaching and run-off in 1990–2008 in Estonia, Gg

Table 6.63. N_2O emissions due to nitrogen leaching and run-off in Estonia in 1990–2008, Gg

Year	Reported emissions of N_2O in 1990–2008 (the 2009 submission)	Recalculated emissions of N_2O (the 2010 submission)
1990	1.390	1.394
1991	1.332	1.336
1992	1.166	1.172
1993	0.736	0.737
1994	0.661	0.662
1995	0.546	0.544
1996	0.482	0.478
1997	0.526	0.526
1998	0.579	0.574
1999	0.487	0.481
2000	0.521	0.510
2001	0.496	0.488
2002	0.450	0.445
2003	0.532	0.525
2004	0.540	0.548
2005	0.485	0.495
2006	0.517	0.526
2007	0.549	0.558
2008		0.679

6.7.7. Source-specific planned improvements

The activity data are kept under consideration and will be updated necessarily.

6.8. Field burning of agricultural residues (CRF 4.F)

The process is the open burning of crop residue on arable land after harvesting. The detailed data on crop production is presented Figure 6.43–Figure 6.45. The data were obtained from ESO. The remarkable inter-annual fluctuations in quantities of crops produced are caused by changes in sown area (see Appendix A_IX) and by variations in weather conditions (see Appendix A_X).

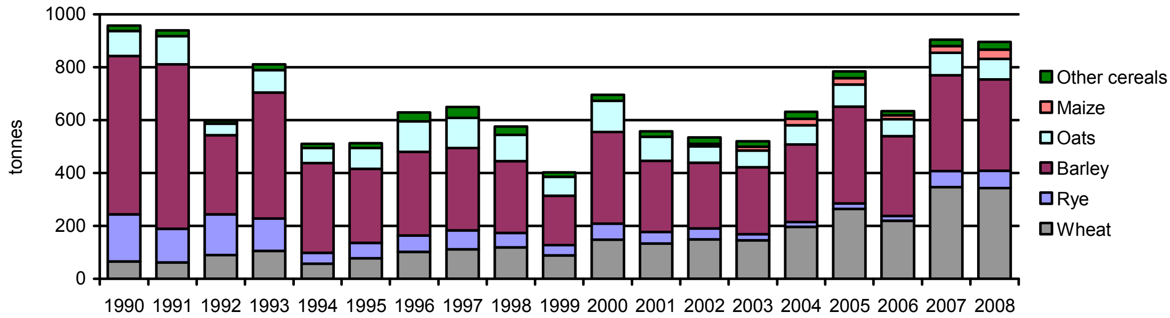


Figure 6.43. Cereals production in 1990–2008 in Estonia, tonnes

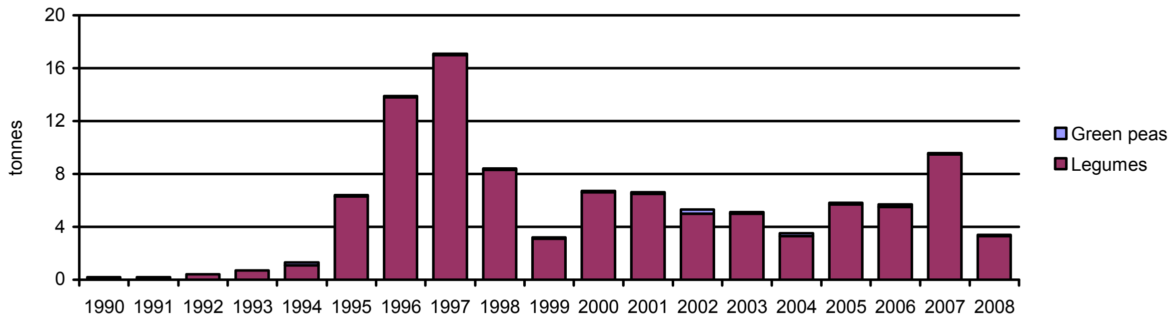


Figure 6.44. Pulse production in 1990–2008 in Estonia, tonnes

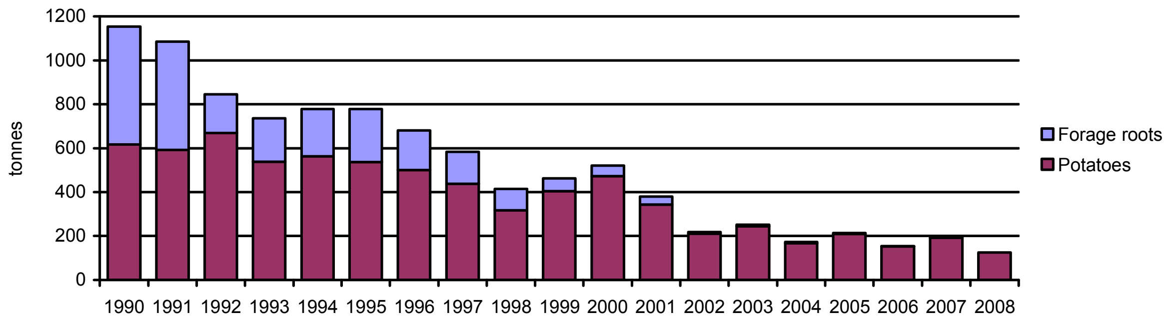


Figure 6.45. Tuber and root production in 1990–2008 in Estonia, tonnes

6.8.1. Methodology, data availability, data sources and emission factors

The method of the Revised 1996 IPCC Guidelines (IPCC 1997) was employed in the estimates:

$$DM_{BN} = Crop_{BN} \times RC_{RATIO} \times DM_{FRACTION} \quad (6.34)$$

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 to Crop Ratio for each type of crops

$DM_{FRACTION}$ – Dry Matter Fraction of each crop residue, Gg DM/Gg FM

$$TBB = DM_{BN} \times OX \quad (6.35)$$

TBB – Total Biomass Burned, Gg

OX – Fraction of Biomass oxidized for each crop type (default 0.9[95])

$$\begin{gathered}\text{Emission of Carbon} = TBB \times Carbon\_Fraction \times Ratios\_for\_CH_4\_or\_CO \quad (6.36)\\ \text{Emission of Nitrogen} = TBB \times Nitrogen\_Fraction \times Ratios\_for\_N_2O\_or\_NO_X\end{gathered}$$

Emission of Carbon – Emission of carbon as methane (CH_4) and carbon monoxide (CO), Gg

Carbon Fraction – carbon content of each crop type, GgC/Gg DM

Ratios for CH_4 or CO – Emission ratios for CH_4 or CO (IPCC 1997[96]).

Emission of Nitrogen – Emission of carbon as nitrous oxide (N_2O) and nitrogen oxides (NO_x), Gg

Nitrogen Fraction – 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).

6.8.2. Quantitative overview – Emissions from field burning of agricultural residues in 2008

The CH_4 and N_2O emissions from field burning of agricultural residues was 0.216 Gg and 0.0027 Gg respectively in 2008 (Figures 6.46-6.47).

[95] IPCC 1997. Agriculture. Workbook. pp. 4.30

[96] Table 4-16 Default Emission Rates for Agricultural Residue Burning Calculations, pp. 4.31

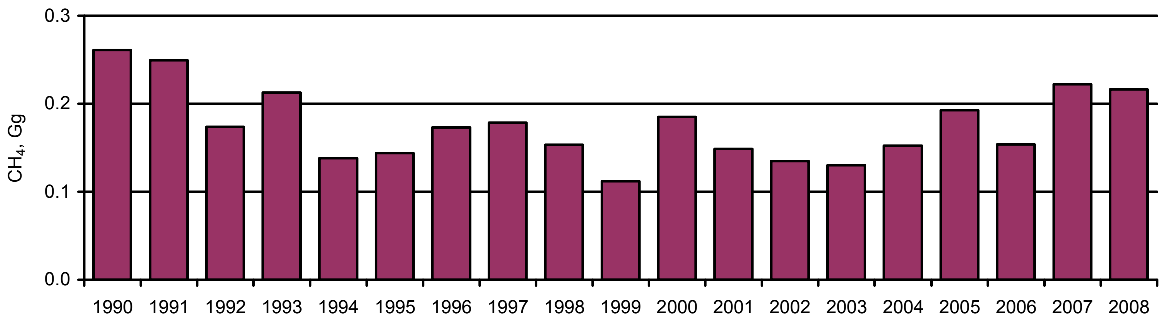


Figure 6.46. CH_4 emissions from field burning of agricultural residues in 1990–2008, Gg

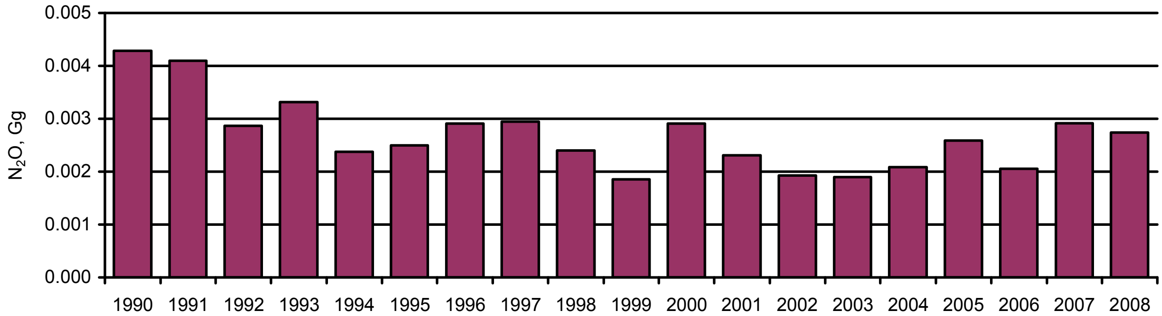


Figure 6.47. **N**$_2$O emissions from field burning of agricultural residues in 1990–2008, Gg

6.8.3. Uncertainties and time-series consistency

The estimation of N_2O and CH_4 emissions from agricultural residue burning is carried out based on activity data (crop residue left on fields) and emission factors is reported in the 1996 and 2000 IPCC Guidelines (Table 6.64).

Table 6.64. Estimated values of uncertainties used in agriculture sector

Input	Uncertainties	References
Activity data		
Crop residue left on agricultural fields	± 20%	IPCC 2001. 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

6.8.4. Source-specific QC/QA 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 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.

6.8.5. Source-specific recalculations

There are three recalculations carried out in the 2010 submission: (1) quantities of triticale residues, (2) maize were taken into account, (3) GHG emissions from dry bean and peas residue burned were estimates separately (a recommendation of the ETR) (Figure 6.48-6.49, Table 6.65-6.66).

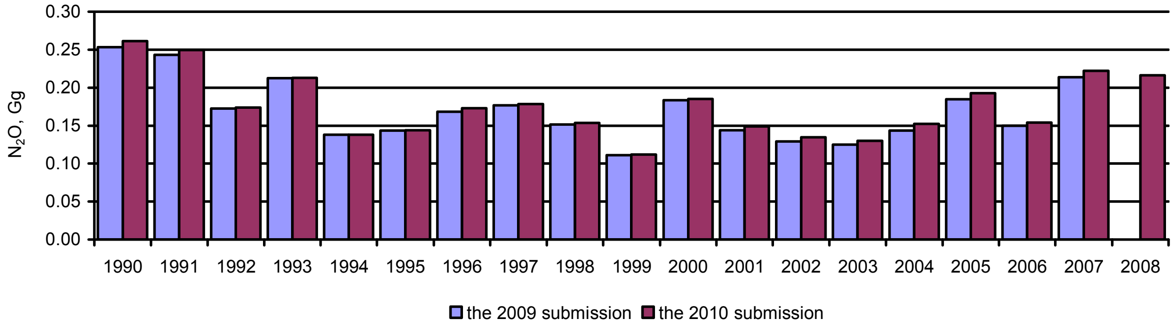


Figure 6.48. CH_4 emissions from field burning of agricultural residues in 1990–2008, Gg

Table 6.65. CH_4 emissions from field burning of agricultural residues in 1990–2008, Gg

Year	Reported emissions of CH_4 (the 2009 submission)	Recalculated emissions of CH_4 in 1990–2008 (the 2010 submission)
1990	0.253	0.261
1991	0.243	0.250
1992	0.173	0.174
1993	0.213	0.213
1994	0.138	0.138
1995	0.144	0.144
1996	0.169	0.173
1997	0.177	0.179
1998	0.152	0.154
1999	0.111	0.112
2000	0.184	0.185
2001	0.144	0.149
2002	0.130	0.135
2003	0.125	0.130
2004	0.144	0.152
2005	0.185	0.193
2006	0.150	0.154
2007	0.214	0.222
2008		0.217

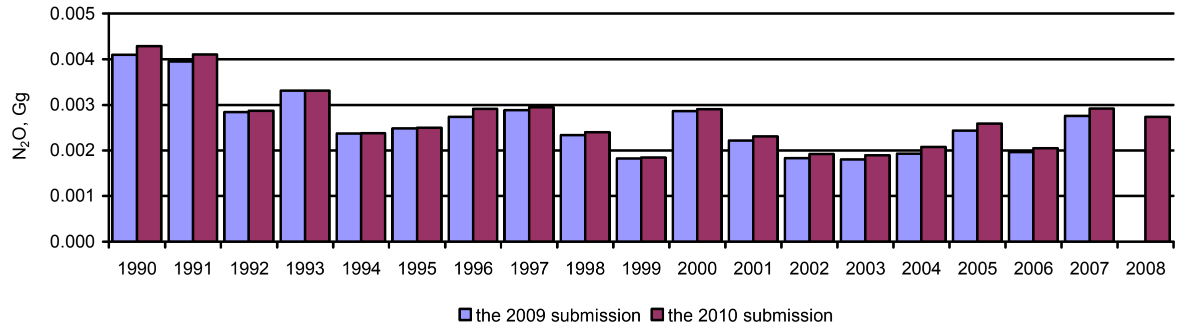


Figure 6.49. N_2O emissions from field burning of agricultural residues in 1990–2008, Gg

Table 6.66. N_2O emissions from field burning of agricultural residues in 1990–2008, Gg

Year	Reported emissions of CH_4 (the 2009 submission)	Recalculated emissions of CH_4 in 1990–2008 (the 2010 submission)
1990	0.0041	0.0043
1991	0.0040	0.0041
1992	0.0028	0.0029
1993	0.0033	0.0033
1994	0.0024	0.0024
1995	0.0025	0.0025
1996	0.0027	0.0029
1997	0.0029	0.0029
1998	0.0023	0.0024
1999	0.0018	0.0019
2000	0.0029	0.0029
2001	0.0022	0.0023
2002	0.0018	0.0019
2003	0.0018	0.0019
2004	0.0019	0.0021
2005	0.0024	0.0026
2006	0.0020	0.0020
2007	0.0028	0.0029
2008		0.0027

6.8.6. Source-specific planned improvements

The activity data are kept under consideration and will be updated necessarily.

7. LAND USE, LAND USE CHANGE AND FORESTRY (CRF 5)

7.1. Overview of the sector

7.1.1. Description and quantitative overview

The LULUCF sector in 2008 was a sink of carbon, a net carbon sink was about 9,729 Gg CO_2 equivalent (Figure 7.2), because total emissions arising from the sector are smaller than the total removals.

Emissions and removals were estimated for the following sub-sectors:

- Forest land: removals due to increment, emissions due to forest harvesting (emissions are considered to be immediate), emissions from organic forest soils;
- Cropland: emissions/removals from/by fruit trees, cropland organic and mineral soils, lime applied on agricultural soils;
- Grassland: emissions/removals from/by grassland organic and mineral soils;
- Wetlands: emissions from peat extraction areas;
- Non-CO_2 emissions from biomass burning

Mostly a *tier 1* approach of common IPCC Guidelines (LULUCF 2003) has been applied to estimate carbon flows associated with land use categories (Table 7.1) for the whole time series. The estimates carried out have high rates of uncertainty, as the process of data collection is still under development.
LULUCF key categories in 2008 estimated in accordance with IPCC Tier 2 method are presented in Table 7.1.

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		Key category
	Method Applied	EF	Method Applied	EF	Method Applied	EF	
A. Forest land							
Forest Land remaining Forest Land							
Managed Native Forests	T1	IPCC					L, T[97]
Biomass Burning	T1	IPCC	T1	IPCC	T1	IPCC	
Organic soils	T1	IPCC					L, T
Mineral soils	NE	NA					

[97] 5.A. Forest Land (carbon stock change – removals) and 5.A. Forest Land (carbon stock change – emissions)

Greenhouse gases source and sink categories	CO_2		CH_4		N_2O		Key category
	Method Applied	EF	Method Applied	EF	Method Applied	EF	
Land converted to Forest Land	NE	NA					
B. Cropland							
Cropland remaining Cropland							
Fruit trees	T1	IPCC					
Organic soils	T1	IPCC					L, T
Mineral soils	NE	NA					T
Lime application on cropland	T1	IPCC					
Land converted to Cropland	T1	IPCC					
Carbon stock change	NE	NA					
Organic soils	NE	NA					
Mineral soils	NE	NA					
C. Grassland							
Grassland remaining Grassland							
Organic soils	T1	IPCC					L, T
Mineral soils	NE	NA					
Land converted to Grassland							
Carbon stock change	NE	NA					
Organic soils	NE	NA					
Mineral soils	T1	IPCC					L, T
D. Wetlands							
Wetlands remaining Wetlands[98]	T1	IPCC					
Land converted to Wetlands	NE	NA					
Non-CO_2 emissions from drainage of soils and wetlands (Peatland)[99]	NO	NA			T1	IPCC	
E. Settlements							
Settlements remaining Settlements	NE	NA					
Land converted to Settlements	NE	NA					
F. Other land							
Other Land remaining Other Land	NE	NA					
Land converted to Other Land	NE	NA					

EF – Emission Factor; NE – not estimated; NA – Not Applicable; T1 – *Tier 1* method

Annual reports published by different institutions (Estonian Forest Centre of Protection and Silviculture (CFPS), Estonian Land Board (ELB), Statistics of Estonia (ESO), etc. (Table 7.2) and CORINE maps (1990, 2000 and 2006) and Estonian soil map have been used in the estimation of carbon fluxes related to the LULUCF sector. The inventory in LULUCF sector was carried out by a research group at Tallinn University of Technology.

Table 7.2. List of institutions (datasets) involved in the inventory of the LULUCF sector

References	Link	Abbreviation	Activity
Tallinn University of Technology	www.ttu.ee	TUT	- activity data processing; - estimations of emissions/removals; - reporting of emissions/removals (the CRF tables, the NIR).
Centre of Forest Protection and Silviculture	www.metsad.ee	CFPS	- collecting and providing data of the National Forest Inventory; - collecting and providing data on land

[98] Organic soils managed for peat extraction
[99] Only peatland extraction areas were defined as 'Peatlands'

References	Link	Abbreviation	Activity
			cover by land category (forest, grassland, wetlands, build-up area); - collecting and providing data on forest biomass stock, biomass increment;
Statistics of Estonia	www.stat.ee	ESO	- collecting and providing data on forest fire areas;
Estonian Land Board	www.maaamet.ee	ELB	- collecting and providing data on land areas by land use categories (Land Balances) for 1970–1990; - areas on peat extraction in 2006–2008

Land use has changed in recent decades (Figure 7.1). The area covered by forest was increased from 38% in 1970 to 49% in 2008 (increase 475 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 for 215 and 207 thousand hectares respectively during the same period.

The total area of cropland increased for 215 thousand hectares in 1970–1990 and decreased for 336 thousand hectares in 1988–2008 due to the economical processes taking place in Estonian agriculture sector.

Area of settlements and roads increased for 177 thousand hectares in Estonia in 1970–2008.

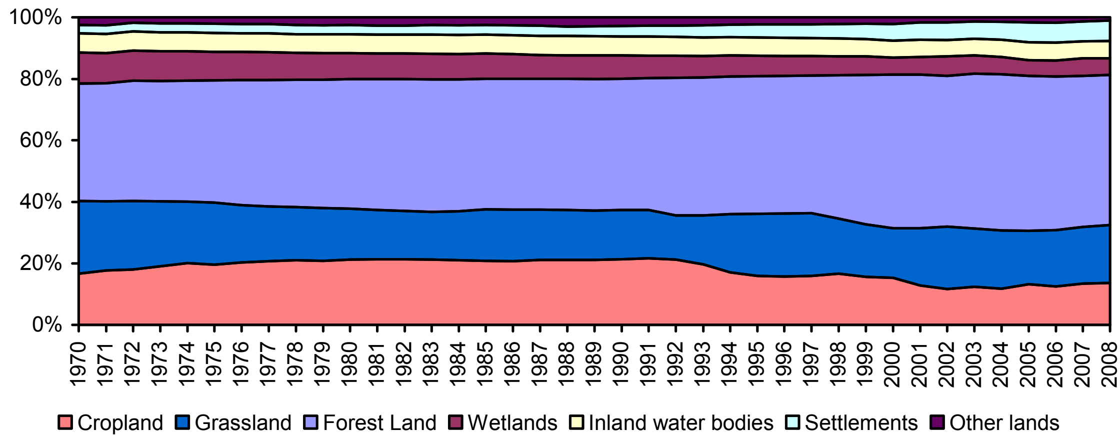


Figure 7.1. Land use in Estonia in 1970–2008, %

The areas of land use defined in accordance with the IPCC land use definitions are reported in Table 7.3.

Table 7.3. The areas of land use classes in 1990–2008, 1000 ha

	Forest land[100]	Cropland[101]	Grassland	Wetlands	Peatland	Settlements[102]	Other land	Inland water bodies
1990	1,926.7	965.8	720.0	338.4	12.0	152.2	114.5	280.4
1991	1,931.6	978.2	707.0	330.8	15.0	159.6	106.8	278.0
1992	2,016.0	957.2	648.1	323.2	15.0	166.9	105.1	275.5
1993	2,021.8	888.6	715.2	315.7	15.0	174.2	103.4	273.1
1994	2,016.6	771.2	852.3	308.1	15.0	181.5	91.6	270.6
1995	2,016.2	721.2	907.2	300.5	15.0	188.8	89.9	268.1
1996	2,016.2	712.8	920.0	292.9	15.0	196.2	88.2	265.7
1997	2,015.5	719.4	918.6	285.3	15.0	203.5	86.5	263.2
1998	2,101.6	755.4	801.0	277.7	15.0	210.8	84.8	260.7
1999	2,187.7	708.3	766.3	273.6	15.0	226.4	78.7	251.0
2000	2,249.4	692.6	722.3	247.4	20.0	239.7	79.7	250.9
2001	2,250.7	579.1	836.8	255.0	20.0	254.2	53.3	252.9
2002	2,205.8	527.2	915.0	284.5	20.0	256.3	55.3	237.9
2003	2,267.3	559.9	850.0	267.5	20.0	255.7	39.4	242.2
2004	2,284.6	532.1	853.1	250.8	20.0	263.5	45.1	252.8
2005	2,264.2	598.8	782.6	230.8	20.0	288.2	56.4	261.0
2006	2,251.9	564.3	822.0	232.3	19.6	290.9	59.8	261.2
2007	2,212.7	607.0	828.8	253.0	20.1	290.2	59.7	250.5
2008	2,197.4	619.9	843.6	244.3	20.3	299.7	49.8	244.3

The net emissions/removals of the Estonian LULUCF sector are presented in Figure 7.2. The main sink of CO_2 in Estonia is forest land. Due to remarkable changes: decreases in cropland areas and increases in grassland areas, carbon flows related with these changes in land use influenced to the total balance of carbon of the LULUCF sector. The total quantities of CH_4 and N_2O emitted are presented in Figure 7.3-7.4.

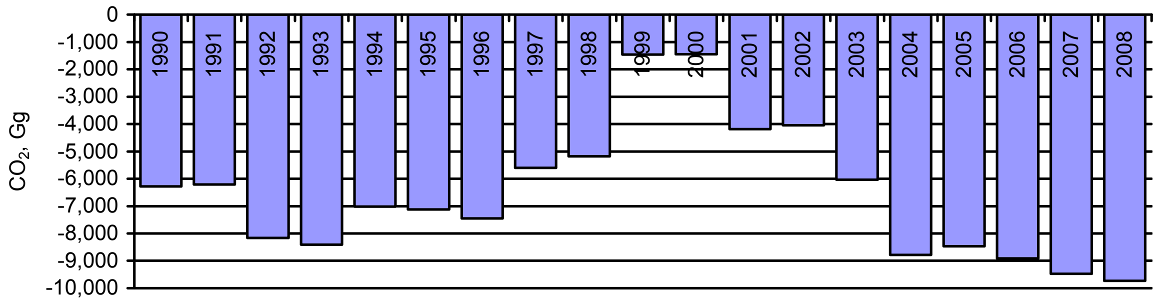


Figure 7.2. Net removal of CO_2 by Estonian LULUCF sector in 1990–2008, CO_2 Gg

[100] Forest land areas are defined according to the Estonian definition of forest
[101] Appendix L_I
[102] Settlements and roads

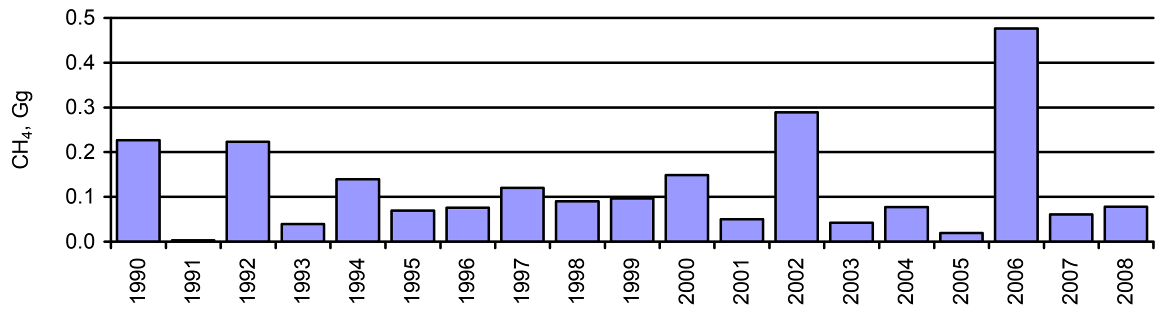


Figure 7.3. Emissions of CH_4 from the LULUCF sector in Estonia in 1990–2008, CH_4 Gg

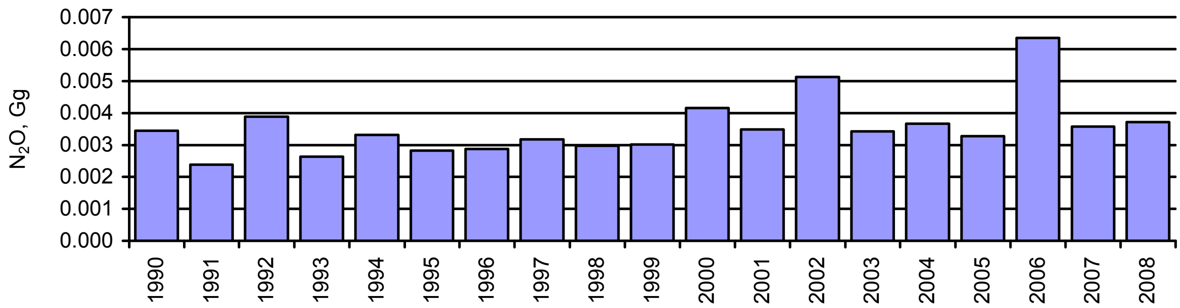


Figure 7.4. Emissions of N_2O from the LULUCF sector in Estonia in 1990–2008, N_2O Gg

7.1.2. Land areas and land-use categories used in the Estonian Inventory

Forest land

The National Forest Inventory (NFI)

The estimation of emitted/removed quantities of carbon was carried out based on data received in the process of the NFI.

Until 1999, forest biomass was monitored using the Complete Forest Inventory with a ten year taxation cycle. The attention was mainly focused on the biomass in government managed forests. The data on private forest were mostly interpolated and therefore quality of the data was low.

The NFI based on the SMI was implemented in Estonia in 1999. This increased remarkably quality of the data and reduced uncertainties related to the data collected.

Forest land 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 Estonian Forest Act stipulates forest as '…any land with an area of 0.1 ha or more, which is covered with trees higher than 1.3 m with a canopy closure of at least 30%, and which is managed in order to produce forest products, or in order to preserve forest vegetation for other objectives'.

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'.

Due to the difference between the current definition of forest stipulated in the Estonian Forest Act and that given in the decision 16/CMP.1, Estonia has established the Estonian 'definition of forest in the context of the Kyoto Protocol', and the main parameters of forest definition are reported in Table 7.4.

Table 7.4. Parameters for forest definition

Minimum tree cover	30%
Minimum land area	0.1 ha
Minimum tree height	2 m

Cropland

Land where the soil is regularly cultivated, and where annual and perennial crops are growing (crops, fodder crops, annual forage crops, multiannual forage crops, other temporary grasslands (seeded once in less than five years), fallow and orchards, see also Appendix L_I). Abandoned cropland is defined as grassland.

The data on cropland areas were extracted from Estonian national statistics (reported by ESO) and Land Balances (published by Estonian Land Board).

Grassland

The NFI grassland (natural grassland) and unused arable land and seeded once over five years grassland and bushes[103] are defined as IPCC grassland.

The data on grassland areas were obtained from the Estonian national statistics (reported by ESO), Land Balances (published by Estonian Land Board) and the NFI.

Wetlands

The NFI wetland areas were defined as IPCC wetlands. The data used were from the NFI (for 1999–2008) and Land Balances (for 1970–1990).

Peat extraction areas were excluded from wetland land use category and reported separately (Table 7.3).

Settlements

The built-up areas, traffic and power lines were reported under settlement land use category (Table 7.3).

The data on settlement areas were obtained from the NFI (for 1999–2008) and Land Balances (for 1970–1990). The data of 1991–1998 were interpolated.

Other land

Rocky lands and mining areas and all other lands not classified as Forest land, Cropland, Grassland, Wetlands and Settlements were defined as other land and reported together as a separate category in the CRF Reporter.

The data on these categories were obtained from the NFI (for 1999–2008) and Land Balances (for 1970–1990).

Land use areas defined as Forest land, Cropland and Grassland were considered to be Managed land.

[103] Area of bushes has been reported under 'Other lands' in the 2009 submission. To include areas of bushes to 'Grassland' was recommended by the ETR.

7.2. Forest Land (CRF 5.A)

GHG emissions/removals related to "Forest Land Remaining Forest Land" and "Biomass Burning" have been estimated in the 2010 submission.

7.2.1. Source category description

Since 1970 forest area has been increasing in Estonia mostly due to abandonment of grassland used for hay production and overgrowing of wetlands, bushes (Figure 7.5).

