GREENHOUSE GAS EMISSIONS IN ESTONIA 1990-2015

NATIONAL INVENTORY REPORT

Submission to the UNFCCC secretariat

Common Reporting Formats (CRF)
1990–2015

Tallinn 2017

PREFACE

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

Part I. Description of the greenhouse gas emission inventory according to the revised UNFCCC reporting guidelines (24/CP.19) containing description of the organization of the national greenhouse gas inventory, IPCC and other methods applied in calculation of the year 2015 emissions and exemptions to the previous inventories. A summarizing table of the emissions data for the years 1990–2015 is included as well as description of the current emission trends.

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

Estonian Environmental Research Centre (Ms Kristina Kaar, Ms Merilyn Möls, Ms Kelly Joa, Ms Hanna-Lii Kupri, Ms Tuuli Jurtom and Mr Andre Tammik) and Estonian Environment Agency (Ms Kadri Konsap and Ms Maris Nikopensius) have made the inventory calculations and/or provided the description of the methodologies and other information included in the National Inventory Report.

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

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

Report co-financed by the Environmental Investment Centre.

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ES.1.1 Background information on climate change

According to available information the impacts of climate change in Estonia are expected not to be as extreme as in many other countries in the European Union (notably in southern Europe) and around the world, and some effects can be considered positive.

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

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

The drafting of the Estonian national strategy and action plan for adapting to climate change was commenced in 2013 in the framework of the project titled 'Elaboration of Estonia's draft national climate change adaptation strategy and action plan', which is part of the programme 'Integrated marine and inland water management' of the European Economic Area Financial Mechanism 2009–2014.

The project activities included aggregation of available scientific information about climate change impacts, creation of Estonia specific climate change scenarios, assessment of sector specific negative and positive impacts of climate change, proposition of potential climate change adaptation measures, estimation of indicative cost of proposed adaptation measures and their prioritisation, elaboration of Estonia's draft climate change adaptation strategy and development of an action plan for the implementation of proposed measures. The project will eventually enhance Estonia's preparedness and capacity to respond to the impacts of climate change at local, regional and national level, developing a coherent approach and improving coordination.

ES.1.2 Background information on greenhouse gas inventories

Estonia signed the Framework Convention on Climate Change at the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992. In 1994 Estonia ratified the UNFCCC and in 2002, the Kyoto Protocol. Under these international agreements, Estonia is committed to provide annually information on its national anthropogenic greenhouse gas emissions by sources and removals by sinks for all greenhouse gases not controlled by the Montreal Protocol.

As a member of the European Union, Estonia has reporting obligations also under the Regulation (EU) No 525/2013 on the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC.

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

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

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

Part II of this report includes information related to Article 3, paragraph 3 (Afforestation, Reforestation, Deforestation) and paragraph 4 (Forest Management) in Chapter 11 and information related to Article 3, paragraph 14 (information on minimization of adverse impacts of climate change) in Chapter 15.

A summary information on accounting of Kyoto units is presented in Chapter 12. Information related to changes in national system and in the national registry are provided in Chapter 13 and Chapter 14 accordingly.

ES.2. Summary of national emission and removal-related trends

ES.2.1 GHG inventory

In 2015, the total emissions of GHGs (with indirect CO_2), measured as CO_2 eq., were 15 681.26 kt, and without LULUCF 18 040.48 kt. From 1990 to 2015 the emissions decreased by 55.3%. Table ES.1 shows the trend in total emissions without LULCF during the period 1990–2015. Figure ES.1 shows greenhouse gas emissions trends in CO_2 eq.

In 2015, the most important GHG in Estonia was carbon dioxide (CO_2), contributing 88.1% to total national GHG emissions expressed in CO_2 eq. (including indirect CO_2), followed by methane (CH_4), 5.9%, and nitrous oxide (N_2O), 4.8%. Fluorocarbons (so-called ‘F-gases’) account for about 1.2% of total emissions (see Table ES.2). The Energy sector accounted for 87.93% of total GHG emissions, followed by Agriculture (7.41%), Industrial processes and product use (2.84%) (including indirect CO_2) and Waste (1.81%).

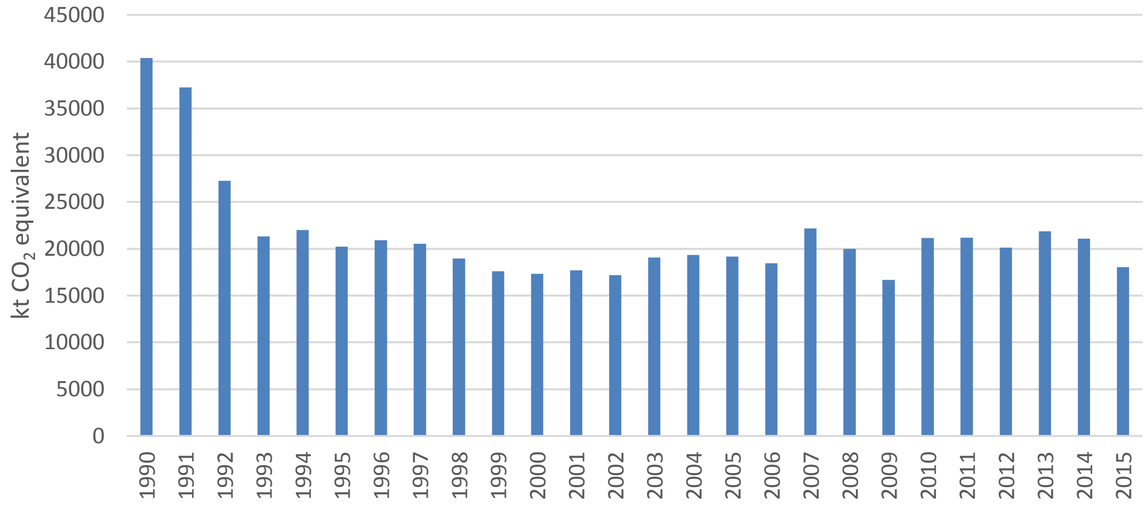

Figure ES.1. Estonia’s greenhouse gas emissions in 1990–2015 (with indirect CO_2), without LULUCF, kt CO_2 eq.

Table ES.1. Greenhouse gas emissions in Estonia. Emission trends, kt CO_2 eq.

GREENHOUSE GAS EMISSIONS	Base year (1990)	1995	2000	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO_2 emissions without net CO_2 from LULUCF (including indirect CO_2)	37 069.22	18 204.82	15 362.56	17 135.83	20 071.65	17 872.08	14 608.91	19 015.14	19 096.97	17 937.93	19 695.55	18 910.21	15 885.37
Indirect CO_2 (from NMVOCs reported under IPPU 2.D.3 Solvent use and road paving with asphalt)*	20.89	20.59	19.24	19.14	18.68	16.53	13.49	12.85	14.00	14.58	15.21	15.72	15.89
CH_4 emissions without CH_4 from LULUCF	1 909.61	1 263.80	1 238.80	1 208.32	1 205.38	1 186.79	1 165.96	1 196.23	1 127.04	1 146.17	1 138.10	1 106.43	1 059.09
N_2O emissions without N_2O from LULUCF	1 423.92	716.25	630.15	676.61	727.81	787.79	744.11	754.82	773.57	838.87	813.33	844.86	870.96
HFCs	NO	28.45	79.15	134.96	170.37	150.39	157.53	175.54	183.32	193.21	207.26	217.52	222.82
PFCs	NO	NO	NO	NA,NO	0.08	0.05	NO	NO	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	NO	3.07	2.61	1.03	0.92	1.29	1.38	1.73	1.77	1.88	2.03	2.10	2.25
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (without LULUCF)	40 402.74	20 216.40	17 313.27	19 156.75	22 176.21	19 998.39	16 677.89	21 143.45	21 182.67	20 118.05	21 856.28	21 081.13	18 040.48
Total (with LULUCF)	38 668.03	18 409.19	13 916.58	16 465.84	19 198.73	17 235.75	13 902.32	19 219.06	19 104.08	18 034.42	20 368.99	19 326.18	15 681.26
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**Base year (1990)**	**1995**	**2000**	**2005**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
1. Energy	36 397.39	17 855.16	14 974.85	16 787.35	19 545.92	17 321.41	14 561.39	18 939.30	18 887.78	17 496.63	19 181.24	18 691.23	15 863.86
2. Industrial processes and product use	965.73	637.43	697.60	726.42	957.72	964.34	475.91	537.58	660.46	904.44	996.01	707.69	512.92
3. Agriculture	2 669.72	1 326.10	1 078.02	1 129.09	1 179.45	1 236.16	1 173.28	1 192.37	1 218.35	1 307.40	1 303.52	1 341.93	1 337.62
4. Land use, land-use change and forestry	-1 734.71	-1 807.21	-3 396.68	-2 690.91	-2 977.48	-27 62.64	-2 775.58	-1 924.39	-2 078.59	-2 083.63	-1 487.29	-17 54.94	-2 359.23
5. Waste	369.90	397.71	562.80	513.89	493.12	476.48	467.32	474.20	416.08	409.58	375.50	340.27	326.08

*indirect CO_2 emissions are calculated from NMVOCs reported under IPPU 2.D.3 Solvent use and road paving with asphalt. These emissions are reported under paragraph 4.4.3.2 Solvent use in NIR and in CRF Reporter sectoral table 2(I).A-Hs2.

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

GHG EMISSIONS kt CO_2 eq.	**1990**		**1995**		**2000**		**2005**		**2010**		**2013**		**2014**		**2015**	
	kt	**%**	**kt**	**%**	**kt**	**%**	**kt**	**%**	**kt**	**%**	**kt**	**%**	**kt**	**%**	**kt**	**%**
CO_2 emissions excluding net CO_2 from LULUCF	37 069.22	91.7	18 204.82	90.0	15 362.56	88.7	17 135.83	89.5	19 015.14	89.9	19 695.55	90.1	18 910.21	89.7	15 885.37	88.1
CH_4 emissions excluding CH_4 from LULUCF	1 909.61	4.7	1 263.80	6.3	1 238.80	7.2	1 208.32	6.3	1 196.23	5.7	1 138.10	5.2	1 106.43	5.2	1 059.09	5.9
N_2O emissions excluding N_2O from LULUCF	1 423.92	3.5	716.25	3.5	630.15	3.6	676.61	3.5	754.82	3.6	813.33	3.7	844.86	4.0	870.96	4.8
HFCs	NO		28.45	0.1	79.15	0.5	134.96	0.7	175.54	0.8	207.26	0.9	217.52	1.0	222.82	1.2
PFCs	NO		NO		NO		NA,NO		NO		NO		NO		NO	
SF_6	NO		3.07		2.61		1.03		1.73		2.03		2.1		2.25	0.0
Total (excluding LULUCF)	40 402.74		20 216.40		17 313.27		19 156.75		21 143.45		21 856.28		21 081.13		18 040.48	

ES.2.2 KP-LULUCF activities

Under Article 3, paragraph 3 of the Kyoto Protocol (KP), Estonia reports emissions and removals from Afforestation (A), Reforestation (R) and Deforestation (D). From Article 3, paragraph 4 Forest management (FM) is reported.

