GREENHOUSE GAS EMISSIONS IN ESTONIA 1990–2006

NATIONAL INVENTORY REPORT

to the UNFCCC secretariat

Common Reporting Formats (CRF)
1990-2006

Tallinn 2008

PREFACE

Estonian National Inventory Report under the UNFCCC (United Framework Convention on Climate Change) 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 organisation of the national greenhouse gas inventory, IPCC and other methods applied in calculation of the year 2006 emissions and exemptions to the previous inventories. A summarising table of the emissions data for the years 1990-2006 is included as well as description of the current emission trends.

Part II. CRF (Common Reporting Format) data tables of Estonian updated greenhouse gas emission inventories for the years 1990-2006. The CFR tables are compiled with the UNFCCC CRF Reporter software (version 3.2).

Methodological improvements in accordance with the IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories and changes since the inventory submission in 2006 are listed in Chapter 7.

Department of Thermal Engineering (Inge Roos), Department of Chemistry at Tallinn University of Technology (Olga Gavrilova) and Estonian Environmental Research Centre 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-ordinates the process of the inventory preparation.

The Ministry of the Environment is responsible for the finalisation of inventory reports and their submission to the UNFCCC Secretariat and the EC Commission.

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EXECUTIVE SUMMARY

ES.1. 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. Under the Protocol Estonia is obliged to reduce during the period 2008-1012 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.

Single national entity with overall responsibility for the Estonian greenhouse gas inventory is the Estonian Ministry of the Environment. Financial resources are planned in the State Budget. Practical work is done on the basis of contracts. The Institute of Ecology at Tallinn University has been responsible for the inventories under contract to the Ministry of the Environment in Estonia until summer 2006. The 2007 GHG inventory was prepared by 2 departments of Tallinn University of Technology (Department of Thermal Engineering and Department of Chemistry) and Climate and Ozone Bureau of Estonian Environment Information Centre co-ordinated the process. The 2008 inventory is produced in collaboration between the Ministry of the Environment, Estonian Environment Information Centre, Tallinn University of Technology and Estonian Environmental Research Centre.

This report presents the national inventory of greenhouse gas (GHG) emissions and removals from 1990 to 2006. The components covered are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O). Data on F-gases - hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) – is partly provided. 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.

In this submission, which reports carbon stock changes and greenhouse gas emissions from LULUCF that occurred in 2006, Estonia has used the new UNFCCC reporting guidelines on annual inventories (FCCC/SBSTA/2004/8) and GPG LULUCF (IPCC 2003) for the third time. The earlier period (1990–2003) has been reported by using previous version of CRF tables (corresponding to 3/CP.5) and methods (IPCC 1997). The whole LULUCF-sector reporting is under ongoing development and will be more complete in forthcoming submissions.

The main sources of data were the Statistical Yearbooks and other publications issued by the Statistical Office of Estonia. Unfortunately the availability and reliability of data from different sectors differs, especially for the first years of independence regained in 1991. During the last 10 years Estonia has made great efforts in all directions, including in order increasing the reliability of statistical 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 3.2). The methodology used in calculations of emissions is harmonised 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 methodology is described in detail in the *Estonia's Third National Communication* (2001) and *Estonia's Fourth National Communication* (2006).

The national inventory and reporting system is being constantly developed and improved.

ES.2. Summary of trends in national emissions and removals

By 2005, Estonia reduced its emissions by 53.57% in comparison to the base year. This drastic decrease was mainly caused by the transition from planned economy to market economy and successful implementation of necessary reforms.

In 2006 the total emission of GHGs, measured as CO_2-equivalents, was 15 404.77 Gg, without CO_2 from LUCF 18 876.18 Gg. From 1990 to 2006 the emissions decreased by 54.62%. Table ES2_1 shows the trends in the total emissions during the period 1990–2006.

In 2006, the most important GHG in Estonia was carbon dioxide (CO_2), contributing 84.61 per cent to total national GHG emissions expressed in CO_2 equivalent, followed by methane (CH_4), 10.58 per cent, and nitrous oxide (N_2O), 4.41 per cent. Fluorocarbons (so-called "F gases") account for about 0.40 per cent of total emissions. The Energy sector accounted for 86.41 per cent of total GHG emissions, followed by Agriculture (6.37 per cent), Waste (3.75 per cent) and Industrial Processes (3.47 per cent).

Table ES2_1. Greenhouse-gas emissions in Estonia – changes with regard to the base year

GHG EMISSIONS	Base year	1990	1995	2000	2001	2002	2003	2004	2005	2006
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	30 979,59	30 979,59	13 567,71	17 352,39	15 530,02	15 666,06	15 254,79	12 813,20	12 062,08	12 489,41
CO_2 emissions excluding net CO_2 from LULUCF	36 358,28	36 358,28	17 749,10	15 278,71	15 454,86	15 154,31	16 938,96	17 103,37	16 488,71	15 971,84
CH_4 emissions including CH_4 from LULUCF	3 190,80	3 190,80	1 973,35	1 959,95	2 001,04	1 866,15	1 926,13	2 011,90	1 998,53	2 006,70
CH_4 emissions excluding CH_4 from LULUCF	3 186,04	3 186,04	1 971,89	1 956,83	2 000,00	1 860,07	1 925,24	2 010,29	1 998,12	1 996,70
N_2O emissions including N_2O from LULUCF	2 048,74	2 048,74	1 081,43	1 005,16	842,96	881,70	814,41	911,11	812,63	832,68
N_2O emissions excluding N_2O from LULUCF	2 048,25	2 048,25	1 081,28	1 004,84	842,85	881,09	814,32	910,95	812,59	831,66
HFCs	NA,NO	NA,NO	0,13	4,19	4,89	5,68	6,59	7,21	7,88	75,18
PFCs	NA,NO	NA,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
SF_6	NA,NO	NA,NO	0,25	1,43	2,24	3,68	4,75	5,28	5,87	0,80
Total (including LULUCF)	**36 219,13**	**36 219,13**	**16 622,86**	**20 323,11**	**18 381,15**	**18 423,27**	**18 006,66**	**15 748,71**	**14 886,99**	**15 404,77**
Total (excluding LULUCF)	**41 592,57**	**41 592,57**	**20 802,64**	**18 246,01**	**18 304,84**	**17 904,83**	**19 689,86**	**20 037,10**	**19 313,17**	**18 876,18**

GHG SOURCE AND SINK CATEGORIES	Base year	1990	1995	2000	2001	2002	2003	2004	2005	2006
	CO_2 equivalent (Gg)									
1. Energy	36 742,15	36 742,15	17 971,78	15 502,78	15 685,10	15 492,91	17 289,02	17 428,60	16 859,64	16 310,97
2. Industrial Processes	945,59	945,59	568,92	587,64	612,05	423,50	467,64	579,95	559,19	655,61
3. Solvent and Other Product Use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4. Agriculture	3 225,37	3 225,37	1 574,65	1 289,43	1 254,99	1 171,58	1 198,63	1 212,15	1 189,07	1 201,66
5. Land Use, Land-Use Change and Forestry(5)	-5 373,45	-5 373,45	-4 179,78	2 077,11	76,32	518,44	-1 683,20	-4 288,39	-4 426,18	-3 471,41
6. Waste	679,47	679,47	687,28	866,15	752,69	816,83	734,57	816,40	705,27	707,95

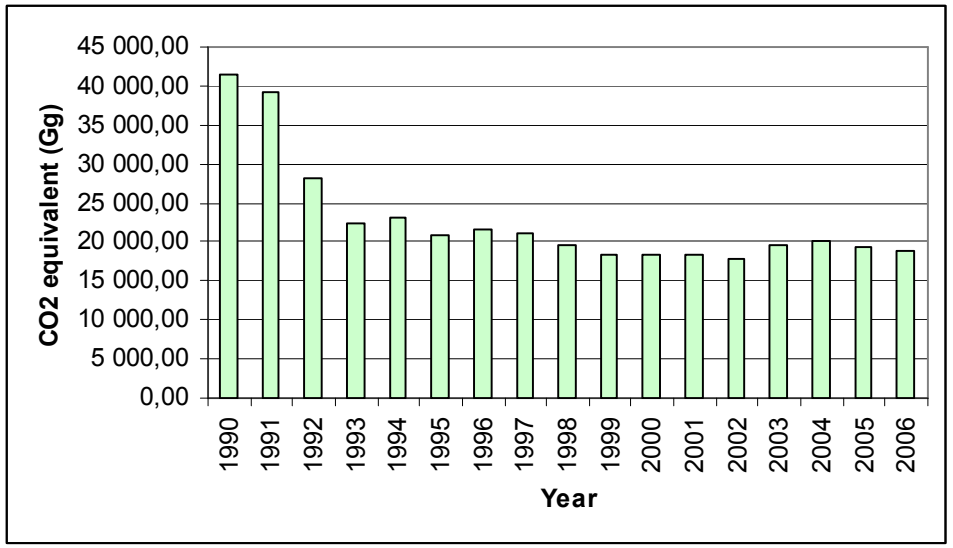


Figure ES2_1. Overall development of greenhouse gases in Estonia, in CO2 equivalents (without CO2 from LULUCF)

Table ES2_2. Greenhouse-gas emissions in Estonia – annual contributions of the various greenhouse gases

GHG EMISSIONS [CO2 equivalent (Gg)]	Base year		1990		1995		2000		2005		2006	
	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]
CO_2 emissions excluding net CO_2 from LULUCF	**36 358,28**	87,42	**36 358,28**	87,42	**17 749,10**	85,32	**15 278,71**	83,74	**16 488,71**	85,38	**15 971,84**	84,61
CH_4 emissions excluding CH_4 from LULUCF	**3 186,04**	7,66	**3 186,04**	7,66	**1 971,89**	9,48	**1 956,83**	10,72	**1 998,12**	10,35	**1 996,70**	10,58
N_2O emissions excluding N_2O from LULUCF	**2 048,25**	4,92	**2 048,25**	4,92	**1 081,28**	5,20	**1 004,84**	5,51	**812,59**	4,21	**831,66**	4,41
HFCs	**NA,NO**		**NA,NO**		**0,13**	0,001	**4,19**	0,02	**7,88**	0,04	**75,18**	0,40
PFCs	**NA,NO**		**NA,NO**		**NA,NE,NO**		**NA,NE,NO**		**NA,NE,NO**		**NA,NE,NO**	
SF_6	**NA,NO**		**NA,NO**		**0,25**	0,001	**1,43**	0,01	**5,87**	0,03	**0,80**	0,004
Total (excluding LULUCF)	**41 592,57**		**41 592,57**		**20 802,64**		**18 246,01**		**19 313,17**		**18 876,18**	

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 ES3_1 shows the contributions of individual source and sink categories to total greenhouse-gas emissions.

Over the period 1990–2006, emissions from the Energy sector decreased by 55.61 per cent, emissions from the Industrial Processes and Agriculture sectors decreased by 30.67 per cent and 62.74 per cent, respectively, and the Waste sector increased 4.19 per cent. Reported net CO_2 removals in the Land-use Change and Forestry (LUCF) sector decreased by 35.4 per cent between 1990 and 2006.

In comparison to the previous year, 2005, total emissions decreased by 2.26 per cent.

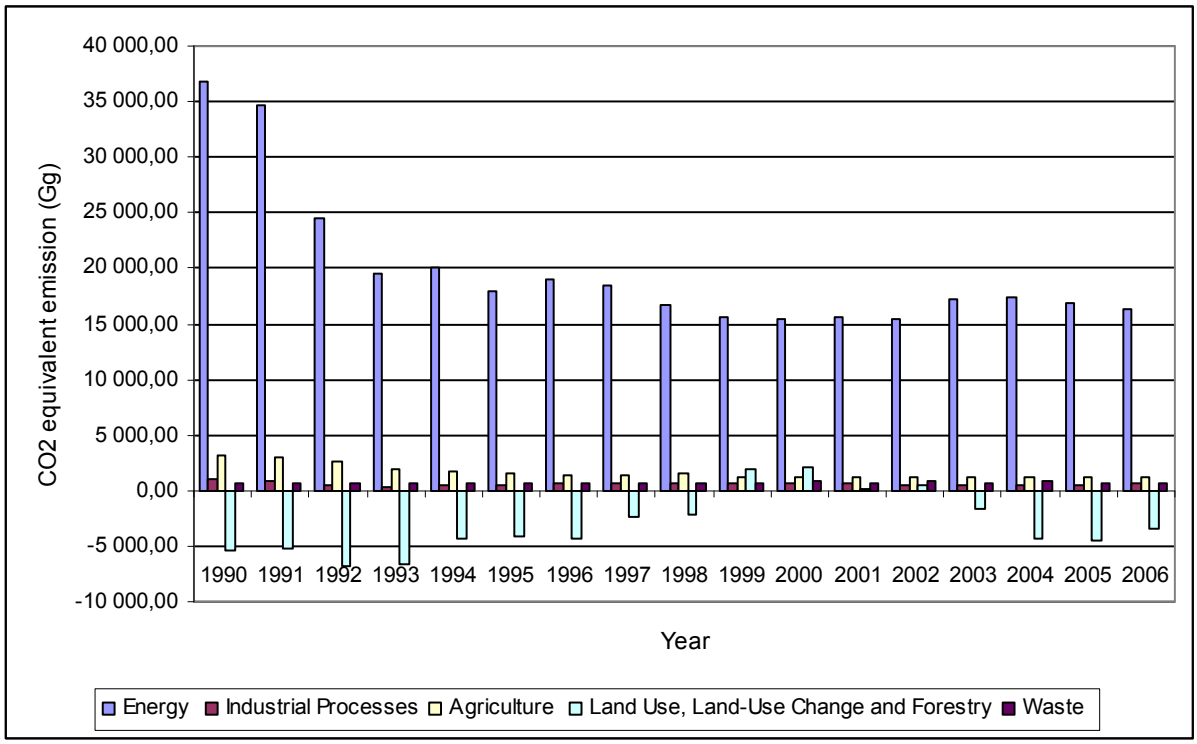


Figure ES3_1. Greenhouse-gas emissions trends, by source groups, in CO2 equivalents

On 30th of April 2004 Estonian Government approved the National Program for reduction of Greenhouse Gas Emissions for years 2003-2012.

CHAPTER 1. INTRODUCTION

1.1. Background and institutional arrangement

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.

The Ministry of the Environment organises the practical providing of GHG inventories and is the designated single national entity. The national inventory compiler is the Climate and Ozone Bureau at the Estonian Environment Information Centre (EEIC). Financial resources for GHG inventory are planned in the State Budget. Practical work has been done on the basis of contracts. The Tallinn Technical University and Estonian Environment Research Centre are responsible for the inventories under contract to the Ministry of the Environment in Estonia. The Ministry of the Environment has signed an agreement with the Tallinn Technical University that sets out the mutual cooperation directions in the field of climate change, including greenhouse gas inventory compilation for 5 years. The Department of Thermal Engineering is responsible for preparing the emission estimates for the energy sector and the Department of Chemistry is responsible for the agriculture, waste and LULUCF sectors. The contract agreement with the Estonian Environmental Research Centre was concluded in 2007 for one year, wherewith the Estonian Environmental Research Centre obligates to compile the industrial processes sector in Estonia's GHG inventory and sets out the base for F-gases section in the inventory.

This report presents the national inventory of greenhouse gas (GHG) emissions and removals from 1990 to 2006. The components covered are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Also reported are four indirect greenhouse gases: nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2).

The structure of this report corresponds to the UNFCCC reporting guidelines on annual inventories 2004 (FCCC/SBSTA/2004/8). Chapter 1 gives an introduction to the background of greenhouse gas inventories and the arrangement for inventory preparation. Chapters 2-6 give information of GHG emission trends from the base year 1990 to year 2006 for the following sectors: energy; industrial processes; agriculture; land use, land-use change and forestry; waste. A number of (methodological) changes have been implemented in the NIR 2008 relative to the NIR of the preceding year. A detailed overview of these changes is provided in Chapter 7. Annex 1 contains QC checklists, in Annex 2 the assessment of completeness is described and Annexes 3-7 includes additional information for the Energy, Industrial Processes, Agriculture, LULUCF and Waste sectors. Annex 8 includes uncertainty analysis (in excel form), Annex 9 includes a list of annual indicators (in excel form) and Annex 10 includes the Table for methodologies, data sources and emission factors (in excel form). Annex 11 includes the supplementary information on land use, land use change and forestry (LULUCF) activities under Article 3.3 and Article 3.4 of the Kyoto Protocol.

1.2. Brief description of the process of inventory preparation

Estonian 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.

1.2.1. Estonian Greenhouse Gas National Inventory System (NIS)

The inventory phases are:

- collecting activity data;
- selecting methods and emission factors appropriately;
- estimating anthropogenic GHG emissions by sources and removals by sinks;
- implementing uncertainty assessment;
- implementing QA/QC activities;
- verification of the inventory data at the national level.

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) and Tallinn University of Technology (TUT). The Estonian Environmental Research Centre (EERC) is also involved since 2007.

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, etc);
- 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, Industrial Processes, Agriculture, Waste and LULUCF sectors. They 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. The EERC is responsible for the industrial process sector together with the fluorinated gases estimates in the 2008 inventory preparation.

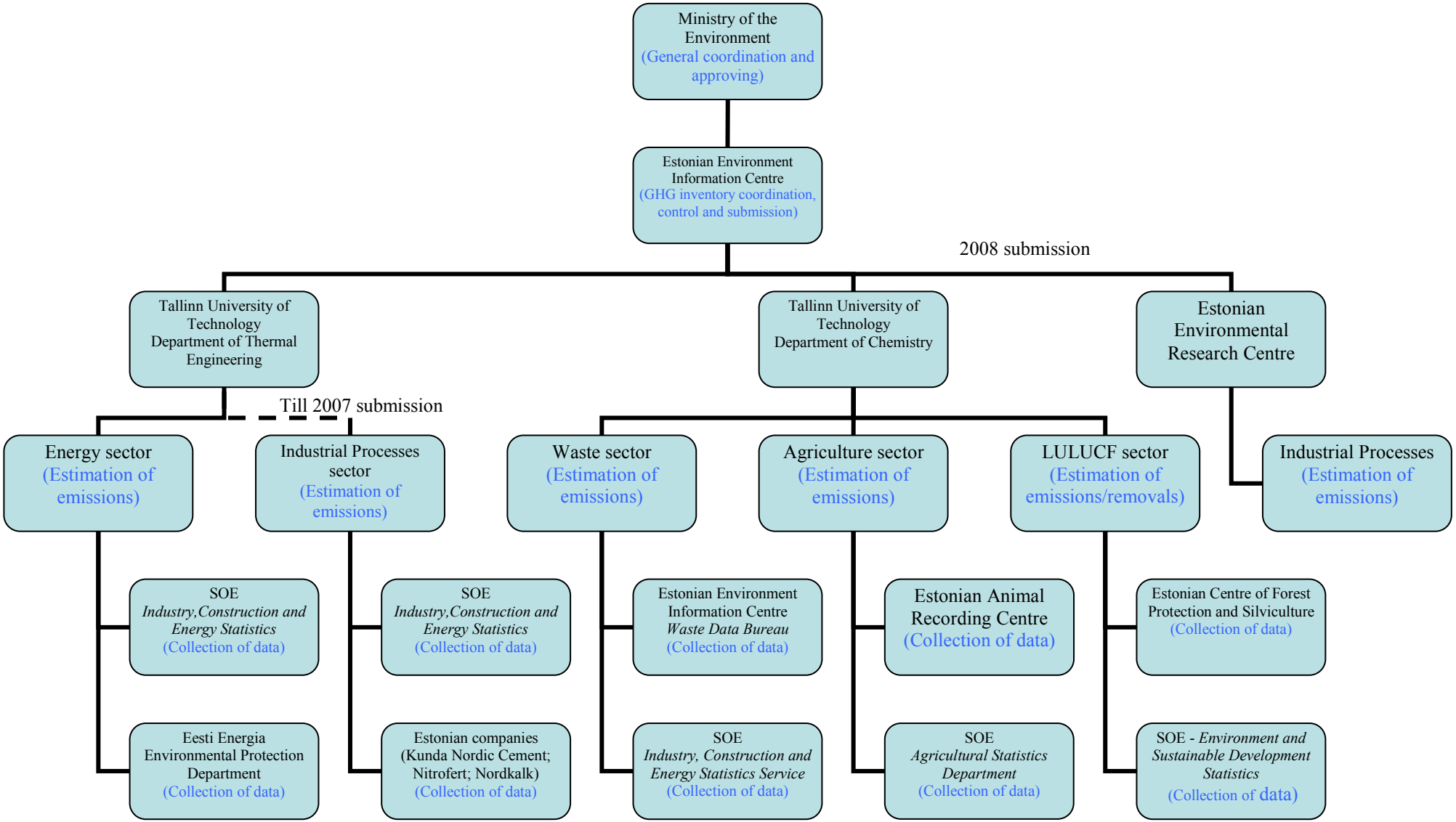
The MoE has signed an agreement with TUT and EERC. Through these agreements, the institutions are committed to implement the QA/QC, uncertainty analysis and archiving procedures, documentation, making information available for review, and delivering data and information in a timely manner to meet the deadline for reporting to the UNFCCC.

The four core institutions: MoE, EEIC, EERC and TUT 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) 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. Structure of the National Inventory System



Methodological improvements in accordance with the "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories", "Revised 2000 IPCC Guidelines for National Greenhouse Gas Inventories" and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, and according to the recommendations by the Expert Review Teams, have been implemented in the present inventory as far as possible and will be implemented in their entirety as soon as possible.

The estimation of GHG emissions in Estonia is based on Intergovernmental Panel on Climate Change (IPCC 1996, 2000) tier 1 and tier 2 methods, default emission factors (EFs) and available Estonian data.

In deriving emissions/removals estimates for LULUCF IPCC *Good Practice Guidance for Land Use, Land-use Change and Forestry* (LULUCF) (hereinafter referred to as the IPCC good practice guidance for LULUCF) and the requirements of decision 14/CP.11 were accounted.

1.3. Database information and methodologies

More detailed description of the methodologies and activity data sources is presented in the "Estonia's fourth National Communication" which is also available in the UNFCCC website.

Main data sources used in current inventory are given in Table 1.1.

Table 1.1. Methodology, activity data and emission factor sources used

IPCC category	Methodology [1]	Emission factor [1]	Activity data
1. Energy	Revised 1996 IPCC methodology; IPCC good practice guidance	Revised 1996 IPCC methodology	Statistics Estonia (SE) and energy companies (AS Eesti Energia, AS Eesti Põlevkivi)
A. Fuel Combustion	T_1, T_2	D, CS	Energy balances and Annual Yearbooks of Statistics Estonia; data of energy companies
B. Transport	T_1	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		Plant specific data
A. Mineral Industry	CS,T_1	CS, D	Statistical Yearbooks; Plant specific data
B. Chemical industry	$T_{1,a}$, T_{1b}	CS	Plant specific data
C. Consumption of halocarbons and SF_6	CS,T_1	CS	Statistical database
4. Agriculture	Revised 1996 IPCC methodology, IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories	Revised 1996 IPCC methodology, IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories	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	D	Estonian statistics; IPCC default parameters
5. LUCF	Revised 1996 IPCC methodology IPCC good practice guidance for LULUCF	Revised 1996 IPCC methodology	
A. Forest land	T_1	CS, D	Statistical Office of Estonia, Estonia forest 2005; Forest Resources Assessment 2005
B. Croplands	NA	NA	
C. Grassland	NA	NA	
D. Wetlands	NA	NA	
E. Settlements	NA	NA	

6. Waste	Revised 1996 IPCC methodology, IPCC 2006	Revised 1996 IPCC methodology, IPCC 2006	
A. Solid Waste Disposal on Land	T_1	D	Estonian Evironment Information Center; Estonian Office of Statistics.
B. Wastewater Handling	T_1	D	Estonian Evironment Information Center; Estonian Office of Statistics.
C. Waste Incineration	T_1	D	

T_1 –IPCC Tier 1; T_2 –IPCC Tier 2; IPCC – IPCC default factors; CS – Country specific; NE – not applicable

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. This data is often too general and inadequate. The availability and reliability of data from different sectors differs, especially for the first years of regained independence from 1991 onward. It is practically not possible to revise estimates for 1990 because at that time absolutely different system of the statistic was practizised. Emissions for the base year are not overestimated but are most probably underestimated. In 1990 in Estonia were a huge amount of Soviet troops and in the inventory were not included emissions from military sources.

General (Tier 1) Quality Control (QC) procedures were applied to all categories as following:

- Activity data were compiled and gross-checked.
- The default factors were used.
- All units were checked

The Estonian inventory also includes carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs) and sulphur oxides (SO_2). Sulphur gases – primarily SO_2 – are believed to contribute negatively to the greenhouse effect.

Estonia has prepared already four climate reports. The Fourth National Communication covers the GHG inventories of the years 1990 to 2004 including also the years for which inventories have been reported earlier and have been recalculated in 2002. The purpose of all recalculations was to improve the accuracy and completeness. Now, the inventory of all years up to 2006 is estimated using the same methodology, adjusted statistical data and emission factors.

1.4. Brief description of key source categories

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 2006), the trend of emissions (change between 1990 and 2006) or both. There are two alternative methods for identifying key categories: Tier 1 and Tier 2. In this report Tier 1 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 95% of inventory level or trend.

Table 1.2 Key sources in 2006. Level Assessment (without LULUFC)

IPCC code	IPCC source category	Fuel	Gas	1990, Gg CO_2 eq	2006, Gg CO_2 eq	Contribution to Level	Cumulative Total
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO_2	21044.63	9064.40	48.01%	**48%**
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO_2	2544.32	1973.04	10.45%	**58%**
1 A 3 b	Road Transportation	Diesel oil	CO_2	674.97	1174.27	6.22%	**65%**
1 A 3 b	Road Transportation	Gasoline	CO_2	1462.15	924.95	4.90%	**70%**
1 A 1 b	Petroleum refining	Solid Fuels	CO_2	369.33	656.61	3.48%	**73%**
6.A.1.	Managed Waste Disposal on Land		CH_4	607.53	551.52	2.92%	**76%**
1 B 2 b	Natural Gas	Gaseous Fuels	CH_4	787.22	519.34	2.75%	**79%**
4.A.	Enteric Fermentation: Cattle (CH4)		CH_4	1052.41	416.00	2.20%	**81%**
2 A 1	Mineral Products/Cement Production	Cement Production	CO_2	483.08	413.65	2.19%	**83%**
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO_2	4825.04	408.99	2.17%	**85%**
1 A 2 f	Other	Solid Fuels	CO_2	792.94	286.74	1.52%	**87%**
1 B 1 a	Solid Fuels /Coal Mining	Solid Fuels	CH_4	407.69	262.08	1.39%	**88%**
4.D.3.2.	Nitrogen Leaching and Run-off		N_2O	467.78	159.28	0.84%	**89%**
4.D.1.5	Cultivation of Histosols		N_2O	166.39	144.19	0.76%	**90%**
1 A 3 c	Railways	Liquid Fuels	CO_2	143.06	135.84	0.72%	**91%**
2 B 1	Chemical Industry/Ammonia Production	Ammonia Production	CO_2	317.16	134.79	0.71%	**91%**
1 A 3 e	Other Transportation	Liquid Fuels	CO_2	451.30	134.64	0.71%	**92%**

4.D.1.1.	Synthetic Fertilizers		N_2O	353.65	123.91	0.66%	**93%**
1 A 2 f	Other	Liquid Fuels	CO_2	324.01	121.22	0.64%	**93%**
1 A 4 b	Residential	Gaseous Fuels	CO_2	118.06	106.45	0.56%	**94%**
1 A 2 f	Other	Gaseous Fuels	CO_2	101.20	105.92	0.56%	**94%**
4.D.1.2.	Animal Manure Applied to Soils		N_2O	300.55	99.17	0.53%	**95%**

Table 1.3 Key sources in 2006. Trend Assessment (without LULUFC)

IPCC code	IPCC source category	Fuel	Gas	1990, Gg CO_2 eq	2006, Gg CO_2 eq	Contribution to Trend	Cumulative Total
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO2	4825.04	408.99	24.02%	24%
1 A 3 b	Road Transportation	Diesel oil	CO2	674.97	1174.27	11.70%	36%
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO2	2544.32	1973.04	11.03%	47%
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO2	21044.63	9064.40	6.60%	53%
1 A 1 b	Petroleum refining	Solid Fuels	CO2	369.33	656.61	6.59%	60%
6.A.1.	Managed Waste Disposal on Land		CH4	607.53	551.52	3.72%	64%
1 A 3 b	Road Transportation	Gasoline	CO2	1462.15	924.95	3.52%	67%
1 A 4 b	Residential	Solid Fuels	CO2	699.69	74.83	3.27%	70%
1 A 4 b	Residential	Liquid Fuels	CO2	547.06	28.85	2.96%	73%
1 A 2 e	Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	438.64	3.11	2.64%	76%
2 A 1	Mineral Products/Cement Production	Cement Production	CO2	483.08	413.65	2.62%	79%
1 B 2 b	Natural Gas	Gaseous Fuels	CH4	787.22	519.34	2.18%	81%
4.B.	Manure Management (N2O)		N2O	344.46	46.20	1.49%	82%
1 B 1 a	Solid Fuels /Coal Mining	Solid Fuels	CH4	407.69	262.08	1.04%	83%
1 A 2 f	Other	Solid Fuels	CO2	792.94	286.74	0.99%	84%
1 A 3 c	Railways	Liquid Fuels	CO2	143.06	135.84	0.96%	85%
1 A 3 e	Other Transportation	Liquid Fuels	CO2	451.30	134.64	0.95%	86%
4.D.1.5	Cultivation of Histosols		N2O	166.39	144.19	0.93%	87%
6.D	Biological treatment		N2O	0.66	62.35	0.84%	88%
4.A.	Enteric Fermentation: Cattle (CH4)		CH4	1052.41	416.00	0.83%	89%
1 A 4 b	Residential	Biomass	CH4	33.67	76.27	0.82%	90%
1 A 2 f	Other	Gaseous Fuels	CO2	101.20	105.92	0.81%	91%
6.D	Biological treatment		CH4	0.60	56.31	0.76%	91%
4.D.3.2.	Nitrogen Leaching and Run-off		N2O	467.78	159.28	0.72%	92%
1 A 4 b	Residential	Gaseous Fuels	CO2	118.06	106.45	0.71%	93%
2 F 2	Foam Blowing		HFC	0.00	43.25	0.58%	93%
4.D.1.2.	Animal Manure Applied to Soils		N2O	300.55	99.17	0.50%	94%
4.D.1.1.	Synthetic Fertilizers		N2O	353.65	123.91	0.49%	94%
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO2	145.36	31.19	0.47%	95%

Table 1.4 Key sources in 2006. Level Assessment (with LULUFC)

IPCC code	IPCC source category	Fuel	Gas	1990, Gg CO_2 eq	2006, Gg CO_2 eq	Contribution to Level	Cumulative Total
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO2	21044.63	9064.40	40.51%	41%
			CO2	-5378.69	-3482.43	15.56%	56%
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO2	2544.32	1973.04	8.82%	65%
1 A 3 b	Road Transportation	Diesel oil	CO2	674.97	1174.27	5.25%	70%
1 A 3 b	Road Transportation	Gasoline	CO2	1462.15	924.95	4.13%	74%
1 A 1 b	Petroleum refining	Solid Fuels	CO2	369.33	656.61	2.93%	77%
6.A.1.	Managed Waste Disposal on Land		CH4	607.53	551.52	2.46%	80%
1 B 2 b	Natural Gas	Gaseous Fuels	CH4	787.22	519.34	2.32%	82%
4.A.	Enteric Fermentation: Cattle (CH4)		CH4	1052.41	416.00	1.86%	84%
2 A 1	Mineral Products/Cement Production	Cement Production	CO2	483.08	413.65	1.85%	86%
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO2	4825.04	408.99	1.83%	88%
1 A 2 f	Other	Solid Fuels	CO2	792.94	286.74	1.28%	89%
1 B 1 a	Solid Fuels /Coal Mining	Solid Fuels	CH4	407.69	262.08	1.17%	90%
4.D.3.2.	Nitrogen Leaching and Run-off		N2O	467.78	159.28	0.71%	91%
4.D.1.5	Cultivation of Histosols		N2O	166.39	144.19	0.64%	91%
1 A 3 c	Railways	Liquid Fuels	CO2	143.06	135.84	0.61%	92%
2 B 1	Chemical Industry/Ammonia Production	Ammonia Production	CO2	317.16	134.79	0.60%	93%
1 A 3 e	Other Transportation	Liquid Fuels	CO2	451.30	134.64	0.60%	93%
4.D.1.1.	Synthetic Fertilizers		N2O	353.65	123.91	0.55%	94%
1 A 2 f	Other	Liquid Fuels	CO2	324.01	121.22	0.54%	94%
1 A 4 b	Residential	Gaseous Fuels	CO2	118.06	106.45	0.48%	95%

Table 1.5 Key sources 2006. Trend Assessment (with LULUFC)

IPCC code	IPCC source category	Fuel	Gas	1990, Gg CO_2 eq	2006, Gg CO_2 eq	Contribution to Trend	Cumulative Total
5 A 1	Forest Land remaining Forest Land		CO2	-5378.69	-3482.43	45.32%	45%
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO2	4825.04	408.99	12.90%	58%
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO2	2544.32	1973.04	7.01%	65%
1 A 3 b	Road Transportation	Diesel oil	CO2	674.97	1174.27	6.97%	72%
1 A 1 b	Petroleum refining	Solid Fuels	CO2	369.33	656.61	3.93%	76%
1 A 3 b	Road Transportation	Gasoline	CO2	1462.15	924.95	2.38%	79%
6.A.1.	Managed Waste Disposal on		CH4	607.53	551.52	2.30%	81%

	Land						
1 A 4 b	Residential	Solid Fuels	CO2	699.69	74.83	1.75%	83%
2 A 1	Mineral Products/Cement Production	Cement Production	CO2	483.08	413.65	1.64%	84%
1 A 4 b	Residential	Liquid Fuels	CO2	547.06	28.85	1.60%	86%
1 B 2 b	Natural Gas	Gaseous Fuels	CH4	787.22	519.34	1.45%	87%
1 A 2 e	Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	438.64	3.11	1.44%	89%
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO2	21044.63	9064.40	0.95%	90%
4.B.	Manure Management (N2O)		N2O	344.46	46.20	0.79%	90%
1 B 1 a	Solid Fuels /Coal Mining	Solid Fuels	CH4	407.69	262.08	0.70%	91%
1 A 3 c	Railways	Liquid Fuels	CO2	143.06	135.84	0.59%	92%
4.D.1.5	Cultivation of Histosols		N2O	166.39	144.19	0.58%	92%
1 A 2 f	Other	Gaseous Fuels	CO2	101.20	105.92	0.49%	93%
6.D	Biological treatment		N2O	0.66	62.35	0.49%	93%
1 A 4 b	Residential	Biomass	CH4	33.67	76.27	0.49%	94%
1 A 3 e	Other Transportation	Liquid Fuels	CO2	451.30	134.64	0.45%	94%
1 A 4 b	Residential	Gaseous Fuels	CO2	118.06	106.45	0.44%	95%

1.5. Information about the QA/QC plan including verification and treatment of confidentiality issues

1.5.1. Quality Assurance and Quality Control (QA/QC)

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.

During preparation of the Estonian 2006 national greenhouse gases (GHG) inventory, "Estonia's National Greenhouse Gas Inventory Quality Control Plan" was implemented. Specific checks were completed.

Quality assurance/quality control plan is under development. General (Tier 1) Quality Control (QC) procedures are applied to all categories as following:

- activity data are compiled and gross-checked;

- mostly default factors are used;
- all units are checked.

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.

1.5.2. QA procedures implemented

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. Quality Assurance checklists are presented in Annex 12.

Also public review was carried out this year. The draft NIR was uploaded to the EEIC website www.keskkonnainfo.ee where all interested parties had an opportunity to comment on it. The public reviews of the draft document offer a broader range of researchers and practitioners in non-governmental organizations, industry and academia, as well as the general public, the

opportunity to contribute to the final document. The comments received during these processes were 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.

1.5.3. QC procedures implemented

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 sectoral experts from TUT and EERC are collecting data for the national inventory. The current system complies with the Tier 1 procedures outlined in the Good Practice Guidance (IPCC, 2000). The Tier 1 QC checks for key sources are carried out and individual source category checklists are produced. Also assessment of completeness is evaluated. The system is being developed so that the system complies with Tier 2.

The sectoral experts send their CRF tables 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 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.

When the draft NIR is completed it is sent to the MoE. The Ambient Air and Radiation Protection Bureau in Environmental Management and Technology 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.

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.

Tier 1 QC checks for key sources of Energy, Industrial Processes, Waste, Agriculture and LULUCF sectors were carried out. The checks incorporated in the CRF reporter were undertaken for the period 1990 – 2006 (checklists of QC are presented in Annex 1).

QC was carried out for the following categories of Inventory:

- **ENERGY**
  - Fuel Combustion Activities (1.A);
  - Fugitive Emissions from Fuel (1.B)

- **INDUSTRIAL PROCESSES**

- **AGRICULTURE:**
  - CH_4 emission from Enteric Fermentation (Dairy Cattle, Non-Dairy Cattle, Sheep, Goats, Horses, Swine) (4.A);
  - CH_4 and N_2O emissions from Manure Management (Dairy Cattle, Non-Dairy Cattle, Sheep, Goats, Horses, Swine, Poultry) (4.B);
  - N_2O emissions from agricultural soils (4.D.1);
  - Indirect N_2O emissions: Atmospheric Deposition (4.D.3.1) and Nitrogen Leaching and Run-off (4.D.3.2)

- **LULUCF:**
  - Forest land remaining Forest land (5.A.1)

- **WASTE:**
  - Solid Waste Disposal on Land (Managed Waste Disposal on Land) (6.A.1);
  - Waste incineration (6.C)
  - Biological treatment (6.D)
  - Human Sewage (6.B.2.2)

1.5.4. Future development of QA/QC systems and planned improvements

Estonia's inventory needs to be further developed before it can fulfil the data quality objectives. All institutions involved in the making of the inventory are all part of developing plans for improving the data. The plan will be based on the UNFCCC review, QA/QC activities, information that came up during the previous reporting cycle and other information.

1.5.5. Archiving

As part of general QC procedures, it is good practice to document and archive all information required to produce the national emissions inventory estimates.

It is good practice for inventory compilers to maintain this 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. But it is necessary to have a central archiving system located at a single location.

Estonian Environment Information Centre (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.
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.

Estonia's archiving system is under development and it will be improved in line with the requirements for the national system.

1.6. Summary of the uncertainty analysis

The uncertainty analysis is presented in Annex 8.

1.7. General assessment of the completeness

Assessment of completeness is presented in Annex 2.

1.8. Description of Estonia's national registry, in accordance with the guidelines under Article 7 of the Kyoto Protocol:

1. Name and contact information of the registry administrator designated by the Party to maintain the national registry:

   Estonian Environment Information Centre (EEIC)
   Mustamäe tee 33
   10 616
   Tallinn
   Estonia
   Tel. +372 6 737 577
   Fax: +372 6 737 599
   E-mail: info@ic.envir.ee

2. Any other Party with which the Party cooperates by maintaining their respective registries in a consolidated system:

Estonia's National Registry (NR) is currently linked to the other operational EU member states' National Registries by way of the European Commission - CITL (Community Independent Transaction Log).

3. The description of the database structure used in the national registry:

   Day-to-day operation of Registry system is held EEIC, Climate and Ozone Bureau. Estonia's NR data-center (technical equipment) is located geographically in Finland, Espoo by our hosting company – Innofactor Ltd. EEIC has 3 year contract with Innofactor Ltd for hosting NR of Estonia. Innofactor Ltd provides the infrastructure (hardware, network and software) and is responsible for the day-to-day support and operation of the infrastructure and software.

   The GRETA registry system is implemented using a MS SQL server 2000 standard edition. Web Service support is provided by MS.NET. 521 unit blocks are involved in transactions and average transaction interval is 2140 minutes. Currently database is 312 MB.

   Estonia's NR production environment is working on GRETA software 2.3 and pre-production environment has GRETA software 3.0.
   Currently Estonia's registry contains:
   a. 55 organizations;
   b. with 125 users;
   c. with 60 holding accounts;
   d. with 400 transactions having been performed;
   Applying a growth of 10 % in organizations, users and accounts we predict that this will result in annual growth in database storage max 10 megabytes per year.

4. A description of how the national registry conforms to the technical standards for the purpose of ensuring the accurate, transparent and efficient exchange of data between national registries, the clean development registry and the independent transaction log:

To ensure the technical standards for purpose of ensuring the accurate, transparent and efficient exchange of data between national registries, daily automated checks and the data reconciliation process is being initiated by the CITL. The process is set in European Commission Regulation No. 2216/2004 for a standardized and secured system of registries pursuant to Directive 2003/87/EC of the European Parliament and of the Council and Decision 280/2004/EC of the European Parliament and the Council. Estonia is using GRETA software which is supplied by DEFRA (Department for Environment Food and Rural Affairs of the United Kingdom). The GRETA registry system has been developed for the EU Emissions Trading Scheme (EU ETS). Under EU ETS requirements its Member States registries have to be compliant with the Data Exchange Standards specified for the Kyoto Protocol. Estonia's registry system has been tested successfully with the EU Commission and after the testing the Registry went live (2005).

In autumn 2007 Estonia successfully passed the Annex H testing for National Registry set out in Data Exchange Standards (DES) under the Kyoto Protocol. The National Registry has fulfilled all of its obligations regarding conformity with the DES. These obligations include having adequate transaction procedures, adequate security measures to prevent and resolve unauthorized manipulations and adequate measures for data storage and registry recovery. The registry is therefore deemed fully compliant with the registry requirements defined in decision 13/CMP.1 and 5/CMP.1, nothing that registries do not have obligations regarding Operational Performance or Public Availability of Information prior to the operational phase.

Security measures employed in the national registry to deter unauthorized manipulations and minimize operator error:

a. Access to the Registry is via Username and Password;
b. The actions that a user can perform are controlled by a permissions system, hence preventing unauthorized access to restricted actions;
c. All actions performed are recorded by audit;
d. Applies validation on all user inputs to ensure that only valid details are submitted for processing;

e. Database manipulations are only carried out by protected, internal stored procedures which are not accessible directly from the user interface and can only be invoked by our internal web-services.
f. And a dedicated Greta development team is available to make any further security enhancements as and when required.

5. A list of the information publicly accessible through the user interface to the national registry:

   The information publicly available is maintained in accordance with the Commission Regulation No 2216/2004 of 21 December for a standardized and secured system of registries pursuant to Directive 2003/87/EC of the European Parliament.

6. An explanation of how to access information through the user interface of the national registry:

   Open Internet Explorer (or similar) and browse to the following URL: http://khgregister.envir.ee/. Select the public reports link at the bottom of the page.

1.9. 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);

No acquisition, holding, transfer, cancellation, withdrawal nor carryover took place with Kyoto units (AAU, RMU, ERU and CER) in 2007 in Estonian national ETS registry. All transactions were made with Pre Kyoto Period units (EUA - European Union Allowances).

Information on legal entities authorised 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;

Trading with Kyoto Units starts at 2008 (except CERs). At the moment Estonian competent authorities have not decided on legal entities that could be authorised to trade with AAUs, RMUs, ERUs and CERs.

CHAPTER 2. ENERGY (CRF 1)

2.1. Overview of sector (CRF 1)

Energy sector is the main source of greenhouse gas emissions in Estonia. In 2006, the energy sector contributed about 86% of total emissions, totalling 16.31 Tg $CO_{2\ eq}$. (Figure 2.1) Compared to the base year 1990, the emissions were about 56% below that level (36.74 Tg CO_2. Most of the energy sector emissions – 95.2% originate from fuel combustion and only 4.8% 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.

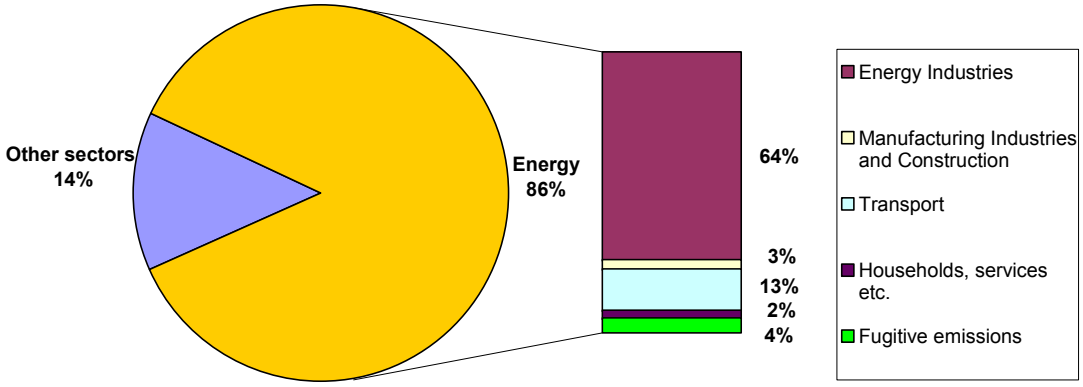


Figure 2.1. Emissions from the energy sector compared to the total emissions in 2006

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 only 26% in the fuels utilized in 2006. The share of renewable energy sources reached 10.5%, wood fuels formed the main part of it, the part of other sources remained on the level of 0.7%. From the energy of primary fuels (208 PJ) 44% was used for electricity production, 21% for heat production, 15% for the production of secondary fuels, about 3% as raw material in industry and 17% for

immediate final consumption (the rest of the energy used for final consumption was converted energy)[1].

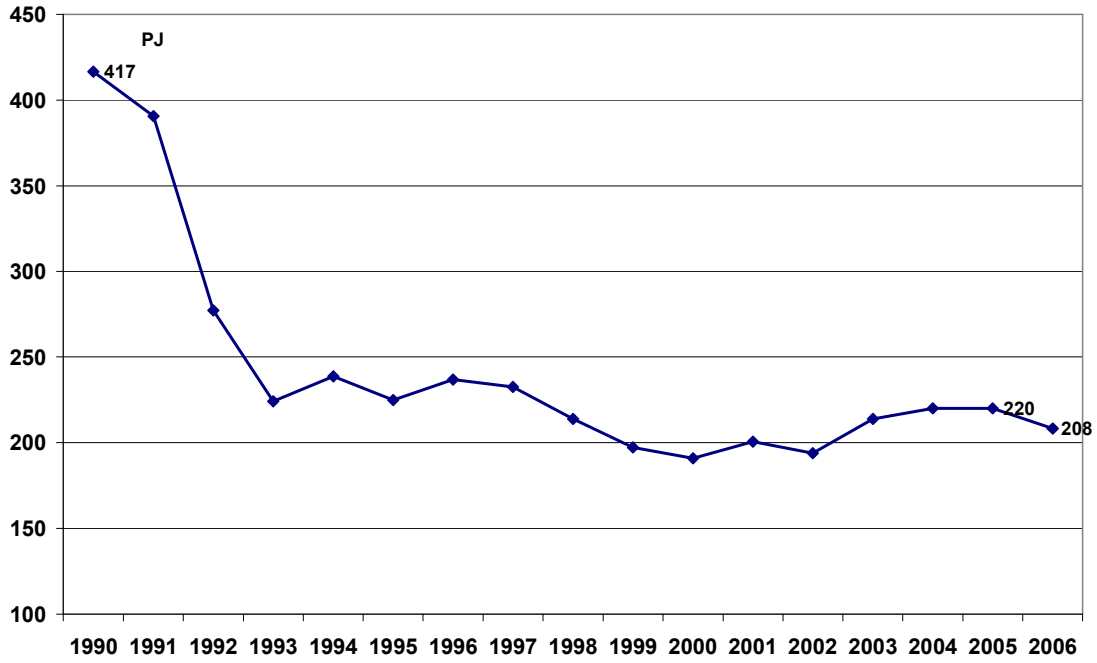


Figure 2.2. Development of Total Primary Energy Supply in Estonia, 1990 – 2006

The development of primary energy supply in Estonia is presented in Figure 2.2. The structure of primary energy supply in 1990 and 2005 accordingly is presented in Figure 2.3.

[1] Energy Balance 2006. Statistics Estonian. Yearbook. Tallinn, pp 39.

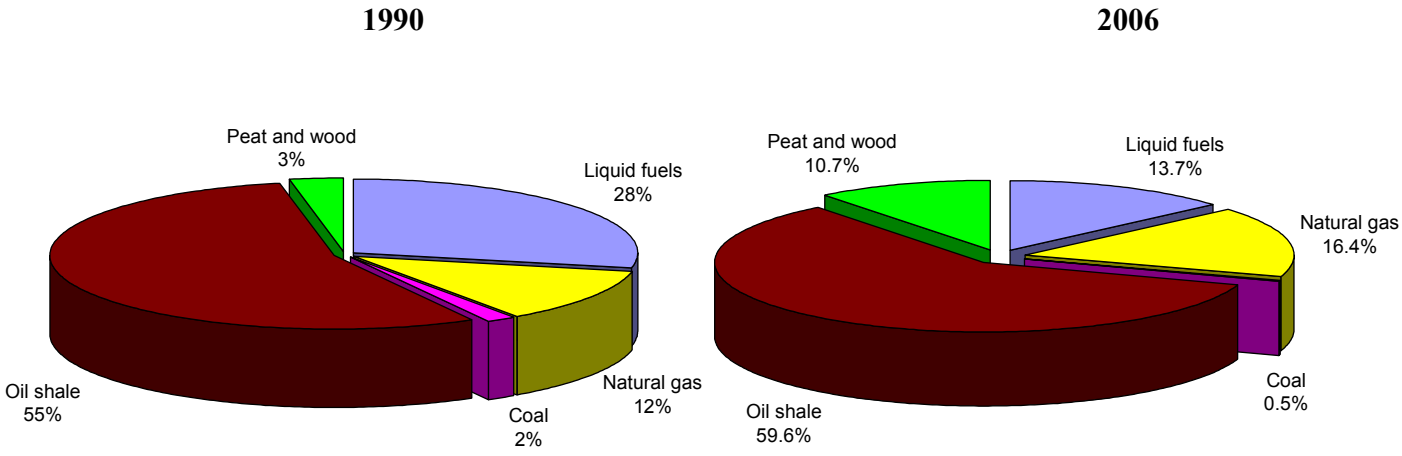


Figure 2.3. Structure of primary energy supply in Estonia in 1990 and 2006.

Analysing the structure of primary energy supply in 2006 we can see that the share of oil shale has risen from 55% in 1990 up to about 60% in 2006. The shares of other local fuels – wood and peat – have significantly increased, accounting for 3% and 10.7%, respectively. From among imported fuels, the share of coal has continued to decline (to 0.5%). The share of oil products has fallen drastically, from 28% up to 13.7%. That of natural gas has slightly risen, from 12% to 16.4%.

The efficiency of primary energy utilisation (the ratio of final energy consumption to the primary energy used) is relatively low in Estonia, making 55% in 2006. This index is lower than in neighboring countries mainly because Estonia does not have large hydro power plants and over 90% power energy is produced by condensing steam power stations, whose efficiency is approximately 36%. The efficiency index of the energy sector is also reduced by losses in electricity and district heating networks and by the export of converted energy (electricity, shale oil and shale coke, peat briquette, wood chips). The national goal in this field is continuous rise of the efficiency of the energy sector and as efficient as possible use of energy.

Table 2.1. Emissions from energy sector in 1990–2006 by subcategories and gases (Tg CO2 eq).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1. Energy	**36.74**	**34.69**	**24.48**	**19.48**	**20.12**	**17.97**	**19.00**	**18.40**	**16.75**	**15.69**	**15.50**	**15.69**	**15.49**	**17.29**	**17.43**	**16.87**	**16.31**
A. Fuel combustion	35.54	33.53	23.68	18.98	19.52	17.34	18.30	17.72	16.15	15.11	14.84	14.99	14.88	16.63	16.69	16.08	15.53
CO_2	35.41	33.41	23.58	18.89	19.41	17.18	18.12	17.54	16.00	14.97	14.70	14.85	14.74	16.48	16.54	15.94	15.39
CH_4	0.08	0.08	0.06	0.06	0.07	0.12	0.14	0.14	0.11	0.11	0.11	0.11	0.10	0.11	0.11	0.10	0.10
N_2O	0.05	0.04	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
B. Fugitive fuel emissions																	
CH_4	1.20	1.16	0.80	0.51	0.60	0.63	0.70	0.68	0.61	0.58	0.66	0.69	0.61	0.65	0.74	0.78	0.79

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 UNFCCC 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).

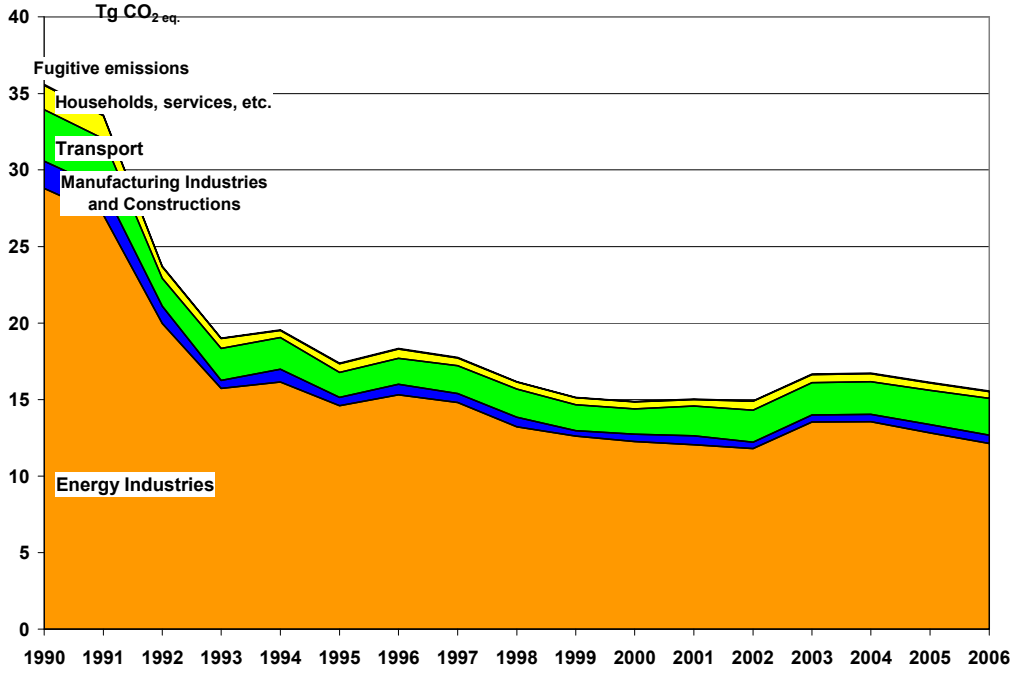


Figure 2.4. Emissions from the energy sector by subcategories in 19900-2006 (Tg CO2 eq.).

2.2. 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).

Quantitative overview

CO_2 emissions from fossil fuel combustion (15.53 Tg) accounted for 95.2% of the energy sector's total emissions and 82% of total greenhouse gas emissions in 2006.