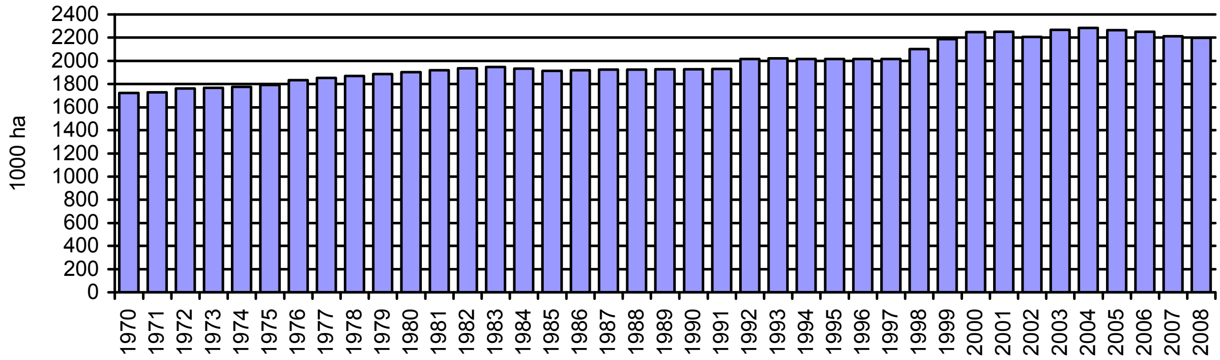


Figure 7.5. Forest land area in Estonia in 1970–2008, 1000 ha[104]

The comparison of the forest areas defined in accordance with different definitions of forest land is presented in Table 7.5. The areas of forest defined according to the FAO definition have been used in the reporting.

Table 7.5. Forest area in Estonia in 1990–2008, 1000 ha

Year	Reported by ESO	Annual change rate (ESO), ha	Reported in the FAO dataset[105]	Annual change rate (FAO), ha
1990	1,921		2,163[106]	
1991	1,926	5.0	2,171[107]	8.0
1992	2,016	90.0	2,179	8.0
1993	2,022	6.0	2,187	8.0
1994	2,017	-5.0	2,195	8.0
1995	2,016	-1.0	2,203	8.0
1996	2,016	0.0	2,211	8.0
1997	2,016	0.0	2,219	8.0
1998	2,102	86.0	2,227	8.0
1999	2,188	86.0	2,235	8.0
2000	2,249	61.0	2,243	8.0
2001	2,251	2.0	2,251	8.0
2002	2,206	-45.0	2,259	8.0

[104] According to the Estonian definition of forest
[105] www.fao.org
[106] FRA 2005
[107] The area was interpolated.

Year	Reported by ESO	Annual change rate (ESO), ha	Reported in the FAO dataset[105]	Annual change rate (FAO), ha
2003	2,267	61.0	2,268	9.0
2004	2,285	18.0	2,276	8.0
2005	2,264	-21.0	2,284[4]	8.0
2006	2,252	-12.0	2,391[108]	107.0
2007	2,213	-39.0	2,346[109]	45.0
2008	2,197	-16.0	2,317[110]	-29.0

7.2.2. Methodological issues

The algorithm employed in order to estimate carbon flows related to 'Forest Land remaining Forest Land' is presented below:

$$\Delta C_{FF} = (\Delta C_{FF_{LB}} + \Delta C_{FF_{DOM}} + \Delta C_{FF_{Soils}}) \quad (7.1)$$[111]

ΔC_{FF} – annual change in carbon stocks from forest land remaining forest land, tC yr^{-1};

ΔC_{FFLB} – annual change in carbon stocks in living biomass (includes above- and below-ground biomass) in forest land remaining forest land, tC yr^{-1};

ΔC_{FFDOM} – annual change in carbon stocks in dead organic matter (includes dead wood and litter) in forest land remaining forest land, tC yr^{-1};

$\Delta C_{FFSoils}$ – annual change in carbon stocks in soils in forest land remaining forest land; tC yr^{-1};

$$\Delta C_{FF_{LB}} = (\Delta C_{FF_G} - \Delta C_{FF_L}) \quad (7.2)$$[112]

ΔC_{FFLB} – annual change in carbon stocks in living biomass (includes above- and below-ground biomass) in forest land remaining forest land, tC yr^{-1};

ΔC_{FFG} – annual increase in carbon stocks due to biomass growth, tC yr^{-1};

ΔC_{FFL} – annual decrease in carbon stocks due to biomass loss, tC yr^{-1};

Annual increase in carbon stock due to biomass increment in forest land

In order to estimate carbon removals due to forest biomass increment the *Tier 1* approach was employed.

$$G_{TOTAl} = G_W \bullet (1 + R) \quad (7.3)$$[113]

where:

[108] Eesti Metsad 2006 (e.g. Estonian Forest 2006)
[109] Eesti Metsad 2007
[110] Eesti Metsad 2008
[111] LULUCF 2003, Equation 3.2.1., pp 3.23
[112] LULUCF 2003, Equation 3.2.2., pp 3.24
[113] LULUCF 2003, Equation 3.2.3., pp 3.24

$$G_W = I_V \bullet D \bullet BEF_1$$

G_{TOTAL} – average annual biomass increment above and below-ground, tonnes of dry matter ha^{-1} yr^{-1};

G_W – average annual aboveground biomass increment, tones of dry matter ha^{-1} yr^{-1};

R – root-to-shoot ratio appropriate to increments, dimensionless;

I_V – average annual net increment in volume suitable for industrial processing, m^3 ha-1 yr^{-1};

D – wood density, tonnes of dry matter m^{-3} (Table 7.8);

BEF_1 – biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment, dimensionless (Table 7.6).

Table 7.6. Default values of BEF[114]

Forest type	BEF_2	BEF_1
Conifer	1.35	1.15
Broadleaf	1.3	1.1

Table 7.7. Average below-ground to above-ground biomass ratio (root-shoot ratio, R)[115]

Forest type	Aboveground biomass, t/ha	Root-shoot ratio
Conifer forest/plantation	50–150	0.32
Other broadleaf forest	75–150	0.26

Table 7.8. Wood density of main tree species[116]

Tree species	Wood density
Pine	0.42
Spruce	0.40
Birch	0.51
Aspen	0.35
Common Alder	0.45
Grey Alder	0.45
Other	0.45

Annual decrease in carbon stocks due to biomass loss in forest land remaining forest land

The *Tier 1* method was employed in order to estimate carbon emissions from biomass felling (emissions are considered to be immediate).

$$\Delta C_{FF_L} = L_{felling} + L_{other\_losses} \quad (7.4)^{117}$$

[114] LULUCF 2003, Table 3A.1.10., pp. 3.178
[115] LULUCF 2003, Table 3A.1.8., pp. 3.168
[116] LULUCF 2003, Table 3.A1.9-1., pp.3.171
[117] LULUCF 2003, Equation 3.2.6, pp. 3.26

ΔC_{FFL} – annual decrease in carbon stocks due to biomass loss in forest land remaining forest land, tC yr^{-1};

$L_{fellings}$ – annual carbon loss due to commercial felling, tC yr^{-1};

$L_{other\ losses}$ – annual other losses of carbon, tC yr^{-1}.

$$L_{felling} = H \bullet D \bullet BEF_2 \bullet (1 - f_{BL}) \bullet CF \qquad (7.5)^{118}$$

$L_{fellings}$ – annual carbon loss due to commercial felling, tC yr^{-1};

H – annually extracted volume, round-wood, m^3 yr^{-1};

D – wood density, tonnes of dry matter, m^{-3};

BEF_2 – biomass expansion factor for converting volumes of extracted round-wood to total aboveground biomass (including bark), dimensionless;

f_{BL} – fraction of biomass left to decay in forest (transferred to dead organic matter) (Table 7.9);

CF – carbon fraction of dry matter (default=0.5), tC (tonne d.m.)$^{-1}$.

Table 7.9. Default values for fraction out of total harvest left to decay in the forest[119], f_{BL}

	f_{BL}
Boreal intensively managed	0.07

CO_2 emissions/removals from/by mineral forest soils

Due to the lack of more advanced methods the Tier 1 approach was implemented, and it was assumed that carbon stock in mineral soil organic matter does not change, regardless of changes in forest management, types and disturbance regimes.

CO_2 emissions from drained organic forest soils

$$\Delta C_{FFOrganic} = A_{Drained} \bullet EF_{Drainage} \qquad (7.6)^{120}$$

$\Delta C_{FFOrganic}$ – 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 7.10);

[118] LULUCF 2003, Equation 3.2.7, pp. 3.27
[119] LULUCF 2003, Table 3A.1.11, pp. 3.178
[120] LULUCF 2003, Equation 3.2.15, pp. 3.42

Table 7.10. Default values for CO_2-C emission factor for drained organic soils[121] in managed forests[122]

Biomes	Emission Factors (tonnes C ha^{-1} yr^{-1})	
	Value	Ranges
Boreal	-0.16	0.08–1.09

7.2.3. Quantitative overview – Carbon emissions/removals from forest land

Annual increase in carbon stock due to biomass increment in forest land

The forest area increased 268 thousand hectares by 2008 in comparison with the base year. The changes in forest area covered by trees are presented in Figure 7.6. As seen, more than 50% of forest area is covered by conifer trees and less than 50% is covered by broad-leaf forest. The main parameters of Estonian forest in 2008 are presented in Table 7.11.

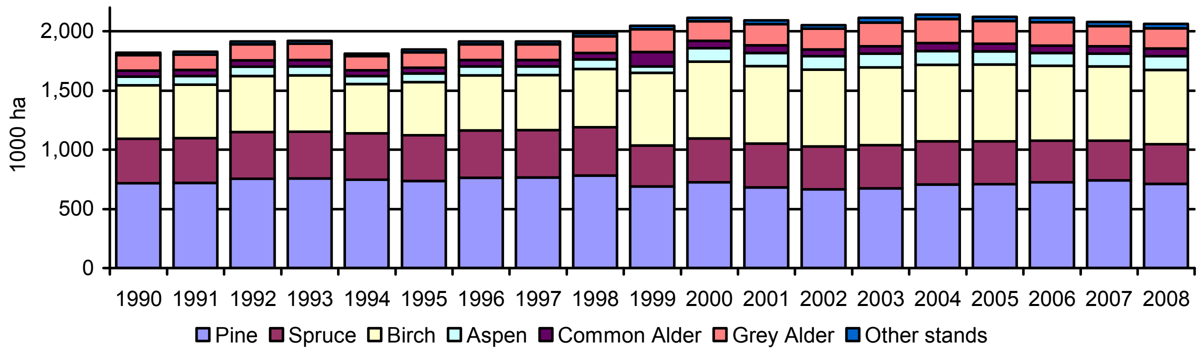


Figure 7.6. Forest area (area of stands) in Estonia in 1990–2008, 1000 ha

Table 7.11. General characteristics of Estonian forest stands in 2008[123] (Appendix L_II)

	Area of stands, 1000 ha	Stock, 1000 m^3	Increment, 1000 m^3
Pine	710.5	169,534	3,561
Spruce	334.3	78,151	2,762
Birch	628.9	112,101	3,145
Asp	115.3	28,057	779
Common Alder	66.5	17,039	356
Grey Alder	170.0	29,252	1,287
Others	37.1	6,049	199
Total	**2,062.8**	**440,182**	**12,089**

The data presented in Figure 7.7 characterize averaged values of carbon sequestrated per hectare in Estonian forest in 1990–2008.

[121] Histosols – classified according to FAO soil taxonomic group (IPCC 1996)
[122] LULUCF 2003, Table 3.2.3, pp. 3.42
[123] Eesti Metsad 2007

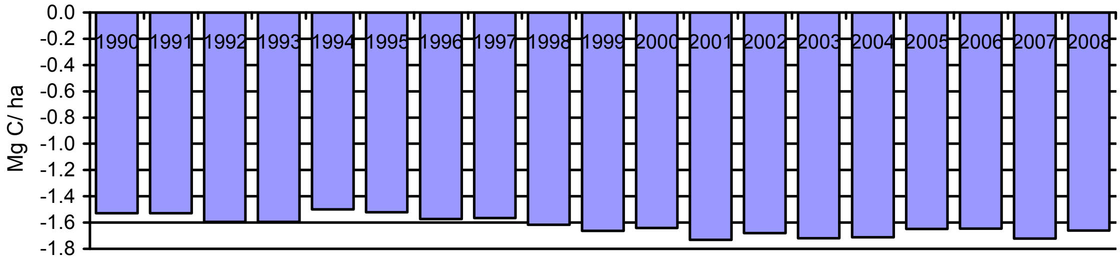


Figure 7.7. Carbon gain by forest biomass in Estonia in 1990–2008, Mg C/ha[124]

Annual decrease in carbon stocks due to biomass loss in forest land remaining forest land

The data on forest felling is collected by ESO and in the process of the NFI. ESO collects forest harvesting data based on forest licenses applied. The data collected in the process of the NFI and by ESO is illustrated in Table 7.12. The data of the NFI and corrected data of ESO based on interpolation approach[125] were used in the estimates (Figure 7.8).

Table 7.12. Amounts and areas of forest biomass harvested in 1990–2008, ha and m^3

Year	Forest harvest documentation[126]		The NFI (the SMI)[127]		Used in the estimates
	Total felling area, ha	Felling outturn, m^3	Total felling area, ha	Felling out-turn, m^3	Felling outturn, m^3
1990		*2,937,803*			*3,819,144*
1991	94,864	3,212,377			*4,176,090*
1992	77,327	2,245,805			*2,919,547*
1993	92,864	2,547,647			*3,311,941*
1994	102,731	3,745,383			*4,868,998*
1995	102,315	3,992,746			*5,190,570*
1996	92,658	4,250,738			*5,525,959*
1997	102,496	5,737,170			*7,458,321*
1998	109,349	6,319,070			*8,214,791*
1999	108,189	7,049,299	81,100	12,697,000	12,697,000
2000	113,391	6,891,981	71,000	12,748,000	12,748,000
2001	116,292	7,217,132	77,500	11,525,000	11,525,000
2002	128,364	7,558,731	77,000	11,526,000	11,526,000
2003	122,549	7,810,554	63,700	9,717,000	9,717,000
2004	132,097	7,632,843	57,600	7,012,000	7,012,000
2005	129,721	5,124,588	60,100	6,380,000	6,380,000
2006	101,414	5,899,053	53,200	5197,000	5,197,000
2007	96,872	6,900,727	54,400	5,310,000	5,310,000
2008	106,081	7,385,854		5,268,000	5,268,000

[124] It should be noted that values reported under 'Carbon gain by forest biomass per ha' do not reflect a transparent picture, as the forest areas reported in the CRF include areas covered and not by trees. However, the estimates were carried out taken into account only areas of stands (forested areas) and average increment.

[125] The italic values have been interpolated, an outturn value is 30% higher than an reported value based on forest harvest documentation

[126] www.stat.ee

[127] Eesti Metsad 2001,…,2008

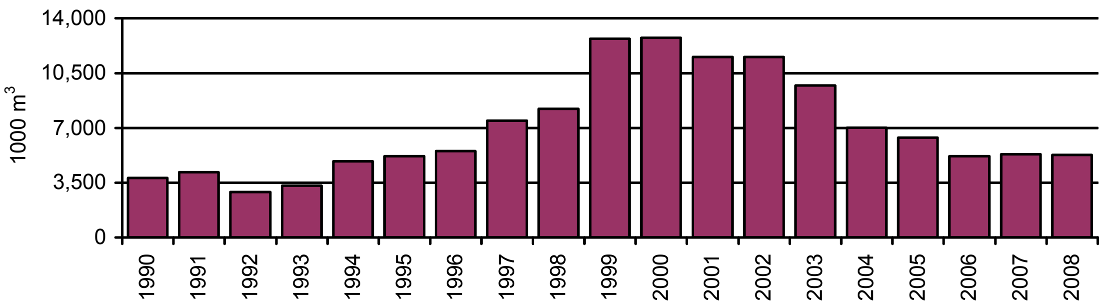


Figure 7.8. Volumes of stems harvested in Estonia in 1990–2008, 1000 m^3

Carbon flows associated with forest soils

The allocation of forest land by soil types (mineral and organic) is presented in Table 7.13. It should be noted that forest soil areas are reported in accordance with the Estonian definition of forest land.

Table 7.13. Areas of mineral and organic soils of Forest land in 1990–2008[128], % and 1000 ha

Year	Mineral soils, %	Organic soils, %	Total, 1000 ha[129]
1990	73	27	1,921
1991	73	27	1,926
1992	74	26	2,016
1993	75	25	2,022
1994	75	25	2,017
1995	75	25	2,016
1996	75	25	2,016
1997	75	25	2,016
1998	76	24	2,102
1999	77	23	2,188
2000	77	23	2,249
2001	77	23	2,251
2002	77	23	2,206
2003	77	23	2,267
2004	77	23	2,285
2005	77	23	2,264
2006	77	23	2,252
2007	77	23	2,213
2008	77	23	2,197

Forest organic soils

Carbon emissions from organic forest soils are reported in Figure 7.9. The activity data on areas of organic soils have been assumed taking into account the datasets of CORINE 1990 and 2000 maps and the data reported in Estonian Forest 2008.

[128] The data were calculated based on CORINE 1990, 2000 datasets and Eesti Metsad 2006 report.
[129] Forest area is reported in accordance with the Estonian definition

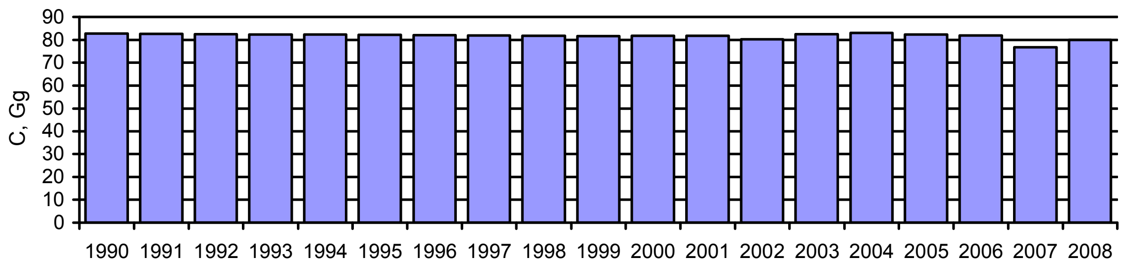


Figure 7.9. Carbon emissions from forest organic soils in 1990–2008 in Estonia, C Gg

7.2.4. Uncertainties and time-series consistency

CO_2 emissions/removals from forest biomass are estimated according to the LULUCF GPG (2003). The activity data are obtained from ESO and CFPS, the emission factors are used from the LULUCF GPG (2003). The uncertainty rates in the activity data and the emission factors are presented in Table 7.14.

Table 7.14. Estimated values of uncertainties used in 'Forest Land' sub-section

Input	Uncertainties	References
Activity data		
Forest land, ha	± 2.1%	'Eesti Metsad 2008'
Stand biomass increment, m^3/ha	± 2.8%	'Eesti Metsad 2008'
Stand stock per hectare, m^3/ha	± 3.1%	'Eesti Metsad 2008'
Felling area, ha	± 15.0%	Estonian Statistical Office
Emission factors		
BEFs (used in calculating increment data)	± 30%	LULUCF, 2003, pp. 3.31
BEFs (used in case of growing stock biomass data)	± 30%	LULUCF, 2003, pp. 3.178
Wood density	± 20%	LULUCF, 2003, pp. 3.31
Value of combustion factor for fires	-85…124%	LULUCF, 2003, pp. 3.179
Emission ratio factor for open burning (CH_4)	± 25%	The 1996 IPCC Guidelines, pp. 5.33
Emission ratio factor for open burning (N_2O)	± 29%	The 1996 IPCC Guidelines, pp. 5.33

7.2.5. 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 1.6.1.

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.

Activity data are checked annually for updating. Emission factors are compared with IPCC default and with emission factors of other countries.

7.2.6. Source-specific recalculations

There is one recalculation carried out in 'Forest land' sub-sector in the 2010 submission: new activity data on forest biomass harvested in 2007 were employed as the data were updated based on the results of National Forest Inventory (Figure 7.10 and Table 7.15).

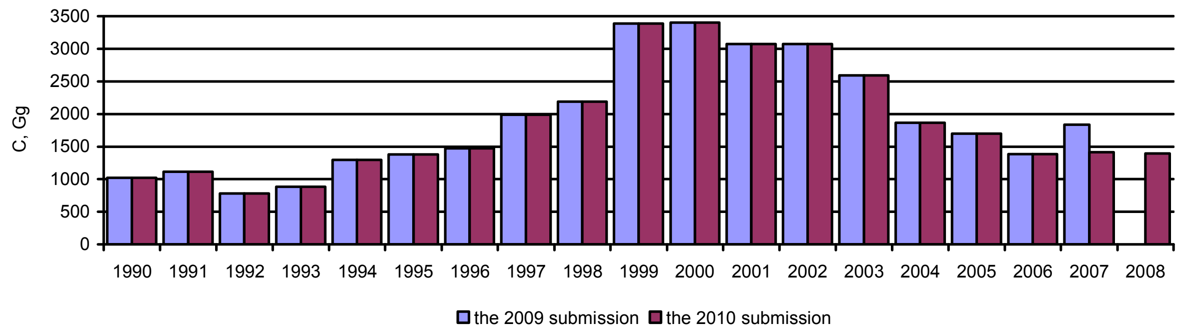


Figure 7.10. Carbon emissions from forest biomass harvesting in 1990–2008, Gg

Table 7.15. Carbon emissions from forest biomass harvesting in 2006–2008, Gg

Year	Reported emissions of carbon (the 2009 submission)	Recalculated emissions of carbon in 2006–2008 (the 2010 submission)
2007	-1,840.4	-1,416.1
2008		-1,395.7

7.2.7. Source-specific planned improvements

A wide number of improvements are required to be carried out in order to guarantee complete, transparent and accurate GHG inventory in the 'Forest Land' sub-section: forest land (forest land remaining forest land and lands converted to forest land) areas, areas of mineral and organic soils under forest land will be revised in the next submissions for 1970–2008.

7.3. Cropland (CRF 5.B)

7.3.1. Source category description

The cropland area has remarkably decreased since 1992 due to the economic processes that have taken place in Estonia (Figure 7.11). Areas of cultivation of annual/multiannual crops started to decrease since 1992 which in turn led to the increase of areas of abandoned arable land (Table 7.16). The area of unused arable land has increased remarkably since 1991. The activity data used to estimate carbon fluxes related to cropland have been obtained from datasets of ESO.

Due to the decrease in the total area of cropland remarkable changes in soil carbon stock have taken place. Changes in soil carbon stock were estimated under ‘Land converted to Cropland’ sub-section. It was assumed that switches in land use practice took place between cropland and grassland (a 20-year difference in land use area). Needless to say that it is necessary to consider each parcel of land separately in order to complete accurate GHG inventory. However, at the present stage the inventory was carried out mostly based on the assumption as the ongoing process of data collection is taking place. Overlaps have not been analyzed in the current submission.

Carbon emissions/removals from/by Cropland remaining cropland have not been estimated due to lack of datasets developed for this purpose. The dataset required is still under development. The results will be presented in the next submissions.

Carbon emissions from liming of agricultural lands has been estimated for the first time in the 2010 submission.

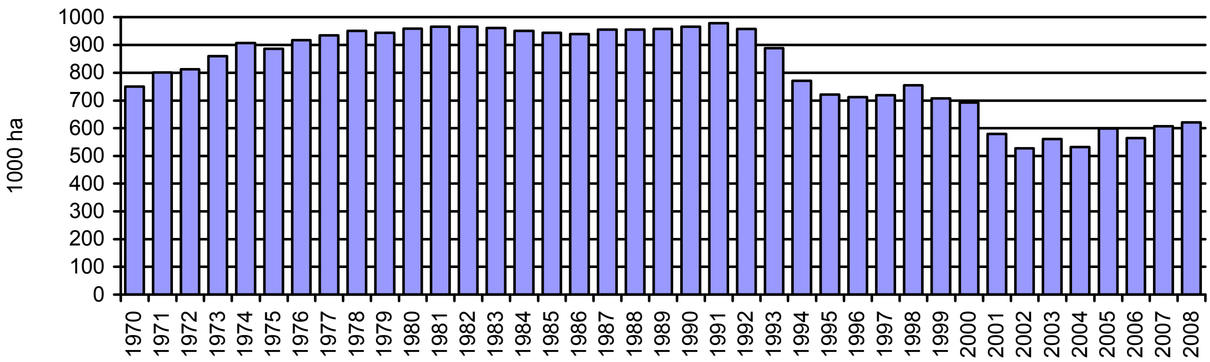


Figure 7.11. Cropland area in Estonia in 1970–2008, 1000 ha

Table 7.16. Unused arable land, 1000 ha[130]

Year	Area
1991	14.0
1992	12.7
1993	62.9
1994	179.1
1995	254.0
1996	243.5
1997	231.1
1998	233.4
1999	260.1
2000	276.4
2001	277.7
…	
2007	286.4[131]

7.3.2. Methodological issues

Carbon stock changes in mineral soils under 'Cropland' were estimated using the Tier 1 approach of the LULUCF GPG (2003).

Fruit trees

The *Tier 1* approach of LULUCF Guidelines (LULUCF 2003) was used in order to estimate CO_2 emissions/removals related to orchards in Estonia in 1990–2008. The data on orchard areas were obtained from Estonian national statistics (ESO).

$$\Delta C_{FF_{LB}} = (\Delta C_{FF_G} - \Delta C_{FF_L}) \qquad (7.7)^{132}$$

ΔC_{FFLB} – annual change in carbon stocks in living biomass (includes above- and belowground biomass), tonnes C yr^{-1};

ΔC_{FFG} – annual increase in carbon stocks due to biomass growth, tonnes C yr^{-1} (Table 7.17);

ΔC_{FFL} – annual decrease in carbon stocks due to biomass loss, tonnes C yr^{-1} (Table 7.17);

Table 7.17. Default coefficients for aboveground woody biomass and harvest cycles in cropping systems containing perennial species[133]

Climate region	Biomass accumulation rate (G), tonnes C ha^{-1} yr^{-1}	Biomass carbon loss (L), tonnes C ha^{-1}
Temperate	2.1	63

[130] Agricultural yearbooks
[131] Muiste et al., 2007
[132] LULUCF 2003, Equation 3.2.2., pp. 3.24
[133] LULUCF 2003, Table 3.3.2., pp.3.71

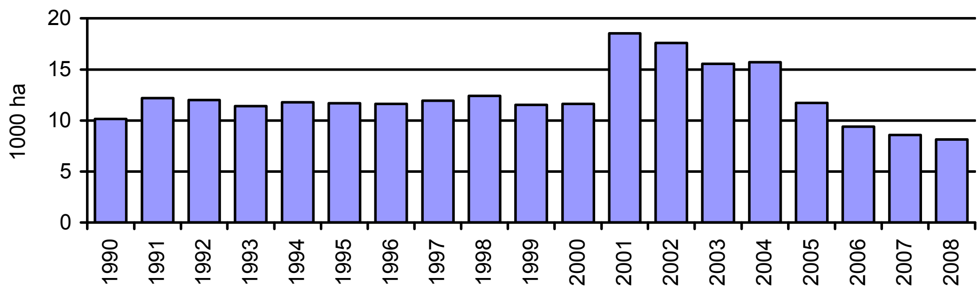


Figure 7.12. Areas of fruit trees in Estonia in 1990–2008, 1000 ha (ESO)

The carbon flows of orchards are presented in Table 7.18. The sharp increase in carbon sequestration took place in 2001 when area of orchards increased from 11.6 to 18.5 thousand hectares (Figure 7.12). However, in 2005-2007 losses of carbon increased due to the drop of the area of orchards. It was assumed that carbon emissions due to orchard biomass losses did not occur in 1990–2005, as the areas of orchards changed negligible in this period. An estimation approach taking into account a principle of harvest/mature cycle of perennial woody crops (orchards) has not applied in the estimates.

Table 7.18. Net emissions and removals of carbon from orchards, Gg

	Gains/Losses of area, ha	Carbon accumulation, Gg C	Carbon losses, Gg C	Net carbon emissions / removals, C Gg
1990	-	-21.3	-	-21.3
1991	-	-25.6	-	-25.6
1992	-	-25.2	-	-25.2
1993	-	-24.0	-	-24.0
1994	-	-24.7	-	-24.7
1995	-	-24.6	-	-24.6
1996	-	-24.4	-	-24.4
1997	-	-25.1	-	-25.1
1998	-	-26.0	-	-26.0
1999	-	-24.2	-	-24.2
2000	-	-24.5	-	-24.5
2001	-	-38.9	-	-38.9
2002	-	-36.9	-	-36.9
2003	-	-32.7	-	-32.7
2004	-	-32.9	-	-32.9
2005	-	-24.6	-	-24.6
2006	2,414	-19.8	152.1	132.3
2007	833	-18.0	52.5	34.5
2008	427	-17.1	26.9	9.8

Mineral soils

The *Tier 1* approach of the LULUCF GPG (2003) was implemented in order to estimate carbon changes in carbon stock of mineral soils.

$$\Delta C_{LCSoils} = \Delta C_{LCMineral} - \Delta C_{LCOrganic} - \Delta C_{LCLiming} \quad (7.8)$$[134]

$\Delta C_{LCSoils}$ – annual change in carbon stocks in soils in land converted to cropland, tonnes C yr^{-1};

$\Delta C_{LCMineral}$ – change in carbon stocks in mineral soils in land converted to cropland, tonnes C yr^{-1};

$\Delta C_{LCOrganic}$ – annual C emissions from cultivated organic soils converted to cropland (estimated as net annual flux), tonnes C yr^{-1};

$\Delta C_{LCLiming}$ – annual C emissions from agricultural lime application on land converted to cropland, tonnes C yr^{-1};

$$\Delta C_{CCMineral} = \left\lfloor (SOC_0 - SOC_{(0-T)} \bullet A \right\rfloor / T$$
$$SOC = SOC_{REF} \bullet F_{LU} \bullet F_{MG} \bullet F_I \quad (7.9)$$[135]

$\Delta C_{CCMineral}$ – annual change in carbon stocks in mineral soils, tonnes C yr^{-1};

SOC_0 – soil organic carbon stock in the inventory year, tonnes C ha^{-1};

$SOC_{(0-T)}$ – soil organic carbon stock T years prior to the inventory, tonnes C ha^{-1};

T – inventory time period, yr (default is 20 yr);

A – land area of each parcel, ha;

SOC_{REF} – the reference carbon stock, tonnes C ha^{-1} (Table 7.19);

F_{LU} – stock change factor for land use or land-use change type, dimensionless (Table 7.20);

F_{MG} – stock change factor for management regime, dimensionless (Table 7.20);

F_I – stock change factor for input of organic matter, dimensionless (Table 7.20);

Table 7.19. Default reference (under native vegetation) soil organic C stocks (SOC_{REF}) (tonnes C per ha for 0-30 cm depth)[136]

Region	HAC soils	Spodic Soils	Wetland soils
Boreal	68	117	146

Table 7.20. Relative stock change factors (F_{LU}, F_{MG} and F_I) (over 20 years) for different management activities on cropland[137]

Factor value type	Level	Moisture regime	GPG revised default
Land use - F_{LU}	Long-term cultivated	Wet	0.71
Tillage - F_{MG}	Full	Dry and Wet	1.0
Input - F_I	Medium	Dry and Wet	1.0

[134] LULUCF 2003, Equation 3.3.12, pp. 3.89
[135] LULUCF 2003, Equation 3.3.3, pp. 3.75
[136] LULUCF 2003, Table 3.3.3, pp. 3.76
[137] LULUCF 2003, Table 3.3.4, pp. 3.77

Carbon emissions due to carbon stock change of mineral soil is presented in Table 7.21. The increases in carbon stock of cropland were due to change of grassland area to cropland. Since 1994, cropland area has remarkably decreased - this has led to losses of carbon in mineral soils.