Estimates of emissions and removals from Article 3.3 and Article 3.4 activities are presented in Table ES.3. In 2015, net emissions from Article 3.3 activities were 6.81 kt CO_2 eq. Uptake from Afforestation and reforestation activities including emissions from biomass burning were estimated to be -177.80 kt CO_2 eq., whereas Deforestation resulted in a net emission of 184.61 kt CO_2 eq. Areas subject to AR and D were 59 382 ha and 19 589 ha, respectively by the end of 2015. Annual rates of afforestation and deforestation have declined continuously from 1.78 kha to 0.04 kha per year for AR and from 1.81 kha to 0.19 kha per year for D during the period 2008–2015.

For Forest management under Article 3.4 activities overview of CO_2 emissions and removals are presented in Table ES.3. In 2015 FM contributed to the total GHG balance with an uptake of -2 438.32 kt CO_2 eq. and with HWP it was -3 518.52 kt CO_2 eq. Total area of FM was 2 361 kha.

Table ES.3. Net CO_2 emissions/removals in the KP LULUCF sector, kt CO_2 eq.

Greenhouse gas sources and sink activities	**Net CO_2 eq. emissions/removals, kt**			
	2013	**2014**	**2015**	**Total**
A. Article 3.3 activities	133.31	45.84	6.81	**185.96**
A.1. Afforestation and Reforestation	-147.67	-164.40	-177.80	-489.86
A.1.1. Units of land not harvested since the beginning of the commitment period	-147.67	-164.40	-177.80	
A.1.1. Biomass burning	0.004	0.004	0.004	
A.1.2. Units of land harvested since the beginning of the commitment period	NA	NA	NA	
A.2. Deforestation	280.97	210.24	184.61	675.82
A.2.1 Biomass burning	NO	NO	NO	
B. Article 3.4 activities				
B.1. Forest management	-2 924.46	-3 031.13	-3 518.52	**-9 474.16**
B.1. Biomass burning	0.002	0.042	0.003	

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

ES.3.1. GHG inventory

The greenhouse gas emissions and removals are divided into the following sectors according to Decision 24/CP.19 of the Conference of the Parties to the UNFCCC on the revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention: Energy (CRF 1), Industrial processes and product use (CRF 2), Agriculture (CRF 3), Land use, land-use change and forestry (LULUCF) (CRF 4) and Waste (CRF 5).

Figure ES.2 shows the contributions of sectors to total greenhouse gas emissions.

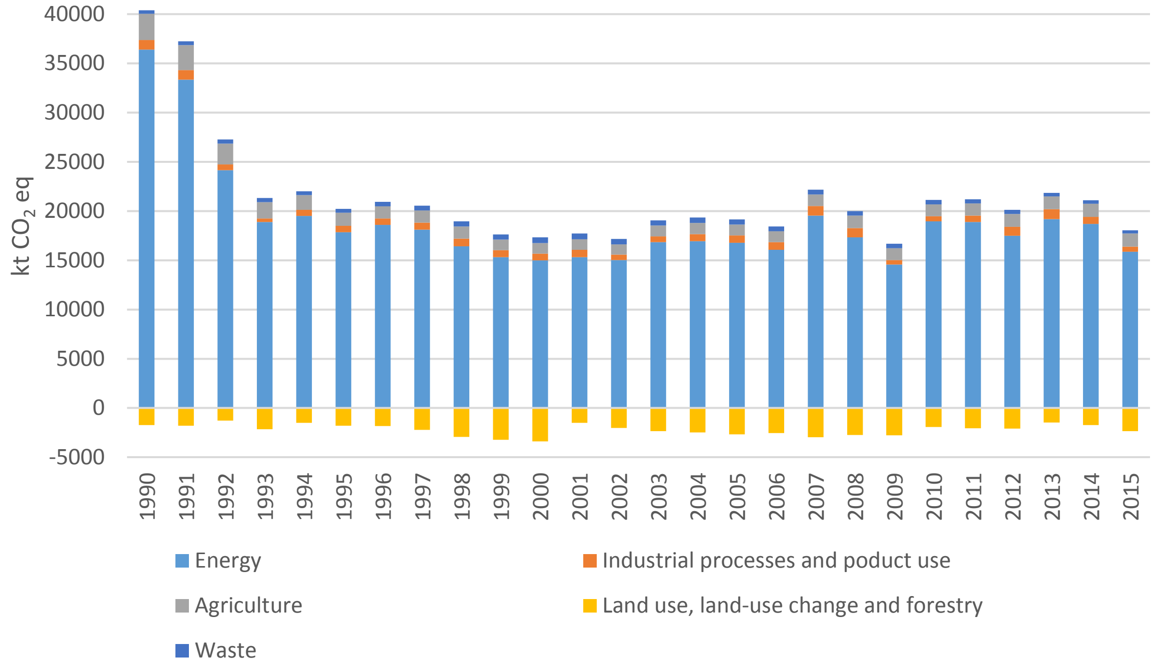

Figure ES.2. Greenhouse gas emissions trends by sector, kt CO_2 eq.

The Energy sector is the most significant source of greenhouse gas emissions in Estonia with 87.93% share of the total emissions in 2015. Since the base year, total GHG emissions in Estonia have decreased by 56.41%. The key driver for the fall in emissions is the transition from a planned economy to a market economy.

Agriculture is the second most significant source of greenhouse gas emissions in Estonia. In 2015 the Agriculture sector contributed 7.41% of the total emissions. Since the base year emissions have decreased by 49.9%, mostly due to the decreasing livestock population and quantities of synthetic fertilizers and manure applied to agricultural fields.

In 2015 Industrial processes and product use greenhouse gas emissions contributed 2.84% of the total greenhouse gas emissions in Estonia. Emissions have decreased by 46.89% between 1990 and 2015 because of closing of some relevant industries and reduced output of the remaining industries. Industrial CO_2 emissions have fluctuated strongly since 1990, reaching the lowest level in 1993. The decrease in the emissions during the early 1990s was caused by the transition from a planned economy to a market economy after 1991 when Estonia became independent.

The Waste sector contributed 1.81% of the total greenhouse gas emissions in 2015. The total emissions in CO_2 eq. from the Waste sector decreased by 11.85% compared to the base year.

In 2015, the LULUCF sector acted as a CO_2 sink, totalling 2 359.23 kt CO_2 eq. Since 1990, net removals have increased by 36.0%.

ES.3.2. KP-LULUCF activities

Estonia reports activities under Article 3, paragraph 3 and Forest management under Article 3, paragraph 4, of the Kyoto Protocol. Estonia has chosen to account for the KP-LULUCF activities at the end of commitment period.

The total emissions related to Afforestation/Reforestation and Deforestation activities were estimated at 6.81 kt CO_2 eq. in 2015. Afforestation/reforestation amounted a net uptake of -177.80 kt CO_2 eq. and Deforestation a net emission of 184.61 kt CO_2 eq. Areas of AR and D were 59 382 ha and 19 589 ha, respectively. In 2015 FM contributed to the total GHG balance with an uptake of -2 438.32 kt CO_2 eq (without HWP contribution). Total area of FM was 2 361 kha.

ES.4. Other information (e.g. indirect GHGs)

Estonia has chosen to report indirect CO_2 emissions calculated from NMVOC emissions from the CRF subcategory 2.D.3. This subcategory consists of

1. Solvent use (Chapter 4.4.3.2);
2. Road paving with asphalt (Chapter 4.4.3.3).

PART 1: ANNUAL INVENTORY SUBMISSION

1. INTRODUCTION

1.1. Background information on greenhouse gas inventories and climate change

1.1.1. Background information on climate change

Air temperature has increased at a more rapid rate in Estonia in the second half of the 20th century than the global average. Climate warming was especially intense from 1966–2010. January characterises the highest increase in temperature. The annual average temperature has increased by 1.8 degrees. Statistically significant warming is also characteristic of April, July and August.

The monthly mean maximum and minimum temperatures have increased in parallel with average warming. It is interesting to note that the increase in the maximum temperature is higher from April to October (except June) while the same applies to the minimum temperature from December to February. The daily temperature range therefore indicates an increasing trend in the warm half-year, especially in April and May, while a decreasing trend can be noted in winter.

Precipitation constitutes the climate indicator with the biggest variability in time and space. Large fluctuations of precipitation can be observed between single days, weeks, months, seasons and even years. The difference in precipitation between locations situated close to one another may be significant, especially in summer. As the measuring methodology of precipitation has changed over time, it is quite difficult to ascertain trends in precipitation. However, the opinion that the amount of precipitation in winter will increase in Northern Europe as the climate becomes warmer is generally recognised.

In the period 1966–2010, it is apparent that the increase in annual precipitation is statistically significant in some Estonian meteorological stations and insignificant in others. A positive trend has above all been noted in January and June, and to a lesser extent in February, March and August. However, a decreasing trend in precipitation has been observed in April, May and September. In summary, it may be stated that precipitation has somewhat increased in winter and summer and decreased in spring and autumn.

It is understandable that changes in snow cover are closely related to changes in air temperature and precipitation. As the air temperature increases, the number of days with snow cover should decrease and the snow cover itself should become more erratic. However, an increase in winter precipitation may result in thicker snow cover.

The duration of snow cover has generally decreased in Estonia in the last few decades, but due to its high variability this trend is not statistically significant. While a number of mild winters with little snow were recorded in the late 1980s and early 1990s, such winters have become scarcer in the last few years and snowy winters have become more frequent.