The portion of CH_4 emissions from fuel combustion in 2006 was about 0.62% and is mainly due to the incomplete combustion of wood fuels (small combustion). N_2O emissions from fuel combustion are relatively small - about 0.24%. N_2O emissions come mainly from energy industries and transport sectors (Table 2.2).

Table 2.2. Emissions from fuel combustion in Estonia in 1990-2006 (Tg CO2 $_{eq.}$).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1. Energy	**36.74**	**34.69**	**24.48**	**19.48**	**20.12**	**17.97**	**19.00**	**18.40**	**16.75**	**15.69**	**15.50**	**15.69**	**15.49**	**17.29**	**17.43**	**16.87**	**16.31**
1.A Fuel combustion total	**35.54**	**33.53**	**23.68**	**18.98**	**19.52**	**17.34**	**18.30**	**17.72**	**16.15**	**15.11**	**14.84**	**14.99**	**14.88**	**16.63**	**16.69**	**16.08**	**15.53**
CO_2 1. Energy Industries	28.78	27.04	19.96	15.71	16.12	14.59	15.28	14.78	13.20	12.59	12.23	12.03	11.77	13.51	13.52	12.79	12.10
CO2 2. Manu-facturing Industries	1.76	1.72	1.12	0.53	0.83	0.54	0.68	0.60	0.62	0.36	0.47	0.58	0.42	0.47	0.47	0.54	0.54
CO_2 3. Transport	3.35	3.22	1.81	2.09	2.07	1.62	1.69	1.79	1.84	1.66	1.64	1.94	2.08	2.09	2.15	2.22	2.41
CO_2 4. Other	1.52	1.43	0.69	0.56	0.39	0.43	0.47	0.38	0.34	0.35	0.35	0.31	0.47	0.42	0.39	0.40	0.34

Sectors																	
CH_4	0.08	0.08	0.06	0.06	0.07	0.12	0.14	0.14	0.11	0.11	0.11	0.11	0.10	0.11	0.11	0.10	0.10
N_2O	0.05	0.04	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

Methods

Emissions from fuel combustion (CRF 1.A 1-1.A 4) 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 (un)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 2006 by level and trend and with and without LULUCF are listed in the Table 2.3 (there are identical).

Table 2.3. Key categories in Energy combustion (CRF 1.A) in 2006 (L=Level, T=Trend with and without LULUCF) (quantitative method used: Tier 2).

IPCC code	IPCC source category	Fuel	Gas	Identification criteria
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO_2	T, L
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO_2	T, L
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO_2	T, L
1 A 1 b	Petroleum refining	Solid Fuels	CO_2	T, L
1.A.2.e	Food Processing	Liquid Fuels	CO_2	T
1 A 2 f	Manufacturing and Construction /Other	Gaseous Fuels	CO_2	T, L
1 A 2 f	Manufacturing and Construction /Other	Liquid Fuels	CO_2	L
1 A 2 f	Manufacturing and Construction /Other	Solid Fuels	CO_2	T, L
1 A 3 b	Transport/Road Transportation	Diesel oil	CO_2	T, L
1 A 3 b	Transport/Road Transportation	Gasoline	CO_2	T, L
1 A 3 c	Transport/Railways	Liquid Fuels	CO_2	T, L
1 A 3 e	Other Transportation	Liquid Fuels	CO_2	T, L
1 A 4 b	Other Sectors/Residential	Biomass	CH_4	T
1 A 4 b	Other Sectors/Residential	Gaseous Fuels	CO_2	T, L
1 A 4 b	Other Sectors/Residential	Liquid Fuels	CO_2	T
1 A 4 b	Other Sectors/Residential	Solid Fuels	CO_2	T
1 B 1 a	Solid Fuels /Coal Mining	Solid Fuels	CH_4	T, L
1 B 2 b	Natural Gas	Gaseous Fuels	CH_4	T, L

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

2.2.1.1. Source category description

Energy industries (CRF1.A.1) and manufacturing industries as well as constructions (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 1990-2006 are presented in the Table 2.4.

Table 2.4. The emissions from Energy industries by relevant subcategories and gases in 1990 2006 (Tg CO_2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CO_2 Energy industries	**28.78**	**27.04**	**19.96**	**15.71**	**16.12**	**14.59**	**15.28**	**14.78**	**13.20**	**12.59**	**12.23**	**12.03**	**11.77**	**13.51**	**13.52**	**12.79**	**12.10**
a. Public Electricity and Heat Production	28.41	26.65	19.48	15.23	15.58	14.04	14.68	14.17	12.78	12.27	11.75	11.55	11.29	13.05	12.93	12.15	11.45
b. Petroleum Refining*	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
CH_4	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
N_2O	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	0.02	0.01
Aggregated GHGs, $CO_{2\ eq}$	**28.81**	**27.07**	**19.98**	**15.72**	**16.14**	**14.61**	**15.30**	**14.80**	**13.22**	**12.61**	**12.25**	**12.05**	**11.79**	**13.53**	**13.54**	**12.82**	**12.12**

** Petroleum refining - there is no oil refining in Estonia. Under this sub-category emissions from oil shale processing for shale oil production are reported.*

The emissions from manufacturing industries and construction by relevant subcategories and gases in 1990-2006 are presented in Table 2.5 below.

Table 2.5. The emissions from manufacturing industries and construction by relevant subcategories and gases in 1990-2006

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CO_2																	
2. Manufacturing Industries	**1.759**	**1.721**	**1.120**	**0.529**	**0.833**	**0.543**	**0.680**	**0.596**	**0.621**	**0.364**	**0.475**	**0.581**	**0.417**	**0.469**	**0.471**	**0.541**	**0.539**
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	0.003	0.002
b. Non-ferrous Metals	0	0	0	0	0	0	0	0	0	0	0.001	0	0.002	0.000	0.002	0.001	0.001

c. Chemicals	0.079	0.085	0.033	0.011	0.041	0.048	0.155	0.140	0.032	0.000	0.004	0.002	0.004	0.006	0.006	0.006	0.007
d. Pulp, Paper and Print	0	0	0.055	0.000	0.001	0.000	0	0.000	0.000	0.001	0.001	0.002	0.003	0.037	0.003	0.004	0.005
e. Food Processing, etc.	0.458	0.476	0.241	0.220	0.350	0.021	0.106	0.094	0.051	0.017	0.017	0.013	0.016	0.016	0.013	0.013	0.009
f. Other	1.218	1.161	0.792	0.298	0.437	0.469	0.418	0.360	0.537	0.346	0.449	0.562	0.390	0.407	0.446	0.515	0.514
CH_4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N_2O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

In Estonia, sub-category *1.A.2.f Other* includes following sub-sectors: "production of other non-metallic minerals"; "production of transport equipment"; "machinery"; "mining and quarrying"; "production of wood and wood products construction"; "textile, leather and clothing industry" and "other industry".

2.2.1.2. Methodological issues

Methods

Emissions from fuel combustion are in general calculated by using the methodology of IPCC Guidelines 1996. Emissions from fuel combustion are calculated with Excel based calculation tables.

All emissions within CRF 1.A 1 and CRF 1.A 2 are based on sectoral and sub-sectoral data from the annual proceeding of Statistics Estonian *Energy Balance*. Emissions are calculated using the annual fuel consumption.

The basic calculation formulas used in calculations are the following:

Carbon dioxide:

$$E = F * EF_{(fuel)} * OF_{(fuel)}, \text{ and } E_{\text{Oil Shale}} = F * EF(\text{technology}) * OF_{(fuel)}$$

Other greenhouse gases:

$$E = F * EF_{(fuel)}$$

F = fuel consumption
$EF(fuel)$ = fuel-specific emission factor

OF(Fuel)= fuel-specific oxidation factor

EF(technology) = technology-specific emission factor

Calculations of the CO_2 emissions are based on country specific methods (Tier 2, Revised (1996) Guidelines) method for local fuels and IPCC method (Tier 1, Revised (1996) Guidelines) for imported fuels.

Calculation of the CO_2 emissions of domestic fuels based on a country-specific (Tier 2, Revised (1996) Guidelines) method using detailed activity (fuel consumption) data and fuel-specific emission factors.

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 powdered 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 MWel) 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, 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 ($k = 0.95 \div 1.0$ for pulverised combustion of oil shale).

Formula (1) gives:

$$CEF_{oil\,shale} = 10 \cdot (20.6 + 0.95 \cdot 17.0 \cdot 12/44) / 8.6 = 29.1 \ tC/TJ$$

The emission factor for oil shale with the value of 29.1 tC/TJ is also included into the revised 1996 IPCC Guidelines for National Greenhouse Case Inventories Guidelines (Greenhouse Gas…, 1996).

This carbon emission factor value – 29.1 tC/TJ was used for estimation of carbon dioxide emissions from oil shale pulverised combustion in the Estonian annual National Inventories of GHG from 1990 up to 2003.

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).

With this regulation, carbon emission factor for oil shale is recalculated using the new value of factor k in formula (1), which takes into account the extent of carbonate decomposition and CO_2 binding at ash fields.

The new value of k was established on the basis of the research made at the Laboratory of Inorganic Materials of the Tallinn University of Technology. The general value of k based on the results of this research is 0.64 (Emissions of…, 2006).
Formula (1) gives:

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

where:

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

mineral carbon dioxide content of oil shale $\left(CO_2\right)_M^r$ = 17.7%;

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

In case the new value (0.64) for *k* is used the carbon emission factor for oil shale pulverised combustion is 27.85 tC/TJ.

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 ahe 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

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. Thermal processing of oil shale takes place without any contact with the ambient atmosphere; therefore no pollutants are emitted.

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

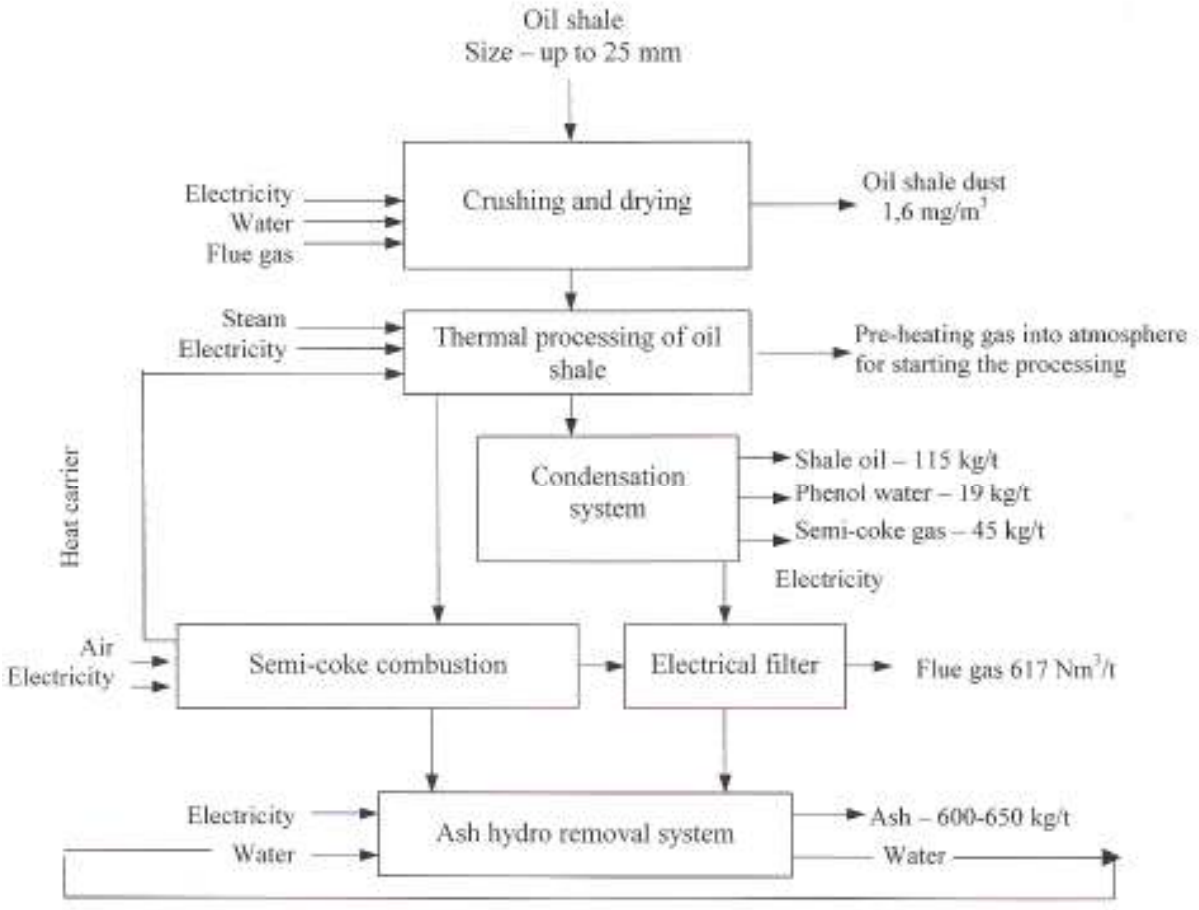


Figure 2.5. Thermal processing of oil shale for shale oil production in SHC

Therefore, in 2006, 33.19 PJ of shale oil was produced in total, only processing of 11.95 PJ of shale oil caused CO_2 emissions (see Table 2.6).

Table 2.6. Oil shale consumption for shale oil production by different technologies, PJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Oil shale for shale oil production	**18.67**	**19.89**	**24.41**	**23.85**	**27.69**	**27.70**	**30.29**	**30.85**	**20.88**	**16.44**	**24.26**	**25.67**	**26.09**	**29.03**	**29.83**	**31.73**	**33.19**
in SHC Plant (Narva)	**6.72**	**7.16**	**8.79**	**8.59**	**9.97**	**9.97**	**10.90**	**11.10**	**7.52**	**5.92**	**8.73**	**8.58**	**8.71**	**8.27**	**10.74**	**11.74**	**11.95**
in vertical reactors (VKG)	11.95	12.73	15.62	15.26	17.72	17.73	19.38	19.74	13.36	10.52	15.52	17.10	17.37	20.75	19.09	19.99	21.24

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

Table 2.7. Calorific values and CO_2 emission factors of different oil shale gases

Plant/technology		Calorific value, MJ/kg	Carbon Emission Factor, tC/TJ
Shale Oil Plant of Narva Power Plants			
Semi-coke gas (SHC -140[2] technology)	q_{sg}	34.21	16,57
Viru Keemia Grupp AS (VKG), Kohtla- Järve			
Generator gas (vertical retort technology)	q_{gg}	3.324	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 Energy Industry/Public Electricity and Heat Production.

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

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 for different fuels are presented in Table 2.8 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 2.8. CO_2 emission factors, oxidation factors and net caloric values by fuel.

Fuels	NCV average	Unit	tC/TJ	Oxidation factor	Source
Liquid fuels					
Natural Gas Liquids	33.6	GJ/t	17.2	0.99	D, IPCC1996
Gasoline	44.0	GJ/t	18.9	0.99	D, IPCC1996
Jet Gerosene	43.0	GJ/t	19.5	0.99	D, IPCC1996
Other Kerosene (light fuel oil)	42.3	GJ/t	20.2	0.99	D, IPCC1996
Shale Oil	39.22	GJ/t	21.1	0.99	CS, MoE 2006
Diesel Oil	42.3	GJ/t	20.2	0.99	D, IPCC1996
Residuel Fuel Oil (heavy fuel oil)	40.15	GJ/t	21.1	0.99	D, IPCC1996
Solid fuels					
Antracite	27.2	GJ/t	26.8	0.98	D, IPCC1996
Oil Shale $_{PC}$ *	9.3	GJ/t	27.85	0.98	CS, MoE 2006
Oil Shale $_{FBC}$ **	9.3	GJ/t	26.94	0.98	CS, MoE 2006
Peat	8.6 - 12	GJ/t	28.9	0.98	D, IPCC1996
Peat Briquette	16.0	GJ/t	28.9	0.98	D, IPCC1996
Oil Shale Semicoke	8.78	GJ/t	15.45	0.98	CS, TUT 2007
Gaseous fuels					
Natural Gas	33.6	GJ/1000 m^3	15.3	0.995	D, IPCC1996
Oil Shale generator gas	3.32	GJ/1000 m^3	34.47	0.995	GS, TUT 2007
Oil Shale semicoke gas	34.21	GJ/1000 m^3	16.57	0.995	GS, TUT 2007
Biomass fuels					
Solid Biomass (solid, includes eg. firewood, bark, chips, sawdust and other industrial wood residues, pellets and briquettes)	6.1 – 17.0	GJ/m^3s	29.9	0.98	D, IPCC1996
Biogas (landfill gas)	19.73	GJ/1000 m^3	15.3	0.995	EE

* 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
TUT 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. 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 annual proceeding of the Statistics Estonia *"Energy Balance 2006*" (Energy…, 2007).

Emission Factors of non- CO_2 Gases from Fuel Combustion

The CH_4, N_2O, 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 2.9 – Table 2.13).

Table 2.9 CH_4 from fuel combustion (kg/TJ)

	Coal	*Natural Gas*	*Oil*	*Wood*	*Coke*	*Peat/ Briquette*
Energy Industries	1	1	3	30	200	30
Manufacturing	10	5	2	30	200	30
Transport						
Domestic Aviation			2			
Road		50	20/5*			
Railways	10		5			
National Navigation	10		5			
Commercial	10	5	10	300	300	300
Residential	300	5	10	300	200	300
Agriculture						
Stationary	300	5	10	300	200	300
Mobile		5	5			

**Gasoline/Diesel*

Source: IPCC 1996 default value

Table 2.10. N_2O from fuel combustion (kg/TJ)

	Coal	*Natural Gas*	*Oil*	*Wood*	*Coke*	*Peat/ Briquette*
Energy Industries	1.4	0.1	0.6	4	4	4
Manufacturing	1. 1.4	0.1	0.6	4	4	4
Transport						
Domestic Aviation			2			
Road		0.1	0.6/0.6*			
Railways	1.4		0.6			
National Navigation	1.4		0.6			
Commercial	1.4	0.1	0.6	4	1	4

Residential	1.4	0.1	0.6	4	1	4
Agriculture						
Stationary	1.4	0.1	0.6	4	1	4
Mobile		0.1	0.6			

**Gasoline/Diesel*

Source: IPCC96 Default value

Table 2.11. NOx from fuel combustion (kg/TJ)

	Coal	***Natural Gas***	***Oil***	***Wood***	***Oil Shale*** **	***Peat/ Briquette***
Energy Industries	300	150	200	100	110	100
2. Manufacturing and Construction	300	150	200	100	110	100
Transport						
Domestic Aviation			300			
Road		600	600/800*			
Railways	300		1200			
National Navigation	300		1500			
Commercial	100	50	100	100	110	100
Residential	100	50	100	100	110	100
Agriculture	100	50	100	100	110	100
Stationary						
Mobile		1000	1200			

**Gasoline/Diesel*

Source: IPCC96 Default value and

*** Country specific (Procedure…, 2004)*

Table 2.12. CO from fuel combustion (kg/TJ)

	Coal	***Natural Gas***	***Oil***	***Wood***	***Oil Shale*** **	***Peat/ Briquette***
Energy Industries	20	20	15	1000	26	1000
3. Manufacturing and Construction	150	30	10	2000	87	4000
Transport						
Domestic Aviation			100			
Road		400	800/1000*			
Railways	150		1000			
National Navigation						
Commercial	2000	50	20	5000	87	5000
Residential	2000	50	20	5000	87	5000
Agriculture						
Stationary	2000	50	20	5000	87	5000
Mobile		400	1000			

**Gasoline/Diesel*

Source: IPCC96 Default value

*** Country specific (Procedure…, 2004)*

Table 2.13. NMVOC from fuel combustion (kg/TJ)

	Coal	*Natural Gas*	*Oil*	*Wood*	*Oil Shale**	*Peat/ Briquette*
Energy Industries	5	5	5	50	60	50
4. Manufacturing and Construction	20	5	5	50	50	50
Transport						
Domestic Aviation			50			
Road		5	1500/200*			
Railways	20		200			
National Navigation	20		200			
Commercial	200	5	5	600		600
Residential	200	5	5	600		600
Agriculture						
Stationary	200	5	5	600		600
Mobile		5	200			

**Gasoline/Diesel*

Source: IPCC96 Default value and

** 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 Estonian . Those data are also published in the annual proceeding of Statistics Estonian *"Energy Balance 2006"* (see Annex 3_I and Annex 3_II). 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 Eesti Energia AS.

Table 2.14. Fuel consumption in Energy industries (CRF 1.A 1) and Manufacturing industries and construction (CRF 1.A 2) in 1990 - 2006 (PJ).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1.A 1																	
Liquid Fuels	63.13	64.25	32.27	33.24	28.09	21.25	21.61	18.64	19.15	17.84	9.71	9.82	8.64	8.12	7.41	7.17	5.40
Solid Fuels	217.14	199.54	164.93	127.03	133.22	121.58	125.79	124.00	108.92	103.41	103.10	99.64	97.54	115.08	116.42	109.78	103.31
Gaseous Fuels	40.15	40.24	22.12	11.54	14.89	18.25	22.29	21.33	17.90	17.73	23.51	25.29	25.44	25.38	27.35	27.90	28.69
Biomass	2.18	2.32	2.22	1.99	3.71	4.63	5.21	5.64	6.16	6.37	6.86	7.76	7.78	7.62	8.66	9.90	7.46
1.A 2																	
Liquid Fuels	10.46	10.47	6.64	3.65	5.73	2.00	3.91	3.79	2.00	1.13	1.31	1.43	1.84	2.65	2.45	2.23	1.80
Solid Fuels	8.10	7.68	5.37	2.22	3.50	3.19	3.07	2.38	3.84	2.29	3.18	3.99	2.23	1.77	2.00	2.75	2.91
Gaseous Fuels	2.81	2.91	1.42	0.56	0.91	1.18	1.32	1.20	1.54	0.95	1.15	1.48	1.08	1.81	1.64	1.85	2.15
Biomass	0.25	0.27	0.24	0.05	0.18	0.15	0.30	0.14	0.14	0.13	0.14	0.15	0.16	1.65	1.69	1.78	0.32

2.2.1.3. Uncertainties and time series consistency

Uncertainty evaluation of CO_2 emission has been conducted for four fuel types used in Estonia in 2006: 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.
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 2006 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

[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

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

- Solid Fuels

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

- Gaseous Fuels

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

- Other Fuels

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 2.15). 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 2.15. Estimated relative uncertainties of CO_2 emission due to fuel combustion in Estonia in 2004.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	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 uncerainty 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.

Table 2.16. 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				
	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.a.Solid Fuels	CH_4	5%	25%	IPCC Good ..., p. 2.92
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

2.2.1.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) for Energy sector according to IPCC Tier 1 method was carried out (see also Individual Source Category Checklists in Annex 1).

2.2.1.5.. Source-specific recalculations

The main recalculations are made in source-category CRF 1.A.1. Fuel Combustion.

1. In sub-category 1.A.1.a Public Electricity and Heat Production recalculations were connected with annexation an additional source – fuel consumption for the own use of power plants.

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

This source was not included in the previous inventory submissions. Recalculations were made for the whole time series (1990-2005).

Table 2.17 Recalculations in sub-category CRF 1.A.1.a Public Electricity and Heat Production

Year	Reported emissions in 1990–2005 (the 2007 submission)				Recalculated emissions (the 2008 submission)			
	Total fuels, TJ	CO_2, Gg	CH_4, Gg	N_2O, Gg	Total fuels, TJ	CO_2, Gg	CH_4, Gg	N_2O, Gg
1990	312 159	28829.08	0.24	0.05	315 875	28413.99	0.31	0.06
1991	288 570	26470.22	0.25	0.05	299 182	26648.46	0.34	0.06
1992	210 754	19869.87	0.15	0.03	212 737	19480.59	0.22	0.04
1993	162 785	15395.15	0.15	0.03	165 214	15234.67	0.21	0.04
1994	166 706	15639.33	0.14	0.03	169 940	15575.88	0.25	0.04
1995	152 257	14070.95	0.14	0.02	155 740	14040.58	0.28	0.04
1996	158 896	14550.37	0.15	0.03	163 987	14683.58	0.32	0.05
1997	154 131	14104.60	0.14	0.02	158 503	14173.40	0.31	0.05
1998	141 179	12825.01	0.12	0.02	144 615	12783.63	0.31	0.05
1999	135 298	12259.75	0.11	0.02	139 432	12266.39	0.30	0.05
2000	129 506	11591.10	0.09	0.01	134 434	11751.64	0.30	0.04
2001	128 489	11320.41	0.10	0.01	133 938	11554.14	0.33	0.05
2002	125 043	10993.67	0.10	0.01	130 695	11294.41	0.34	0.05
2003	141 430	12768.29	0.10	0.01	147 917	13051.30	0.33	0.05
2004	99 116	9774.82	0.01	0.00	149 097	12930.99	0.35	0.05
2005	93 016	9099.37	0.01	0.00	143 008	12145.95	0.39	0.05

2. The second reason for recalculations was the specification of CO_2 emission calculation method and carbon emission factors for oil shale gas. In previous inventory submissions the value of CEF for oil shale gas was taken equal to 15.3 tC/TJ, but as it is described in chapter 1.2.1.2 Source Category Description/ Oil Shale Gas, there are two different types of oil shale gases (depending of oil shale processing technology) in Estonia. See also Table 2.7.

In 2007, a special study on oil shale thermal processing was carried out. Oil shale gas is a by-product of oil shale processing and calorific values and carbon emission factors depend on technology used. There are two different oil shale gases in Estonia: semi-coke gas and generator gas, with carbon emission factors of 16.57 and 34.47 tC/TJ, accordingly. For calculations of total

CO_2 emissions from oil shale gas combustion CO_2 emissions from semi-coke gas combustion and generator gas combustion were calculated separately and summed up (see Table 2.18).

Table 2.18. Recalculations in source category CRF 1.A.1.a Public Electricity and Heat Production / Gaseous Fuels

Year	Reported emissions in 1990–2005 (the 2007 submission)		Recalculated emissions of CO_2 (the 2008 submission)					
	Oil Shale Gas, TJ	CO_2, Gg	Oil Shale Gas total, TJ.	Semi-coke gas, TJ	CO_2, Gg	Generator gas, TJ	CO_2, Gg	CO_2 into atmosphere
1990	4338	242.15	4338	0	0	4338	545.54	545.54
1991	3488	194.70	3488	0	0	3488	438.64	438.64
1992	2315	129.22	2315	0	0	2315	291.13	291.13
1993	2832	158.08	2832	0	0	2832	356.15	356.15
1994	3776	210.77	3776	0	0	3776	474.86	474.86
1995	3949	220.43	3949	709	42.86	3240	407.46	407.46
1996	5131	286.410	5131	968	58.52	4163	523.53	523.53
1997	4696	262.13	4696	1020	61.66	3676	462.29	462.29
1998	3338	186.33	3338	896	54.17	2442	307.10	307.10
1999	2710	151.27	2710	767	46.37	2233	280.82	280.82
2000	4243	236.84	4243	1014	61.30	3619	455.12	455.12
2001	4719	263.41	4719	1224	73.994	3927	493.85	493.85
2002	5220	291.38	5220	1221	73.81	4566	574.21	574.21
2003	5220	291.38	5220	1286	77.742	4619	580.88	580.88
2004	5485	306.17	5485	1436	86.81	4268	536.74	536.74
2005	5720	319.29	5720	1547	93.52	4438	558.11	558.11

EF used= 15.3 tC/TJ (in 2007 submission)

EF semi-coke = 16.57 tC/TJ (in 2008 submission)

EF generator gas = 34.47 tC/TJ (in 2008 submission)

The amount of oil shale gas used in 1999-2005 was increased because of own use of fuels in power plants which was not included in the previous submission (see Table 2.18).

3. Recalculations are made also in sector CRF 1.A1.b Petroleum Refining (in our case - oil shale processing for shale oil production). To calculate CO_2 emissions from shale oil

production, in previous submissions oil shale amount used for shale oil production was multiplied to $EF_{Oil\ Shale}$ =27.85 tC/TJ.

According to the latest knowledge, the amounts of CO_2 emissions are directly connected with the applied oil shale processing technology (see also 2.2.1.2. Source-category description / oil shale processing). CO_2 emissions are emitted into atmosphere only by using solid heat carrier technology. It means that recalculated CO_2 emissions are less significant comparing to the previous submission. CO_2 emissions from 1.A.1.b have been recalculated for the whole period 1990-2005.

Some improvements in activity data have in previous years been applied because Statistical Office has the practice to improve previous years' Energy Balances (Table 2.19).

Table 2.19. Recalculations in sub category CRF 1.A.1.b Petroleum refining

Year	Reported emissions of CO_2 in 1990–2005 (the 2007 submission)		Recalculated emissions of CO_2 (the 2008 submission)			
	Oil shale, TJ	CO_2	Oil shale, TJ	In SHC	In generators	CO_2 into atmosphere, Gg
1990	18 670	1608.60	18 670	6 721	11 949	369.33
1991	19 886	1556.72	19 886	7 159	12 727	393.39
1992	24 406	1924.53	24 406	8 786	15 620	482.80
1993	23 849	1862.97	23 849	8 586	15 263	471.79
1994	27 692	2168.49	27 692	9 969	17 723	547.81
1995	27 696	2177.68	27 696	9 971	17 725	547.89
1996	30 286	2386.76	30 286	10 903	19 383	599.12
1997	30 847	2452.94	30 847	11 105	19 742	610.22
1998	20 877	1618.04	20 877	7 516	13 361	412.99
1999	16 436	1280.86	16 436	5 917	10 519	325.14
2000	24 257	1854.28	24 257	8 733	15 524	479.86
2001	25 674	2250.40	25 674	8 575	17 099	471.21
2002	26 087	2233.52	26 087	8 713	17 374	478.79
2003	29 027	2455.48	29 027	8 273	20 754	454.59
2004	29834	2571.81	29834	10 740	19 094	590.18
2005	31 728	2743.26	31 728	11 739	19 989	645.08

4. Recalculations in sub category CRF 1.A.1.c Manufacture of Solid Fuels.

In Estonia, there are two types of solid fuels produced from primary energy: oil shale coke and peat briquettes.

Oil shale coke is a by-product of oil shale processing for shale oil production and produced only from the SHC technology. There is no any CO_2 emission from coke production, because there are already taken into account in sub-categories CRF 1.A.1.a and CRF 1.A.1.b.

There are also no other GHG emissions from peat briquette production. In the previous inventory submission 1990-2005 CO_2 emissions from peat production were calculated and allocated into sub category CRF 1.A.1.C by mistake. In the current inventory submission, all GHG emissions in CRF 1.A.1.c are deleted.

Table 2.20. Recalculations in sub category CRF 1.A.1.c Manufacture of solid fuels

Year	Reported Solid Fuel Production in 1990–2005 (the 2007 submission)				Recalculated Solid Fuel Production (the 2008 submission			
	Peat, TJ	CO_2 (EF 28.9)	CH4 (EF 30)	N2O (EF 4)	Peat, TJ	CO_2	CH4	N2O
1990	3 733	383.71	0.11	0.01	3 733	NO	NO	NO
1991	3 653	375.48	0.11	0.01	3 653	NO	NO	NO
1992	2 882	296.23	0.09	0.01	2 882	NO	NO	NO
1993	2 286	234.97	0.07	0.01	2 286	NO	NO	NO
1994	2 273	233.64	0.07	0.01	2 273	NO	NO	NO
1995	3 021	310.52	0.09	0.01	3 021	NO	NO	NO
1996	2 884	296.44	0.09	0.01	2 884	NO	NO	NO
1997	2 216	227.78	0.07	0.01	2 216	NO	NO	NO
1998	1 726	177.41	0.05	0.01	1 726	NO	NO	NO
1999	1 772	182.14	0.05	0.01	1 772	NO	NO	NO
2000	1 458	149.86	0.04	0.01	1 458	NO	NO	NO
2001	1 920	197.35	0.06	0.01	1 920	NO	NO	NO
2002	2 158	221.82	0.06	0.01	2 158	NO	NO	NO
2003	1 967	202.18	0.06	0.01	1 967	NO	NO	NO
2004	1067	109.67	0.03	0.00	1067	NO	NO	NO
2005	1 086	111.63	0.03	0.00	1 086	NO	NO	NO

2.2.1.6. Source-specific planned improvements

A special analysis has been carried out by the researchers of the Tallinn University of Technology on calculation methods for determining the emissions of pollutants of ambient air. This research was ordered and financed by the Estonian Ministry of the Environment. As a result of this research some country specific non-CO_2 emission factors will by specified in next inventory submission.

2.2.2. Transport (CRF 1.A 3)

2.2.2.1. Source category description

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

- Civil Aviation
- Road Transport,
- Railways
- Domestic navigation and
- Other transportation (mobile sources in agriculture sector).

Road transport includes all transportation on the roads in Estonia. The types of vehicles with combustion engines are: 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.e other transportation.

Railway transport in Estonia includes railway transport operated by diesel locomotives. Domestic navigation includes the most important domestic waterway transport in Estonia: seagoing ships, icebreakers, working boats and leisure boats.

The emissions from civil aviation 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 (Table 2.21).

Greenhouse gas emissions from the transport sector have increased since 1990. In 1990, the emissions from the transport sector were 8.1% of the total greenhouse gas emissions in Finland. In 2006, the corresponding figure was 12.8%.

Table 2.21. Emissions from the Transport sector in 1990–2006 by subcategories (Tg CO2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CO_2 3. Transport	**3.35**	**3.22**	**1.81**	**2.09**	**2.07**	**1.62**	**1.69**	**1.79**	**1.84**	**1.66**	**1.64**	**1.94**	**2.08**	**2.09**	**2.15**	**2.22**	**2.41**
a. Civil Aviation	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01
b. Road transport	2.15	1.94	0.97	1.10	1.39	1.39	1.43	1.55	1.58	1.45	1.44	1.76	1.79	1.78	1.85	1.94	2.10
c. Railways	0.16	0.15	0.11	0.11	0.11	0.11	0.12	0.11	0.13	0.14	0.14	0.13	0.16	0.14	0.12	0.12	0.14
d. Navigation	0.58	0.68	0.40	0.63	0.41	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
e. Other transp.	0.45	0.43	0.32	0.25	0.14	0.10	0.11	0.10	0.10	0.04	0.04	0.03	0.09	0.15	0.15	0.13	0.13
CH_4, $CO_{2\,eq}$	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, $CO_{2\,eq}$	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01

2.2.2.2. 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 traveled by the vehicles. In general, the first approach (fuel sold) is appropriate for CO_2 and the second (distance traveled by vehicle type and road type) is appropriate for CH_4 and N_2O.

In the current inventory report the emissions of CO_2, are calculated on basis of the amounts and type of fuel combusted and its carbon content.

The *Tier 1* approach calculates CO_2, N_2O and CH_4 emissions by multiplying the estimated fuel sold with a default emission factor. This approach can be expressed as:

$$\text{Emissions} = \Sigma\,[\text{Fuel}_a \times \text{EF}_a]$$

where: Emissions '= Emissions of CO_2 , CH_4 and N_2O (Gg)

$Fuel_a$ = Fuel sold (TJ)

EF_a - emission factor

A = type of fuel (e.g. petrol, diesel, natural gas, LPG etc)

Emission Factors

CO_2 emission factors used in Transport sector are the same as for fossil fuel combustion and given in the Table 2.7 and non-CO_2 emission factors are presented in the Table 2.9 and Table 2.10.

Table 2.22. Fuel consumption in transportation sector, 1990-2006, PJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1.A 3.a Civil aviation																	
Jet Kerosene	0.17	0.17	0.04	0.09	0.09	0.09	0.09	0.09	0.12	0.21	0.09	0.01	0.03	0.01	0.03	0.02	0.13
1.A.3.b Road Transportation																	
Gasoline	21.31	19.17	8.98	9.57	12.40	10.61	11.68	12.98	12.46	11.92	12.01	14.33	13.15	12.61	12.15	12.40	13.48
Diesel Oil	9.21	8.36	4.76	5.98	7.24	9.02	8.50	8.95	9.86	8.57	8.37	10.54	12.10	12.45	13.80	14.79	16.01
Natural Gas Liquids	0.14	0.09	0.09	0.03	0.17	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.004
1.A.3.c Railways																	
Liquid Fuels	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	1.69	1.85
Solid Fuel	0.119	0.143	0.049	0.053	0.055	0.039	0.059	0.037	0.014	0.003	0.006	0.008	0.001	0	0	0	0
Other Fuels	0.105	0.087	0.047	0.004	0.021	0.019	0.011	0.006	0.001	0.001	0	0	0.012	0	0	0	0
1.A.3.d National Navigation																	
Residual Fuel Oil	6.17	7.24	3.32	3.68	2.62	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Diesel Oil	1.44	1.72	2.04	4.64	2.88	0.17	0.30	0.26	0.25	0.23	0.32	0.30	0.45	0.35	0.36	0.34	0.47
1.A.3.e Other Transportation																	
Liquid Fuels	6.23	5.97	4.48	3.39	1.96	1.36	1.57	1.43	1.43	0.57	0.53	0.43	1.27	2.00	2.07	1.78	1.84
Biomass	0.008	0.008	0	0.001	0.003	0.002	0.002	0.001	0	0.001	0	0	0	0	0	0	0

Activity data for calculation of CO_2, CH_4 and N_2O emissions from the Transport sector are received from the Statistics Estonian (*Energy Balance 2006*).

2.2.2.3. Source-specific recalculations

In the previous inventory submission (1990-2005) GHG emissions from use of diesel oil and gasoline in agriculture sector were allocated into sub category CRF 1.A.4.c Agriculture. In the current submission those emissions are reallocated into category CRF 1.A.3.e Other transportation.

Table 2.23. Reallocations of GHG emissions from sub-category 1.A.4 Agriculture /Forestry/Fishery (Mobil) into CRF 1.A.3.e Other Transportation

Year	Diesel Oil and G consumption, TJ	CO_2	CH_4	N_2O	Total in CO_2 eq.
1990	5884	426.505	0.045	0.004	**428.547**
1991	5501	400.063	0.038	0.003	**401.884**
1992	4226	306.379	0.032	0.003	**307.842**
1993	3391	247.129	0.022	0.002	**248.217**
1994	1607	117.665	0.009	0.001	**118.144**
1995	1359	99.367	0.008	0.001	**99.781**
1996	1491	109.032	0.008	0.001	**109.485**
1997	1426	104.200	0.008	0.001	**104.639**
1998	1434	104.701	0.009	0.001	**105.148**
1999	567	41.420	0.003	0.000	**41.596**
2000	533	38.903	0.003	0.000	**39.071**
2001	425	30.961	0.003	0.000	**31.098**
2002	1271	92.933	0.007	0.001	**93.321**
2003	1996	145.868	0.012	0.001	**146.482**
2004	2070	151.167	0.012	0.001	**151.810**
2005	1779	130.367	0.009	0.001	**130.890**

2.2.3. Other Sectors (CRF 1.A.4)

2.2.3.1. Source category description

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

- residential (households)
- commercial, institutional and
- agriculture/forestry/fisheries.

Table 2.24. Emissions from other sectors (Commercial/Institutional, Residential and Agriculture/Forestry/Fisheries) in 1990-2006, Tg $CO_{2\ eq.}$

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CO_2 4. Other sectors	**1.52**	**1.43**	**0.69**	**0.56**	**0.39**	**0.43**	**0.47**	**0.38**	**0.34**	**0.35**	**0.35**	**0.31**	**0.47**	**0.42**	**0.39**	**0.40**	**0.34**
Commercial/Institutional	0.09	0.09	0.04	0.01	0.02	0.03	0.02	0.02	0.03	0.03	0.03	0.04	0.09	0.11	0.09	0.10	0.08
Residential	1.36	1.27	0.60	0.47	0.35	0.38	0.43	0.34	0.28	0.31	0.28	0.23	0.24	0.20	0.23	0.23	0.21
Agriculture/Forestry/ Fisheries	0.07	0.07	0.04	0.08	0.02	0.02	0.02	0.02	0.03	0.01	0.04	0.04	0.14	0.10	0.08	0.07	0.05
4. CH_4 other sectors	0.06	0.06	0.05	0.05	0.06	0.11	0.12	0.12	0.10	0.09	0.09	0.09	0.09	0.09	0.10	0.08	0.08
4. N_2O other sectors	0.02	0.01	0.01	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

2.2.3.2. Methodological issues

Methods

Emissions from sub-categories 1.A4 are calculated by using the methodology of the IPCC Guidelines 1996. Emissions from fuel combustion are calculated with the Excel based calculation tables.

Activity data

The activity data for sub-category CRF 1.A 4 is taken from annual energy statistics (see Annex 3_I and Annex 3_II). It covers fuel used in commercial, institutional and residential and agricultural sectors. Motor fuels (*diesel oil and gasoline*) used in agriculture sector (Agriculture Mobile) are included into the sub- sector CRF 1.A.3.e. Other transportation.

The fuel consumption data for CRF 1.A 4 is presented in Table 2.25.

Table 2.25. Fuel consumption in CRF categories 1.A 4, PJ.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1.A.4																	
Liquid Fuels	8.94	7.41	2.18	2.14	1.06	0.89	1.12	0.99	1.35	1.42	1.73	1.62	2.97	2.49	2.36	2.16	1.65
Solid Fuels	7.26	7.25	3.93	2.57	1.49	2.53	3.03	2.23	1.42	1.55	1.27	0.95	1.11	0.80	1.13	1.05	0.78
Gaseous Fuels	2.52	3.11	2.42	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
Biomass	5.93	5.62	5.39	5.33	8.09	15.20	17.71	18.49	14.41	14.01	14.12	13.90	13.83	14.57	14.79	12.74	12.47

Emission Factors

Both, IPCC and National (country specific) emission factors are used (Table 2.8).

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

2.3.1. Overview of the sector

Description

Under fugitive emissions from fuels, Estonia reports CH_4 emissions from: solid fuels (oil shale mining and handling), oil and natural gas, including the following activities:

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

In 2006, fugitive emissions from natural gas and oil were 24.92 Gg CH_4 (523.25 Gg $CO_{2\ eq.}$) and from oil shale mining and handling were 12.48 Gg CH_4 (262.08 Gg $CO_{2\ eq.}$).

Table 2.26 Fugitive emission from oil and gas (Gg $CO_{2\ eq.}$)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Solid fuels																	
CH_4 1.B.1.a Oil shale mining and handling	19.41	17.55	16.25	13.40	13.17	12.13	13.47	13.02	10.76	9.74	11.25	11.02	10.63	10.92	11.26	12.29	12.48
Oil																	
Shale Oil production (1.B 2 a.2)	0.02	0.02	0.04	0.04	0.05	0.05	0.05	0.06	0.03	0.02	0.04	0.04	0.04	0.05	0.05	0.05	0.06
Oil transport (1.B 2 a.3)	0.20	0.10	0.06	0.06	0.07	0.07	0.07	0.09	0.09	0.09	0.04	0.04	0.05	0.04	0.05	0.05	0.06
Oil storage (1.B 2 a.4)	0.05	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.01	0.01	0.01	0.01	0.02	0.01	0.02
Natural Gas																	
Natural gas transmission and distribution (1.B 2 b.3)	23.47	23.53	13.75	6.82	9.79	11.17	12.32	11.97	11.36	11.06	12.71	13.65	11.43	12.60	14.87	15.33	15.52
Other leakage (1.B 2 b.5)	14.02	13.98	8.06	3.80	5.58	6.54	7.30	7.09	6.68	6.51	7.51	8.09	6.76	7.48	8.85	9.10	9.21
Venting (1.B.2.e)	0.02	0.02	0.04	0.04	0.05	0.05	0.05	0.06	0.03	0.02	0.04	0.04	0.04	0.05	0.05	0.05	0.06
Total CO_2 eq.	**1200.9**	**1159.7**	**802.7**	**507.8**	**603.4**	**630.5**	**698.8**	**678.7**	**608.5**	**576.9**	**663.4**	**690.7**	**608.3**	**654.2**	**738.0**	**774.7**	**785.4**

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

2.3.2.1. Source category description

This section covers fugitive emissions of CH_4 from production, processing, handling and utilisation of oil shale. In Estonia, only oil shale is mined and burned for energy generation and shale oil production. There are no coal mines in Estonia.

2.3.2.2. Methodological issues

Methods

The emissions are calculated by multiplying the amounts of produced oil shale with national emission factors. Annual activity data is received from AS Eesti Energia who owns the oil shale mining company AS Eesti Põlevkivi.

*CH_4 emissions (Gg) = CH_4 Emission Factor (m3 CH_4/ton of oil shale mined) x Oil Shale Production (Mt) x Conversion Factor (Gg/*106 m^3)

The structure of the CH_4 emissions from mining (underground and surface mining) and post mining activities (underground and surface mining) is given in the Greenhouse Gas Workbook, Vol. 3, 1996:

Emission factors and other parameters

The emission factors used for the calculation of fugitive emissions from oil shale mining are estimated by Estonian oil shale mining experts.

Table 2.27 CH_4 emission factors for fugitive emissions from solid fuel mining and handling

SOLID FUEL	Emission Factor	Unit	Source
Oil Shale mining and handling			
Underground mining	2	m^3 CH_4/t	CS
Underground post-mining	0.2	m^3 CH_4/t	CS
Surface mining	0.3	m^3 CH_4/t	CS
Surface post-mining	0.1	m^3 CH_4/t	CS

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

2.3.3.1. 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.

2.3.3.2. Methodological issues

Methods

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

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

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 2.28)

Table 2.28 CH_4 emission factors for fugitive emissions from oil and gas activities

	Emission Factor	Unit	Source
OIL			
Production of Shale Oil	4 000	kg CH_4/PJ	D
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

2.3.3.3. Uncertainty and time series' consistency

To estimate the uncertainties of this category the IPCC Tier1 method was used.
Uncertainties of activity data (±5) and emission factors (±25) were taken from the IPCC, 2000. Good Practice Guidance (see also Table 2.26).
Combined uncertainty in the category fugitive emissions from fuel as % of total national emissions in year 2006 was around ±0.7%.

2.3.3.4. Source-specific recalculations

No source-specific recalculation has been carried out.

2.3.3.5. Source-specific planned improvements

It is planned to find country specific emission factors for fugitive CH4 emissions from shale oil production.

2.4. Reference Approach

Reference approach (RA) is carried out using import, export, production and stock change data from the Energy Balance (EB) annual proceeding published by Statistics of Estonia. However, the RA table requires liquid fuels reported to a more disaggregated level than in the EB sheet. This data was taken from the background data of the EB. In the 2006 inventory, the difference of CO_2 emissions between RA and Sectoral Approach (SA) was 4.4%, which is acceptable.

2.5. International Bunkers

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

In 2006, GHG emissions from marine bunkers were 672.23 $GgCO_{2eqv}$ and aviation bunkers 95.73 $GgCO_{2\ eq.}$

The emissions were calculated using the IPCC metrology and default emission factors. Fuel consumption data for marine bunkering and aviation bunkering was obtained from the Energy Balance (EB) annual proceeding published by Statistics of Estonia. No recalculations and uncertainty estimation for international bunkers has been carried out.

CHAPTER 3. INDUSTRIAL PROCESSES (CRF 2)

3.1. Overview of sector

3.1.1. Description

Estonia's emissions from Industrial Processes sector are divided into Mineral products (CRF 2.A), Chemical industry (CRF 2.B), and Consumption of halocarbons and SF_6 (CRF 2.F) and Other production (CRF 2.D). Under Mineral products Estonia reports the emissions from cement production and lime production. Under Chemical industry emissions from ammonia production are reported. Under Other production (CRF 2.D) Estonia reports NMVOC emissions from the pulp and paper and food industries.

The CRF category 2.F covers emissions of F-gases. The presented preliminary data are based on the first results from the Twinning Project EE2005/IB/EN/01 "Enhancing the capacity to reduce the emissions of fluorinated greenhouse gases in Estonia". The project started in the second half of 2007 (Twinning project between the Estonian Ministry of the Environment and the German Ministry for the Environment, Nature Conservation and Nuclear Safety). Within the framework of this project a basic inventory of F-gas consumption in Estonia will be established up to mid 2008.

3.1.2. Quantitative overview

Industrial greenhouse gas emissions contribute about 3.5% of the total anthropogenic greenhouse gas emissions in Estonia (Figure 3.1). The most important greenhouse gas emissions from industrial processes in Estonia's inventory in 2006 are the CO_2 emissions from the cement, ammonia and lime production with the 2.19%, 0.71% and 0.17% shares of the total greenhouse gas emissions, respectively. Data on F-gas emissions are incomplete as the Twinning Project is not yet finished. The herewith reported data comprise together about 0.43 % of the total greenhouse gas emissions in Estonia. The strong differences in Table 3.1 between the years 2005 and 2006 show that with 2006 firstly real data on F-gas emissions will be established; the data for former years are only estimations and extrapolations which have to be recalculated after finishing the Twinning Project.

Industrial CO_2 emissions have decreased considerably since 1990 having the lowest value in 1993 and after small increase in 1994 the trend of CO_2 emissions have stabilized (except a small fall in 2002). In 2006, GHG emissions from Industrial Processes sector formed about 70% of the 1990's level (see Table 3.1 and Figure 3.1).

Table 3.1 Trend in greenhouse gas emissions from industrial processes (Gg CO2 eqv.)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CO2																	
A. Mineral Products	628	634	388	245	344	361	375	411	429	386	394	402	386	363	396	402	445
B Chemical Industry	317	292	150	60	202	207	211	222	242	217	188	203	28	93	171	144	135
HFCs	0	0	0	0	0	0.13	0.73	1.39	2.44	3.33	4.19	4.89	5.68	6.59	7.21	7.88	75.18
SF6	0	0	0	0		0.25	0.31	0.58	0.81	1.05	1.43	2.24	3.68	4.75	5.28	5.87	0.79
PFC	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE	NE	NE

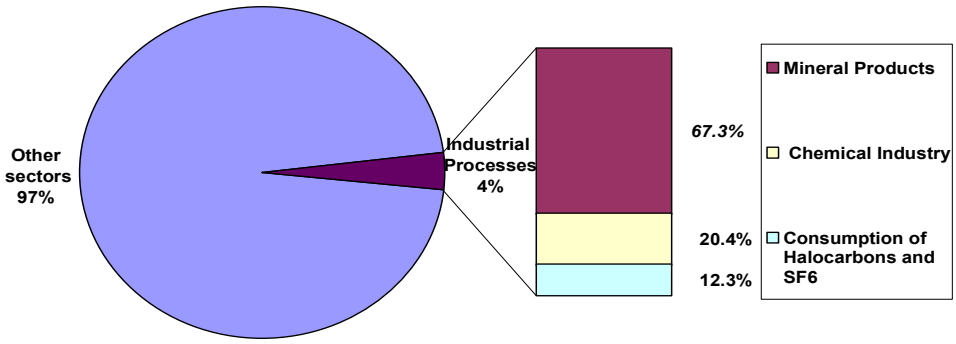


Figure 3.1 Emissions from industrial processes in Estonia in 2006.

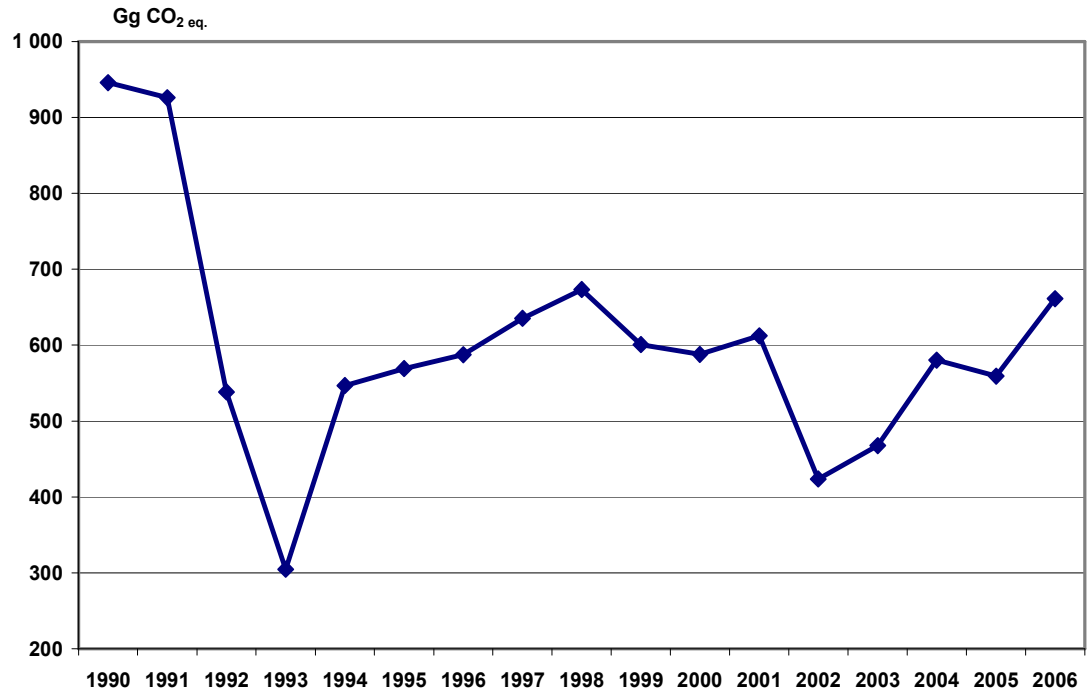


Figure 3.2 Emission from industrial processes in 1990-2006 in Estonia (Gg CO2 eq.)

Key categories

Key categories under industrial processes in 2006 calculated with IPCC Tier 1 method were CO_2 from cement, lime and ammonia production by level and trend method without LULUCF.

3.2. Mineral Products (CRF 2.A)

3.2.1. Source category description

In this category the non-fuel emissions from cement and lime production are reported 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. Also, CO_2 emissions from lime production and limestone and dolomite use are due to calcination of calcium and magnesium carbonates at high temperatures. The activity data and emission factors used in calculations are from AS Kunda Nordic Cement and AS Nordkalk.

Table 3.2. CO_2 emissions from mineral products (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
2.A 1 Cement production	483	471	315	228	330	348	361	396	404	361	379	387	364	339	369	373	414
2.A 2 Lime Production	145	163	72	17	14	13	14	15	25	25	16	16	22	24	27	29	31
Total	628	634	388	245	344	361	375	411	429	386	394	402	386	363	396	402	445

3.2.2. Methodological issues

Methods

Emissions from cement and lime production are calculated by multiplying emission factor with activity data. Activity data is collected mainly directly from the industry. Emission factors are calculated by the industry (cement production and lime production) or are based on IPCC's default factors (lime production). The methods for calculating emissions from cement production and lime production are consistent with IPCC Tier 1 and Tier 2 level method. (For lime production tier 1 and for cement production tier 2 methods).

Emission factors

Cement and lime production

Emission factors used in calculation of emissions from cement and lime production are national provided by the industry (i.e. production plants). Previously emission factors have not been directly collected from the industry on as detailed a level as in the present inventory. Annual emission factors vary slightly, since the parameters affecting them vary slightly from year to year (Table 3.3).