Table 7.21. Net carbon stock change (emissions) due to grassland converted to cropland activities, C Gg[138]

Year	Carbon stock change
1990	251.2
1991	207.4
1992	168.9
1993	33.6

Organic soils

The *Tier 1* method of LULUCF Guidelines (LULUCF 2003) was applied in order to estimate CO_2 emissions from cultivated organic soils.

$$\Delta C_{CCOrganic} = \sum_{c} (A \bullet EF)_C \qquad (7.10)^{139}$$

$\Delta C_{CCOrganic}$ – 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 7.22), tonnes C ha^{-1} yr^{-1};

Table 7.22. Annual emission factor (EF) for cultivated organic soils[140]

Climatic temperature regime	IPCC Guidelines default, tonnes C ha^{-1} yr^{-1}
Cold Temperate	-1.0

The total area of organic soils under cropland is illustrated in Figure 7.13. The area of organic soils was interpolated based on CORINE maps (1990, 2000).

[138] Carbon losses
[139] LULUCF 2003, Equation 3.3.5., pp. 3.79
[140] LULUCF 2003, Table 3.3.5., pp. 3.79

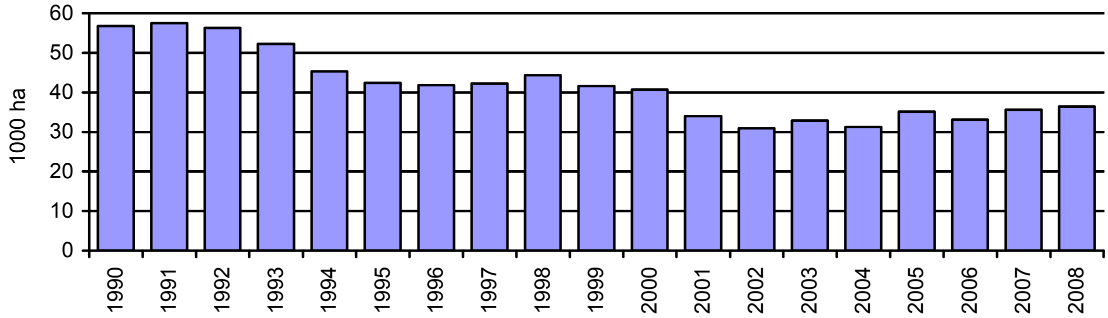


Figure 7.13. Areas of organic soils under cropland in Estonia in 1990–2008, 1000 ha

Carbon emissions from organic soils is presented in Figure 7.14. The emissions of 2008 were 133.6 Gg of carbon.

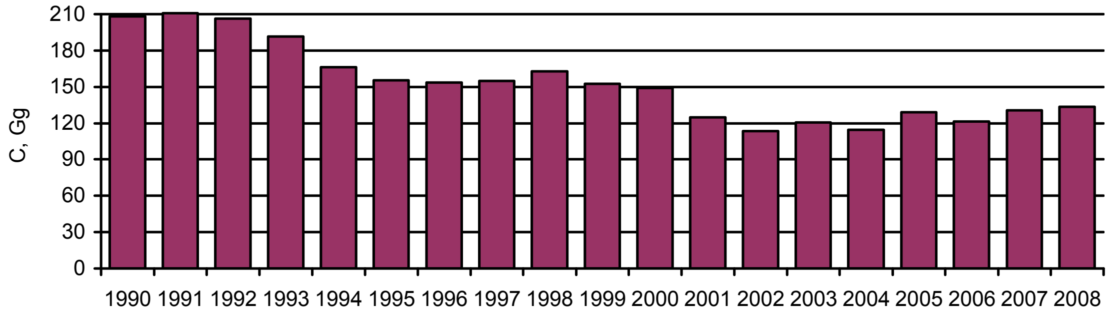


Figure 7.14. Carbon emissions from cultivated organic soils in 1990–2008, C Gg

CO_2 emissions from liming (CRF 5(IV))

The IPCC Guidelines (LULUCF 2003) 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.

The *Tier 1* method was used to estimate CO_2 emissions from liming of cropland (7.11, Table 7.16). Activity data on agricultural land areas on which lime was applied were obtained from Estonian Ministry of Agriculture (Figure 7.15). The average quantity of lime applied per one hectare (5 tonne per hectare) of agricultural land was taken from a report published by Estonian Research Institute of Agriculture (Järvan M., 2005).

$$\Delta C_{CC_{Lime}} = M_{Limestone} \bullet EF_{Limestone} + M_{Dolomite} \bullet EF_{Dolomite} \qquad (7.11)^{141}$$

ΔC_{CCLime} – 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};

[141] LULUCF 2003, Equation 3.3.6., pp. 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 $CaMg(CO_3)_2$)).

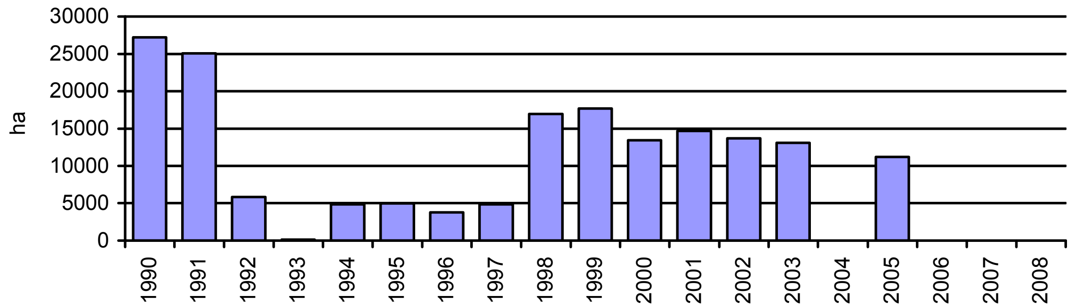


Figure 7.15. Lime application on agricultural land in 1990–2008, 1000 ha (Ministry of Agriculture)

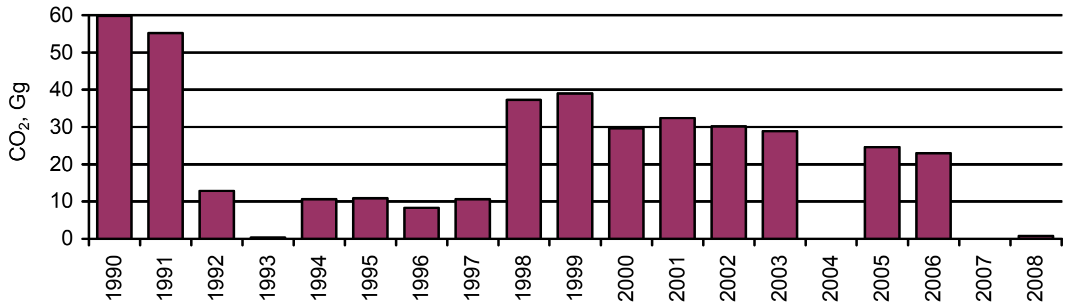


Figure 7.16. CO_2 emissions from lime application on agricultural land in 1990–2008, Gg

7.3.3. Uncertainty and time series' consistency

The estimates of the changes in mineral soil carbon stock, CO_2 emissions from organic soils, and CO_2 emissions due to the changes in the total area of fruit trees were carried out in the 2010 submission. The activity data were obtained from Estonian national statistics, emission factors were employed from the LULUCF GPG (2003). The uncertainty rates in the activity data and the emission factors used in the estimates are reported in Table 7.23.

Table 7.23. Estimated values of uncertainties used in 'Cropland' sub-section

Input	Uncertainties	References
Activity data		
Cropland area, ha	NA	
Area of orchards, ha	NA	
Emission factors		
Default reference soil organic C stock (SOC_{REF})	± 95%	LULUCF 2003, pp. 3.76
Relative stock change factor (F_{LU})	± 12%	LULUCF 2003, pp. 3.77
Relative stock change factor (F_{MG})	NA	LULUCF 2003, pp. 3.77
Relative stock change factor (F_I)	NA	LULUCF 2003, pp. 3.77

Input	Uncertainties	References
Annual emission factor for cultivated organic soils	± 90%	LULUCF 2003, pp. 3.79
Default coefficients for aboveground woody biomass and harvest cycles in cropping systems containing perennial species	± 75%	LULUCF 2003, pp. 3.71

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 are presented in Section 1.6.1.

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.

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

There are two recalculations carried out in the 2010 submission: 1) emissions from losses of fruit trees (Figure 7.17 and Table 7.24) due to updating of the approach employed (inter-annual changes in orchard land areas were used in the estimation in the prevous submission); 2) emissions from lime applied on agricultural lands were estimated for the first time in the present submission.

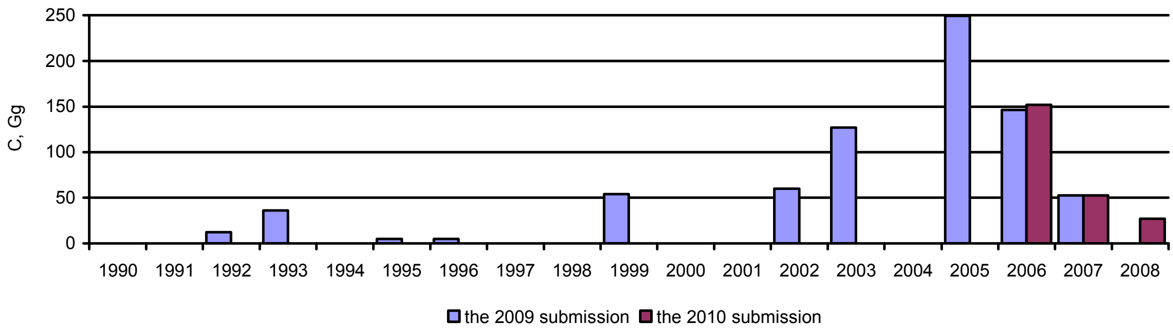


Figure 7.17. Carbon emissions from biomass losses of fruit trees in 1990–2008, Gg

Table 7.24. Carbon emissions from biomass losses of fruit trees in 1990–2008, Gg

Year	Reported emissions of carbon in 1990–2008 (the 2009 submission)	Recalculated emissions of carbon in 1990–2008 (the 2010 submission)
1990	-	-
1991	-	-
1992	12.3	-
1993	36.0	-
1994	-	-
1995	4.9	-
1996	-4.9	-
1997	-	-
1998	-	-
1999	53.9	-
2000	-	-
2001	-	-
2002	59.7	-
2003	127.0	-
2004	-	-
2005	249.3	-
2006	146.5	152.1
2007	52.5	52.5
2008		26.9

7.3.6. Source-specific planned improvements

Several improvements should be made in order to guarantee accurate, complete and transparent inventory in the future: areas of cropland should be checked, areas of changed land use practice should be revised.

7.4. Grassland (CRF 5.C)

7.4.1. Source category description

The total area of grassland started to increase since 1993 in the result of abandonment of cultivated (cropland) land (Table 7.18, Appendix L_I). Carbon emissions from mineral soils under land converted to grassland have been estimated for 1994–2008, carbon emissions organic soils under Grassland were estimated and reported under 'Grassland remaining grassland' sub-section for the entire time period (see also Chapter 7.3.1).

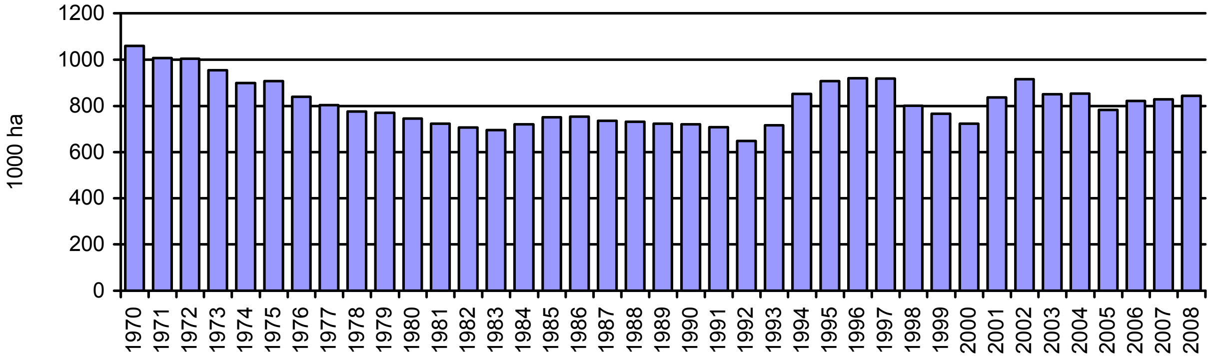


Figure 7.18. Grassland area in Estonia in 1970–2008, 1000 ha

7.4.2. Methodological issues

Carbon stock change in mineral soils was calculated in the 2010 submission based on assumptions. It was assumed that the total area of grassland has increased mostly due to decrease in the area of cropland taken into account as unused arable land and increase of areas of seeded once over five years grassland. Areas of bush trees were defined as grassland.

Carbon emissions/removals associated mineral and organic soils under Grassland remaining Grassland and Land converted to Grassland have been estimated and reported in the 2010 submission, however carbon flows related to grassland above- and below-ground biomass were not estimated due to the lack of activity data.

Mineral soils

The *Tier 1* approach was implemented in order to estimate carbon emissions/removals associated with land converted to grassland (LULUCF 2003).

$$\Delta C_{LGSoil} = \Delta C_{LGMineral} - \Delta C_{LGOrganic} - \Delta C_{LGLime} \quad (7.12)^{142}$$

$\Delta C_{LGSoils}$ – annual change in stocks in soils in land converted to grassland, tonnes C yr^{-1};
$\Delta C_{LGMineral}$ – change in carbon stocks in mineral soils in land converted to grassland, tonnes Cyr^{-1};
$\Delta C_{LGOrganic}$ – annual C emissions from organic soils converted to grassland (estimated as net annual flux), tonnes C yr^{-1};

[142] LULUCF 2003, Equation 3.4.17, pp. 3.126

$$\Delta C_{CCMineral} = \left[(SOC_0 - SOC_{(0-T)}) \bullet A \right] / T$$
$$SOC = SOC_{REF} \bullet F_{LU} \bullet F_{MG} \bullet F_I \qquad (7.13)^{143}$$

$\Delta C_{GGMineral}$ – annual change in carbon stocks in mineral soils, tonnes C yr^{-1};

SOC_0 – soil organic carbon stock in the inventory year, tonnes C ha^{-1};

$SOC_{(0-T)}$ – soil organic carbon stock T years prior to the inventory, tonnes C ha^{-1};

T – inventory time period, yr (default is 20 yr);

A – land area of each parcel, ha;

SOC_{REF} – the reference carbon stock, tonnes C ha^{-1}(Table 7.25);

F_{LU} – stock change factor for land use or land-use change type, dimensionless (Table 7.26);

F_{MG} – stock change factor for management regime, dimensionless (Table 7.26);

F_I – stock change factor for input of organic matter, dimensionless (Table 7.26);

Table 7.25. Default reference (under native vegetation) soil organic stocks (SOC_{REF}) (tonnes C per ha for 0-30 cm depth)[144]

	HAC soils	Spodic Soils	Wetland soils
Boreal	68	117	146

Table 7.26. Relative stock change factors for grassland management[145]

Factor	Level	GPG revised default
Land Use - F_{LU}	All	1.0
Management - F_{MG}	Nominally managed (non-degraded)	1.0
Input (applied only to improved grassland) - F_I	Nominal	1.0

Organic soils

The *Tier 1* approach was used in order to calculate CO_2 emissions from organic soils under grassland (LULUCF 2003). The activity data were interpolated based on datasets of CORINE 1990 and 2000 maps.

$$\Delta C_{GGOrganic} = \sum_c (A \bullet EF)_C \qquad (7.14)^{146}$$

$\Delta C_{GGOrganic}$ – CO_2 emissions from cultivated organic soils in grassland remaining grassland, tonnes C yr^{-1};

[143] LULUCF 2003, Equation 3.4.8., pp. 3.112
[144] LULUCF 2003, Table 3.4.4., pp.3.117
[145] LULUCF 2003, Table 3.4.5., pp.3.118
[146] LULUCF 2003, Equation 3.4.10., pp.3.114

A – land area of organic soils in climate type *c*, ha;

EF – emission factor for climate type *c*, tonnes C ha^{-1} yr^{-1};

7.4.3. Quantitative overview – Carbon emissions/removals from grassland soils

Mineral soils

Carbon emissions from mineral soils of ‘Grassland remaining Grassland’ land use category has not been estimated due to the lack of activity data. The estimates have been provided for ‘Land converted to Grassland’ land use category. Mineral soil carbon stock of grassland started to grow since 1994 in the result of the increase of the total grassland area. The activity data presented in Table 7.27 illustrate carbon flows occurring in the results of land use changes from Grassland to Cropland (carbon stock change in cropland) and from Cropland to Grassland (carbon stock change in grassland).

Needless to note that the activity data on land use changes were assumed as datasets required to carry out the inventory is currently under development. Estonia is establishing institutional agreements among institutions, which provided with activity data.

Table 7.27. Carbon emissions/removals by cropland and grassland soils in Estonia in 1990–2008, C Gg (see also Table 7.21)

Year	Carbon stock change in Cropland	Carbon stock change in Grassland
1990	251.2	-
1991	207.4	-
1992	168.9	-
1993	33.6	-
1994	-	184.8
1995	-	223.4
1996	-	277.2
1997	-	292.3
1998	-	265.2
1999	-	320.1
2000	-	361.1
2001	-	524.4
2002	-	594.9
2003	-	544.1
2004	-	567.9
2005	-	468.3
2006	-	508.8
2007	-	472.6
2008	-	455.5

Organic soils

Carbon emissions from organic soils under grassland have been estimated for 'Grassland remaining Grassland' land use category (Figure 7.19). Carbon emissions from 'Land converted to Grassland' category have been included into the estimation of carbon fluxes related to 'Grassland remaining Grassland' land use category.

Figure 7.19. Carbon emissions from grassland organic soils in Estonia in 1990–2008, C Gg

7.4.4. 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). The activity data were employed from Estonian national statistics and literature, 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 'Grassland' sub-section

Input	Uncertainties	References
Activity data		
Grassland, ha	NA	
Emission factors		
Default reference soil organic C stock (SOC_{REF})	± 95%	LULUCF, 2003, pp. 3.117
Annual emission factor for cultivated organic soils	± 90%	LULUCF, 2003, pp. 3.118

7.4.5. 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 1.6.1.

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.

Activity data are checked annually for updating. Emission factors are compared with IPCC default and with emission factors of other countries.

7.4.6. Source-specific recalculations

There are two recalculations carried out in the 2010 submission: carbon flows associated with grassland 1) mineral and 2) organic soils have been recalculated due to update of activity data: areas of bush trees were defined as grassland (Figures 7.20-7.21, and Table 7.29-7.30).

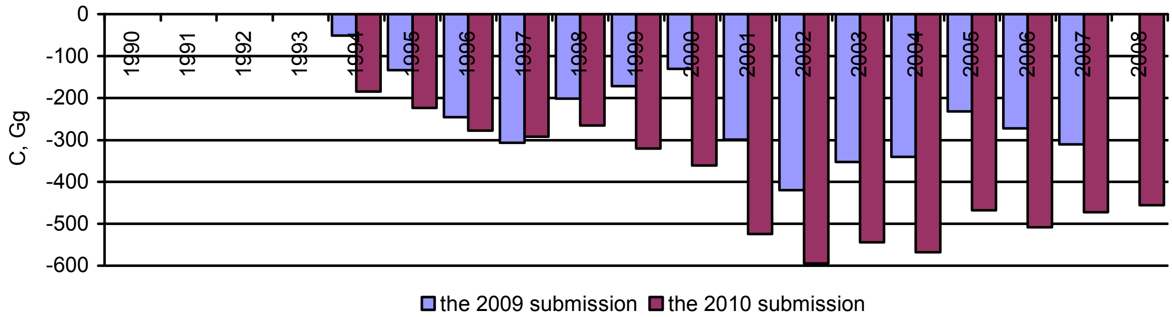


Figure 7.20. Carbon flows associated with carbon stock change grassland mineral soils in 1994–2008, Gg

Table 7.29. Carbon flows associated with carbon stock change in grassland mineral soils in 1994–2008, Gg

Year	Reported carbon stock change in 1994–2008 (the 2009 submission)	Recalculated carbon stock change in 1994–2008 (the 2010 submission)
1994	-51.2	-184.8
1995	-133.2	-223.4
1996	-245.6	-277.2
1997	-306.7	-292.3
1998	-201.3	-265.2
1999	-171.3	-320.1
2000	-130.2	-361.1
2001	-298.9	-524.4
2002	-420.4	-594.9
2003	-352.8	-544.1

Year	Reported carbon stock change in 1994–2008 (the 2009 submission)	Recalculated carbon stock change in 1994–2008 (the 2010 submission)
2004	-340.0	-567.9
2005	-231.7	-468.3
2006	-271.9	-508.8
2007	-310.6	-472.6
2008		-455.5

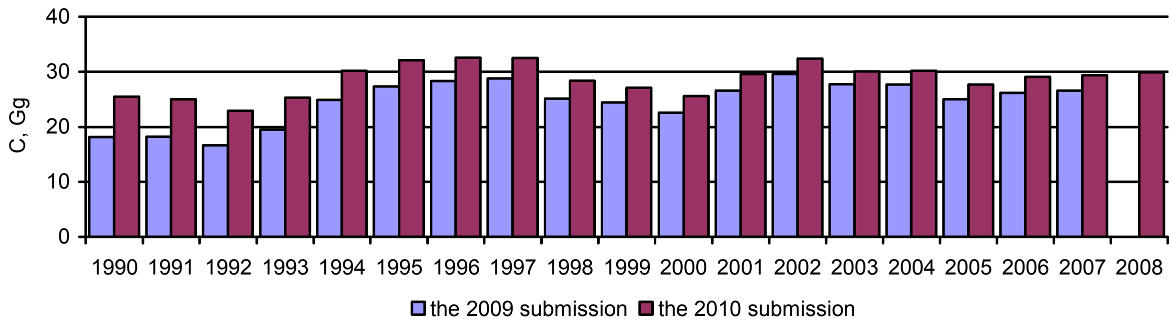


Figure 7.21. Carbon emissions from grassland organic soils in 1990–2008, Gg

Table 7.30. Carbon emissions from grassland organic soils in 1990–2008, Gg

Year	Reported emissions of carbon in 1990–2008 (the 2009 submission)	Recalculated emissions of carbon in 1990–2008 (the 2010 submission)
1990	18.1	25.5
1991	18.2	25.0
1992	16.6	23.0
1993	19.5	25.3
1994	24.9	30.2
1995	27.4	32.1
1996	28.3	32.6
1997	28.8	32.5
1998	25.1	28.4
1999	24.4	27.1
2000	22.6	25.6
2001	26.6	29.6
2002	29.6	32.4
2003	27.8	30.1
2004	27.7	30.2
2005	25.0	27.7
2006	26.2	29.1
2007	26.6	29.3
2008		29.9

7.4.7. Source-specific planned improvements

Several improvements should be made in the next submissions in order to provide accurate and complete GHG inventory: areas of grassland should be checked carefully in accordance with IPCC definition, changes in areas from/to grassland land use category should be revised and carbon emissions/removals associated with above- and below-ground biomass should be estimated.

7.5. Wetland (CRF 5.D)

7.5.1. Source category description

The total area of wetland has decreased during the last decades (Figure 7.22) mostly due to drainage of wetlands for agricultural and forestry purposes. Carbon fluxes related to Wetlands remaining Wetlands land category have not been estimated due to the lack of activity data.

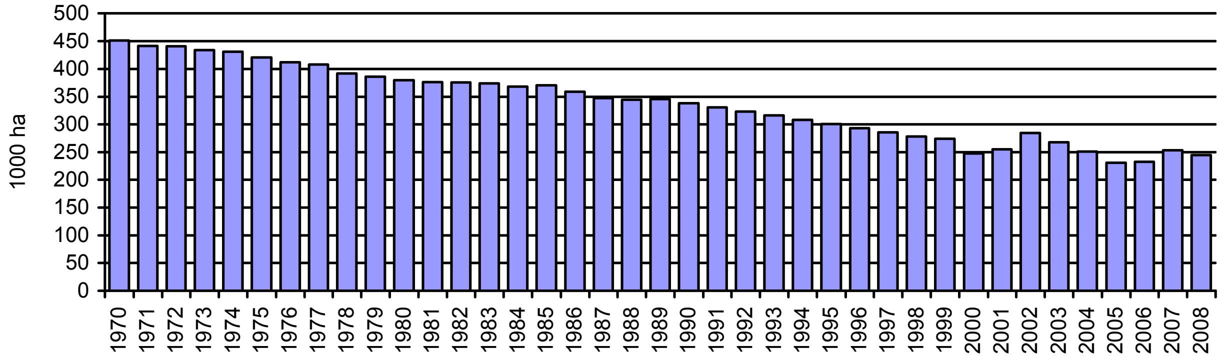


Figure 7.22. Area of wetlands in Estonia in 1970–2008, 1000 ha

Non-CO_2 emissions related to peatland were estimated based on Estonian activity data and the *Tier 1* approach of LULUCF GPG (LULUCF 2003). The data on industrial peat extraction (Table 7.31) were obtained from the literature (Orru jt, 2005) and Estonian Land Board.

Table 7.31. Area of industrial peat production, 1000 ha

Year	Peat extraction fields
1990	12.0
1991	15.0
1992	15.0
1993	15.0
1994	15.0
1995	15.0
1996	15.0
1997	15.0
1998	15.0
1999	15.0
2000	20.0
2001	20.0
2002	20.0
2003	20.0
2004	20.0
2005	20.0
2006	19.6

Year	Peat extraction fields
2007	20.1
2008	20.3

7.5.2. Methodological issues

The approach presented in LULUCF GPG (2003) was employed in order to estimate Non-CO_2 emission from peatland.

$$\Delta C_{WWpeat\_Soil,extraction} = A_{peat\_Nrich} \bullet EF_{peat\_Nrich} + A_{peat\_Npoor} \bullet EF_{peat\_Npoor} \qquad (7.16)^{147}$$

$\Delta C_{WW\ peat\ Soils,\ extraction}$ – CO_2 emissions from organic soils managed for peat extraction expressed as carbon, tonnes C yr^{-1};

$A_{peatNrich}$ – area of nutrient rich organic soils managed for peat extraction, including abandoned areas in which drainage is still present, ha;

$A_{peat\ Npoor}$ – area of nutrient poor organic soils managed for peat extraction, including abandoned areas in which drainage is still present, ha (Table 7.32);

$EF_{peatNrich}$ – emission factors for CO_2 from nutrient rich organic soils managed for peat extraction, tonnes C ha^{-1} yr^{-1} (Table 7.32);

Table 7.32. Emission factors for CO_2-C and associated uncertainty for organic soils after drainage

Region / Peat Type	Emission Factor, tonnes C ha^{-1} yr^{-1}	Emission Factor, kg N_2O-N ha^{-1} yr^{-1}
Nurtrient Poor, EF_{Npoor}	0.2[148]	0.1[149]

7.5.3. Quantitative overview – Carbon emissions/removals from peat extraction areas

The emissions of N_2O and CO_2 due to industrial peat extraction are presented in Figure 7.23-7.24.

[147] LULUCF, 2003. Equation 3a.3.6, pp.3.279
[148] LULUCF, 2003. Equation 3a.3.6, pp.3.280
[149] LULUCF, 2003, Table 3a.3.4, pp. 3.284

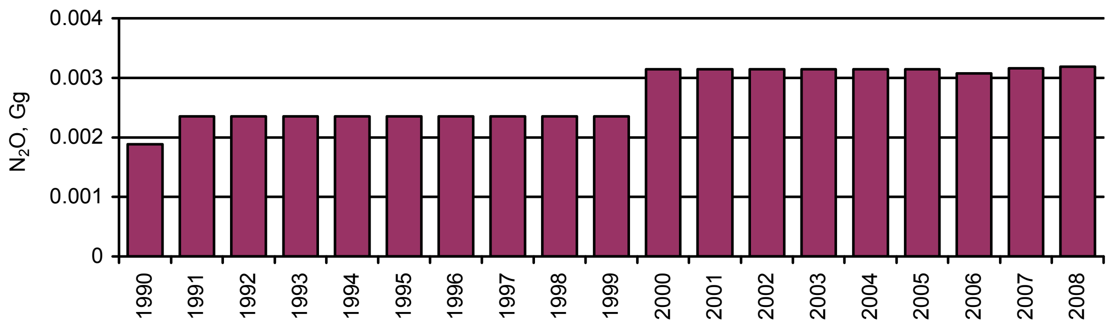


Figure 7.23. N_2O emissions due to industrial peat extraction in 1990–2008, N_2O Gg

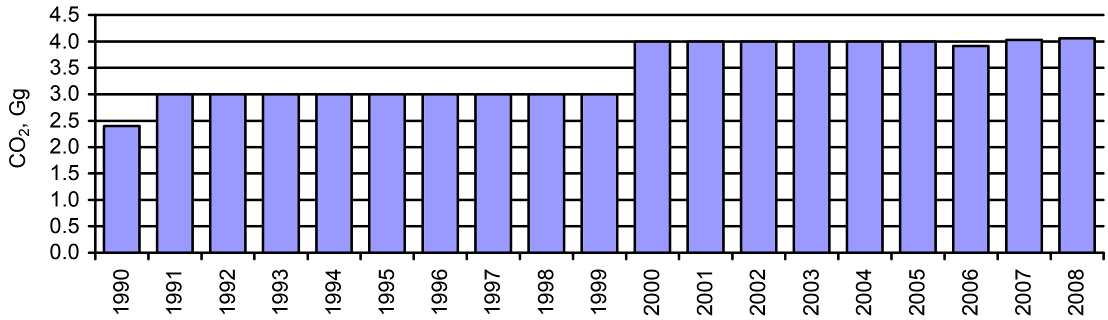


Figure 7.24. CO_2 emissions due to industrial peat extraction in 1990–2008, CO_2 Gg

7.5.4. Uncertainty and time series' consistency

The estimates of GHG flows were carried out based on the LULUCF GPG (2003). The activity data were obtained from Estonian national statistics, the emission factors – from the LULUCF GPG (2003). The uncertainty rates are listed in Table 7.33.

Table 7.33. Estimated values of uncertainties used in 'Other Land' sub-section

Input	Uncertainties	References
Activity data		
Peatland area, ha	NA	
Emission factors		
Emission factor for CO_2-C	-100…215%	LULUCF 2003, pp. 3.280
Emission factor for N_2O	-100…200%	LULUCF 2003, pp. 3.284

7.5.5. 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 1.6.1.

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.

Activity data are checked annually for updating. Emission factors are compared with IPCC default and with emission factors of other countries.