It is extremely difficult to adequately assess long-term changes in wind speed as it largely depends on the obstacles to wind situated close to the measuring site. However, research has been conducted into changes in wind directions in the period from 1966–2008. This indicates that the proportion of westerly and south-westerly winds has significantly increased in winter while the proportion of south-easterly and easterly winds has decreased.

Extreme climate phenomena occur in Estonia from time to time. In summer, hot weather and unstable air stratification along with thunderstorms result in whirlwinds (tornadoes/ waterspouts) of destructive force. In winter, the most hazardous climate phenomena have been powerful snowstorms accompanying cyclones, resulting in the obstruction and even closure of road traffic.

Even though climate change is not likely to be as extreme in Estonia as in many other countries in the EU (notably in southern Europe) and around the world, and although some effects can be considered positive, we expect a continued rise in temperatures and a resulting decrease in ice and snow cover; more frequent heat waves and droughts in summer; more health problems and forest fires caused by longer heat waves; more storms and power failures; more floods; changes in vegetation, species and habitats; invasions of alien species (incl. new plant pests and infectious agents); and other adverse effects[1].

1.1.2. Background information on greenhouse gas inventories

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

Single national entity with overall responsibility for the Estonian greenhouse gas inventory is the Estonian Ministry of the Environment (MoE). Financial resources are partly planned in the State Budget and partly applied from Environmental Investment Centre. Practical work is done mostly on the basis of contracts.

The Institute of Ecology at Tallinn University was responsible for the inventories under contract to the Ministry of the Environment in Estonia until summer 2006. The 2008–2013 inventories were produced in collaboration between the MoE, Estonian Environment Information Centre (EEIC), Tallinn University of Technology (TUT) and Estonian Environmental Research Centre (EERC). The 2014–2017 inventory were produced in collaboration between the MoE, Estonian Environment Agency (EtEA) and EERC, responsiblitites between different institutions are shown in Figure 1.1.

This report presents the national inventory of greenhouse gas emissions and removals from 1990 to 2015. The GHGs covered are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). Estimates on the precursor gases nitrogen oxides (NOx), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2) were also included in inventory data.

The report and associated Common Reporting Format (CRF) tables were prepared in accordance with the UNFCCC reporting guidelines on annual inventories. The CRF tables are produced with the CRF Reporter software (version 6.0.1.1). The methodology used in calculations of emissions is harmonized with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines).

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[1] Estonia's Sixth National Communication under the UN Framework Convention on Climate Change. (2013). Ministry of the Environment. Estonian Environmental Research Centre. Tallinn.

The structure of this NIR follows the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (Decision 24/CP.19). Chapter 1 gives an introduction to the background of greenhouse gas inventories and the arrangement for inventory preparation. Chapter 2 presents the overall emission trend in Estonia from the year 1990 to the year 2015. Chapters 3–8 give information of GHG emission trends from the base year 1990 to year 2015 for the following sectors: Energy, Industrial processes and product use, Agriculture, Land use, land-use change and forestry, and Waste. Chapter 9 gives an overview of indirect CO_2 and nitrous oxide emissions. In Chapter 10 improvements and recalculations since the previous submission are summarised. Chapter 11 provides description of KP-LULUCF, Chapter 12 information on accounting of Kyoto units, Chapter 13 information on changes in national system and Chapter 14 information on changes in national registry. Chapter 15 gives information on minimisation of adverse impacts in accordance with Article 3, paragraph 14 of KP. Annex 1 contains key category reporting tables and Annex 2 the assessment of uncertainty. Annex 3 gives information on detailed methodological descriptions for individual source or sink categories. Annex 4 contains the national energy balance for the most recent inventory year. Assessment of completeness of inventory estimates is presented in Annex 5. Annex 6 contains the Standard Independent Assessment Report.

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

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

Part II of this report includes information related to Article 3, paragraph 3 (Afforestation, Reforestation, Deforestation) and paragraph 4 (Forest management) in Chapter 11 and information related to Article 3, paragraph 14 (information on minimization of adverse impacts of climate change) in Chapter 15. A summary of information on accounting of Kyoto units is presented in Chapter 12 and more detailed information is presented in Standard Electronic Tables (SEF). Information related to changes in national system and in the national registry are provided in Chapter 13 and Chapter 14 accordingly.

Estonia has chosen to report greenhouse gas emission removals from activities under Article 3.3 (i.e. Afforestation, Reforestation and Deforestation) and Article 3.4 (Forest management) for the second commitment period (CP).

1.2. A description of the national inventory arrangements

1.2.1. Institutional, legal and procedural arrangements

Institutional arrangements

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

The MoE is responsible for:

- coordinating the inventory preparation process as a whole;
- approving the inventory before official submission to the UNFCCC;
- reporting the greenhouse gas inventory to the UNFCCC, including the National Inventory Report and CRF tables;

- entering into formal agreements with inventory compilers (EERC);
- coordinating cooperation between the inventory compilers and UNFCCC Secretariat;
- informing the inventory compilers of the requirements of the national system and ensuring that existing information in national institutions is considered and used in the inventory where appropriate;
- informing the inventory compilers of new or revised guidelines; and
- coordinating the UNFCCC inventory reviews and communication with the expert review team, including responses to the review findings.

The EERC, as the inventory coordinator, is responsible for:

- compiling the National Inventory Report according to the parts submitted by the inventory compilers;
- coordinating the implementation of the QA/QC plan;
- coordinating the inventory process; and
- the overall archiving system.

The EERC is responsible for preparing the estimates for the Energy, Industrial processes and product use, Agriculture and Waste sectors. The Data Management Department of the Estonian Environment Agency is responsible for LULUCF and KP LULUCF estimates. Sectoral experts collect activity data, estimate emissions and/or removals, implement QC procedures and record the results, fill in sectoral data to the CRF Reporter and prepare the sectoral parts of the NIR. These experts are also responsible for archiving activity data, estimates and all other relevant information according to the archiving system.

Legal arrangements

In accordance with §143 of the Atmospheric Air Protection Act (RT I, 05.07.2016, 1), activities for the reduction of climate change are organised by the Ministry of the Environment on the basis of the requirements for the restriction of the limit values of emissions of greenhouse gases provided by the UNFCCC, the Kyoto Protocol and the European Union legislation.

In accordance with §6 of the Statutes of the Ministry of the Environment (RT I 2009, 63, 412), the MoE is responsible for climate change related tasks and according to §23 section 8, the Climate and Radiation Department task is to organize, develop and implement climate change mitigation and adaptation policies. In accordance with the Statutes of the Climate and Radiation Department of the MoE, the department is responsible for organizing and coordinating GHG emission reporting activities under the UNFCCC, the Kyoto Protocol and the European Union legislation.

The Estonian Environment Agency (EtEA) is a state authority administered by MoE, which was formed as a result of the merger of the Estonian Meteorological and Hydrological Institute (EMHI) and the Estonian Environment Information Centre (EEIC) in 2013. In accordance with §9 section 5 of the Statute of the EtEA, the tasks of the Data Management Department are to collect, process, analyse and publicise sectoral data, comply national and international reporting obligations.

The Estonian Environmental Research Centre (EERC) is a joint stock company, all of the shares in which are held by the Republic of Estonia. The EERC belongs to the government area of the Ministry of the Environment. It compiles the GHG inventory on the basis of contract agreements with the MoE.

A three-year contract agreement (for the 2011, 2012 and 2013 submissions) was entered into with the EERC for inventory compilation in the Industrial processes, Solvent and other product use and Waste sectors. A one-year contract agreement (for the 2013 submission) was entered into with the EERC for inventory preparation in the Energy and Agriculture sectors and for inventory coordination.

A new contract agreement with the EERC for inventory compilation in the Energy, Industrial processes and product use, Agriculture and Waste sectors and for inventory coordination was entered into in 2013 for three years (for the 2014, 2015 and 2016 submissions). Again, a new contract agreement with the EERC for inventory compilation in the Energy, Industrial processes and product use, Agriculture and Waste sectors and for inventory coordination was entered into in 2016 for three years (for the 2017, 2018 and 2019 submissions). The MoE plans to use the three-year contract approach in the coming years to ensure the continuity of inventory preparation.

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

Procedural arrangements

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

All three institutions are in close contact with one another. Several cooperation meetings are held annually to discuss and agree on methodological issues, problems that have arisen and improvements that need to be implemented. As Estonia is a small country and only two institutions are preparing the inventory estimates there is close contact between inventory experts (EERC and EtEA) and inventory coordinator (MoE and EERC) and as a result different problems and misunderstandings are also solved on a daily basis.

During the cooperation meetings the following subjects are addressed:

- preparation of the annual review;
- discussion on the comments received from the expert review and agreeing on possible changes that have to be made;
- discussion on the different problems that came up during the last inventory preparation and find solutions to improve the overall system;
- discussion on methodologies and possible changes in the future;
- discussion on QA/QC plan, available resources and possible improvements;
- discussion on data availability and collection;
- agreement on recalculations;
- archiving system, updating and possible improvements;
- exchange of relevant information; and
- reporting the conclusions from the meetings.