Emission factor of cement production is based on the CaO and MgO contents of clinker. Cement kiln dust and by pass dust as well as the amounts of CaO and MgO that are calcined already before the process (and therefore do not cause emissions) are taken into account. Emission factor for lime production is taken from the IPCC's 1996 Revised Guidelines and based on the estimate CaO and MgO contents of lime derived.

Activity data

Activity data (Table 3.3) for cement and lime production is collected mainly directly from the industry and taken partly from industrial statistics.

Table 3.3 Activity data and emission factor for mineral products (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
2. A.1. Clinker production, kt	790	773	517	378	540	571	591	651	659	590	620	629	591	560	623	635	705
EF clinker (t/t)	0.549	0.547	0.548	0.542	0.549	0.547	0.546	0.543	0.546	0.546	0.545	0.548	0.549	0.545	0.544	0.547	0.547
Cement kiln dust, kt	120	117	78.5	57.4	82	86.7	95.8	105.5	107	95.7	100.5	102.5	96.1	84.8	74.9	61.9	69
EF owen dust (t/t)	0.410	0.415	0.409	0.405	0.410	0.408	0.408	0.406	0.408	0.408	0.408	0.409	0.410	0.407	0.406	0.408	0.408
2. A.2. Lime production, kt	294.0	270.2	140.0	55.0	180.0	201.3	203.0	205.9	210.7	199.3	176.8	183.2	47.1	98.3	201.7	212.6	211.4
EF lime(t/t)	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857

3.2.3. Uncertainties and time-series consistency

Since the activity data was prepared in cooperation with manufacturer and taken partly from industrial statistics as well, the rate of emissions are considered sufficiently precise. The listed uncertainties were determined via experts assessment pursuant to Tier 1of the IPCC GPG rules. The uncertainty estimation for the activity rates used for cement was ±7 %. This expert assessment took into account the following error sources:

- Uncertainty of collection and transferring data,
- Uncertainty of determination of activity data.

The emission factor was estimated as 0,547 t/t. The uncertainty estimation for the emission factor used was ± 10 %. This expert assessment took into account the following error sources:

- the uncertainty related to the average fractions of limestone and other raw materials.

The uncertainty estimation for the activity rates used for lime was ±10 %. This expert assessment took into account the following error sources:

- Uncertainty of collection and transferring data,
- Uncertainty of determination of activity data.

The emission factor was estimated as 0,7857 t/t. The uncertainty estimation for the emission factor used was ± 7 %. This expert assessment took into account the following error sources:

- the uncertainty related to the average fractions of limestone and other raw materials.

3.2.4. Source-specific QA/QC and verification

General (Tier 1) Quality Control (QC) procedures applied to category Mineral products (CRF 2.A)

- Assumptions and criteria for the selection of activity data and emission factors are documented.
- For subcategories CRF 2.A 1 and 2.A 2 the whole time series of emissions, correctness of the calculation formulas, use of appropriate units have been checked.
- The consistency of input data and methods over the time series has been checked.

3.2.5. Source-specific recalculations including changes made in response to the review process

Cement and lime production

No recalculations have been made since the previous inventory.

3.3. Chemical Industry (CRF 2.B)

3.3.1. Source category description

In Estonia's inventory this category includes the non-fuel emissions from ammonia production (Table 3.4). The annual ammonia production figures 1990-2006 and natural gas consumption figures have been obtained from the ammonia production plant Nitrofert AS and presented in Table 3.4.

All ammonia currently produced in Estonia is produced in one company - AS Nitrofert.

Table 3.4. Emissions of CO2 from ammonia production (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
2.B.1 Ammonia production	317	292	150	60	202	207	211	222	242	217	188	203	28	93	171	144	135

3.3.2. 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 the Estonia's ammonia production factory Nitrofert a different ammonia production technology is in use. Not all CO_2 emissions are emitted into air, part of them are used as raw material for carbamide production and some part is sold (liquefied and exported).

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.

According to the Tier 1a method:

Emissions (Gg) = Consumption of gas (kt) x carbon content x 44/12

where carbon content of natural gas = 0.5568 kg/m3

Tier 1b: An alternative is to calculate the emissions from the ammonia production:

Emissions (Gg) Production of ammonia (kt) x Emission factor

In the current inventory calculations the tier 1b method has been used. In the Annex 4_I, CO_2 emissions from ammonia production using method Tier1a are presented.

Emission factors

The emission factor for calculation of CO_2 emissions from ammonia production is country specific and based on technology used in the factory.

In the IPCC 1996 Guideline, Vol.3, p. 1.16 same examples for used emission factors are given for Canada and Norway. These emission factories are equal to 1.5 – 1.6 tCO_2/tonne NH_3 produced. In Estonia, ammonia production emission factors are, depending on the year, between 1.407 – 1.572 6 tCO_2/tonne NH_3 produced.

Activity data

The annual ammonia production figures 1990-2006 have been obtained from the production plants and presented in (Table 3.5)

Table 3.5. Production ammonia (1000 tonnes)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Ammonia production, kt	294	270	140	55	180	201	203	206	211	199	177	183	47	98	202	213	211
Emission factor	1.564	1.572	1.572	1.572	1.580	1.485	1.458	1.417	1.396	1.428	1.431	1.487	1.469	1.529	1.366	1.407	1.412
CO_2, kt	460	425	220	86	284	299	296	292	294	285	253	272	69	150	276	299	299
CO_2 for carbamide production	143	133	70	27	82	91	85	69	53	68	65	70	41	57	104	156	164
Total CO_2 emissions, Gg	**317**	**292**	**150**	**60**	**202**	**207**	**211**	**222**	**242**	**217**	**188**	**203**	**28**	**93**	**171**	**144**	**135**

3.3.3. Uncertainties and time-series consistency

The annual ammonia production figures for year 2006 have been obtained from the production plants, so the rate of emissions is considered sufficiently precise. The listed uncertainties were determined via experts assessment pursuant to country specific methods. The uncertainty estimation for the activity rates used for ammonia was ±5 %.

In Estonia, ammonia production emission factors are depending on the year between 1.407 – 1.572 6 tCO_2/tonne NH_3 produced, and determined for year 2006 as 1,412 based on statistics. The uncertainty estimation for the emission factor used was ± 20 %.

3.3.4. Source-specific QA/QC and verification

General (Tier 1) Quality Control (QC) procedures applied to category Chemical industry (CRF 2.B)

- Assumptions and criteria for the selection of activity data and emission factors are documented.
- For whole time series the emission calculation formulas have been checked.
- For whole time series the use of appropriate units throughout the calculations has been checked.
- Several interviews to describe and explain production technology with factory technologist have been carried out.
- The consistency of input data and methods over the time series has been assessed.

3.3.5. Source-specific recalculations including changes made in response to the review process

There are no recalculations made for the mineral industry sector in 2008 (on 2006 data) inventory submission.

3.4. Other Consumption (CRF 2.D)

3.4.1. 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.

3.4.2. Methodological issues

NMVOC emissions from the pulp and paper and food industry are calculated at the Department of Thermal Engineering of the Tallinn University of Technology. Activity data of the years 1990 – 2002 is obtained from the annual proceeding of the Statistics Estonia "Industry" and of the years 2003-2006 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.

3.4.3. Source-specific recalculations including changes made in response to the review process.

No recalculations have been made since the previous inventory.

3.4.4. Source-specific planned improvements

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

3.5. Consumption of Halocarbons and SF_6 (CRF 2.F)

3.5.1. Source category description

Production of Halocarbons and SF6

HFCs, PFCs and SF6 are not produced in Estonia. By-product emissions and production-related emissions of Halocarbons and SF6 do not occur.

Consumption of Halocarbons and SF6

The consumption of Halocarbons and SF6 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.

As outlined in the Estonian NIR 1990-2005 (p. 43), the country had so far no database on domestic consumption of halocarbons and SF6. Hence no empirical based assessment of F-gas

emissions and reporting on these greenhouse gases was possible. In the second half of 2007 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) started. Within the framework of this project a basic inventory of F-gas consumption in Estonia will be established up to mid 2008.

In this NIR, a first assessment of F-gas consumption in Estonia based on results from the Twinning project is given. Within the project all sectors of possible F-gas consumption as described in the IPCC Guidelines for National Greenhouse Gas Inventories (2006 edition) are under investigation. The research is 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 a.o.). 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 or 2b according to IPCC guidelines 2006).

It has to be underlined that the actual report on F-gases is of preliminary nature. Only some sectors and subsectors of F-gas consumption are already covered in total, e.g. Foam Blowing, Stationary Air-Conditioning, Metered Dose Inhalers. In other sectors relevant subsectors are still under investigation, e.g. reefer containers in the sector of Transport Refrigeration. Mobile Air Conditioning is the perhaps most important sector of HFC emissions; in this sector we present just the data for emissions from ships as the work on other MAC subsectors (passenger cars, trucks, buses, agricultural machines, railway vehicles) with emissions not yet finally determined is still ongoing. SF6 consumption as well is not yet fully included. In all those cases the entry in the CRF tables is NE combined with the remark "Still under investigation within the Twinning Project".

The emissions from the sectors already studied amount to some 76 gG CO2 equivalents. It may be assumed that this represents only a fraction between a third and a half of the total F-gas emissions of the country.

Hence the provisional data on estimated F-gas emissions given in the last year's NIR (2007, p.44) of less than 14 gG CO2 equivalents are obviously too low, but a recalculation will be possible only after finishing the Twinning project and the presentation of a full scale view of the countries F-gas consumption. This should be done in the 2009 NIR. Thus, for all years from 1995-2005 the entry in the CRF-tables is NE.

Quality control of activity data, emission factors and data on measured emissions was made as far as possible within the Twinning Project by the data collecting expert and cooperators from the Estonian Environmental Research Centre.

3.5.2. Refrigeration and air-conditioning systems

This sector covers domestic, commercial, transport and industrial refrigeration, stationary and mobile air-conditioning.

3.5.2.1.Domestic Refrigeration

Still under investigation within the Twinning Project.

3.5.2.2.Commercial Refrigeration

Still under investigation within the Twinning Project.

NB: Estonia reported already on 18.9 kg PFC-218 as component (9%) of the refrigerant blend R413A, which was sold in 2006 within the country. As the data for the refrigerant sector are not yet established emissions from this are not yet reported in the CRF tables.

3.5.2.3. Transport Refrigeration

Truck systems (trucks and trailers)

Source-category description

As of 31.12.2006 more than 1.300 vans and trucks and about 800 trailers with refrigeration units were registered in Estonia. Estonian trucks and trailers are imports, mostly second hand. The average age with regard to the building year of the in 2006 firstly registered trucks was 8.7 years. About 50% of the refrigeration units of imported (older) trucks and trailers is empty and has to be refilled within the country (vans: about 20%). Only a few refrigerated vans are built and equipped with refrigeration units firstly filled in Estonia. Refrigerants in use are HFC-134a (vans, smaller trucks) and the mixture HFC-404A (bigger trucks, trailers). In case of older trucks and trailers some refrigeration units still operate with HCFC-22.

Methodological issues

The Estonian car register includes data on the actual stock of registered truck systems with refrigeration. Information on the patterns of refrigeration units of the Estonian truck systems, their use of HFC-types, on charges, emissions and frequency of refilling was supplied from the two biggest service companies. Both are connected with leading international manufacturers of refrigeration units for trucks and trailers. The share of older refrigeration units with non-HFC-refrigerants was estimated with max. 7% of the stock. Vans and smaller trucks (cat. N1 and half of cat. N2 according to 2001/16/EC) are equipped with HFC-134a systems (charge on average 2.0 kg/unit), bigger trucks (half of cat N2 and cat N3 in total) with HFC-404A systems (on an average 5.8 kg/unit). For trailers a charge of on average 8.0 kg HFC-404A is supposed. Emissions from (re)filling are estimated by the Estonian experts with 1%. Emission from the first (re)filling of imported trucks/trailers with empty refrigeration unit is treated as emissions from manufacturing (“filled in new manufactured products”) as it does not represent the refilling of losses, which occurred within the country. The annual losses from the operating systems (EFop) including refilling losses amount to on average 30% of the refrigerant units charge (trucks and trailers). Method according to IPCC guidelines 2006: Tier 2a with country specific determination of EF.

Uncertainties and time-series consistency

The data are precise as based on the official car register and direct information from the service companies. Times series are not yet established as 2006 was the first year of investigation.

Source-specific quality assurance/control and verification

The data for this report was collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting expert and co-operators.

Source-specific recalculations

As 2006 is the first year within the F-gas inventory, no preceding data could be recalculated.

Planned improvements (source-specific)

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

3.5.2.4. Industrial Refrigeration

Still under investigation within the Twinning Project.

3.5.2.5. Stationary Air Conditioning

Stationary Air Conditioning includes as sub-application domains heat pumps and equipment for stationary and room air conditioning with HFC-104a, HFC-407C and HFC-410A.

Heat pumps

Source-category description

The use of heat pumps – ground and mainly air heat pumps – started in Estonia in 1993. Disposal has not yet occurred as the bulk of the systems got installed in the last years. Ground heat pumps operate with HFC-407C, air heat pumps with HFC-410A. In general, heat pumps are imported to the country and already charged with refrigerant. Only a small number of ground heat pumps was manufactured and filled with refrigerant in Estonia itself.

Methodological issues

The leading 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. 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 these sources the stock of installed heat pumps in Estonia amounted to about 10.000 systems in 2006 (3.000 ground- and 7.000 air heat pumps), nearly half of them newly installed in 2006 (4.750). The average charge was estimated with 2.0 kg for ground - and 1.0 kg refrigerant for air HP. The new systems are mainly (85%) air heat pumps. The discussion with Estonian experts resulted in emission factors for manufacturing (EFmanu) of 2.0% and for operating systems (EFop) of 2.5%. Method according to IPCC guidelines 2006: Tier 2a with country specific determination of EF.

Uncertainties and time-series consistency

The data are precise as they are based on information from the relevant associations, companies and experts for heat pumps and refrigeration systems in Estonia. Time series are not yet established as 2006 was the first year of investigation.

Source-specific quality assurance/control and verification

The data for this report was collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting expert and co-operators.

Source-specific recalculations

As 2006 is the first year within the F-gas inventory no preceding data could be recalculated.

Planned improvements (source-specific)

To date with regard to data collecting no improvement seems to be urgent.

Stationary and Room Air Conditioning

Source-category description

Stationary and room air-conditioning systems including chillers, ventilation and split systems are normally imported to Estonia. Split systems are imported with HFC charge, newly installed chillers (2006: 40 systems) and ventilation systems (2006: 400 systems) are firstly filled inside the country. Thus, in these cases emissions from filling (manufacturing) has to be considered. As refrigerants for chillers HFC-134a and the blend R 407c are in use, for ventilation systems and split systems the used blends are R 407C and R 410A.

Methodological issues

Activity data: The 2006 newly installed systems, the total 2006 stock of equipment, the equipments HFC charge by HFC types and EF from domestic manufacturing and stock was determined in cooperation with the experts from the Estonian Refrigeration Association and companies (manufacturer, trader, service companies) belonging to this association. As mentioned above, the classification of heat pumps on the one hand and stationary resp. room air conditioning systems on the other hand was discussed together with the Estonian Heat Pump Association to avoid double counting. The investigation revealed (operating systems) 400 chillers, 2.800 ventilation systems and 16.000 split systems ("mini-splits") as 2006 stock. The EFmanu (first filling) was determined with losses of 20g/system for chillers (factor: 0.00019) and 40g/system (factor: 0.0024) for ventilation systems, the EFbank (Product Life Factor) with 0.01 (chillers), 0.125 (ventilation systems) and 0.03 (split systems). Chillers and split systems are industrially manufactured and closer than ventilation systems assembled on site. Method according to IPCC guidelines 2006: Tier 2a with country specific determination of EF.

Uncertainties and time-series consistency

Precise data are based on direct measurement. Times series is not yet established as 2006 was the first year of investigation.

Source-specific quality assurance/control and verification

The data for this report was collected within the framework of the Twinning Project EE2005/IB/EN/01. QC was done by the data collecting expert and cooperators.

Source-specific recalculations

As 2006 is the first year within the F-gas inventory no preceding data could be recalculated.

Planned improvements (source-specific)

To date with regard to data collecting no improvement seems to be urgent.

3.5.2.6. Mobile Air Conditioning

HFC as cooling agents in mobile air conditioning systems (MACs) are a very important source of HFC emissions in Estonia. Within the framework of the Twinning project all relevant sub groups – passenger cars, trucks, buses, agricultural machines, ships and rail vehicles – are under investigation. In this NIR, emissions from ships – except tugboats and naval ships for which it was not yet possible to collect data – are reported.

Ships

Source-category description

All merchant ships >100 GT are expected to be equipped with air-conditioning systems and provision refrigeration, tugs with air-conditioning and fishing vessels >18 m with refrigeration. Ship air-conditioning with HFC started from 1996 onwards substituting HCFC-22. Refrigerants in use are HFC 407C (mixture), HFC 404A (mixture) and HFC-134a as the standard refrigerant (Öko-Recherche 2007). The cooling ad freezing systems of the Estonian deep sea freezer trawlers operate as usual without HFC (refrigerants: R-22 and ammonia).

Methodological issues

Ships under Estonian flag built in 2000 or later with GT 100 or more and fishing vessels >18 m are listed in the Estonian Ship Register (Estonian Maritime Authority). Data on A/C and provision cooling systems of these ships – except 7 tugboats – were collected, additionally data

on all ferries of the two relevant Estonian ferryboat companies. (The oldest ship with HFC air-conditioning and provision cooling was built in 1968.) The data on type of refrigerant, charge and refilling in 2006 came directly from the ship owners. One big ship under Estonian flag was newly built and delivered in 2006 but not built on an Estonian shipyard. Hence, the first HFC refrigerant filling of the A/C system and emissions from this first filling are not reported as activity data for 2006 but are taken account for the calculation of the bank in operating systems. The EFop from stock is based on direct measurement (refilling data 2006). Method according to IPCC guidelines 2006: Tier 2b with country specific determination of EF based on mass balance.

Uncertainties and time-series consistency

Precise data as based on direct measurement. Times series is not yet established as 2006 was the first year of investigation.

Source-specific quality assurance/control and verification

The data for this report was collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting expert and co-operators.

Source-specific recalculations

As 2006 is the first year within the F-gas inventory no preceding data could be recalculated.

Planned improvements (source-specific)

Tugboats >100 GT are still under investigation as well the Estonian naval ships.

Passenger cars, trucks, buses, agricultural machines, rail vehicles

Still under investigation within the Twinning Project.

3.5.3. Foam Blowing

3.5.3.1. Hard Foam

The use of HFC as blowing agents for foam production (mainly polyurethane foam, only to a minor degree extruded polystyrene foam) is an important source of HFC emissions in Estonia. Sub-groups are: PU-foam products, PU installation foam (one component foam, OCF) and XPS hard foam. The by far greatest amount of 2006 HFC emissions in this sector arose from manufacturing and use of open cell foam (OCF) in Estonia.

PU foam products

Source-category description

PU rigid foam products are manufactured and used in Estonia. The field of application of PU rigid foam includes in this sub-group:

a) panels and sandwich-elements,

b) products from integral-skin foam,

c) on-site applied foam for insulation (injection or spray foam).

a) Panels and sandwich-elements: The 2006 basic investigation showed that panels and sandwich elements with HFC as blowing agent for the PU core are not manufactured in Estonia. One Estonian company manufacturing PU panels and sandwich elements changed in 2001 from CFC directly to the water/CO_2 reaction. The sole manufacturer of industrially preformed insulation elements for buildings (some type of sandwich element) combining PU spray foam and polystyrene changed from 2004 onwards from HCFC-141b as blowing agent to CO_2/water and methyl formate. Since 1998 on the long run decreasing amount of PU sandwich elements with HFC-134a as blowing agent was imported building up a small bank for future emissions. As the EFop from this bank is very low, the emissions from bank are also very small.

b) Integral-skin foam: One company in Estonia used HFC-365mfc for manufacturing a very small amount of PU integral skin products.

c) Injection and spray foam: Additionally a similarly small sector of use of HFC-365mfc/HFC-227ea and of HFC 134a for in-situ-insulation with spray respectively injection foam was found.

Methodological issues

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

a) Panels and sandwich-elements: Information on manufacturing in Estonia (no HFC use) came from the above mentioned companies and their (foreign) polyol suppliers. The stock of PU foam with HFC as cell gas in imported sandwich elements was assessed by a model as the import/export data from the Estonian customs only indicate origin and total weight of sandwich elements without information on the insulating material. The model is based on information from 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). The HFC-134a content in the foam-stock is calculated with 7.5%. According to a 10% first year loss during and after manufacturing (FYL) 90% of the blowing agent remain within the cell of the foam; the annual emission from this bank (EFop) is 0.5% (cf. UBA 2005:137). The decreasing quota of PU sandwich elements with HFC-134a reflects the change from this HCFC-141b-substitute to CO2 and pentane since the end of the 1990s. The annual emission of HFC-134a from the stock of PU sandwich elements remains within the kg-order (2006:77 kg).

Import of HFC containing PU panels for insulating (building sector, mortuaries, meat factories, transport vehicles, etc.) was not reported.

b) Integral skin foam: Information came from the manufacturer of integral skin products in Estonia and its foreign polyol supplier (amount of HFC-365mfc consumption in 2006). The EFmanu is 100% (according to polyol supplier and UBA 2005: 144).

c) Spray and injection foam: In the area of on-site applied foam the hardly inflammable blowing agent HCFC-141b was no longer permitted as of 2004 as the latest. Problems with HFC-alternatives arose from two sides. On the one hand the substitution of HCFC-141b by HFC-365mfc is from a technical point of view not trivial. On the other hand the market demand for HFC-365mfc could not be satisfied as the manufacturer of this substance had to struggle with

production problems. Hence in the following time HFC-141b was Europe-wide still in use – according to polyol supplier also in Estonia.

Waterbased [HFC-free] PU spray foam systems for insulating soil-laid heating pipes in-situ are used in Estonia up to an amount of some tons/year. The one company using spray foam for production of thermal insulation elements mentioned above changed from HCFC-141b to a combination of water/C02 reaction and methyl formate.

In Estonia, firstly for 2006 two companies reported use of HFC-365mfc/HFC-227ea respectively some kg HFC 134a as blowing agent for on-site applied PU foam. The HFC percentage in sprayfoam is according to polyol supplier 7.5%. Manufacturing loss (EFmanu) includes the HFC fraction released on and after manufacturing (EFFYL, first year loss). For PU rigid on-site foam in contrast to the IPCC guidelines (2006:7.35: EFFYL 10%) a EFFYL value of 20% is used for HFC-134a and HFC-365mfc/HFC227ea (cf. Krähling a.o./Solvay 2002: 15% loss on manufacturing, 5% loss within the first year). 80% of the blowing agent remain within the cell of the foam. Stock 2006: 50% of the HFC remaining within the foam manufactured in 2006 are entered in the table as stock 2006.

Uncertainties and time-series consistency

A time series could only be calculated for PU foam sandwich elements with HFC-134a as blowing agent. HFC driven spray foam started in 2006.

Source-specific quality assurance/control and verification

The data for this report was collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting expert and co-operators.

Source-specific recalculations

As 2006 is the first year within the F-gas inventory no preceding data could be recalculated.

Planned improvements (source-specific)

Use of HFC-134a for sandwich elements has to be revised in 2007.

PU installation foam (one component foam [OCF])

Source-category description

PU foam (one component foam) in cans for installation is manufactured in Estonia and mainly exported. The domestic consumption is supplied by domestic suppliers and by imports. As blowing agents amongst other non- HFC substances HFC-134a and HFC-152a are used.

Methodological issues

The following data was collected for calculation of emissions from manufacturing and use:

- number of cans (in terms of 750 ml content) with HFC as blowing agent manufactured in Estonia, average amount of HFC per can, filling losses;
- number of OCF cans (in terms of 750 ml content) with HFC as blowing agent sold on the Estonian market, average amount of HFC per can.

Information sources: The two Estonian companies manufacturing OCF within the country; Estonian companies and main foreign companies selling OCF to the Estonian market; experts from internationally operating PU foam companies. The share of additional "other" (foreign) companies selling to the Estonian market was also estimated. The EFmanu was based on information from manufacturers and compared to international data. It is assumed that all HFC used are emitted. In contrast to the IPCC method but in accordance with other submissions under the UNFCCC it is assumed that all emissions occur in the year of sale (use and disposal occurring promptly after sale). The category "stock" is equated with the HFC content of OFC cans sold to the Estonian market and used in 2006. Hence only emissions from manufacturing and use (= stock) are entered in the CRF table, no emissions from disposal. Method according to IPCC guidelines 2006: Tier 2a with country specific determination of EF.

Uncertainties and time-series consistency

A time series is not yet available as the 2006 inventory is the basic F-gas inventory for Estonia. The manufacturer's figures on amounts of HFC contained and on filling losses could be cross checked by comparing similar data from international sources.

Source-specific quality assurance/control and verification

The data for this report was collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting expert and co-operators.

Source-specific recalculations

As 2006 is the first year within the F-gas inventory no preceding data could be recalculated.

Planned improvements (source-specific)

The possibility to obtain data from statistics is under review. In 2007 the share of "other" foreign suppliers of the Estonian OFC market – which was estimated for 2006 – should be directly investigated (in 2006 this share was <10% of HFC emissions from domestic consumption).

XPS hard foam

Source-category description

Extruded polystyrene foam (XPS foam) can be blown with HFC and become from this a source of HFC emissions. The 2006, basic research showed the following results: XPS foam is not manufactured in Estonia. Imported XPS sandwich elements are without any importance on the Estonian market whereas XPS board for thermal insulation is imported. In the past the shift from HCFC to HFC-134a and to CO2 as blowing agent took place stepwise. The main suppliers of the Estonian market with XPS board use since the end of the 1990s CO2. One big international supplier currently using CO_2 or HFC-134a as blowing agent serves the Estonian market from a Scandinavian factory with CO_2-foam. HFC-152a is today only used as blowing agent for a small sector of thicker high-value XPS foam. Another very small sector of the Estonian market was supplied by imports of HCFC-142b/HCFC-22 blown XPS foam, substances which are not covered by the Kyoto Protocol.

Methodological issues

Data on the XPS foam market in Estonia came from seven international operating companies. HFC-152a is lost widely during manufacturing and therefore estimated to be not present as cell gas in imported XPS board (cf. UBA 2005: 156ff). That is why no HFC-152a operating

emissions from the stock are calculated. In case of HFC-134a the larger part of the blowing agent remains within the XPS foam whereas some 27% are lost to the atmosphere (EFmanu). From company information the growing Estonian XPS foam market and stock and the simultaneously diminishing small share of XPS board blown with HFC-134a was calculated for 2001 (12.5%) – 2006 (0%), on average 5% of XPS in total. Based on half-life data for HFC-134a in XPS board the annual EFop is assessed with 0.66% of the remaining fraction. The amount of HFC-134a used for foam blowing is given with 3.3 kg/m3 (UBA 2005). Method according to IPCC guidelines 2006: Tier 2a with country specific determination of EF.

Uncertainties and time-series consistency

No statistical data on the XPS board consumption in Estonia could be found. Thus the stock of XPS foam with HFC-134a in 2006 had to be calculated with experts. The estimated 3600 tons XPS foam with HFC-134a represent 5% of the XPS foam stock in total. The other input data (HFC-134a content; EFop) are empirically based. The HFC-134a emission in 2006 is very small (57.2 kg).

Source-specific quality assurance/control and verification

The data for this report was collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting expert and co-operators.

Source-specific recalculations

As 2006 is the first year within the F-gas inventory no preceding data could be recalculated.

Planned improvements (source-specific)

According to experts (supplying companies) from 2006 onwards no HFC-134a containing XPS foam was put on the Estonian market. Thus an improvement of data acquisition seems not to be urgent.

3.5.3.2. Soft Foam

F-gas not occurring.

3.5.4. Fire Extinguishers

Still under investigation within the Twinning Project.

3.5.5. Aerosols

Under the category of metered dose inhalers (MDI) with HFC in pharmaceutical quality for natural medicals and for treatment of asthma/COPD (chronic obstructive pulmonary diseases), General Aerosols and Novelty Aerosols.

Metered Dose Inhalers (MDI)

Source-category description

Metered Dose Inhalers for natural medical products with HFC-134a as propellant in pharmaceutical quality are manufactured in Estonia and partially exported, but not imported; in contrast MDI for asthma/COPD are simply imported.

Methodological issues

The manufacturer submitted the data on manufacturing, domestic consumption and export of MDI for natural medical products including the emissions rate from manufacturing (EFmanu = 3 %). Emissions from the use of such MDI are determined in the same way as emissions from MDI for asthma/COPD: The amount of MDI sold on the domestic market in 2006 (production - export) is taken as stock of the year. The consumption of the product follows soon after buying as the maximum usability period is short. Therefore, annual domestic stock, consumption and emission are identical. HFC-134a is exhausted after inhalation without chemical degradation. A 100% emissions level from use is assumed (EFuse = 1).

In 2006, MDIs (asthma/COPD) with HFC-134a as propellant from six companies were registered in Estonia, but only three companies put their products on the market. Detailed information and

sales figures for the different medical products were supplied from the Medical Board (RAVIMIAMET) and the respective companies, which gave also information on the HFC content per device. In case of one company the HCF content per device had to be estimated. The determination of emissions follows the way described above. A country specific surcharge factor for hospitals and doctors' samples of 5% is estimated.

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

Uncertainties and time-series consistency

In general precise data as based on directly submitted information from the medical board and companies (manufacturer and trade departments); times series not yet established as 2006 was the first year of investigation.

Source-specific quality assurance/control and verification

The data for this report was collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting expert and co-operators.

Source-specific recalculations

As 2006 is the first year within the F-gas inventory no preceding data could be recalculated.

Planned improvements (source-specific)

Improvement of data quality in case of one company.

General aerosols

Still under investigation within the Twinning Project.

Novelty sprays

Still under investigation within the Twinning Project.

3.5.6. Solvents

Still under investigation within the Twinning Project.

3.5.7. Semiconductors

Still under investigation within the Twinning Project.

3.5.8. Electrical Equipment

Electrical equipment for electrical power supply is the countries largest individual SF_6 consumption sector.

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) gas insulated switchgear and controlgear (GIS) of the electrical transmission grid (high-voltage) and distribution network (medium-voltage). In Estonia the use of SF_6 for this purpose started from about 1988 (high-voltage) resp. 1999 (medium-voltage) onwards. The equipment is not manufactured within the country. Medium-voltage GIS (distribution equipment) operate with low pressure and little gas quantities of only some kg. They are imported with SF_6 charge and are hermetically sealed ("Sealed Pressure Systems"). High-voltage GIS (transmission equipment) with a higher operating pressure and bigger gas quantities ("Closed Pressure Systems") have to be replenished during their lifetime. They are imported with a transport filling and are filled up in situ (on site erection). According to IPCC GL 2006 (1999) the emission factor for sealed MV equipment is 0.1% per year and for HV switchgear 0.7% per year.

Methodological issues

Three Estonian companies dealing with power distribution operate SF6 containing HV-GIS (two companies) and MV-GIS (two companies). The companies supplied data on their equipment, on their SF6 consumption in total and on refilling during the last years. The third company, Estonian Railway, operates several own MV-GIS. 95% of the SF6-stock is concentrated at the main power distributor of the country. One other user of a small volume of SF6 (142 kg stock in 2006) has

not yet reported detailed data, for which reason emissions from this source could not yet be determined.

The reported refilling data of the HV-equipment 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 $EF_{manufacturing}$ (replenishing of imported HV-GIS within the country) was estimated by the main owner of HV-GIS at 0.1%. The EF_{op} of HV- and MV-GIS was based on the IPCC GL factors with 0.7 resp. 0.1% per year.

Method according to IPCC guidelines 2006: Tier 2.

Uncertainties and time-series consistency

The data are based on direct information from industry; times series have not yet been established because 2006 was the first year of investigation.

Source-specific quality assurance/control and verification

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

Source-specific recalculations

As 2006 is the first year of the F-gas inventory no preceding data could be recalculated.

Planned improvements (source-specific)

Recalculation of emissions.

3.5.9. Other Electrical Equipment

Under "Other Electrical Equipment" usage and emissions of SF_6 for radiotherapy devices are reported. Other applications – e.g. SF_6 insulated particle accelerators or gas impregnation of power capacitors – do not occur in Estonia.

Source-category description

Two hospitals in Estonia use SF_6 insulated radiotherapy equipment (oncology), each one device of different size.

Methodological issues

Data on filling volume and losses were directly submitted from the medical operator. The emission rate from the operating systems was calculated by the operator at 10% a year in case of the 2006 newly installed modern system (estimation) and at 30% a year in case of the smaller and much elder system (calculated from experience of the last four years).

Method according to IPCC GL 2006: country specific.

Uncertainties and time-series consistency

The data are based on estimation and direct measurement of the operator; times series have not yet been established as 2006 was the first year of investigation.

Source-specific quality assurance/control and verification

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

Source-specific recalculations

As 2006 is the first year of the F-gas inventory no preceding data could be recalculated.

Planned improvements (source-specific)

Recalculation of emissions.

3.5.10. Other

Soundproof glazing

According to information from the Estonian Association Building Materials' Producers and relevant companies SF6 for soundproof glazing was not used in Estonia.

Car tyres

Still under investigation within the Twinning Project.

Sport Shoes

Still under investigation within the Twinning Project.

Tracer gas

Still under investigation within the Twinning Project.

3.5.11. Conclusion

Due to the lack of activity data there was in the past no possibility to calculate actual emissions of F-gases in Estonia. F-gas emissions firstly are determined empirically within the Twinning Project which is not yet finished.

Table 3.6 contains on the one hand emissions of HFC-s, PFC-s and SF6 for the years 1995-2005 which were calculated together with the European Commission in accordance with Commission Decision 280/2004/EC Article 4(1) and Decision 2005/166/EC Article 13 and 14 using linear extrapolation method. These data are not empirically based and have to be recalculated in future. The table contains on the other hand first results from the Twinning Project which does not yet cover all relevant sectors of F-gas consumption of the country. It makes no sense to compare the data up to 2005 with the 2006 data as they are gained by different methods. Of the investigated sectors the biggest emission source is one component PU-foam, followed by refrigeration (not fully covered yet).

The share of actually reported emissions of HFC-s, PFC-s and SF6 in the total GHG emissions in the investigated sectors was 0.40% in 2006.

Table 3.6. Estimated emissions of HFC-s, PFC-s and SF6 in 1990-2006, Gg CO2

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
HFCs	NO	NO	NO	NO	NO	0.13	0.73	1.39	2.44	3.33	4.19	4.89	5.68	6.59	7.21	7.88	75.18
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE	NE	NE
SF6	NO	NO	NO	NO	NO	0.25	0.31	0.58	0.81	1.05	1.43	2.24	3.68	4.75	5.28	5.87	0.80
Total	NO	NO	NO	NO	NO	0.38	1.04	1.97	3.25	4.38	5.62	7.130	9.36	11.34	12.49	13.75	75.98

Uncertainties and time-series consistency

It is not yet possible to quantify the uncertainties for emission factors and activity rates for halocarbons and SF6's as the investigation of the F-gas sector is not yet finished. The uncertainty estimations for the herewith reported activity rates as well as for the emission factors is estimated at ±10 %.

3.6. Feedstock and Non-energy Use of Fuels (CRF 7)

3.6.1. Source category description

This source covers the CO_2 emissions from non-energy use of natural gas. The amount of natural gas is used as feedstock in the Chemical Industry sector for ammonia production and corresponding CO_2 emission is taken into account in the Industrial Processes sector.

CHAPTER 4. AGRICULTURE (CRF 4)

4.1. Overview of source category description and methodology

Agricultural GHG emissions in Estonia consist of CH_4 emissions from enteric fermentation of domestic livestock (14 sub-categories of livestock) and CH_4 end N_2O emissions from manure management systems, as well as direct and indirect N_2O emissions from agricultural soils. Direct N_2O emissions include emissions from synthetic fertilizers, 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 and leaching and run-off (Table 4.1).

The following improvements were carried out in this submission:

c) N_2O emissions from manure management were recalculated for 1990–2005 due to updating of the nitrogen excretion factor;
d) N_2O emissions from cultivation of histosols were estimated for 1990–2006.

Rice is not cultivated in Estonia. Savannas areas do not exist in Estonia. Emissions from crop residue burning were not estimated due to the lack of activity data (Table 4.1).

Table 4.1. Methods and emissions factors used for estimations of emission from agriculture

	CH_4		N_2O	
	Method Applied	Emission Factor	Method Applied	Emission Factor
I. Enteric Fermentation				
1. Cattle				
a. Cows, bulls and heifers (2 years and over)				
Dairy cattle	T2	IPCC, CS		
Non-Dairy cattle				
…Mature Females	T2	IPCC, CS		
…Mature Males	T2	IPCC, CS		
b. Bovine animals (ages between 1 and 2 years)	T2	IPCC, CS		
c. Calves (less than 1 year old)	T2	IPCC, CS		
2. Swine				
a. Piglets, live weight less than 20 kg	T1, L	IPCC, CS		
b. Young pigs, live weight 20 - <50 kg	T1, L	IPCC, CS		
c. Fattening pigs, live weight				
50 - <80 kg	T1, L	IPCC, CS		
80 - <110 kg	T1, L	IPCC, CS		
110 kg or more	T1, L	IPCC, CS		

	CH_4		N_2O	
	Method Applied	Emission Factor	Method Applied	Emission Factor
d. Breeding pigs, live weight 50 kg and more	T1, L	IPCC, CS		
3. Sheep	T1	IPCC, CS		
4. Goats	T1	IPCC		
5. Horses	T1	IPCC		
6. Poultry	NE			
II. Manure Management				
1. Cattle				
a. Cows, bulls and heifers (2 years and over)				
Dairy cattle	T1	IPCC, CS	T1	IPCC, CS
Non-Dairy Cattle				
Mature Females	T1	IPCC	T1	IPCC, CS
Mature Males	T1	IPCC	T1	IPCC, CS
b. Bovine animals (ages between 1 and 2 years)	T1	IPCC	T1	IPCC, CS
c. Calves (less than 1 year old)	T1	IPCC	T1	IPCC, CS
2. Swine				
a. Piglets, live weight less than 20 kg	T1	IPCC, CS	T1	IPCC, CS
b. Young pigs, live weight 20 - <50 kg	T1	IPCC, CS	T1	IPCC, CS
c. Fattening pigs, live weight				
50 - <80 kg	T1	IPCC, CS	T1	IPCC, CS
80 - <110 kg	T1	IPCC, CS	T1	IPCC, CS
110 kg or more	T1	IPCC, CS	T1	IPCC, CS
d. Breeding pigs, live weight 50 kg and more	T1	IPCC, CS	T1	IPCC, CS
3. Sheep	T1	IPCC	T1	IPCC
4. Goats	T1	IPCC	T1	IPCC
5. Horses	T1	IPCC	T1	IPCC
6. Poultry	T1	IPCC	T1	IPCC
III. Rice Cultivation				
IV. Agricultural soil				
1. Direct Soil Emissions				
a. Synthetic Fertilizers			T1	IPCC
b. Animal Waste Applied to Soils			T1	IPCC
c. N-fixing crops			T1	IPCC
d. Crop Residues			T1	IPCC
e. Cultivation of Histosols			T1	IPCC
2. Animal Production			T1	IPCC
3. Indirect Emissions				
a. Atmospheric Deposition			T1	IPCC
b. Leaching and Run-off			T1	IPCC
V. Prescribed Burning of Savannas				
VI. Field Burning of Agricultural Residues			NE	NE

T1 –Tier 1; T – Tier 2; L – literature; IPCC – IPCC default factors; CS – Country specific

4.1.1. 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 (Table 4.2), emission factors mostly were taken from the IPCC Guidelines (IPCC, 1997; IPCC, 2000).

A list of institutions directly and indirectly involved in the inventory process is presented in Table 4.2.

Table 4.2. 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.
Estonian Environmental 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)

4.1.2. Quantitative overview

The total emission from the agriculture sector was 1,201.66 Gg of CO_2 equiv in 2006. It was 6.4%[5] of the total GHG emission in Estonia (Figure 4.1). CH_4 emission from enteric fermentation (36.2% in CO_2 equiv.) and direct N_2O emission from agricultural soils (35.4% in CO_2 equiv) contributed the main share to the total emissions from the agricultural sector.

[5] GHG emissions of LULUCF sector are not included

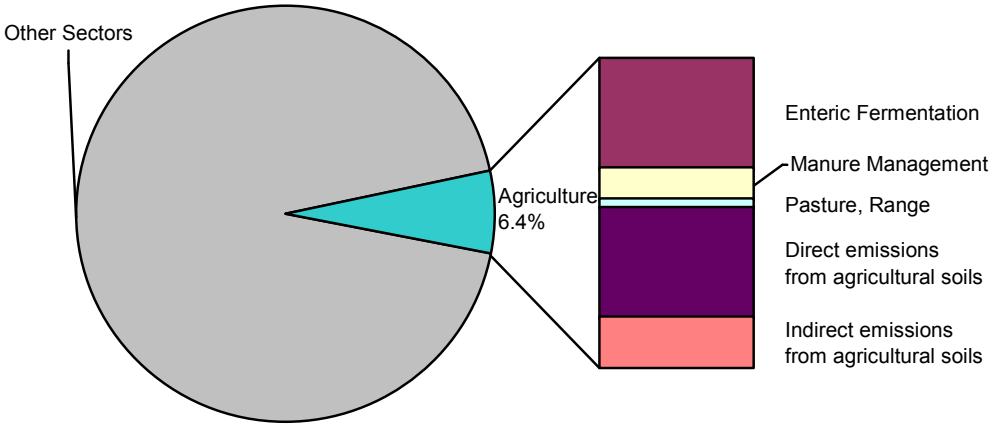


Figure 4.1. Emissions from agriculture compared to total GHG emissions in 2006, Gg

CO_2 equiv emissions from the sector have decreased 2.7 fold compared with the base year, mostly due to decreases in livestock population and to the use of synthetic fertilizers and animal manure applied on agricultural fields (Figure 4.2, Table 4.3).

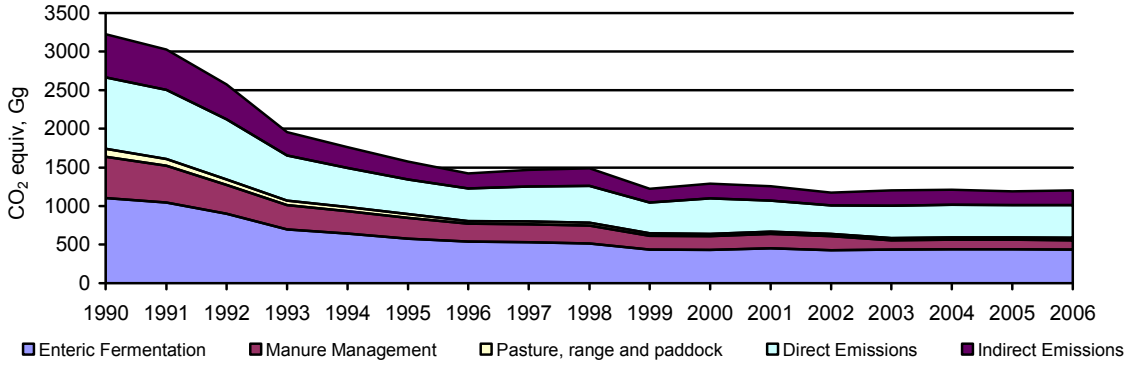


Figure 4.2. Trend in agricultural emissions by source categories in 1990–2006, Gg

Table 4.3. Estonia's agricultural greenhouse gases emissions by sources in 1990–2006, Gg

Year	Enteric Fermentation	Manure Management		Agricultural soils		**Total CH_4 emissions**	**Total N_2O emissions**	**Total CO_2 equiv emissions**
				Direct	Indirect			
	CH_4	CH_4	N_2O[6]	N_2O	N_2O	CH_4	N_2O	**CO_2 equiv**
1990	52.59	9.01	1.43	2.99	1.81	61.60	6.23	3,225.4
1991	49.61	7.93	1.29	2.89	1.69	57.54	5.87	3,029.5
1992	42.69	5.95	1.03	2.53	1.46	48.65	5.01	2,575.6
1993	33.25	4.74	0.88	1.89	0.97	37.99	3.74	1,957.4
1994	30.57	4.75	0.79	1.63	0.87	35.33	3.29	1,762.7

[6] N_2O emissions emitted during livestock pasturing is included into the total.

Year	Enteric Fermentation	Manure Management		Agricultural soils		**Total CH_4 emissions**	**Total N_2O emissions**	**Total CO_2 equiv emissions**
				Direct	Indirect			
	CH_4	CH_4	N_2O[6]	N_2O	N_2O	CH_4	N_2O	**CO_2 equiv**
1995	27.34	4.46	0.73	1.46	0.74	31.80	2.93	1,574.7
1996	25.68	3.56	0.62	1.35	0.63	29.24	2.61	1,422.7
1997	25.37	3.60	0.62	1.46	0.68	28.97	2.76	1,464.2
1998	24.47	3.64	0.62	1.54	0.74	28.12	2.91	1,491.1
1999	20.78	2.68	0.48	1.29	0.58	23.46	2.36	1,223.4
2000	20.55	2.70	0.48	1.48	0.62	23.25	2.58	1,289.4
2001	21.46	2.87	0.50	1.31	0.59	24.33	2.40	1,255.0
2002	20.41	2.77	0.48	1.19	0.54	23.19	2.21	1,171.6
2003	20.72	3.53	0.25	1.34	0.64	24.24	2.22	1,198.6
2004	20.89	3.54	0.25	1.36	0.64	24.43	2.26	1,212.1
2005	20.97	3.53	0.25	1.34	0.58	24.50	2.18	1,189.1
2006	20.69	3.48	0.25	1.37	0.62	24.17	2.24	1,201.7

4.1.3. Key categories

Agricultural key categories in 2006 calculated with IPCC Tier 1 method[7] were:

4.A	Enteric Fermentation (CH_4) (Cattle)	L, T[8]
4.B	Manure Management (N_2O)	T
4.D.3.2	Nitrogen leaching and Run-off (N_2O)	L, T
4.D.1.5	Cultivation of Histosols (N_2O)	L, T
4.D.1.2	Synthetic Fertilizers (N_2O)	L, T
4.D.1.1	Animal Manure applied on agricultural fields	L, T

4.1.4. Uncertainty assessment

The most uncertain emission source in agriculture is N_2O emission from animal manure management and N_2O emission from agricultural soils. The highest uncertainty rates are associated with estimates of indirect N_2O emissions from agricultural soil (atmospheric deposition and nitrogen leaching and run-off).

The combined uncertainties related to agriculture sector as percent from the total national emission in 2006 are follows[9]:

[7] GHG emissions/removals of LULUCF sector are not included in the estimation.
[8] L – Level Assessment method; T – Trend Assessment method.
[9] Uncertainty calculation for the Estonian GHG inventory **excluding LULUC** (following IPCC Tier 1)

4.A.	Enteric Fermentation (CH_4)	2.7693%
4.B.	Manure Management (CH_4)	0.0912%
4.B.	Manure Management (N_2O)	0.2479%
4.D	Agricultural soils (N_2O)	5.5309%
CRF 4	Agriculture sector total	8.6393%

4.2 Enteric fermentation and manure management

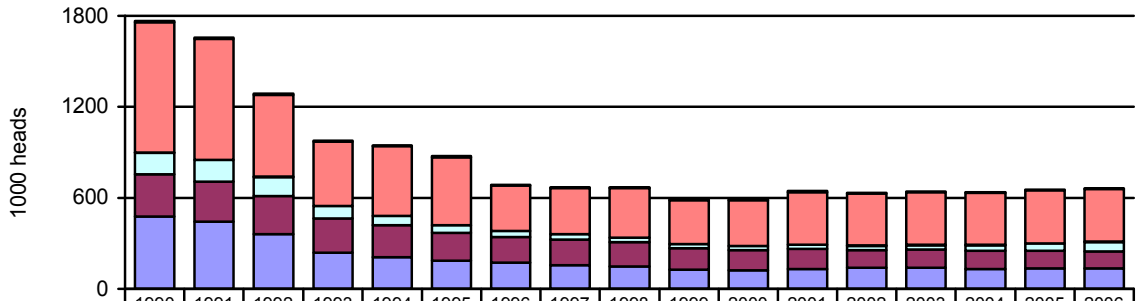
4.2.1. Source category description

Emissions of CH_4 and N_2O from livestock are reported under this category.

4.2.2. Livestock activity data

Livestock population decreased in comparison with the base year: the total number of swine decreased 2.5 fold, horses – 1.8 fold and poultry – 4.0 fold. The number of dairy cattle decreased 2.6 fold: from 280.7 thousand heads to 108.4 thousand heads, the number of non-dairy cattle decreased from 477 thousand heads in 1990 to 136.4 thousand heads in 2006. The number of sheep decreased 2.2 fold and the number of goats increased from 0.9 thousand heads to 3.3 thousand heads from 1990 to 2006 (Figure 4.3, Figure 4.4).

The detailed data on livestock population by counties of Estonia in 1990–2006 is presented in Annex 5_I.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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
Swine	860	799	541	424	460	449	298	306	326	286	300	345	341	345	340	346.5	345.8
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
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
Dairy cattle	281	264	253	227	211	185	172	168	159	138	131	129	116	117	117	112.8	108.4
Non-dairy cattle	477	444	361	237	208	185	171	158	149	129	122	132	138	140	133	136.7	136.4

Figure 4.3. Population of livestock in Estonia from 1990 to 2006, 1000 heads

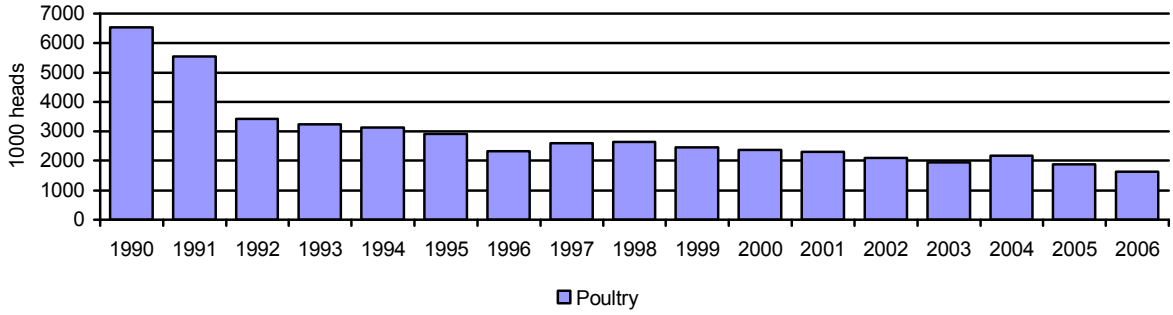
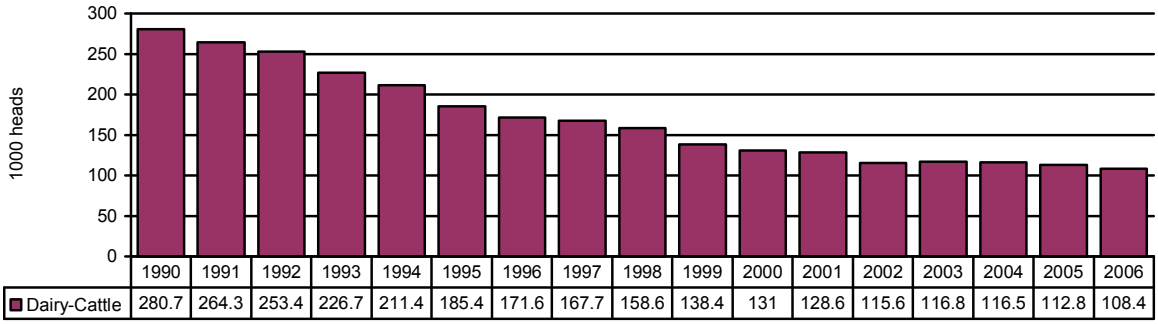


Figure 4.4. Population of poultry in Estonia from 1990 to 2006, 1000 heads

Figures 4.3–4.7 give the cattle and swine population by sub-categories of animals (more detailed data are presented in Annex 5_I).



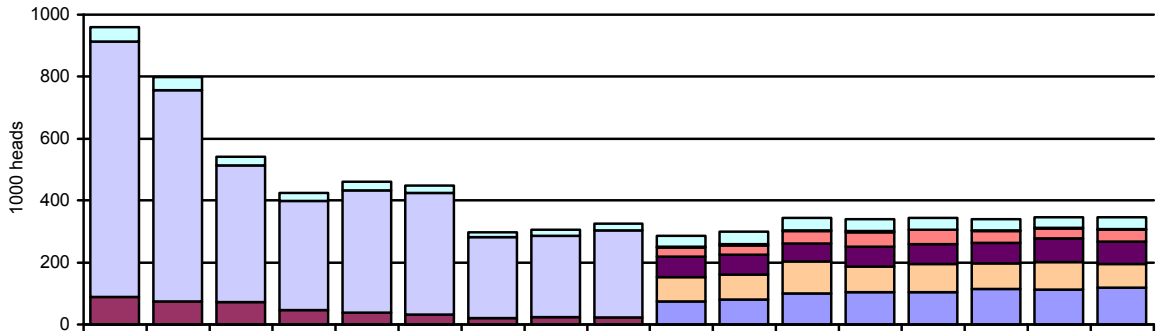
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Dairy-Cattle	280.7	264.3	253.4	226.7	211.4	185.4	171.6	167.7	158.6	138.4	131	128.6	115.6	116.8	116.5	112.8	108.4

Figure 4.5. Population of dairy cattle in Estonia in 1990–2006, 1000 heads

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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
Bovine Animals	223.2	221.9	180.8	119	101.1	87.3	81.7	76.9	71	48.5	44.8	48.8	55.1	52.8	51	51.9	51.6
Mature Males	2	2.1	1.6	0.6	1.2	0.7	0.6	0.6	0.8	1.6	1.2	1.2	1.1	0.8	1.3	0.8	1.7
Mature Females										14.5	14.7	12	12.1	14.5	14.7	16.8	11.1

Figure 4.6. Population of non-dairy cattle in Estonia in 1990–2006, 1000 heads[10]

[10] 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);



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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
F	823.3	682.1	440.9	352.3	394.2	393.9	259.8	261.1	282.3								
P110m										3.8	3.2	1.7	3.6	1.8	3.3	1.5	2.4
P110										29	32	40.8	45.8	44.6	37.8	31.7	36.5
P80										66	63.8	57	64.7	64.3	65.5	77.2	72.8
P50										77.9	79.5	103.6	82.8	91.9	83.9	87.2	76.9
P20										75.2	81.2	100.3	104.1	104.1	113.7	113.3	118.8
YS	89.5	75	72.5	46.7	39	31.5	21	23.9	21.5								

Figure 4.7. Population of pigs in Estonia in 1990–2006, 1000 heads[11]

The activity data used in the estimations in the 2008 submission differ from those reported in FAO statistic dataset due to different methods of data reporting (Table 4.4).