7.5.6. Source-specific recalculations

There is one recalculation carried out in the 2010 submission: activity data on peat extraction areas in 2006-2007 were updated, since institutional cooperation with the department of Geology of Estonian Land Board (Table 7.34-7.35).

Table 7.34. N_2O emissions due to industrial peat extraction in 1990–2008, N_2O Gg

Year	Reported N_2O emissions (the 2009 submission)	Recalculated N_2O emissions (the 2010 submission)
2006	0.00314	0.00307
2007	0.00314	0.00316
2008		0.00319

Table 7.35. CO_2 emissions due to industrial peat extraction in 1990–2008, CO_2 Gg

Year	Reported CO_2 emissions (the 2009 submission)	Recalculated N_2O emissions (the 2010 submission)
2006	4.000	3.913
2007	4.000	4.026
2008		4.056

7.5.7. Source-specific planned improvements

Several improvements should be made in the next submissions in order to report complete and accurate GHG inventory in ‘Wetlands’ sub-section: carbon flows related to wetland living biomass should be estimated, areas of land converted to/from wetlands will be checked, a higher tier will be applied to estimate emissions from peat extraction areas.

7.6. Settlements (CRF 5.E)

7.6.1. Source category description

The areas of settlements in 1990–2008 are reported in Table 7.36. Carbon flows related to settlements have not calculated in the 2010 submission.

Table 7.36. Areas of settlements in 1990–2008, 1000 ha

Year	Total	…roads	…settlements
1990	152.2	76.9	75.3
1991	159.6	79.9	79.7

Year	Total	…roads	…settlements
1992	166.9	82.8	84.1
1993	174.2	85.8	88.5
1994	181.5	88.7	92.8
1995	188.9	91.6	97.2
1996	196.2	94.6	101.6
1997	203.5	97.5	106.0
1998	210.8	100.4	110.4
1999	226.4	107.7	118.7
2000	239.7	112.2	127.5
2001	254.2	109.6	144.6
2002	256.3	110.5	145.8
2003	255.7	112.6	143.1
2004	263.5	108.3	155.2
2005	288.2	118.6	169.6
2006	290.9	119.2	171.7
2007	290.2	125.1	165.1
2008	299.7	125.2	174.5

7.7. Emissions of greenhouse gases from biomass burning (CRF 5 (V))

In this section CO_2 and non-CO_2 greenhouse gases emissions from forest biomass burning were considered.

This source category includes non-CO_2 greenhouse gas emissions (CH_4 and N_2O) and CO_2 from biomass burning on forested land due to wildfires.

7.7.1. Methodology, data availability and sources, emission factors

Equation (7.17) was used to estimate the emissions of non-CO_2 greenhouse gases. The combustion factor (0.34) was taken from Table 3A.1.12 (LULUCF 2003), and the Nitrogen-Carbon ratio (0.01)[150] of burned biomass was taken from (IPCC 1997). Activity data on areas damaged by fires were obtained from ESO (Figure 7.25), an average value of forest growing stock was employed from (Estonian Forest 2008).

$$L_{fire} = A \bullet B \bullet C \bullet D \bullet 10^{-6} \qquad (7.17)^{151}$$

L_{fire} – quantity of GHG released due to fire, tonnes of GHG;

[150] IPCC 1997, Workbook, Chapter 5. pp. 5.18
[151] LULUCF 2003, Equation 3.2.20, pp. 3.49

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.)$^{-1}$ (Table 7.37);

Table 7.37. Factors used to estimate emissions of non-CO_2 greenhouse gases emitted due to forest fires[152]

	Emission ratios
CH_4	0.012
CO	0.06
N_2O	0.007
NO_x	0.121

7.7.2. Quantitative overview – Carbon emissions/removals from biomass burning

The total area of Estonian forest affected by wildfires is presented in Figure 7.25. Emissions of GHG due to biomass burning are illustrated in Figure 7.26. The total GHG emissions were 19.7 Gg of CO_2 equivalents.

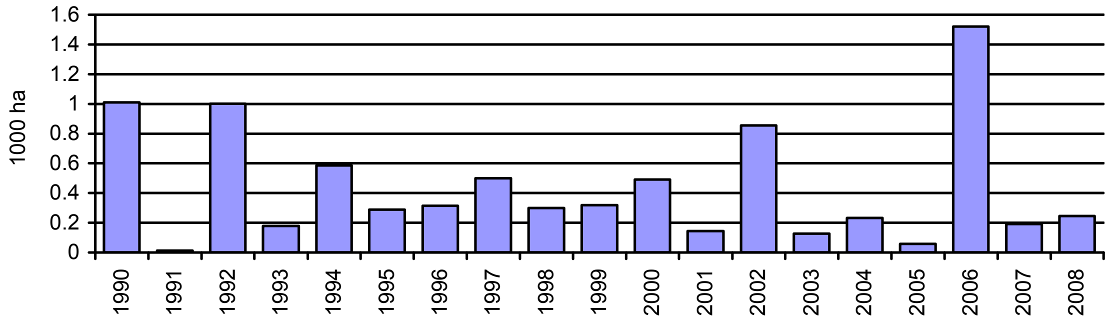


Figure 7.25. Area of Estonian forest affected by fires in 1990–2008, 1000 ha

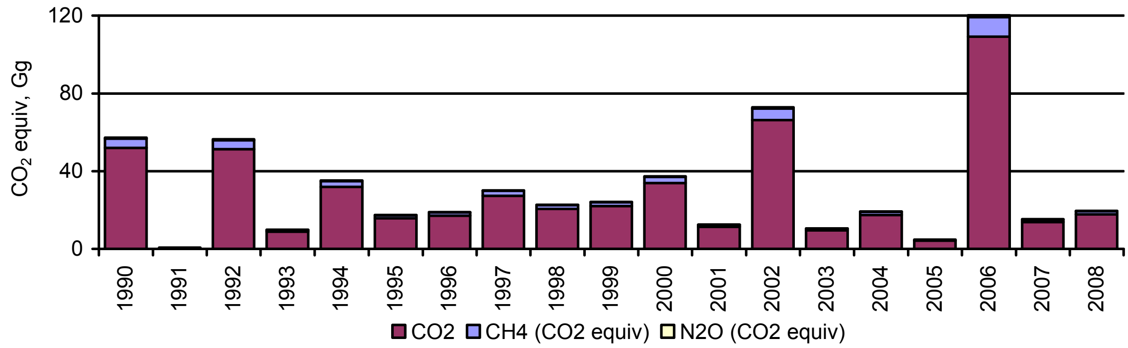


Figure 7.26. CO_2 equiv emissions from forest biomass wildfires in Estonia in 1990–2008, Gg

[152] LULUCF 2003, Table 3A.1.15 – Emissions ratios for open burning of cleared prests

7.7.3. Uncertainties and time-series consistency

Estimates of CO_2, CH_4 and N_2O emissions from forest fires are carried out based on the data of forest area burned, average biomass stock per hectare, BEFs, value of combustion factor for fires and emission ratios for open burning. The uncertainty rates employed in the estimates are reported in Table 7.38.

Table 7.38. Estimated values of uncertainties used in 'Biomass Burning' sub-section

Input	Uncertainties	References
Activity data		
Stand biomass increment, m^3/ha	± 2.8%	'Eesti Metsad 2008' report
Stand stock per hectare, m^3/ha	± 3.1%	'Eesti Metsad 2008' report
Emission factors		
Wood density	± 20%	LULUCF 2003, pp. 3.31
Value of combustion factor for fires	-85…124%	LULUCF 2003, pp. 3.179
Emission ratio for open burning (CH_4)	± 25%	The 1996 IPCC Guidelines, pp. 5.33
Emission ratio for open burning (N_2O)	± 29%	The 1996 IPCC Guidelines, pp. 5.33

7.7.4. 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 1.6.1.

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.

Activity data are checked annually for updating. Emission factors are compared with IPCC default and with emission factors of other countries.

7.7.5. Source-specific recalculations

No recalculations have been carried out in the 2010 submission.

7.7.6. Source-specific planned improvements

Activity data will be updated necessarily.

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[153]. 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 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[154].

The Estonian inventory of greenhouse gas emissions (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 and biological treatment. 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 is treated in wastewater treatment plants using anaerobic processes. Preliminary information about wastewater treatment and emissions is reported in the current NIR; however the category will be covered thoroughly in the 2011 submission.

[153] Waste Management Plan, Riigi Jäätmekava 2008-2013
[154] The background information on waste management policy was included as the recommendation of the UNFCCC review team.

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.

Table 8.1 Methods and emission factors used for estimations of emissions from waste sector

Greenhouse gases source and sink categories	CO_2		CH_4		N_2O	
	Method Applied	EF	Method Applied	EF	Method Applied	EF
6. Waste						
A. Solid Waste Disposal on Landfills			T1 (The FOD)	IPCC		
B. Wastewater Handling (anaerobic)			T1	IPCC		
B. Human sewage					T1	IPCC
D. Biological Treatment			T1	IPCC	T1	IPCC

T1 – *Tier 1* method, the FOD – the First Order Decay method.

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 the Statistical Office of Estonia (ESO).

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	ESO	- Collection and reporting of data on product production in Estonia
Estonian Environment Information Centre -Waste Bureau	www.keskkonnainfo.ee	EEIC	- Collection of data on solid waste generation, disposal, and recovery, incl. waste incineration and biological treatment
-Water Bureau			-Collection of data on waste water generation
-Air Bureau			-Collection of data on methane recovery

8.1.2. Quantitative overview of the waste sector

In 2008 CO_2 equiv emissions from waste sector were 674,82 Gg in Estonia. It made up 3.3 % of the total GHG emissions in 2008 (Figure 8.1). CH_4 emissions from solid waste landfilled and GHG emissions (CH_4 and N_2O) from biological treatment (composting) are the most significant emissions of the waste sector in Estonia in 2008.

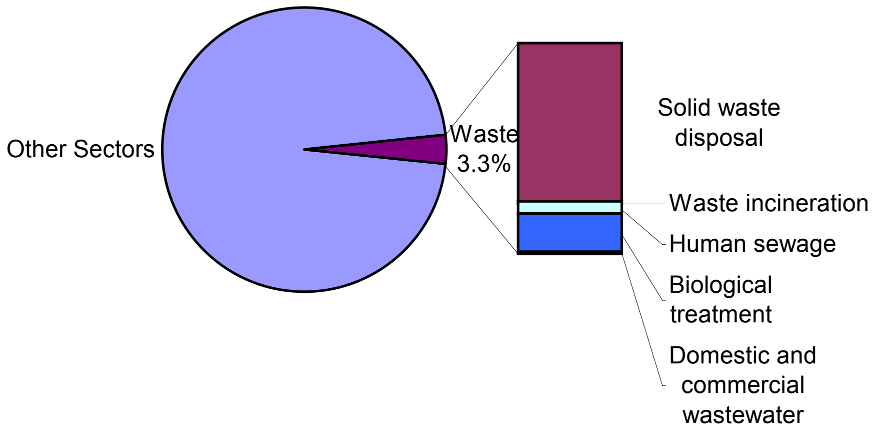


Figure 8.1 CO_2 equiv emissions from the waste sector compared with the total GHG emissions in Estonia in 2008, Gg

The total CO_2 equivalent emissions from the waste sector decreased 0,8 % in comparison with the base year: the emissions from solid waste landfilled decreased by 14,3 % and emissions from waste composting processes increased about 100 fold – from 1.26 Gg to 121 Gg in 2008 (Figure 8.2).
As seen from the table (Table 8.3) there has been a sharp fluctuation in the quantities of GHG emissions from waste incineration in 2000, 2002, 2004, and 2008. The main reason for the augmentation is that, in 2000, 2002 and 2004 large amounts of inert and organic waste (including also textiles and wood) were burnt and in 2008 the sudden fallout took place, as no wastes were incinerated (D10 operation) without energy recovery.

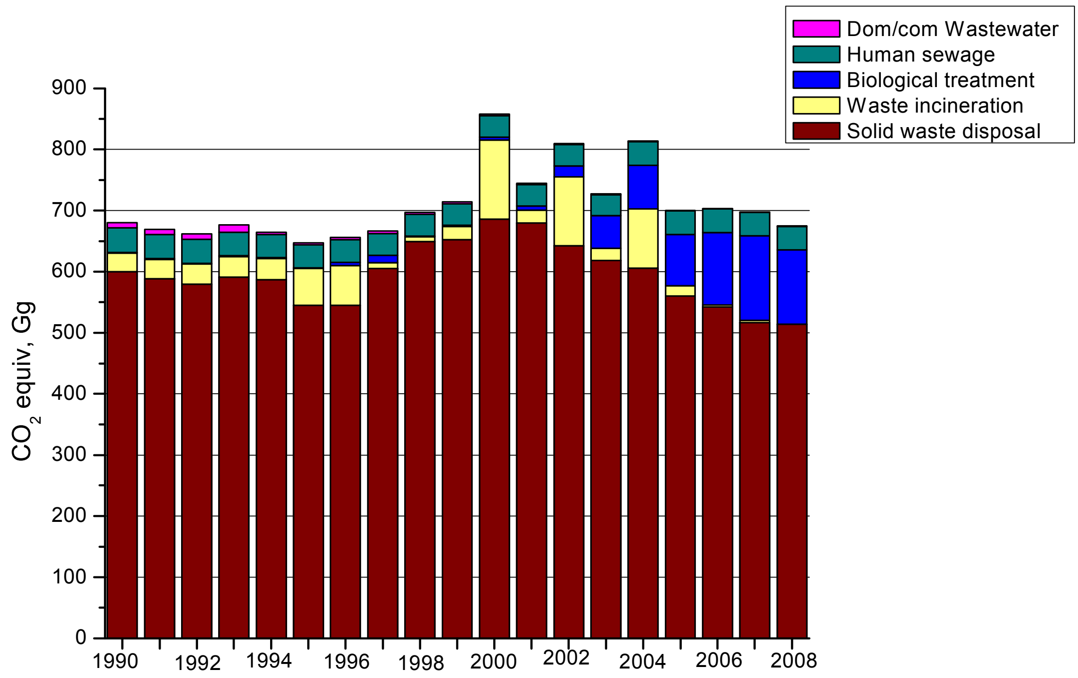


Figure 8.2 Trends of GHG emissions in the waste sector by source categories in 1990-2008

Table 8.3 GHG emissions from waste sector in Estonia in 1990-2008

Year	Solid waste disposal	Waste incineration		Biological treatment		Wastewater treatment		**Total CO_2 equiv emissions**
						Human sewage	Domestic and commercial	
	CH_4	CO_2[155]	N_2O	CH_4	N_2O	N_2O	CH_4/domestic	CO_2 equiv
1990	28.57	0.051	0.098	0.029	0.002	0.130	0.3858	679.99
1991	28.03	0.051	0.101	0.030	0.002	0.129	0.3851	669.30
1992	27.60	0.051	0.105	0.032	0.002	0.128	0.42522	662.08
1993	28.15	0.051	0.108	0.033	0.002	0.125	0.57904	676.88
1994	27.95	0.051	0.112	0.035	0.003	0.122	0.16156	664.51
1995	25.95	0.088	0.193	0.037	0.003	0.120	0.15850	647.12
1996	25.96	0.035	0.209	0.126	0.009	0.118	0.19488	656.01
1997	28.81	0.046	0.032	0.262	0.020	0.116	0.19225	666.61

[155] CO_2 emissions 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).

1998	30.92	0.063	0.025	0.026	0.002	0.115	0.15239	697.19
1999	31.05	0.068	0.070	0.043	0.003	0.114	0.15012	714.16
2000	32.67	0.154	0.416	0.107	0.008	0.113	0.11234	857.26
2001	32.38	0.109	0.068	0.143	0.011	0.113	0.11204	744.92
2002	30.59	0.113	0.364	0.396	0.030	0.112	0.07445	809.18
2003	29.44	0.167	0.066	1.192	0.089	0.112	0.07424	727.75
2004	28.86	0.370	0.311	1.614	0.121	0.125	0.03699	813.85
2005	26.69	0.125	0.053	1.920	0.141	0.125	0.03688	700.52
2006	25.81	0.071	0.011	2.682	0.201	0.125	0.03681	703.67
2007	24.59	0.042	0.013	3.119	0.234	0.124	0.03675	697.71
2008	24.48	NE	NE	2.743	0.206	0.124	0.03671	674.72

8.1.3. Key categories

Waste key categories in 2008 calculated with the *Tier 1* method[156] were:

6.A Solid Waste Disposal on Land/Managed Waste Disposal on Land (CH_4) L,T[157]

6.B.2.2 Domestic and Commercial Wastewater – human sewage T

6.D Biological Treatment (N_2O) L,T

6.D Biological Treatment (CH_4) L,T

[156] GHG emissions/removals of LULUCF sector are not included.
[157] L-Level Assessment method; T-Trend Assessment method.

8.1.4. Uncertainty assessment

The combined uncertainties related to the waste sector as percent from the total national emissions in 2008 are follows:

Table 8.4 The combined uncertainties related to waste sector (%)

Source category	Uncertainties
6.A Solid Waste Disposal on Land (CH_4)	1,58%
6.B Domestic and Commercial wastewater	0,00%
6.B.2.2. Human Sewage (N_2O)	0,19%
6.D. Biological Treatment (CH_4)	0,28%
6.D. Biological Treatment (N_2O)	0,31%
CRF 6 Waste sector total	2,37%

8.2. Solid waste disposal on landfills (CRF 6.A)

8.2.1. Source category description

In 2008, there were 15 landfills, where municipal wastes were deposited. Due to rearrangements in waste management system, 10 of them were closed in summer 2009, for not being in accordance with environmental requirements applied to landfills. The remaining landfills (Jõelähtme, Uikala, Väätsa, Torma, Paikre) 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)[158]. There are several landfills in Estonia, which are closed but still 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 reusable waste; separation of preliminarily separated waste, separation and destruction of wood; composting; collection of hazardous waste; separation of demolished constructional waste; etc.

In the current report all 15 solid waste disposal sites has been taken into account.

[158] Operating landfills in Estonia in 2008

Table 8.5 Number of urban population and amounts of municipal waste generated in 2008 by counties of Estonia

	Number of urban population	Amount of municipal waste generated, tonnes[159]
Harju County	436 283	257 832.9
Hiiu County	3 678	2 199.8
Ida-Viru County	139 128	48 646.4
Jõgeva County	12 605	6 052.8
Järva County	9 756	7 222.4
Lääne County	11 702	8 437.3
Lääne-Viru County	20 324	14 171.4
Põlva County	6 516	5 995.4
Pärnu County	48 027	30 860.0
Rapla County	-[160]	8 421.6
Saare County	14 956	15 109.3
Tartu County	109 320	71 443.1
Valga County	16 890	7 693.7
Viljandi County	22 672	14 675.1
Võru County	14 467	7 716.4
Whole Country	866 324	506 477.7

[159] Code 20 of the Commission of the European Communities 2000/532/EC
[160] The data on urban population of Rapla County can't be prescribed, due to the rearrangement in territorial border in 1996, since when no differentation on urban population is made.

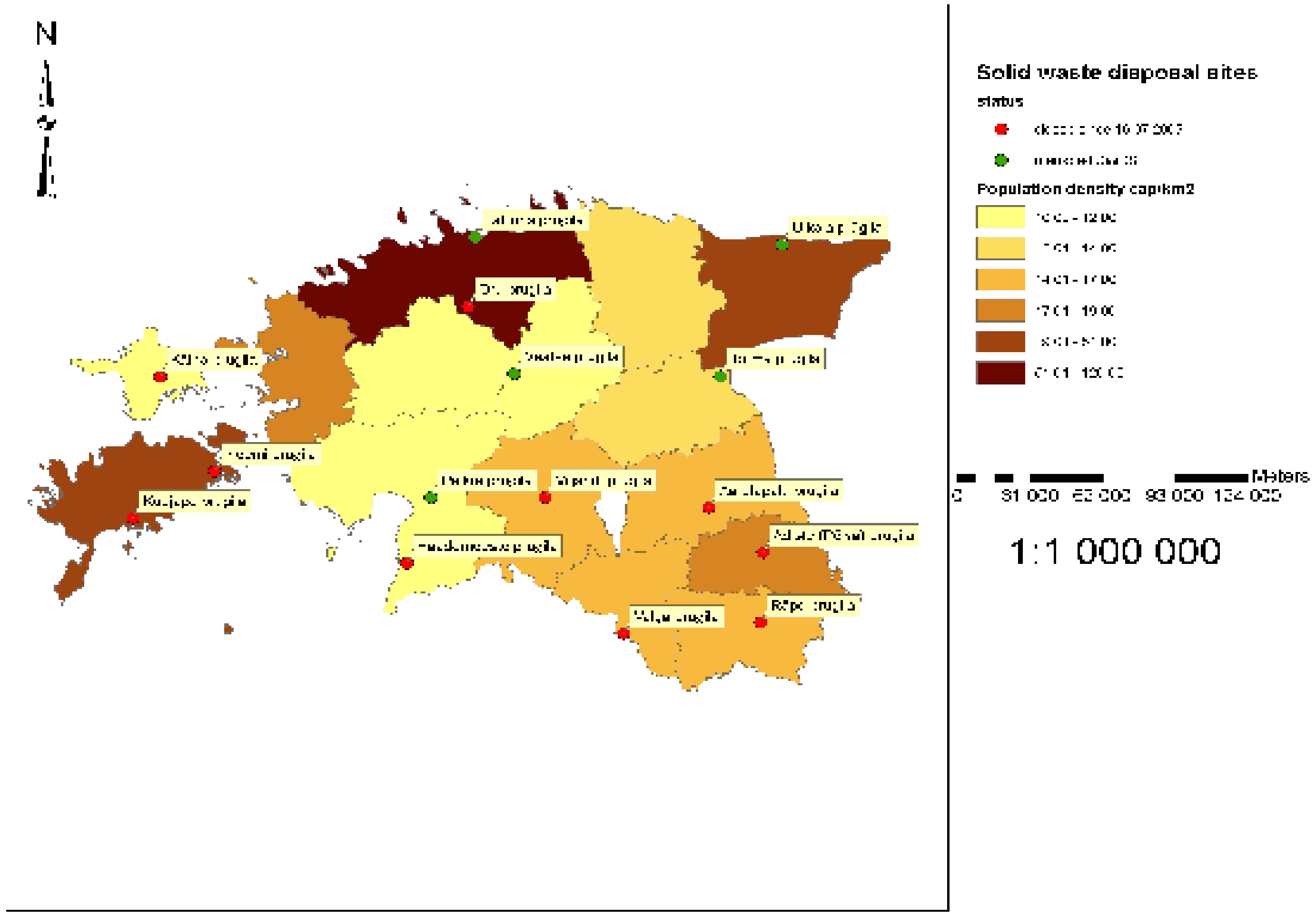


Figure 8.3 The map of Estonia's population, population density and operating landfills of municipal wastes in 2008

The annual trend of inert[161] and degradable waste generated in Estonia in 1990-2008 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).

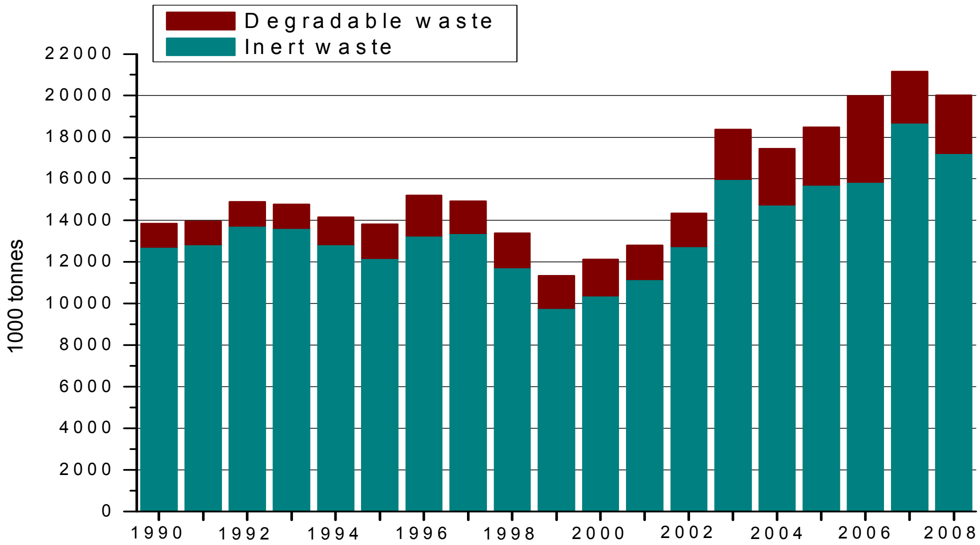


Figure 8.4 Amounts of waste generated in Estonia in 1990-2008, 1000 tonnes

As seen from the Figure 8.5 the quantity of DOC[162] generated has increased 3.4 times in 2008, compared with the base year. Although in comparison with the year 2007 the amount of DOC generated in 2008 has decreased 9,8 %, and the ratio of DOC landfilled to DOC generated has made a growth from 8,2 % to 9, 8%.

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 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.

[161] 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.)
[162] DOC-Degradable Organic Carbon

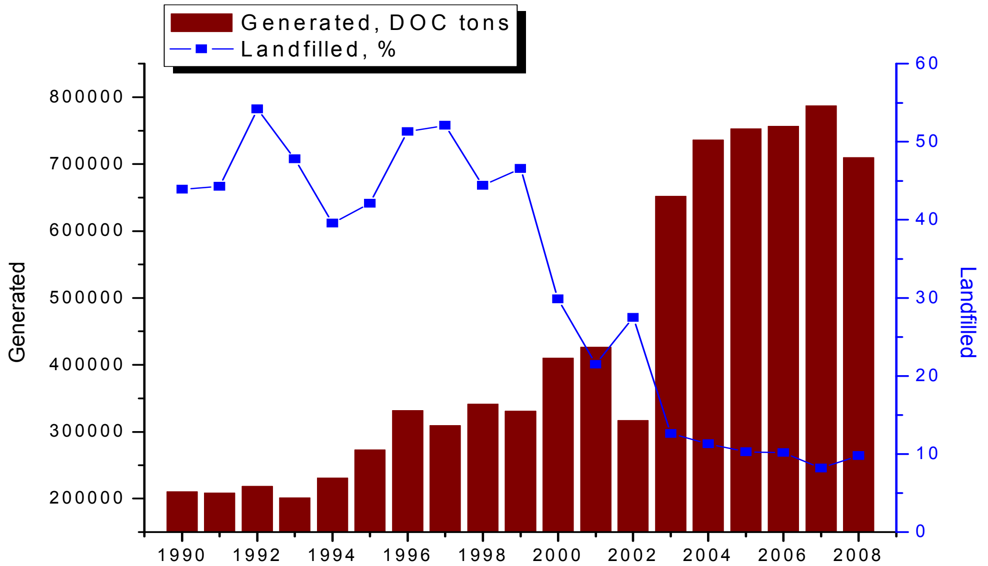


Figure 8.5 Quantity of DOC generated (tonnes) and ratio of DOC landfilled to DOC generated (%) in 1990-2008

The data on methane recovery in 2008 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. According to the data of the Air bureau, the summary amount of CH_4 recovered from two landfills (Tallinn and Pääsküla landfills) in 2008 was 3.03 Gg. No rearrangements were made in the data about the CH_4 recovery for the previous years, as the amounts of methane recovered weren't available for the whole time series at the time of compiling the inventory. The time series for the methane recovery will be corrected for the next submission.

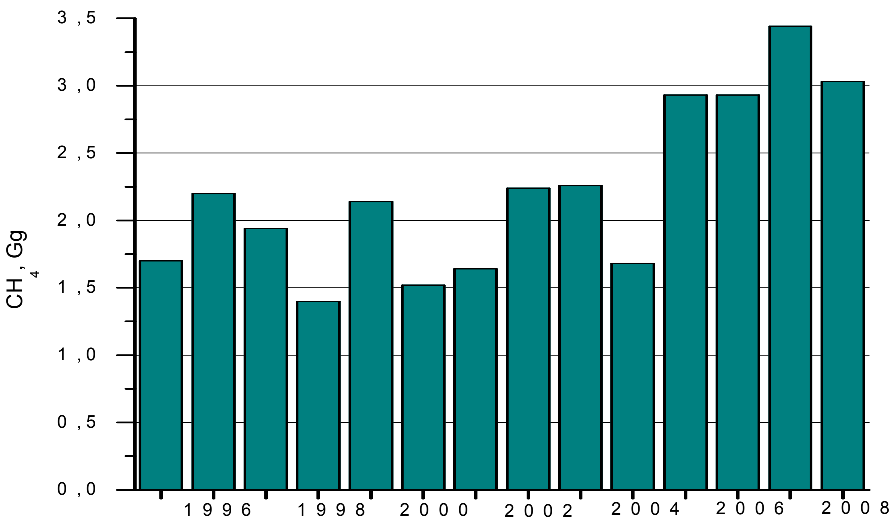


Figure 8.6 CH_4 recovered from landfills 1995-2008, Gg

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 2008 (collected from Estonian Environment Information Centre (EEIC) and amount of recovered methane (obtained from the EEIC Air bureau) are used as activity data.

In 2008, 20 million tonnes of waste was generated in Estonia. About 71 % of waste generated was produced by oil shale industry (wastes from mining and physical-chemical treatment, thermal processes, and other oil shale wastes[163]). The quantity of municipal waste generated in 2008 was about 577 thousand tonnes (including municipal sludge), being 2,9% of the total amount of the waste generated. The total amount of waste disposed onto landfills was 11,7 millions tonnes, about 331 thousand tonnes of it comprised the municipal waste.

Municipal waste includes separately collected fractions – 20% of the total amount of municipal waste generated, garden and park wastes (2,4 %) and other municipal wastes (incl. mixed municipal waste, waste from markets and street-cleaning residues, etc. –77,8 %). Compared to the year 2007 the amount of separately collected fractions has increased from 10% to 20% 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 (IPCC 2000).

$$CH_4,\ Gg/year = \sum_x [A \bullet k \bullet MSW_{T(W)} \bullet SW_{F(X)} \bullet L_0(x) \bullet e^{-k(t-x)}] \qquad (8.1)^{164}$$

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;

[163] wastes from the treatment of the oil shale and coal, e.g a pitch

[164] IPCC, 2000. Waste. pp 5.6

k- methane generation rate constant, 1/yr;

$MSW_{T(W)}$ – total municipal solid waste (MSW) generated in year x, Gg/yr;

$SW_{F(X)}$ – fraction of SW 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).

$$CH_4, \text{ Gg/year} = [\, CH_4 \text{ generated in year } t - R(t)] - (1 - OX) \quad (8.3)$$ [165]

R(t) – recovered CH_4 in inventory year t, Gg/yr;

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*.