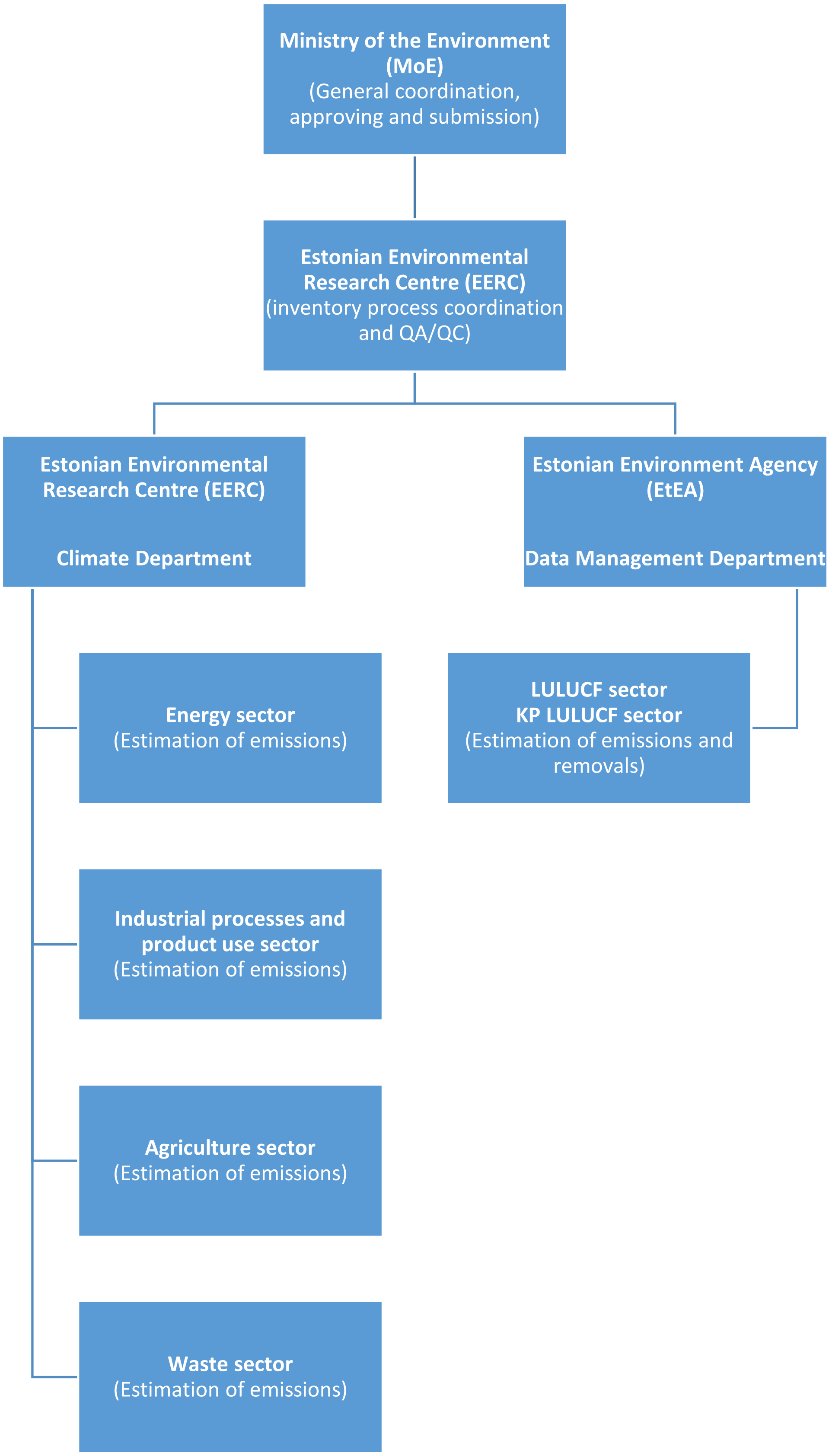

Figure 1.1. National System for GHG inventory in Estonia

1.2.2. Overview of inventory planning, preparation and management

1.2.2.1. Inventory planning

Estonia's national GHG inventory system is designed and operated according to the guidelines for national system under article 5, paragraph 1, of the Kyoto Protocol (Decision 19/CMP.1) to ensure the transparency, consistency, comparability, completeness and accuracy of inventories. Inventory activities include planning, preparation and management of the inventories.

The EERC and the MoE have developed an inventory production plan that sets out the schedule for inventory preparation. The schedule, which is annually reviewed, forms part of Estonia's QA/QC plan and must be followed by all core institutions (MoE, EERC and EtEA). The inventory production plan is presented in Table 1.1. More detailed information about Estonia's QA/QC plan is presented in the section 1.2.3.

Table 1.1. Inventory production plan

Activity	Responsible	Deadline
Annual meeting: Will be discussed how the previous inventory cycle has been, what should be improved/changed; new contracts, etc	*All*	*April 15*
Sectoral experts notify the EERC and MoE of the planned methodological changes, reasons for changes and how they plan to incorporate the UNFCCC review results to the next report	EERC, EtEA	Oct. 17
Annual meeting: Sectoral experts notify the EERC and MoE of the planned methodological changes, reasons for changes, overview of the planning of the new inventory cycle and how they plan to incorporate the UNFCCC review results to the next report. MoE and EERC give an overview of the new requirements, plans, etc	*All*	*Oct. 30*
Sectoral experts complete data entry to the CRF Reporter and notify the EERC and MoE	EERC, EtEA	Dec. 15
QC checks are carried out (CRF Reporter) and documented by inventory coordinator (MoE and EERC) and sent to the sectoral experts	EERC, MoE	Dec. 15-21
Sectoral experts send the necessary data for uncertainty analysis to EERC and MoE	EERC, EtEA	Dec. 21
MoE compiles the CRF tables and sends them to the sectoral experts for approval. CRF tables are also sent to the independent experts	MoE	Dec. 22
Sectoral experts provide the draft NIR to the EERC and MoE. Prior to this the QC checks should be carried out and documented	EERC, EtEA	Dec. 28

Activity	Responsible	Deadline
Independent experts will carry out the QA for the CRF tables and submit the documented results to EERC. EERC submits the results to sectoral experts	Independent experts	Jan. 5
EERC and MoE perform QC of the NIR and send the comments to the sectoral experts and independent experts for review	EERC, MoE	Jan. 9
Sectoral experts send their comments and possible changes on the CRF tables according to the QA/QC (performed by independent experts, MoE and EERC) to EERC, MoE. EERC sends comments to independent experts	EERC	Jan. 11
EERC performs the key category analysis and uncertainty analysis and sends the results to the sectoral experts and independent experts	EERC, EtEA	Jan. 11
MoE provides the chapters on accounting of Kyoto units, changes on national system and minimization of adverse impacts in accordance with Article 3, paragraph 14, to the EERC	MoE	Jan. 11
EERC compiles the draft NIR according to the submitted sectoral parts and sends it to the sectoral experts and MoE for approval	EERC	Jan. 12
Reporting to the EU (CRF tables and draft NIR)	MoE	Jan. 15
Draft NIR is sent to different departments of MoE and other relevant insitutions for approval	MoE	Jan. 18
The draft NIR along with the CRF tables is uploaded to the MoE webpage for public review	MoE	Jan. 18
Independent experts carry out QA of the NIR and submit the results to EERC and MoE. EERC submits the results to sectoral experts	Independent experts	Febr. 13
MoE different departments and other relevant institutions carry out QA of the CRF tables and NIR and submits the results to the EERC	MoE	Febr. 16
EERC submits the results of the MoE QA to the sectoral experts and independent expert	MoE, EERC	Febr. 16
Sectoral experts send their comments and possible changes according to the QA/QC (performed by the MoE and independent experts) to EERC, MoE. EERC sends comments to independent experts	EERC, EtEA	Febr. 24
Annual meeting: The comments given during the inventory preparation and the last UNFCCC review report will be looked through. Also questions/problems that have been raised will be discussed before the submission to the EU	*All*	*Before March 15*

Activity	Responsible	Deadline
Answers to the EU initial check and if possible then corrections are made to the inventory	All	Febr 28-March 15
Reporting to the EC (CRF tables and NIR)	MoE	March 15
MoE approves the final inventory	MoE	April 11
Reporting to the UNFCCC	MoE	April 15
NIR and CRF tables are uploaded to the MoE webpage	MoE	April 20
Sectoral experts present complete archives to the MoE and EERC	EERC, EtEA	May 2

1.2.2.2. Inventory preparation and management

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

Inventory planning

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

Inventory preparation

- Identify key source categories;
- Prepare estimates in accordance with the methods described in the 2006 IPCC Guidelines;
- Collect sufficient activity data, process information and emission factors as are necessary to support the methods selected for estimating anthropogenic GHG emissions by sources and removals by sinks;

- Make a quantitative estimate of inventory uncertainty for each source category and for the inventory in total, following the 2006 IPCC Guidelines;
- Ensure that any recalculations of previously submitted estimates of anthropogenic GHG emissions by sources and removals by sinks are prepared in accordance with the 2006 IPCC Guidelines and relevant decisions;
- Compile the national inventory;
- Implement general inventory QC procedures (tier 1) in accordance with its QA/QC plan following the 2006 IPCC Guidelines;
- Implement category-specific QC procedures and provide for a basic review of the inventory of personnel that have not been included in the inventory development.

Inventory Management

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

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

1.2.3. Quality assurance, quality control and verification plan

The starting point in accomplishing a high-quality GHG inventory is consideration of expectations and inventory requirements. The quality requirements set for annual inventories are continuous improvement, transparency, consistency, comparability, completeness, accuracy and timeliness. The setting of concrete annual quality objectives is based on these requirements.

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

The next step is development 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, 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 Estonia's QA/QC plan consist of seven parts: (1) production plan (see Table 1.1); (2) annual meetings; (3) QA/QC checks; (4) QA results documentation form; (5) archiving structure; (6) response tables to the review process and (7) a list of planned activities and improvements.

All institutions involved in the inventory process (MoE, EERC and EtEA) 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 EERC and EtEA. The EERC as a coordinator has an overall responsibility for QC of the data of the emission inventory. MoE as the national entity is responsible for the overall QA of the national system, including the UNFCCC reviews and any national reviews undertaken.

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

1.2.3.1. Quality control procedures

The QC procedures used in Estonia's GHG inventory comply with 2006 IPCC Guidelines. General inventory QC procedures[2] include routine checks of the integrity, correctness and completeness of data, identification of errors and deficiencies, documentation and archiving of inventory data and quality control actions. Once the experts have implemented the QC procedures, they complete the QA/QC checklist for each source/sink category, which provides a record of the procedures performed. The QA/QC checklists are part of Estonia's QA/QC plan. Also assessment of completeness is evaluated.

EERC checks the QC checklists completed by EERC and EtEA. When EERC disagrees with the information provided in the checklists then the errors are discussed and changes are made if necessary.

In addition to the general inventory QC procedures, Estonia applied category-specific QC procedures on some source/sink categories in the 2017 submission, focusing on key categories and on those categories in which significant methodological changes and/or data revisions occurred. More detailed information can be found under sectoral chapters.