Table 4.4. The number of livestock population in Estonia in 1992–2006, in accordance with ESO and FAO datasets1000 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
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

[11] P20 - Piglets, live weight less than 20 kg;
P50 - Young pigs, live weight 20–<50 kg;
F - Fattening pigs;
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
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

As it was mention, ESO datasets have been used in the estimates of the 2008 submission.

4.2.3. CH_4 emissions from Enteric Fermentation

4.2.3.1. 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.

Methane emission from enteric fermentation makes up 86% from the total agricultural emission of CH_4 in Estonia. CH_4 emission of 2006 is 60% lower than the emission of the base year due especially to decreasing number of livestock (Figures 4.3-4.7).

Table 4.5. CH_4 emissions from Enteric Fermentation by animal type in 1990–2006 in Estonia, Gg

Year	Cattle	Pigs	Sheep	Goats	Horses	Poultry	**Total**	**Total CO_2 equiv**
1990	50.11	1.20	1.12	0.005	0.15	NE	52.59	1,104.5
1991	47.33	1.00	1.14	0.005	0.14	NE	49.61	1,041.8
1992	40.92	0.66	0.98	0.01	0.12	NE	42.69	896.6
1993	31.96	0.52	0.66	0.01	0.09	NE	33.25	698.2
1994	29.42	0.58	0.48	0.01	0.09	NE	30.57	642.0
1995	26.29	0.57	0.39	0.01	0.08	NE	27.34	574.1
1996	24.91	0.38	0.30	0.01	0.08	NE	25.68	539.2
1997	24.63	0.39	0.27	0.01	0.08	NE	25.37	532.9
1998	23.75	0.41	0.23	0.01	0.07	NE	24.47	514.0
1999	20.23	0.24	0.23	0.01	0.07	NE	20.78	436.5
2000	19.97	0.25	0.23	0.02	0.08	NE	20.55	431.5
2001	20.83	0.28	0.23	0.02	0.10	NE	21.46	450.7
2002	19.78	0.28	0.24	0.02	0.10	NE	20.41	428.7
2003	20.07	0.28	0.25	0.02	0.10	NE	20.72	435.1
2004	20.20	0.27	0.31	0.01	0.09	NE	20.89	438.8
2005	20.19	0.28	0.40	0.01	0.09	NE	20.97	440.3

Year	Cattle	Pigs	Sheep	Goats	Horses	Poultry	**Total**	**Total CO_2 equiv**
2006	19.81	0.28	0.50	0.02	0.09	NE	20.69	434.5
%, 2006	95.7%	1.4%	2.4%	0.1%	0.4%	NE		

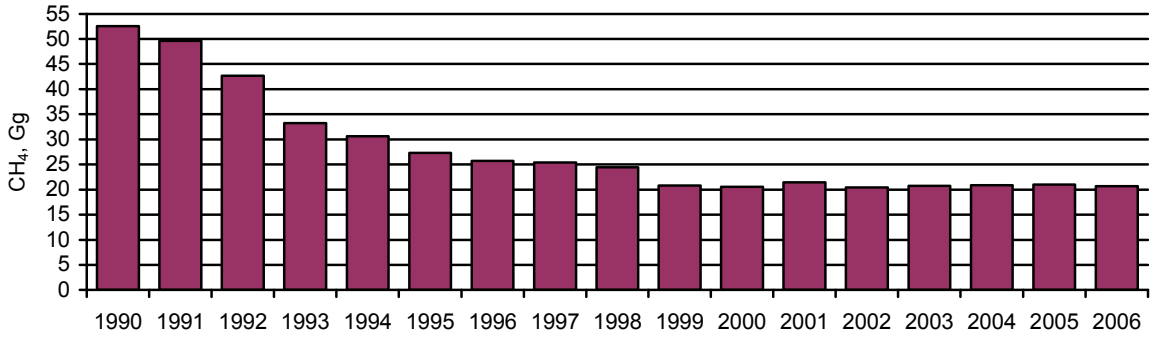


Figure 4.8. CH_4 emissions from Estonia's livestock enteric fermentation in 1990–2006, Gg

4.2.3.2. Cattle

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

The *Tier 2* method (IPCC, 1997) was used to estimate CH_4 emission from enteric fermentation of the main cattle livestock sub-categories (presented by ESO). A disaggregation on county level of Estonia was applied (Table 4.6).

Table 4.6. Symbols used in the algorithm for cattle

County	Cattle classes
i1- Harju county	j1- Dairy Cattle
i2- Hiiu county	j2- Mature Females
i3- Ida-Viru county	j3- Mature Males
i4- Jõgeva county	j4- Bovine cattle
i5- Järva county	j5- Calves (less than 1 year old)
i6- Lääne county	
i7- Lääne-Viru country	
i8- Põlva county	
i9- Pärnu county	
i10- Rapla county	
i11- Saare county	
i12- Tartu county	
i13- Valga county	
i14- Viljandi county	
i15- Võru county	

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

$$NE_{mji}(MJ/day) = C_{f\,ji} \times (weight\_in\_kg_{ij})^{0.75} \quad (4.1)^{12}$$

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 4.7);

Table 4.7. C_f coefficient[13]

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

Net energy for activity for animals

$$NE_{aji} = C_a \times NE_{mji}\_for\_cattle \quad (4.2)^{14}$$

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 (4.1);

Table 4.8. Activity coefficients corresponding to animal's feeding situation[15]

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

$$NE_{gji}(MJ/day) = 4.18 \times \left\{(0.035W_{ji}^{0.75} \times WG_{ji}^{1.119}) + WG_{ji}\right\} \quad (4.3)^{16}$$

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

[12] IPCC 2000, Agriculture, Equation 4.1, pp 4.13.
[13] IPCC 2000, Agriculture, Table 4-4 – Coefficient for calculating NEm, pp. 4.15
[14] IPCC 2000, Agriculture, Equation 4.2a, pp. 4.12.
[15] IPCC 2000, Table 4.5 – Activity coefficients corresponding to animal's feeding situation, pp. 4.15
[16] IPCC 1996, Agriculture, Reference Manual, Equation 3, pp. 4.18.

$$NE_{l_i}\,(MJ/day) = kg\_of\_milk/day_i \times (1.47 + 0.40 \times Fat_i) \quad (4.4)^{17}$$

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

$$NE_{pregnancy}\,(MJ/281-day\_period) = 28 \times calf\_birth\_weight\_in\_kg \quad (4.5)^{18}$$

$$Calf\_birth\_weight\_(kg) = 0.266 \times (cow\_weight\_in\_kg)^{0.79} \quad (4.6)$$

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

$$NE/DE_{ji} = 1.123 - (4.092 \times 10^{-3} \times DE_{ji}\%) + (1.126 \times 10^{-5} \times (DE_{ji}\%)^2) - 25.4/DE_{ji}\% \quad (4.7)^{19}$$

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;

[17] IPCC 2000, Agriculture, Equation 4.5a, pp. 4.17.
[18] IPCC 1996, Agriculture, Reference Manual, Equation 6, pp. 4.19.
[19] IPCC 2000, Agriculture, Equation 4.9, pp. 4.19.

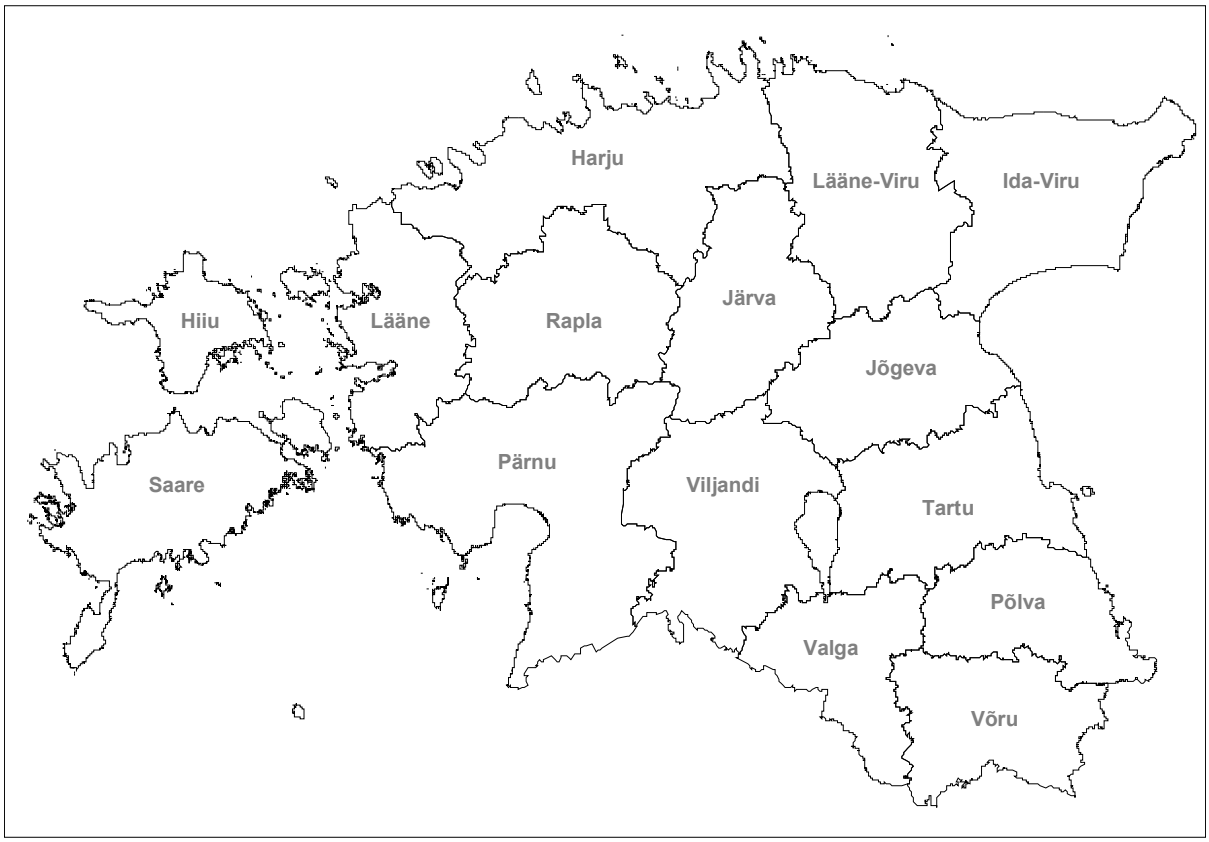


Figure 4.9. Administrative boundaries of Estonia's counties (Estonian Land Board)

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

$$NE_g/DE_{ji} = 1.164 - (5.160\times10^{-3}\times DE_{ji}\%) + (1.308\times10^{-5}\times(DE_{ji}\%)^2) - 37.4/DE_{ji}\% \qquad (4.8)^{20}$$

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

$$GE = \frac{(NE_{m\,ji} + NE_{feedji} + NE_{lji} + NE_{workji} + NE_{pregnancyji})\times\left(\frac{100}{DE_{ji}\%}\right)}{(NE/DE)_{ji} + (NE_{gji}/\{NE_g/DE\}_{ji})} \qquad (4.9)^{21}$$

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

[20] IPCC, 1997, Agriculture, Reference Manual, Equation 10, pp. 4.19.
[21] IPCC, 1997, Reference Manual, Equation 16, pp. 4.21.

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[22], 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

$$E = \left[GE \times Y_m \times (365 days/yr)\right] / \left[55.65 MJ / CH_4\ kg\right] \quad (4.10)^{23}$$

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;

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 cattle were obtained from the IPCC reported tables[24] (Annex 5_III).

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 4.9). The data in Table 4.10 illustrates the trend of milk yield per cow in Estonia and fat content of milk in 1990–2006. (Annex 5_II)

Fat content of milk, % - the data were taken from EARC (Table 4.9). (Annex 5_II)

Percentage of cows that give birth in a year, % – the data were employed from EARC (Table 4.9). (Annex 5_)

[22] Net energy for work was not calculated

[23] IPCC, 2000, Agriculture, Equation 4.14, pp. 4.26.

[24] IPCC, 1997, Agriculture, Reference Manual, Table A-1- Data for estimating enteric fermentation emission factors for dairy cattle. pp. 4.31

Feed digestibility, % - data were used from databases (tables) presented by IPCC[14] (Annex 5_III)

Table 4.9. Average milk yield per cow, fat content and percentage of cows that gave birth in 2006

County	Average milk yield per cow, kg/day	Fat content[25], %	Percentage of cows that gave birth in 2005, %
Estonian average	17.22	4.17	92.2
Harju county	16.27	4.21	79.5
Hiiu county	12.93	4.24	78.4
Ida-Viru county	15.38	4.06	75.7
Jõgeva county	18.40	4.24	100.0
Järva county	18.90	4.14	99.7
Lääne county	14.64	4.28	99.3
Lääne-Viru county	17.92	4.07	95.9
Põlva county	19.52	4.14	92.9
Pärnu county	17.33	4.20	88.1
Rapla county	16.72	4.05	77.6
Saare county	14.97	4.26	87.1
Tartu county	18.66	4.19	100.0
Valga county	15.34	4.19	94.9
Viljandi county	14.89	4.27	97.4
Võru county	15.92	4.28	83.8

Table 4.10. Average milk yield [kg/head/yr] per cow and fat content of milk [%] in 1990–2006

Year	Fat content of milk, %	Milk yield per cow, kg/head/yr
1990[26]	4.14	10.8
1991	4.14	10.8
1992	4.07	9.67
1993	4.10	9.10
1994	4.12	8.61
1995	4.20	8.79
1996	4.34	9.50
1997	4.32	10.5
1998	4.40	11.4
1999	4.36	11.2
2000	4.42	12.3
2001	4.44	13.5
2002	4.43	13.3
2003	4.44	13.4
2004	4.40	14.2
2005	4.21	16.1
2006	4.17	17.2

[25] www.jkkeskus.ee/pages/sta/2005/ka2005.htm
[26] The values of 1991

Methane emission factors were estimated based on above presented method (the *Tier 2* method), available Estonian data and IPCC default parameters (Table 4.11).

Table 4.11. CH_4 emission factor from enteric fermentation of cattle in 2006, kg CH_4/head/year

County	Emission factors for Enteric Fermentation, kg CH_4/head/yr						
	Dairy Cattle		Non-Dairy Cattle				
			Mature Males	Mature Females	Bovine animals	Calves	IPCC [27]
	used in the estimation	IPCC	used in the estimation	used in the estimation	used in the estimation	used in the estimation	
Total		100					48
Harju county	121		68	59	63	34	
Hiiu county	107		68	59	63	34	
Ida-Viru county	116		68	59	63	34	
Jõgeva county	130		68	59	63	34	
Järva county	132		68	59	63	34	
Lääne county	115		68	59	63	34	
Lääne-Viru county	127		68	59	63	34	
Põlva county	134		68	59	63	34	
Pärnu county	125		68	59	63	34	
Rapla county	121		68	59	63	34	
Saare county	116		68	59	63	34	
Tartu county	131		68	59	63	34	
Valga county	117		68	59	63	34	
Viljandi county	116		68	59	63	34	
Võru county	120		68	59	63	34	

The average enteric fermentation emission factor of dairy cattle is continuing to grow since 1995 due mostly to increasing milk production by cow.

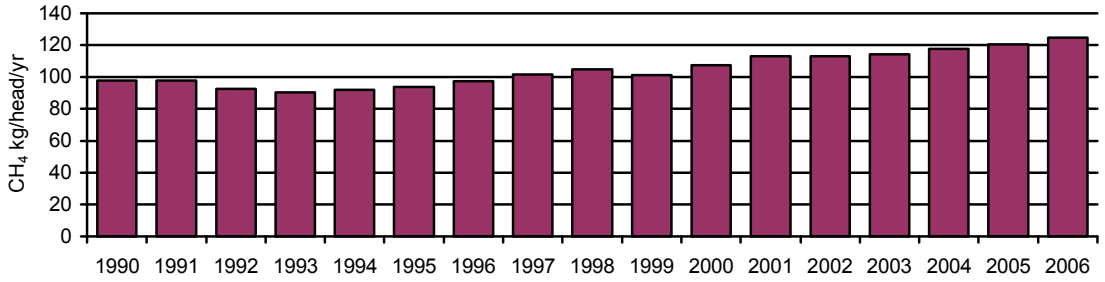


Figure 4.10. Average enteric fermentation emission factor of dairy cattle in 1990–2006, CH_4 kg/head/yr

[27] IPCC 1997, Agriculture. Reference Manual. Table 4-4 - Enteric fermentation emission factors for cattle. pp 4.11

4.2.3.2.2. Quantitative overview – CH4 emission from enteric fermentation of cattle in 2006

The total CH_4 emission from enteric fermentation of cattle was 19.81 Gg in 2006. Dairy cattle livestock was/is a main contributor to the total CH_4 emission from cattle enteric fermentation in Estonia (Table 4.12).

Table 4.12. CH_4 emissions from Enteric Fermentation of cattle in 1990–2006 in Estonia[6], Gg

	Cattle				
Year	DC	MF	MM	B	C
1990	27.46	-	-	13.99	8.67
1991	25.85	-	-	13.91	7.57
1992	23.44	-	-	11.33	6.16
1993	20.48	-	-	7.46	4.02
1994	19.44	-	-	6.34	3.64
1995	17.44	-	-	5.52	3.34
1996	16.68	-	-	5.16	3.07
1997	17.05	-	-	4.82	2.77
1998	16.65	-	-	4.45	2.65
1999	14.04	0.83	0.11	3.04	2.21
2000	14.08	0.88	0.08	2.83	2.10
2001	14.55	0.71	0.08	3.08	2.41
2002	13.09	0.72	0.08	3.48	2.41
2003	13.32	0.86	0.05	3.34	2.49
2004	13.73	0.88	0.09	3.22	2.28
2005	13.58	0.99	0.05	3.25	2.31
2006	13.53	0.65	0.12	3.23	2.27
%, 2006	68.3%	3.3%	0.6%	16.3%	11.5%

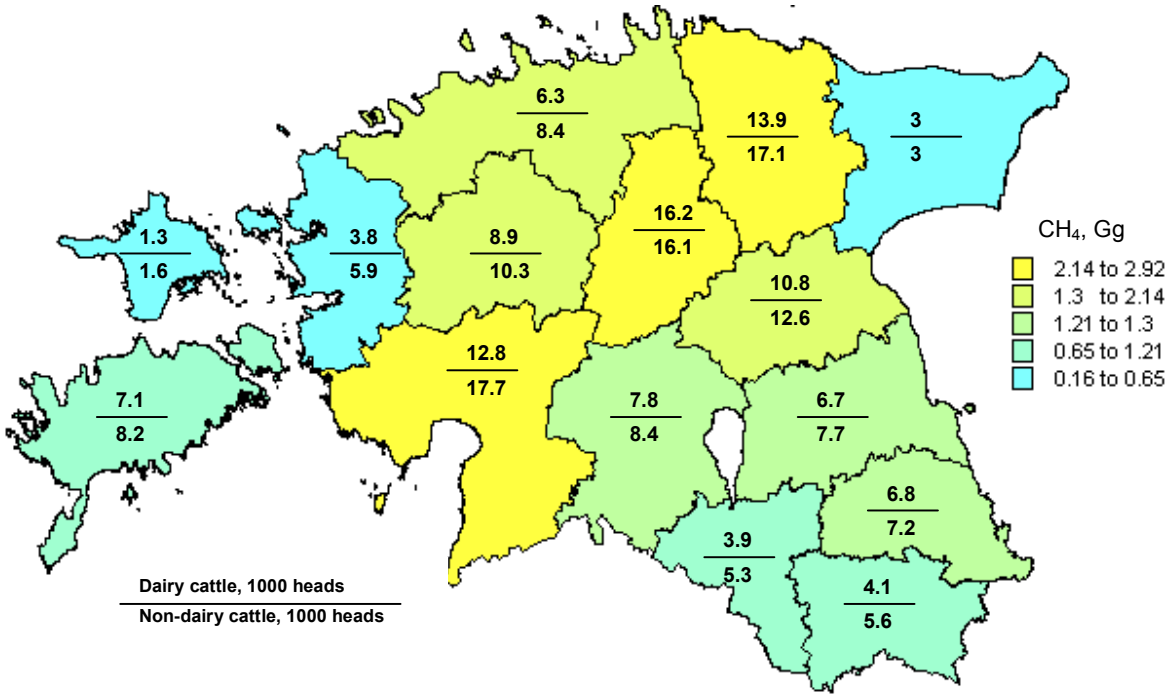


Figure 4.11. Population of cattle and CH_4 emissions from cattle enteric fermentation by counties of Estonia in 2006, 1000 heads, Gg (see also Figure 4.9)

4.2.3.3. Pigs

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

The *Tier 1* (IPCC, 1997) was used for the estimation of CH_4 emission from enteric fermentation of pigs, the estimation was carried out for the main sub-categories of pigs reported by the ESO (Table 4.13).

Table 4.13. Symbols used in the algorithm for swine

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

County	Swine classes
i15- Võru county	

Gross energy intake by swine

$$E_{ji} = 2.0 \times w_{ji}^{0.63} \quad (4.11)^{28}$$

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

$$E = [GE \times Y_m \times (365 days/yr)] / [55.65 MJ / CH_4\ kg] \quad (4.12)^{29}$$

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

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

Y_m – Methane conversion rate, which is the factor of gross energy in feed converted to methane;

Estimated CH_4 emission factors of pig enteric fermentation are presented in Table 4.14.

Table 4.14. 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[30]
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	

The averaged swine enteric fermentation emission factors reported in the CRF are presented in Figure 4.12.

[28] Oll *et al*., 1991; Turnpenny *et al.*, 2001.
[29] IPCC, 2000. Agriculture. Equation 4.14, pp. 4.26.
[30] IPCC, 1997. Agriculture. Reference Manual. Table 4-3 – Enteric Fermentation Emission Factors. pp. 4.10

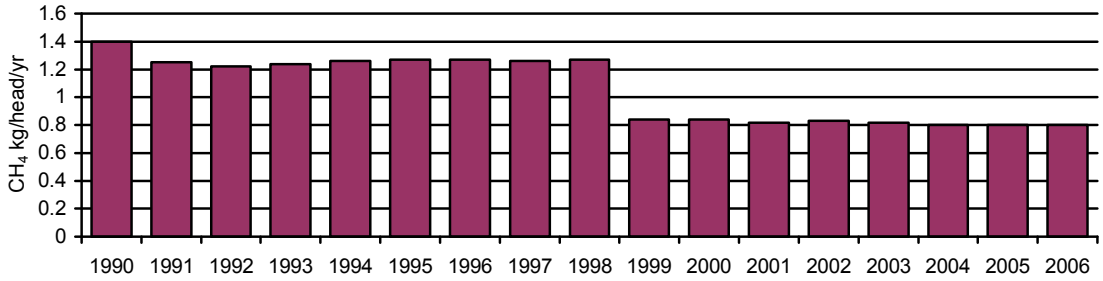


Figure 4.12. Average swine enteric fermentation emission factor, CH_4 kg/head/year.

4.2.3.3.2. Quantitative overview – CH4 emission from enteric fermentation of pigs in 2006

The total CH_4 emission from enteric fermentation of pigs was 0.28 Gg in 2006. The emissions have decreased 77% since the base year due mostly to decreasing number of pigs (Table 4.15).

Table 4.15 CH_4 emissions from Enteric Fermentation of pigs in 1990–2006 in Estonia[7], Gg

	Swine						
Year	P20	P50/YS	F	P80	P110	P100m	Br
1990		0.0481	1.0975				0.0563
1991		0.0403	0.9093				0.0496
1992		0.0390	0.5878				0.0331
1993		0.0251	0.4697				0.0302
1994		0.0210	0.5255				0.0318
1995		0.0169	0.5251				0.0280
1996		0.0113	0.3463				0.0210
1997		0.0128	0.3481				0.0254
1998		0.0116	0.3763				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
%, 2006	14.4%	20.6%		28.8%	18.3%	1.3%	16.6%

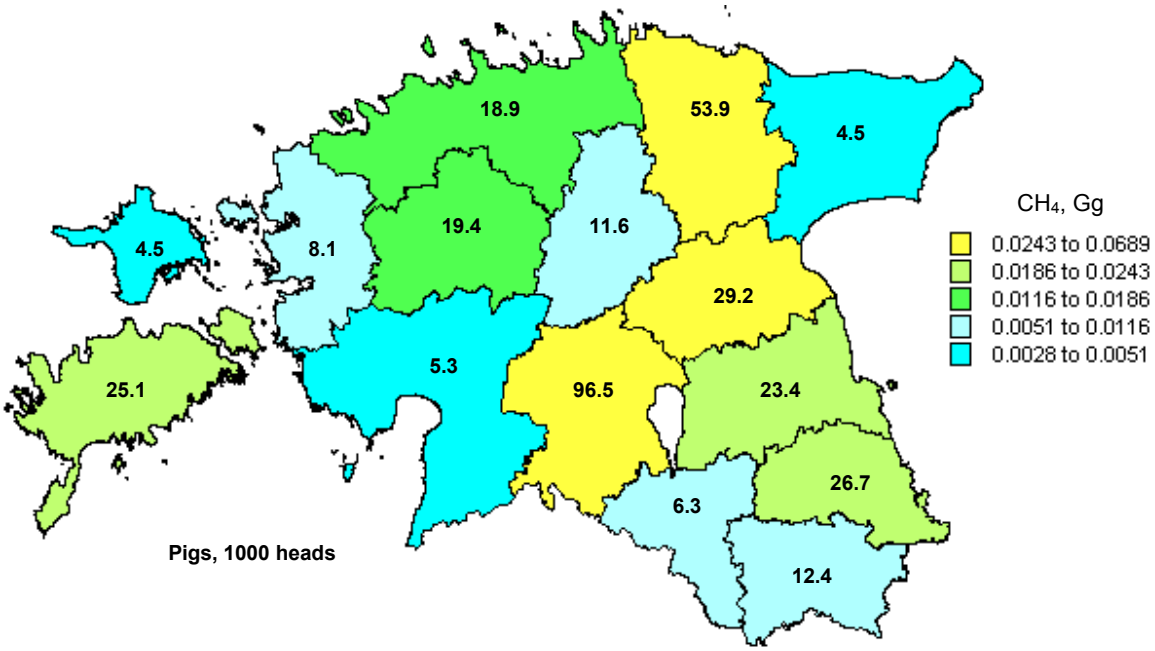


Figure 4.13. Population of pigs and CH_4 emissions from pig enteric fermentation by counties of Estonia in 2006, 1000 heads, Gg[31]

4.2.3.4. Other livestock

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

The algorithm based on the *Tier 1* (IPCC, 1997) and is presented below by the formula (4.13).

$$CH_4 \text{ Emissions} = EF_{ji} \times \text{population}_{ji} / (10^6 \text{ kg/Gg}) \quad (4.13)^{32}$$

CH_4 $Emissions_{ji}$ – Methane emission 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 IPCC (1997) reports the average methane emission factor for some livestock types both for developing and for developed countries. The emissions factors (for developed countries) were used in the process of the estimation of CH_4 emission from sheep, goats and horses (Table 4.16).

[31] The number of pig population of Hiiu and Ida-Viru Counties was calculated.
[32] IPCC, 2000. Agriculture. Equation 4.12, pp. 4.25.

Table 4.16. Enteric fermentation methane emission factors, kg CH_4/head/year[33]

Enteric Fermentation	Emission Factor, kg CH_4/head/yr
Sheep	8
Goats	5
Horses	18
Poultry	Not estimated

4.2.3.4.2. Quantitative overview – CH_4 emission from enteric fermentation of other livestock in 2006

The total CH_4 emission from other livestock enteric fermentation was 0.61 Gg. The 2006 emission is 52.2% lower than the CH_4 emission of the base year.

Table 4.17. CH_4 emissions from Enteric Fermentation of other livestock in 1990–2006 in Estonia, Gg

	Other Livestock		
Year	Sheep	Goats	Horses
1990	1.118	0.005	0.15
1991	1.135	0.005	0.14
1992	0.985	0.006	0.12
1993	0.658	0.006	0.09
1994	0.480	0.008	0.09
1995	0.386	0.009	0.08
1996	0.301	0.008	0.08
1997	0.271	0.009	0.08
1998	0.230	0.011	0.07
1999	0.226	0.014	0.07
2000	0.232	0.016	0.08
2001	0.230	0.018	0.10
2002	0.239	0.020	0.10
2003	0.246	0.018	0.10
2004	0.310	0.015	0.09
2005	0.397	0.014	0.09
2006	0.501	0.017	0.09
%, 2006	84.2%	2.8%	14.8%

4.2.3.5. Uncertainties and time-series consistency

The estimations of CH_4 emission 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

[33] IPCC, 1997. Agriculture. Reference Manual. Table 4-3 Enteric Fermentation Emission Factors (default values for developed countries) pp. 4.10

Guidelines (1997, 2000). The *Tier 1* method is used to estimate CH_4 emissions from other livestock: swine, goats, horses and sheep.

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 4.18).

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 4.18) (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 4.18) (IPCC, 2000).

Table 4.18. Estimated values of uncertainties used in agriculture sector (enteric fermentation)

Input	Uncertainties	References
Activity data		
Estonia's Livestock Population (cattle, swine, sheep, goats, horses, poultry)	± 10%	Rypdal K., et al., 2001
Emission factors		
Enteric Fermentation (CH_4) (cattle, swine)	± 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

The combined uncertainties related to 'enteric fermentation' sub-sector (CRF 4.A) as percent from the total national emission in 2006 are follows[34]:

4.A.	Cattle	2.5522%
4.A.	Sheep	0.0110%
4.A.	Goats	0.0004%
4.A.	Horses	0.0019%
4.A.	Swine	0.2038%

4.2.3.6. Source-specific recalculations

There is one important recalculation in the 2008 submission. The emissions from cattle were recalculated due to an omission made in the 2007 submission.

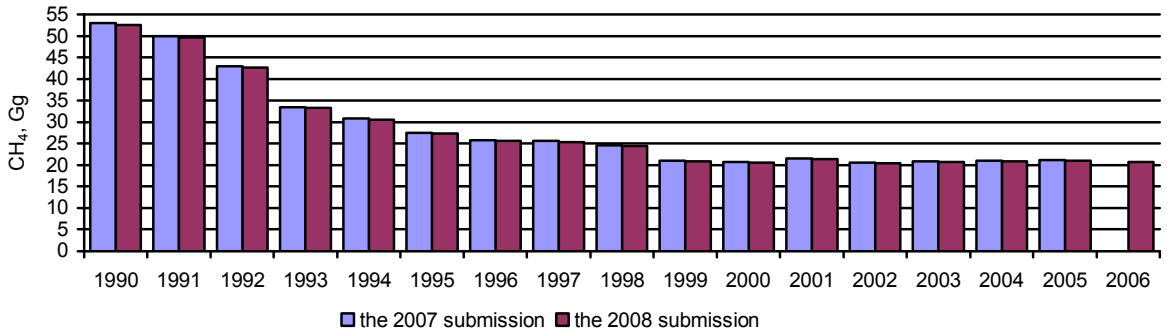


Figure 4.14. CH_4 emissions from enteric fermentation of Estonia's livestock in 1990–2006, Gg

4.2.3.7. Source-specific planned improvements

The data (activity data, emission factors) are kept under consideration and will be improved necessarily.

4.2.4. CH_4 emissions from Manure Management

4.2.4.1. 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 emission from manure management directly depend on the manure management system and temperature.

[34] Uncertainty calculation for the Estonian GHG inventory **excluding LULUC** (following IPCC Tier 1)

Methane emissions from manure management comprised 14.4% from the total agricultural emission in Estonia. Between 1990 and 2006, CH_4 emission declined by 61% due to decreasing number of livestock (Figures 4.3-4.7).

Table 4.19. CH_4 emissions from manure management in 1990–2006 in Estonia, Gg

Year	Cattle	Pigs	Sheep	Goats	Horses	Poultry	**Total**	**Total CO_2 equiv**
1990	3.73	4.73	0.026	0.0001	0.012	0.510	9.01	189.2
1991	3.53	3.93	0.027	0.0001	0.011	0.432	7.93	166.5
1992	3.06	2.59	0.023	0.0001	0.009	0.267	5.95	125.0
1993	2.41	2.06	0.016	0.0001	0.007	0.252	4.74	99.6
1994	2.22	2.27	0.011	0.0002	0.007	0.244	4.75	99.8
1995	1.98	2.24	0.009	0.0002	0.006	0.227	4.46	93.7
1996	1.87	1.49	0.007	0.0002	0.006	0.181	3.56	74.7
1997	1.86	1.52	0.006	0.0002	0.006	0.203	3.60	75.5
1998	1.80	1.63	0.005	0.0003	0.005	0.206	3.64	76.5
1999	1.53	0.95	0.005	0.0003	0.005	0.192	2.68	56.2
2000	1.50	1.00	0.006	0.0004	0.006	0.185	2.70	56.6
2001	1.57	1.11	0.005	0.0004	0.008	0.179	2.87	60.2
2002	1.48	1.11	0.006	0.0005	0.007	0.164	2.77	58.3
2003	2.55	0.81	0.006	0.0004	0.008	0.152	3.53	74.0
2004	2.58	0.78	0.007	0.0003	0.007	0.170	3.54	74.3
2005	2.58	0.79	0.009	0.0003	0.007	0.147	3.53	74.1
2006	2.55	0.79	0.012	0.0003	0.007	0.128	3.48	73.1
%, 2006	73.1%	22.7%	0.3%	0.0%	0.2%	3.7%		

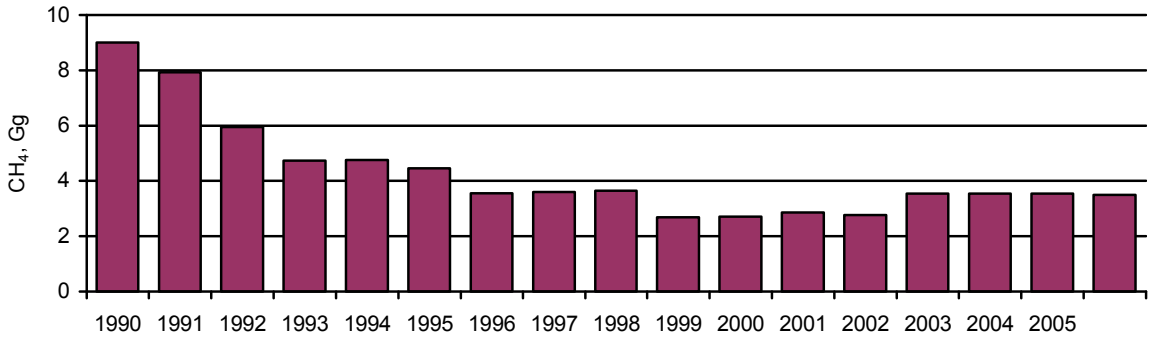


Figure 4.15. CH_4 emissions from Estonia's livestock manure management in 1990–2006, Gg

4.2.4.2. Cattle

4.2.4.2.1. 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 emission from manure management

$$CH_4\_Emissions_{ji} = Emission\_Factor_{ji} \times Population_{ji} / (10^6\ kg/Gg) \quad (4.14)^{35}$$

CH_4 $Emissions_{ji}$ – Methane emission 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

$$EF_{ji} = VS_{ji} \times 365\_days/yr \times B_{oji} \times 0.67 kg/m^3 \times \sum_{nK} MCF_{nk} \times MS\%_{jiK} \quad (4.15)^{36}$$

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

VS_{ji} - Daily VS excreted for for *j* category of cattle in *i* county, kg;

Bo_{ji} – Maximum CH_4 producing capacity for manure produced by *j* category of cattle in *i* county, kg of VS (Table 4.20);

MCF_{ik} - CH_4 conversion factors for each manure management system *n* by climate region *k* (Table 4.21);

MS_{ijk} - Fraction of animal species/category *j*'s manure handled using manure system *n* in *i* country in climate region *k* (Table 4.21);

[35] IPCC 2000. Agriculture. Equation 4.15, pp. 4.30.
[36] IPCC 2000. Agriculture. Equation 4.17, pp. 4.34.

Volatile Solid excretion rates

$$VS_{ji}\ (kg\ \ dm/day) = \frac{GE_{ii}}{18.45} \times (1 - \frac{DE_{ji}\%}{100\%}) \times (1 - \frac{ASH\%}{100\%}) \qquad (4.16)^{37}$$

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 4.20);

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

Table 4.20. Parameters used in the estimates[38]

	Feeding	Digestibility of Feed, %	CH_4 Conversion	Bo (m^3 CH_4/kg VS)
Cows, bulls and heifers (2 years and over)				
...Dairy	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 4.21. Manure management system usage (%) and methane conversion factor (MCFs)[39]

	Lagoon	Liquid/ Slurry Solid	Solid Storage	Dry lot	Pasture/ Range	Daily Spread	Digester	Burned for Fuel	Other
	Manure Management System Usage (%)[40]								
Dairy Cattle	0	40	18	0	19	20	0	2	1

[37] IPCC 2000. Agriculture. Equation 4.16, pp. 4.30.

[38] Table A-1 and Table A-2 of the 1996 Revised IPCC Guidelines. Agriculture. Reference Manual. pp. 4.31

[39] Table B-3 (Western Europe) of the 1996 Revised IPCC Guidelines. Agriculture. Reference Manual. pp. 4.43

[40] For Dairy Cattle – IPCC 1996. Agriculture. Reference Manual. Table B-3 – Manure Management Emission Derivation for Dairy Cattle. pp. 4.43

For Non-Dairy Cattle – IPCC 1996. Agriculture. Reference Manual. B-4 – Manure Management Emission Derivation for Non-Dairy Cattle. pp. 4.44

Non-Dairy Cattle	0	50	0	2	38	0	0	2	8
	Methane Conversion Factors (MCFs)[41]								
	90%	10%	1%	1%	1%	0.1%	10.0%	7.5%	1%

Basing on the algorithm presented CH_4 emission factor was estimated as follows (Table 4.22):

Table 4.22. Manure management emission factors for cattle, kg CH_4/head/year

Year	Cattle		
	Dairy Cattle	Mature Non-dairy Cattle	Calves
IPCC default (Eastern Europe)[42]	*6*	*4*	
1990	7.60	4.65	2.23
1991	7.60	4.65	2.23
1992	7.18	4.65	2.23
1993	7.02	4.65	2.23
1994	7.14	4.65	2.23
1995	7.30	4.65	2.23
1996	7.55	4.65	2.23
1997	7.89	4.65	2.23
1998	8.15	4.65	2.23
1999	7.88	4.51	2.23
2000	8.35	4.50	2.23
2001	8.79	4.53	2.23
2002	8.79	4.54	2.23
IPCC default (Western Europe)	*14*	*6*	
2003	15.44	7.20	3.57
2004	15.96	7.20	3.57
2005	16.30	7.17	3.57
2006	16.90	7.43	3.57

Activity data on livestock population employed in the estimates are reported in the Chapter 4.2.2.

4.2.4.2.2. Quantitative overview – CH_4 emission from cattle manure management in 2006

The total Estonian CH_4 emission from cattle manure management was 2.55 Gg in 2006. The emissions decreased by 31% from 1990 to 2006 (Table 4.23).

[41] IPCC 2000. Agriculture. Table 4-10 – MCF Values for Manure Management System (for cool climate). pp 4.37

[42] Table 4-6 of the 1996 IPCC Guidelines. Agriculture. Reference Manual. pp. 4.13

Table 4.23. CH_4 emissions from cattle manure management activities in 1990–2006 in Estonia[6], Gg

	Cattle				
Year	DC	MF	MM	B	C
1990	2.133			1.037	0.563
1991	2.008			1.031	0.492
1992	1.821			0.840	0.399
1993	1.591			0.553	0.261
1994	1.510			0.470	0.236
1995	1.354			0.406	0.217
1996	1.296			0.380	0.199
1997	1.324			0.357	0.180
1998	1.293			0.330	0.172
1999	1.090	0.059	0.007	0.225	0.144
2000	1.094	0.059	0.006	0.208	0.137
2001	1.130	0.048	0.006	0.227	0.156
2002	1.016	0.049	0.005	0.256	0.156
2003	1.803	0.093	0.006	0.391	0.258
2004	1.859	0.095	0.010	0.378	0.237
2005	1.838	0.108	0.006	0.384	0.240
2006	1.831	0.073	0.013	0.392	0.236
%, 2006	71.9%	2.9%	0.5%	15.4%	9.3%

4.2.4.3. Pigs

4.2.4.3.1. 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 4.2.4.2.1.

Methane conversion factor and the system of manure management usage (%) for cattle manure storage are presented in Table 4.24**.** The factors (DE, B_o) used in the estimates were obtained from IPCC tables on default factors (Table 4.25). Estimated emission factors are reported in Table 4.26.

Table 4.24. Manure Management System Usage (%) and Methane Conversion Factor (MCFs)

	Solid Storage	Dry lot	Pit < 1 month	Pit > 1 month	Other
	Manure Management System Usage (%)[43]				
Swine	21	2	3	73	1
	Manure Management Conversion Factor (MCFs)[44]				
Swine	1%	1%	5%	10%	1%

Table 4.25. 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 4.26. Methane emission factors from swine manure management systems, kg CH_4/head/year

Category of Swine	Emission factor, kg CH_4/head/yr	
	used in the estimation	IPCC
Estonian average		3.0[45]
Piglets, live weight less than 20 kg	0.96	
Young pigs, live weight20–<50 kg	2.11	
Fattening pigs		
...live weight 50–<80 kg	3.12	
...live weight 80–<110 kg	3.96	
...live weight 110 kg or more	5.39	
Breeding pigs, live weight 50 kg or more	3.41	

Averaged reported in the CRF factors on CH_4 emission from pig manure management system are reported in Figure 4.16.

[43] IPCC, 1997. Agriculture. Reference Manual. Table B-6 – Manure Management Emission Factor Derivation (for swine)

[44] IPCC 2000. Agriculture. Table 4 -10 – MCF Values for Manure Management System (for cool climate). pp 4.37

[45] IPCC, 1997. Agriculture. Reference Manual. Table 4-6 – Manure management emission factors for cattle, swine and buffalo (Western Europe, cool climate)

The sharp decrease in emission factors estimated (averaged) in 1999 is explained by changing of a methodology of activity data collection: ESO started to gain the data on 6 sub-categories of pigs instead of 3 sub-categories.

The sharp decrease in emission factors estimated (averaged) is defined by changing of a module of pig manure management system in 2003. Since 2003 Estonia has estimated CH_4 emissions from manure management employing the Western Europe manure management system.

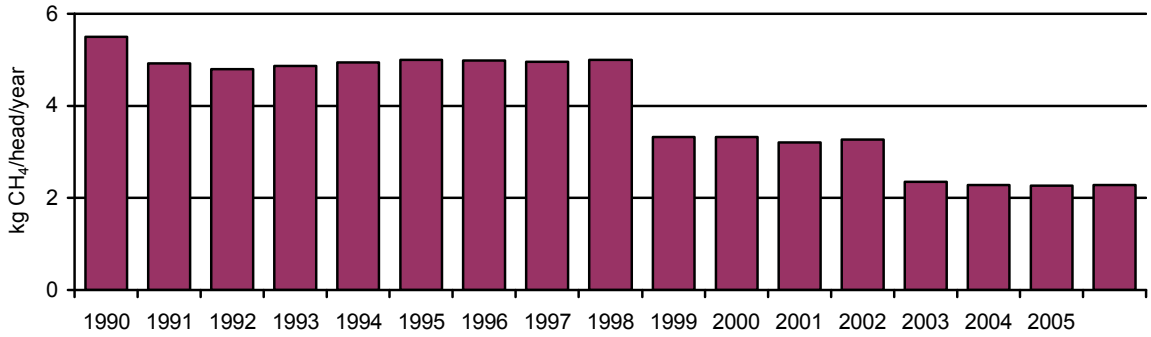


Figure 4.16. Averaged CH_4 emission factor for pig manure management system in 1990–2006, kgCH_4/head/year

4.2.4.3.2. Quantitative overview – CH_4 emission from pig manure management in 2006

The total CH_4 emission from pig manure management system was 0.79 Gg in Estonia in 2006. The CH_4 emission declined by 83% by 2006 due especially to decreasing number of pig population and applying of the module typical for Western Europe manure management.

Table 4.27. CH_4 emissions from swine manure management activities in 1990–2006 in Estonia[7], Gg

	Swine						
Year	P20	P50/YS	F	P80	P110	P100m	Br
1990		0.189	4.316				0.221
1991		0.159	3.576				0.195
1992		0.153	2.311				0.130
1993		0.099	1.847				0.119
1994		0.082	2.067				0.125
1995		0.067	2.065				0.110
1996		0.044	1.362				0.083
1997		0.051	1.369				0.100
1998		0.045	1.480				0.106
1999	0.099	0.226		0.283	0.158	0.023	0.159

Year	Swine						
	P20	P50/YS	F	P80	P110	P100m	Br
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	0.100	0.194		0.200	0.177	0.008	0.129
2004	0.109	0.177		0.204	0.150	0.014	0.122
2005	0.109	0.184		0.241	0.126	0.007	0.121
2006	0.114	0.162		0.227	0.145	0.010	0.131
%, 2006	14.4%	20.6%		28.8%	18.3%	1.3%	16.6%

4.2.4.4. Other livestock

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

CH_4 emission from manure management for other livestock was calculated in accordance with formula (4.14) 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 4.28)

Table 4.28. Methane emission factors for 'other livestock' from manure management, kg CH_4/head/year [46]

Category of livestock	Emission Factor, kg CH_4/head/yr
Sheep	0.19
Goats	0.12
Horses	1.4
Poultry	0.078

4.2.4.4.2. Quantitative overview – CH_4 emission from other livestock manure management in 2006

The total CH_4 emission from other livestock manure management was 0.15 Gg in Estonia in 2006 (Figure 4.17). The emissions declined by 73% by 2006 in comparison with the base year due to decrease in the number of 'other livestock' population.

[46] IPCC 1997. Agriculture. Reference Manual. Table 4-5 manure management emission factors (developed countries, cool climate region). pp. 4-12

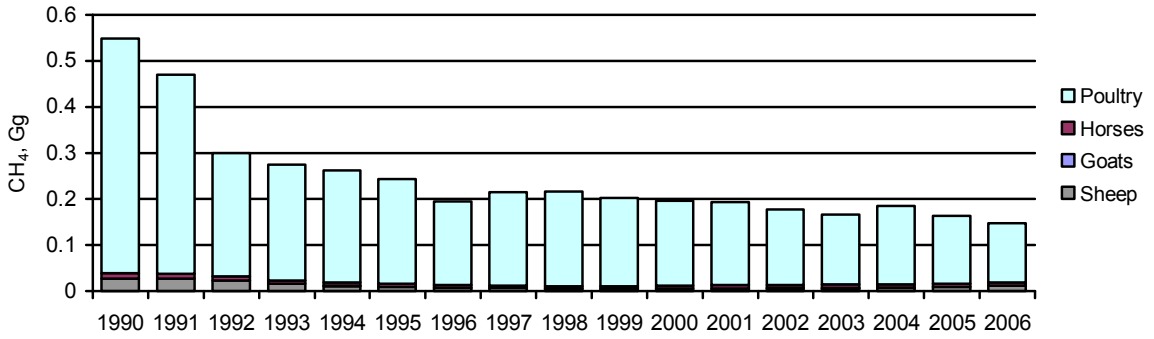


Figure 4.17. CH_4 emission from other livestock manure management in 1990–2006, Gg

4.2.4.5. Source-specific recalculations

One recalculation was carried out due to an omission made in the 2007 submission (Table 4.29, Figure 4.18): it was reported that Estonia uses the module of Western Europe cattle manure management system, however the module of Eastern Europe cattle manure management system has been taken into the estimates.

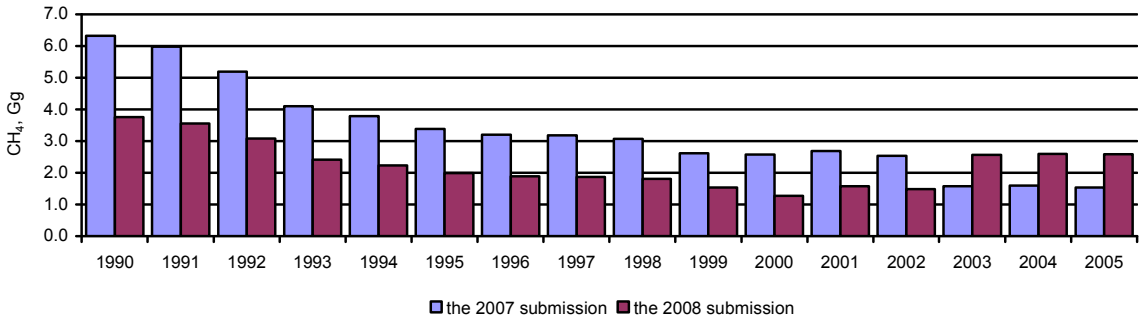


Figure 4.18. Reported and recalculated CH_4 emissions from cattle manure management in 1990–2006, Gg

Table 4.29. Reported and recalculated CH_4 emissions from cattle manure management in 1990–2006, Gg

	Reported emissions of CH_4 in the 2007 submission	Recalculated emissions of CH_4 (the 2008 submission)
1990	6.323	3.733
1991	5.980	3.531
1992	5.195	3.060
1993	4.107	2.405
1994	3.790	2.216
1995	3.382	1.977

	Reported emissions of CH_4 in the 2007 submission	Recalculated emissions of CH_4 (the 2008 submission)
1996	3.209	1.875
1997	3.191	1.861
1998	3.081	1.795
1999	2.617	1.525
2000	2.578	1.503
2001	2.689	1.567
2002	2.537	1.483
2003	1.582	2.552
2004	1.598	2.578
2005	1.541	2.577
2006		2.546

4.2.5. N_2O emissions from Manure Management

4.2.5.1. 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 6.7% from the total agricultural emission in Estonia in 2006. N_2O emission from animal manure stored of the base year is 7.5 fold higher than 2006 emission (Table 4.30, Figure 4.19).

The sharp decrease in 2003 in the N_2O emission is explained by applying of Western Europe module of manure management system, before 2003 Estonia has employed a module of Eastern Europe manure management system.

Table 4.30. N_2O emissions from manure management in 1990–2006 in Estonia, Gg

Year	Cattle	Pigs	Sheep	Goats	Horses	Poultry	**Total**	**Total CO_2 equiv**
1990	0.789	0.48	0.0190	0.0000	0.0000	0.0892	1.111	344.46
1991	0.748	0.40	0.0167	0.0000	0.0000	0.0756	1.008	312.45
1992	0.655	0.26	0.0167	0.0000	0.0000	0.0467	0.809	250.88
1993	0.591	0.21	0.0006	0.0000	0.0000	0.0440	0.692	214.40
1994	0.486	0.23	0.0081	0.0000	0.0000	0.0427	0.621	192.56
1995	0.438	0.23	0.0065	0.0000	0.0000	0.0397	0.572	177.42
1996	0.417	0.15	0.0051	0.0000	0.0000	0.0317	0.496	153.72
1997	0.412	0.15	0.0046	0.0000	0.0000	0.0355	0.496	153.61
1998	0.412	0.16	0.0039	0.0000	0.0000	0.0360	0.495	153.39
1999	0.343	0.09	0.0038	0.0000	0.0000	0.0336	0.392	121.39
2000	0.339	0.09	0.0039	0.0000	0.0000	0.0323	0.389	120.68

Year	Cattle	Pigs	Sheep	Goats	Horses	Poultry	**Total**	**Total CO_2 equiv**
2001	0.352	0.10	0.0039	0.0000	0.0000	0.0313	0.405	125.43
2002	0.329	0.10	0.0041	0.0000	0.0000	0.0286	0.386	119.63
2003	0.154	0.04	0.0020	0.0000	0.0000	0.0314	0.154	47.60
2004	0.156	0.04	0.0025	0.0000	0.0000	0.0353	0.158	49.13
2005	0.156	0.04	0.0032	0.0000	0.0000	0.0303	0.154	47.78
2006	0.151	0.04	0.0041	0.0000	0.0000	0.0265	0.149	46.20
%, N_2O	58.9%	15.6%	12.5%	1.0%	1.4%	10.6%		

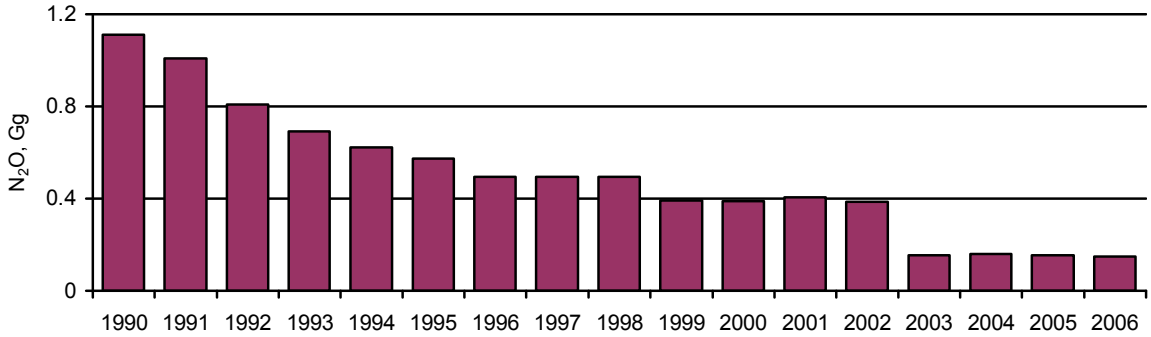


Figure 4.19. N_2O emissions from Estonia's manure management in 1990–2006, Gg

4.2.5.2. Cattle

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

The key methodology used for the estimation of N_2O emission from manure management was *Tier 1* method (IPCC, 1997).

$$(N_2O - N)_{(mm)} = \sum_{(S)} \{ [\sum_{(T)} N_{(T)} \bullet Nex_{(T)} \bullet MS_{(T,S)}] \bullet EF_{3(S)} \} \quad (4.17)^{47}$$

$(N_2O\text{-}N)_{(mm)}$ – 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;

[47] IPCC 2000. Agriculture. Equation 4.18. pp. 4.42

$EF_{3(S)}$ – 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:

$$N_2O_{(mm)} = (N_2O - N)_{(mm)} \bullet 44/28 \quad (4.18)$$

The data on population of livestock by categories were obtained from database of the ESO (Annex 5_I). The percentage of manure production per animal waste management systems (Table 4.39) and emission factors for N_2O from manure management (Table 4.32) were used from the reports of IPCC (1997).

Nitrogen excretion factor was estimated using the algorithm presented in Chapter 4.2.5.2.1. An example of the estimation of the factor for dairy and non-dairy cattle for 1990 is presented in Box 1. The average N excretion factors reported in the CRF is presented in Table 4.31.