Table 8.6 Default DOC content of different waste types (wet basis)[166]

Waste group	DOC content
Solid municipal waste	
Food, Grease	0.15
Municipal	(Table 8.5)
Garden	0.20
Glass	-
Inert	-
Paper	0.40
Plastic	-

[165] Equation 5.2 of the IPCC 2000, pp 5.7
[166] Table 2.4 and Table 2.5 of the 2006 IPCC Guidelines, pp 2.14-2.16

Textile	0.24
Wood	0.43
Other	-
Municipal Sludge	
Sludge	0.05
Industrial Waste	
Organic	0.15
Textile	0.24
Wood	0.43
Paper	0.40
Plastic	-
Leather	0.39
Glass	-
Clinical	-
Pottery	-
Rubber	0.39
Inert	-
Metal	-
Petroleum-products	-
Oil	-
Solvents	-
Asphalt	-
Industrial Sludge	
Sludge	0.045

Table 8.7 Emission factors and parameters used in calculations

Factor/Parameter	Value	Reference
MCF	1	IPCC 2000, Waste. pp 5.9
DOC_f	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/textiles waste	0.06	IPCC 2006, pp 3.17
k2=wood/rubber waste	0.03	IPCC 2006, pp 3.17
k3=organic/garden and park waste	0.1	IPCC 2006, pp 3.17
k4=food waste/sewage sludge	0.185	IPCC 2006, pp 3.17
k5=industrial waste	0.09	IPCC 2006, pp 3.17

The earlier data on waste composition is 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 were used since 2000.

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 (Table 8.8).

Table 8.8 The waste composition of solid municipal waste, %[167]

	1940	1958	1971	1980	1990	2000	2008[168]
Organic household waste and non-defined non separated waste	64	56	52	53	52	42.1	36.65
Paper and cardboard	22	20	26	21	25	25.3	17.53
Wood			3.3	3.3	3.3	3.3	0.44
Textiles	2	1	2	2	2	0.9	4.43

Table 8.9 DOC content of mixed municipal waste in Estonia in 1940-2008

	1940	1958	1971	1980	1990	2000	2008-onward
DOC content	**0.2208**	**0.1944**	**0.2270**	**0.2090**	**0.2230**	**0.2018**	**0.1559**

8.2.3. Quantitative overview - CH_4 emissions from solid waste disposal (CRF 6.A)

In 2008 the total CH_4 emissions from solid waste disposed onto landfills in Estonia were 24,48 Gg (Figure 8.7). The breakdown of CH_4 emissions emitted from disposal of different type of waste are presented in Table 8.10. As seen from the table, in 2008 the light decrease has taken place in the quantities of methane emitted from different types of biodegradable solid waste, except the emissions from the garden waste which have raised negligible and wood waste, which remained the same compared to the year 2007.

When characterizing the time series of the methane recovery, the amount of reused CH_4 has been the highest so far in 2007; the value of the same quantity has decreased about 10% in 2008.

Generally it can be said, that CH_4 emissions from organic and food waste, paper, textiles, sludge and emission from leather and rubber waste have decreased gradually during the last years, while emissions from garden waste have slightly increased. CH_4 emissions from the wood waste enlarged till the year 2006, in 2007 the trend fell into decay and then stabilized in 2008 (Table 8.10).

[167] The data on the waste composition of 1940, 1958, 1971, 1980 and 1990 was taken from http://www.mnp.nl/mnc/i-en-0141.html, the data on waste composition of 2000 was taken from (Olmejäätmete koostise… 2000)

[168] The data on the waste composition of 2008 was taken from (Eestis tekkinud olmejäätmete… 2008)

Table 8.10 Quantities of CH_4 emissions and recovery from biodegradable solid waste disposed in landfills in 1990-2008, Gg

Year	Organic/ Food	Garden	Paper	Wood	Textiles	Sludge	Leather/ Rubber	Recovery
1990	14.24	0	11.44	1.52	0.60	0.64	0.116	
1991	13.62	0	11.45	1.58	0.60	0.66	0.116	
1992	13.11	0	11.46	1.62	0.60	0.69	0.116	
1993	13.18	0	11.64	1.71	0.62	0.88	0.123	
1994	12.90	0	11.69	1.76	0.62	0.85	0.123	
1995	12.38	0	11.70	1.80	0.61	1.03	0.123	-1.70
1996	12.71	0	11.92	1.84	0.62	0.94	0.122	-2.20
1997	14.12	0	12.33	1.97	0.64	1.56	0.123	-1.94
1998	14.97	0	12.80	2.07	0.66	1.69	0.125	-1.40
1999	15.41	0	13.18	2.20	0.68	1.60	0.127	-2.14
2000	16.07	0.020	13.52	2.32	0.69	1.44	0.124	-1.52
2001	15.71	0.059	13.82	2.35	0.68	1.28	0.121	-1.64
2002	14.68	0.079	13.80	2.40	0.66	1.08	0.118	-2.24
2003	13.71	0.099	13.82	2.41	0.64	0.91	0.115	-2.26
2004	12.73	0.118	13.74	2.46	0.62	0.77	0.112	-1.68
2005	11.93	0.149	13.68	2.49	0.61	0.64	0.108	-2.93
2006	11.23	0.164	13.61	2.50	0.60	0.54	0.105	-2.93
2007	10.68	0.183	13.54	2.48	0.58	0.46	0.102	-3.44
2008	10.27	0.196	13.51	2.48	0.57	0.39	0.099	-3.03

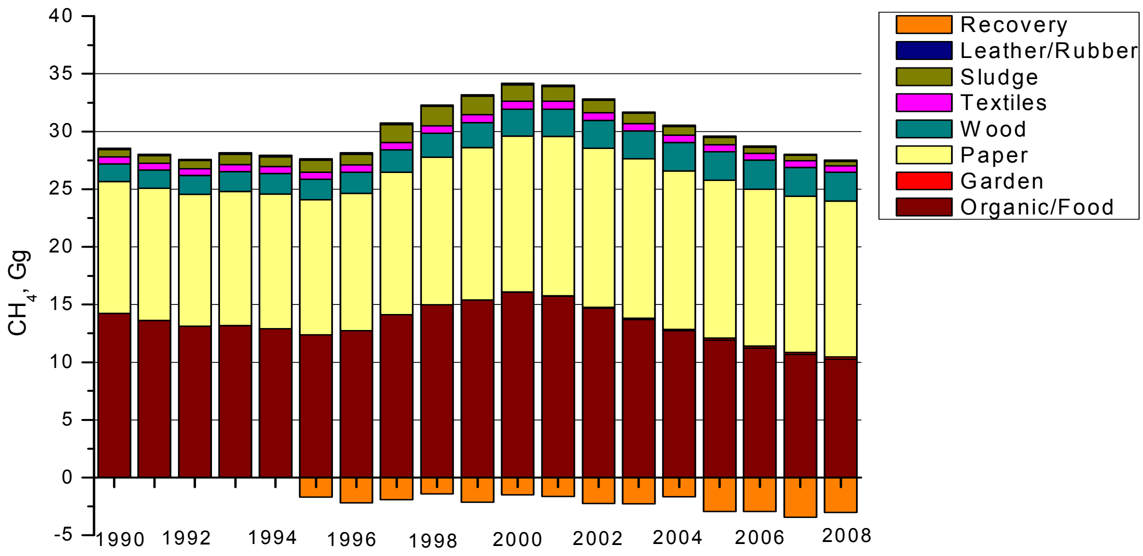


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Figure 8.7 CH_4 emissions and recoveries from landfills in Estonia, in 1990-2008

8.2.4. Source-specific recalculations

In the 2009 submission the recalculation of the quantities of the waste generation by the type in 1940-1990 was made, however no specific recalculations in the estimation of CH_4 emissions from solid waste disposed onto landfills were carried out in the 2010 submission.

8.2.5. Uncertainties and time series consistency

The estimations of CH_4 emissions from municipal waste disposal are carried out based on activity data and emission factors (methane correction factor-MCF, degradable organic carbon-DOC, fraction of DOC, fraction of CH4 in landfill gas-F).

Uncertainties of default emission factor used in the estimations are represented in IPCC 2000. Values are presented in Table 8.11.

The combined uncertainty rates related to “solid waste disposal waste” sub-category are reported in Chapter 8.1.4.

Table 8.11 Estimated uncertainties of parameters used in the waste sector calculations

Input	Uncertainties	References
Activity data		
Managed Waste Disposal on Land	± 10%	IPCC, 2000. Waste, pp. 5.12
Total uncertainty of waste composition	± 10%	2006 IPCC, Waste, Chapter 3, pp 3.27
Emission factors		

Degradable Organic Carbon (DOC)	-50%...+20%	IPCC, 2000. Waste, pp. 5.12
Fraction of DOC Dissimilated	-30%...0%	IPCC, 2000. Waste, pp. 5.12
Methane correction factor	-10%...0%	IPCC, 2000. Waste, pp. 5.12
Fraction of CH4 in Landfill Gas	-0%...20%	IPCC, 2000. Waste, pp. 5.12
Methane Recovery (R)	± 10%	2006 IPCC. Waste, pp. 3.27
Methane generation rate constant (k)		
k1=paper/textiles waste	±17%	2006 IPCC. Waste, Table 3.3, pp 3.17
k2=wood/rubber waste	±33%	2006 IPCC. Waste, Table 3.3, pp 3.17
k3=organic/garden and paper waste	-40%...0%	2006 IPCC. Waste, Table 3.3, pp 3.17
k4=food waste/sewage sludge	-46%...8%	2006 IPCC. Waste, Table 3.3, pp 3.17
k5=industrial waste	±11%	2006 IPCC. Waste, Table 3.3, pp 3.17

8.2.6. Source specific planned improvements

For the next submissions, historical activity data on waste composition will be corrected, as the recommendation of the UNFCCC review team, and data used so far from Netherlands' analysis will be replaced with data more properate for Estonian's situation.

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 (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 treatment centre, 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. 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[169].

Most of the industrial wastewater in Estonia is released into domestic sewer systems.

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 stabilized 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 2008 was 1,66 billion m^3, from which 1,22 billion m^3 was used as cooling water for the production of energy and therefore no water treatment was needed. 385,8 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 383,8 million m^3.

As Estonia hasn't reported the GHG emissions from wastewater treatment since the year 2006, the missing quantities of the emissions for the years 2006 and 2007 will be presented in addition to the year 2008 (Table 8.12, Table 8.13).

Table 8.12 Wastewater generation by type, 1000 m^3

Year	Total	Cooling Water	Total wastewater, exp cooling water	Mining water	Sewage	Rainfall water
2006	1,614,981	1,314,428	300,553	184,102	109,551	8,422
2007	1,880,234	1,535,874	344,360	212,488	117,349	14,524
2008	1,658,736	1,22,6470	432,266	296,664	120,851	14,751

169 The information on the wastewater streams and treatment was included as the recommendation of the UNFCCC review team.

Table 8.13 Wastewater generation by economic sectors in Estonia, 1000 m^3

Year	Cooling/energy	Cooling/industry	Other	Agriculture	Domestic	Industry
2006	6,144	12,78663	6,170	4,629	41,770	43,614
2007	6,962	15,38802	5,837	4,112	44,384	34,258
2008	6,285	12,27902	6,221	4,047	47,343	30,357

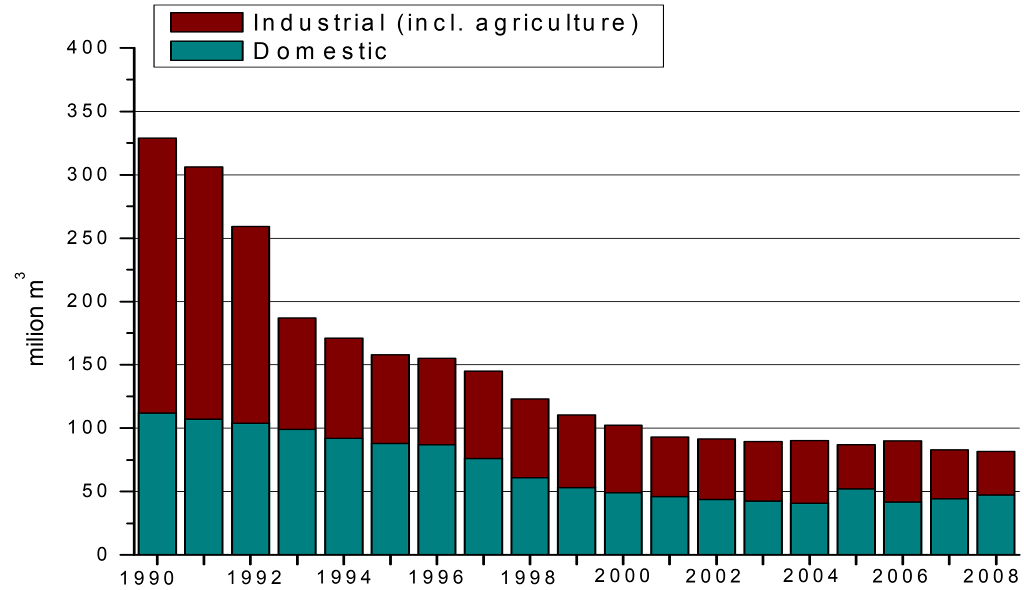

Figure 8.8 Amounts of wastewater treated in Estonia in 1990-2008, million m^3

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 the amount of products produced (for equation 8.6) were derived from the ESO.

Methodology

Estimating the emissions from domestic and industrial wastewater in anaerobic conditions, *Tier 1* method from IPCC 1996 was used.

Emissions= (Total Organic Waste ● Emission Factor) – Methane Recovery	(8.4)

Domestic wastewater:

$TOW_{dom} = P \bullet D_{dom}$	(8.5)

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;

D_{dom} – Domestic/commercial degradable organic component in kg BOD/1000 persons/year;

Industrial wastewater

TOW_{ind} (kg COD/year) = $W \bullet O \bullet D_{ind} \bullet (1-DS_{ind})$	(8.6)

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.

$EF_i = B_0 \bullet \sum (WS_{ix} \bullet MCF_x)$	(8.7)

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

Table 8.14 Emission factors used in the calculations

Factor/parameter	Value	Reference

BOD (kg/1000person/yr	18,250	IPCC 1996, Waste. pp 6.23, Table 6-5
COD (kg COD/m^3)	Variable	IPCC 2000, Waste Chapter, Table 5.4
B_0 (kg CH_4/Kg BOD)	0.25	IPCC 1996, Waste. pp 6.20
WS		
-Domestic	Variable	Estonian NIR 2004, Waste Chapter, Table 6.14
-Industrial	Variable	Estonian NIR 2004, Waste Chapter, Table 6.15
MCF	0.6	Estonian NIR 2004, Waste Chapter, Table 6.14, 6.15

8.3.3. Quantitative overview – CH_4 emissions from domestic/ commercial and industrial wastewater handling

In 2008 the total amount of CH_4 emissions from domestic and commercial wastewater handling were 0,0367 Gg (figure 8.9). So far, the quantity of CH_4 emissions have 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 emissions from domestic and commercial wastewater have stabilizised since 2004 because the fraction of the anaerobical treatment in wastewater handling system has decreased, as wastewater is mostly treated using aerobic treatment.

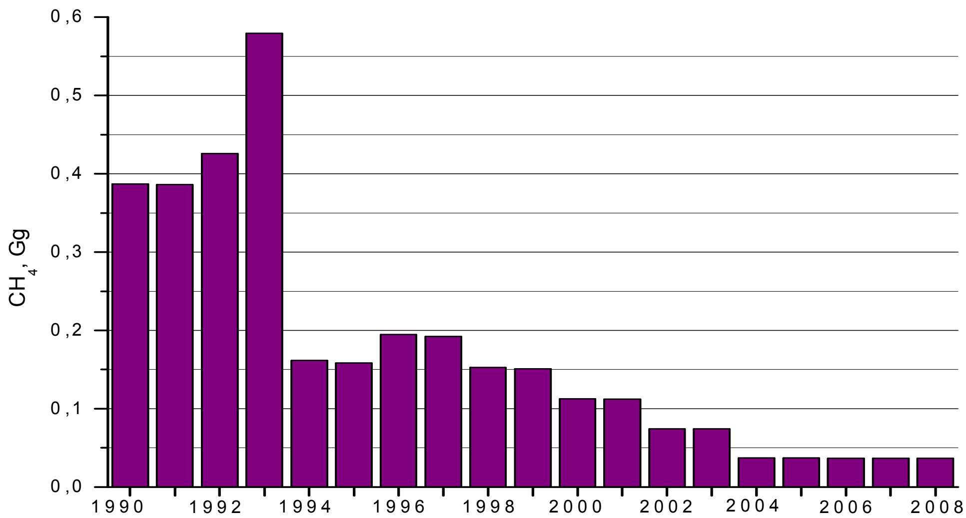

Figure 8.9 CH_4 emissions from domestic/commercial wastewater handling, Gg

The estimation of CH_4 emissions from industrial wastewater are preliminary, as there were inconsistency issues in the activity data used in the estimations (mostly in product output of food and beverage), however most available data was used to carrie out the primal estimations[170]. The total amount of CH_4 emissions from industrial wastewater handling were 0,254 Gg. As seen from the figure (Figure 8.10) the quantities of CH_4 from 1990 to 1994 has not been carried out due to the lack of activity data on amounts of products produced in these years. The trend shows also the gradual increase in the quantities of the methane emissions from industrial wastewater in years 1995-2000, which is due to the increase of the production output and the fraction of wastewater treated by the anaerobical handling system

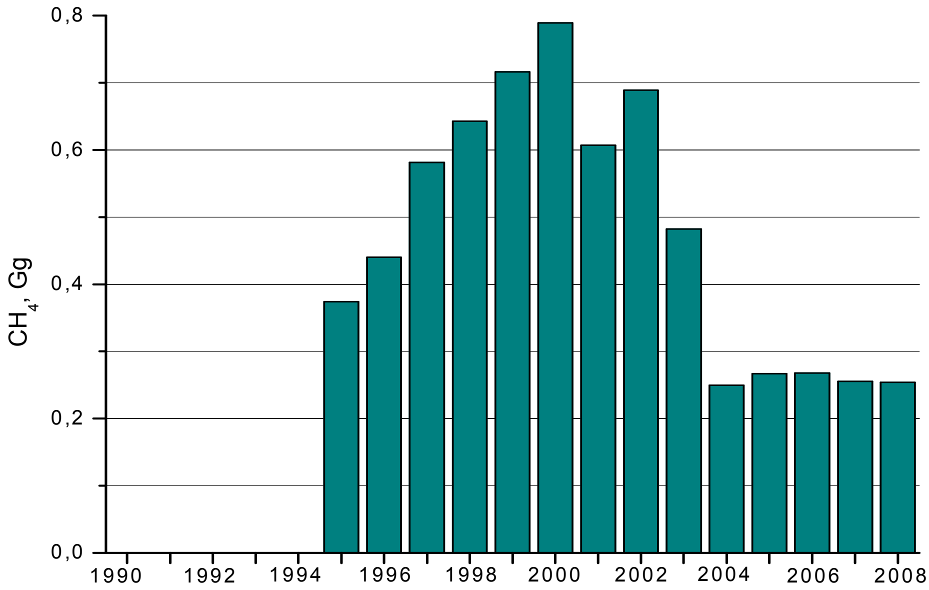

Figure 8.10 CH_4 emissions from industrial wastewater handling, Gg

8.3.4. Source specific planned improvements

For the next submissions, the activity data on production output of industrial wastewater handling will be improved and corrected and CH_4 estimations of wastewater handling will be covered thoroughly. As all estimations under industrial wastewater handling category are preliminary, no analyses for trends were made, explanations for trend movements will be added for the next submission.

[170] CH_4 emission from industrial wastewater was not reported in CRF Reporter, as the category needs more thoroughgoing investigation in an activity data used in the estimations. Emissions will be added to the CRF Reporter for the next annual submission.

8.4. N_2O emissions 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 ESO. The annual per capita protein consumption was used from FAO statistical databases – 101 g/person/day (for 2004-2007).[171] The same amount of per capita protein consumption was used for 2008 estimation of N_2O emissions, as the newer data wasn't available for the inventory compiler at the time of estimating the emissions from human sewage.

Methodology

The default IPCC (the *Tier 1*) method was used to estimate emissions from the atmospheric deposition.

$$N_2O - N = PROTEIN \bullet Nr_{PEOLPE} \bullet Frac_{NPR} \bullet EF_6 \qquad (8.7)$$[172]

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.

[171] Dietary energy, protein and fat consumption, FAO
[172] IPCC 2000. Agriculture. Equation 4.39, pp. 4.72

Emission factors

Emission factors used in the calculations are default emission factors from IPCC 1996 and IPCC 2000 Agriculture chapter.

Table 8.15 Factors used in the algorithm of human consumption followed by municipal sewage treatment

Factor	Value
$Frac_{NPR}$ EF_6	0.16 kg N/kg of protein[173] 0.01 kg N2O-N/ kg N discharged sewage effluent[174]

8.4.3. Quantitative overview – Human consumption followed by municipal sewage treatment

The total N_2O emissions from human sewage in Estonia in 2008 were 0,124 Gg (Figure 8.11). The amount remained the same due to the stabilisation of the population and the unchanging in the number of the annual per capita protein consumption. Since 1990 until 2004, the emissions have declined slightly due to decreasing population, however since 2004 the slight increase has taken place due to increase in protein consumption factor – from 90 (in 1990-2003) to 101 (in 2004-2008) g/person/day.

[173] IPCC 1996. Agriculture. Workbook. Table 4-24 – Default values of parameters for indirect emissions. pp. 4.106
[174] IPCC 1996. Agriculture. Workbook. Table 4-18 – Default emission factors for estimating indirect N2O emissions from N used in agriculture. Pp. 4.73

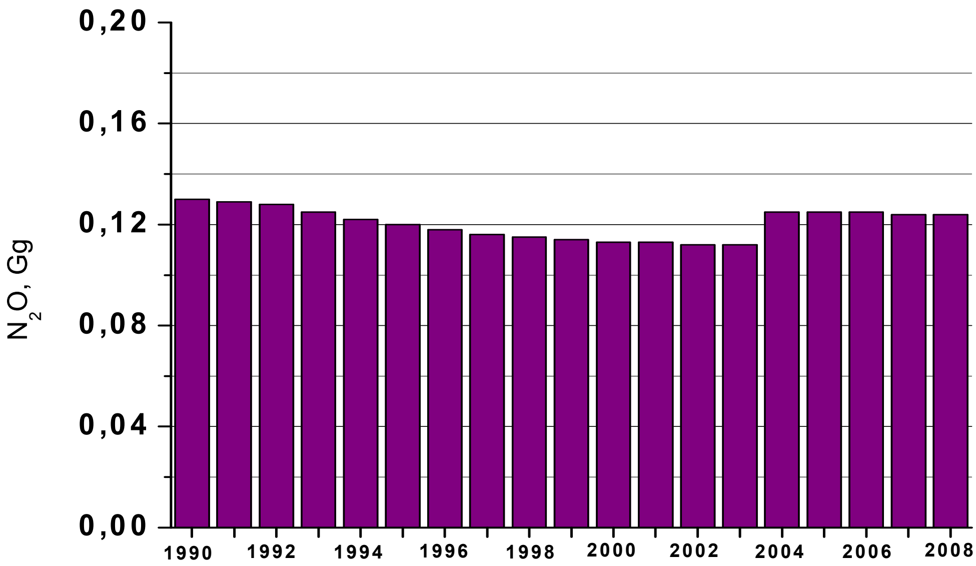

Figure 8.11 N_2O emissions from human sewage in Estonia in 1990-2008, Gg

8.4.4. 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 8.16 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, 1996. pp. 4.105, Table 4-23

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 at least two enterprises at the moment, 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. The first one is an "AS Kunda Nordic Tsement" factory, which produces constructional cements and crushed limestone, and the other one is a factory of constructional materials "Maxit Estonia" in Pärnu County. Also one of the Estonians biggest hazardous wastes handling company "AS Epler & Lorenz" has a waste incineration system with a purpose to generate energy[175].

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

The activity data on amounts of waste incinerated is collected and reported by the EEIC. The data were reported in previous Submissions according to two operations: 1) waste combusted to generate energy (the estimates were not carried out in order to avoid double accounting), 2) incineration without energy recovery. The data on 1990-1994 were interpolated basing on rough assumptions.

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

[175] The information on waste incineration facilities was included as the recommendation of the UNFCCC review team.

energy recovery is part of the energy sector, the data and emissions will be reported under the energy sector.

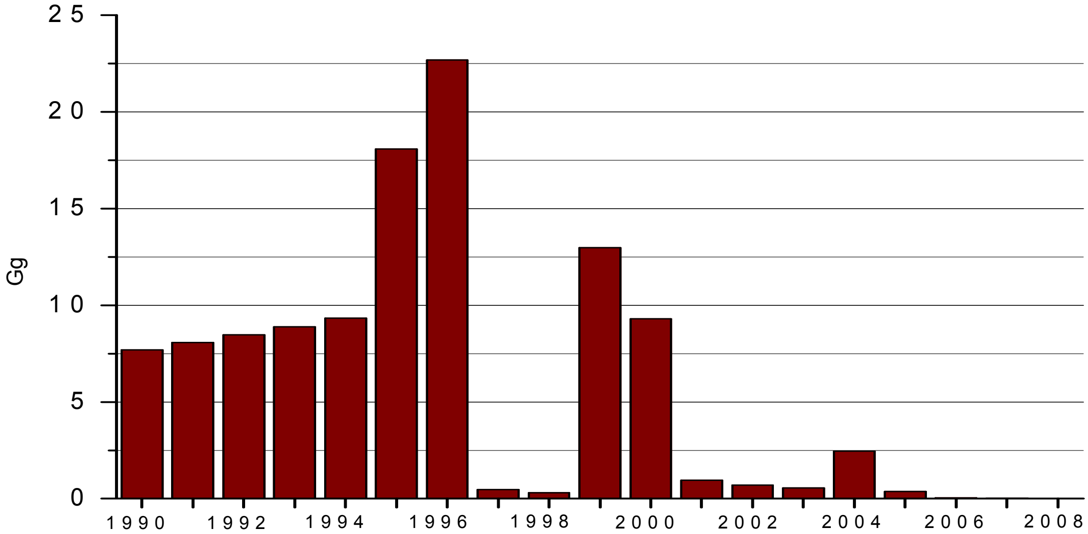

Figure 8. 12 Amounts of waste incinerated without energy recovery in Estonia in 1990-2008, Gg

Table 8.17 Amounts of waste incinerated in Estonia in 1990-2008, tonnes[176]

	Inert waste	Leather and Rubber	Municipal Waste	Petroleum-products and Oil	Organic Waste	Paper	Plastic	Sludge	Textiles	Wood	**Total**
1990[177]	*41*	*6*	*12*	*165*	*27*	*117*	*10*	*1*	*22*	*7,280*	*7,682*
1991	*41*	*6*	*12*	*164*	*27*	*117*	*10*	*1*	*22*	*7,663*	*8,065*
1992	*41*	*6*	*12*	*163*	*27*	*117*	*10*	*1*	*22*	*8,067*	*8,467*
1993	*41*	*6*	*12*	*164*	*27*	*117*	*10*	*1*	*22*	*8,491*	*8,893*
1994	*41*	*6*	*12*	*167*	*27*	*117*	*10*	*1*	*22*	*8,938*	*9,342*
1995	41	15	23	292	15	389	5	2	61	17,237	18,084
1996		2	14	149	24	35	4		25	22,445	22,699
1997		4	2	90	55	40	12		2	276	482
1998	41	5	8	135	14	7	19		0	90	319
1999	122			145		16	10			4,643	12,979
2000	466		3	2	41	2	5			815	9,301
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	2,063			25	1	2			321		2,457
2005	63			106	0	2			176	10	366
2006					0				40		41
2007									14	7	21

[176] D10 operation of the waste disposal activities – Incineration on land
[177] The data of 1990-1994 was interpolated

2008											0

As seen from the previous figure (Figure 8.12) there has been a sharp increase in the amounts of waste incinerated in 1995-1996, 1999-2000 and 2004. The remarkable fluctuation of quantities is due to the large amounts of waste from wood and sludge was incinerated in these years. Generally the trend of waste incineration has decreased through the years since 2000 (except the fluctuation in 2004) and has reached the zero point in 2008, as more and more waste is recycled, composted or incinerated with the purpose to generate energy and the amount of waste properate for combustion without energy recovery is therefore minimized.

The explanation of unstable trend of waste incineration was included as the recommendation of the UNFCCC review team.

Methods

Tier 1 approach was employed in order to estimate CO_2 emissions from solid waste burnt in controlled incineration facilities (IPCC, 2006). CO_2 emissions were estimated based on the total amount of waste combusted.

$$CO_2 \text{ emissions, Gg/yr} = \sum_i (SW_i \bullet dm_i \bullet CF_i \bullet FCF_i \bullet OF_i) \bullet 44/12 \qquad (8.8)$$[178]

CO_2 emissions - CO_2 emissions in inventory year ,Gg/yr;

SW_i – total amount of solid waste of type *i* (wet weight) incinerated, Gg/yr;

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);

[178] The IPCC Guidelines, Chapter 5: Incineration and Open Burning of Waste, pp. 5.7, equation 5.1

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)

Table 8. 18 Default dry matter content, total carbon content and fossil carbon content of different waste components[179],[180],[181]

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 emissions were estimated based on the waste input to the incineration.

$$N_2O \text{ emissions, Gg/yr} = \sum_i (IW_i \bullet EF_i) \bullet 10^{-6} \qquad (8.9)^{182}$$

[179] Table 2.4 of the 2006 IPCC Guidelines, pp. 2.14
[180] Table 2.5 of the 2006 IPCC Guidelines, pp. 2.16
[181] Table 2.6 of the 2006 IPCC Guidelines, pp. 2.16
[182] The 2006 IPCC Guidelines, Chapter 5: Incineration and Open Burning of Waste, pp. 5.14, equation 5.5

N_2O emissions - N_2O emissions in inventory year, Gg/yr;

IW_i – amount of incinerated waste of type *i*, Gg/yr;

EF_i – N_2O emission factor for waste of type *i*, kg N_2O/Gg of waste;

10^{-6} – conversion to gigagram;

i – catagory or 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)

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 8.19 N_2O emission factors for incineration of waste[183]

Waste category	Emission factor, g N_2O/t waste incinerated	Weight basis
MSW	8[184]	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 2008 no CO_2 and CH_4 emissions emitted from solid waste incineration without energy recovery, as all wastes were burnt with a purpose to generate energy (Figure 8.13). Emissions from waste incineration with energy recovery will be reported under energy sector.

The sharp increases in 1995-1996, 2000, in 2002 and in 2004 were due to large amounts of wood and sludge waste was incinerated. The Figure 8.13 shows that the trend of the GHG

[183] Table 5.5 of the 2006 IPCC Guidelines, Chapter 5, pp. 5.21

[184] An experience of Germany

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.