After the sectoral experts have completed entering data to the CRF Reporter, EERC carries out some general (including visual) checks on the data entered. When the CRF tables are finalized, the experts will start preparing the sectoral chapters of the NIR. These parts are sent to the compiler (EERC) who adds the introduction part and puts the draft NIR together. The compiler arranges the different chapters into one uniform document and makes sure that the structure of the report follows the UNFCCC guidelines. All figures on emissions and removals in tables and text are checked to make sure that they are consistent with those reported in the CRF. The sectoral experts and the inventory compiler also checks that all methodological changes, recalculations, trends in emission and removals are well explained.

In addition, the QA/QC of Member States' submissions conducted under the European Union GHG monitoring mechanism (e.g. completeness checks, consistency checks and comparison across Member States) produces valuable information on errors and deficiencies, and the information is taken into account before Estonia submits its final annual inventory to the UNFCCC.

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

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[2] IPCC 2006 Guidelines, Volume 1, Chapter 6: Quality Assurance/Quality Control and Verification, pages 6.10–6.11, table 6.1.

1.2.3.2. Quality assurance procedures

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

Estonia’s GHG inventory is checked annually by one or more independent experts. From the 2009 submission to 2012 submission all data collected by institutions involved in the inventory process was checked by an independent expert from Tallinn University of Technology. In the 2013–2016 submission the inventory was reviewed in parts by the EERC, TUT, University of Tartu, Estonian University of Life Sciences (EULS) and other national experts. The 2017 submission was checked by experts from TUT, EULS and other national experts. The findings of the independent experts are looked through by experts (in collaboration with the EERC) and adjustments carried out as a result, if necessary.

The draft NIR is uploaded to the MoE website www.envir.ee where all interested parties have the 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 this process are reviewed and, as appropriate, incorporated into the NIR.

The inventory is also checked by different Ministries and institutions. The inventory will be sent to the Ministry of Economic Affairs and Communications, to Forest, Waste and Water Departments in MoE, to Ministry of Rural Affairs and Waste Department in EtEA. During the in-country review in 2012, UNFCCC review team encouraged Estonia to strengthen its QA procedures by involving Statistics Estonia in the quality checking of the inventory. Taking into account the recommendation, starting from the 2013 submission, inventory is annually sent to Statistics Estonia for quality checking.

UNFCCC reviews are part of QA. The reviews are performed by a team of experts (sectoral experts and generalist) from other countries. They examine the data and methods that Estonia is using and check 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 in which the inventory is in need of improvements.

The GHG inventories submitted in 2012 from all Member States were subject to a technical review of GHG emission estimates with a particular focus on the years 2005, 2008, 2009 and 2010. The technical review process for GHG inventories included three stages: initial checks of the completeness, initial consistency and comparability checks and a detailed technical review.

The GHG inventories submitted by Member States in 2016 were subject to comprehensive review carried out for years 2005, 2008, 2009, 2010, 2013 and 2014. The review was performed in two steps. Step 1 was combined with the ‘EU QA/QC procedures’ (i.e. initial checks) and was carried out by the EU inventory team (ETC/ACM, JRC, Eurostat). All findings from the initial checks that were relevant for the Effort Sharing Decision (ESD) and that were not resolved within the initial check phase were followed up in the second step of the comprehensive review. Step 2 of the ESD comprehensive review 2016 was performed by a Technical Expert Review Team (TERT).

Peer review

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

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

1.2.3.3. Archiving

It is good practice for inventory compilers to maintain the documentation for every inventory produced and to provide it for the review team, if requested. 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 emission calculations. EERC bears the responsibility of archiving and Estonia's central inventory archive is located there. When the reporting cycle ends and all inventory calculations are finalized all experts send their documentation to the compiler and it is stored in one place.

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

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

Following the recommendation of the UNFCCC review team (ARR 2012, para 35) Estonia improved its archiving system again for the 2013 inventory. The archiving structure was modified the way that all relevant materials (e.g. XML files provided by the inventory compilers to the producers of the CRF tables, also relevant materials from the ftp site) would be stored in the archive. The materials used in the 2013–2017 inventory submission were archived according to the improved archiving system.

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

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

1.2.3.4. Verification activities

The EU emissions trading system (EU ETS) is a cornerstone of the Europeans Union's policy to combat climate change and its key tool for reducing industrial greenhouse gas emissions cost-effectively. In contrast to traditional 'command and control' regulation, emissions trading harnesses market forces to find the cheapest ways of reducing emissions.

The EU ETS works on the 'cap and trade' principle. The overall volume of greenhouse gases that can be emitted each year by the power plants, factories and other companies covered by the system is subject to a cap set at EU level. Within this Europe-wide cap, companies receive or buy emission allowances which they can trade if they wish.

Businesses must monitor and report their EU ETS emissions for each calendar year and have their emission reports checked by an accredited verifier. They must surrender enough allowances to cover their total emissions by 30 April of the following year[3].

The EU ETS reports' data can be used, in aggregated form, to draw category specific conculsions regarding the completeness and consistency of the certain parts of the GHG inventories. Comparison of EU ETS emissions with emissions reported in national GHG inventory was carried out for year 2015. The results indicated that share of verified ETS emissions in Stationary combustion (includes emissions of 1.A.1, 1.A.2 and 1.A.4) was about 87.7% in 2015. Share of verified ETS emissions in CRF category 2.A Mineral products was about 99.4% in 2015.

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

1.2.3.5. Treatment of confidential issues

In most of Industrial processes categories there is only one major manufacturer in Estonia. This is the reason why not all data can be disclosed in the NIR.

Activity data used in calculations in carbon balances are collected from private companies and are therefore considered confidential. Activity data on oil shale, shale oil and oil shale gases production by oil companies and calculations of carbon balances are not part of the national inventory report and are allocated into archive. The data will be made available during the review process for the review team, if requested.

[3] European Commission. (2013). The EU Emissions Trading System (EU ETS). [www] https://ec.europa.eu/clima/sites/clima/files/factsheet_ets_en.pdf (09.01.2017).

1.2.4. Changes in the national inventory arrangements since previous annual GHG inventory submission

Changes in national inventory arrangements since the previous annual inventory are described in Chapter 13.

1.3. Inventory preparation, and data collection, processing and storage

1.3.1. Inventory preparation

The UNFCCC, the Kyoto Protocol and the European Union (EU) greenhouse gas monitoring mechanism require Estonia to submit annually a NIR and CRF tables. The annual submission contains emission estimates for the years between 1990 and the year before last year. So the 2017 submission contains estimates for the years 1990–2015.

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

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

1.3.2. Data collection, processing and storage

The inventory process for the next inventory cycle starts with an examination of previous years and an analysis of the available datasets in order to improve the inventory through new knowledge and the activity data developed.

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

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

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

The data sources for each sector are described below.

<u>Energy</u>

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

SE publishes:

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

2. Aditionally, EERC asks also more detailed energy balance from SE (some data is not published on the homepage of SE).

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

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

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

Viru Keemia Grupp AS (Viru Chemistry Group Ltd. in Kohtla-Järve) – Oil shale consumption for shale oil production, shale oil, semi-coke gas and generator gas production data.

Kiviõli Keemiatööstuse OÜ (Kiviõli Oil Shale Processing and Chemicals Plant Ltd.) – Oil shale consumption for shale oil production, shale oil, semi-coke gas and generator gas production data.

EtEA – GHG emission estimations from Civil aviation and Road transport sector. EtEA has a special model Copert IV for calculation of emissions from Transport, incinerated waste fuel data. Also data on fuel use for national and international aviation separately.

EtEA – activity data on combustible waste amounts.

EtEA – activity data on transport biofuel amounts used in Estonia.

Industrial processes and product use

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

CO_2 emissions from Mineral industry are reported in six sub-sectors: cement (2.A.1), lime (2.A.2) and glass production (2.A.3), ceramics (2.A.4.a) (bricks, tiles and lightweight gravel production), soda ash use (2.A.4.b) and limestone use for flue gas desulphurisation (2.A.4.d).

Data on clinker production (raw material in cement production) were received directly from the cement industry. Activity data on lime production were collected mainly from the industry and taken partly from industrial statistics (to calculate the output of the plant that closed in 1996). Data on flat glass production were received from SE and data on container glass production from industry. Data on bricks and roof tiles production were collected from production plants and taken partly from industrial statistics. Activity data on lightweight gravel production and soda ash use were received from industry. Data on limestone use for flue gas desulphurisation (only in 2012–2013 and 2015) were provided by industry.

In Chemical industry sector only CO_2 emissions from Ammonia production were calculated in years 1990-2013. Natural gas feedstock quantities were received from SE (there was only one ammonia producer). Data for EF calculation (carbon content of gas and amounts of produced carbamide) were provided by the production plant.

Under Non-energy products from fuel and solvent use, CO_2 emissions from use of lubricants, paraffin waxes and urea based catalytic converters for motor vehicles are reported as well NMVOCs and indirect CO_2 from solvent use and road paving from asphalt. Data on international trade of lubricants and paraffin waxes were provided by SE. Data on production of lubricants, paraffin waxes and candles were received from SE. Also candle industry provided their production data. Data on urea based catalysts for vehicles is calculated on basis of diesel fuel consumption of certain motor vehicles. Diesel fuel consumption of different types of vehicles is calculated by EtEA.

NMVOC emissions from Solvent use and Road paving with asphalt were calculated by EtEA. Emissions from point sources are gathered from the web-based air emissions data system for point sources (OSIS) and the emissions for diffuse sources are calculated from the data received and gathered from Statistics Estonia and Eurostat using international emission factors and expert opinions. The main database of emission factors is the EMEP/EEA Guidebook 2013.

Data on hot asphalt mix production was received from the Estonian Asphalt Pavement Association for the years 1990–2015. Default NMVOC factors are taken from EMEP/EEA Guidebook – 2013.

Product uses as substitutes for ODS covers HFCs from Refrigeration and air conditioning, Foam blowing, Aerosols and Fire extinguishers. In these sub-sectors data were collected from national and international companies, associations, public institutions etc.

Under Other product manufacture and use, SF_6 from Electrical switchgear (2.G.1) and Particle accelerators (2.G.2) are reported as well as historically used SF_6 in car tyres, PFCs and SF_6 in sport shoes (2.G.2). Data on SF_6 in switchgear is provided by the electricity network operators. Data on SF_6 in particle accelerators is provided by the people servicing them. Subcategory 2.G.3 covers medical N_2O and use in consumer goods. Activity data used to estimate N_2O emissions from product use was collected from wholesalers.