Table 4.31. Average N excretion factors used in the estimates, kg N/head/year

Year	Dairy Cattle	Mature Non-dairy cattle	Young cattle
1990	74.74	47.50	17.20
1991	74.74	47.50	17.20
1992	70.68	47.50	17.20
1993	79.66	47.50	17.20
1994	69.39	47.50	17.20
1995	71.86	47.50	17.20
1996	74.29	47.50	17.20
1997	76.37	47.50	17.20
1998	80.20	47.50	17.20
1999	77.51	46.46	17.20
2000	82.13	46.53	17.20
2001	86.43	46.29	17.20
2002	86.50	46.39	17.20
2003	87.15	46.17	17.20
2004	90.08	46.13	17.20
2005	92.02	45.99	17.20
2006	93.53	46.42	17.20

Box 1

Table B1.1. Estimating of Nitrogen Excretion factor of dairy cattle

		Reference
Weight, kg	550	IPCC, 1997. Table A-1, pp. 4.31
Feeding Situation	Stall Fed	IPCC, 1997. Table A-1, pp. 4.31
Milk, kg/day	10.9	ESO
Pregnant, %	80%	IPCC, 1997. Table A-1, pp. 4.31
Digestibility of Feed, %	60%	IPCC, 1997. Table A-1, pp. 4.31
Energy Intake (MJ/day)	248.6	
Feed Intake, kg/day	13.5	
Manure, kg/hd/ d DM	5.4	
Manure, kg/hd/yr DM	1,967	
Moisture Content, %	15%	Applying Nutrient Management
Manure, tonnes/hd/yr	13.1 $M, kg/hd/yr = \frac{Manure \times (100\% - 15\%)}{15\%} + Manure, kgDM/hd$	Estimated using the algorithm presented in Chapter 4.2.3.2.1 Equation 1
N content in manure, kg/t	5.7	Kaasik A., *at al.*, 2002
Nitrogen Excretion per head, kg/head/yr	74.7 $N\_factor, kg/hd/yr = Ncontent, kg/t \times Manure, t/hd/yr$	Equation 2

Table B1.2. Estimating of Nitrogen Excretion factor of dairy cattle

	Mature Females	Mature Males	Replacement / Growing	Young/ Calves	Reference
Weight, kg	500	600	400	230	IPCC, 1997. Table B-1, pp 4.39
Weight Gain, kg/day	0		0.75	0.5	Põllukultuuride väetamine
Feeding Situation	Pasture Range	Pasture Range	Pasture Range	Pasture Range	
Digestibility of Feed, %	60%	60%	60%	60%	
Energy Intake (MJ/day)	138.4	158.7	159.2	87.5	
Feed Intake, kg/day	7.5	8.6	8.6	4.7	
Manure, kg/hd/ d DM	3.0	3.4	3.5	1.7	
Moisture Content, %	13%	13%	13%	13%	Applying Nutrient Management
Manure, tonnes/hd/yr	8.4	9.7	9.7	4.7	Estimated using the algorithm presented in Chapter 4.2.3.2.1
	$M, kg/hd/yr = \frac{Manure \times (100\% - 13\%)}{13\%} + Manure, kgDM/hd$				Equation 1
N content in manure, kg/t	4.9	4.9	4.9	3.7	Kaasik A., *at al.*, 2002
Nitrogen Excretion per head, kg/head/yr	41.3	47.3	47.5	17.2	Equation 2
	$N\_factor, kg/hd/yr = Ncontent, kg/t \times Manure, t/hd/yr$				

Table 4.32. Percentage of Manure Production per Animal Waste Management Systems, %[48] and default Emission Factors for N_2O from Manure Management [49]

Type of Animal	Anaerobic Lagoon	Liquid System	Daily Spread	Solid Storage and Dry lot	Pasture Range and Paddock	Other System
Non-Dairy Cattle	0%	55%	0%	2%	33%	9%
Dairy Cattle	0%	46%	24%	21%	8%	1%
EF_3 (kg N_2O-N/kg Nitrogen excreted)	0.001	0.001	0.0	0.02	0.02[50]	0.001[51]

4.2.5.2.2. Quantitative overview – N_2O emission from cattle manure management in 2006

The total N_2O emission from cattle manure management 0.15 Gg was in 2006 in Estonia (Table 4.33). The emission decreased 5.2 fold in comparison with the base year.

Table 4.33.Table N_2O emissions from cattle manure management[6], Gg

	Cattle				
Year	DC	MF	MM	B	C
1990	0.534			0.181	0.074
1991	0.503			0.180	0.065
1992	0.456			0.147	0.053
1993	0.459			0.097	0.034
1994	0.373			0.082	0.031
1995	0.339			0.071	0.029
1996	0.324			0.066	0.026
1997	0.326			0.062	0.024
1998	0.326			0.062	0.024
1999	0.273	0.010	0.001	0.039	0.019
2000	0.274	0.010	0.001	0.036	0.018
2001	0.283	0.008	0.001	0.040	0.021
2002	0.254	0.009	0.001	0.045	0.021
2003	0.100	0.007	0.0005	0.031	0.015
2004	0.103	0.007	0.001	0.030	0.014
2005	0.102	0.009	0.0005	0.030	0.014
2006	0.100	0.006	0.001	0.030	0.014
%, 2006	66.3%	3.7%	0.7%	20.0%	9.3%

[48] 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 Western Europe were used). pp 4-11

[49] IPCC, 2000. Agriculture. Table 4.12 – Default emission factors for N_2O from manure management. pp 4.43

[50] The factors were used in the 'Animal waste applied to soils and excreted on pasture' chapter

[51] 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

4.2.5.3. Pigs

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

The data on population of livestock by categories were obtained from database of the ESO (Annex 5_I). The percentage of manure production per animal waste management systems and emission factors for N_2O from manure management were used from the reports of the IPCC (Table 4.34).

Nitrogen excretion factor was estimated using the algorithm presented in Chapter 4.2.3.2.1 (for cattle). Examples of the estimation of the factor for pigs for 1990 and 1999[52] are presented in Box 2, the factors were employed in the estimation for each sub-category of pigs.

The averaged N excretion factors reported in the CRF is presented in Figure 4.20.

Table 4.34. Percentage of Manure Production per Animal Waste Management Systems, %[53] and default Emission Factors for N_2O from Manure Management [54]

Type of Animal	Anaerobic Lagoon	Liquid System	Daily Spread	Solid Storage and Dry lot	Pasture Range and Paddock	Other System
Swine	0%	77%	0%	23%	0%	0%
EF_3 (kg N_2O-N/kg Nitrogen excreted)	0.001	0.001	0.0	0.02	0.02[55]	0.02[56]

[52] The year of changing methodology of data collection by ESO

[53] 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 Western Europe were used). pp 4-11

[54] IPCC, 2000. Agriculture. Table 4.12 – Default emission factors for N_2O from manure management. pp 4.43

[55] The factors were used in the 'Animal waste applied to soils and excreted on pasture' chapter

[56] 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

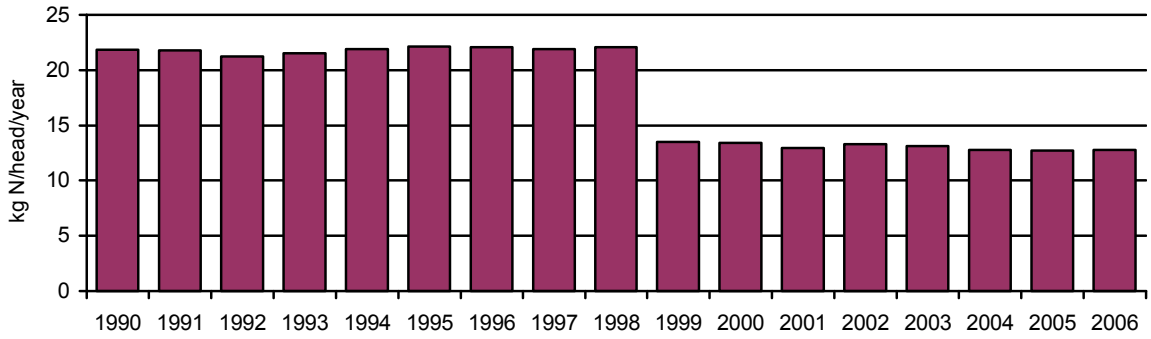


Figure 4.20. Averaged Nitrogen excretion factor reported in the CRF for 1990–2006, kg N/head/year

Box 2

Table B2.1. Estimating of N excretion factor for each pig sub-category (for 1990–1998)

	Mass (average), kg	Feed Digestibility %	Energy Intake MJ/day	Feed Intake kg/day	Manure, kg/h/d dm	Manure, kg/hd/yr dm	Manure, tonnes/hd/yr wm	N content	Nitrogen Excretion per Head (estimated)	IPCC Default kg N /hd/yr
Fattening pigs	90	75%	34	1.83	0.46	167	1.89	12.50	23.7	
Young sows (4 months and over)	23	75%	14	0.76	0.19	70	0.79	10.90	8.6	
Breeding sows	75	75%	30	1.63	0.41	149	1.69	8.80	14.9	
										20

Table B2.2. Estimating of N excretion factor for each pig sub-category (for 1999–2006)

	Mass (average), kg	Feed Digestibility %	Energy Intake MJ/day	Feed Intake kg/day	Manure, kg/h/d DM	Manure, kg/hd/yr DM	Manure, t/hd/yr	N content	Nitrogen Excretion per head (estimated)	IPCC Default kg N /hd/yr
Piglets, live weight less than 20 kg	10	75%	9	0.5	0.114	42	0.474	10.9	5.2	
Young pigs, live weight 20–<50 kg	35	75%	19	1.0	0.252	92	1.044	10.9	11.4	
Fattening pigs										
...live weight 50–<80 kg	65	75%	28	1.5	0.372	136	1.543	12.5	19.3	
...live weight 80–<110 kg	95	75%	35	1.9	0.472	172	1.959	12.5	24.5	
...live weight 110 kg or more	110	75%	39	2.1	0.518	189	2.149	12.5	26.9	
Breeding pigs, live weight 50 kg or more	75	75%	30	1.6	0.407	149	1.688	8.8	14.9	
										20

Swine manure dry matter – 8.8% (Dustan A., 2002)

4.2.5.3.2. Quantitative overview – N_2O emission from pig manure management in 2006

The total N_2O emission from pig manure management was 0.037 Gg in Estonia in 2006. The emission declined by 91% by 2006 in comparison with the base year due to decreasing number of pigs.

Table 4.35. N_2O emissions from swine manure management in 1990–2006 in Estonia[7], Gg

	Swine						
Year	P20	P50/YS	F	P80	P110	P100m	Br
1990		0.02	0.44				0.02
1991		0.01	0.37				0.01
1992		0.01	0.24				0.01
1993		0.01	0.19				0.01
1994		0.01	0.21				0.01
1995		0.01	0.21				0.01
1996		0.004	0.14				0.01
1997		0.005	0.14				0.01
1998		0.004	0.15				0.01
1999	0.01	0.02		0.03	0.02	0.002	0.01
2000	0.01	0.02		0.03	0.02	0.002	0.01
2001	0.01	0.03		0.02	0.02	0.001	0.01
2002	0.01	0.02		0.03	0.03	0.002	0.01
2003	0.005	0.01		0.01	0.01	0.0004	0.005
2004	0.005	0.01		0.01	0.01	0.001	0.005
2005	0.005	0.01		0.01	0.01	0.0003	0.004
2006	0.005	0.01		0.01	0.01	0.001	0.005
%, 2006	13.9%	19.8%		31.7%	20.2%	1.5%	12.9%

4.2.5.4. Other livestock

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

The activity data on other livestock population were taken from a dataset of ESO (Annex 5_I). A module of manure management system, emission factors (Table 4.37) and nitrogen excretion factors (Table 4.36) were obtained from the Revised 1996 IPCC Guidelines (IPCC, 1997).

Table 4.36. Nitrogen excretion factors per head of animal

Animal category	Nitrogen Excretion factor, kg N/head/year
Poultry	0.6
Sheep	20
Other animal	25

Table 4.37. Percentage of Manure Production per Animal Waste Management Systems, %[57] and Default Emission Factors for N_2O from Manure Management [58]

Type of Animal	Anaerobic Lagoon	Liquid System	Daily Spread	Solid Storage and Dry lot	Pasture Range and Paddock	Other System
Poultry	0	13	0	1	2	84
Sheep	0	0	0	2	87	11
Other animals	0	0	0	0	96	4
EF_3 (kg N_2O-N/kg Nitrogen excreted)	0.001	0.001	0.0	0.02	0.02[59]	0.02[60]

4.2.5.4.2. Quantitative overview – N_2O emission from other livestock manure management in 2006

The total Estonian N_2O emission from other livestock manure management was 0.03 Gg in 2006 (Table 4.30).

4.2.5.5. Quantitative overview - Manure management systems

The data reported in the chapter demonstrates N_2O emissions from each system of manure management.

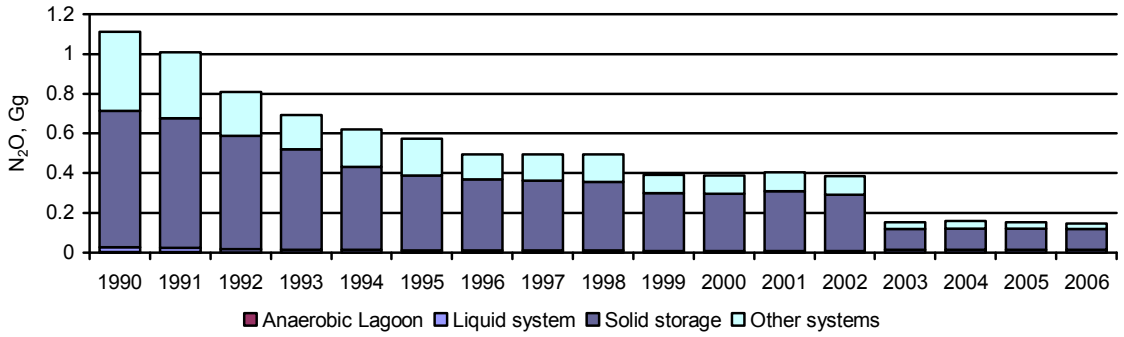


Figure 4.21. N_2O emissions from Estonia's manure management systems, Gg

[57] 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 Western Europe were used). pp 4-11

[58] IPCC, 2000. Agriculture. Table 4.12 – Default emission factors for N_2O from manure management. pp 4.43

[59] The factors were used in the 'Animal waste applied to soils and excreted on pasture' chapter

[60] 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 4.38. N_2O emissions from Estonia's manure management systems in 1990–2006, Gg

Year	Anaerobic Lagoon	Liquid System	Solid Storage	Other system
1990	0.002	0.027	0.686	0.397
1991	0.002	0.024	0.650	0.332
1992	0.001	0.019	0.568	0.221
1993	0.001	0.015	0.506	0.170
1994	0.001	0.014	0.417	0.189
1995	0.001	0.013	0.376	0.183
1996	0.001	0.011	0.357	0.127
1997	0.001	0.011	0.352	0.132
1998	0.001	0.011	0.345	0.139
1999	0.001	0.008	0.293	0.090
2000	0.000	0.008	0.289	0.091
2001	0.001	0.008	0.301	0.095
2002	0.001	0.008	0.282	0.095
2003	NO	0.017	0.103	0.033
2004	NO	0.017	0.104	0.038
2005	NO	0.017	0.104	0.033
2006	NO	0.016	0.102	0.030
%, 2006		11.0%	68.7%	20.2%

4.2.5.6. Uncertainties and time-series consistency

CH_4 emission from manure management is 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 4.39). 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 4.39), the factor was developed based on the experience of other countries. Rypdal documented that an uncertainty in CH_4 emission 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 emission from livestock manure management is 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 4.39).

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 4.39).

Table 4.39. 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)	± 10%	Rypdal K., *et al.*, 2001
Emission factors		
Manure Management (CH_4) (cattle, swine)	± 25%	Rypdal K., *et al.*, 2001
Manure Management (CH_4) (sheep, goats, horses)	± 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

The combined uncertainties related to 'manure management' sub-sector (CRF 4.B) as percent from the total national emission in 2006 are follows[61]:

4.B.	Cattle (CH_4)	0.0672%
4.B.	Sheep (CH_4)	0.0003%
4.B.	Goats (CH_4)	0.0000%

[61] Uncertainty calculation for the Estonian GHG inventory **excluding LULUC** (following IPCC Tier 1)

4.B.	Horses (CH_4)	0.0002%
4.B.	Swine (CH_4)	0.0208%
4.B.	Poultry (CH_4)	0.0028%
4.B.	Anaerobic Lagoon (N_2O)	0.0000%
4.B.	Liquid system (N_2O)	0.0274%
4.B.	Solid storage and dry lot (N_2O)	0.1704%
4.B.	Other AWMS (N_2O)	0.0502%

4.2.5.7. Source-specific recalculations

There are two recalculations in the 2008 submission: 1) the recalculation of CH_4 emissions from cattle manure management due to an omission made in the 2007 submission (Figure 4.18); 2) the estimates of nitrogen excretion factor for each sub-category of cattle and pigs and the recalculation of N_2O emission from these categories of animals (Figure 4.22, Figure 4.23).

In the estimates of N_2O emission from cattle manure management, the emission factor (EF_3) of 'the other manure management system' was changed from 0.005[62] kg N_2O-N/kg N excreted (Cattle and deep litter manure system) to 0.001 kg N_2O-N/kg N excreted (Open pits below animal confinements) (Figure 4.22).

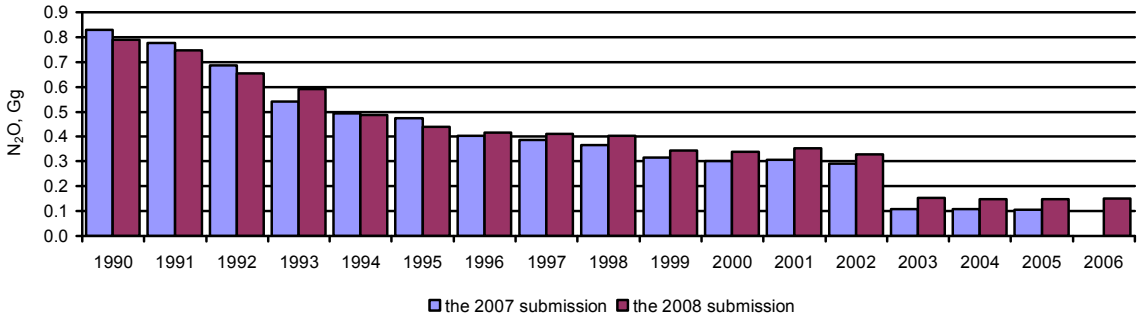


Figure 4.22. N_2O emissions from cattle manure management systems in 1990–2006, Gg (including N_2O emissions emitted during cattle pasture)

[62] Table 4.12 of the 1996 IPCC Guidance. Agriculture. pp 4.44

Table 4.40. N_2O emissions from cattle manure management in 1990–2005, Gg

Year	Reported emissions of N_2O in 1990–2005 (the 2007 submission)	Recalculated emissions of N_2O (the 2008 submission)
1990	0.829	0.789
1991	0.776	0.748
1992	0.688	0.655
1993	0.542	0.591
1994	0.494	0.486
1995	0.475	0.438
1996	0.403	0.417
1997	0.386	0.412
1998	0.365	0.404
1999	0.317	0.343
2000	0.300	0.339
2001	0.305	0.352
2002	0.291	0.329
2003	0.108	0.154
2004	0.107	0.149
2005	0.105	0.149
2006		0.151

The emission factor (EF_3) was changed as well in the estimates of N_2O emissions from pig manure management system. 0.005[63] kg N_2O-N/kg N excreted (Cattle and deep litter manure system, <1 month) was employed in the 2007 submission, and the estimates of the 2008 submission were based on 0.02 kg N_2O-N/kg N excreted (Cattle and deep litter manure system, >1 month) (Figure 4.23).

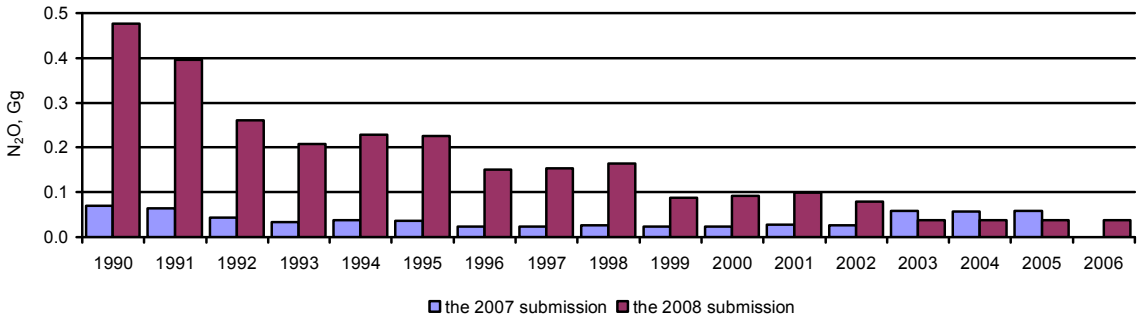


Figure 4.23. N_2O emissions from pig manure management systems in 1990–2006, Gg

[63] Table 4.12 of the 1996 IPCC Guidance. Agriculture. pp 4.44

Table 4.41. N_2O emissions from pig manure management in 1990–2006, Gg

Year	Reported emissions of N_2O in 1990–2005 (the 2007 submission)	Recalculated emissions of N_2O (the 2008 submission)
1990	0.069	0.477
1991	0.064	0.396
1992	0.043	0.261
1993	0.034	0.208
1994	0.037	0.229
1995	0.036	0.226
1996	0.024	0.150
1997	0.024	0.153
1998	0.026	0.164
1999	0.023	0.088
2000	0.024	0.092
2001	0.028	0.099
2002	0.027	0.080
2003	0.058	0.038
2004	0.057	0.037
2005	0.058	0.037
2006		0.037

4.2.5.8. Source-specific planned improvements

Currently, the highly uncertain factor in the estimates of CH_4 and N_2O emissions from animal manure is the module of manure management system used in the calculations. Therefore, Estonia will keep investigating in this area of the inventory. A country-specific module on manure management system will be employed in the future submissions.

4.3. 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 and sewage sludge application;

- Cultivation of high organic content soils;

4.3.1. Source category description

The total direct N_2O emission from agricultural soils was 1.37 Gg in Estonia in 2006. The N_2O emissions decreased 2.2 fold by 2006 in comparison with the base year (Table 4.42).

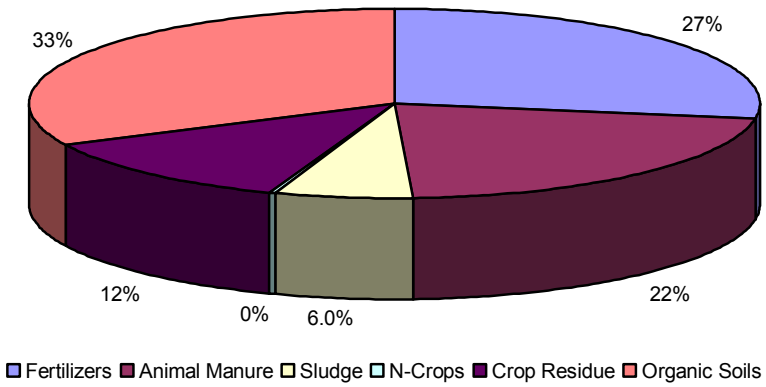


Figure 4.24. Direct N_2O emissions from agricultural soils in Estonia in 2006, Gg

Table 4.42. Direct N_2O emissions from agricultural soils in Estonia in 1990–2006, Gg

Year	Synthetic fertilizers	Animal manure	Sludge applied	N-fixing crops	Crop residue	Organic soils	**Total**	**Total CO_2 equiv**
1990	1.14	0.97	0.004	0.0002	0.34	0.54	2.99	926.2
1991	1.11	0.88	0.005	0.0002	0.33	0.57	2.90	896.1
1992	1.03	0.69	0.001	0.0004	0.24	0.56	2.53	783.1
1993	0.53	0.59	0.008	0.0007	0.28	0.49	1.90	586.2
1994	0.46	0.53	0.008	0.0011	0.21	0.43	1.64	506.0
1995	0.33	0.49	0.012	0.0065	0.21	0.41	1.46	451.3
1996	0.29	0.41	0.014	0.0141	0.23	0.39	1.35	419.6
1997	0.36	0.41	0.010	0.0174	0.23	0.43	1.46	452.0
1998	0.44	0.41	0.014	0.0085	0.19	0.47	1.53	476.7
1999	0.35	0.31	0.015	0.0032	0.15	0.46	1.29	401.0
2000	0.40	0.31	0.025	0.0068	0.24	0.51	1.49	459.8
2001	0.35	0.32	0.017	0.0067	0.19	0.43	1.31	404.9
2002	0.30	0.31	0.016	0.0051	0.16	0.40	1.19	368.2
2003	0.42	0.31	0.021	0.0051	0.16	0.43	1.35	415.9
2004	0.44	0.32	0.001	0.0034	0.17	0.43	1.36	421.7
2005	0.36	0.32	0.001	0.0050	0.21	0.45	1.35	416.3
2006	0.40	0.32	0.001	0.0047	0.18	0.47	1.37	424.9

4.3.2. 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 map (scale 1:100 000) and Estonian soil map (scale 1: 10 000).

4.3.3. N_2O emission from Synthetic Fertilizer nitrogen applied to soils (CRF 4.D.1.1)

The emission of N_2O is estimated from annual synthetic nitrogen applied to soils.

More than 50% of the total amount mineral fertilizers applied to soils were nitrogen fertilizers. The agricultural area fertilized was 488 thousand hectares in 2006 in Estonia (Agriculture 2006).

4.3.3.1. 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.

$$F_{SN} = N_{FERT} \times (1 - Frac_{GASF}) \quad (4.19)^{64}$$

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 emission into the atmosphere from using of synthetic nitrogen was calculated based on the formula (4.22).

$$N_2O_{direct} - N = F_{SN} \bullet EF \bullet 44/28_1 \quad (4.20)$$

[64] IPCC, 1997. Agriculture. Workbook. Equation 1, pp. 4.33.

Table 4.43. IPCC default factors used in the estimation

Factors	Value
EF_1 for F_{SN}	1.25%[65]
$Frac_{GASF}$	0.1 kg NH_3-N + NO_x-N/kg of synthetic fertilizer nitrogen applied[66]

4.3.3.2. Quantitative overview – N_2O emission from synthetic fertilizers applied to soils

The total quantity of synthetic fertilizers applied to agricultural soils was 22,313 tonnes in 2006 in Estonia.

The N_2O emission from fertilizers applied was 0.40 Gg in 2006. The N_2O emission of 2006 is 65% lower than the N_2O emission emitted in 1990.

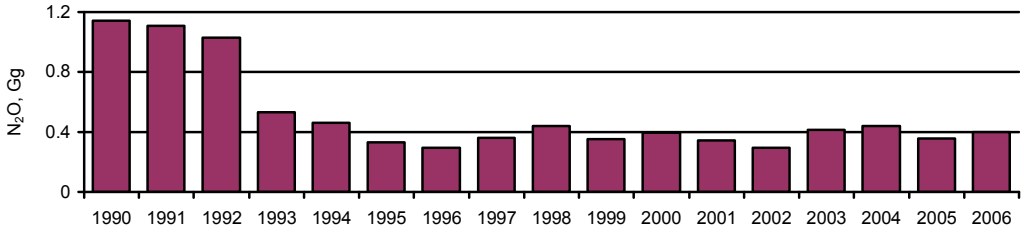


Figure 4.25. N_2O emissions from synthetic fertilizers applied to agricultural soils in 1990–2006 in Estonia, Gg

4.3.3.3. Source-specific recalculations

There is one recalculation in the estimation of N_2O emissions from synthetic fertilizers applied to soils in the 2008 submission. The recalculation was carried out due to an omission made in the 2007 submission.

[65] IPCC, 2000. Agriculture. Table 4-17. Updated default emission factors to estimate direct N_2O emissions from agricultural soils, pp. 4.60

[66] IPCC, 1997. Agriculture. Reference Manual. Table 4-17 Summary of default values for parameters, 1996, pp. 4.35

Table 4.44. N_2O emissions synthetic fertilizers applied to soils in Estonia in 1990–2006, Gg

Year	Reported emissions of N_2O in 1990–2005 (the 2007 submission)	Recalculated emissions of N_2O (the 2008 submission)
1990	1.27	1.14
1991	1.23	1.11
1992	1.15	1.03
1993	0.59	0.53
1994	0.51	0.46
1995	0.37	0.33
1996	0.33	0.29
1997	0.40	0.36
1998	0.49	0.44
1999	0.39	0.35
2000	0.44	0.40
2001	0.39	0.35
2002	0.33	0.30
2003	0.46	0.42
2004	0.49	0.44
2005	0.39	0.36
2006		0.40

4.3.4. N_2O emission from Animal Manure applied to soils and excreted on pasture (CRF 4.D.1.2)

N_2O emits from agricultural soil through manure application to fields as organic fertilizer and animal pastures by grazing animals.

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

N_2O emission into the atmosphere from animal waste applied to agricultural fields as organic fertilizer was estimated according to the algorithm suggested by IPCC (1997).

$$N_2O_{direct} - N = F_{AW} \bullet EF_1 \quad (4.21)$$

$$F_{AW} = (Nex \bullet (1 - Frac_{FUEL} + Frac_{GRAZ} + Frac_{GASM})) \quad (4.22)^{67}$$

$$Nex = \sum [N_{(T)} \times Nex_{(T)}] \quad (4.23)$$

[67] IPCC 1996. Agriculture. Workbook. Equations 2-4, pp 4.33.

$$Nex_{(AWMS)} = \sum [N_{(T)} \times Nex_{(T)} \times AWMS_{(T)}] \quad (4.24)$$

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 4.45).

Table 4.45. IPCC default factors used in the estimation of N_2O emission from animal waste applied to soils

Factor	Value
$Frac_{FUEL}$	0.0 kg N/kg nitrogen excreted[68]
$Frac_{GRAZ}$	see Tables 4.32, 4.34 and 4.37 (Pasture, Range and Paddock)
$Frac_{GASM}$	0.2 kg NH_3-N + NO_x-N/kg of nitrogen excreted by livestock[45]

[68] IPCC, 1997. Agriculture. Workbook. Table 4-17 – Summary of default values for parameters. pp 4.35

4.3.4.2. Quantitative overview – N_2O emission from Animal Manure applied to soils and excreted on pasture

The total N_2O emission from animal manure applied to soils was 0.32 Gg in Estonia in 2006. The N_2O emission declined by 67% by 2006 in comparison with the base year due to decreasing number of livestock (Figure 4.26).

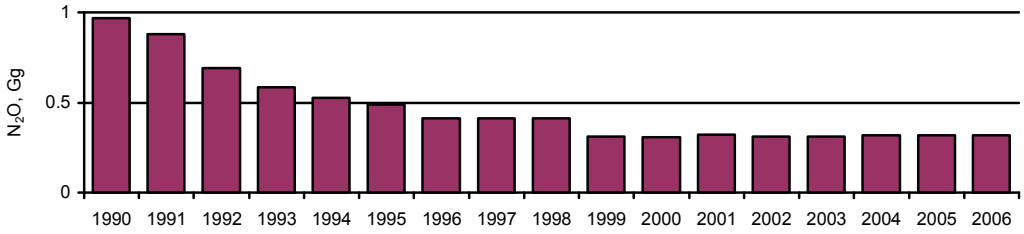


Figure 4.26. N_2O emissions from animal manure applied to agricultural soils in 1990–2006 in Estonia, Gg

4.3.4.3. Source-specific recalculations

There is one recalculation in the estimation of N_2O emissions from animal manure applied to soils in the 2008 submission. The recalculation was carried out due to the changes of nitrogen excretion factors of cattle and pigs.

Table 4.46. N_2O emissions animal manure applied to soils in Estonia in 1990–2006, Gg

Year	Reported emissions of N_2O in 1990–2005 (the 2007 submission)	Recalculated emissions of N_2O (the 2008 submission)
1990	1.027	0.970
1991	0.957	0.878
1992	0.778	0.694
1993	0.605	0.586
1994	0.572	0.526
1995	0.546	0.487
1996	0.439	0.412
1997	0.428	0.411
1998	0.417	0.411
1999	0.366	0.311
2000	0.357	0.308
2001	0.376	0.323
2002	0.364	0.311

Year	Reported emissions of N_2O in 1990–2005 (the 2007 submission)	Recalculated emissions of N_2O (the 2008 submission)
2003	0.465	0.313
2004	0.459	0.317
2005	0.566	0.318
2006		0.320

4.3.5. Nitrogen input in N-fixing crops (CRF 4.D.1.3)

The amount of nitrogen fixed by N-fixing crops cultivated annually (IPCC, 2000).

4.3.5.1. 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.

$$F_{BN} = 2 \times Crop_{BF} \times Frac_{NCRBF} \quad (4.25)^{69}$$

$Crop_{BF}$ – Production of pulses + soybeans in country, kg dry biomass/yr;
$Frac_{NCRBF}$ – Fraction of nitrogen in N-fixing crop, kg N/kg of dry biomass;

Factor 2, which converts the crop production to total crop biomass, was changed by the factor from presented in the work by Jonas M., *et al*., 2001(Table 4.47).

The activity data on the production of N-fixing crops in Estonia were obtained from the ESO (Table 4.47). IPCC default factor was in the estimation (Table 4.47). The factor for conversion of the crop production from Fresh Matter (FM) to Dry Matter (DM) was obtained from Jonas M., *et al.*, 2001.

Annual N_2O emission from N-fixing crops was calculated using the formula (4.26) (the *Tier 1*, IPCC 1997)

[69] IPCC 1996. Agriculture. Workbook. Equation 5, pp. 4.35.

$$N_2O_{direct} = F_{BN} \bullet EF_1 \bullet 44/28 \quad (4.26)$$

EF_1 – IPCC default factor for N-fixing crops (Table 4.47);

Table 4.47. Factors used in the algorithm of the estimation

Factor	Value
$Frac_{NCRBF}$[70]	0.03 kg N/kg of Dry Matter
Conversion factor from FM to DM[71]	0.87 t DM / t FM
Grain-to-Straw ratio for Legumes[48]	1.525
EF_1 for F_{BN}	1.25%

4.3.5.2. Quantitative overview – N_2O emission from growing of N-fixing crops

The total production of legumes in Estonia was 5,542 tonnes in 2006 (Table 4.48) that equals 239,496 kg N.

The N_2O emission from growing of N-fixing crops was 0.005 Gg in 2006. The emission increased by 2006 in comparison with the base year. However, the contribution of the emission from growing of N-fixing crops to the total direct N_2O emission from agricultural soils is negligible (Figure 4.24, Figure 4.27).

Table 4.48. Production of Legumes in Estonia in 2006 (Agriculture 2006)

	Area, ha	Harvest, tonnes	Total production, t DM
Harju county	226	314	452
Hiiu county	0	0	0
Ida-Viru county	3	8	12
Jõgeva county	3	3	4
Järva county	170	286	412
Lääne county	414	430	619
Lääne-Viru county	594	672	968
Põlva county	90	103	148
Pärnu county	782	918	1,322
Rapla county	113	100	144
Saare county	347	412	593
Tartu county	408	511	736
Valga county	348	659	949
Viljandi county	705	808	1,164

[70] IPCC 1996. Agriculture. Workbook. Table 4-17 – Summary of default values for parameters. pp 4.35

[71] Jonas *et al*., 2001

	Area, ha	Harvest, tonnes	Total production, t DM
Võru county	422	318	458

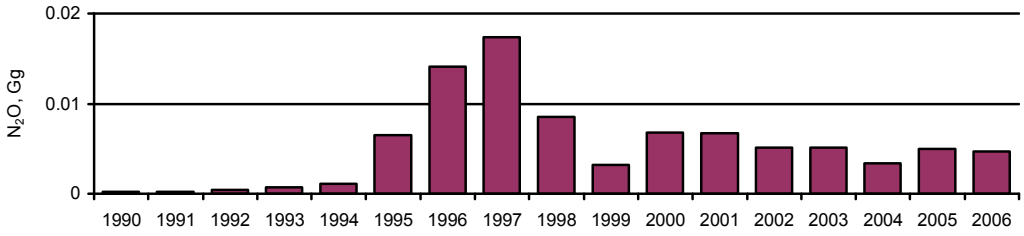


Figure 4.27. N_2O emissions from growing of N-fixing crops in 1990–2006 in Estonia, Gg

4.3.5.3. Source-specific recalculations

No specific recalculations were carried out.

4.3.6. N_2O emission fro nitrogen input from crop-residue (CRF 4.D.1.4)

The amount of nitrogen returned to soils annually through the incorporation of crop residues.

4.3.6.1. 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.

$$F_{CF} = 2 \times [Crop_0 \times Frac_{NCR0} + Crop_{BF} \times Frac_{NCRBF}] \times (1 - Frac_R) \times (1 - Frac_{BURN}) \quad (4.27)^{72}$$

$Crop_{BF}$ - Production of pulses + soybeans in country, kg dry biomass/yr;
$Crop_0$ – Production of non-N-fixing crops in country, kg dry biomass/yr;
$Frac_{NCRBF}$ – 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;

[72] IPCC 1996. Agriculture. Workbook. Equation 6. pp. 4.36

$Frac_{BURN}$ – Fraction of crop residue that is burned rather than left on field;

2 – The factor converts the crop production to total crop biomass. The factor was suggested by IPCC methodology, however the factors from (Jonas M., *et al*, 2001) were used instead of this factors in the estimation;

Annual N_2O emission from crop residues was calculated using the formula (4.28) (the *Tier 1* method, IPCC 1997).

$$N_2O_{direct} = F_{CR} \bullet EF_1 \bullet 44/28 \quad (4.28)$$

Table 4.49. Factors used in the algorithm of the estimation of N_2O emissions from crop residues[73]

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%[74]

4.3.6.2. Quantitative overview – N_2O emission from crop-residues in 2006

The production of cereals was 619,292 tonnes, legumes - 5,542 tonnes, potatoes - 152,632 tonnes, fodder roots - 1,972 tonnes and industrial crops - 84,749 tonnes in Estonia in 2006. The data on the total production of crops in dry matter is presented in Table 4.50.

Table 4.50. Crop harvest in Estonia in 2006, DM tonnes (with residues)

	Cereals	Legumes	Potatoes	Fodder roots	Industrial crops
Whole country	961,438	7,983	183,158	2,366	66,443
Harju county	45,848	452	10,970	79	4,029
Hiiu county	3,138	0	5,291	35	136
Ida-Viru county	22,907	12	8,400	1	2,293
Jõgeva county	110,658	4	16,401	1,598	5,596
Järva county	81,021	412	6,443	0	5,821
Lääne county	28,120	619	10,218	17	2,072

[73] IPCC 1996. Agriculture. Workbook. Table 4-17 – Summary of default values for parameters. pp 4.35

[74] IPCC 2000. Agriculture. Table 4-17 – Updated default emission factors to estimate direct N2O emissions from agricultural soils. pp 4.60

	Cereals	Legumes	Potatoes	Fodder roots	Industrial crops
Lääne-Viru county	123,863	968	15,069	55	8,548
Põlva county	63,431	148	20,614	1	5,004
Pärnu county	59,918	1,322	12,518	182	4,017
Rapla county	39,407	144	11,978	166	3,014
Saare county	15,640	593	13,107	122	700
Tartu county	150,791	736	14,753	86	8,767
Valga county	54,211	949	6,611	5	3,977
Viljandi county	121,972	1,164	13,359	7	11,008
Võru county	40,515	458	17,427	11	1,460

The N_2O emission from crop residues left on fields made up 0.179 Gg in Estonia in 2006. The N_2O emissions have decreased smoothly since 1990 due to decreasing in crop production (Figure 4.28).

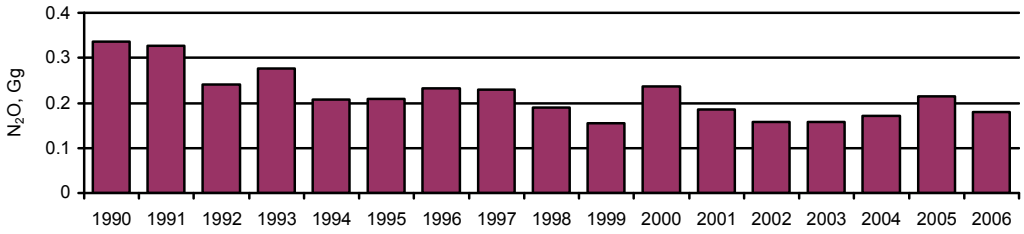


Figure 4.28. N_2O emissions from crop residues left on agricultural fields in 1990–2006 in Estonia, Gg

4.3.6.3. Source-specific recalculations

No specific recalculations were carried out.

4.3.7. N_2O emission from Organic Soils Cultivation (CRF 4.D.1.5)

Large N_2O emissions occur as a result of cultivation of organic soils (Histosols) 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).

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

The *Tier 1* method was applied in order to estimate N_2O emission from organic soils cultivation (IPCC, 1997).

$$N_2O_{direct} = F_{OS} \bullet EF_2 \bullet 44/28 \quad (4.29)$$

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 4.59);

Table 4.51. Factors used in the algorithm of the estimation of N_2O emissions from cultivated organic soils[75]

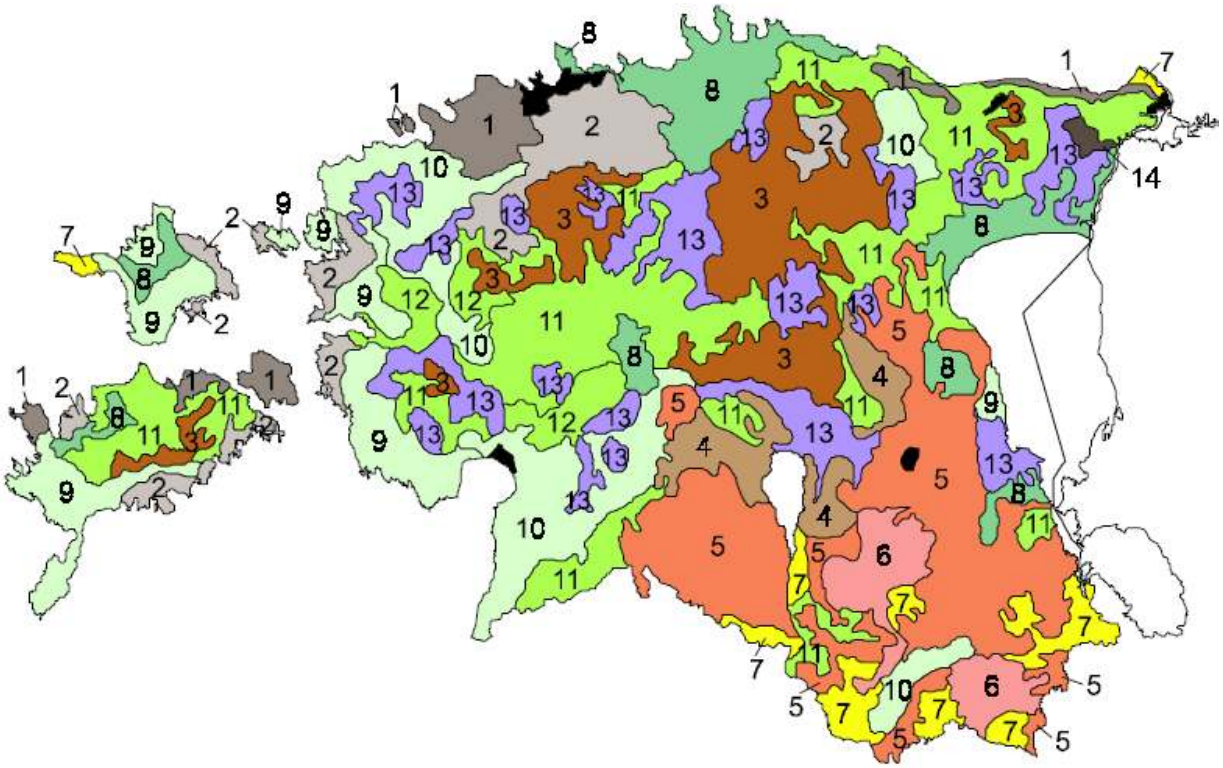
Factor	Unit
EF_2	8 kg N/kg of Dry Matter

4.3.7.2. Quantitative overview – N_2O emission from organic soils cultivated in 2006

Estonian N_2O emission from cultivated organic soils was 0.47 Gg in 2006.

The estimation of N_2O emissions from cultivated histosols was carried out basing on the data received from combination of three maps of Estonia: a soil map (Figure 4.29) and 1990 CORINE map (Figure 4.30) and 2000 CORINE map (Figure 4.31). Areas with CORINE codes 211 and 242 were taken into the estimates. The areas of cultivated organic soils for 1991 – 1999 and 2001–2006 were interpolated using the data of ESO on the total arable lands in Estonia and the data from the combination of the maps: the soil map and the 1990 CORINE map, and the soil map and the 2000 CORINE map. The results of the interpolation are reported in Figure 4.32.

[75] IPCC 2000. Agriculture. Table 4.17 – Updated default factors to estimate direct N_2O emissions from agricultural soils, pp 4.60



	Soil type	No	Symbol
	Calcaric Regosols	1	RGc
		2	RGc
	Calcaric Cambisols	3	CMc
	Calc(ar)ic Luvisols	4	LVk
	Stagnic	5	LVj
	Luvisols	6	LVj
		7	PZh
	Carbic Podzols	8	PZc
	Eutric	9	GLe
	Gleysols	10	GLe
		11	GLe
		12	GLe
	Histosoils	13	HS
	Soils disturbed by man	14	

Figure 4.29. A soil map of Estonia (Reintam L., *et al.*, 2001)

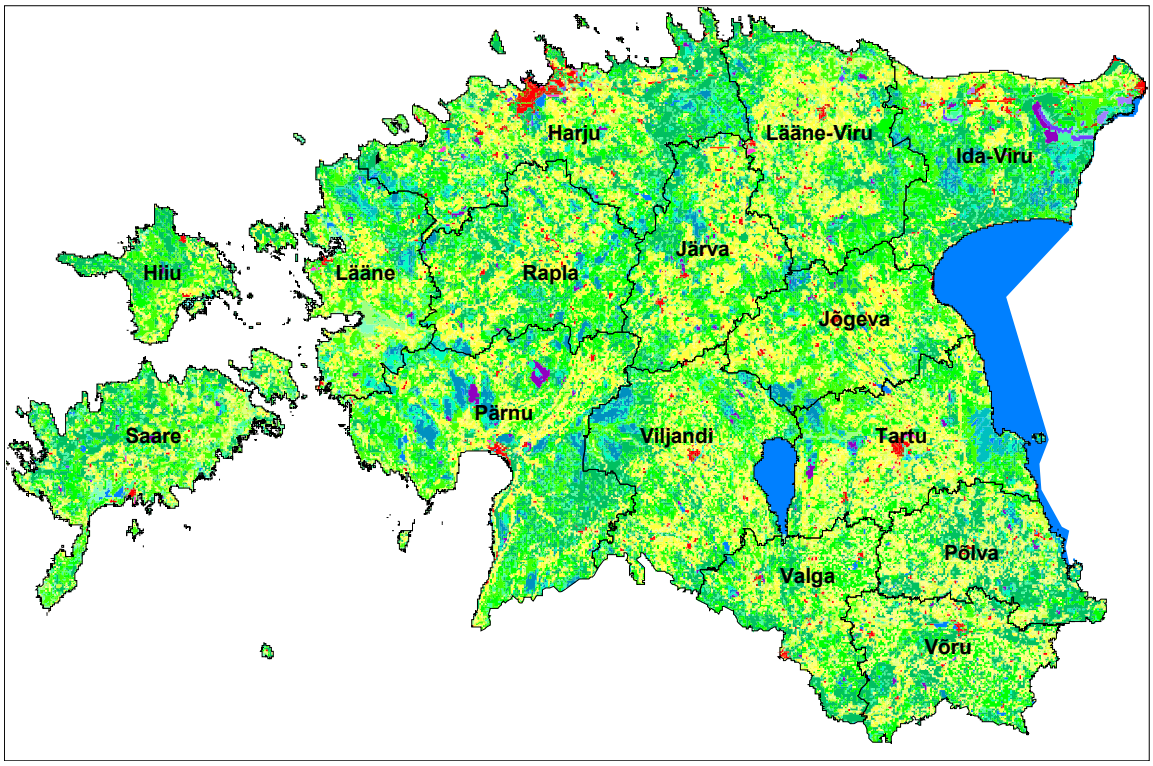


Figure 4.30. Land cover of Estonia in 1990 (the map was obtained from the EEIC)

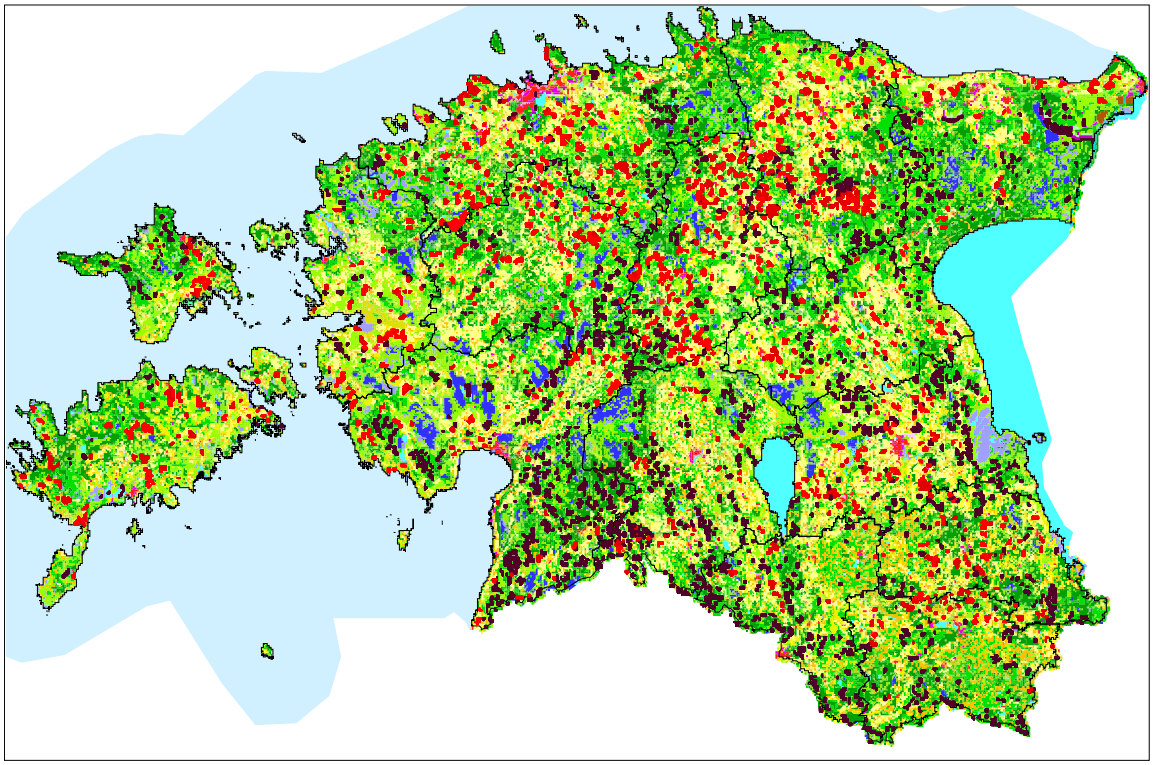


Figure 4.31. Land cover of Estonia in 2000 (the map was obtained from the EEIC)

Artificial surfaces
Agricultural areas
Wetlands
Forest and semi- natural areas

Table 4.52. Total area of agricultural lands by country in 1990, ha[76] (in accordance with the 1990 CORINE map)[77]

County	211	%	222	%	231	%	242	%	243	%
Harju	59,906	13.8	24.0	0.01	28,218	6.5	28,218	6.5	29,685	6.9%
Hiiu	7,688	7.5	33.4	0.03	5,217	5.1	5,217	5.1	6,895	6.7%
Ida-Viru	33,319	9.9	68.6	0.02	7,321	2.2	7,321	2.2	15,209	4.5%
Järva	63,994	24.4			22,037	8.4	22,037	8.4	9,589	3.7%
Jõgeva	63,634	24.4	25.0	0.01	15,369	5.9	15,369	5.9	14,863	5.7%
Lääne	39,840	16.7	24.7	0.01	8,529	3.6	8,529	3.6	13,394	5.6%
Lääne-Viru	60,939	17.6	132.3	0.04	40,369	11.7	40,369	11.7	19,861	5.7%
Pärnu	69,432	14.4			20,180	4.2	20,180	4.2	35,560	7.4%
Põlva	20,430	9.4	65.5	0.03	21,152	9.8	21,152	9.8	28,580	13.2%
Rapla	65,502	22.0	132.1	0.04	9,621	3.2	9,621	3.2	17,029	5.7%
Saare	19,930	6.8	45.0	0.02	26,712	9.1	26,712	9.1	23,389	8.0%
Tartu	55,684	18.6	670.5	0.22	26,491	8.9	26,491	8.9	19,504	6.5%
Valga	21,926	10.7	166.9	0.08	21,274	10.4	21,274	10.4	25,776	12.6%
Viljandi	60,355	17.6	652.7	0.19	20,712	6.1	20,712	6.1	33,414	9.8%
Võru	20,130	8.7			18,633	8.1	18,633	8.1	46,543	20.2%
Total	662,710		2,041		291,834		163,823		339,291	

Table 4.53. Areas of histosols under agricultural lands by county, ha (the base year)

County	211	%	222	%	231	%	242	%	243	%
Harju	8,759	14.6			7,775	27.6	612	6.1	1,921	6.5
Hiiu	185	2.4			284	5.5	3	0.3	31	0.4
Ida-Viru	1,241	3.7			1,091	14.9	834	11.2	509	3.3
Järva	2,380	3.7			5,084	23.1	294	3.2	752	7.8
Jõgeva	3,768	5.9	0.28	1.1	4,815	31.3	514	6.1	1,354	9.1
Lääne	2,680	6.7			1,874	22.0	99	4.5	288	2.2
Lääne-Viru	913	1.5			7,037	17.4	570	3.4	1,172	5.9
Pärnu	3,093	4.5			4,350	21.6	207	2.5	893	2.5
Põlva	336	1.6	0.19	0.3	3,122	14.8	759	3.2	3,084	10.8
Rapla	4,301	6.6			2,161	22.5	176	2.7	519	3.0
Saare	2,272	11.4			4,872	18.2	173	1.7	143	0.6
Tartu	1,815	3.3	8.72	1.3	6,287	23.7	1,329	5.0	1,794	9.2
Valga	573	2.6	0.23	0.1	3,992	18.8	450	4.6	2,798	10.9
Viljandi	2,764	4.6	1.59	0.2	5,174	25.0	631	5.4	2,562	7.7
Võru	432	2.1			3,779	20.3	534	4.3	4,791	10.3
Total	35,511		11		61,697		7,184		22,610	

[76] The red areas mean changes in area of agricultural land between the 1990 CORINE and the 2000 CORINE maps; the black areas – changes in areas of other land use categories

[77] 211 – Non-irrigated arable land;
222 – Fruit trees and berry plantations;
231 – Pastures;
242 – Complex cultivation patterns;
243 – Land principally occupied by agriculture, with significant areas of natural vegetation.