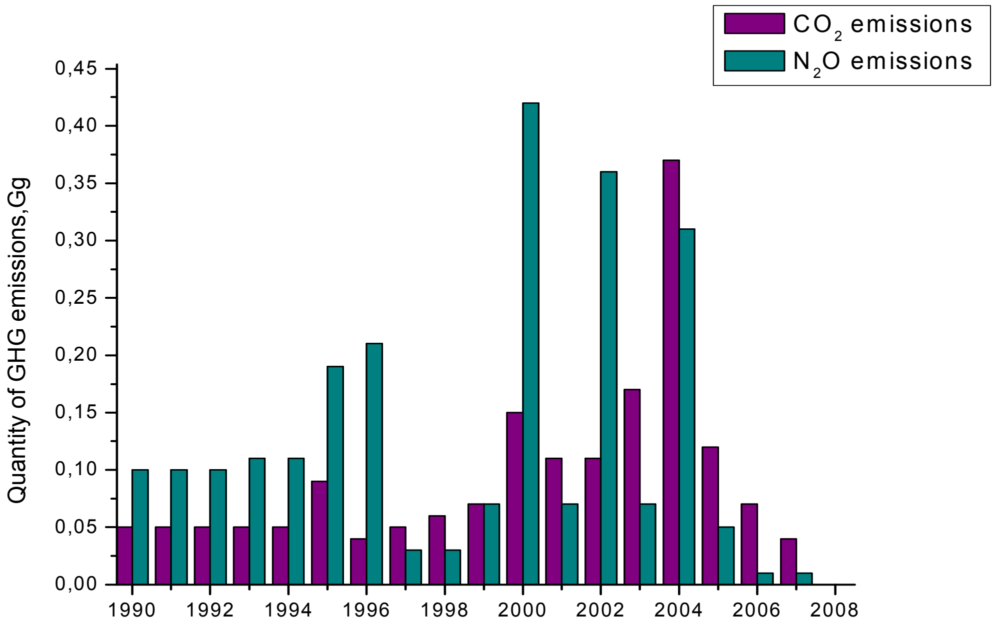

Figure 8.13 CO_2 and N_2O emissions from waste incineration without energy recovery in Estonia in 1990-2008

8.5.4. 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. Values employed in the estimates are presented in Table 8.20.

The combined uncertainty rates related to "waste incineration" sub-category are reported in Chapter 6.1.4.

Table 8.20 Estimated values of uncertainties used in 'Waste Incineration' category of the Waste sector

Input	Uncertainties	References
Activity data		
Amounts of waste incinerated	±10%	IPCC 2000, Waste, pp. 5.12
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

8.6. 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 2008 are used as activity data. The data is provided by EEIC. In 2008, 685 707 tonnes of wastes were treated biologically (composted) in Estonia; it made up 3,4 % of the total amount of waste generated. Compared with the year 2007 the amount of wastes composted has decreased (Table 8.21). The downtrend is coming from the fact, that larger amount of fractions from solid wastes is collected separately and recovered if capable and therefore less decomposable waste is composted.

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 8.21 Amounts of waste used for composting in Estonia in 1990-2008, tonnes[185]

	Leather and Rubber	Municipal Waste	Organic Waste	Paper	Sludge	Textiles	Wood	Total
1990	*n.d.*[186]	*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	9,370
1996	3		30,481	846		59	133	31,519
1997	11		62,341	890	102	72	1,993	65,398
1998	61		4,340	565	78	80	1,494	6,557
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

185 The data of 1990-1995 were interpolated basing on rough assumptions made

186 n.d. not determined

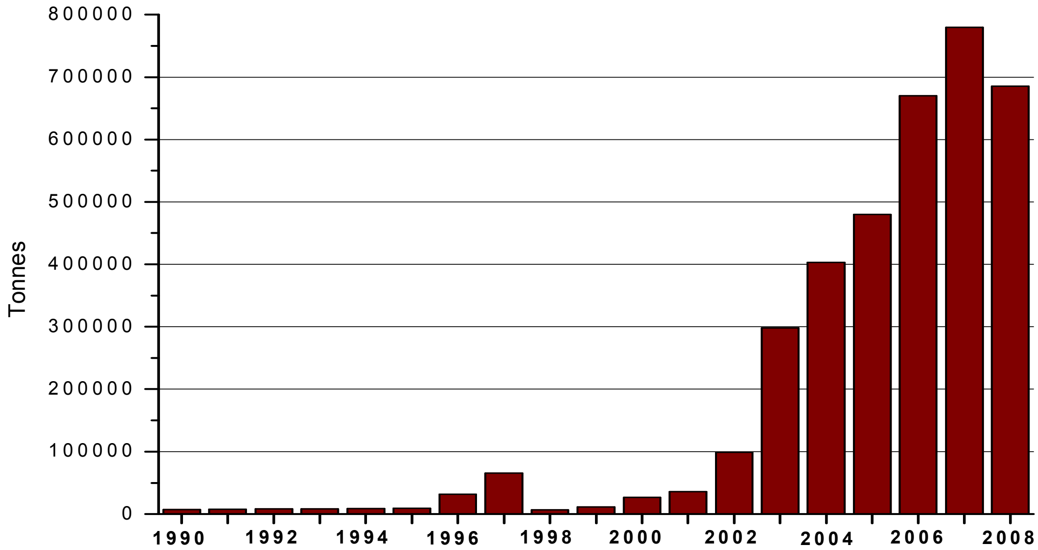

Figure 8.14 Amounts of organic waste used in composting in Estonia in 1990-2008, tonnes

Methods

In order to estimate emissions from biological treatment of solid waste *Tier 1* approach was used (IPCC, 2006).

CH_4, Gg = $\sum_i(M_i \bullet EF_i) \bullet 10^{-3} - R$	(8.10)[187]

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 = $\sum_i(M_i \bullet EF_i) \bullet 10^{-3}$	(8.11)[188]

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.

[187] IPCC 2006, Chapter 4, equation 4.1, pp. 4.5
[188] 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 2000 Good Practice Guidance* and *IPCC 2006 Guidelines for National Greenhouse Gas Inventories.*

Table 8.22 Default emission factor for CH_4 and N_2O emissions from biological treatment of waste[189]

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 0,21 Gg and CH_4 emissions 2,74 Gg in 2008 (Figure 8.15). 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. Compared with the year 2007, the GHG emissions have decreased due to the amount of organic waste treated using composting process has decreased. The sharp upturn in the quantities of CH_4 emissions since 2002 is due to the large amount of wood, sludge and organic waste was composted in these years.

[189] IPCC 2006, Chapter 4, Table 4.1, pp. 4.6, on a wet basis

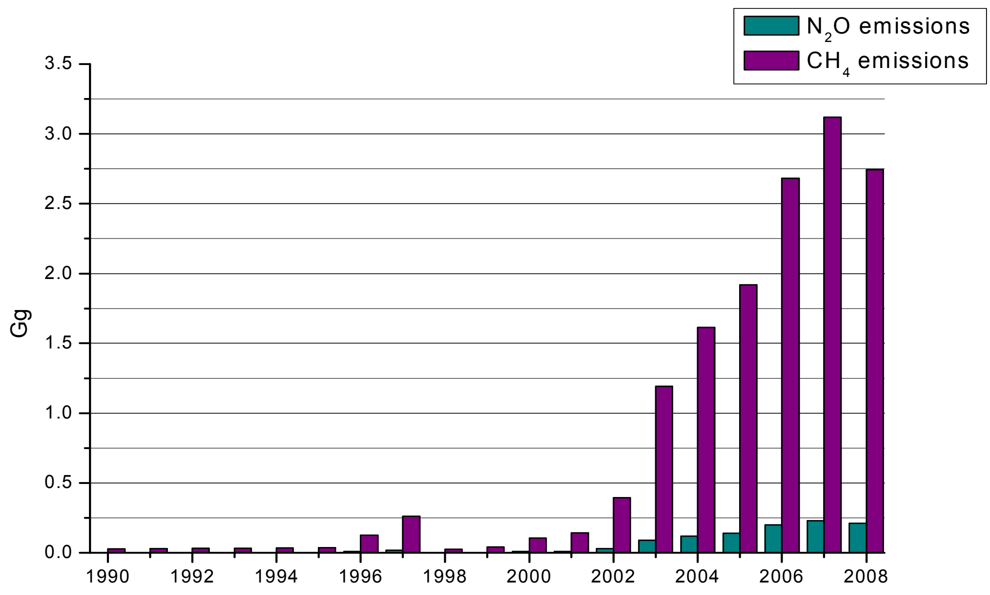

Figure 8.15 CH_4 and N_2O emissions from biological treatment in Estonia in 1990-2008

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. Values employed in the estimates are presented in Table 8.23.
The combined uncertainty rates related to "biological treatment" sub-category are reported in Chapter 8.1.4.

Table 8.23 Estimated values of uncertainties used in 'composting' category of the Waste Sector

Input	Uncertainties	References
Activity data		
Managed Waste Disposal on Land	±10%	IPCC, 2000. Waste, pp. 5.12
Emission factors		
Emission factor for treatment (CH_4)	-99%...+100%	2006 IPCC, Waste, Cahpter 4, pp. 4.6
Emission factor for treatment (N_2O)	-80%...+100%	2006 IPCC, Waste, Cahpter 4, pp. 4.6

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 2010 inventory submission by the CRF category and their implications.

SECTOR	SOURCE	RECALCULATION
ENERGY	Energy Industries (CRF 1.A.1) and Manufacturing Industries and Construction (CRF 1.A.2)	1. Corrected activity data: Statistical Office of Estonia has a practice to correct statistical data of previous years. In current GHG submission practically all activity data (1990-2007) are over checked and updated if necessarily. 2. In the current GHG inventory submission CO_2 emissions from shale oil production are reported under CRF source category 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries. Shale oil is a liquid fuel made from solid fuel oil shale. In the previous submission emissions from shale production were incorrectly reported under 1.A.1.b.

		3. In the current GHG inventory submission CO_2 emission factor of natural gas was updated. In the 2009 submission IPCC default value was used (15.3 tC/TJ). In the 2010 submission the Finnish CS CO_2 EF for natural gas (15.01 tC/TJ) was used, because Estonia, like Finland imports natural gas only from Russia (a recommendation of UN Country Review Team). 4. In the 2010 submission Lithuanian CS CO_2 EF for motor gasoline has been used. Estonia imports almost all motor gasoline from Lithuania (a recommendation of UN Country Review Team). 5. In the 2010 inventory submission N_2O emissions from oil shale fluidised bed combustion are estimated and reported in the CRF source – category 1.A.1.a (a recommendation of UN Country Review Team). 6. To the current inventory submission CH_4 and N_2O emissions from CRF 1.A.1.c (Shale oil production) are added. In previous inventory submissions these emissions were not reported (a recommendation of UN Country Review Team). 7. CO_2 emissions from the use of peat have been calculated separately for sod peat and milled peat. CO_2 EF for sod peat and peat briquette has been changed (see Table 3.20). 8. CH_4 and N_2O emissions from use of biomass have been increased because an additional biofuel – black liquor has been added (a recommendation of UN Country Review Team). 9. To the current inventory submission CH4 and N2O emissions from LPG are added. In previous inventory submissions these emissions were not reported (a recommendation of UN Country Review Team). 10. There is a new CRF source category Other Fuels added to the CRF 1.A.2.f. There are three different types of other fuels: technical waste oils, plastics and other fossil based waste fuels (SMW). Carbon emission factors used in calculation of CO_2 emissions are plant specific. The Kunda Nordic Cement factory belongs also to the Estonian ETS. 11. In the current GHG inventory submission a new carbon emission factor value 14.89 tC/TJ (IPCC 2006) was used for estimation of CO_2 emissions from Gas Biomass (landfill gas and WWT (waste water treatment gas) combustion (in the NIR 2009 CEF for biogas 15.3 tC/TJ was used). 12. In the current GHG inventory submission CH_4 and N_2O emissions from shale oil production are reported under CRF

		source category 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries. In the previous submission this emissions were failed. 13. In the 2010 submission the fuel use and resulting emissions from the ammonia production factory are included into CRF source category 1.A.2.c Chemical industries. In the 2010 inventory submission following CO_2 emission factors have been changed (Table 3.20) (a recommendation of UN Country Review Team):
	Transport (CRF 1.A.3)	1. Recalculations in the Transport sector subcategory 1.A.3.a: Domestic Aviation/Aviation Gasoline are connected with activity data of the years 1997-2001 and 2003 corrected by Statistics Estonia. 2. In the 2010 inventory submission GHG emissions from LTO in the Transport sector subcategory 1.A.3.a: Domestic Aviation/Aviation are estimated and added to Cruise emissons. In previous submission only emissions from fuel used for Cruise have been calculated. 3. Recalculations in the Transport sector subcategory 1.A.3.d: Domestic Navigation/Liquid fuels are connected with activity data of the years 1990-1994 corrected by Statistics Estonia. 4. In the current inventory submission CRF source category 1.A.3.f Other Transportation has been removed and relevant emissions are reported under CRF 1.A.4.c Agriculture/Mobil. 5. In the previous 2009 inventory submission there was planned to use in the 2010 submission the Copert model also for CO_2 emission calculation from the road transportation but according to the recommendations of the Country Review Team (in September 2009) we still calculate CO_2 emissions by multiplying the amount of motor fuel sold (TJ) with emission factor of the fuel sold (IPCC Tier 2 method).
	Other Sector (CRF 1.A.4)	1. The main recalculations made in the sectors CRF 1.A.4. Other Sectors are connected with non–CO_2 emission (CH_4 and N_2O) factors change and CO_2 emission factor change for gasoline (Table 3.38 and Table 3.39). In the previous inventory submission non_CO_2 emissions from 1.A.4 were calculated using the same emission factors as in sectors 1.A.1 and 1.A.2. New CH_4, N_2O, NOx, CO, NMVOC and SO_2 EF are presented in the Table 3.37. 2. In the 2010 inventory submission a new source category has been added: emissions from gasoline and diesel oil

		used in gardening machines (in lawn movers and tractors). 3. Emissions from off road agricultural transportation is reported under CRF source category 1.A.4.c Agriculture /Mobil. In the last (2009) inventory submission these emissions were reported under CRF 1.A.3.e Other Transportation (a recommendation of the UN Country Review Team).
	Other (CRF 1.A.5)	1. In the 2010 inventory submission a new CRF source category 1.A.5 Other is added. Under CRF 1.A.5 emissions from the use of liquid military transport fuels are reported
	Oil and natural gas (CRF 1.B.2)	1. The CRF source category 1.B.2.A.2 Oil Production is removed from the 2010 submission because CH_4 from the production of shale oil is already taken into account in the sub-category 1.A.1.c.
	International Bunkers (CRF	1.Some corrections have been made in Activity Data – amounts of Jet Kerosene used in International Aviation are corrected The reason of these changes is manly connected with specification of the Jet Kerosene calorific value and also data processing mistakes.
INDUSTRIAL PROCESSES	Cement production (CRF 2.A.1)	1.Emissions from cement production were recalculated throughout the time series due to more specific data over the emissions factors from plant. 2.Also, in 2010 Submission method has been changed from country-specific (accordance with Tier 2) to good practice guidance method Tier 2.
	Lime production (CRF 2.A.2)	1.Emissions from lime production were recalculated throughout the time series. 2.Emissions in 1990-1996 were recalculated due to applying plant specific emission factors to two production plants. 3.Emissions in 1997-2007 were recalculated due to better activity data and plant specific emission factors available.
	Glass production (CRF 2.A.7.1)	1. As it was the first year of reporting emissions from glass production, data was recalculated from 1993-2007.
	Ammonia production (CRF 2.B.1)	1.CO_2 emissions from ammonia production were recalculated throughout time series. Previously the method used in calculating CO_2 ammonia production emissions did not take into account CO_2 from ammonia production that was used for carbamide (urea) production and CO_2 for sale. 2.In 2010 submission, method Tier 1a was used, taking also into account CO_2 for urea production and CO_2 for sale.
	Other Consumption (CRF 2.D)	1. The amount of produced food and drink was corrected for year 1992, 1995-2007. Those recalculations were due to corrections in meat production data. The emissions from pulp and paper were corrected for years 1992, 1993, 1999-2007.

	Commercial Refrigeration (CRF 2.IIA.F.1.2)	1. Emissions from commercial refrigeration were recalculated in case of R-134a from 1993-2005, in case of R-404A from 1995-2005 and in case of R-407C from 1997-2005. Those years represent the years of starting using those refrigerants. Previously German percentages of the years 1995-2005 were used. In 2010 submission emissions were calculated as a steady increase (every year the same quantity of new equipment) as it is believed that it is more appropriate method for Estonia. There is no backdating information based on real usage of F-gases available in Estonia.
	Industrial Refrigeration (CRF 2.IIA.F.1.4)	1. Emissions from industrial refrigeration were recalculated in case of R-134a from 1993-2005, in case of R-404A from 1995-2005 and in case of R-407C from 1997-2005. Those years represent the years of starting using those refrigerants. Previously German percentages of the years 1995-2005 were used. In 2010 submission emissions were calculated as a steady increase (every year the same quantity of new equipment) as it is believed that it is more appropriate method for Estonia. There is no backdating information based on real usage of F-gases available in Estonia.
	Heat Pumps (sub sector under 2.IIA.F.1.5 Stationary Air-Conditioning)	1. Emissions from heat pumps were recalculated from 1998 – 2004 due to better data available from Estonian Heat Pump Association.
	Stationary and room air-conditioning (sub-sector under 2.IIA.F.1.5 Stationary Air-Conditioning)	1. Emissions from stationary and room air-conditioning were recalculated from 1995-2005. In Estonia usage of room air-conditioning equipment with R-407C started in 1998, with R-410A in 2000. Usage of stationary air-conditioning equipment with R-134a started in 1995, with R-407C in 1997. Previously German percentages of the years 1995-2005 were used. In 2010 submission emissions were calculated as a steady increase (every year the same quantity of new equipment) as it is believed that it is more appropriate method for Estonia. There is no backdating information based on real usage of F-gases available in Estonia.
	Other electrical equipment (sub sector under 2.F.9 Other)	1. In 2010 submission disposal emissions from other electrical equipment were recalculated for year 1998. Previously no disposal emissions were reported.
AGRICULTURE	CH4 emissions from Enteric fermentation (CRF 4.A)	1. Weight of mature dairy-cattle was updated for the entire time-series, a country specific value (Appendix A_IV) was used in the estimates instead of IPCC default. The results of the recalculation are reported in Figure 6_17 and in Table 6_19.
	CH4 emissions from Manure management (CRF 4.B)	1. Weight of mature dairy-cattle was updated for the entire time-series. A country specific value (Appendix A_IV) was used in the estimates instead of IPCC default. The results of the

		recalculation are reported in Figure 6_21 and in Table 6_31.
	N2O emissions from Manure Management (4.B; 4.D.2)	1. Weight of mature dairy-cattle was updated for the entire time-series, a country specific value (Appendix A_IV) was used in the estimates instead of IPCC default; 2. The quantities of nitrogen excreted by fur animals were estimated for the first time in the 2010 submission. The results of the recalculations are reported in Figures 6_24–6_25 and in Tables 6_41–6_42.
	N2O emissions from Pasture, Range and Paddock (CRF 4.D.2)	1. Weight of mature dairy-cattle was updated for the entire time-series, a country specific value (Appendix A_IV) was used in the estimates instead of IPCC default. The results of the recalculation are reported in Table 6_43.
	Direct emissions from agricultural soils (CRF 4.D.1)	1. 'Animal manure applied to agricultural soils' sub-sector was carried out in the 2010 submission: weight of mature dairy-cattle was updated for the entire time-series (Appendix A_IV), a country specific value was used in the estimates instead of IPCC default. The results of the recalculation are reported in Table 6_56. 2. 'N_2O emission from sewage sludge applied onto agricultural soils' sub-section in the 2010 submission (Table 6_57): activity data on amounts of sewage sludge applied onto soils were updated. In the 2009 submission, the quantities of industrial and sewage sludge treated under R10 category were taken into the estimates, quantity of sewage sludge treated under R3 category were not considered. In the 2010 submission, the amounts of sewage sludge treated under R3 and R10 categories were employed in the estimates and quantities of industrial sludge were excluded from the estimates.
	Indirect emissions from agricultural soils (CRF 4.D.3)	1. 'Atmospheric deposition of NO_x and NH_4' category of the 2010 submission: activity data on weight of dairy-cattle and on amounts of sewage sludge applied on agricultural soils were updated (Figure 6_41, Table 6_62). 2. 'Nitrogen leaching and run-off' category of the 2010 submission: activity data on weight of dairy-cattle and on amounts of sewage sludge applied on agricultural soils were updated (Figure 6_42, Table 6_63).
	Field burning of agricultural residues (CRF 4.F)	1. The data of quantities of triticale and maize were updated. 2. GHG emission from dry bean and peas residue burned were estimates separately (a recommendation of the ETR) (Figure 6_48-6_49, Table 6_65-6_66).
LULUCF	Forest land (CRF 5.A)	1. Activity data on forest biomass harvested in 2007 were updated (Figure 7_10 and Table 7_15).
	Cropland (CRF 5.B)	1. Emissions from losses of fruit trees (Figure 7_17 and Table

		7_24); 2. Emission from lime applied on agricultural lands was estimated for the first time in the present submission.
	Grassland (CRF 5.C)	1. Mineral and 2. Organic soils have been recalculated due to update of activity data: areas of bush trees were defined as grassland (Figures 7_20-7_21, and Table 7_29-7_30).
	Wetland (CRF 5.D)	1. Activity data on peat extraction areas in 2006-2007 were updated (Table 7_34-7_35).
WASTE	Solid waste disposal on landfills (CRF 6.A)	1. In the 2009 submission the recalculation of the quantities of the waste generation by the type in 1940-1990 was made, no specific recalculations in the estimation of CH_4 emission from solid waste disposed onto landfills were carried out in the 2010 submission.

10.1.2. KP-LULUCF inventory

The estimates of carbon flows associated with ARD activities were carried out for the first time in the 2010 submission. Therefore, no recalculations were provided in this submission.

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 -3.65 % (1991) and 0.16 % (2007). Therefore, the implications of the recalculations on the level and on the trend, 1990-2007, of this national total are small, refer Table 10.2.

For the National total CO_2 equivalent emissions with Land-Use, Land-Use Change and Forestry, the general impact of the recalculations is relatively large. The differences vary between -10.86 % (2007) and 0.05 % (1995), refer Table 10.2.

Table 10.2. Recalculation performed year 2010 for 1990-2007. Differences in pct of CO_2 equivalent between this submission and the April 2009 submission for Estonia.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total CO2 equivalent emissions with LULUCF	-2.83	-4.10	-0.54	-5.25	-2.85	0.05	-1.54	-0.41	-0.21	-1.86
Total CO2 equivalent without LULUCF	-2.60	-3.65	-0.35	-2.81	-2.03	0.05	-1.02	-0.66	-0.36	-0.80

	2000	2001	2002	2003	2004	2005	2006	2007
Total CO2 equivalent emissions with LULUCF	-1.08	-0.55	-3.05	-3.53	-1.98	-9.43	-2.42	-10.86
Total CO2 equivalent without LULUCF	-1.04	-0.49	-1.27	-0.24	-1.01	-1.15	-1.40	0.16

10.2.2. KP-LULUCF inventory

The estimates of carbon flows associated with ARD activities were carried out for the first time in the 2010 submission. Therefore, no recalculations were provided in this submission.

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 Tables 10.3-10.5.

Table 10.3. Recalculation for CO_2 performed year 2010 for 1990-2007. Differences in CO_2 equivalent between this and the April 2009 submission for Estonia.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total National Emissions and Removals		**-1,061.01**	**-1,402.33**	**-135.20**	**-756.61**	**-439.79**	**73.31**	**-140.42**	**8.21**	**30.97**	**-251.09**
1. Energy		**-1,236.60**	**-1,569.60**	**-168.44**	**-666.40**	**-509.79**	**0.97**	**-201.72**	**-112.88**	**-36.72**	**-124.98**
1.A.	Fuel Combustion Activities	-1,236.60	-1,569.60	-168.44	-666.40	-509.79	0.97	-201.72	-112.88	-36.72	-124.98
1.A.1.	Energy Industries	-672.32	-959.57	-148.72	-230.17	-284.12	-204.24	-393.59	-317.06	-247.15	-300.76
1.A.2.	Manufacturing Industries and Construction	232.70	317.30	395.41	110.83	52.22	145.35	134.85	134.05	122.74	108.39
1.A.3.	Transport	-895.29	-981.74	-664.50	-822.67	-473.45	-62.21	-68.00	-61.57	-64.64	-8.15
1.A.4.	Other Sectors	54.70	0.98	215.13	264.78	184.56	93.28	108.74	118.00	132.86	55.43
1.A.5.	Other	43.61	53.44	34.24	10.83	10.99	28.80	16.27	13.70	19.48	20.13
2. Industrial Processes		**88.81**	**87.04**	**42.28**	**20.10**	**59.07**	**74.84**	**59.94**	**44.07**	**27.69**	**43.96**
2.A.	Mineral Products	-14.09	-11.80	-7.54	1.19	2.11	2.34	2.18	2.41	2.39	3.05
2.B.	Chemical Industry	102.89	98.84	49.82	18.91	56.96	72.50	57.76	41.66	25.30	40.91
5. Land Use, Land-Use Change and Forestry		86.78	80.23	-9.04	-110.30	10.93	-2.51	1.37	77.02	40.00	-170.07
5.A.	Forest Land										
5.B.	Cropland	59.84	55.18	-32.20	-131.57	10.65	-7.11	-9.70	10.63	37.32	-158.76
5.C.	Grassland	26.94	25.05	23.16	21.27	-470.46	-313.10	-100.43	66.39	-222.45	-535.68
5.D.	Wetlands										
5.F.	Other Land					470.75	317.70	111.50		225.13	524.37

		2000	2001	2002	2003	2004	2005	2006	2007
Total National Emissions and Removals		**-106.52**	**-2.31**	**-360.87**	**-422.49**	**-157.70**	**-1,074.00**	**-175.34**	**-1,434.37**
1. Energy		**-156.12**	**-56.99**	**-187.09**	**-10.75**	**-213.58**	**-292.26**	**-338.30**	**-5.27**
1.A.	Fuel Combustion Activities	-156.12	-56.99	-187.09	-10.75	-213.58	-292.26	-338.30	-5.27
1.A.1.	Energy Industries	-397.97	-395.37	-442.85	-285.85	-520.23	-588.40	-666.59	-380.90
1.A.2.	Manufacturing Industries and Construction	93.24	130.97	50.50	87.79	177.26	163.80	165.07	167.07
1.A.3.	Transport	8.33	29.30	-5.21	-102.29	-112.27	-88.29	-90.22	-97.92
1.A.4.	Other Sectors	120.37	156.31	192.64	267.65	210.75	182.37	218.04	271.88
1.A.5.	Other	19.92	21.81	17.82	21.95	30.91	38.26	35.41	34.61
2. Industrial Processes		**42.02**	**43.26**	**29.64**	**43.87**	**79.24**	**131.67**	**142.27**	**139.56**
2.A.	Mineral Products	-1.47	-2.64	-5.49	0.11	-0.05	3.09	5.45	4.00
2.B.	Chemical Industry	43.50	45.89	35.13	43.76	79.29	128.59	136.82	135.56
5. Land Use, Land-Use Change and Forestry		7.58	11.42	-203.42	-455.61	-23.36	-913.42	20.69	-1,568.67
5.A.	Forest Land								-1,555.54
5.B.	Cropland	29.64	32.38	-188.78	-436.83		-889.50	43.53	
5.C.	Grassland	-835.68	-815.42	-629.52	-693.03	-826.44	-857.64	-857.83	-583.86
5.D.	Wetlands							0.32	-0.09
5.F.	Other Land	813.61	794.46	614.88	674.26	803.08	833.72	834.68	570.82

Table 10.4. Recalculation for CH_4 performed year 2010 for 1990-2007. Differences in CO_2 equivalent between this and the April 2009 submission for Estonia.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total National Emissions and Removals		**-2.79**	**-2.81**	**-14.31**	**-12.52**	**-37.34**	**-71.48**	**-85.88**	**-76.73**	**-60.48**	**-56.92**
1. Energy		**-23.05**	**-22.78**	**-34.93**	**-35.71**	**-51.26**	**-84.11**	**-98.95**	**-96.88**	**-72.42**	**-67.83**
1.A.	Fuel Combustion Activities	-22.69	-22.46	-34.01	-34.85	-50.25	-83.07	-97.81	-95.67	-71.69	-67.34
1.A.1.	Energy Industries	-0.32	-1.03	0.06	0.13	0.09	0.04	0.41	0.26	0.17	0.30
1.A.2.	Manufacturing Industries and Construction	-1.04	-0.95	-0.50	-0.17	-0.14	-0.28	-0.28	-0.28	-0.30	-0.19
1.A.3.	Transport	4.53	1.54	-0.37	-1.51	-1.82	2.86	-1.93	-0.29	1.64	2.57
1.A.4.	Other Sectors	-25.90	-22.08	-33.24	-33.32	-48.39	-85.72	-96.03	-95.38	-73.22	-70.04
1.A.5.	Other	0.05	0.06	0.04	0.01	0.01	0.03	0.02	0.02	0.02	0.02
1.B.	Fugitive Emissions from Fuels	-0.36	-0.32	-0.92	-0.86	-1.01	-1.03	-1.14	-1.21	-0.72	-0.50
1.B.2.	Oil and Natural Gas	-0.36	-0.32	-0.92	-0.86	-1.01	-1.03	-1.14	-1.21	-0.72	-0.50
4. Agriculture		**12.13**	**11.86**	**11.68**	**11.03**	**10.52**	**9.29**	**8.97**	**16.10**	**8.73**	**7.74**
4.A.	Enteric Fermentation	10.87	10.65	10.62	10.06	9.63	8.55	8.17	15.36	7.99	7.13
4.B.	Manure Management	1.09	1.08	1.04	0.96	0.90	0.74	0.71	0.71	0.70	0.60
4.F.	Field Burning of Agricultural Residues	0.16	0.13	0.02	0.00	0.00	0.01	0.09	0.03	0.04	0.02
6. Waste		8.13	8.11	8.94	12.16	3.40	**3.33**	**4.10**	**4.04**	**3.20**	**3.17**
6.B.	Waste-water Handling	8.13	8.11	8.94	12.16	3.40	3.33	4.10	4.04	3.20	3.17

		2000	2001	2002	2003	2004	2005	2006	2007
Total National Emissions and Removals		**-61.34**	**-59.81**	**-59.91**	**-66.65**	**-66.62**	**-57.13**	**-56.98**	**-79.69**
1. Energy		**-71.20**	**-69.85**	**-68.60**	**-75.47**	**-74.72**	**-65.00**	**-64.61**	**-87.09**
1.A.	Fuel Combustion Activities	-70.41	-69.01	-67.70	-74.47	-73.64	-63.86	-63.41	-85.89
1.A.1.	Energy Industries	0.04	0.28	0.53	0.65	0.62	0.79	0.82	0.82
1.A.2.	Manufacturing Industries and Construction	-0.37	-0.56	-0.25	-1.05	-1.25	-1.30	-0.49	-0.91
1.A.3.	Transport	1.35	1.01	0.73	0.14	-0.39	-0.51	-1.69	-2.65
1.A.4.	Other Sectors	-71.46	-69.76	-68.72	-74.24	-72.66	-62.89	-62.08	-83.18
1.A.5.	Other	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.04
1.B.	Fugitive Emissions from Fuels	-0.79	-0.84	-0.90	-1.00	-1.08	-1.14	-1.20	-1.21
1.B.2.	Oil and Natural Gas	-0.79	-0.84	-0.90	-1.00	-1.08	-1.14	-1.20	-1.21
4. Agriculture		**7.49**	**7.68**	**7.13**	**7.27**	**7.33**	**7.09**	**6.86**	**6.62**
4.A.	Enteric Fermentation	6.88	6.94	6.40	6.51	6.47	6.26	6.12	5.81
4.B.	Manure Management	0.58	0.64	0.61	0.64	0.68	0.65	0.65	0.63
4.F.	Field Burning of Agricultural Residues	0.03	0.11	0.12	0.11	0.18	0.17	0.08	0.18
6. Waste		**2.37**	**2.36**	**1.57**	**1.56**	**0.78**	**0.77**	**0.77**	**0.79**
6.B.	Waste-water Handling	2.37	2.36	1.57	1.56	0.78	0.77	0.77	0.79