Agriculture

Activity data used in the estimates were obtained mainly from Statistics Estonia (SE). The data received from SE (see Table 5.3):

- number of livestock (by livestock category and sub-category);
- data on milk production per cow;
- crop yields and sown areas of field crops (by crop type);
- volume of N fertilizers, compost and carbonate lime applied to agricultural soils;
- location of animal waste management systems;
- import - export of urea fertilizers.

SE opens the data annually by July–August.

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

- Estonian Animal Recording Centre (fat content of milk, percentage of cows that give birth);
- Scientific publications (model of gross intake by pigs, feed digestibility of cattle and swine, nitrogen content of feed, etc.);
- Activity data on organic soils cultivated were obtained in the framework of National Forest Inventory (NFI);
- Activity data on sewage sludge applied to agricultural soils were provided by Estonian Environment Agency;
- Plant specific activity data were used on urea fertilizers produced in Estonia;
- Marketing activity data of lime and urea fertilizers were provided by Estonian Agricultural Board.

LULUCF

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

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

- dynamics of land-use changes, including afforestation/reforestation and deforestation;

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

Activity data of wildfires is obtained from Estonian Rescue Service. In 2014, the Estonian Environment Agency started annual fieldwork to to record wildfire locations, determining the precise area and biomass burned.

Information regarding orchards is received from the Ministry of Rural Affairs and Statistics Estonia. Harvested wood products (HWP) information about foreign trade and production data is also provided by Statistics Estonia.

Storm damaged forest area is obtained from Statistics Estonia and Estonian Environment Agency (NFI).

<u>Waste</u>

Activity data for calculating CH_4 emissions from Solid waste disposal include data on solid waste generation and disposal that are collected from EtEA. The reported waste data is available in an online waste reporting system JATS. The data on the population of Estonia is obtained from the dataset of SE. The composition of municipal solid waste is based on the Municipal Solid Waste Sorting Studies of 2000, 2008 and 2013. Activity data on methane recovery is derived from Estonia's Annual Questionnaire on renewables and Waste 2013 (REN Estonia) and EtEA's Air Bureaus information system for ambient air pollution sources (OSIS).

Activity data for calculating CH_4 and N_2O emissions from Composting is collected from EtEA and revised by EERC to ensure the quality of the data.

Activity data for calculating CO_2, CH_4 and N_2O emissions from incineration is collected from EtEA. Activity data on the amount of waste incineration without energy recovery is based on the company reports and is revised by EERC to ensure the quality of the data. Activity data on the amount of waste open burned is based on the expert judgement given by MoE. Activity data on the population of Estonia is obtained from the dataset of SE. Composition of municipal solid waste incinerated is based on the waste composition from the Municipal Solid Waste Sorting Studies of 2000, 2008 and 2013.

Activity data for calculating CH_4 emissions from Domestic wastewater is based on „The national inventory of wastewater treatment types in low density settlements" by Infragate (2014). The rate of wastewater treated aerobically in 1990–1997 is interpolated based on an expert judgement and the data from years 1998–2014 is obtained from EtEA Water Bureau. Data on population is obtained from the dataset of the SE. The calculation of CH_4 emission from Industrial wastewater is based on the plant specific information gathered from a yeast factory, which is the only industrial facility treating its wastewater anaerobically. For calculating N_2O emission the data on population of Estonia was used as activity data and obtained from the dataset of the SE. The annual per capita protein consumption data was taken from FAO statistical database. The nitrogen in sludge is calculated based on the data obtained from the dataset of the EtEA.

Activity data for calculating CH_4 and N_2O emissions from biogas burnt in a flare is, derived from OSIS. Country-specific emission factors are based on a research which included flared biogas measurements in landfills.

Archiving

All institutions are responsible for archiving the data they collect and the estimates they calculate. But it is necessary to have a central archiving system located at a single location. EERC bears the responsibility of archiving and Estonia's central inventory archive is located there.

1.4. Brief general description of methodologies and data sources used

1.4.1. GHG inventory

The methodologies used for the Estonia's greenhouse gas inventory are consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006). Detailed descriptions of the methodologies used can be found in the sectoral Chapters 3 to 8.

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

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

IPCC category	Methodology	Emission factor	Activity data
1. Energy	IPCC 2006	IPCC 2006	Statistics Estonia and energy companies (Eesti Energia AS, Viru Keemia Grupp AS, Kiviõli Keemiatööstuse OÜ), Estonian Environment Agency (EtEA)
A. Fuel combustion	T1, T2, T3	D, CS, PS	National Energy Balances and Annual Yearbooks and the statistical data base of Statistics Estonia; data of energy companies, waste fuel data from EtEA
A.1. Energy industries	T1, T2, T3	D, CS, PS	National Energy Balances and Annual Yearbooks and the statistical data base of Statistics Estonia; data of energy companies
A.2. Manufacturing industries and construction	T1, T2, T3	D, CS, PS	National Energy Balances and Annual Yearbooks and the statistical data base of Statistics Estonia; data on waste fuels from EtEA
A.3. Transport	T1, T2, T3	D, CS	National Energy Balances and Annual Yearbooks and the statistical data base of Statistics Estonia; data on aviation and road transport fuels and corresponding GHG emission estimations from EtEA
A.4. Other sectors	T1, T2	D, CS	National Energy Balances from the statistical data base of Statistics Estonia
A.5. Other	T1, T2	D, CS	National Energy Balances from the statistical data base of Statistics Estonia

IPCC category	Methodology	Emission factor	Activity data
B. Fugitive emissions	T1	D	National Energy Balances from the statistical data base of Statistics Estonia
2. Industrial processes and product use	IPCC 2006	IPCC 2006	Statistics Estonia; plant specific data; national and international companies; associations; public institutions
A. Mineral industry	T1, T2, T3	D, PS	Statistics Estonia; plant specific data
B. Chemical industry	T3	PS	Statistics Estonia; plant specific data
D. Non-energy products from fuels and solvent use	T1,T2,D	D	Statistics Estonia, Estonian Environmental Agency
F. Product uses as substitutes for ODS	T2	CS	National and international companies; associations; public institutions
G. Other product manufacture and use	T2, T3	CS	National and international companies
3. Agriculture	IPCC 2006	IPCC 2006	Statistics Estonia, National Forest Inventory, Estonian Environment Agency, plant specific data, Estonian Agricultural Board, Estonian Animal Recording Centre
A. Enteric fermentation	D, T1, T2	D, CS, OTH	Statistics Estonia, Estonian Animal Recording Centre
B. Manure management	D, T1, T2	D, CS	Statistics Estonia
D. Agricultural soils	D, T1, T2, CS	D	Statistics Estonia, National Forest Inventory; Estonian Environment Agency
G. Liming	D, T1	D	Statistics Estonia, Estonian Agricultural Board
H. Urea application	T1	D	Statistics Estonia, plant specific data, Estonian Agricultural Board
4. LULUCF	IPCC 2006	IPCC 2006	National Forest Inventory (Estonian Environment Agency); Statistics Estonia; Estonian Rescue Service; Ministry of Rural Affairs
A. Forest land	T1, T2	D, OTH	National Forest Inventory; Estonian Rescue Service
B. Cropland	T1, T2	D	National Forest Inventory; Ministry of Rural Affairs; Statistics Estonia
C. Grassland	T1, T2	D, OTH	National Forest Inventory; Estonian Rescue Service
D. Wetlands	T2	D, CS, OTH	National Forest Inventory; Estonian Rescue Service
E. Settlements	T2	OTH	National Forest Inventory
F. Other land	T2	OTH	National Forest Inventory
G. Harvested wood products	T2, T3	D, CS	National Forest Inventory, Statistics Estonia
5. Waste	IPCC 2006	IPCC 2006	Estonian Environment Agency; Statistics Estonia
A. Solid waste disposal	T2	D	Estonian Environment Agency; Statistics Estonia
B. Biological treatment of solid waste	T1	D	Estonian Environment Agency
C. Incineration and open burning of waste	T1, T2	D	Estonian Environment Agency

IPCC category	Methodology	Emission factor	Activity data
D. Wastewater treatment and discharge	T1	D	Estonian Environment Agency; Statistics Estonia
E. Other	T2	CS	Plant specific data

T1 – IPCC Tier 1; T2 – IPCC Tier 2; T3 – IPCC Tier 3; CS – Country specific; D – IPCC default value, PS – Plant specific

1.4.2. KP-LULUCF inventory

Estonia implements Reporting Method 1, approach 2 based on the National Forest Inventory sampling grid for tracking land-use changes and land subject to activities under Article 3.3 and FM under Article 3.4. The area of Estonia is not divided into regions.

Information on the IPCC land use and land-use change categories for each sample plot is presented in the forest inventory database. The annual land-use change areas were calculated for 1990–2015. Land-use matrix was developed by adding and subtracting the transition areas to and from land-use category areas.

Area and the volume of growing stock and dead wood of ARD activities is obtained from the NFI. The area of deforestation is also based on NFI data and is equivalent to the area of forest land converted to other land uses under the UNFCCC reporting. CO_2 emissions due to biomass loss related to deforestation are estimated assuming that the volume of growing stock on deforested area is the same as under the forest land remaining forest land category in the UNFCCC reporting.

1.5. Brief description of key categories

1.5.1. GHG inventory

Key categories are the categories of emissions/removals, which have a significant influence on the total inventory in terms of the absolute level of emissions (1990 or 2015), the trend of emissions (change between 1990 and 2015) or both. There are two alternative methods for identifying key categories: Tier 1 and Tier 2. In this report Tier 1 and Tier 2 method have been used. The results are presented in Table 1.3 and Annex 1.