Table 4.54 Changes in land use from 1990 to 2000 by category of land, ha[78]

	112	121	133	211	231	242	243	311	313	324	412	∑
211					4,583	275	38	1				4,897
231				1,237		1,511	84			116	6	2,954
242	4			5	110							118
243	16	2	0.09	0.3					2	7		27
∑	20	2	0	1,242	4,693	1,786	122	1	2	123	6	

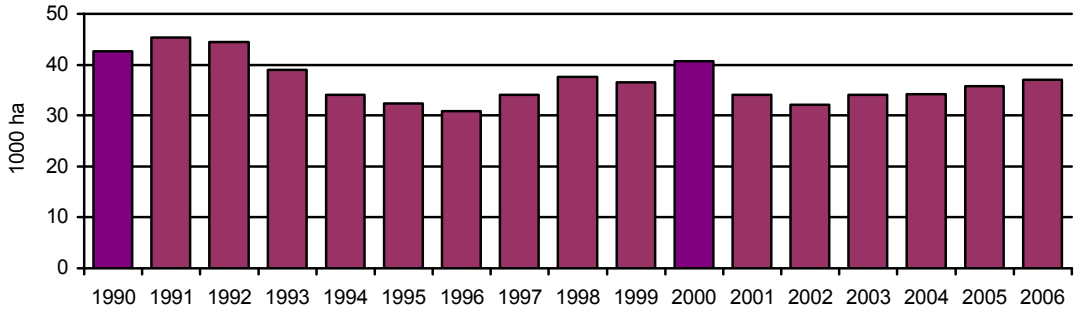


Figure 4.32. Areas of cultivated organic soils in 1990–2006 in Estonia, 1000 ha[79]

4.3.7.3. Source-specific recalculations

The 2008 submission is the first which reports the data on N_2O emission from cultivated organic soils.

No specific recalculations were carried out.

[78] 112 – Discontinuous urban fabric;
121 – Industrial or commercial units;
133 – Construction sites;
311 – Broad-leaved forest;
313 – Mixed forest;
324 – Transitional woodland-shrub;
412 – Peat bogs;

[79] The data was received from the combination of the maps.

4.3.8. N_2O emission from Pasture, Range and Paddock (CRF 4.D.2)

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

The algorithm described in Chapter 4.2.5.2.1 was used in order to estimate N_2O emission from livestock pasture, range and paddock.

The activity data used in the estimates are presented in Figure 4.5-Figure 4.7. Emission factors and parameters required for the estimation were used from Table 4.31, Table 4.32, Table 4.34, Table 4.36 and Table 4.37.

4.3.8.2. Quantitative overview – N_2O emission from pasture, range and paddock in 2006

The N_2O emission from livestock pasture, range and paddock was 0.10 Gg in 2006. The trend of N2O emissions in 1990–2006 is presented in Figure 4.33. The emission of 2006 is 67% lower than the emission of the base year due to decreasing number of livestock.

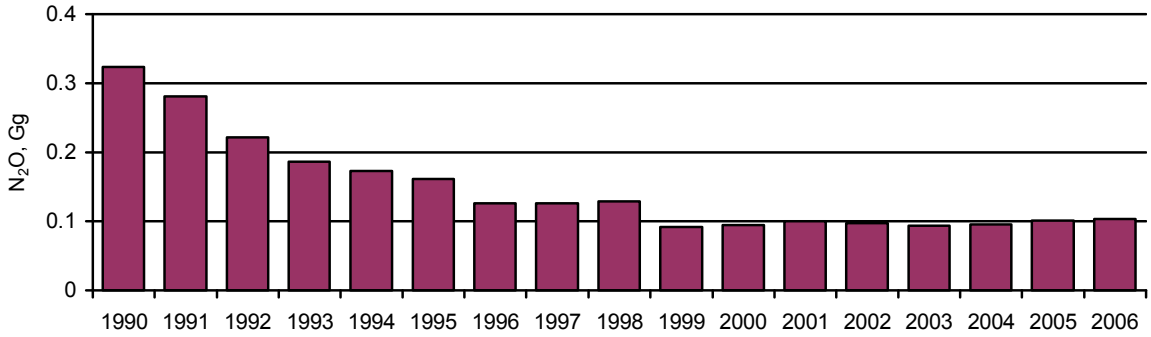


Figure 4.33. N_2O emissions from livestock pasture, range and paddock in 1990–2006, Gg

4.3.8.3. Source-specific recalculations

N_2O emissions from pasture, range and paddock are included in detailed reporting by categories of livestock in Chapter 4.2.5.7.

4.3.8.4. Uncertainties and time-series consistency

4.3.8.4.1. Synthetic Fertilizers used (CRF 4.D.1.1)

The estimation of N_2O emissions from synthetic fertilizers used are 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 4.55).

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).

4.3.8.4.2. Animal Manure Applied to Soils (CRF 4.D.1.2)

The estimation of N_2O emission 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 (1996) at ±80% (Table 4.55) (IPCC, 1997).

4.3.8.4.3. N-fixing Crops and Crop Residues (CRF 4.D.1.3 and CRF 4.D.1.4)

The estimation of N_2O emission 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.

The uncertainty of N content in N-fixing crops and non-nitrogen crops and the fraction of crop residue left on fields have not been estimated in the submission of 2007 due to lack of data.

IPCC default nitrogen emission factor has been used in the estimates. IPCC gives an uncertainty of the factor at ±80% (Table 4.55) as the value of the factor is 0.0125 with a range of 0.0025–0.0255 (IPCC, 1997).

Table 4.55. 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

The combined uncertainties related to 'Direct emissions from agricultural soils' sub-sector (CRF 4.D) as percent from the total national emission in 2006 are follows[80]:

4.D.1.1	Synthetic Fertilizers (N_2O)	0.4974%
4.D.1.2	Animal Manure Applied to Soils (N_2O)	0.4323%
4.D.1.3	N-fixing Crops (N_2O)	0.0054%
4.D.1.4	Crop Residue (N_2O)	0.2075%
4.D.1.5	Cultivation of Histosols (N_2O)	0.8012%
4.D.1.6	Sludge applied on agricultural fields (N_2O)	0.0024%
4.D.2	Pasture, Range and Paddock Manure (N_2O)	0.1727%

[80] Uncertainty calculation for the Estonian GHG inventory **excluding LULUC** (following IPCC Tier 1)

4.4 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 (the formula 4.30):

- Leaching and runoff of N that is applied to, or deposited on, soils;
- Disposal of sewage N;
- Formation of N_2O in the atmosphere from NH_3 emissions originating from anthropogenic activities;
- Disposal of processing effluents from food processing and other operations;

4.4.1. Source category description

The total indirect N_2O emission from agricultural soils was 0.62 Gg in Estonia in 2006. N_2O emission decreased by 66% by 2006 in comparison with the base year (Table 4.56).

Table 4.56. Indirect N_2O emissions from agricultural soils in Estonia in 1990–2006, Gg

Year	Atmospheric Deposition	Leaching and Run-off	**Total**	**Total CO_2 equiv**
1990	0.301	1.509	1.810	561.1
1991	0.279	1.416	1.695	525.45
1992	0.234	1.221	1.455	451.05
1993	0.168	0.804	0.972	301.32
1994	0.150	0.717	0.867	268.77
1995	0.131	0.605	0.736	228.16
1996	0.112	0.521	0.633	196.23
1997	0.117	0.564	0.681	211.11
1998	0.125	0.619	0.744	230.64
1999	0.096	0.484	0.580	179.8
2000	0.101	0.517	0.618	191.58
2001	0.099	0.491	0.590	182.9
2002	0.091	0.446	0.537	166.47
2003	0.103	0.532	0.635	196.85
2004	0.104	0.537	0.641	198.71
2005	0.097	0.482	0.579	179.49
2006	0.109	0.514	0.620	195.21

4.4.2. Atmospheric deposition of NO_x and NH_4 (CRF 4.D.3.1)

Atmospheric deposition of nitrogen compounds such as nitrogen oxides (NO_x) and ammonium (NH_4) fertilizes soils and surface waters, which results in enhanced biogenic N_2O formation (IPCC, 2000).

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

The default IPCC *Tier 1* method was is used to estimate emissions from the atmospheric deposition.

$$N_2O_{(G)} - N = [(N_{FERT} \bullet Frac_{GASF}) + (\sum_T (N_{(T)} \bullet Nex_{(T)}) \bullet Frac_{GASM})] \bullet EF_4 \quad (4.30)^{81}$$

$N_2O_{(G)}$ – N_2O produced from atmospheric deposition of N, kg N/yr;
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 4.57. 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[82]
$Frac_{GASM}$	0.2 kg NH_3-N + NO_x-N/kg of nitrogen excreted by livestock[83]
EF_4	0.01 kg N_2O-N per kg NH_3-N and NO_x-N emitted

4.4.2.2. Quantitative overview – Atmospheric deposition of NO_x and NH_4 in 2006

The quantity of N_2O emission from the atmospheric deposition was 0.10 Gg in Estonia in 2006. The emission declined by 66% by 2006 in comparison with the base year (Figure 4.34).

[81] IPCC, 2000. Agriculture. Equation 4.31, pp 4.68.
[82] IPCC, 1997. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35
[83] IPCC, 1997. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35

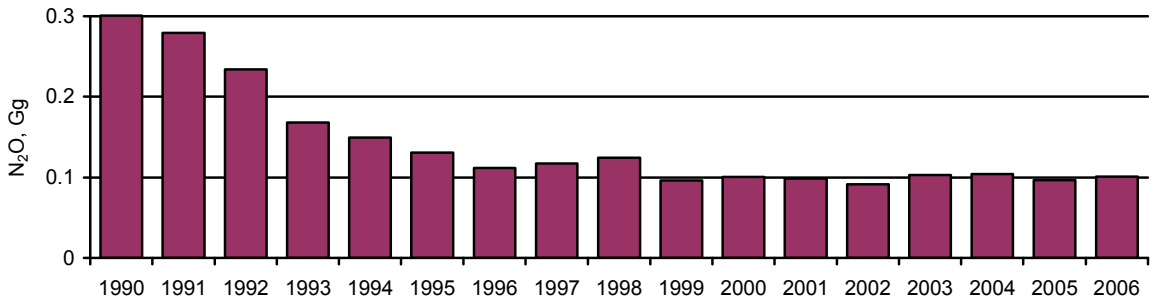


Figure 4.34. Atmospheric deposition of NO_x and NH_4 in 1990–2006, Gg

4.4.2.3. Source-specific recalculations

There is one recalculation in the 'Atmospheric deposition of NO_x and NH_4' category of the 2008 submission. The recalculation was carried out due to the re-estimated nitrogen excretion factors employed in the estimates.

Table 4.58. N_2O emissions from atmospheric deposition in Estonia in 1990–2006, Gg

Year	Reported emissions of N_2O in 1990–2005 (the 2007 submission)	Recalculated emissions of N_2O (the 2008 submission)
1990	0.312	0.301
1991	0.295	0.279
1992	0.251	0.234
1993	0.171	0.168
1994	0.158	0.150
1995	0.142	0.131
1996	0.116	0.112
1997	0.120	0.117
1998	0.125	0.125
1999	0.106	0.096
2000	0.108	0.101
2001	0.108	0.099
2002	0.101	0.091
2003	0.132	0.103
2004	0.133	0.104
2005	0.126	0.097
2006		0.101

4.4.3. 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).

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

The default IPCC *Tier 1* method was is used to estimate emissions from the atmospheric deposition.

$$N_2O_{(L)} - N = [N_{FERT} + \sum_T (N_{(T)} \bullet Nex_{(T)})] \bullet Frac_{LEACH} \bullet EF_5 \quad (4.31)^{84}$$

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 4.59);

Table 4.59. 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[85]
EF_5	0.025 kg N_2O-N per kg NH_3-N and NO_x-N emitted[86]

4.4.3.2. Quantitative overview – Leaching/Run-off of applied or deposited nitrogen in 2006

The quantity of N_2O emission from leaching was 0.51 Gg in Estonia in 2006. The emission of 2006 is 62% lower than the emission of the base year (Figure 4.35).

[84] IPCC 2000. Agriculture. Equation 4.34, pp. 4.71
[85] IPCC 1996. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35
[86] IPCC 2000. Agriculture. Table 4-18 –Default emission factors for estimating indirect N_2O emissions from N used in agriculture. pp 4.73

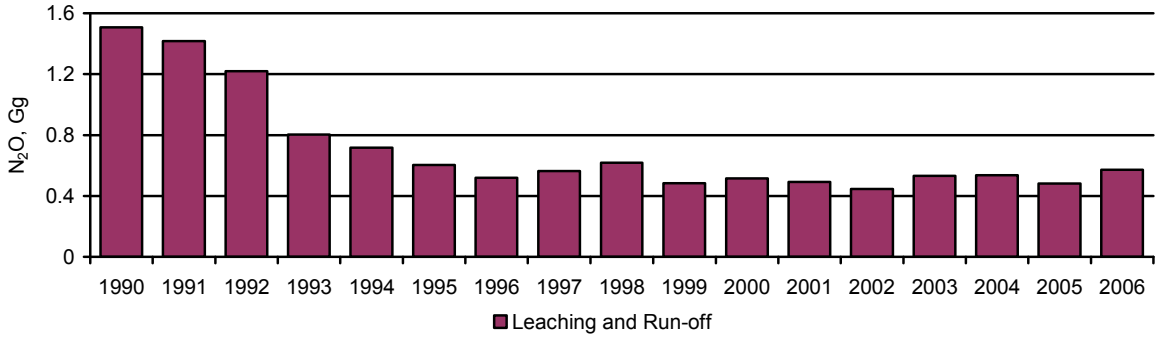


Figure 4.35. N_2O emissions from leaching and run-off in 1990–2006, Gg

4.4.3.3. Source-specific recalculations

There is one recalculation in the 'Leaching/Run-off applied nitrogen' category of the 2008 submission. The recalculation was carried out due to the re-estimated nitrogen excretion factors employed in the estimates.

Table 4.60. N_2O emissions from run-off in Estonia in 1990–2006, Gg

Year	Reported emissions of N_2O in 1990 – 2005 (the 2007 submission)	Recalculated emissions of N_2O (the 2008 submission)
1990	1.551	1.509
1991	1.476	1.416
1992	1.286	1.221
1993	0.819	0.804
1994	0.747	0.717
1995	0.643	0.605
1996	0.533	0.521
1997	0.571	0.564
1998	0.615	0.619
1999	0.516	0.484
2000	0.539	0.517
2001	0.520	0.491
2002	0.477	0.446
2003	0.631	0.532
2004	0.646	0.537
2005	0.590	0.482
2006		0.514

4.4.3.4. Uncertainties and time-series consistency

4.4.3.4.1. 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 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 4.61).

4.4.3.4.2. Nitrogen Leaching and Run-off (CRF 4.D.3.2)

The estimation of N_2O emission 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 4.61).

Table 4.61. 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		

Input	Uncertainties	References
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

CHAPTER 5. LAND USE, LAND USE CHANGE AND FORESTRY (CRF 5)

5.1. Overview of source category

Estonia, as a Party of Annex I, is required to prepare a full LULUCF inventory. In order to uphold this responsibility in future years, Estonia is developing databases and methods needed to report in complete accordance with LULUCF Guidelines (LULUCF, 2003), including the improvement in our method of gathering national data on land use.

The inventory of the 2008 submission includes carbon removals due to forest biomass increment, emissions from forest biomass felling and biomass burning. A simple scheme of the LULUCF sector is presented in Figure 5.1. The sub-sectors considered are accented in bold. Table 5.62 summarizes information used in the estimates: activity data applied, and approaches employed.

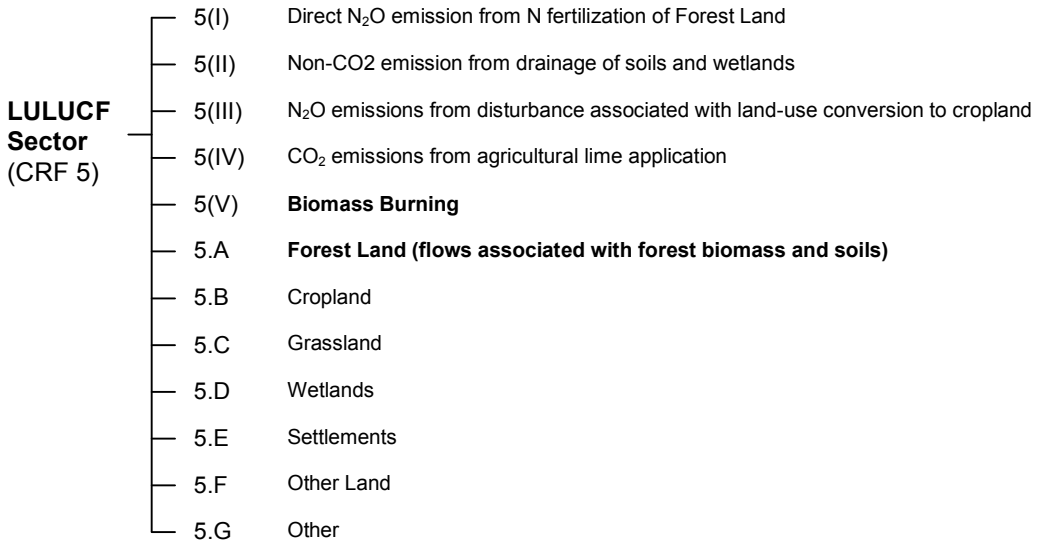


Figure 5.36. The structure of LULUCF sector

Table 5.62. Methods and emission factors used to estimate the emissions/removals of CO_2 from land use in Estonia

Greenhouse gases source and sink categories	CO_2		CH_4		N_2O	
	Method Applied	EF	Method Applied	EF	Method Applied	EF
A. Forest land						
Forest Land remaining Forest Land						
Managed Native Forests	T1	IPCC				
Biomass Burning	T1	IPCC	T1	IPCC	T1	IPCC
Land converted to Forest Land	NE	NA				
B. Cropland						
Cropland remaining Cropland	NE	NA				
Land converted to Cropland	NE	NA				
C. Grassland						
Grassland remaining Grassland	NE	NA				
Land converted to Grassland	NE	NA				
D. Wetlands						
Wetlands remaining Wetlands	NE	NA				
Land converted to (from) Wetlands	NE	NA				
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

5.1.1. References – sources of information

The inventory in LULUCF sector is carried out through research in Tallinn University of Technology. The main institutions – that provide activity data used in the estimates are listed in Table 4.2.

Table 5.63. List of institutions (datasets) involved in the inventory for the LULUCF sector

References	Link	Abbreviation	Data
Tallinn University of Technology	www.ttu.ee	TUT	- activity data processing; - estimation of emissions/removals; - reporting of emissions/removals (the CRF tables, the NIR).
Centre of Forest Protection and Silviculture	www.metsad.ee	CFPS	- carrying out of the National Forest Inventory; - reporting of data on land cover by land category (forest, grassland, wetlands, build-up area); - reporting of data on forest biomass stock, biomass increment;

References	Link	Abbreviation	Data
Statistics of Estonia	www.stat.ee	ESO	- collection and reporting of data on forest fire areas;

5.1.2. Quantitative overview

Land use has changed in recent decades (Figure 5.37). The area covered by forest biomass increased from 23% in 1945 to almost 50% in 2006. The rise has taken place mostly due to abandonment of grassland areas and overgrowing of wetlands. Since then, the area of grassland declined from 30% to 6% in the same period.

Built-up area (settlements and roads) increased by more than 3-fold in Estonia from 1945–2006. However, the share of built-up land use category is not very high – 6.4% of the total land cover in Estonia in 2006.

Also, noticeable changes have taken place in the method of data collection on areas of land by category. Until 1990 in Estonia, land use data by land use categories was collected by the Estonian Land Board (ELB) and published annually in a "Land Balance" report. Since 1991 Land Reform was started in Estonia (the reform continues today). The main goal of the Land Reform was to establish conditions for the creation of land market and participants of the market, who have private ownership rights since the Soviet Union (during the process of collectivization) 'removed' any private ownership rights. ELB has started, with the launching of the Land Reform, to collect data only on land, which is registered in the Land Cadastre.

In the period of 1991–1999, the data reported on land use in annual reports of ELB does not reflect a full picture of land cover in Estonia. By 2006, 83% of Estonian land was accounted for in the Land Cadastre.

In 1999, mostly in order to collect actual, impartial and continually updated data on Estonia forest land and other lands, the National Forest Inventory (NFI) basing on the Statistical Sampling Method (SMI) was launched. The inventory is also in the process of being compiled. Current Estonia's land cover is illustrated in Figure 5.39.

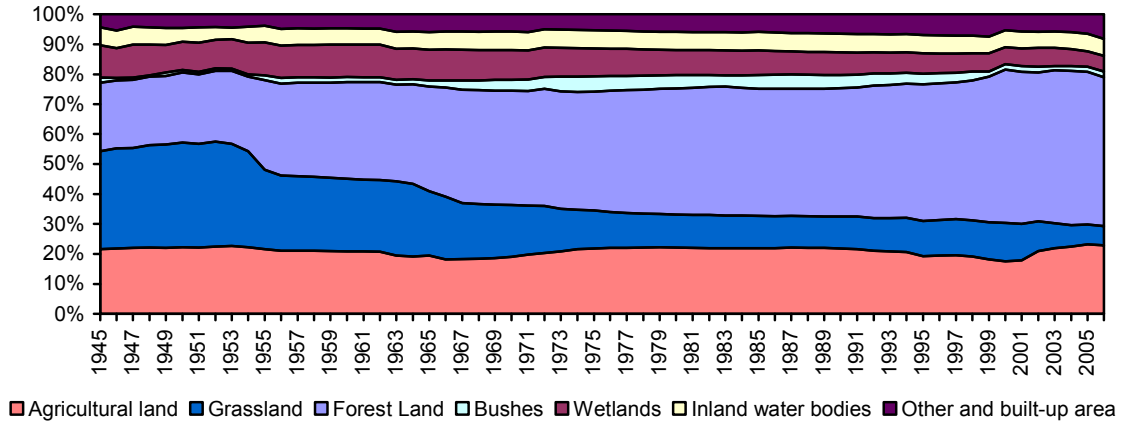


Figure 5.37. Land used in Estonia in 1945–2006, %[87]

3,472 Gg of CO_2-equivalent was removed by forest biomass in Estonia in 2006. The trend of net carbon removals/emissions taken place in Estonian forests is presented in Figure 5.38.

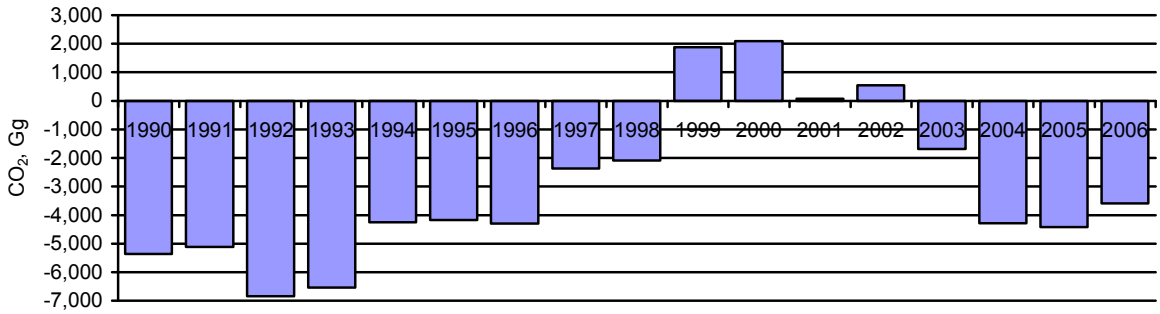


Figure 5.38. Net emissions/removals of CO_2 by Estonian forests biomass in 1990–2006, CO_2 Gg

[87] *1945–1985* – Eesti NSV maafond 1945–1985; *1986* – Eesti NSV 1986 a. maabilanss; *1987* – Eesti NSV 1987 a. maabilanss; *1988* – Eesti NSV 1988 a. maabilanss; *1989* – Eesti NSV 1989 a. maabilanss; *2000* – Eesti Metsad 2000; *2001* – Eesti Metsad 2001; *2002* – Eesti Metsad 2002; *2003* – Eesti Metsad 2003; *2004* – Eesti Metsad 2004; 2005 – Eesti Metsad 2005; 2006 – Eesti Metsad 2006.

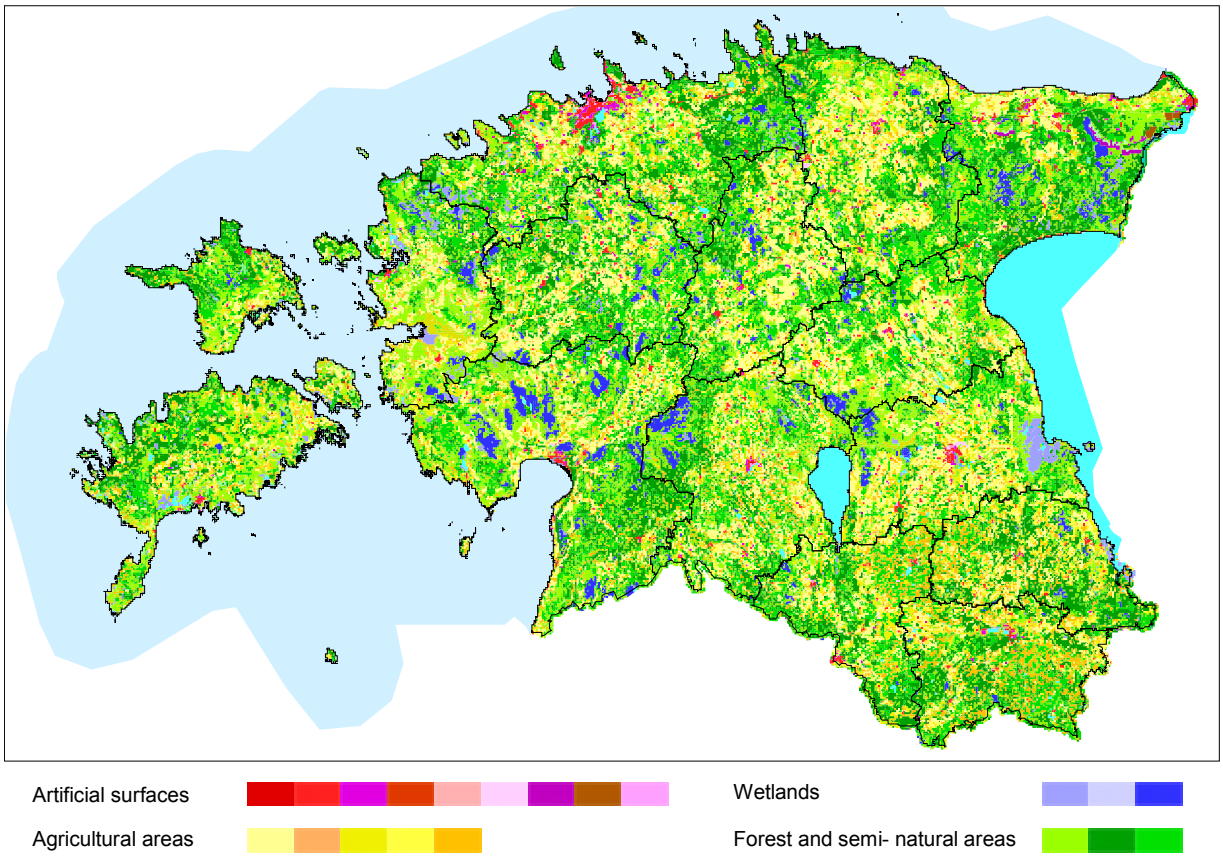


Figure 5.39. CORINE land cover in 2000 (the map was obtained from EEIC)

Methods used to estimate all GHG flows are presented in Table 5.62. GHG emissions/ removals due to forest biomass increment, felling, from forest drained organic soils and due to wildfires in forest biomass were considered in the 2008 submission.

5.1.3. Key categories

Net CO_2 removals by forest biomass ('Forest land remaining forest land' sub-category) were found to be a key category in 2006 based on level and trend assessments.

5.1.4. Uncertainty assessment

The most uncertain emission/removal source in LULUCF sector is CO_2 removals by forest biomass. The highest uncertainty rate is also associated with estimates of CO_2 removals.

The combined uncertainties related to LULUCF sector as percent from national emission in 2006 as follows:

5.A.1	*Forest Land remaining Forest Land*	
	Gains (CO_2)	43.4528%
	Losses (CO_2)	0.0091%
	Organic Soils (CO_2)	0.0097%
	Wildfires (CO_2)	0.9149%
	Wildfires (CH_4)	0.0234%
	Wildfires (N_2O)	0.0024%
	LULUCF sector total	44.4123%

5.2. Forest Land (CRF 5.A)

Forest biomass plays an important role in the carbon cycle in Estonia.

Forest Land (5.A) section includes two sub-sections: 'Forest land remaining Forest Land' (CRF 5.A.1) and 'Forest Land converted to Forest Land' (CRF 5.A.2). The 2008 submission considers only carbon flows (CO_2 equiv) related to 'Forest Land remaining Forest Land'.

The National Forest Inventory

As mentioned, the estimation of carbon quantities emitted/removed 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. It means that annually about 10% of forest data was updated, with attention being focused on the biomass in government managed forests. The data on reconstituted forest lands in the framework of the Land Reform was not available. The data on forest biomass and areas were mostly interpolated, and therefore quality of the data is low.

The NFI basing on the SMI was implied in 1999 in Estonia. The quality of monitored and reported forest data is increasing and that in turn decreases uncertainty related to the estimation of forest area and forest biomass.

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 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 that given in the decision 16/CMP.1, Estonia has established the Estonian 'definition of forest in the context of the Kyoto Protocol', the main parameters of forest determined in the definition is reported in Table 5.64.

Table 5.64. Parameters for forest definition

Minimum tree cover	30%
Minimum land area	0.1 ha
Minimum tree height	2 m

5.2.1. Forest Land remaining Forest Land (CRF 5.A.1)

This section deals with managed forests that have been under Forest Land for over 20 years, or for over a country-specific transition period. GHG inventory for Forest Land Remaining Land involves estimation of changes in carbon stock from five carbon pools, as well as emissions of non-CO_2 gases (IPCC, 2006).

Currently Estonian GHG inventory in the LULUCF sector includes estimations of carbon removals due to forest biomass increment and carbon emissions from forest harvesting (considered to be immediate emission) and from biomass burning. Also, GHG emissions from organic and mineral soils were included in the 2008 submission.

5.2.1.1 Activity data

Since 1945 forest area is continuing to increase in Estonia (**Figure 5.40**). It is mainly explained by abandonment of grassland used for hay production and overgrowing of wetland (Figure 5.51, Figure 5.52).

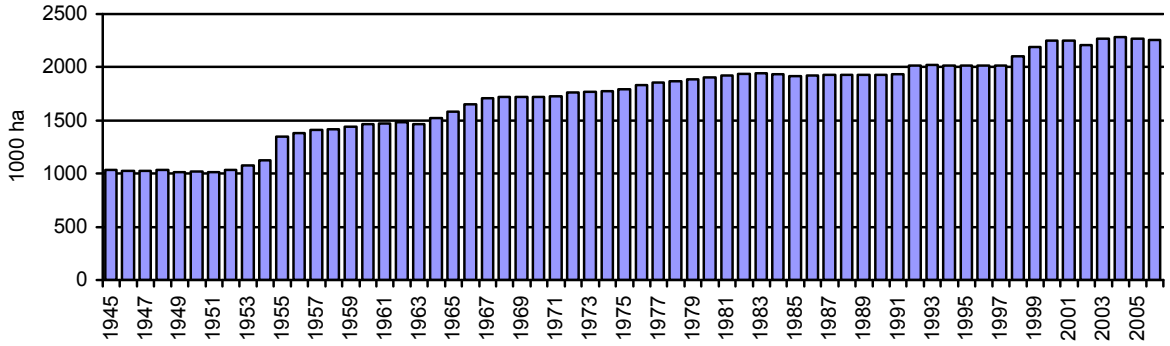


Figure 5.40. Forest area in Estonia in 1945–2006, 1000 ha

The data presented in Table 5.65 illustrates forest areas obtained from different datasets: ESO and FAO. The distinction in forest areas between two datasets is explained by different definitions of terms applied in order to determine forest land areas. The data presented in Table 5.66 reports the difference in forest areas included into other Estonian land use categories and which should be included into 'forest in the context of the Kyoto Protocol'.

The FAO data were used in the estimates of GHG emissions/removals associated with forest land (Table 5.65).

Table 5.65. Forest area in Estonia in 1990–2006, 1000 ha

Year	Reported by ESO	Annual change rate (ESO), ha	Reported in the FAO dataset[88]	Annual change rate (FAO), ha
1990	1,921		2,163[89]	
1991	1,926	5.0	2,171[90]	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
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[91]	8.0
2006	2,252	-12.0	2,391[92]	107.0

Table 5.66. Forest area in accordance with different definitions of forest in Estonia in 2006, 1000 ha

	Estonian Land Use category	FAO forest
Forest	**2,251.9**	2,251.9
Bushes	82.4	24.1
Grassland	292.3	38.3
Wetland	232.3	73.2
Other	1,663.8	3.5
Total		**2,391.1**

5.2.1.2. Methodology, data availability and sources, emission factors

The algorithm employed in order to estimate carbon flows related to 'Forest Land remaining Forest Land' is presented below:

[88] www.fao.org
[89] FRA 2005
[90] The area was interpolated.
[91] FRA 2005
[92] Eesti Metsad 2006

$$\Delta C_{FF} = (\Delta C_{FF_{LB}} + \Delta C_{FF_{DOM}} + \Delta C_{FF_{Soils}})$$

(5.1)[93]

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};

$$\Delta C_{FF_{LB}} = (\Delta C_{FF_G} - \Delta C_{FF_L})$$

(5.2)[94]

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};

In order to estimate carbon removals due to forest biomass increment the *Tier 1* approach was employed.

$$G_{TOTAl} = G_W \bullet (1 + R)$$

(5.3)[95]

where:

$$G_W = I_V \bullet D \bullet BEF_1$$

G_{TOTAL} – average annual biomass increment above and below-ground, tonnes d.m. ha-1 yr^{-1};

G_W – average annual aboveground biomass increment, tonnes d.m. ha^{-1} yr^{-1};

R – root-to-shoot ratio appropriate to increments, dimensionless;

[93] LULUCF 2003, Equation 3.2.1., pp 3.23
[94] LULUCF 2003, Equation 3.2.2., pp 3.24
[95] LULUCF 2003, Equation 3.2.3., pp 3.24

I_V – average annual net increment in volume suitable for industrial processing, m^3 ha-1 yr^{-1};

D – basic wood density, tonnes d.m. m^{-3};

BEF_1 – biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment, dimensionless.

Table 5.67. Default values of BEF[96]

Forest type	BEF_2	BEF_1
Conifer	1.35	1.15
Broadleaf	1.3	1.1

Table 5.68. Average below-ground to above-ground biomass ratio (root-shoot ratio, R)[97]

Forest type	Aboveground biomass, t/ha	Root-shoot ratio
Conifer forest/plantation	50–150	0.32
Other broadleaf forest	75–150	0.26

Annual decrease in carbon stocks due to biomass loss in forest land remaining land

The *Tier 1* method was employed in order to estimate carbon emission from biomass felling (emission is considered to be immediate).

$$\Delta C_{FF_L} = L_{felling} + L_{other\_losses} \quad (5.4)^{98}$$

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, tonnes C yr^{-1}.

$$L_{felling} = H \bullet D \bullet BEF_2 \bullet (1 - f_{BL}) \bullet CF \quad (5.5)^{99}$$

[96] LULUCF 2003, Table 3A.1.10., pp. 3.178
[97] LULUCF 2003, Table 3A.1.8., pp. 3.168
[98] LULUCF 2003, Equation 3.2.6, pp. 3.26
[99] LULUCF 2003, Equation 3.2.7, pp. 3.27

$L_{fellings}$ – annual carbon loss due to commercial felling, tC yr^{-1};

H – annually extracted volume, round-wood, m^3 yr^{-1};

D – basic wood density, tonnes d.m. 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);

CF – carbon fraction of dry matter (default=0.5), tC (tonne d.m.)$^{-1}$.

Table 5.69. Default values for fraction out of total harvest left to decay in the forest[100], f_{BL}

	f_{BL}
Boreal intensively managed	0.07

5.2.1.3. Quantitative overview – Carbon emissions/removals from forest land

The forest area increased 1.2-fold by 2006 in comparison with the base year. The changes in forest area covered by trees are presented in Figure 5.41. 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 used in the estimates are presented in Table 5.70.

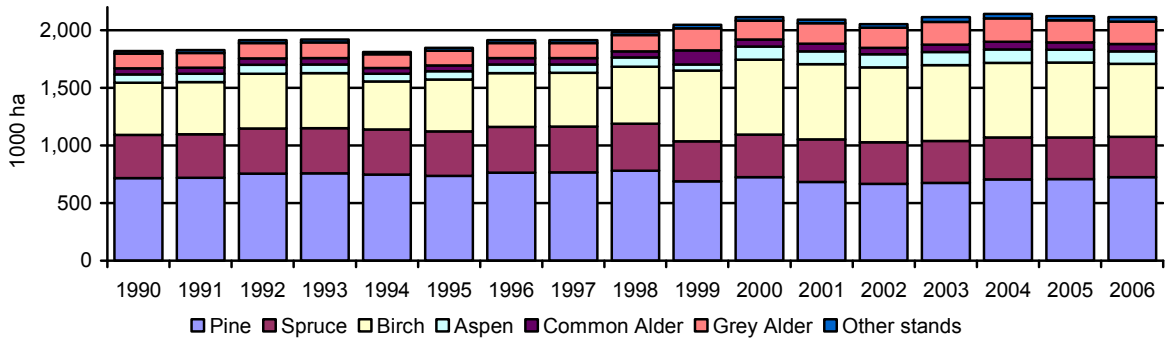


Figure 5.41. Forest area (area of stands) in Estonia in 1990–2006, 1000 ha (see also Annex 6_I)

[100] LULUCF 2003, Table 3A.1.11, pp 3.178

Table 5.70. Overall characterization of Estonian forest stands in 2006[101]

	Area of stands, 1000 ha	Stock, 1000 m^3	Stock, m^3/ha	Increment, 1000 m^3	Increment, m^3/ha
Pine	724.3	169,441	233.9	3,587	5.0
Spruce	352.4	80,279	227.8	2,499	7.1
Birch	631.4	114,118	180.7	2,994	4.7
Asp	109.2	29,849	273.3	670	6.1
Common Alder	62.7	14,109	225.0	327	5.2
Grey Alder	195.2	35,543	182.1	1,347	6.9
Others	38	7,002	184.3	204	5.4
	2,113.2	**450,341**		**11,628**	

The data in Figure 5.42 demonstrates averaged values of carbon sequestrated per hectare in Estonian forest in 1990–2006. The averaged value is increasing due to better management of Estonian forest biomass.

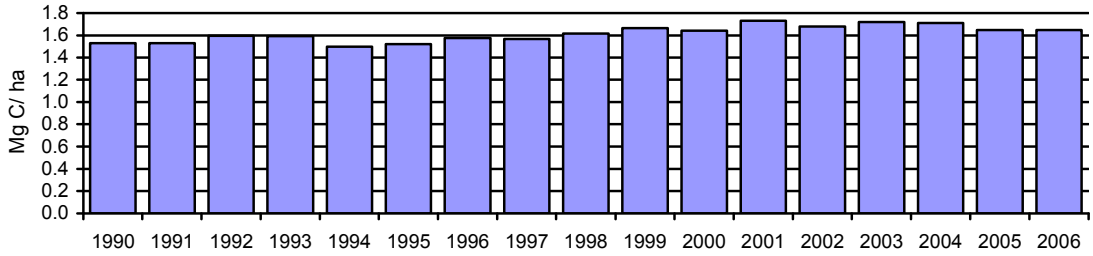


Figure 5.42. Carbon gain by forest biomass in 1990–2006 in Estonia, Mg C/ha[102]

The data on forest felling is gathered 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 5.71.

[101] Eesti Metsad 2006

[102] 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 with forest biomass and without forest biomass. However, the estimates were carried out taken into account only areas of stands (forested areas) and average increment.

Table 5.71. Amounts and areas of forest biomass harvested, ha and m^3

	Forest harvest documentation[103]		The NFI (the SMI)[104]		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			***7,078,864***

As seen from Table 5.71, amounts of felling out-turn differ between two methods of data collection. Thus, the data received in the process of the NFI was taken into account in the estimates for 1999–2004. In order to guarantee comparability in activity data, the data on forest felling for 1990–1998 were assumed basing on amounts of forest biomass harvested and reported in accordance with forest harvest documentation and taking into account the experience received in the process of the NFI (Figure 5.43).

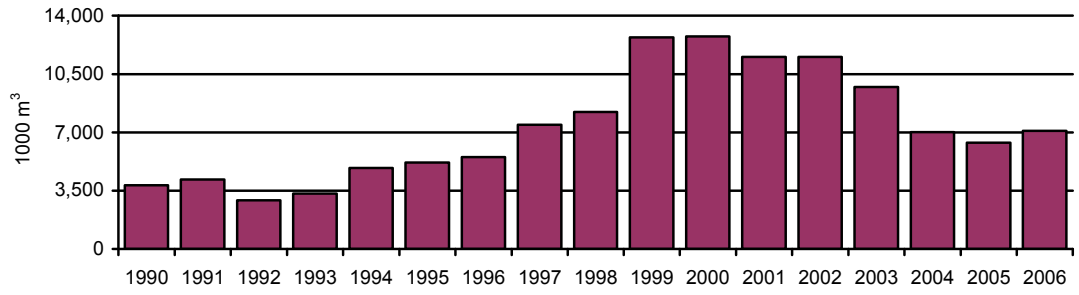


Figure 5.43. Volumes of forest harvested in Estonia in 1990–2006, 1000 m^3

[103] www.stat.ee
[104] Eesti Metsad 2001,…, 2006

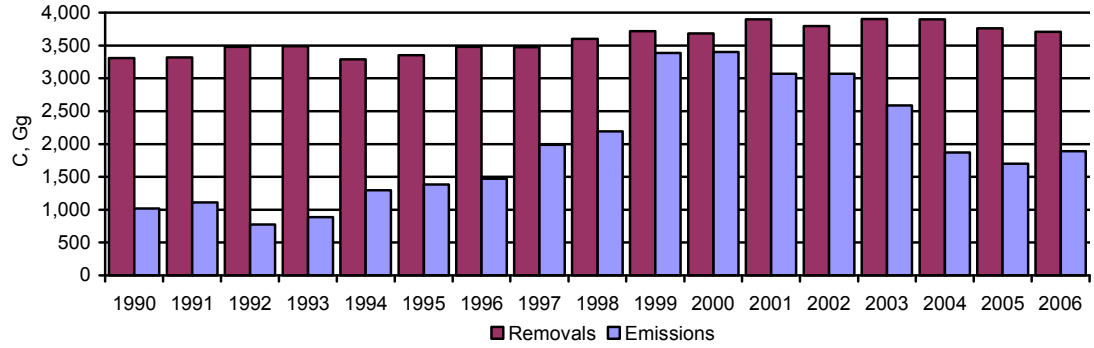


Figure 5.44. Volumes of carbon emitted due to forest felling and sequestrated due to biomass increment in Estonia in 1990–2006, C Gg [105]

Figure 5.44 and Figure 5.45 demonstrate that carbon emissions and removal from forest biomass in Estonia in 1990–2006. As seen, immediate emissions from forest biomass felling exceed amounts of carbon sequestrated in 1999 and 2000.

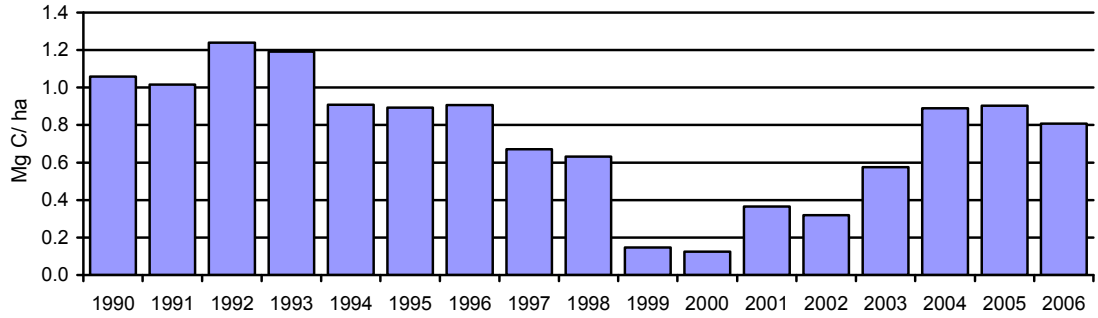


Figure 5.45. Net carbon stock change in forest biomass in Estonia in 1990–2006, Mg C/ha

5.2.1.4. Source-specific recalculations

There are several recalculations carried out in the 2008 submission. The estimates were carried out taking into consideration values of area and biomass increment by tree species. BEFs and wood densities reported in (LULUCF, 2003) were employed. The estimates in the preceding submissions were carried out basing on the total forest area and average increment of forest biomass.

[105] Removals – with minus

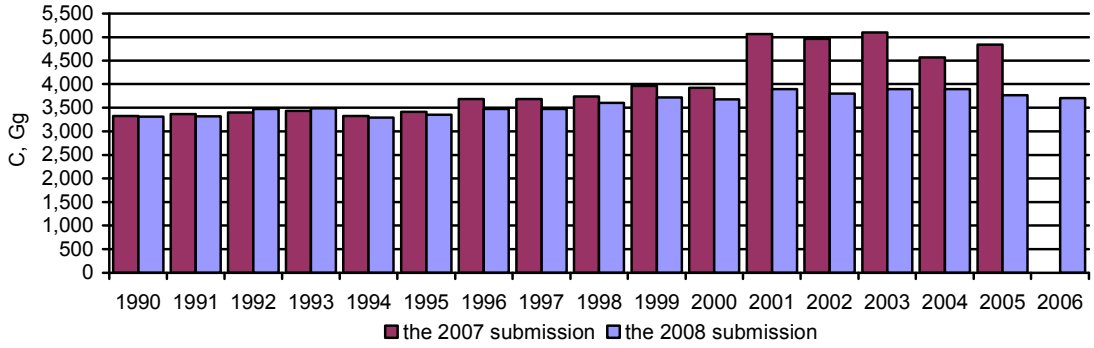


Figure 5.46. Amounts of carbon sequestrated by forest biomass in Estonia in 1990–2006, Gg

Table 5.72. Amounts of carbon sequestrated by forest biomass in Estonia in 1990–2006, Gg

Year	Reported removals of carbon in 1990–2005 (the 2007 submission)	Recalculated removals of carbon (the 2008 submission)
1990	3,326	3,308
1991	3,363	3,320
1992	3,401	3,478
1993	3,439	3,487
1994	3,322	3,292
1995	3,414	3,352
1996	3,688	3,477
1997	3,687	3,476
1998	3,741	3,601
1999	3,966	3,717
2000	3,922	3,681
2001	5,065	3,897
2002	4,963	3,796
2003	5,101	3,900
2004	4,572	3,895
2005	4,843	3,763
2006		3,708

There is one recalculation carried out in order to report carbon emissions from forest felling. In order to ensure more accurate and transparent results on carbon emissions, updated amounts of forest biomass harvested were taken into the estimation. BEFs and wood densities were obtained from (LULUCF, 2003).

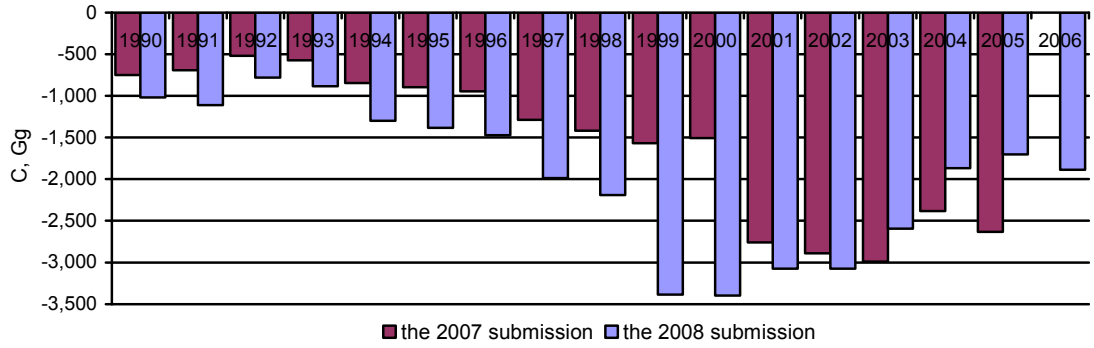


Figure 5.47. Carbon emissions due to forest felling in Estonia in 1990–2006, Gg

Table 5.73. Carbon emissions due to forest felling in Estonia in 1990–2006, Gg

Year	Reported emissions of carbon in 1990–2005 (the 2007 submission)	Recalculated emissions of carbon (the 2008 submission)
1990	-749	-1,019
1991	-690	-1,114
1992	-519	-779
1993	-571	-883
1994	-847	-1,299
1995	-894	-1,384
1996	-943	-1,474
1997	-1,288	-1,989
1998	-1,418	-2,191
1999	-1,569	-3,386
2000	-1,507	-3,400
2001	-2,761	-3,074
2002	-2,891	-3,074
2003	-2,988	-2,591
2004	-2,386	-1,870
2005	-2,633	-1,702
2006		-1,888

5.2.1.5. Uncertainties and time-series consistency

CO_2 emissions/removals from forest biomass are estimated according to the IPCC Guidelines in Estonia (IPCC, 1997). Activity data are obtained from ESO and CFPS, emission factors are used from the IPCC. The uncertainty in activity data is presented in Table 5.74. The uncertainty for 2003 was used as representative for all years (1991–2006) due to lack of data.

Uncertainties are stated as follows: forest land area, ±1.8%, annual biomass increment per hectare, ±1.7%, average biomass stock per hectare, ±2.2%. Uncertainties of wood density and carbon content were not taken into account.

The IPCC Guidelines present uncertainties in BEFs by conifers and broad-leaf forest type (LULUCF, 2003).

The estimation of CO_2 and CH_4 emissions from forest felling are calculated based on forest biomass area, growing stock (m^3/ha), wood density, carbon content and BEFs. The uncertainty of harvested forest area is ±15%.

The uncertainty in biomass stock per hectare is ±2.2%. The uncertainty in BEFs of growing stock was used as ±30%, due to lack of data.

However, Estonia will continue to improve these data and more accurate, recalculated numbers will be available in the near future.

The combined uncertainty rates related to 'solid waste disposal waste' sub-category are reported in Chapter 5.1.4.

Table 5.74. Estimated values of uncertainties used in LULUC sector

Input	Uncertainties	References
Activity data		
Forest land, ha	± 15%	LULUCF, 2003. pp. 3.32
Stand biomass increment, m^3/ha	± 1.7%	'Eesti Metsad 2003'
Stand stock per hectare, m^3/ha	± 2.2%	'Eesti Metsad 2003'
Felling area, ha	± 15.0%	Estonian Statistical Office
Emission factors		
BEFs (used in connection to increment data)	± 30%	LULUCF, 2003, pp. 3.31
BEFs (used in connection to 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 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

5.2.1.6. Planned Improvements

All datasets used in the estimates are being under development, further improvements will be provided in the next submission.

5.2.2 Change in carbon stock in soils (CRF 5.A.1)

LULUCF Guidelines include procedures for estimating change in carbon stocks from and to forest soils. Separate guidance is provided for two types of forest soil carbon pools: 1) organic fraction of mineral forest soils, and 2) organic soils (LULUCF, 2003).

5.2.2.1 Activity data

The carbon pool in forest soil was estimated at 314 Tg which is 1.3 times more carbon than fixed in forest biomass (Table 5.74). The data on soil carbon was collected in the periods of 1967–1985, 1986–1995, and 1999–2002. The database contains 232 experimental areas of forest soil. Uncertainties of carbon pool due to the forest soil type vary from ±20% to ±40% (Kõlli *et al.*, 2004).

Table 5.75. Forest soil groups, thickness of soil cover and pools of soil organic carbon in Estonian forest soils in 1991[106]

Group No	Soil code by WRB				% from forest land	Forest land area in 1991, 1000 ha	Thickness of soil cover (SC) mean (M) standard deviation (SD)			SOC pools of soil cover Mg/ha	Sum of SOC pools of soil cover in Gg
							M	+	SD		
I	LP	rz	sk	gl	0.8	16.1	24	+	3.6	102	1,642
II	CM	ca	skn		1.9	38.3	56	+	18.9	109	4,175
III	CM	mo	gln		3.3	66.5	47	+	8.1	76	5,054
IV	CM	gls			1.3	26.2	43	+	9.8	96	2,515
V	LV	ct	gln		2.4	48.4	70	+	18.8	95	4,590
VI	AB	gs	gls		3.6	72.6	92	+	18.7	64	4,646
VII	AB	ha			2.7	54.4	86	+	13.9	88	4,787
VIII	AB	gln			1.6	32.2	72	+	19.4	65	2,093
IX	PZ	ha			3.8	76.6	67	+	25.0	45	3,447
X	PZ	gln			2.2	44.3	62	+	16.7	44	1,949
XI	GL	mo	cc	eu	12.1	243.9	39	+	12.6	120	29,268
XII	GL	lv	dye		8.0	161.3	55	+	21.0	126	20,324
XIII	GL	sd	um	dy	9.2	185.4	70	+	14.6	113	20,950
XIV	GL	his			5.3	106.8	51	+	11.9	209	22,321
XV	PZ	hif			3.1	62.5	76	+	18.0	114	7,125
XVI	FL	eu	sz		1.1	22.2	26	+	5.7	84	1,685
XVII	HS	eu	sa		16.3	328.6	50	+	0	333	109,424

[106] FRA 2005

Group No	Soil code by WRB	% from forest land	Forest land area in 1991, 1000 ha	Thickness of soil cover (SC) mean (M) standard deviation (SD)			SOC pools of soil cover Mg/ha	Sum of SOC pools of soil cover in Gg
				M	+	SD		
XVIII	HS dy	6.9	139.1	50	+	0	210	29,211
XIX	HS fi	13.7	276.2	50	+	0	139	38,392
XX	RG pr sp	0.7	14.1	<25	+		43	619
Total			**2,016**					**314,397**

I – Renzidic & Sceletic & Gleyic Leptosols; II – Calcaric & Endosceletic Cambisols; III – Mollic & Endogleyic Cambisols; IV – Sceletigleyic Cambisols; V – Cutanic & Endogleyic Luvisols; VI – Glossic & Gleyiglossic Albeluvisols; VII – Haplic Albeluvisols; VIII – Endogleyic Albeluvisols; IX – Haplic Podzols; X – Endogleyic Podzols; XI – Mollic & Calcic & Eutric Gleysols; XII – Luvic & Epidystric Gleysols; XIII – Spodic & Umbric & Dystric Gleysols; XIV – Saprihistic Gleysols; XV – Fibrihistic Podzols; XVI – Eutric & Salic Fluvisols; XVII – Eutric & Sapric Histosols; XVIII – Dystric Histosols; XIX – Fibric Histosols; XX – Protic & Spolic Regosols.