Table 10.5. Recalculation for N_2O performed year 2010 for 1990-2007. Differences in CO_2 equivalent between this and the April 2009 submission for Estonia.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total National Emissions and Removals		**58.60**	**57.37**	**41.77**	**31.49**	**17.36**	**5.15**	**5.44**	**4.92**	**0.40**	**-8.29**
1. Energy		**50.96**	**50.27**	**32.68**	**26.94**	**13.21**	**3.92**	**5.17**	**2.56**	**1.57**	**-5.78**
1.A.	Fuel Combustion Activities	50.96	50.27	32.68	26.94	13.21	3.92	5.17	2.56	1.57	-5.78
1.A.1.	Energy Industries	0.65	0.64	0.72	0.71	0.78	0.79	1.67	1.06	0.75	1.07
1.A.2.	Manufacturing Industries and Construction	0.15	0.22	0.22	0.05	0.15	0.06	0.07	0.07	0.07	0.06
1.A.3.	Transport	2.46	2.39	0.88	-0.03	1.74	-0.85	-0.33	-1.20	-4.27	-5.20
1.A.4.	Other Sectors	46.93	46.09	30.29	26.02	10.35	3.44	3.49	2.40	4.68	-2.07
1.A.5.	Other	0.77	0.93	0.56	0.19	0.18	0.48	0.27	0.23	0.33	0.35
4. Agriculture		**7.64**	**7.10**	**9.09**	**4.55**	**4.16**	**1.23**	**0.27**	**2.36**	**-1.17**	**-2.51**
4.B.	Manure Management	4.06	4.01	3.84	3.55	3.25	2.60	2.50	2.49	2.47	2.01
4.D.	Agricultural Soils	3.52	3.05	5.24	1.00	0.91	-1.38	-2.29	-0.15	-3.66	-4.53
4.F.	Field Burning of Agricultural Residues	0.06	0.05	0.01	0.00	0.00	0.00	0.05	0.02	0.02	0.01
5. Land Use, Land-Use Change and Forestry											
5.D.	Wetlands										

		2000	2001	2002	2003	2004	2005	2006	2007
Total National Emissions and Removals		**-14.80**	**-17.07**	**-12.71**	**-14.70**	**-4.95**	**-7.33**	**-11.84**	**-14.42**
1. Energy		**-7.60**	**-13.44**	**-11.20**	**-11.92**	**-14.04**	**-17.82**	**-22.30**	**-24.72**
1.A.	Fuel Combustion Activities	-7.60	-13.44	-11.20	-11.92	-14.04	-17.82	-22.30	-24.72
1.A.1.	Energy Industries	0.68	1.23	1.66	1.93	4.94	8.69	8.76	9.00
1.A.2.	Manufacturing Industries and Construction	0.08	0.15	0.11	-1.35	-1.67	-1.69	0.21	0.28
1.A.3.	Transport	-7.00	-12.59	-18.07	-22.85	-28.13	-35.18	-42.00	-43.44
1.A.4.	Other Sectors	-1.71	-2.62	4.77	9.95	10.30	9.71	10.14	8.87
1.A.5.	Other	0.34	0.38	0.33	0.39	0.53	0.64	0.59	0.57
4. Agriculture		**-7.20**	**-3.63**	**-1.50**	**-2.78**	**9.09**	**10.49**	**10.48**	**10.29**
4.B.	Manure Management	1.97	2.32	2.25	2.41	2.63	2.44	2.43	2.39
4.D.	Agricultural Soils	-9.19	-5.97	-3.79	-5.22	6.42	8.00	8.02	7.85
4.F.	Field Burning of Agricultural Residues	0.01	0.03	0.03	0.03	0.05	0.05	0.03	0.05
5. Land Use, Land-Use Change and Forestry								**-0.02**	0.01
5.D.	Wetlands							-0.02	0.01

10.3.2. KP-LULUCF inventory

The estimates of carbon flows associated with ARD activities were carried out for the first time in the 2010 submission. Therefore, no recalculations were provided in this submission.

10.4. Recalculations, including in response to the review response, and planned improvements to the inventory

10.4.1. GHG inventory

Table 10.6. summarises the sectoral improvement needs for the forthcoming inventories recognised by the Estonian experts responsible for the calculations and brought out in the review processes. More detailed information about planned improvements can be found under the sectoral chapters.

Table 10.6. Sector-specific improvement needs of Estonia´s national greenhouse gas inventory.

SECTOR	SOURCE	IMPROVEMENTS
ENERGY	Transport (CRF 1.A.3)	Today, the share of biofuels used in transport sector is very small in Estonia (less than 0.3%) and the biofuels are not separately reported in the national energy balance. Nevertheless, Estonia Ministry of Environment will make a proposal to the Statistical Office to start collect and report bio fuel consumption data separately from other motor fuels in road transportation.
	Other sectors (CRF 1.A.4) and Others (CRF 1.A.5)	During 2010, the final consumption of natural gas in 2002-2003 will be over checked by Statistics Estonia. In 2002-2003, there is a big derivation in the trend of gaseous fuels consumption in Commercial/Institutional sector. According to the information received from Statistics Estonia, the total final consumption figure is correct but break down by sectors should be corrected. More detailed research is needed to separate military stationary fuels from the source category 1.A.4.b Commercial/Institutional. There is planned to separate in the future agricultural mobile fuels, fishing boats used fuels and in off-road transportation used fuels. According to the information received from the Statistics Estonia amount of fishing boats used fuels is very small. Nevertheless, Estonia will ask Statistical Office to start report the fishing boats used fuels data separately from other agricultural mobile fuels.
	Oil and natural gas (CRF 1.B.2)	It is planned to find country specific emission factors for fugitive CH_4 emissions from shale oli production.
INDUSTRIAL PROCESSES	Glass production (CRF 2.A.7.1)	To complete the investigation over time series
	Refrigerated Vehicles (sub sector under 2.IIA.F.1.3 Transport Refrigeration)	In the future, attempts should be made to determine more precisely the share of second hand imports with empty refrigeration units. Time series starting from base year 1990 will be established.
	Reefer Containers (sub sector under 2.IIA.F.1.3 Transport Refrigeration)	Time series starting from base year 1990 will be established
	Industrial Refrigeration (CRF 2.IIA.F.1.4)	More detailed research of refilling ratios
	Stationary and room air-conditioning (sub sector under 2.IIA.F.1.5 Stationary Air-Conditioning)	The emission factors of split systems and chillers estimated by the national sector experts are deemed by far too low compared with values discussed in other countries. They should be reviewed in the next years.
	Passenger Cars (sub sector under 2.IIA.F.1.6 Mobile Air- Conditioning)	Time series starting from base year 1990 will be established.
	Trucks (sub sector under 2.IIA.F.1.6 Mobile Air-Conditioning)	Time series starting from base year 1990 will be established.
	Buses (sub sector under 2.IIA.F.1.6 Mobile Air-Conditioning)	Time series starting from base year 1990 will be established.

	Ships (sub sector under 2.IIA.F.1.6 Mobile Air-Conditioning)	Data on tugboats >100 GT and Estonian naval ships will be collected. Time series starting from base year 1990 will be established.
	Railways (sub sector under 2.IIA.F.1.6 Mobile Air-Conditioning)	Time series starting from base year 1990 will be established.
	Wheel Tractors and mobile machinery (sub sector under 2.IIA.F.1.6 Mobile Air-Conditioning)	Time series starting from base year 1990 will be established.
	One Component PU Foam (sub sector under 2.IIA.F.2.1 Hard Foam)	Time series starting from base year 1990 will be established.
	Metered Dose Inhalers (CRF 2.IIA.F.4.1)	Time series starting from base year 1990 will be established.
	General and Novelty Aerosols (CRF 2.IIA.F.4.2 Other)	Time series starting from base year 1990 will be established.
	Electrical equipment (CRF 2.F.8)	The data of the two missing operators shall be collected. Time series starting from base year 1990 will be established.
AGRICULTURE	CH_4 emissions from Enteric fermentation (CRF 4.A)	The activity data are kept under consideration and will be updated necessarily.
	CH_4 emissions from Manure management (CRF 4.B)	A dataset on country-specific manure management system will be developed in the next submissions. The data on types of manure management system were collected by ESO in 2001 (see Appendix A_V), the next cycle of data collection will take place in 2010. Estonian manure management system will be developed based on these two datasets. The data for years of 2002–2009 will be interpolated and module on manure management system for years of 1990–2000 will be extrapolated taking into consideration agricultural expert opinions.
	N_2O emissions from Manure management (CRF 4.B; 4.D.2)	A dataset on country-specific manure management system will be developed in the next submissions. The data on types of manure management system were collected by ESO in 2001 (see Appendix A_V), the next cycle of data collection will take place in 2010. Estonian manure management system will be developed based on these two datasets. The data for years of 2002–2009 will be interpolated and module on manure management system for years of 1990–2000 will be extrapolated taking into consideration agricultural expert opinions.
	N_2O emissions from Pasture, range and paddock (CRF 4.D.2)	A dataset on country-specific manure management system will be developed in the next submissions. The data on types of manure management system were collected by ESO in 2001 (see Appendix A_V), the next cycle of data collection will take place in 2010. Estonian manure management system will be developed based on these two datasets. The data for years of 2002–2009 will be interpolated and module on manure management system for years of 1990–2000 will be extrapolated taking into consideration agricultural expert opinions.
	Direct emissions from agricultural soils (CRF 4.D.1)	The activity data are kept under consideration and will be updated necessarily. Special attention will be paid to activity data employed in 'Sewage sludge applied on

		agricultural soils', the investigation of main flows of sludge generated by main producers will be carried out in the next submissions.
	Indirect emissions from agricultural soils (CRF 4.D.3)	The activity data are kept under consideration and will be updated necessarily.
	Field burning of agricultural residues (CRF 4.F)	The activity data are kept under consideration and will be updated necessarily.
LULUCF	Forest land (CRF 5.A)	A wide number of improvements are required to be carried out in order to guarantee complete, transparent and accurate GHG inventory in the 'Forest Land' sub-section: forest land (forest land remaining forest land and lands converted to forest land) areas, areas of mineral and organic soils under forest land will be revised in the next submissions for 1970–2008.
	Cropland (CRF 5.B)	Several improvements should be made in order to guarantee accurate, complete and transparent inventory in the future: areas of cropland should be checked, areas of changed land use practice should be revised.
	Grassland (CRF 5.C)	Several improvements should be made in the next submissions in order to provide accurate and complete GHG inventory: areas of grassland should be checked carefully in accordance with IPCC definition, changes in areas from/to grassland land use category should be revised and carbon emissions/removals associated with above- and below-ground biomass should be estimated.
	Wetland (CRF 5.D)	Several improvements should be made in the next submissions in order to report complete and accurate GHG inventory in 'Wetlands' sub-section: carbon flows related to wetland living biomass should be estimated, areas of land converted to/from wetlands will be checked, a higher tier will be applied to estimate emissions from peat extraction areas.
	Settlements (CRF 5.E)	Activity data will be updated necessarily.
WASTE	Solid waste disposal on landfills (CRF 6.A)	For the future submissions, historical activity data on waste composition will be corrected, as the recommendation of the review team, and data used so far from Netherlands' analysis will be replaced with data more properate for Estonian situation.
	Wastewater treatment (CRF 6.B)	For the future submissions, the activity data on production output of industrial wastewater handling will be improved and corrected and CH4 estimations of wastewater handling will be covered thoroughly.

Table 10.7. summarises Estonia ´s responses to the review of the initial report under the Kyoto Protocol.

Tabel 10.7. 2009 Estonia National GHG Inventory In-Country Review response

No	Sector	Findings	Recommendations	Estonia response
I. GENERAL				
1	General, completness	Some IPCC categories are not reported, e.g. Glass Production, Solvent and other product use, Field burning of some agriculture residues, Wastewater handling, deforestation, Land use change	The ERT recommends to continue work to estimates emissions from missing categories	Estonia will continue work to estimate emissions from missing categories. In 2010 Submission CO_2 emissions from glass production are reported since year 1992. Investigation in glass production category as well as in Solvent and other product use sector will continue in 2010 and the results will be reported in 2011 NIR (stated also in 2010 NIR).
2	General, consistency - transparency	Additional information is necessary to improve the transparency of the NIR, e.g.: consistency with CRF table could be improved (methods used or energy EF, IP activity data, solid waste disposal, other examples in sector presentations)high variations in trends of activity data (N2O from soil, agriculture products, SWD& WI for waste sector, gas and liquid consumption in civil sector)	The ERT recommends to further work on consistency of information between CRF and NIR, to improve references for EF used and to report trend explanations in NIR	Estonia is making efforts to improve consistency between CRF and NIR.
3	General, recalculations	The rationale for the recalculations (first time estimates of F-gasses emissions and for many LULUCF categories, revision of Industrial Process activity data) was only partially explained in NIR and it was learned during the review	Recalculations should be reported in next NIR	Recalculations are reported in the NIR 2010 (section 10.1.).
4	General, key categories	The results of the key category analysis are not a driving factor for setting priorities for improvements of the inventory, particularly in the prioritization of resources and choice of methodology	The ERT recommends to use key category analysis to streamline planned improving of inventory methods and Efs	In the future Estonia has planned using key category analyses to streamline planned improving of inventory methods and EFs.
5	General, uncertainties	Estonia is not using the results of uncertainty analysis to prioritize improvements in the inventory	The ERT recommends to use uncertainty estimations to streamline planned improving of inventory methods and Efs	Estonia will make an effort to use uncertainty estimations to streamline planned improving of inventory methods and EFs in the next submissions.

6	General, QA/QC	Activity data for many key sources shows high volatility, no consistent time series are available	According to GPG , ch 8.7, "significant changes in emissions from previous years may indicate possible input or calculation errors". In those cases "It is standard QC practice to compare emissions from each source category with emissions previously provided from the same source category or against historical trends and reference calculations as described below. … If the estimates seem unreasonable, emission checks can lead to a re-evaluation of emission factors and activity data before the inventory process has advanced to its final stages." …]	Activity data are obtained from national statistics; the remarkable changes in activity data values or emissions between two years or the entire trend of emissions are explained in the NIR.
7	General, QA/QC	Estonia is not following GPG when estimating emissions with high volatility in data time series, in particular for the following sources: N_2O from soil, N_2O emissions from agriculture, GHG emissions from SWD& WI, gas and liquid fuel consumption in commercial and institutional	Inventory experts should attempt to improve consistency of activity data	Estonia will make efforts in order to improve the estimates of N_2O emissions from agricultural sector, GHG emissions from SWD & WI, gas and liquid fuel consumption in commercial and institutional
8	General, QA/QC	Time series of some key categories are inconsistent	ERT recommends that Estonia put sufficient efforts and resources to improve time series consistency of key categories before the start of commitment period	Estonia is making an effort to improve time series consistency of key categories.
9	General, QA/QC	The higher tier method have not been implemented yet. Good relationships with data providers in the government and private industry needed e.g. availability of detailed data directly from operators, access to confidential data.	The ERT recommends to use those valuable sources of data to improve methods used (tier1 to tier2). However this will require specialised expertise involved in inventory preparation.	In the NIR 2010 Tier 2 method is used.
10	General, archiving	ERT found that centralized archiving is not well structured and store insufficient information on methods, EFs and sources of information	ERT recommends to insert relevant provision in sectorial experts contract and monitor the delivery of information.	In 2010 Estonia will start using more appropriate archiving system. In the new archiving system information on methods, EFs and sources of information is brought out.
11	General, sustainability of the National System	The short duration / instability of the contracts with sectorial experts creates uncertainty if needed improvements in the inventory estimates are implemented	ERT recommends that Estonia implement a system that ensure the involvement of required competences [experts] for a longer time in inventory preparation, with an aim to build capacity and secure the quality of inventory for the entire commitment period.	Estonia is currently looking for different possibilities to ensure the involvement of required competences (experts) for a longer time in inventory preparation.

12	General, KP-LULUCF	The Initial KP Review in 2007 made clear recommendations on the need to develop institutional relationships and to initiate development of needed land area data. Limited progress in these areas is noted by the ERT	Much more attention should be paid on this complex and time consuming task, which requires collaboration, resources and specialized expertise	The estimates on carbon fluxes related to activities established under Article 3.3 of the KP will be provided in the 2010 submission for the first time. Estonia is making effort to build up institutional arrangements, to develop datasets required for estimation of carbon flows.
II. ENERGY				
14	Energy, transparency	Background data on CS EF is not sufficiently explained	Develop more CS EF for key categories, explain background data	Estonia has CS CO_2 emission factors for oil shale (for pulverised and fluidised combustion); shale oil (a liquid fuel from oil shale), oil shale semi coke and oil shale semi coke gas and oil shale generator gas. Estonia plans in the nearest future to develop CS EF also for the rest of key categories.
15	Energy, transparency	Lack of trend explanation in NIR	Include trend explanations in the next NIR	In the NIR 2010 trend explanations are added to main source categories.
16	Energy, transparency	Calculation sheet is vulnerable to errors and not transparent	Upgrade the calculation sheet: security, archiving, transparency	Energy sector calculation sheets are upgraded. AD and EF tables are linked to the calculation sheets.
17	Energy, consistency	Inconsistency between sectors: Energy & Waste, Energy & IP	Encourage more cooperation among the different inventory experts to improve total inventory	Inconsistency between different sectors Energy & Waste, Energy & IP has been analysed, some additional source categories into Energy sector included and the total inventory qality has been improved.
18	Energy, accuracy	Mostly Tier 1 is used for key categories	Use Key Category Analysis and Uncertainty Analysis for prioritization of improvements	Estonia can use Tier2 after elaboration of CS EF s.
19	Energy, accuracy	AD unstable		Energy expert works together with Estonian Statistical Office to improve the quality of AD.
20	Energy, accuracy	Use of notation keys not always correct	Improve the use of notation keys	In the 2010 submission the use of notation keys has been improved.
21	Energy, accuracy	No use of ETS data for verification or EF	Use ETS data for verification and EF	In the 2010 submission ETS data have

				been used for verification of EF-s.
22	Energy, completeness	Use of waste fuels (oil shale fusses & waste oils) is reported as NO but is actually occurring	Use of waste fuels (oil shale fusses & waste oils) should be estimated: Public Electricity & Heat Production, Other industries (cement industry)	In the 2010 submission GHG emissions from the use of waste fuels (oil shale fusses & waste oils) are estimated and reported in the CRF source category 1.A.2.f Other (cement industry).
23	Energy, completeness	Energy use and emissions (CH4 & N2O) of biogas from WWTP and landfill gas is not included	Energy use and emissions (CH4 & N2O) of biogas from WWTP and landfill gas should be estimated	In the 2010 submission energy use and emissions (CH4 & N2O) of biogas from WWTP and landfill gas are estimated and reported in the CRF source category 1.A.1.a Public Electricity and Heat Production.
24	Energy, comparability	Several allocation issues: Autoproducer CHP & boilers etc.	Review inventory for proper allocation to fuel categories and subsectors	In the 2010 submission several changes/ reallocations have been done. Shale oil production and corresponding emissions are reported in the CRF source category 1.A.1.c (in previous submission in the 1.A.2.b); Oil shale gas is reported under solid fuels, because it is the by product of shale oil production using oil shale thermal processing (in previous submissions under gaseous fuels), etc.
25	Energy, 1A1 Energy Industries	Solid: use of oil shale,(and derived products) - difficult to review	Give more explanation & background; not only theoretical but also regarding the calculation	In the NIR 2010 more explanation & background are given to explain oil shale production and CO2 emission calculations from the process.
26	Energy, 1A1 Energy Industries	Solid: some misallocations (oil shale refining, oil shale gas)	Reallocate	In the 2010 submission emissions from shale oil production are reallocated from CRF source category 1.A.1.b into 1.A.1.c because to produce shale oil from oil shale the oil shale thermal processing is used.
27	Energy, 1A1 Energy Industries	Solid: not all CH4 & N2O emissions are accounted for	Calculate and add to inventory	In the 2010 submission N2O emissions from oil shale fluidised bed combustion are estimated and reported in the CRF source –category 1.A.1.a.

28	Energy, 1A1 Energy Industries	Gaseous: calculation of emissions from key category sources	Use CS EF for CO2 or give an explanation for using default	In the 2010 submission Finnish CS CO_2 EF for natural gas has been used. Lithuania imports like Estonia all natural gas from Russia.
29	Energy, 1A1 Energy Industries	Liquid: calculation of emissions	Use CS EF for CO2 (not only for shale oil) or give an explanation for using default	In the 2010 submission Lithuanian CS CO2 EF for motor gasoline has been used. Estonia import almost all motor gasoline from Lithuania.
30	Energy, 1A1 Energy Industries	Biomass & Other fuels: lack of completeness	Include emissions from waste fuels, biogas from WWTP and landfill gas.	In the 2010 submission emissions from waste fuels, biogas from WWTP and landfill gas are estimated and reported in the CRF source category 1.A.1.a /Biomass.
31	Energy, 1A2 Manufacturing Industries	Solid: the CO2 EF used for coal is IPCC default	Use CS EF or give an explanation for using default	In 2008 the coal share in fuel balance was only 1.5 %, nevertheless Estonia plans to develop CS EF for coal.
33	Energy, 1A2 Manufacturing Industries	Gaseous, lack of completeness	Include the fuel use and resulting emissions from the ammonia plant	In the 2010 submission the fuel use and resulting emissions from the ammonia plant are included into CRF source category 1.A.2. c Chemical industry.
34	Energy, 1A2 Manufacturing Industries	Other fuels, lack of completeness	Calculate the use of waste fuels and corresponding emissions	In the 2010 submission emissions from the use of waste fuels are included into CRF source category 1.A.2. f Other industries (including cement production).
35	Energy, 1A3 Transport	Gasoline & diesel oil in 1A3b (Road Transport) - key category	Use CS EF for CO2 or give an explanation for using default	During the 2009 country review a recommendation was given by the energy expert of the CRT to use Lithuanian CS CO2 EF for motor gasoline because most of the gasoline is imported from Lithuania. After analysing of the motor fuels import data clarified that Lithuania is the biggest importer of gasoline only in resent years but before 2000 over 60% of gasoline was imported from Russia. Russia use also IPCC 1996 default EF-

				s for gasoline. It means that Estonia will use in the 2010 inventory submission the Lithuanian CO2 emission factors for motor fuels (gasoline and gas oil) until we are able to elaborate own CS emission factors.
36	Energy, 1A3 Transport	Separation national and international transport unclear in NIR, explanation provided during review	Provide this explanation in the NIR	In the NIR 2010 explanations are provided how are separated motor fuels used in national and international transport.
37	Energy, 1A3 Transport	Biofuels & blends are not yet taken into account	Start analyzing the amount of biofuels and adjust the emissions accordingly	Today, the share of biofuels used in transport sector is very small in Estonia (less than 0.3%) and the biofuels are not separately reported in the national energy balance. Nevertheless, Estonia will ask Statistical Office to start report the biofuels consumption data separately from other motor fuels (but there are not jet included in the NIR 2010).
38	Energy, 1A3 Transport	Data includes (part of) military fuel use, use for agricultural vehicles and (part of) fuel use for fishing	Reallocate to proper categories	In the 2010 submission data of military fuel use are reported in the CRF source category 1.A.5. Other, data of agricultural of-road machinery and fishing boats fuel use in the CRF 1.A.4.c Other Sectors/Agriculture.
39	Energy, 1A4 Other sectors	Solid fuels: incorrect CH4 EF for coal & coke	Use a correct CH4 EF for coal & coke	In the 2010 submission a correct CH4 EF for Coal and Coke has been used.
40	Energy, 1A4 Other sectors	Gaseous fuels	Provide trend explanation	In the NIR 2010 the trend explanation of gaseous fuels use in the 1A4 Other sector provided.
41	Energy, 1A4 Other sectors	Gaseous fuels	Move stationary military emissions to 1A5	The use of stationary military fuels needs a deeper investigation and will be solved in next inventory submissions.
42	Energy, 1A4 Other sectors	Liquid fuels	Include fuel use agricultural vehicles; include fuel use fishing vessels	In the 2010 submission data of agricultural of-road machinery and fishing boats fuel use in the CRF 1.A.4.c Other Sectors/Agriculture.

43	Energy, 1A4 Other sectors	Liquid fuels	Provide trend explanation	In the NIR 2010 the trend explanation of the use of liquid fuels in the 1A4 Other sectors provided.
44	Energy, 1A4 Other sectors	Biomass	Use CS EF for CH_4 or give an explanation for using default	In the NIR 2010 IPCC 2006 default values are used for CH_4 and N_2O EF-s. In the future Estonia plans to elaborate CS EF for CH_4 from biomass combustion.
45	Energy, 1B Fugitive emissions	Mining: Only oil shale mining (IEA:lignite)	Provide lignite data	There is no any lignite mines in Estonia. In the IEA statistics oil shale is reported under lignite, because IEA does not have such fuel type like oil shale.
46	Energy, 1B Fugitive emissions	Mining: no CH_4 emissions reported	Provide sufficient justification or use the default EF	An explanation on oil shale mining added into NIR 2010.
47	Energy, 1B Fugitive emissions	Oil & Gas: oil production reported is shale oil	Remove from inventory	In the 2010 inventory submission CH_4 emissions from 1.B Fugitive emissions/Oil and Gas/ oil production are removed from the inventory , because the CH_4 emissions from shale oil production are already taken into account in the CRF source category 1.A.1.c.
48	Energy, 1B Fugitive emissions	Emissions from gas transmission are calculated using default EF	Moving to a higher Tier will reduce emissions	There in no CS CH_4 EF for fugitive emissions in Estonia. In the future Estonia plans to elaborate CS EF for CH_4 from fugitive emissions.
49	Energy, Reference Approach & International bunkers	There are (small) differences between activity data and IEA data	Analyse the (small) differences between activity data and IEA data and try to use one dataset	The small differences between activity data and IEA data are caused by different net calorific values (NCV) of fuels reported in IEA and National Energy statistics. IEA use content NCV-s for every year but Estonian national statistic use annually average NCV-s. Estonia can not use IEA data for GHG inventories because of different deadlines for IEA and National

				statistics data. The deadline for NIR is December 1, but IEA data will by ready for sending to IEA also by the beginning of December.
50	Energy, Reference Approach & International bunkers	RA-SA differences	Explain differences RA-SA on fuel level	Differences on RA and SA are caused by the fact that there is lot of secondary fuels used in final consumption Shale oil, semi coke and oil shale gas – all made from oil shale, etc.
51	Energy, Reference Approach & International bunkers	Default EF is used for coke oven coke	Use a CS EF for coke oven coke	In 2008 the coal share in fuel balance was only 1.5 %, nevertheless Estonia plans to develop CS EF for coal.
52	Energy, Reference Approach & International bunkers	The data and information on carbon stored is not sufficient	Improve the data and information on carbon stored: Natural gas for ammonia; Oil shale; Peat	In the 2010 inventory submission more information is provided about carbon stored.
53	Energy, Reference Approach & International bunkers	No information about fuel use for military and fishing	Assess whether fuel use for military and fishing is included in international bunkers	According to the information received from Statistics Estonian fuel use for military and fishing is not included in international bunkers.
III. INDUSTRIAL PROCESSES				
54	Industrial processes, completeness	Following emissions are reported as ‘NE’s: Glass Production, CO2 and Iron and Steel, CO2, CH4, N2O	To estimate emissions from missing sources	2010 Submission includes CO_2 emissions from glass production since 1992. Emissions from 1990 to 1991 are still under investigation (noted under planned improvements in 2010 Submission). Investigation in Iron and Steel sector was completed in 2009. No emissions were identified.
55	Industrial processes, completeness	Following emissions are reported as ‘NO’s or ‘NA’s: Limestone use, CO2; Soda ash use, CO2; Solvent and other product use, N2O, NMVOC	To estimate emissions from missing sources	Emissions from Limestone and Dolomite Use and also Solvents and other product use are marked as under investigation in 2010 Submission.