Table 1.3. Summary overview of Tier 1 and Tier 2 key categories

IPCC source category	Gas	Tier 1						Tier 2					
		Criteria identification (without LULUCF)			Criteria identification (with LULUCF)			Criteria identification (without LULUCF)			Criteria identification (with LULUCF)		
		Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend
1.A.1.a Energy Industries/Public Electricity and Heat Production - Biomass	N2O			x			x			x			
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO2	x	x	x	x	x	x	x		x			
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	x	x	x	x	x	x	x		x	x		x
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO2		x	x		x	x		x	x		x	x
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CO2	x	x	x	x	x	x						
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	x	x		x	x	x	x	x		x	x	x
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CO2		x	x		x	x		x	x		x	x
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	CO2	x		x	x		x						
1.A.2.c Manufacturing Industries and Construction/Chemicals - Liquid Fuels	CO2			x			x						
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CO2	x		x	x		x	x		x	x		x
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Gaseous Fuels	CO2			x									
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	CO2	x		x	x								
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Liquid Fuels	CO2	x		x									
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CO2		x	x		x	x		x	x		x	x
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	x	x	x	x	x	x	x	x	x	x	x	x
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CO2	x	x	x	x	x	x						
1.A.2.g Manufacturing Industries and Construction/Other - Solid Fuels	CO2			x									
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	x	x	x	x	x	x		x	x		x	x
1.A.3.c Transport/Railways - Liquid Fuels	CO2	x	x			x							
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	CO2		x	x		x	x						
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	CO2		x	x		x	x						

IPCC source category	Gas	Tier 1						Tier 2					
		Criteria identification (without LULUCF)			Criteria identification (with LULUCF)			Criteria identification (without LULUCF)			Criteria identification (with LULUCF)		
		Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend
1.A.4.b Other Sectors/Residential - Biomass	N2O			x					x	x			x
1.A.4.b Other Sectors/Residential - Biomass	CH4		x	x		x	x	x	x	x		x	x
1.A.4.b Other Sectors/Residential - Gaseous Fuels	CO2		x	x		x	x						
1.A.4.b Other Sectors/Residential - Liquid Fuels	CO2	x	x	x	x	x	x						
1.A.4.b Other Sectors/Residential - Peat	CO2	x		x	x		x	x		x	x		x
1.A.4.b Other Sectors/Residential - Solid Fuels	CO2	x		x	x		x	x		x	x		x
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	CO2	x	x	x	x	x	x			x			
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	N2O			x									
2.A.1 Cement production	CO2	x	x		x	x							
2.A.2 Lime production	CO2		x	x		x							
2.B.1 Ammonia production	CO2	x		x	x		x						
2.F.1.a Commercial Refrigeration	HFC		x	x		x	x			x			
2.F.1.c Industrial Refrigeration	HFC		x	x		x	x			x			
2.F.1.d Refrigerated Vehicles	HFC			x									
2.F.1.d Refrigerated Vehicles	HFC						x						
2.F.1.e Mobile Air-Conditioning - Passenger cars	HFC			x			x						
2.F.1.e Stationary and Room Air-Conditioning	HFC			x									
2.F.1.f Stationary and Room Air-Conditioning	HFC						x						
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	x	x		x	x	x	x	x		x	x	
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	x	x	x	x	x		x	x		x	x	
3.B.1.1 Manure Management - Dairy Cattle	CH4			x			x						
3.B.1.1 Manure Management - Dairy Cattle	CH4												
3.B.2.5 Indirect N2O Emissions from Manure Management	N2O							x	x		x	x	
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	x	x	x	x	x	x	x	x	x	x	x	x
3.D.1.2a Direct Soil Emissions - Animal Manure Applied to Soils	N2O		x			x		x	x		x	x	
3.D.1.2c Direct Soil Emissions - Compost Applied to Soils	N2O								x	x			x

IPCC source category	Gas	Tier 1						Tier 2					
		Criteria identification (without LULUCF)			Criteria identification (with LULUCF)			Criteria identification (without LULUCF)			Criteria identification (with LULUCF)		
		Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N_2O	x	x		x	x		x	x	x	x	x	
3.D.1.4 Direct Soil Emissions - Crop Residue	N_2O	x	x	x	x	x	x	x	x	x	x	x	x
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N_2O		x	x		x	x	x	x	x	x	x	x
3.D.2.1 Indirect Emissions - Atmospheric Deposition	N_2O		x					x	x	x	x	x	x
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N_2O	x	x	x	x	x	x	x	x	x	x	x	x
4.A.1. Forest Land remaining Forest Land - dead wood	CO_2				x	x	x						
4.A.1. Forest Land remaining Forest Land - living biomass	CO_2				x	x	x				x	x	x
4.A.1. Forest Land remaining Forest Land - mineral soils	CO_2				x	x	x				x	x	x
4.A.1. Forest Land remaining Forest Land - organic soils	CO_2				x	x	x				x	x	x
4.A.2.1. Cropland converted to Forest Land - dead wood	CO_2					x	x						
4.A.2.1. Cropland converted to Forest Land - mineral soil	CO_2					x							
4.A.2.1. Cropland converted to Forest Land - mineral soil	CO_2						x					x	x
4.A.2.2. Grassland converted to Forest Land - dead wood	CO_2					x	x						
4.A.2.2. Grassland converted to Forest Land - living biomass	CO_2					x	x					x	x
4.A.2.2. Grassland converted to Forest Land - mineral soils	CO_2						x						x
4.B.1 Cropland remaining Cropland - mineral soils	CO_2				x	x	x				x	x	x
4.B.1 Cropland remaining Cropland - organic soils	CO_2				x	x	x				x	x	x
4.B.2.2 Grassland converted to Cropland - mineral soils	CO_2					x	x						x
4.B.2.2 Grassland converted to Cropland - organic soils	CO_2						x					x	x
4.C.1 Grassland remaining Grassland – organic soils	CO_2					x	x						
4.C.2 Land converted to Grassland – mineral soils	CO_2					x	x					x	x
4.C.2 Land converted to Grassland – living biomass (excl. FL)	CO_2						x						
4.C.2 Land converted to Grassland – organic soils	CO_2					x	x					x	x
4.C.2.1 Forest Land converted to Grassland - dead wood	CO_2						x						
4.C.2.1 Forest Land converted to Grassland - living biomass	CO_2					x	x					x	x
4.D.1 Wetlands remaining Wetlands\Peatland - organic soils managed for peat extraction CO2	CO_2				x	x	x				x	x	x
4.E.2.1 Forest Land converted to Settlements – deadwood	CO_2					x	x						

IPCC source category	Gas	Tier 1						Tier 2					
		Criteria identification (without LULUCF)			Criteria identification (with LULUCF)			Criteria identification (without LULUCF)			Criteria identification (with LULUCF)		
		Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend	Level 1990	Level 2015	Trend
4.E.2.1 Forest Land converted to Settlements – living biomass	CO2					x	x						x
4.E.2.1 Forest Land converted to Settlements (min+org soils)	CO2					x	x						x
4.E.2.2 Cropland converted to Settlements - soils	CO2					x	x						x
4.E.2.3 Grassland converted to Settlements - soils	CO2					x	x						x
Semi-Chemical wood pulp	CO2						x						x
Wood panels and sawnwood	CH4					x	x					x	x
5.A Solid waste disposal	CH4	x	x	x	x	x	x	x	x	x	x	x	x
5.B.1 Composting	CH4			x						x			
5.D.1 Domestic wastewater	N2O			x					x	x		x	
5.D.1 Domestic wastewater	CH4		x			x		x	x			x	
5.E Other (Biogas Burnt in a flare)	CH4			x			x						

1.5.2. KP-LULUCF inventory

Key category analysis for KP-LULUCF was performed according to chapter 2.3.6 of the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol. The basis for the assessment of key categories under Article 3.3 and Article 3.4 of the KP is the same as the assessment made for the UNFCCC inventory. The key categories are CO2 removals due to Afforestation/reforestation, CO2 emissions from Deforestation and CO2 removals due to Forest management.

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

1.6.1. GHG inventory

This section provides an overview of the approach to uncertainty analysis adopted for Estonia's inventory. The mandatory reporting table of the analysis is presented in Annex 2.

The uncertainty estimate of the 2017 inventory has been done according to the Tier 1 method presented by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006). Tier 1 method combines the uncertainty in activity rates and emission factors, for each source category and greenhouse gas, and then aggregates these uncertainties, for all source categories and greenhouse gases, to obtain the total uncertainty for the inventory.

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

Uncertainties are estimated for direct greenhouse gases, e.g. CO_2, CH_4, N_2O and F-gases. The uncertainty analysis was done for the sectors: Energy, Industrial processes and product use, Agriculture, LULUCF and Waste sector.

Compared to the 2016 submission there were corrections made for emissions factor uncertainty values in the LULUCF and Waste sector.

Table 1.4 shows the estimated uncertainties for total greenhouse gas emissions in 2015 and the trend (with and without LULUCF).

Table 1.4. Inventory uncertainties in 2015

	Combined as % of total national emissions in 2015	Introduced into the trend in total national emissions
	Uncertainty [%]	
Without LULUCF	5.05	1.81
With LULUCF	11.65	4.16

1.6.2. KP-LULUCF inventory

Tier 2 was implemented for estimating uncertainty rates related to activity data and emission factors employed in the estimates under Article 3.3. and Article 3.4 activities (Chapter 11.3.1.5).

1.7. General assessment of completeness

1.7.1. GHG inventory

Estonia has provided estimates for all significant IPCC source and sink categories according to the detailed CRF classification. Estimates are provided for the following gases: CO_2, N_2O, CH_4, F-gases (HFC, PFC, SF_6 and NF_3[4]), NMVOC, NOx, CO and SO_2.

Assessment of completeness is presented in Annex 5.

The geographical coverage of the inventory is complete.

1.7.2. KP-LULUCF inventory

Estonia provides emission/removal estimates for all required carbon pools: above- and below-ground biomass, litter, dead wood, mineral and organic soils and biomass burning (CH4, N2O) for ARD and FM activities.

Estonia does not separate gains and losses (a net change is reported) for living biomass estimates, since it is not feasible due to the stock-change method used.

[4] NF_3 emissions do not occur in Estonia.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

2.1. Description and interpretation of aggregated GHG emission trends

This chapter provides the trends in GHG emissions and removals by sinks in Estonia for the years 1990–2015.

The GHGs covered are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), nitrogen trifluoride (NF_3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Emission estimates for nitrogen oxides (NOx), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2) are also included in the inventory.

Estonia's base year for calculating the emissions of CO_2, CH_4, N_2O and fluorinated gases is 1990[5].

Total emissions of the greenhouse gases in Estonia (without LULUCF) decreased steadily from 40 402.74 kt CO_2 eq. in 1990 to 18 040.48 kt CO_2 eq. in 2015 (Figure 2.1). From 1990 to 2015 the GHG emissions decreased by 55.3%. This decrease was mainly caused by the transition from a planned economy to a market economy and the successful implementation of the necessary reforms.