The data reported in Table 5.75 illustrate that more than 740 thousand hectares under forest biomass are organic soils. Ilomets (2005) argues that more than 760 thousand hectares of wetlands were drained for agricultural purposes and for forest biomass growing during the last decades.

The data received from the combining process of CORINE maps (CORINE 1990, 2000) and Estonian soil map determine that more than 520 thousand of hectares of organic soils are under forest biomass in Estonia.

Thus, the results of the latest research (Kõlli *et al.*, 2004, Table 5.75) were taken into the estimates of carbon emissions from drained organic forest soils. The data from 1992–2006 were interpolated using the data on forest area and the data obtained from CORINE maps (1990, 2000).

5.2.2.2. Methodology, data availability and sources, emission factors

Mineral soils

The *Tier 1* method was employed in this sub-section. Under the *Tier 1* method, it was assumed that forest remains forest and carbon stock in soil organic matter does not change, regardless of changes in forest management, types, and disturbance regimes (LULUCF, 2003).

Organic soils

The *Tier 1* method was employed in order to estimate CO_2 emissions from organic soils. The approach is based on the data on the area of drained, organic forest soils and the default emission factor (5.7).

$$\Delta C_{FF_{Organic}} = A_{Drained} \bullet EF_{Drainage}$$

(5.7)[107]

$\Delta C_{FFOrganic}$ – 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}.
Carbon emission factor was employed from (LULUCF, 2003), where the factor is presented in range of 0.08–1.09 tonnes C ha^{-1} yr^{-1}. Ilomets (2005) argues that carbon emission factor from drained wetland soils is 4 tC/ha. This value was investigated in Finland, and the same value could be applied in the estimates in Estonia due to similar climatic conditions of wetlands. However, in order to avoid incomparability in the factor used across countries (with boreal forest) the factor reported in the LULUCF guidelines was applied in the estimates.

Table 5.76. Emission factors, tonnes C ha^{-1} yr^{-1}

	Value
Boreal forest	1.09[108]

[107] LULUCF 2003, Equation 3.2.15, pp 3.42.
[108] LULUCF 2003, Table 3.2.3, pp. 3.42.

5.2.2.3. Quantitative overview – Carbon emissions/removals from forest soils

Mineral soils

The *Tier 1* approach of LULUCF (2003) was employed.

Organic Soils

Carbon emission from organic forest soils was 841 Gg in Estonia in 2006. The emission from soils has changed slightly since 1990.

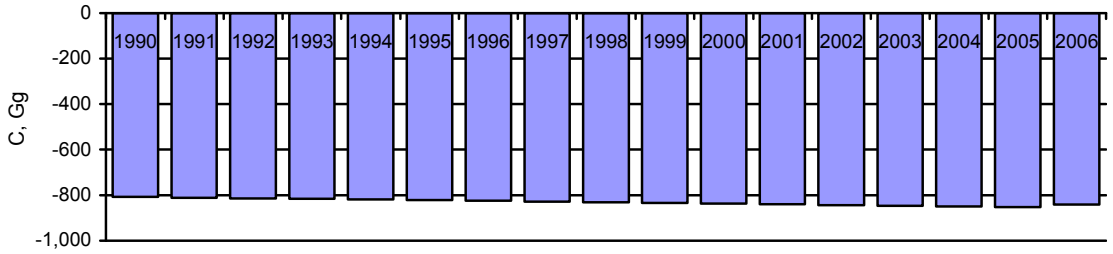


Figure 5.48. Carbon emission from drained organic forest soils in Estonia in 1990–2006, C Gg

5.2.2.4. Source-specific recalculations

The following recalculations were carried out in 'Forest Land remaining Forest Land' sub-section of the inventory in LULUCF sector:

- updating of the data required for estimation of carbon removal quantities due to forest biomass increment.
- re-estimation of the data needed for estimation of carbon emission values due to forest biomass felling.
- estimation (first time) of carbon emissions from drained organic forest soils.

The difference between the data (carbon emissions/removals) of the 2007 and the 2008 submissions is presented in Figure 5.49 (Figure 5.46, Figure 5.47).

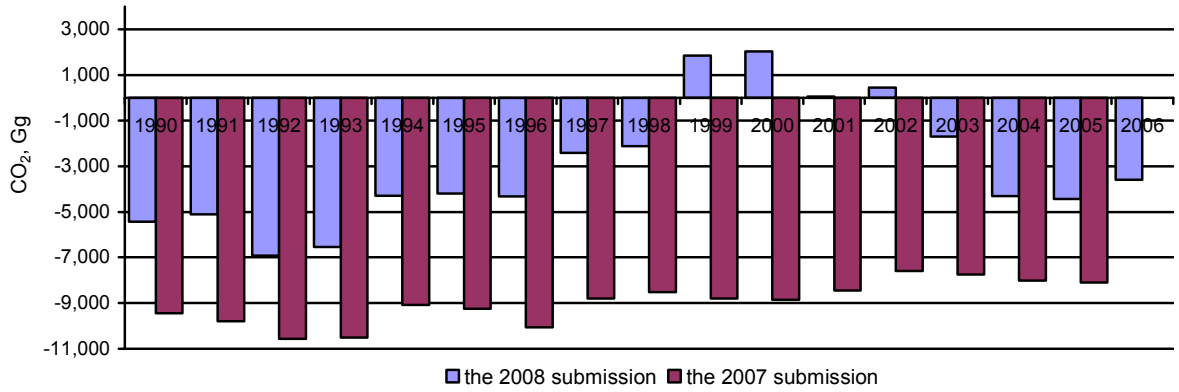


Figure 5.49. Emissions/removals from 'Forest Land remaining Forest Land' in Estonia in 1990–2006, CO_2 Gg

5.3. Cropland (CRF 5.b) and Carbon Emission from Agricultural Liming (CRF (IV))

As mentioned in the beginning of this chapter, Estonia is still developing datasets required in order to estimate carbon emissions/removals associated with Cropland. Since, not all data requested in GPG LULUCF (LULUCF, 2003) was available to perform a complete GHG inventory in this land category using the *Tier 1* method. Thus, Estonia is unable to report emissions from Croplands in this submission, however all future reports will consider emissions from Croplands.

The data on area of agricultural land is collected by ESO and by CRPS. The data reported in Figure 5.50 covers areas of arable lands in Estonia, where areas of seeded annual and multi-annual forage crops (grassland) are included.

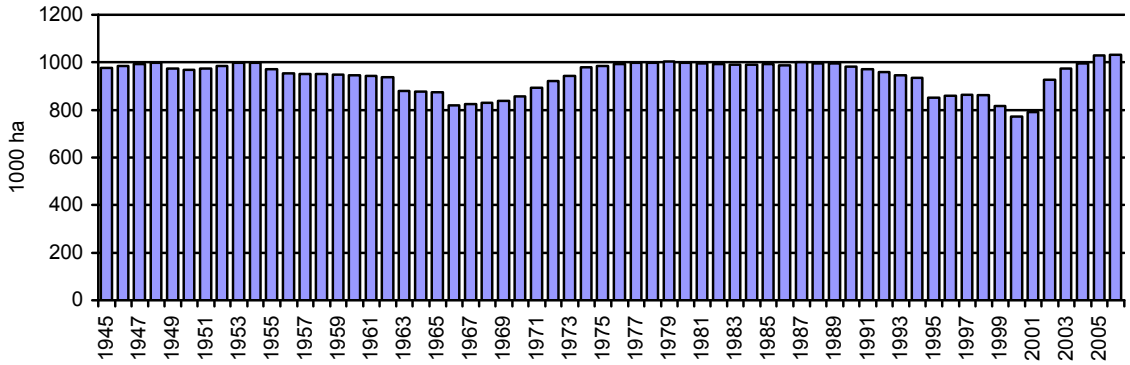


Figure 5.50 Area of agricultural land in Estonia in 1945–2006, 1000 ha[109]

5.4. Grassland (CRF 5.C)

As mentioned in the beginning of this chapter, Estonia is still developing datasets required in order to estimate carbon emissions/removals related to Grassland. Since, not all data requested in GPG LULUCF was available to perform a complete GHG inventory in this land category using the *Tier 1* method. Thus, Estonia is unable to report emissions from Grasslands in this submission, however all future reports will consider carbon flows (emissions/removals) of Grassland.

Figure 5.51 illustrates the data on grassland areas in Estonia in 1945–2006. The data will be used in the future submission in order to estimate carbon flows associated with Grassland.

[109] The data of 1990–1998 were interpolated basing on the trends of 1945–1989 and 1999–2006.

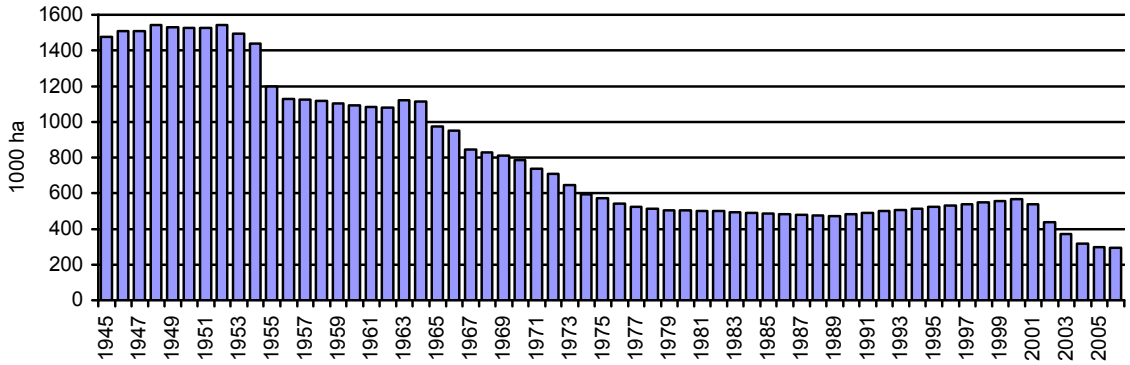


Figure 5.51 Area of Grassland in Estonia in 1945–2006, 1000 ha[110]

5.5. Wetlands (CRF 5.D)

As mentioned in the beginning of this chapter, Estonia is still developing datasets required in order to estimate carbon emissions/removals related to Wetlands. Since, not all data requested in GPG LULUCF was available we were unable to perform a complete GHG inventory in this land category using the *Tier 1* method. Thus, Estonia is unable to report emissions from Wetlands in this submission, however all future reports will consider carbon flows (emissions/removals) of Wetlands.

Figure 5.52 illustrates the data on wetlands areas in Estonia in 1945–2006. The data will be used in the future submission in order to estimate carbon flows associated with Wetlands. The data on areas of peat lands are being collected.

[110] The data of 1990–1998 were interpolated basing on the trends of 1945–1989 and 1999–2006.

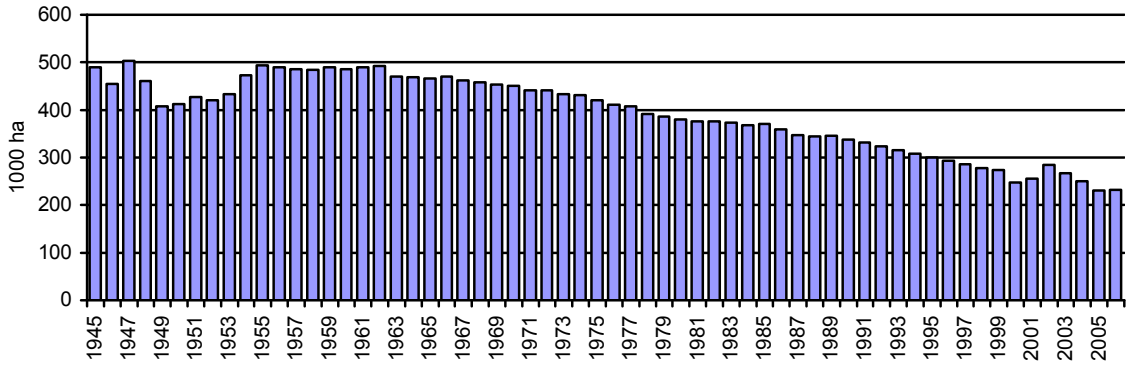


Figure 5.52 Area of wetlands in Estonia in 1945–2006, 1000 ha[111]

5.6. Settlements (CRF 5.E) and Other Land (CRF 5.F)

As mentioned in the beginning of this chapter, Estonia is still developing datasets required in order to estimate carbon emissions/removals related to Settlements and Other Land. Since, not all data requested in GPG LULUCF was available to perform a complete GHG inventory in this land category using the *Tier 1* method. Thus, Estonia is unable to report emissions from Settlements and other lands in this submission.

Figure 5.53 illustrates the data on settlements and other land areas in Estonia in 1945–2006. The data will be used in the future submission in order to estimate carbon flows associated with Settlements and Other Land.

[111] The data of 1990–1998 were interpolated basing on the trends of 1945–1989 and 1999–2006.

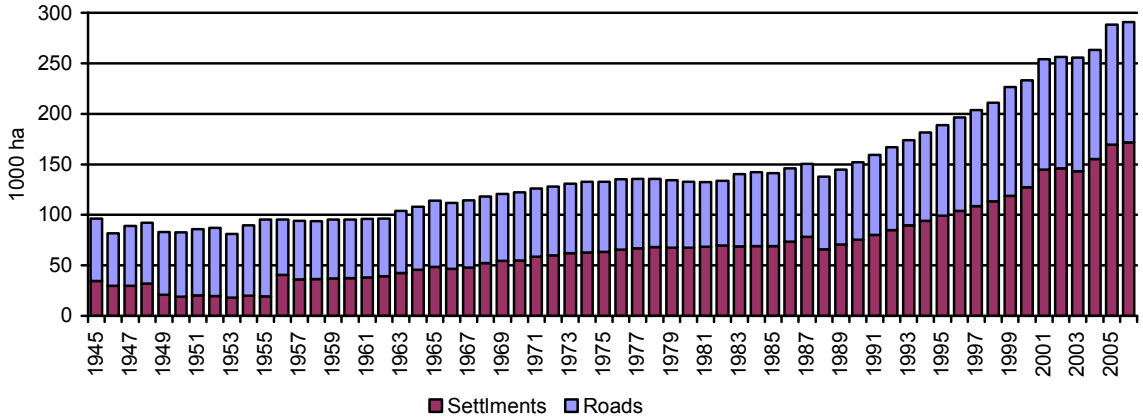


Figure 5.53 Area covered by build-up land (Settlements and Roads) in Estonia in 1945–2006, 1000 ha[112]

The changes in 'Other Land' land use category are not consistent over time. The land category includes open-pit mining areas (oil shale, peat, limestone and granite mines), areas of which are re-cultivated after closing.

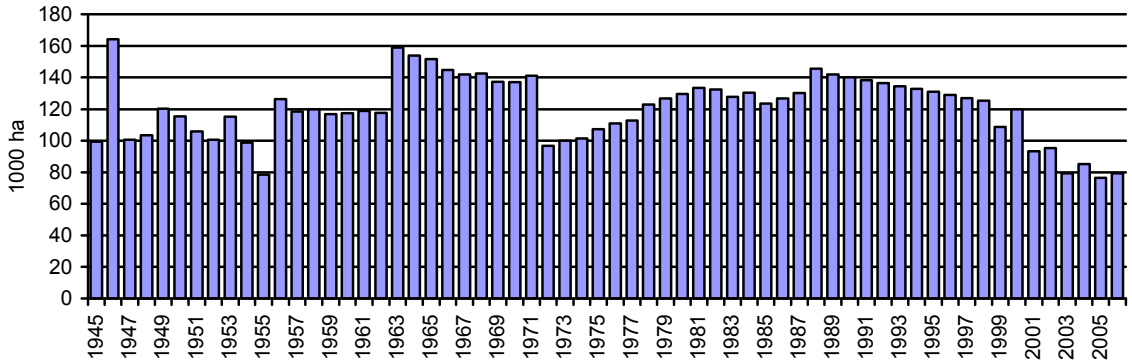


Figure 5.54 Area of other lands in Estonia in 1945–2006, 1000 ha[113]

[112] The data of 1990–1998 were interpolated basing on the trends of 1945–1989 and 1999–2006.
[113] The data of 1990–1998 were interpolated basing on the trends of 1945–1989 and 1999–2006.

5.7. Emissions of Greenhouse Gases from Biomass Burning

The section considers CO_2 and non-CO_2 greenhouse gases emissions from forest biomass burning.

5.7.1. Biomass burning (CRF 5 (V))

This source category includes non-CO_2 greenhouse gas emissions (only CH_4 and N_2O) from biomass burning on forested land due to wildfires. CO_2 emission from biomass burning was reported also in the chapter.

5.7.1.1. Activity data

The data on the area of forest fires were taken from the ESO. The office reports the data on forest biomass destroyed and damaged by fires (Figure 5.55).

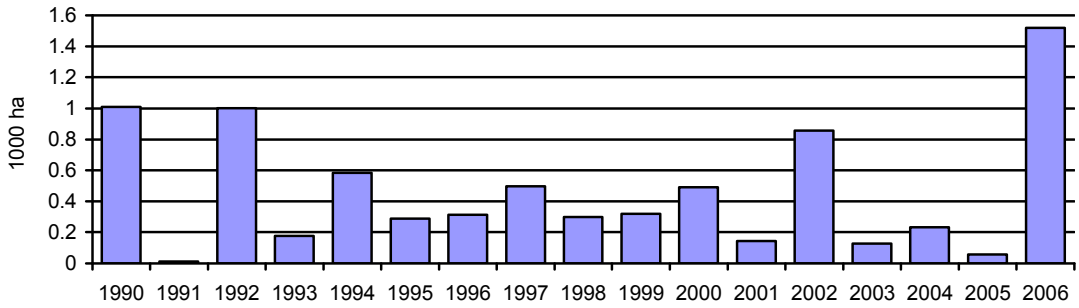


Figure 5.55. Area of Estonian forest affected by fires in 1990–2006, 1000 ha

5.7.1.2. Methodology, data availability and sources, emission factors

Equation (5.6) was used to estimate the emissions of non-CO_2 greenhouse gases. The combustion factor (0.34) was taken from Table 3A.1.12[114] (LULUCF, 2003), and the Nitrogen-Carbon ratio (0.01)[115] of burned biomass was taken from (IPCC, 1997).

[114] Combustion factor values (proportion of pre-fire biomass consumed) for fires in a range of vegetation types, pp 3.179
[115] IPCC, 1997, Workbook, Chapter 5. pp. 5.18

$$L_{fire} = A \bullet B \bullet C \bullet D \bullet 10^{-6}$$

(5.8)[116]

L_{fire} – quantity of GHG released due to fire, tonnes of GHG

A – area burnt, ha

B – mass of 'available' fuel, kg d.m. ha^{-1}

C – combustion efficiency (or fraction of the biomass combusted), dimensionless

D – emission factor, g (kg d.m.)$^{-1}$. (Table 5.77)

Table 5.77. Factors used to estimate emission of non-CO_2 greenhouse gases emitted due to forest fires[117]

	Emission ratios
CH_4	0.012
CO	0.06
N_2O	0.007
NO_x	0.121

5.7.1.3. Quantitative overview – GHG emissions from wildfires in 2006

The total area of forest land disturbed by fire in 2006 was 1,520 ha. The emission of CO_2 from these fires was 109.2 Gg, CH_4 – 0.48 Gg, and N_2O – 0.003 Gg (Figure 5.56).

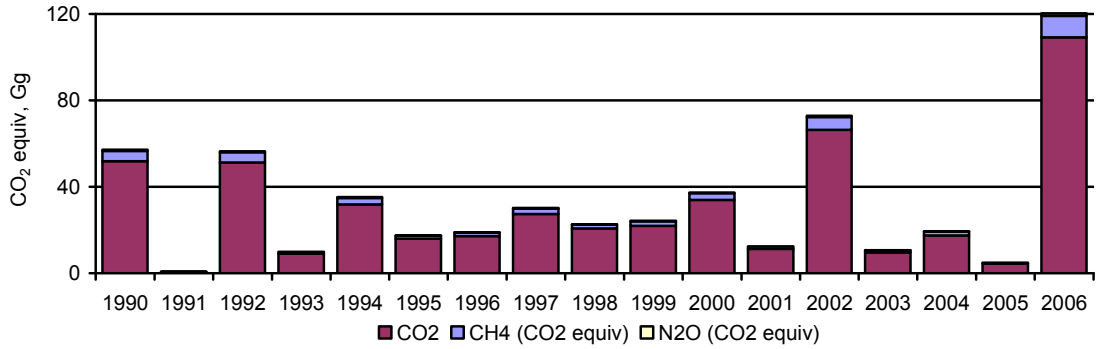


Figure 5.56 CO_2 equiv emissions from forest biomass wildfires in Estonia in 1990–2006, Gg

[116] Equation 3.2.20 from (LULUCF, 2003), Chapter 3, pp. 3.49

[117] LULUCF, 2003, Table 3A.1.15 – Emissions ratios for open burning of cleared prests

5.7.1.4. Source-specific recalculations

There is one recalculation carried out in this sub-section. Updated BEFs were implied in the estimates.

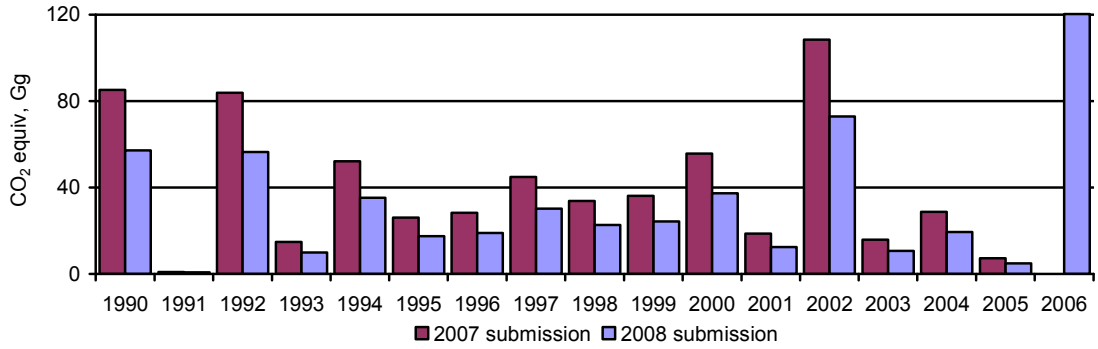


Figure 5.57 CO_2 equiv recalculations from forest wildfires in Estonia in 1990–2006, Gg

Table 5.78. Carbon emissions from wildfires in Estonian in 1990–2006, Gg

Year	Reported emissions of carbon in 1990–2005 (the 2007 submission)	Recalculated emissions of carbon (the 2008 submission)
1990	85.11	57.24
1991	1.01	0.68
1992	83.90	56.44
1993	14.86	10.00
1994	52.30	35.18
1995	26.05	17.52
1996	28.30	19.03
1997	44.90	30.20
1998	33.83	22.75
1999	36.12	24.29
2000	55.64	37.42
2001	18.70	12.58
2002	108.50	72.98
2003	15.77	10.61
2004	28.82	19.38
2005	7.32	4.92
2006		120.22

5.7.1.5. 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.

Uncertainties in forest area burned are not investigated very well for all years considered (from 1991 to 2004). However, based on the data presented for the years 2003–2006, uncertainties are as follows: 2003– ± 87.6%; 2004– ± 113.1% and 2005– ± 114.7%. Thus, due to a lack of data, averaged uncertainties have been used in the estimates – ± 100%. This value has been used in the estimates. A value of average biomass stock per hectare was used from (Eesti Metsad 2003).

Uncertainties in the value of combustion factors and emission ratios for open burning are presented in (IPCC, 1997 and LULUCF, 2003).

CHAPTER 6. WASTE (CRF 6)

6.1. Overview of source category description and methodology

The Estonian inventory emissions include CH_4 emissions from solid waste disposal sites including solid municipal and industrial wastes, domestic and industrial sludge. Also the Waste Sector covers GHG emissions from waste incineration and composting. N_2O emissions from sludge application in agriculture are reported in the Agriculture Sector. However, the estimates are provided in the waste chapter. Emissions from wastewater handling do not occur in Estonia, as all wastewater is treated using aerobic processes.

Table 6.1 summarizes the data on approaches and emissions employed for estimation of GHG emissions from each sub-sector of the waste sector.

Table 6.79. 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			The FOD	IPCC		
B. Wastewater handing (anaerobic)			NO	NA	NO	NA
C. Waste Incineration	T1	IPCC			T1	IPCC
D. Biological treatment			T1	IPCC	T1	IPCC
E. Sludge application in agriculture					T1	IPCC

NO – Not Occurring; NA – Not Applicable; T1 – *Tier 1* method; the FOD – the First Order Decay method; CS – country specific.

6.1.1. References – sources of information

The inventory is carried out by researchers at Tallinn University of Technology. The main providers of activity data used in the estimates are the Statistical Office of Estonia (ESO) and Estonian Environment Information Centre (EEIC) (Table 6.80).

Table 6.80. List of institutions (datasets) involved in the inventory for the waste sector

Reference	Link	Abbreviation	Activity/Data
Tallinn University of Technology	www.ttu.ee	TUT	- activity data gathering; - estimation of emissions; - reporting;
Statistics of Estonia	www.stat.ee	ESO	- collection and reporting of data on product production in Estonia - data collection on quantities of biogas produced
Estonian Environment Information Centre - Waste Data Bureau	www.keskkonnainfo.ee	EEIC	- collection of data on solid waste generation and disposal, waste incineration and biological treatment;
- Water Bureau			- collection of data on amount of wastewater treated, methods of wastewater treatment;

6.1.2. Quantitative overview of the waste sector

Emission from the waste sector was 707 Gg of CO_2 equiv in 2006. It was 3.4% of the total GHG emission in Estonia in 2006. CH_4 emissions from landfills are the most significant GHG emissions from the waste sector in Estonia (Figure 6.58).

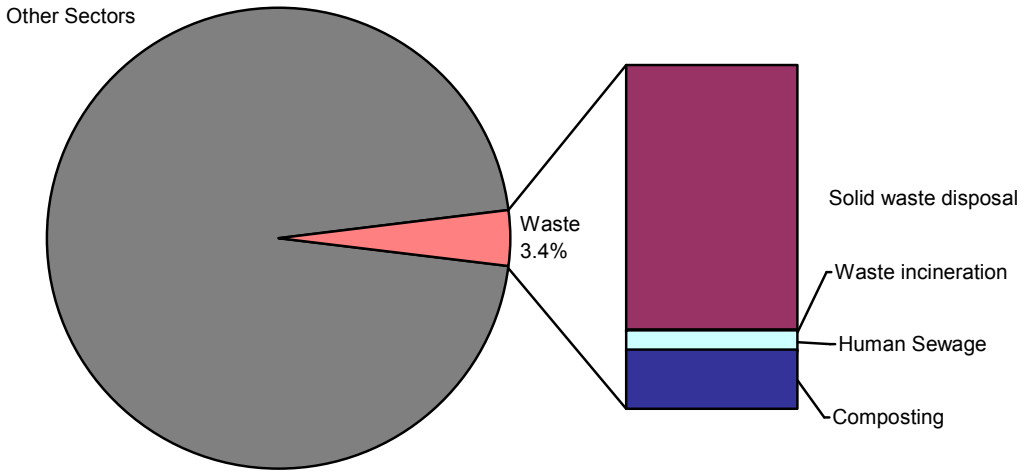


Figure 6.58. CO_2 equiv emissions from the waste sector compared with the total GHG emissions in Estonia in 2006, Gg

The total CO_2 equiv emission from the waste sector increased negligibly in 2006 – by 4% from the base year (Figure 6.59, Table 6.81) mostly due to GHG emitted from waste composting.

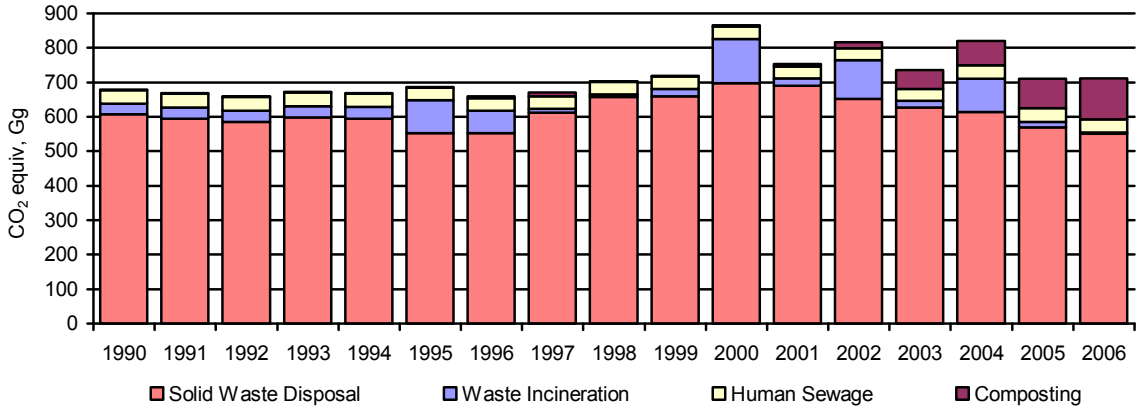


Figure 6.59. Trends of GHG emissions in the waste sector by source categories in 1990–2006, Gg

Table 6.81. Waste sector's greenhouse gases emissions in Estonia in 1990–2006, Gg

Year	Solid waste disposal	Waste incineration		Biological treatment		Human Sewage	Total CO_2 emissions	Total CH_4 emissions	Total N_2O emissions	**Total CO_2 equiv emissions**
	CH_4	CO_2	N_2O	CH_4	N_2O	N_2O	CO_2	CH_4	N_2O	**CO_2 equiv**
1990	28.93	0.051	0.10	0.03	0.002	0.1297	0.05	28.96	0.230	679.5
1991	28.35	0.051	0.10	0.03	0.002	0.1295	0.05	28.38	0.233	668.2
1992	27.89	0.051	0.10	0.03	0.002	0.1284	0.05	27.92	0.235	659.4
1993	28.47	0.051	0.11	0.03	0.002	0.1248	0.05	28.5	0.235	671.6
1994	28.30	0.051	0.11	0.03	0.003	0.1220	0.05	28.33	0.236	668.2
1995	26.31	0.088	0.31	0.04	0.003	0.1196	0.09	26.35	0.432	687.3
1996	26.32	0.035	0.21	0.13	0.009	0.1177	0.04	26.45	0.337	659.6
1997	29.19	0.046	0.03	0.26	0.020	0.1161	0.05	29.45	0.168	670.6
1998	31.31	0.063	0.03	0.03	0.002	0.1151	0.06	31.34	0.143	702.2
1999	31.43	0.068	0.07	0.04	0.003	0.1139	0.07	31.47	0.188	719.1
2000	33.21	0.154	0.42	0.11	0.008	0.1133	0.15	33.32	0.537	866.1
2001	32.87	0.109	0.07	0.14	0.011	0.1129	0.11	33.01	0.192	752.7
2002	31.03	0.113	0.36	0.40	0.030	0.1124	0.11	31.43	0.506	816.8
2003	29.84	0.167	0.07	1.19	0.089	0.1120	0.17	31.03	0.267	734.6
2004	29.23	0.370	0.31	1.61	0.121	0.1116	0.37	30.84	0.544	816.4
2005	27.11	0.125	0.05	1.92	0.144	0.1113	0.13	29.03	0.309	705.3
2006	26.26	0.071	0.01	2.68	0.201	0.1111	0.07	28.94	0.323	707.9

6.1.3. Key categories

Waste key categories in 2006 calculated with the *Tier 1* method[118] were:

6.A	Solid Waste Disposal on Land/Managed Waste Disposal on Land (CH_4)	L, T[119]
6.D	Biological treatment (N_2O)	T
6.D	Biological treatment (CH_4)	T

6.1.4. Uncertainty assessment

The most uncertain emission source in waste sector is CH_4 emission from 'solid waste disposal on land' and N_2O emission from 'human sewage'. The highest uncertainty rates are associated with estimates of GHG emissions from waste incineration and human sewage.

The combined uncertainties related to waste sector as percent from the total national emission in 2006 are follows:

6.A	Solid Waste Disposal on Land (CH_4)	0.9368%
6.B.2.2	Human Sewage (N_2O)	0.2059%
6.C.	Waste Incineration (CO_2)	0.0003%
6.C.	Waste Incineration (N_2O)	0.0156%
6.D.	Biological Treatment (CH_4)	0.0263%
6.D.	Biological Treatment (N_2O)	0.0291%
CRF 6	Waste sector total	1.2140%

6.2. Solid waste disposal on landfills (CRF 6.A)

6.2.1. Activity data

In 2006, 20 million tonnes of waste were generated in Estonia. Most of this waste was produced by the oil shale industry – about 80%, less than 34% from the total of waste generated were hazardous waste (Figure 6.61).

593,268 tonnes of municipal waste were generated in 2006. Municipal waste includes waste from households (mixed municipal waste, 64% of the total amount of municipal waste), and

[118] GHG emissions/removals of LULUCF sector are not included
[119] L – Level Assessment method; T – Trend Assessment method.

institutional and commercial wastes (waste from markets and street-cleaning residues-1.1%) as well as separately collected fractions (7%). About 70% of the population of Estonia was covered by waste collection.

Tartu County generated the most mixed municipal waste per capita in Estonia in the year 2006 (Table 6.4).

In 2006, about 55% of the total amount of waste generated was disposed in landfills (Table 7_I.1 and Table 7_I.2 of Annex 7_I). There were 351 landfills in Estonia, 36 of which were in operation in 2006 (domestic solid waste and industrial waste) (Figure 6.60).

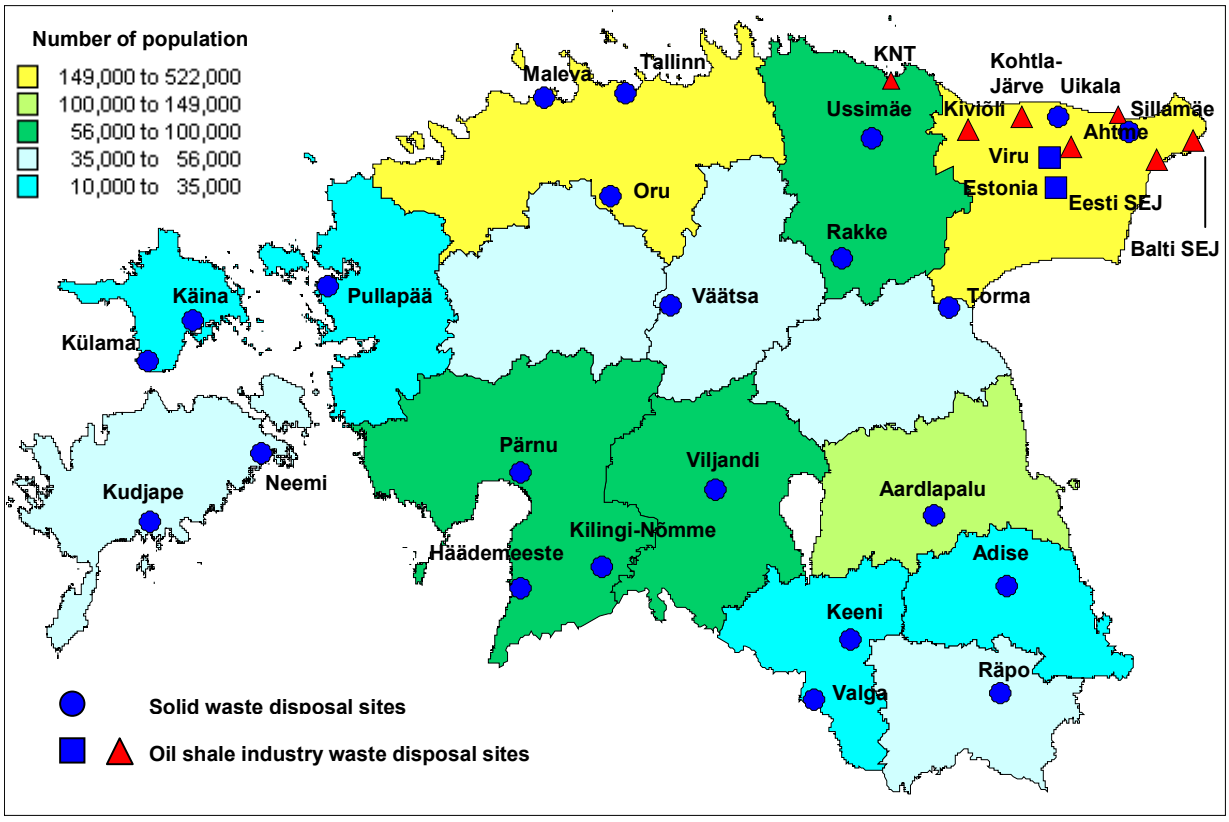


Figure 6.60. The map of operating landfills in Estonia in 2006 (see also Figure 4.10)

Table 6.82. Population number and amounts of municipal waste generated in 2006 by counties of Estonia

	Population	% of urban population	Amounts of municipal waste generated, tonnes[120]	Waste generation per capita of urban population, kg/capita
Harju County	521,313	83.4	313,012	720
Hiiu County	10,222	36.4	1,973	530
Ida-Viru County	172,775	81.5	46,442	330
Jõgeva County	37,305	34.1	8,177	643
Järva County	36,457	26.7	8,828	905
Lääne County	27,853	42.3	8,588	729
Lääne-Viru County	67,770	30.2	19,984	977
Põlva County	31,547	20.6	5,114	786
Pärnu County	89,017	54.2	28,201	585
Rapla County	36,869	no data	8,791	*238*
Saare County	35,076	42.5	12,906	865
Tartu County	148,969	73.0	111,268	1,023
Valga County	34,661	49.2	6,530	383
Viljandi County	56,370	40.6	15,541	679
Võru County	38,480	37.8	8,520	585
Whole Country	1,344,684	64.5	866,907	697

The yearly trend in amounts of waste generated by each waste group is illustrated in Figure 6.61 (see Annex 7_I). Data from 1990–1991 was interpolated based on the data of 1992–1998 taking into account the Estonian GDP and population. The total amount of sludge generated and disposed in 1990–1991 was interpolated using the total number of each wastewater treatment facility and their overall capacity.

Since 1992 the EEIC has started to collect waste data in accordance with Estonian waste classification (Annex 7_II); however in 1999 a waste classification system adopted from the European Waste Catalogue was applied by the EEIC.

[120] Code 20 of the European Waste catalogue (2002)

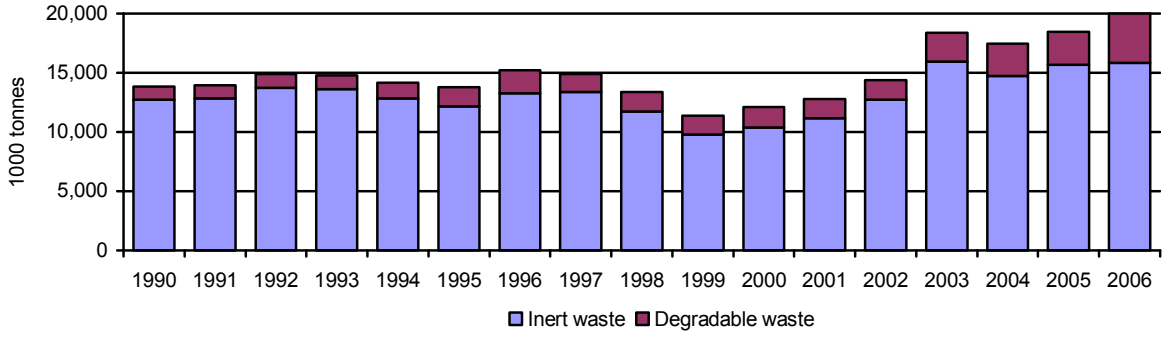


Figure 6.61. Amounts of waste generated in Estonia in 1990–2006, 1000 tonnes

As seen from Figure 6.62, the quantity of DOC generated increased 3.6 fold by 2006, however recycling of biodegradable waste increased from 60% in 1990 to 90% in 2006.

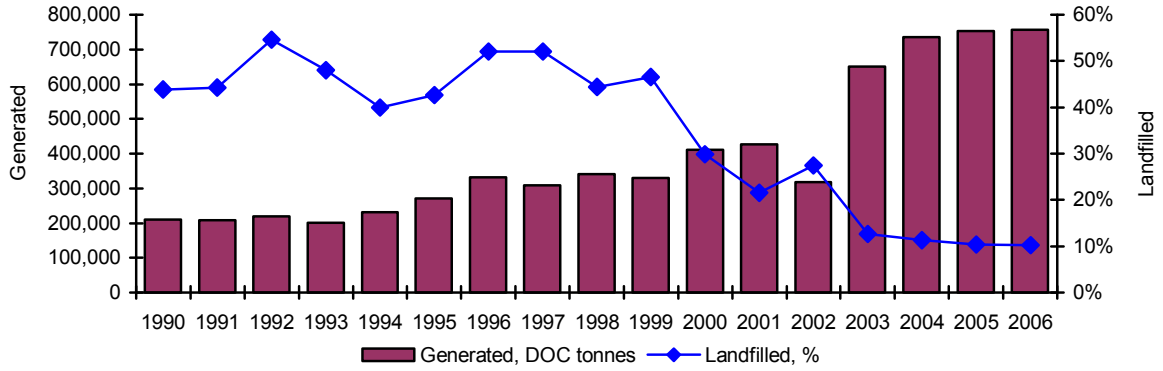


Figure 6.62. Quantity of DOC generated [tonnes] and ratio of DOC landfilled to DOC generated [%] in 1990–2006

The data presented in Figure 6.63–Figure 6.9 illustrate flows of the most important flows of biodegradable waste in Estonia in 2006.

Table 6.83. Breakdown of DOC generated by waste category and the ratio of DOC landfilled in each waste category in Estonia in 1990–2006, %

	Mixed municipal waste		Paper		Textiles		Wood		Organic waste		Sludge	
	%, G[121]	%, D[122]	%, G	%, D	%, G	%, D	%, G	%, D	%, G	%, D	%, G	%, D
1990	40.7	92	0.7	77	0.2	37	15.5	15	41.0	6	2.1	53
1991	40.9	92	0.6	75	0.2	37	15.4	15	41.0	6	1.7	68
1992	44.2	100	0.8	36	0.3	72	17.8	20	33.6	9	2.7	106
1993	41.2	100	0.3	72	0.1	84	12.8	18	42.2	7	3.1	39
1994	45.7	75	0.3	36	0.1	0	13.5	14	35.9	2	4.3	66
1995	43.0	88	0.5	37	0.2	5	19.5	7	30.5	9	6.1	10
1996	38.0	100	0.2	94	0.1	50	23.4	13	31.9	18	6.3	76
1997	42.8	100	0.5	100	0.2	35	26.5	10	27.0	13	2.9	79
1998	36.4	100	0.6	100	0.1	29	35.3	10	24.8	11	2.6	38
1999	38.0	101	0.5	17	0.2	13	40.5	8	16.3	25	4.3	14
2000	28.1	96	0.4	20	0.2	32	56.5	1	11.1	16	3.7	10
2001	18.9	100	1.8	3	0.1	0	66.0	2	10.1	9	2.6	3
2002	27.5	97	2.5	1	0.2	15	49.9	1	14.2	1	5.3	1
2003	14.0	82	1.9	3	0.2	26	71.2	1	10.3	1	2.2	1
2004	12.9	79	2.5	2	0.2	38	71.3	1	10.8	1	2.2	1
2005	12.5	78	3.3	1	0.1	56	69.9	0	11.6	1	2.4	0.5
2006	12.5	78	3.9	0	0.1	47	63.7	0	7.2	1	12.3	0.2

The data on methane recovery from landfill is reported annually in the Estonian Energy Balance, with the quantity of CH_4 captured in 2006 reported as 5,000 tce (Energy Balance 2006) or 2.93 Gg. There is currently only one Estonian gas collection plant in operation, located at the Tallinn Landfill.

[121] % from the total quantity of DOC generated.
[122] % of DOC disposed on landfills.

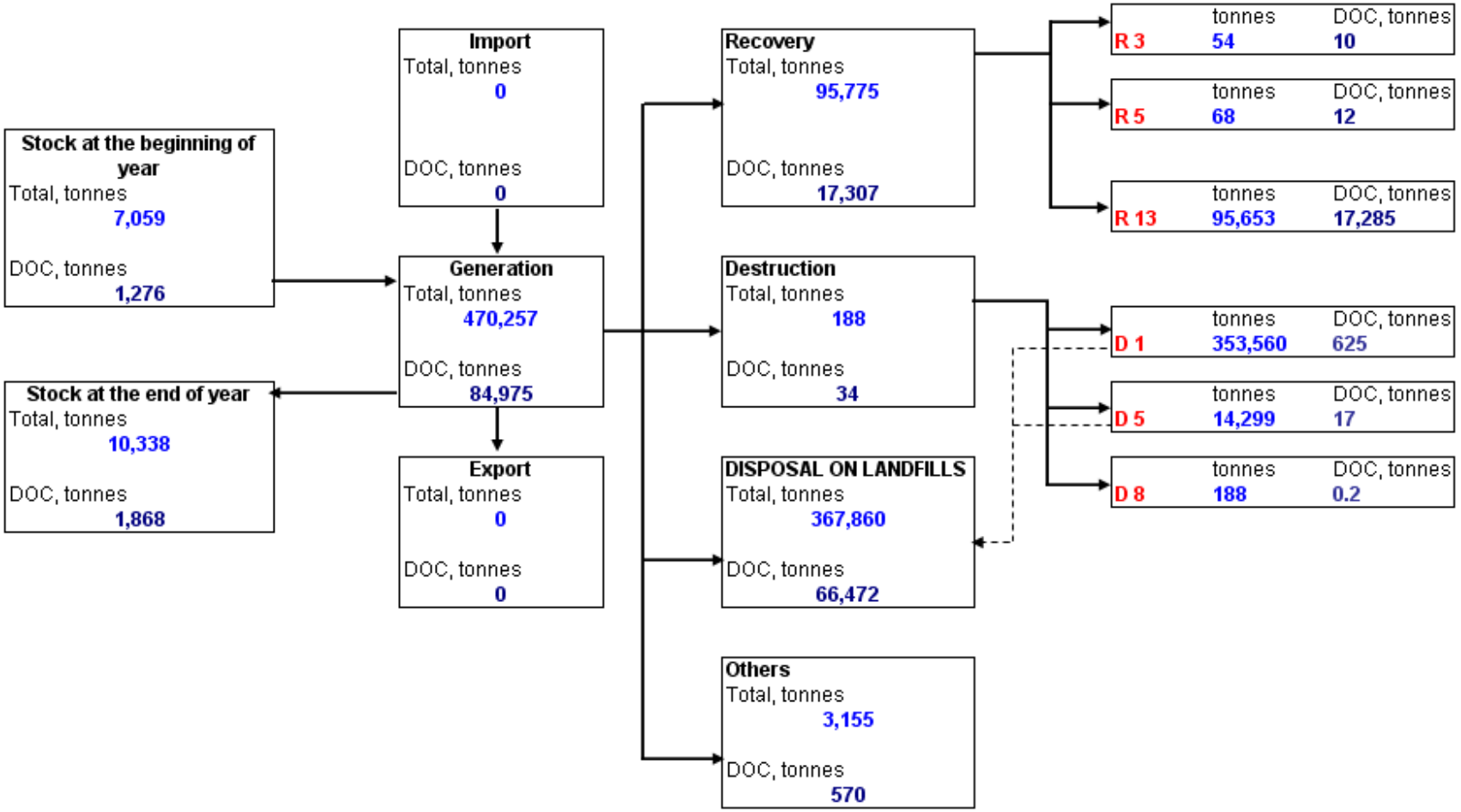


Figure 6.63. Flows of mixed municipal waste in Estonia in 2006, tonnes[123]

Input[124]	Output[125]
477,316	477,316

[123] See also Annex W_III (Waste recovery and destruction in Estonia in 1995-2006)
[124] Input flows: Stock at the beginning of year, Generation, Import
[125] Out flows: Stock at the end of year, Export, Recovery, Destruction, Disposal on Landfills, Other activities

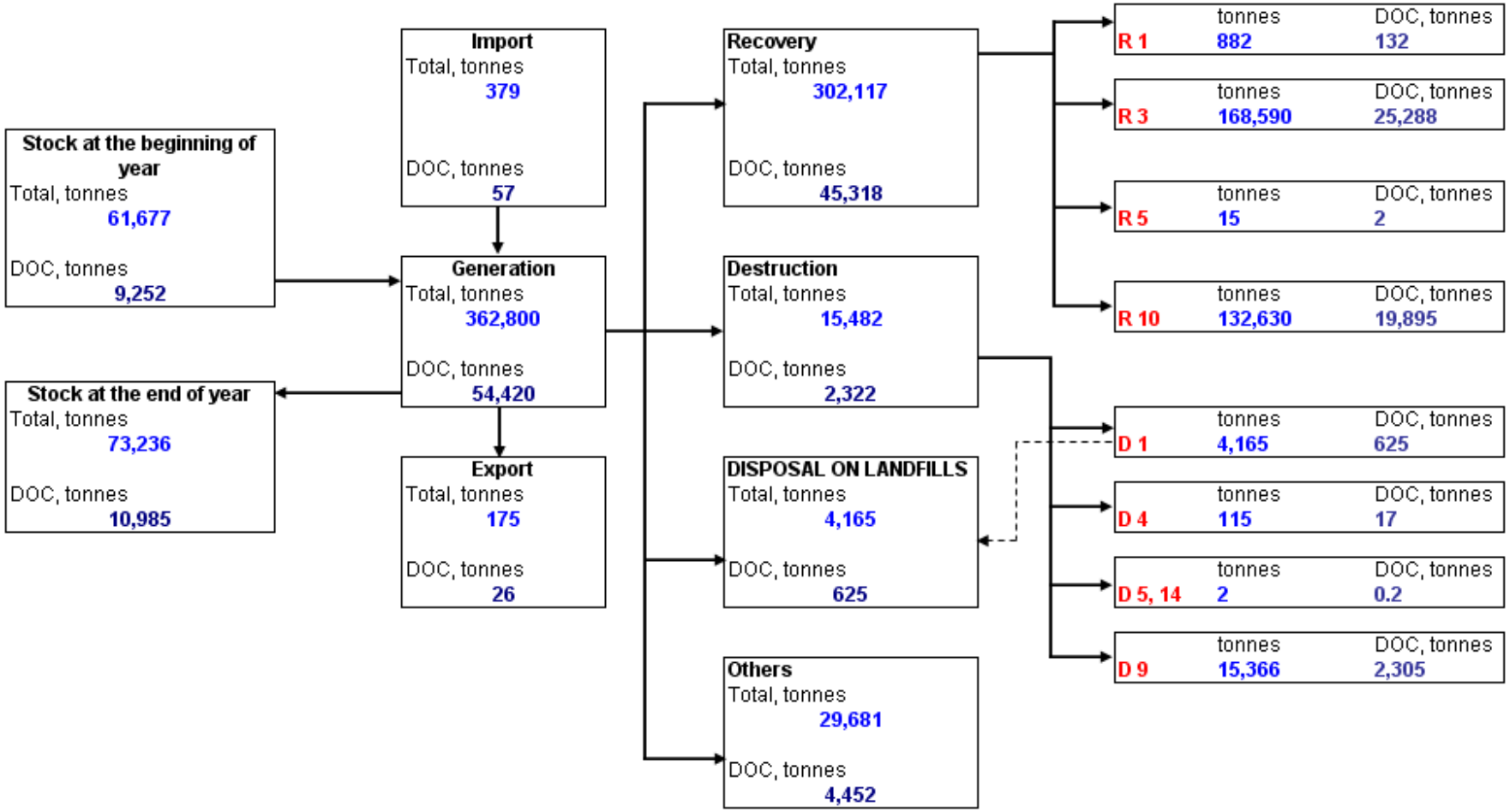


Figure 6.64. Flows of organic waste in Estonia in 2006, tonnes

Input	Output
424,856	424,856

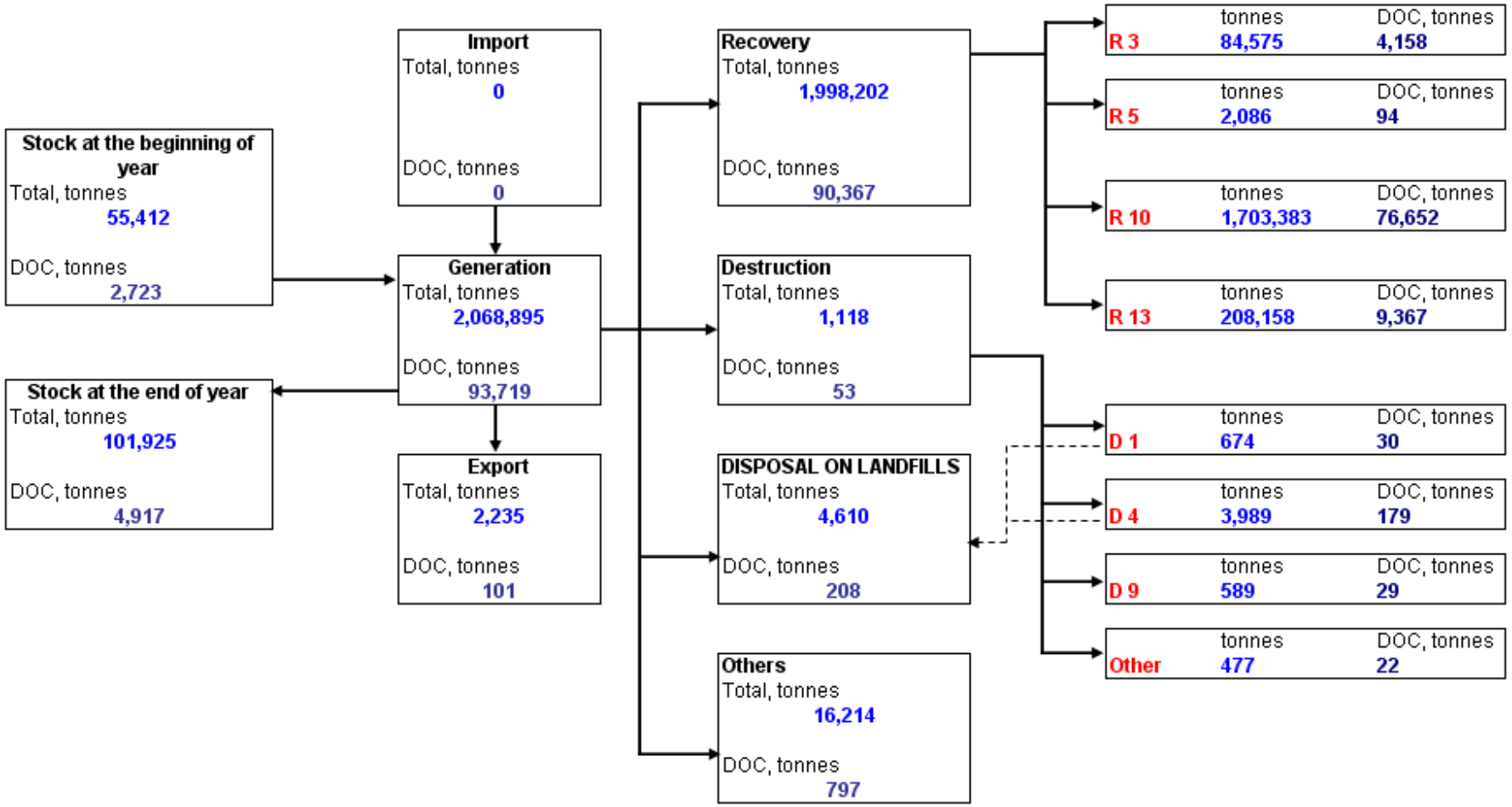


Figure 6.65. Flows of sludge (domestic and industrial) waste in Estonia in 2006, tonnes[126]

Input	Output
2,124,306	2,124,306

[126] About 1,683,690 tonnes of sludge generated are with dry matter at 0.06%.