				Investigation started in 2009. No emissions from Soda ash use has been identified.
56	Industrial processes	The description of methodology used, AD and applied EF is not sufficient	To elaborate the description of the methodology used, AD and applied EFs	More detailed description of methodology used, AD and applied EF is brought out in NIR.
57	Industrial processes	Documentation and archiving	To ensure proper documentation and archiving of sub-sectoral reports, calculation sheets, methodology and data	Estonia changed archiving system in 2009 to more appropriate one.
58	Industrial processes	Cement production – CO2. The Party is planning to calculate clinker production emissions using CKD correction factor.	It is recommended in the GPG Tier 2 method	In 2010 Submission Estonia used method Tier 2 to calculate emissions from cement production.
59	Industrial processes	Cement production – CO2	Provide more detailed description of technological process of cement production, data and used emission factors in next submission for the improvement of the transparency of the report	Description of technological process has been included. More detailed descriptions of activity data and emission factors has been included.
60	Industrial processes	Cement production – CO2	Use EU-ETS data for verification	Estonia is planning to use EU-ETS data from 2011 Submission.
61	Industrial processes	Lime production – CO2. The Party is planning to calculate emissions using plant specific emission factor instead of default one due to more precise information received from the existing plant. Also one more lime producer has been found	ERT recommends to provide more detailed description of activity data and used emission factors in next submission for the improvement of the transparency of the report; to report emission estimations from new lime producer	In 2010 Sumbission Estonia uses plant specific emission factors. Also data from one additional producer is included. More detailed description of activity data and emission factors is included.
62	Industrial processes	The ERT was informed that Estonia is planning to use method Tier1a to calculate emissions from ammonia production using plant specific data and CO2 for sale and carbamide production will be included	The ERT welcomes the efforts made by the Party to improve the inventory and encourages Estonia to continue these improvements	In 2010 Submission Estonia uses method Tier 1a with plant specific data to calculate emissions from ammonia production. CO_2 for sale and carbamide production are included.
IV. AGRICULTURE				
63	Argiculture	Some key categories still use Tier 1 method	Improvement program should address the remaining key categories that still use Tier 1 method	The improvement program will be developed for sub-sectors determined as key category

64	Argiculture	Description of methodology	Where CS values are used, concrete methodology, with sufficient peer reviewed referencing is required	CS IF, methodology employed will be described and be provided in the NIR.
65	Argiculture	Description of QA/QC procedures	In the NIR all of the work that has been done to QA/QC inventory information should be highlighted	'Source-specific QA/QC and verification' chapter was provided in the NIR
66	Argiculture	Explanation of discrepancies	Where discrepancies occur, details of reasons should be reported	Detailed reasons of discrepancies or remarkable changes will be provided in the 2010 submission.
67	Argiculture	Uncertainty	Improving the CS emission factors, and other studies will reduce the uncertainties	The program to improve the estimates (EF, methods) of emissions will be developed.
68	Argiculture	Explanations in the NIR	The ERT recommends that Estonia provide sufficient explanation in the NIR to improve transparency	The AD, EFs and methods employed to estimate GHG emissions from sectors of Agriculture will be reported transparently in the NIR.
69	Argiculture	Use of notation keys	The ERT recommends that Estonia correct the use of notation keys (where NE is used instead of NA, or NO)	Correct notation keys will be used in the 2010 submission.
70	Argiculture	Uncertainty	The ERT recommends that Estonia carry out more research to develop CS uncertainty ranges	The program will be developed.
71	Argiculture	Explanations of noticeable changes in AD and methods	The ERT recommends that Estonia discuss with external experts the cases when noticeable changes in AD or method employed are applied	Explanations of remarkable changes in AD will be provided in the NIR and the discussions will be organized.
72	Argiculture	CH4 Enteric Fermentation. Country specific parameters were used for cattle and swine using milk productivity, fat content, % of cows give birth.	Other country specific parameters could be carried out: weigh, weight gain, digestibility, feeding situation from existing institutions. Resulted CS EF should be compared with similar countries in the region.	Improvement program will be developed; the research will be carried out in accordance with schedule of the program.
73	Argiculture	CH_4 Enteric Fermentation. No estimates for CH_4 and N_2O from fur animals are provided but	ERT recommends to provide estimates for CH_4 and N_2O emissions from fur animals in the next	The estimates will be provided.

		envisaged in the next submission	submission	
74	Agriculture	N_2O Manure Management. Country specific parameters were used for cattle and swine using milk productivity, fat content, % of cows give birth	Other country specific parameters could be carried out: weigh, weight gain, digestibility, feeding situation from existing institutions. Resulted CS EF should be compared with similar countries in the region	Improvement program will be developed; the research will be carried out in accordance with schedule of the program.
75	Agriculture	N_2O Manure Management. No N_2O emissions from fur animals are provided, but envisaged in next submission	Provide estimates for N_2O emissions from fur animals	The estimates will be provided.
76	Agriculture	N_2O Manure Management. IPCC Default values for Eastern European manure management system (ES) were used in the recalculation. Western European manure management system (WS) were used in some years of the previous submission	Additional research need to be carried out in this section	Improvement program will be developed; the research will be carried out in accordance with schedule of the program.
77	Agriculture	N_2O Manure Management. Inconsistency due to lack of accuracy	Should be corrected	The correction will be provided in the 2010 submission.
78	Agriculture	Estonia reported and recalculated CH_4 emissions from cattle manure management in 1990–2007. The assumptions used for recalculation assumption resulted in considerably lower emissions (Figure 4.18 in the NIR). No transparent supporting references for the choice of the methodology has been provided	Provide supporting references for the choice of the methodology of recalculation	The correction will be provided in the 2010 submission.
V. LULUCF				
79	LULUCF	Deforestation emissions	Need land use change data to identify areas converted from forest to non-forest	Improvement program will be developed; the research will be carried out in accordance with schedule of the program.
80	LULUCF	N_2O from soil oxidation when land is converted to cropland	Need land use change data	Improvement program will be developed; the research will be carried out in accordance with schedule of the program.
81	LULUCF	CO_2 from liming	Need activity data on amount of lime applied	Improvement program will be

			(have areas)	developed; the research will be carried out in accordance with schedule of the program.
82	LULUCF	Biomass burning on non-forest land	Need activity data for non-forest categories	Improvement program will be developed; the research will be carried out in accordance with schedule of the program.
83	LULUCF	Limitation of estimation approach: cannot separate out ER from Afforestation/Reforestation	Need land use change data	Improvement program will be developed; the research will be carried out in accordance with schedule of the program.
84	LULUCF	Land use, land use change area estimates. Land use definitions were not researched and reconciled with each other, therefore, area estimates may contain significant overlaps and/or gaps	Further research and collaboration is needed to develop the capacity to determine specific land use transitions. Needed to improve UNFCCC reporting and critical for Article 3.3	Improvement program will be developed; the research will be carried out in accordance with schedule of the program. The first estimates will be provided in the 2010 NIR.
85	LULUCF	Forest land – Biomass. Time series for forest area data is inconsistent	Provide explanations in the NIR	The explanation will be provided in the 2010 NIR.
86	LULUCF	Forest land – Biomass. Interpolation of removals data could be improved	Interpolation of removals data should be improved	Improvement program will be developed; the research will be carried out in accordance with schedule of the program. The first estimates will be provided in the 2010 NIR.
87	LULUCF	Forest land – Biomass. Needs more explanation of trends	Include explanation of Land reform and impacts on harvesting rates	The explanation will be provided in the next submissions.
88	LULUCF	Forest land – Biomass. For complete picture of carbon flows, CO_2 emissions from wildfires should be included in the estimate for net carbon stock change in biomass	Include CO_2 emissions from wildfires in the estimate for net carbon stock change in biomass. Suggest exploring use of biomass equations to estimate carbon stocks in biomass (also recommended in Twinning study)	The explanation will be provided in the next submissions.
89	LULUCF	Tier 1 is used	Encouraged to use a Tier 2 estimation approach	Improvement program will be

				developed; the research on AD and method applied will be carried out in accordance with schedule of the program.
90	LULUCF	Insufficient collaboration between institutions, lack of methodology development	Requires involvement of forest inventory experts and collaboration with NFI program to share information. Methodology development should cover KP and UNFCCC reporting needs	Institutional agreements are being established, the cooperation between two teams of experts will be implemented in the future.
91	LULUCF	Forest land – other C pools. Tier 1 defaults assumption of no changes in DOM and mineral soils. Next year the YASSO model will be used for mineral soils	Recommend initiating work as soon as possible, requires in-depth expertise to apply properly	Improvement program will be developed. The YASSO model will be implied in the next submissions.
92	LULUCF	Organic soils - Tier 1 method with IPCC default. Issues noted: limited information on how soil areas were estimated; emission factor was revised in 2009 submission; lowered estimated emissions & increased removals in FL; contributed to recalculation trends; factor for boreal forests used, may not be appropriate 100%	ERT recommends provide more transparency and expert consultation	The data will be provided in the next submissions.
93	LULUCF	Forest land – Burning	Recommend: reporting CO_2 emissions as biomass sub-category for complete carbon flux accounting; more transparency on activity data; explore available data for other types of burning (prescribed part of management)	The explanation will be provided in the next submission.
94	LULUCF	Cropland - Biomass. Review of calculation worksheets found incorrect implementation of the method	Recommend: correcting the approach, using best available activity data; evaluating trends to identify problems; expert consultation	The recalculations will be provided in the 2010 submission.
95	LULUCF	Cropland - Mineral soils. Lack of transparency challenged review; estimates reported for 1990-1993 only; land should continue to be accounted for in the rest of the time series - once land enters the category it should be tracked for a period of 20 years or until land transitions to another use; requires better land use/land use change information	Recommend: transparency and expert consultation; developing estimates for Cropland remaining Cropland	Institutional agreements are being established, the cooperation between two teams of experts will be implemented in the future.

96	LULUCF	Cropland - Organic soils. Lack of transparency challenged review; justification for choice of emission factor needed - cold temperate climate zone (recall boreal was used for forests)?	Recommend: transparency and expert consultation; developing estimates for Cropland remaining Cropland	Institutional agreements are being established, the cooperation between two teams of experts will be implemented in the future.
97	LULUCF	Grassland - Mineral soils. Lack of transparency challenged review; trends influenced by land conversion from cropland; Land use change data may not be reliable	Recommend: transparency and expert consultation; developing estimates for Grassland remaining Grassland	Institutional agreements are being established, the cooperation between two teams of experts will be implemented in the future.
98	LULUCF	Grassland - Organic soils. Lack of transparency challenged review; justification for choice of emission factor needed; cold temperate climate zone (recall boreal was used for forests)?	Recommend: transparency and expert consultation; developing estimates for Cropland remaining Cropland	Institutional agreements are being established, the cooperation between two teams of experts will be implemented in the future.
99	LULUCF	Other land - biomass. This category exists for consistent representation of land areas only (no ER estimate expected); likely misclassification; GHG expert indicated estimate was for recently abandoned cropland that contained bushes/shrubs	Recommend: consulting experts to determining proper classification; could be AR land or Land converted to Grassland	Institutional agreements are being established, the cooperation between two teams of experts will be implemented in the future. The first efforts to estimate carbon flows related to AR activities will be provided in the 2010 submission.
100	LULUCF	Key categories. Does not appear that the key category analysis, requirements of GPG, or consideration of reporting needs under Article 3.3. are driving decision making. Limited involvement of subject matter experts also hinders progress on methodology development	Implement Key Category analysis at finer level of detail, per guidance in Chapter 5 of the GPG (Table 5.4.1). Use Key Categories to guide prioritization of methodology development	The determination of key categories based on detailed analysis will be provided in the next submissions.
101	LULUCF	Transparency	Describe national circumstances relevant to the sector; describe unusual trends in context of national circumstances; provide more details on methodological approach in NIR; report data by disaggregate levels as well as aggregated into totals for each land category	Remarkable changes in trends will be explained in the 2010 NIR.
VI. WASTE				
102	Waste	The background information on waste management policy was not included in the NIR	The ERT recommends Estonia to include information on waste management in the NIR	Information about waste management policy has been included in the NIR

103	Waste	Used AD on solid waste disposal on land are not documented	Provide explanation on used model for AD estimation for the whole time-series	
104	Waste	Insufficient information (justification) on the used EFs (DOC & MCF)	More information (justification) is needed for the used EFs (DOC & MCF)	Justification on used EFs (DOC&MCF) will be included in the next (2011) NIR
105	Waste	Emissions from Industrial wastewater were not estimated, due to lack of AD	The ERT recommends to estimate emissions from Industrial wastewater	Preliminary estimations about emissions from Industrial wastewater has been included
106	Waste	Historical AD seems to be overestimated	Historical AD should be corrected	Historical AD will be corrected in the future
107	Waste	Used MCF =1 for whole time series is not documented and it is incorrect	Used MCF should be corrected and documented	MCF will be corrected and documented in future submissions
108	Waste	CH_4 recovery is not well documented (the emissions from energy recovery were not reported under energy sector)	The ERT recommends to report emissions under energy sector.	CH_4 emissions with energy recovery will be reported under energy sector
109	Waste	Uncertainty 1,15% is among the lowest the reported parties, it is probably underestimated	Re-estimate the uncertainty	
110	Waste	Accuracy and completness	The ERT recommends to develop data collection system for AD of landfills and wastewater handling; use national available data on waste composition, landfills characteristics (managed and unmanaged); provide information on incineration and composting facilities	Estonia has taken into consideration to develop activity data collection system for the future submissions, no development plan hasn't been in use so far.
111	Waste	Wastewater Handling CH_4 and N_2O. GHG emissions from waste-water are not estimated due to lack of activities data (CRF table 9). There is no any information in the NIR concerning the wastewater system used	For the further transparency improving information on the wastewater streams and treatment should be included in the NIR	Information about wastewater system and treatment has been included in the NIR
112	Waste	Wastewater Handling CH_4 and N_2O. During the review week it was mentioned that at least two WWTP (Tallinn and Narva) are equipped with methane tank and CH_4 is used for the energy purpose	The ERT recommends to report emissions under energy sector	Emissions are reported under Energy sector

113	Waste	Incineration. There is no any information in NIR on waste incineration facilities	Provide information on waste incineration facilities	Information about waste incineration facilities has been included in the NIR
114	Waste	Incineration. GHG emissions from the waste incineration with energy recovery are not estimated	The ERT recommends to estimate GHG emissions from the waste incineration with energy recovery	Emissions from the waste incineration with energy recovery are reported under energy sector
115	Waste	Incineration. Trend on waste incineration is unstable, no any explanation on the fluctuations (1996 – 22,699 tonnes, 1997- 482 tonnes, 1999 – 12, 979 tonnes)	Provide explanation of the trend in the next NIR	The explanation is included in the NIR
116	Waste	Emissions from wastewater handling (CH4 and N2O) are not estimated	The ERT recommends to estimate GHG emissions from wastewater handling	Preliminary estimation about emissions from wastewater handling has been included
117	Waste	Waste incineration with energy recovery (CO2, N2O and CH4) – is not estimated. Emissions form the Energy recovery of CH4 from landfills and WWTP (N2O and CH4) are not estimated	These emissions should be reported under the energy sector	As no wastes weren't burnt on land in 2008 in Estonia, waste incineration with energy recovery are reported in Energy sector

10.4.2. KP-LULUCF inventory

The estimates of carbon flows associated with ARD activities were carried out for the first time in the 2010 submission. Therefore, no recalculations were provided in this submission.

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

11. KP-LULUCF

11.1. General information

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 Estonian Forest Act stipulates forest as '…any land with an area of **0.1 ha** or more, which is covered with trees higher than **1.3 m** with a **canopy** closure of at least **30%**, and which is managed in order to produce forest products, or in order to preserve forest vegetation for other objectives'.

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'.

Due to the difference between the current definition of forest stipulated in the Estonian Forest Act and Kyoto forest given in the decision 16/CMP.1, Estonia has established the Estonian 'definition of forest in the context of the Kyoto Protocol', which is used under UNFCCC reporting (LULUCF sector), the main parameters of forest determined in the definition is reported in Table 11.1.

Table 11.1. Parameters for forest definition

Minimum tree cover	30%
Minimum land area	0.5 ha
Minimum tree height	2 m

11.1.2. Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

Estonia did not choose to account GHG emissions/removals from 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. A wide range of supplementary research is in the progress in Estonia and the reporting under Article 3.3 will be remarkably improved by the end of the first commitment period.

To date, only carbon fluxes related AR according to Estonian definition of forest have been estimated. Carbon emissions associated with deforestation in Estonia have been calculated according to 'definition of forest in the context of the Kyoto Protocol', as detailed research has been carried in this area.

11.2. Land-related information

11.2.1. Spatial assessment unit used for determining the area of the units of land under Article 3.3

A statistical approach is used to estimate the total area of ARD units following Reporting Method 1 of the LULUCF GPG. The spatial assessment unit for the submission of the Kyoto Protocol (KP) LULUCF tables covers the entire territory of Estonia.

The data on AR areas were obtained from Estonian Office of Statistics, which reports the areas for each county of Estonia (Table 11.2). Originally, these data are collected based on licence by Centre of Forest Protection and Silviculture. Land areas reported under afforestation, reforestation and deforestation activities in the framework of the KP-LULUCF are not relevant to the inter-annual growth in forest areas reported under the LULUCF sector inventory. Since 1990ies, large agricultural areas of land have been abandoned in Estonia. The areas were overgrown by bushes and by forest trees. However, the activity can not be defined as direct human-induced and therefore these areas were not taken for reporting. Some further observations relating to identification of AR areas on areas of 'Land converted to Forest land' should be provided.

The data on deforestation areas in 1990–1999 were developed in the framework of a twinning project with Finnish colleagues. The data on deforestation areas in 1999–2008 are collected in the process of National forest inventory (NFI), which was established in 1999 in Estonia. The data for the entire time-series are presented in Table 11.3.

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. Estonia is developing datasets required to report carbon fluxes related to land use changes and is establishing agreements among different institutional units.

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

A tier 1 approach has been employed to estimate carbon removals/emissions related to ARD activities. More detailed information on parameters used in the estimates is presented in Chapter 7. Applied growth of trees has been employed at 2.2 m^3/ha per year, the average deforested stock of trees was employed at 70 m^3/ha.

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

A *tier 1* approach has been employed to estimate carbon fluxes related to soils. It was assumed that carbon stock in mineral soil organic matter does not change, regardless of changes in forest management, types and disturbance regimes.

Supplementary research will be carried out to estimate omitting carbon pools: a possibility of a YASSO soil model (Liski et al, 2005) usage will be analysed. It will help to include carbon flows related to mineral soils and litter.

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)

No recalculations were performed since the last submission.

11.3.1.5. Uncertainty estimates

Uncertainty rates related to activity data and emission factors employed in the estimates under Article 3.3 are presented in the LULUCF greenhouse gases inventory.

11.4. Article 3.3

11.4.1. Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

The activity data on afforested/reforested areas is presented in Table 11.2. The areas are allocated by type of afforestation/reforestation activity; planting of new forest is the main human-induced activity directed towards increasing of forest area in Estonia. Afforestation activities have been implemented on agricultural lands and quarries worked out.

Table 11.2. Afforestation and reforestation activities, ha

Year	Reforestation			Afforestation			Total, ha
	Sowing	Planting	Contribution to natural forest renewal	…of quarries	…of agricultural land	..of other areas	
1990	*1,215*	*5,499*	*1,027*	*319*	*569*	*0*	*8,629*
1991	1,215	5,499	1,027	319	569	0	8,629
1992	780	3,042	532	52	81	0	4,487
1993	1,062	2,889	524	156	63	0	4,694
1994	1,252	2,934	628	175	32	0	5,020
1995	1,303	2,982	968	185	36	0	5,473
1996	1,392	3,003	1,012	180	74	0	5,662
1997	1,441	3,494	1,129	243	116	0	6,423
1998	1,679	3,814	1,347	313	85	40	7,277
1999	1,623	4,513	1,999	308	91	0	13,047
2000	1,698	4,961	2,503	305	145	0	14,573
2001	1,280	5,805	2,727	435	184	0	16,235
2002	1,204	5,649	3,152	322	123	0	16,098
2003	1,695	6,029	3,583	178	89	295	17,898
2004	1,309	6,263	2,979	127	93	172	17,206
2005	1,312	6,027	845	173	520	155	15,059
2006	1,490	6,219	639	44	816	333	15,761
2007	908	5,907	442	0	0	29	13,193
2008	1,234	6,620	512	213	0	9	15,208
by 2008	25,091	91,148	27,576	4,046	3,685	1,033	210,572

The activity data on deforestation areas in 1990–1999 were estimated by Finnish colleagues in the framework of the twinning project (Table 11.3). Satellite images from Global Land Cover Facility have been used in the estimates. The activity data on deforestation areas in 2000–2008 were obtained from the NFI, which was launched in Estonia in 1999.

Table 11.3. Deforestation activities, ha

Year	1000 ha
1990	6,404
1991	6,404
1992	6,404
1993	6,404
1994	6,404
1995	6,404
1996	6,404
1997	6,404
1998	6,404
1999	6,404
2000	1,980
2001	1,980
2002	1,980
2003	1,980
2004	1,980
2005	1,980
2006	1,980
2007	1,980
2008	1,980
by 2008	81,863

Carbon fluxes related to afforested/reforested and deforested forest biomass are presented in Table 11.4. A *tier 1* approach was applied to estimate carbon emissions/removals from/by litter and soils and it was assumed that carbon stock in mineral soil organic matter does not change, regardless of changes in forest management, types and disturbance regimes.

The net carbon emissions due to ARD activities under Article 3.3 are estimated to be 1,654.4 Gg (i.e., 6,065.9 CO_2 Gg) by 2008 in Estonia (Table 11.4).

Table 11.4. Carbon flows associated with afforested/reforested and deforested forest biomass, C Gg

Year	Afforestation/Reforestation		Deforestation	
	Above-ground biomass	Below-ground biomass	Above-ground biomass	Below-ground biomass
1990	4.62	1.34	109.15	31.65
1991	4.62	1.34	109.15	31.65
1992	2.40	0.70	109.15	31.65
1993	2.51	0.73	109.15	31.65
1994	2.69	0.78	109.15	31.65
1995	2.93	0.85	109.15	31.65
1996	3.03	0.88	109.15	31.65
1997	3.44	1.00	109.15	31.65
1998	3.90	1.13	109.15	31.65
1999	6.99	2.03	109.15	31.65
2000	7.81	2.26	33.75	9.79
2001	8.70	2.52	33.75	9.79
2002	8.62	2.50	33.75	9.79
2003	9.59	2.78	33.75	9.79
2004	9.22	2.67	33.75	9.79
2005	8.07	2.34	33.75	9.79
2006	8.44	2.45	33.75	9.79
2007	7.07	2.05	33.75	9.79
2008	8.15	2.36	33.75	9.79
By 2008	112.80	32.71	1,395.24	404.62

11.4.2. Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

Temporary unstocked areas (e.g. harvested areas, disturbances) remain forests and not accounted as deforestation. The NFI team reports annually the data (for 1999–2008) on forest areas as forest area with forest and forest area without forest. The data on areas of deforestation taken place in 1990–1999 have been estimated based on satellite images, and the result still are being under development and will be improved by the next submission.

11.4.3. Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

The data on forest areas that have lost cover but which are not classified as deforested are under development and more precise information will be presented in the next submission.

11.5. Article 3.4

Estonia did not choose to account greenhouse gas emissions/removals from activities under Article 3.4 for the first commitment period.

11.6. Other information

11.6.1. Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

The key categories identified in UNFCCC inventory for the LULUCF sector were the result of a *tier 2* analysis. In order to identify key categories of the items under the Kyoto Protocol Article 3.3, the association between the LULUCF key categories and KP Article 3.3 should be carried out. However, Estonia still is developing datasets required to report the complete greenhouse gas inventory in the LULUCF sector and the datasets developed for KP Article 3.3 are being built into the database of the whole LULUCF sector, the estimation of key categories of KP Article 3.3 has not been provided in this submission. The identification of the key categories will be presented in the next submission.

11.7. Information relating to Article 6

Estonia has not implemented Joint Implementation projects that are LULUCF projects.

12. INFORMATION ON ACCOUNTING OF KYOTO UNITS

12.1. Background information

Standard Electronic Format report information correspond 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 v4.0" in "SEF_EE_2010_1_10_43-28 13-1-2010.xls". The Standard Electronic Format (hereinafter as SEF) report for 2009 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 second time (please see SEF_EE_2010_1_10-43-28 13-1-2010.xls). The SEF tables include information about AAU, ERU, CER, t-CER, l-CER and RMU in Estonian NR (standing 31st of December 2009). Also the SEF includes information on transfers of the units during the year 2009.

12.2. Summary of information reported in the SEF tables

The total number of AAU units in the registry at the beginning of the year 2009 was 197 210 637. In the end of the year the total balance of AAUs - 196 463 804 was distributed as following: 172 427 649 units were in the Party holding account; 10 483 580 units in the entity holding accounts; and 13 552 575 units in the Retirement account. The number of ERUs in registry corresponded to 44 934 (in entity holding accounts). The units of CERs in the registry corresponded to 957 (in entity holding accounts).

Estonian NR did not contain any RMUs, t-CERs or 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 SIAR 2009 report as Appendix 1.

12.3. Discrepancies and notifications

Discrepancies and notifications occurred in 2009 are reported in SIAR Reports 2010_EE v1.0.xls (also included in Estonian SIAR report 2009 as Appendixes 2-5).

The contents of the report can also be found as Annex 6 of this document.

12.4. Publicly accessible information

Following information is publicly accessible through the user interface of the registry web page (https://khgregister.envir.ee)

Account information (Information on paragraph 45 of the annex to the decision 13/CMP.1);
JI projects in Estonia (Information on paragraph 46 of the annex to the decision 13/CMP.1);
Information about unit holdings and transactions (Information on paragraph 47 of the annex to the decision 13/CMP.1);

Information about Entities Authorized to Hold Units (Information on paragraph 48 of the annex to the decision 13/CMP.1);

Information on paragraph 45 of the annex to the decision 13/CMP.1:
Information is available at NR web page:
https://khgregister.envir.ee (Selecting from the left hand menu “Public Reports”)

Information on paragraph 46 of the annex to the decision 13/CMP.1:
Information is available at Climate web:
http://www.keskkonnainfo.ee/index.php?lan=EE&sid=582&tid=525&l3=339&l2=323&l1=320

Information on paragraph 47 of the annex to the decision 13/CMP.1:
Information is available at NR web page:
https://khgregister.envir.ee (Selecting from the left hand menu “Public Reports”)

Information on paragraph 48 of the annex to the decision 13/CMP.1:

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 (Te 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 at Climate web:
http://www.keskkonnainfo.ee/index.php?lan=EE&sid=582&tid=525&l3=339&l2=323&l1=320

Public information required by Commission regulation (EC) No 2216/2004 (in addition to the above-mentioned public information):
Installation and permit details (available on the Estonian NR interface – Under "Public Reports": https://khgregister.envir.ee/);

Information about verified emissions, surrenders and compliance status of installations (On Estonian Environment Information Centre Climate web page: http://www.keskkonnainfo.ee/index.php?lan=EE&sid=352&tid=332&l2=326&l1=320 – available in Estonian);

National allocation plan for Estonia (NAP) (On Estonian Environment Information Centre Climate web page:
http://www.keskkonnainfo.ee/index.php?lan=EE&sid=352&tid=332&l2=326&l1=320 – available in Estonian).

Other public information is available in Estonian Environment Information Centre Climate web page (in Estonian and in English)
(http://www.keskkonnainfo.ee/index.php?lan=EE&sid=582&tid=525&l3=339&l2=323&l1=320)
Allocated allowances vs. verified emissions (On Estonian Environment Information Centre Climate web page:

http://www.keskkonnainfo.ee/index.php?lan=EE&sid=352&tid=332&l2=326&l1=320 – available in Estonian).

12.5. Calculation of the commitment period reserve (CRP)

The commitment period reserve is 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 2008. This would mean that five times the emissions from the total inventory of 2008 would be lower, than 90% of the assigned amount. This would give an estimated commitment period reserve of **101,267,900 tonnes CO2 eq**.

20253.58 x 5 = 101267.9 Gg CO2 = 101 267 900 t CO2

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.

The net emissions due to ARD activities under Article 3.3 of the KR were equalled to 6,065.98 CO_2 Gg by 2008 in Estonia.

Table 12.1. Calculation of accounting quantities for activities under Article 3, paragraphs 3 and 4

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net emissions/removals, Mt CO_2 equivalent							Accounting limit	Accounting quantity
	BY	**2008**	**2009**	**2010**	**2011**	**2012**	**Total**		
A. Article 3.3 activities									
A.1. Afforestation and Reforestation									-533.52
A.1.1. Units of land not harvested since the beginning of the commitment period		-533.52							-533.52
A.1.2. Units of land harvested since the beginning of the commitment period		NE							NA
A.2. Deforestation		6,599.51							6,599.51
B. Article 3.4 activities									
B.1. Forest management		NO	NO	NO	NO	NO	NO	NA	NA

B.2. Cropland management		NO	NO	NO	NO	NO	NO	NA	NA
B.3. Grazing land management		NO	NO	NO	NO	NO	NO	NA	NA
B.4. Revegeneration		NO	NO	NO	NO	NO	NO	NA	NA

13. INFORMATION ON CHANGES IN NATIONAL SYSTEM

There has been changes in Estonia's National Inventory System. Starting from 2010 submission Estonian Environmental Research Centre is in charge of the inventory data of the Waste sector (see Figure 1.1). Previously TUT was preparing the estimates for the Waste sector.

14. INFORMATION ON CHANGES IN NATIONAL REGISTRY

During autumn 2009 the Estonian Environment Information Centre changed the software used for the Estonian emissions trading registry. The decision for the registry software change was based on need to have it more supported and user-friendly software into use. Software what was used till that time was called GRETA (developed by the Defra – Department for Environment, Food and Rural Affairs of United Kingdom) and it was changed against CR (developed by the European Commission). From the Estonian registry point of view, the CR software has some preferable qualities over the previously used Greta software. For example, the user interface of the CR software is more user-friendly and certain repetitive operations are more easy and flexible to carry out.

Whereas Greta software was a closed system (apart from the user interface components) based on .NET and Microsoft technologies (MS IIS and MS SQL database), the CR is open-source software (based on J2EE, using Web Logic and Oracle database), provided free-of-charge for European Union members states.

Due to the fact, that the CR software is open source, all developments and fixes carried out by other registries for the CR software are freely available for other registries as well. The access to the source code of the software also enables more efficient problem solving and localizations.
In addition, some of the heaviest functionalities related to registry activities, which require a lot of processing, are more optimized in CR software, thus making it easier to perform these activities.

Currently only the user interface of the Estonian registry is localized to Estonian language. No further localizations are planned at this time.

The process of changing the registry software from Greta software to CR registry included the following high-level steps:

1) creating the needed migration scripts, in order to transfer the registry database as fully as possible from Greta to CR;
2) testing the CR internally (including the language term changes;

3) validating the migrated data in the localized CR software. Due to the comprehensive changes between Greta and CR software, not all data could be migrated from Greta to CR. However, the data that could not be migrated, was stored, and can be accessed by the EE registry admin at any time;
4) completing the official ITL and CITL acceptance tests (Annex H and ETS test, respectively) with the CR software;
5) performing the Go-live migration for the production registry instance.

More detailed information is reported in Estonian SIAR 2009 report.

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

15.1. Information on how the 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 not Administrative Member State for any aircraft operators from third countries but this might change in the future. 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.

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 priorities of development 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.

In 2008 Estonia supported the following projects:

- Promoting integrated transboundary water management and stakeholder participation in Moldova with the help of Estonian expertise (20,365 EUR);
- Estonian-Moldovan co-operation project on forestry database development (2,342 EUR)
- Transfer of Estonian experience in establishing innovation support structures and making the technology transfer function to Georgian civil servants, representatives of research and development institutions and private enterprises (63,819 EUR)

Other method of supporting developing countries is through support of international environmental organisations – the United Nations Environment Programme and the Global

Environment Fund – in their activities in supporting environmentally friendly development in developing countries.

In 2008 the contributions for these projects were 32,820 EUR and for 2009 the contribution is estimated to be 27,918 EUR.

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, excluding 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 is 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. Estonia has already introduced the tax on shale oil.

Also 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. Estonia imposed excise duty on natural gas on 1 January 2008.
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 throuh 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 has been 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 reseach for of enhancing technologies that emit less greenhouse gases 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 contributes 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).

16. OTHER INFORMATION

16.1. Information of implementation of flexible mechanisms of Kyoto Protocol

Information from the national registry, once established, on the issue, acquisition, holding, transfer, cancellation, withdrawal and carryover of assigned amount units, removal units, emission reduction units and certified emission reductions during the previous year (year x-1);

The European Commission, Member States and the secretariat of the UNFCCC completed the live connection between the CITL, the UNFCCC International Transaction Log (ITL) and Member State registries on 16th of October 2008, Estonia included. Estonia issued after establishing the live connection pursuant to Article 3.7 and 3.8 Kyoto units. More detailed information about year 2009 Kyoto unit holdings, transfers, cancellations, etc is available in report "SEF_EE_2010_1_10-43-28 13-1-2010" (submitted as a part of annual inventory).

Information on legal entities authorized to participate in mechanisms under Articles 6 (JI), 12 (CDM) and 17 (IET) of the Kyoto Protocol, in compliance with relevant national or Community provisions;

Estonian 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.

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