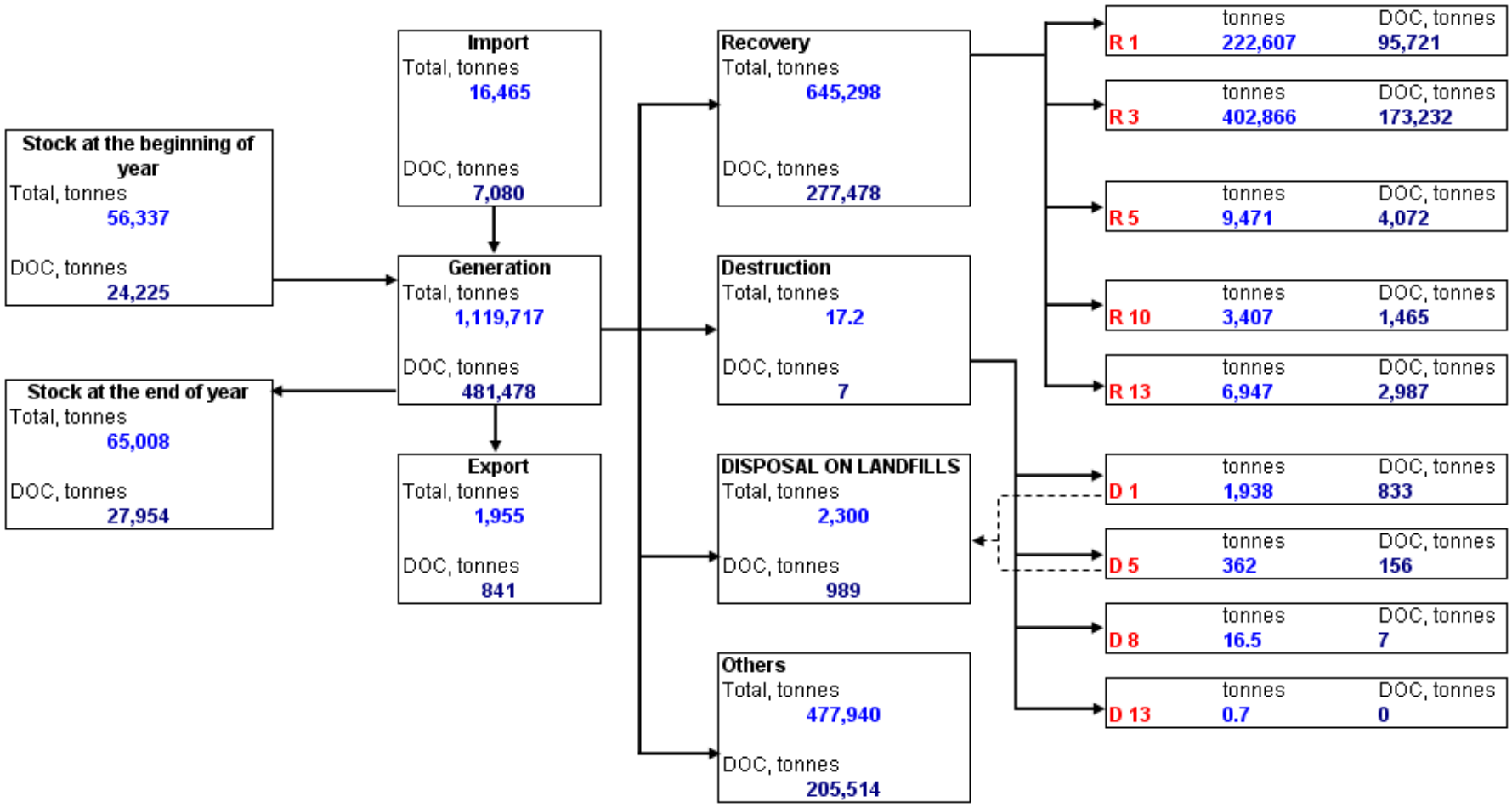


Figure 6.66. Flows of wood waste in Estonia in 2006, tonnes

Input	Output
1,192,518	1,192,518

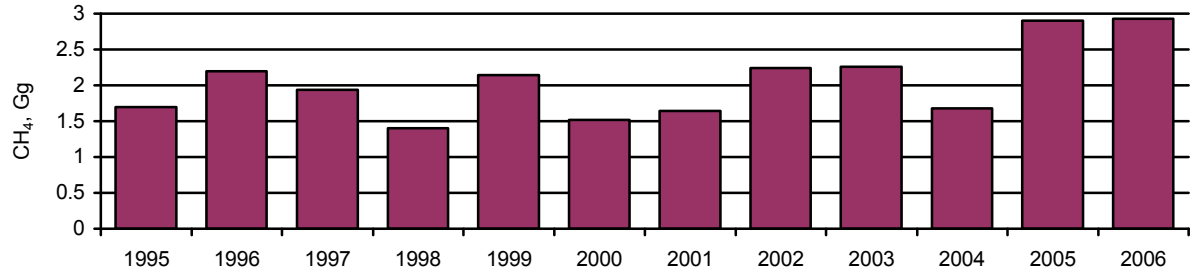


Figure 6.67. CH_4 recovered from landfills in the years 1995–2006, Gg

6.2.2. Methodology, data availability and sources, emission factors

In order to estimate CH_4 emission from solid waste disposed on landfills the First Order Decay (the FOD) approach was employed (IPCC, 2000).

$$CH_4, Gg/year = \sum_X [(A \bullet k \bullet SW_{T(X)} \bullet SW_{F(X)} \bullet L_0(x) \bullet e^{-k(t-x)}$$

(6.1)[127]

for x = initial year to t

t – year of inventory;

x – years for which input data should be added;

$A – (1 – e^{-k}) / k$; normalization factor which corrects the summation;

k – Methane generation rate constant, 1/yr;

$SW_{T(x)}$ – Total solid waste (SW) generated in year x, Gg/yr;

$SW_{F(x)}$ – Fraction of SW disposed at SWDS in year x.

$L_0(x)$ – Methane generation potential:

$$L_o(x) = MCF_{(x)} \bullet DOC_{(X)} \bullet DOC_F \bullet F \bullet 16/12, GgCH_4/Gg\_waste$$

(6.2)

$MC_{F(x)}$ – 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;

[127] IPCC, 2000. Waste. pp 5.6

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).

$$CH_4, Gg/year = [CH_4\_generated\_in\_year\_t - R(t)] - (1 - OX)$$

(6.3)[128]

R(t) – Recovered CH_4 in inventory year t, Gg/yr;

OX – Oxidation factor (fraction).

The data used in the estimates are reported in Table 6.84-Table 6.87.

Table 6.84. Emission factors and parameters used in the 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	1996 IPCC, 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

Table 6.85.Default DOC content of different waste types (wet basis)[129]

Waste group	DOC content
Solid municipal waste	
Food, Grease	0.15
Municipal	(Table 6.9)
Garden	0.20
Glass	-
Inert	-
Paper	0.40
Plastic	-
Textile	0.24
Wood	0.43
Other	-
Municipal Sludge	

[128] Equation 5.2 of the IPCC 2000, pp 5.7

[129] Table 2.4 and Table 2.5 of the 2006 IPCC Guidelines, pp 2.14 -2.16

Waste group	DOC content
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

The earlier data on waste composition is not available, so 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.

Table 6.86.The waste composition of solid municipal waste, %[130]

	1940	1958	1971	1980	1990	2000-onward
Organic household waste, bread, animal waste and non-defined non-separated waste	64	56	52	53	52	42.1
Paper and cardboard	22	20	26	21	25	25.3
Wood			3.3[131]	3.3	3.3	3.3
Textiles	2	1	2	2	2	0.9

Table 6.87. DOC content of mixed municipal waste in Estonia in 1940–2006

	1940	1958	1971	1980	1990	2000-onward
DOC content	0.2208	0.1944	0.2270	0.2090	0.2230	0.2018

[130] The data on 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)

[131] (Olmejäätmete koostise… 2000)

6.2.3. Quantitative overview – CH_4 emission from solid waste disposal

The total CH_4 emission from solid waste disposed on landfills was 26.3 Gg in Estonia in 2006. CH_4 emission changed negligibly by 2006 in comparison with the base year (Figure 6.68).

Table 6.88. Quantities of CH_4 emission and recovery from biodegradable solid waste disposed in Estonian landfills in 1990–2006, Gg

Year	Organic/Food	Garden	Paper	Wood	Textiles	Sludge	Leather/Rubber	Recovery
1990	14.43	0.000	11.60	1.54	0.61	0.64	0.116	
1991	13.78	0.000	11.60	1.59	0.61	0.66	0.116	
1992	13.25	0.000	11.60	1.64	0.61	0.69	0.116	
1993	13.33	0.000	11.79	1.73	0.62	0.88	0.123	
1994	13.07	0.000	11.85	1.77	0.62	0.86	0.123	
1995	12.54	0.000	11.87	1.81	0.62	1.04	0.123	-1.70
1996	12.87	0.000	12.08	1.86	0.63	0.95	0.122	-2.20
1997	14.29	0.000	12.51	1.98	0.65	1.58	0.123	-1.94
1998	15.14	0.000	12.98	2.09	0.67	1.71	0.125	-1.40
1999	15.57	0.000	13.35	2.22	0.69	1.61	0.127	-2.14
2000	16.35	0.020	13.75	2.34	0.70	1.45	0.124	-1.52
2001	15.94	0.059	14.03	2.37	0.69	1.29	0.121	-1.64
2002	14.88	0.080	14.01	2.42	0.67	1.09	0.118	-2.24
2003	13.88	0.099	14.02	2.43	0.65	0.92	0.115	-2.26
2004	12.87	0.118	13.93	2.48	0.63	0.77	0.112	-1.68
2005	12.11	0.151	13.89	2.51	0.62	0.65	0.108	-2.93
2006	11.43	0.166	13.83	2.52	0.61	0.54	0.105	-2.93

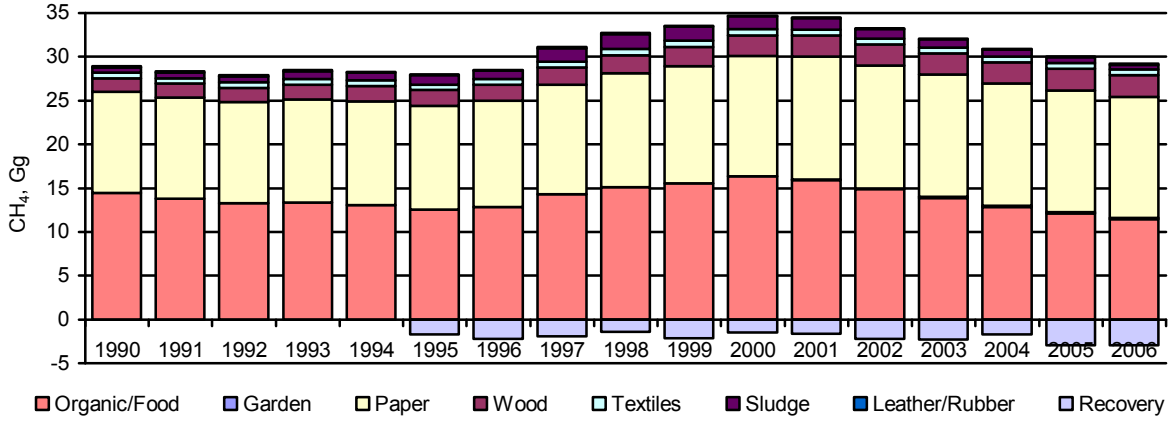


Figure 6.68. CH_4 emissions and recoveries from solid waste disposed in Estonia in 1990–2006, Gg

6.2.4. Source-specific recalculations

There is one recalculation carried out in the 2008 submission. The FOD approach was employed in order to estimate CH_4 emissions from solid waste disposed on landfills.

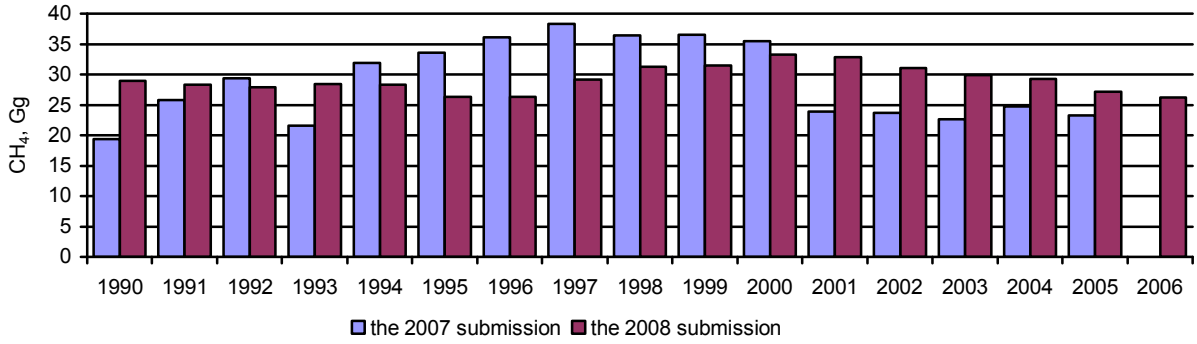


Figure 6.69. CH_4 emissions from solid waste disposed in Estonia in 1990–2006, Gg

Table 6.89. CH_4 emissions from solid waste disposed in Estonia in 1990–2006, Gg

Year	Reported emissions of CH_4 in 1990–2005 (the 2007 submission)	Recalculated emissions of CH_4 (the 2008 submission)
1990	19.37	28.93
1991	25.75	28.35
1992	29.42	27.89
1993	21.56	28.47
1994	31.88	28.30
1995	33.56	26.31
1996	36.13	26.32
1997	38.32	29.19
1998	36.41	31.31
1999	36.53	31.43
2000	35.46	33.21
2001	23.91	32.87
2002	23.71	31.03
2003	22.66	29.84
2004	24.76	29.23
2005	23.31	27.11
2006		26.26

6.2.5. Uncertainties and time-series consistency

The estimation of CH_4 emission from municipal waste disposal is carried out based on activity data and emission factors (methane correction factor (MCF), degradable organic carbon (DOC), fraction of DOC, fraction of CH_4 in landfill gas (F)).

Uncertainties of default emission factors used in the estimations are represented in (IPCC, 2000). Values are presented in Table 6.90.

The combined uncertainty rates related to 'solid waste disposal waste' sub-category are reported in Chapter 6.1.4.

Table 6.90. 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 CH_4 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 park 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

6.2.6. Planned improvements

The FOD approach was first applied in the 2008 Estonian submission. Further improvements in the waste classification in accordance with waste groups accepted in the IPCC Guidelines will be provided.

6.3. Waste incineration (CRF 6.C)

Waste incineration is defined as the combustion of solid and liquid waste in controlled incineration facilities (IPCC, 2006).

6.3.1. Activity data

The data on amounts of waste burned is collected and reported annually by the EEIC. The data are reported in accordance with operations specified in the Council Directive (75/442/EEC) (Annex 7_III).

The data on amounts of waste combusted are presented by two types of operation: 1) waste incinerated to generate energy (Table 6.91) and 2) open-land waste burning (Table 6.14).

The data from Table 6.91 is partly reported/taken into account in the Energy Sector for estimating of GHG emissions from combustion activities. Thus, in order to avoid double accounting GHG emissions from incineration of inert waste (mostly semi-coke and fusses), from petroleum products waste and wood waste were not considered.

Table 6.91. Amounts of waste used to generate energy in Estonia in 1990–2006, tonnes[132]

	Inert waste	Leather and Rubber	Municipal waste	Petroleum-products and Oils	Organic waste	Paper	Plastic	Sludge	Textile	Wood	Total
1990[133]	*4,166*	*5*	*35*	*1,020*	*29*	*31*		*70*	*18*	*23,623*	***29,002***
1991	*3,472*	*5*	*35*	*935*	*29*	*31*		*70*	*18*	*26,247*	***30,847***
1992	*2,893*	*5*	*35*	*857*	*29*	*31*		*70*	*18*	*29,164*	***33,107***
1993	*2,411*	*5*	*35*	*787*	*29*	*31*		*70*	*18*	*32,404*	***35,795***
1994	*2,009*	*5*	*35*	*723*	*29*	*31*		*70*	*18*	*36,004*	***38,929***
1995	1,674	12	35	862	14,624[134]	31	1	70	18	40,005	**57,442**
1996	1,315	5	6	431	29	33	0	60	35	53,326	**55,245**
1997	723	1	14	980	45	77	0	60	28	107,311	**109,242**
1998	176	3	5	1,042	15	48		40	5	102,632	**103,975**
1999	13,618		0	707	149	51	9	41		102,333	**116,912**
2000	1,140		2	888	94	500	30	793		151,586	**155,034**
2001	12,549		2	1,304	94	474	21	20		168,640	**183,104**
2002	31,598			3,400	246	141	19	762	12	159,086	**195,265**
2003	48,469		6	4,961	4,277	597	38	30	9	239,421	**297,808**
2004	37,822	4		6,147	7,430	574	20	80	6	215,790	**267,874**
2005	26,373			5,212	1,989	463	19	53	6	263,892	**298,018**
2006	27,561			5,141	1,048	10			197	222,607	**256,567**

Table 6.92. Amounts of waste incinerated on land in Estonia in 1990–2006, tonnes[135]

	Inert waste	Leather and Rubber	Municipal waste	Petroleum-products and Oils	Organic waste	Paper	Plastic	Sludge	Textile	Wood	Total
1990	*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**

[132] R1 operation of the waste recovery activities (the Council Directive 75/442/EEC)
[133] The data of 1990-1994 was interpolated
[134] Pig manure was incinerated to generate energy in Estonia in 1995
[135] D10 - Incineration on land operation (the Council Directive 75/442/EEC)

	Inert waste	Leather and Rubber	Municipal waste	Petroleum-products and Oils	Organic waste	Paper	Plastic	Sludge	Textile	Wood	Total
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			52	1	2			321		**2,457**
2005	63			106	0	2			176	10	**366**
2006					0				40		**41**

Figure 6.70 summarizes the total amounts of waste combusted in Estonia in 1990–2006, the data of 1990–1994 were interpolated basing on rough assumptions. As seen, a sharp increase in waste burned was in 1995–1996 due to increases in organic waste (pig manure) and wood waste burned.

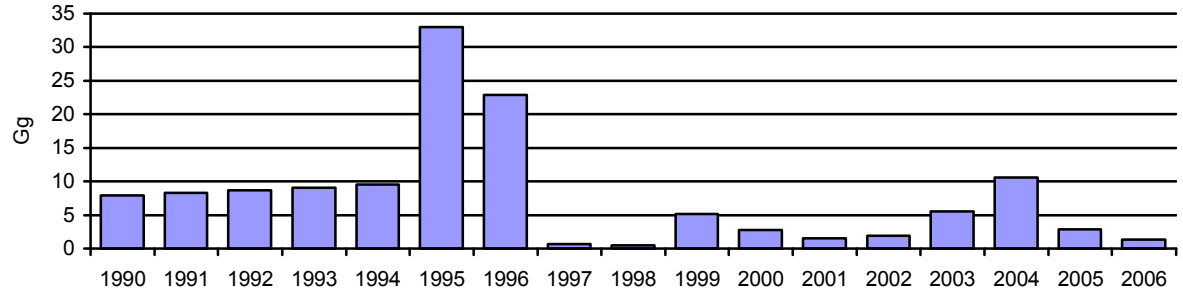


Figure 6.70. Amounts of waste burned in Estonia in 1990–2006, Gg

Figure 6.71 presents the trend of the quantities of fossil carbon contained in waste incinerated in Estonia. More than 2 thousand tonnes of waste from construction activities (inert waste) were burned in 2004, this fact explains the sharp increase in the trend in 2004.

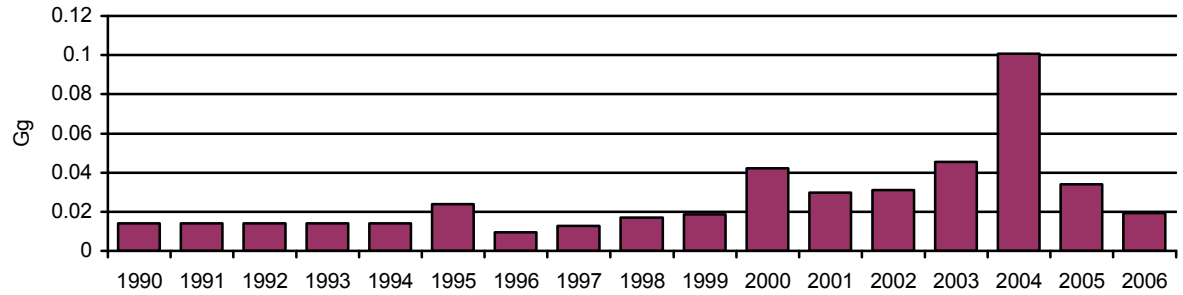


Figure 6.71. Quantity of fossil carbon fraction contained in waste burned in Estonia in 1990–2006, Gg

6.3.2. Methodology, data availability and sources, emission factors

Tier 1 approach was employed in order to estimate GHG emissions from solid waste burnt in controlled incineration facilities (IPCC, 2006).

CO_2 emission estimate based on the total amount of waste combusted

$$CO_2 \text{emissions, Gg/yr} = \sum_i (SW_i \bullet dm_i \bullet CF_i \bullet FCF_i \bullet OF_i) \bullet 44/12 \quad (6.4)^{136}$$

CO_2 Emissions – CO_2 emissions in inventory year, Gg/yr;

SWi – total amount of solid waste of type *i* (wet weight) incinerated or open-burned, Gg/yr;

dm_i – dry matter content in the waste (wet weight) incinerated or open-burned, (fraction);

CF*i* – fraction of carbon in the dry matter (total carbon content), (fraction);

FCFi – fraction of fossil carbon in the total carbon, (fraction);

OFi – oxidation factor, (fraction);

44/12 – conversion factor from C to CO_2;

i – type of waste incinerated/open-burned 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 6.93. Default dry matter content, total carbon content and fossil carbon content of different waste components[137,138,139]

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	-

[136] The 2006 IPCC Guidelines, Chapter 5: Incineration and Open Burning of Waste, pp 5.7, equation 5.1

[137] Table 2.4 of the 2006 IPCC Guidelines, pp 2.14

[138] Table 2.5 of the 2006 IPCC Guidelines, pp 2.16

[139] Table 2.6 of the 2006 IPCC Guidelines, pp 2.16

Waste component	Dry matter content in % of wet weight	Total carbon content in % of dry matter	Fossil carbon fraction in % of total carbon
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

N_2O emission estimate based on the waste input to the incinerators

$$N_2O\text{emissions, Gg/yr} = \sum_i (IW_i \bullet EF_i) \bullet 10^{-6}$$

(6.5)[140]

N_2O Emissions – N_2O emissions in inventory year, Gg/yr;

IW*i* – amount of incinerated waste of type *i*, Gg/yr;

EFi – N_2O emission factor for waste of type *i*, kg N_2O/Gg of waste;

10^{-6} – conversion to gigagram;

i – category or type of waste incinerated/open-burned, specified as follows:

MSW: municipal solid waste

ISW: industrial solid waste

HW: hazardous waste

CW: clinical waste

SS: sewage sludge, others (that must be specified).

[140] The 2006 IPCC Guidelines, Chapter 5: Incineration and Open Burning of Waste, pp 5.14, equation 5.5

Table 6.94. N_2O emission factors for incineration of waste[141]

Waste category	Emission factor, g N_2O/ t waste incinerated	Weight basis
MSW	8[142]	wet basis
Industrial waste	100	wet basis
Sludge (except sewage sludge)	450	wet basis
Sewage sludge	900	wet basis

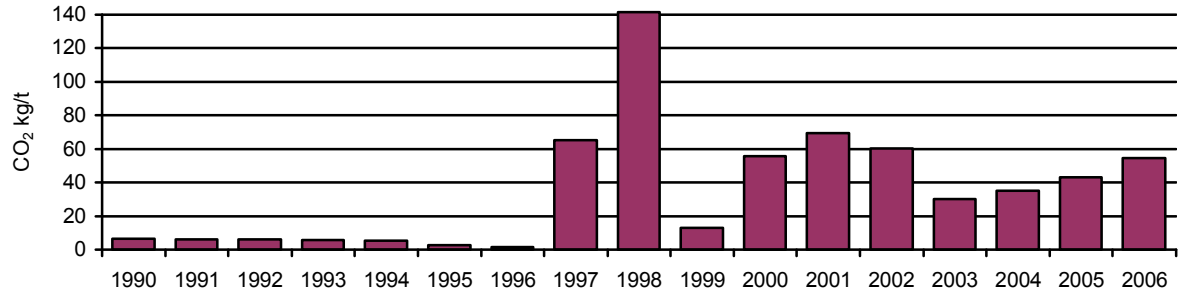


Figure 6.72. Averaged CO_2 emission factors implied in the estimates, CO_2 kg/t

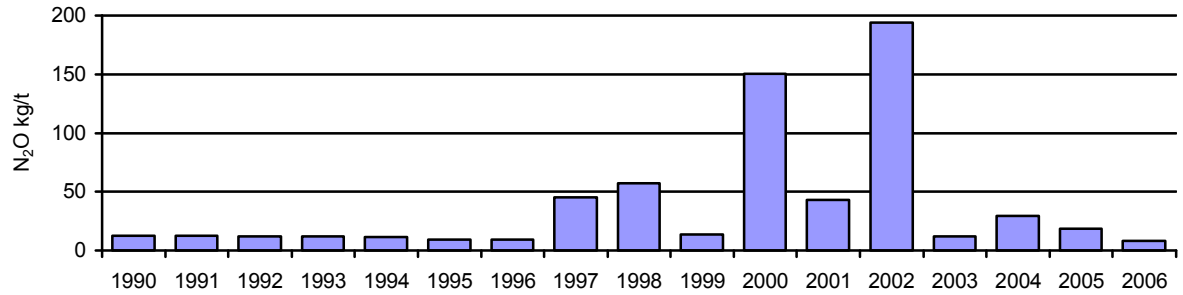


Figure 6.73. Averaged N_2O emission factors implied in the estimates, N_2O kg/t

The sharp increases in emission factors implied are explained by different composition of amounts of waste burned.

6.3.3. Quantitative overview – CO_2 and N_2O emissions from solid waste incineration

In 2006, Estonia emitted 0.07 Gg and 0.01 Gg of CO_2 and N_2O into the atmosphere respectively (Figure 6.74, Figure 6.75).

Due to the increase in the quantity of fossil carbon fraction burned in 2004 (Figure 6.71), a sharp increase in CO_2 emission took place in 2004.

[141] Table 5.5 of the 2006 IPCC Guidelines, Chapter 5, pp 5.21
[142] An experience of Germany

As seen from Figure 6.75 N_2O emissions in 1995–1996 and 2000, 2002 and 2004 are noticeably larger in comparison with other years due to large amounts of wood- and sludge waste burned.

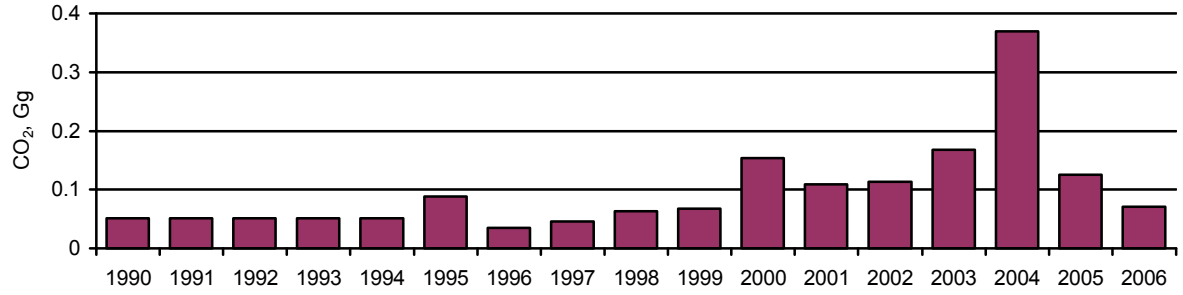


Figure 6.74. Emissions of CO_2 from waste incineration in 1990–2006, Gg

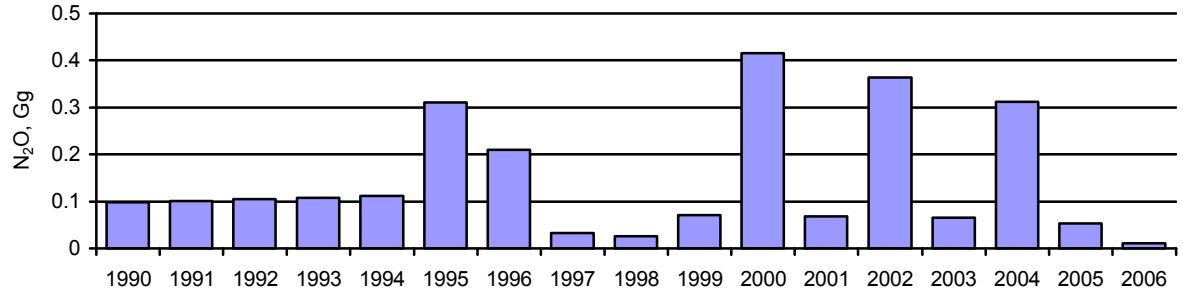


Figure 6.75. Emissions of N_2O from waste incineration in 1990–2006, Gg

6.3.4. Uncertainties and time-series consistency

The estimation of GHG emissions from waste combustion is carried out taking into account activity data (amounts of waste burned) and emission factors. Values employed in the estimates are presented in Table 6.95.

The combined uncertainty rates related to 'waste incineration' sub-category are reported in Chapter 6.1.4.

Table 6.95. Estimated values of uncertainties used in 'Waste Incineration' category of the Waste Sector

Input	Uncertainties	References
Activity data Amounts of waste incinerated[143]	± 10%	IPCC, 2000. Waste, pp. 5.12
Emission Factors **Total carbon content:**		

[143] Managed Waste Disposal on Land

Input	Uncertainties	References
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%...+12%	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%...+67%	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

6.3.5. Planned improvements

The GHG emissions from Waste Incineration were estimated and reported for the first time in the 2008 submission.

The data on amounts of waste burned by each waste category will be kept under consideration, with special attention being paid on the accuracy of waste classification into each waste group.

6.4. Biological Treatment (Composting) of Waste (CRF 6.D)

Composting and anaerobic digestion of organic waste, such as food waste, garden (yard) and park waste and sludge, is common in many countries (IPCC, 2006).

6.4.1. Activity data

Table 6.96 illustrates amounts of waste used in composting in Estonia in 1990–2006. The data was collected by the EEIC in accordance with a classification of waste management activities specified in Council Directive (75/442/EEC) (Annex 7_III). Amounts of waste used in composting are reflected by R3 activity[144].

[144] Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes)

Inert and petroleum products wastes consist of soil and stones, and waste from the oil shale industry. These groups of waste were not taken in the estimates of emissions from waste composting, and plastic waste was not considered at all.

The trend in amounts of waste used for the estimates of GHG emissions is presented in Figure 6.76. As seen, the practice of degradable waste composting has grown since 2002 and continues to increase.

Table 6.96. Amounts of waste used for composting in Estonia in 1990–2006, tonnes[145]

	Inert waste	Leather and Rubber	Municipal waste	Petroleum-products and Oils	Organic waste	Paper	Plastic	Sludge	Textile	Wood
1990	*n.d*[146]	*n.d.*	*n.d.*	*n.d.*	*3,751*	*364*	*n.d.*	*127*	*144*	*2,753*
1991	*n.d.*	*n.d.*	*n.d.*	*n.d.*	*3,948*	*383*	*n.d.*	*127*	*144*	*2,898*
1992	*n.d.*	*n.d.*	*n.d.*	*n.d.*	*4,156*	*404*	*n.d.*	*127*	*144*	*3,050*
1993	*n.d.*	*n.d.*	*n.d.*	*n.d.*	*4,375*	*425*	*n.d.*	*127*	*144*	*3,211*
1994	*n.d.*	*n.d.*	*n.d.*	*n.d.*	*4,605*	*447*	*n.d.*	*127*	*144*	*3,380*
1995	394	1	1	60	4,847	471	15	127	366	3,558
1996	2,221	3		30	30,481	846	129		59	133
1997	17,462	11		3,113	62,341	890	17	102	72	1,993
1998	9,763	61		617	4,340	565	32	78	80	1,494
1999	5,731			11	6,226	600	29	220	319	3,480
2000	10,986			792	22,073	830		120	419	3,277
2001	2,187			782	20,241	775		12,168		2,498
2002	42,710			1	20,992	694	11	6,104	54	71,109
2003	692,465		84	1,687	130,504	2,988	214	35,904	83	128,339
2004	252,075		3,752		110,599	3,657	3,533	55,062	344	229,993
2005	465,582		1,210	861	184,907	5,032	5,377	68,527	52	220,197
2006	349,156		54	710	176,229	6,564	9,570	84,575	109	402,866

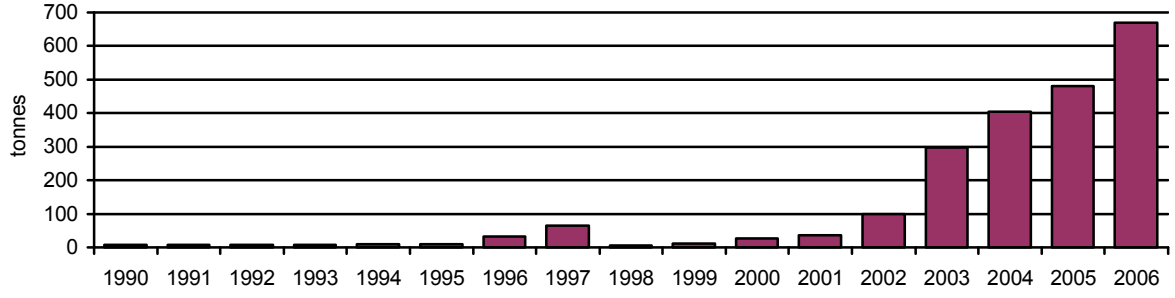


Figure 6.76. Amounts of organic waste used in composting in Estonia in 1990–2006, tonnes

[145] The data of 1990–1995 were interpolated basing on rough assumptions made
[146] n.d. – not determined

6.4.2. Methodology, data availability and sources, emission factors

Tier 1 approach was used in order to estimate emissions from biological treatment of solid waste (IPCC, 2006).

$$CH_4, Gg = \sum_i (M_i \bullet EF_i) \bullet 10^{-3} - R \quad (6.6)^{147}$$

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;

i – composting or anaerobic digestion;

R – total amount of CH_4 recovered in inventory year, Gg CH_4.

$$N_2O, Gg = \sum_i (M_i \bullet EF_i) \bullet 10^{-3} \quad (6.7)^{148}$$

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.

Table 6.97. Default emission factors for CH_4 and N_2O emissions from biological treatment of waste[149]

Type of biological treatment	CH_4 emission factors (g CH_4/kg waste treated)	N_2O emission factors (g N_2O/kg waste treated)
Composting	4	0.3

[147] IPCC 2006, Chapter 4, equation 4.1, pp 4.5
[148] IPCC 2006, Chapter 4, equation 4.2, pp 4.5
[149] on a wet basis, Table 4.1 of the 2006 IPCC, Chapter 4, pp 4.6

6.4.3. Quantitative overview – CH_4 and N_2O emissions from biological treatment of waste

The total emissions of CH_4 and N_2O were 2.7 Gg and 0.2 Gg, respectively, in Estonia in 2006. As seen from Figure 6.77 and Figure 6.78, emissions from waste biological treatment increased due to increasing amounts of waste used for composting.

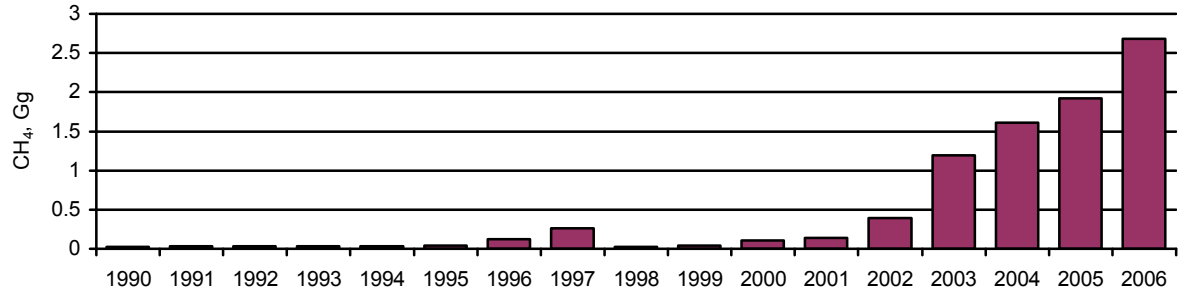


Figure 6.77. Emissions of CH_4 from biological treatment of waste in Estonia in 1990–2006, Gg

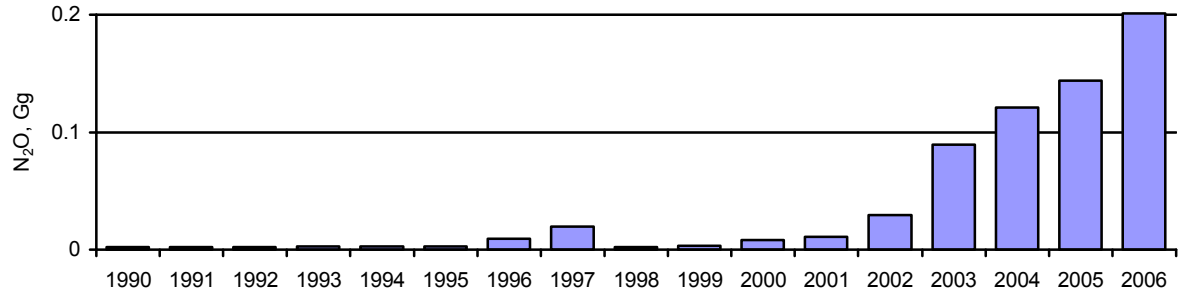


Figure 6.78. Emissions of N_2O from biological treatment of waste in Estonia in 1990–2006, Gg

6.4.4. Uncertainties and time-series consistency

The estimation of GHG emissions from biological waste treatment is carried out taking into account activity data and emission factors. Values employed in the estimates are presented in Table 6.20.

The combined uncertainty rates related to 'biological treatment' sub-category are reported in Chapter 6.1.4.

Table 6.98. 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

Input	Uncertainties	References
Emission factors		
Emission factor for treatment (CH_4)	-99%...+100%	2006 IPCC, Waste, Chapter 4, pp 4.6
Emission factor for treatment (N_2O)	-80%...+100%	2006 IPCC, Waste, Chapter 4, pp 4.6

6.4.5. Planned improvements

The GHG emissions from Waste Incineration were estimated and reported for the first time in the 2008 submission.

Data on the amount of waste burned by each waste category will be kept under consideration, with special attention being paid on accuracy of waste classification by each waste group.

6.5. Sludge Application on Agricultural Land

Sludge from domestic and industrial wastewater treatment plants is used on agricultural land. Emissions from sludge applied on land are reported in the Agriculture Sector.

6.5.1. Activity data

Activity data on sludge recycled is collected by the EEIC (Table 6.91). The data in Table 6.99 demonstrates a share of sludge in the total amounts of waste used in agriculture and for improvement of environmental situation.

As seen amounts of sludge applied on land has decreased up to 2006. However, in 2006 the total quantity of sludge generated by enterprises of pulp and furniture industry was 5 times higher than in 2005 and almost all amounts of sludge were used in agriculture.

In 1990–2005, more than 70% of waste applied was waste from the oil shale industry (Table 6.99).

Table 6.99. Amounts of Municipal Sludge Application on agricultural land, tonnes[150]

Year	Sludge
1990	*45,069*
1991	*53,533*
1992	*6,616*
1993	*89,666*
1994	*90,594*

[150] R10 of the European Waste Catalogue (2002)

Year	Sludge
1995	134,542
1996	153,382
1997	108,813
1998	163,341
1999	174,327
2000	278,846
2001	190,515
2002	175,466
2003	237,289
2004	7,238
2005	10,739
2006	1,703,383[151]

6.5.2. Methodology, data availability and sources, emission factors

The *Tier 1* approach was employed in order to estimate N_2O emission from sludge applied on agricultural land (IPCC, 1997).

$$F_{SL} = N_{SLUDGE} \times (1 - Frac_{GASF})$$

(6.8)[152]

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;

$$N_2O_{direct} - N = F_{SL} \bullet EF \bullet 44/28_1$$

(6.9)

EF – emission factor.

The emission factors used in the estimates are presented in Table 6.100.

Table 6.100. Parameters and Factors used in the estimates

Factors	Value	
FracGASF	0.10[153]	kg NH_3-N + NOx-N/kg of sludge nitrogen applied
EF for F_{SL}	1.25%	
Sludge (sewage) N content	5[154]	% dry matter

[151] Where 1,683,690 tonnes was sludge from 'Wood processing and the production of panels and furniture, pulp, paper and cardboard' with dry matter at 0.06%

[152] The 1996 Revised IPCC Guidelines. Agriculture. Workbook. Equation1, pp 4.33

[153] The 1996 Revised IPCC Guidelines. Agriculture. Reference Manual. Table 4-17-Summary of default values for parameters, pp. 4.35

Factors	Value	
Sludge N content (from pulp and paper industry)	0.87[155]	% dry matter

6.5.3. Quantitative overview – N_2O emission from sludge applied on agricultural land

Estonia emitted 0.002 Gg of N_2O in 2006. N_2O emission decreased by 52% by 2005 compared with the base year. However, in 2006 N_2O emission sharply increased due to remarkable increase in amount of sludge generated by the pulp and cardboard industry and its use afterwards for agricultural purposes.

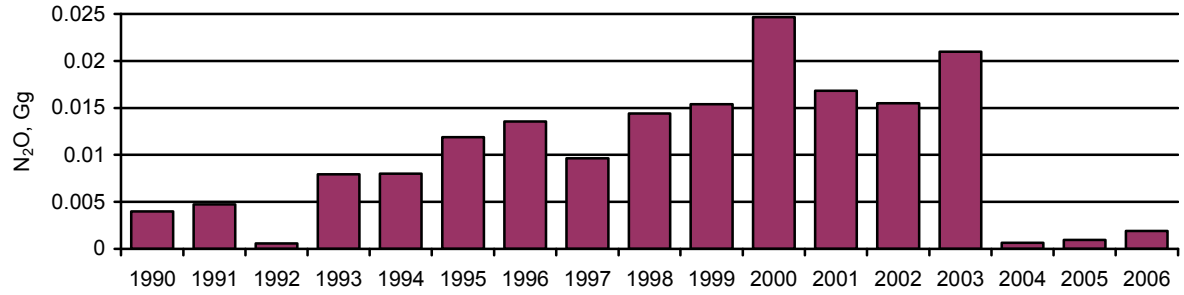


Figure 6.79. Emissions of N_2O from sludge applied on agricultural land in Estonia in 1990–2006, Gg

6.6. CH_4 emission from wastewater handling (CRF 6.B)

The handling of domestic and industrial wastewater under anaerobic conditions produces CH_4 (IPCC, 2000).

6.6.1. Activity data

In 1966, Estonian built its first biological wastewater treatment plant. As seen, the period of 1967–1975 is noted by rapid construction of new wastewater treatment plants. The number of plants and overall treatment capacity reached a maximum in 1990. Since then, the number of plants has declined (Figure 6.80).

[154] 'CH_4 and N_2O Emissions from Waste Water Handling' background paper
[155] Tucker, 2005.

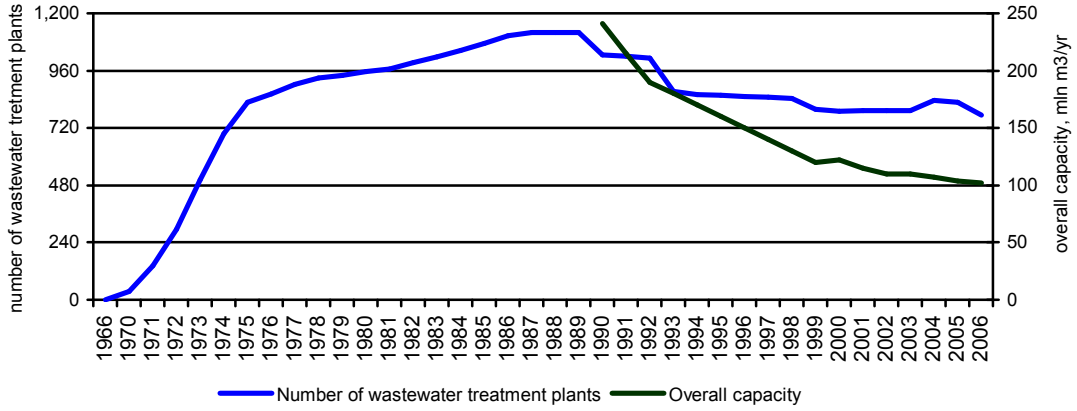


Figure 6.80. Number of wastewater treatment plants and their overall capacity in 1966–2006[156]

Water consumption for domestic and industrial purposes has begun to decrease as well since 1990, mostly due to declines in product manufacturing and more sustainable water consumption by Estonian inhabitants and industry (Figure 6.81).

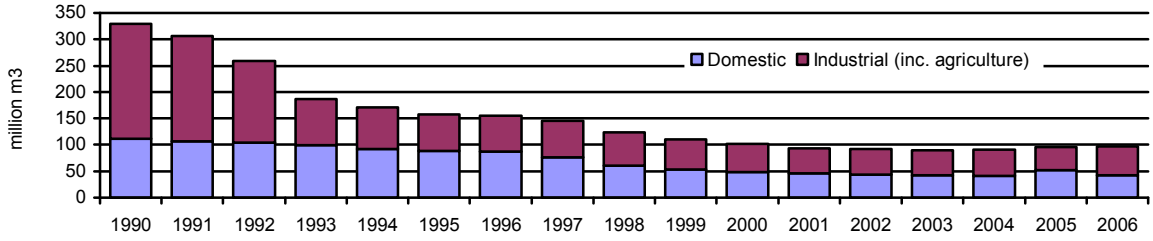


Figure 6.81. Domestic and Industrial water consumption in Estonia in 1990–2006, million m^3 (157)

Mechanical, biological and chemical methods are used in Estonia for wastewater treatment (Figure 6.82). Thus, only aerobic wastewater treatment is employed in Estonia. There is no wastewater treatment plant that uses the anaerobic method in Estonia.

[156] Velner *et al.*, 2003. Veekaitse Eestis 1945-2002
[157] www.stat.ee

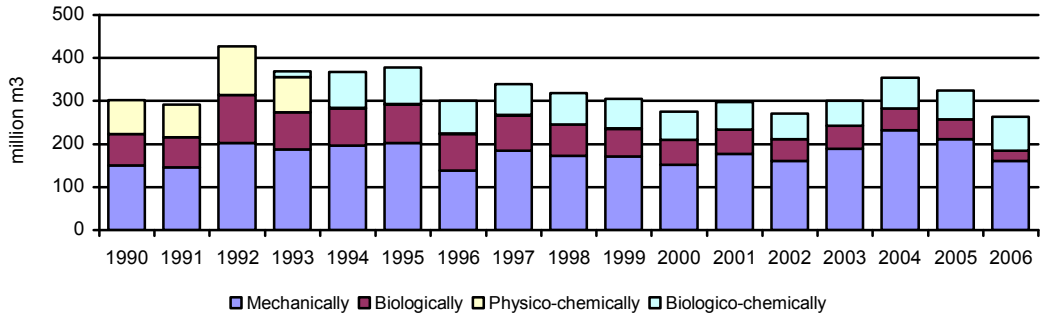


Figure 6.82. Wastewater treatment in Estonia in 1990–2006, million m^3 [158,159,160]

6.6.2. Source-specific recalculations

There is one recalculation carried out in the 2008 submission due to incorrect data used in the preceding submissions (Table 6.101).

Table 6.101. CH_4 emissions from wastewater treated in Estonia in 1990–2006, Gg

Year	Reported emissions of CH_4 in 1990–2005 (the 2007 submission)	Recalculated emissions of CH_4 (the 2008 submission)
1990	6.150	-
1991	5.448	-
1992	4.018	-
1993	1.282	-
1994	0.404	-
1995	0.532	-
1996	0.615	-
1997	0.747	-
1998	0.746	-
1999	0.759	-
2000	0.761	-
2001	0.581	-
2002	0.598	-
2003	0.442	-
2004	0.224	-
2005	0.247	-

[158] The data of 1990–1991 were interpolated basing on the total amount of wastewater treated using the data of (Environment 1992)

[159] Primary treatment – Mechanical treatment, mostly mining water is treated by mechanical treatment;
Secondary Treatment – Biological treatment;
Tertiary treatment – Biological-chemical treatment.

[160] www.stat.ee, Veemajanduse ülevaade... 2001

6.7. N_2O emission from human consumption followed by municipal sewage treatment (CRF 6.B.2.2)

6.7.1. 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 groundwater systems, be disposed of directly on land, or be discharged into a water source (e.g. rivers and estuaries) (IPCC, 2000).

6.7.2. Methodology, data availability and sources, emission factors

The default IPCC (the *Tier 1*) method was used to estimate emissions from the atmospheric deposition.

$$N_2O - N = PROTEIN \bullet Nr_{PEOPLE} \bullet Frac_{NPR} \bullet EF_6$$

(6.10)[161]

PROTEIN – The annual per capita protein consumption, kg protein/person-year;

Nr_{PEOPLE} - The national population;

$Frac_{NPR}$ - The fraction of protein that is nitrogen, kg N/kg of protein (Table 6.102);

Table 6.102. Factors used in the algorithm of human consumption followed by municipal sewage treatment

Factor	Value
$Frac_{NPR}$	0.16 kg N/kg of protein[162]
EF_6	0.01 kg N_2O-N/ kg N discharged sewage effluent[163]

The data on population of Estonia were obtained from the ESO, the annual per capita protein consumption was used from FAO statistical databases – 101 g/person/day[164] (for 2004–2006).

[161] IPCC 2000. Agriculture. Equation 4.39, pp. 4.72

[162] IPCC 1996. Agriculture. Workbook. Table 4-24 - Default values of parameters for indirect emissions. pp 4.106

[163] IPCC 1996. Agriculture. Workbook. Table 4-18 – Default emission factors for estimating indirect N_2O emissions from N used in agriculture. pp 4.73

[164] Dietary energy, protein and fat consumption, FAO

6.7.3. Quantitative overview – Human consumption followed by municipal sewage treatment

The quantity of N_2O emission from human consumption was 0.111 Gg in Estonia in 2006. Since 1990, the emissions have declined slightly due mostly to decreasing population (Figure 6.83).

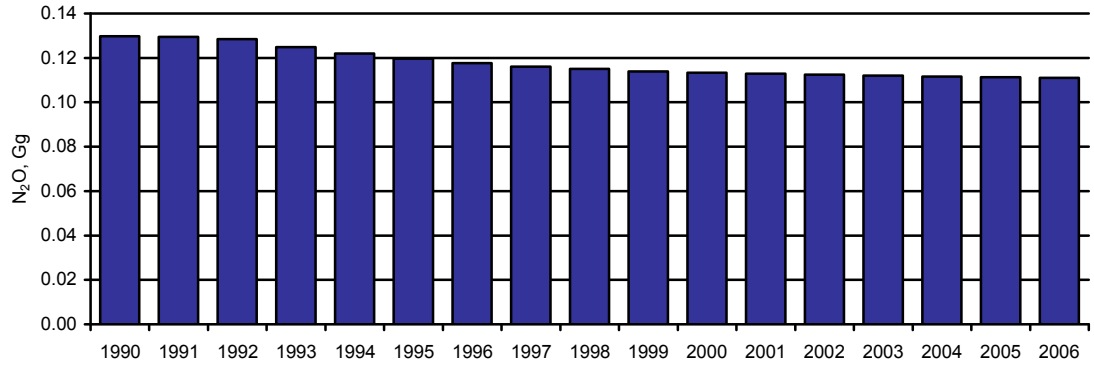


Figure 6.83. N_2O emissions from Human sewage in Estonia in 1990–2006, Gg

6.7.4. Source-specific recalculations

There is one recalculation carried out in the 2008 submission due to an omission made in the preceding submission.

Table 6.103. N_2O emissions from human sewage in Estonia in 1990–2006, Gg

Year	Reported emissions of N_2O in 1990–2005 (the 2007 submission)	Recalculated emissions of N_2O (the 2008 submission)
1990	0.1456	0.1297
1991	0.1453	0.1295
1992	0.1441	0.1284
1993	0.1401	0.1248
1994	0.1369	0.1220
1995	0.1243	0.1196
1996	0.1223	0.1177
1997	0.1207	0.1161
1998	0.1195	0.1151
1999	0.1177	0.1139
2000	0.1171	0.1133
2001	0.1167	0.1129
2002	0.1162	0.1124
2003	0.1158	0.1120
2004	0.1153	0.1116
2005	0.1158	0.1113
2006		0.1111

6.7.5. Uncertainty and time-series consistency

The data on protein consumption per capita were plotted from FAO databases; the uncertainty of this parameter is not recorded. Thus, this factor was not considered in the 2007 submission. 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 (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 6.1.4.

Table 6.104. Estimated values of uncertainties used in waste sector

Input	Uncertainties	References
Activity data		
Population	± 5%	IPCC, 2000. Waste, pp. 5.19
Emission factors		
Emission factor (human sewage)	-80%...100%	Table 4-23 of the 1996 IPCC Guidelines, pp. 4.105

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