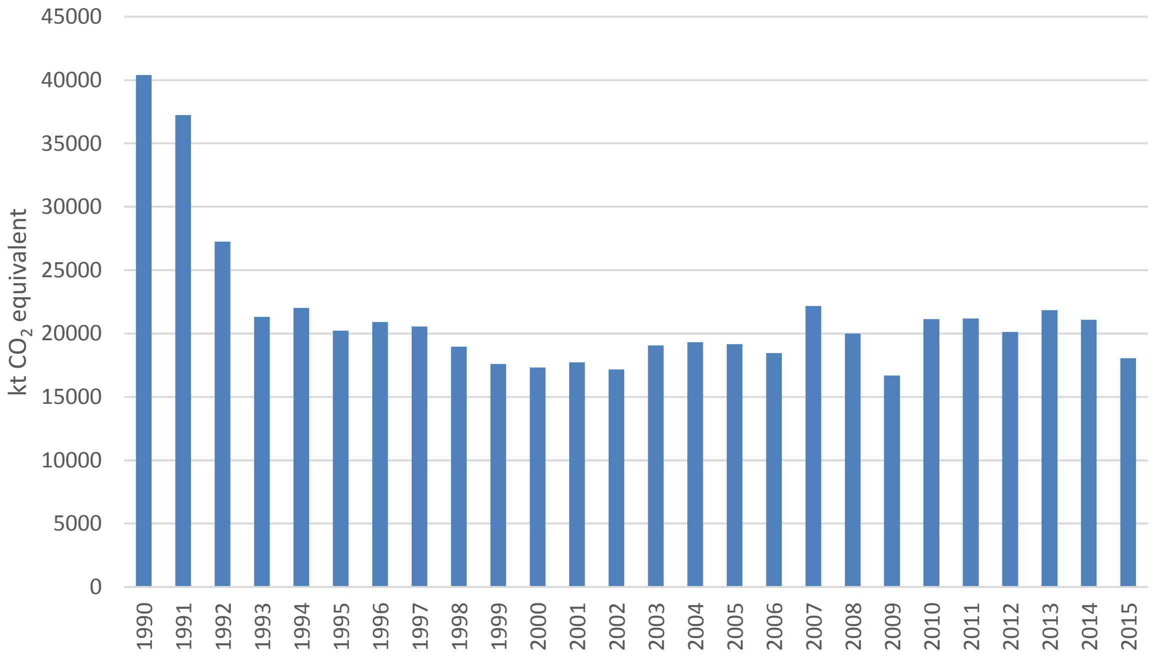

Figure 2.1. Overall development of greenhouse gases in Estonia, without LULUCF, kt CO_2 eq.

In 2015, the main GHG in Estonia was carbon dioxide (CO_2), accounting for 88.1% of the total GHG emissions (with indirect CO_2 and without LULUCF) expressed in CO_2 eq., followed by

[5] Estonia's base year for F-gases under the Kyoto Protocol is 1995 (and for NF_3).

methane (CH_4) on 5.9% and nitrous oxide (N_2O) on 4.8%. Fluorinated gases (the so-called 'F-gases') collectively accounted for about 1.2% of overall GHG emissions (Figure 2.2).

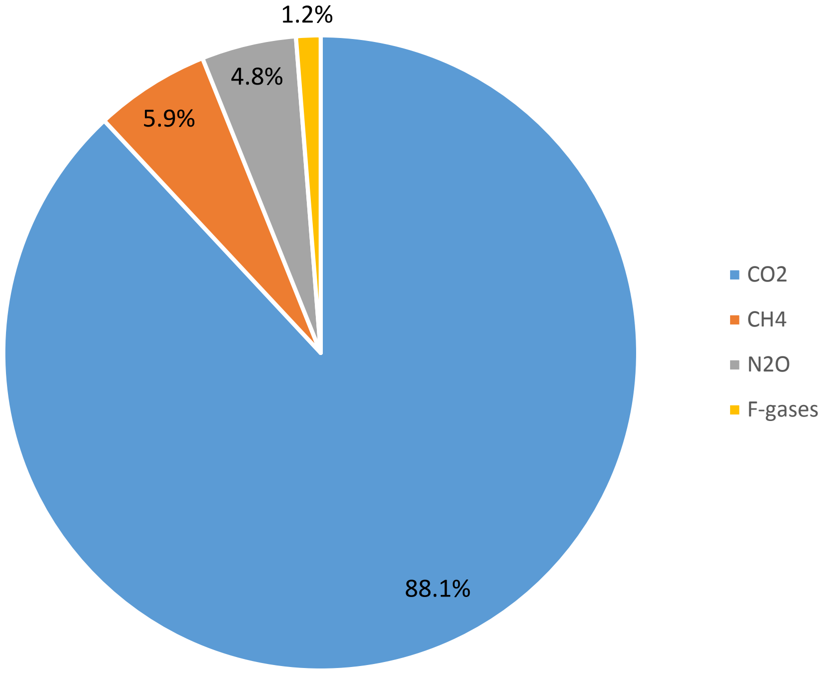

Figure 2.2. GHG emissions by gas in 2015, %

Figure 2.3 shows GHG emission trends by gas in 1990 to 2015. Emissions of CO_2 (with indirect CO_2) decreased by 57.2% from 37 069.22 kt in 1990 to 15 885.37 kt in 2015, especially CO_2 emissions from Energy sub-sector Public electricity and heat production, which is the major source of CO_2 in Estonia.

Methane is the second most significant contributor to greenhouse gas emissions in Estonia after CO_2. Emissions of CH_4 decreased by 44.5% from 1 909.61 kt CO_2 eq. in 1990 to 1 059.09 kt CO_2 eq. in 2015, the downturn was especially noticeable in the Agriculture sub-sector Enteric fermentation, which is a major source of CH_4 in Estonia.

Emissions of N_2O decreased by 38.3% from 1 423.92 kt CO_2 eq. in 1990 to 870.96 kt CO_2 eq. in 2015, especially N_2O emissions from Agriculture sub-sector Agricultural soils, which is the main contributor of N_2O emissions in Estonia.

Emissions of the F-gases (HFCs, PFCs and SF_6) increased from 0 kt CO_2 eq. in 1990 to 225.07 kt CO_2 eq. in 2015, especially HFC emissions from Refrigeration and air conditioning, which is the major source of halocarbons in Estonia. A key driver behind the growing emission trend in Refrigeration and air conditioning sector has been the substitution of ozone depleting substances with HFCs. The second largest source is Foam blowing agents which showed relatively steady increase of emissions until 2007. In 2001 one of two big Estonian producers of one component foam replaced HFC-134a with HFC-152a, followed by the other producer starting from 2007. Due to much lower GWP of HFC-152a the emissions decreased suddenly in the corresponding years.

NF_3 emissions do not occur in Estonia.

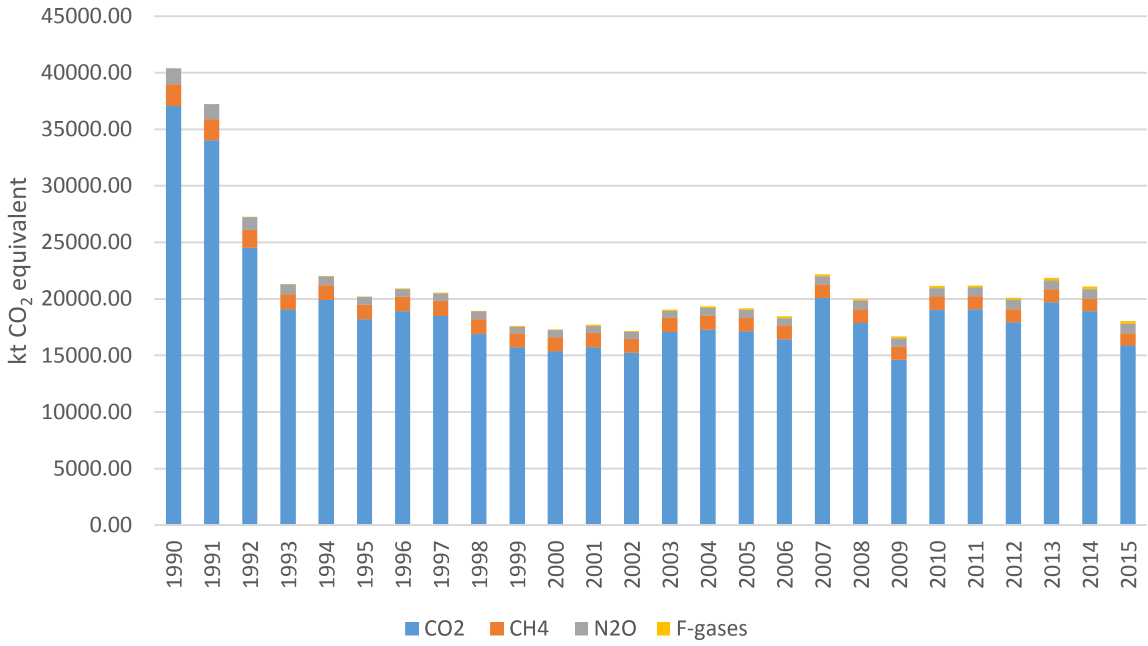

Figure 2.3. Estonia's greenhouse gas emissions by gas 1990–2015 (without LULUCF), kt CO_2 eq.

2.2. Description and interpretation of emission trends by sector

Greenhouse gas emissions broken down by IPCC sector are presented in Figure 2.4. It can be clearly seen that the largest contribution is Energy sector, which in 2015 contributes 87.93% of total greenhouse gas emissions (excl. LULUCF). The second largest sector is Agriculture, which accounted for 7.41% of the total emissions in 2015. Emissions from Industrial processes and product use and Waste sectors accounted 2.84% and 1.81%, respectively of total emissions in 2015.

Over the period 1990–2015, emissions from Energy sector decreased by 56.4%, emissions from Industrial processes and product use sector decreased by 46.9% and emissions from Agriculture sector decreased by 49.9%. Emissions from Waste sector decreased by 11.9%. Reported net CO_2 removals on Land use, land use change and forestry sector increased by 36.0% between 1990 and 2015. See Figure 2.4 Greenhouse gas emission trends, by sectors, in CO_2 eq.

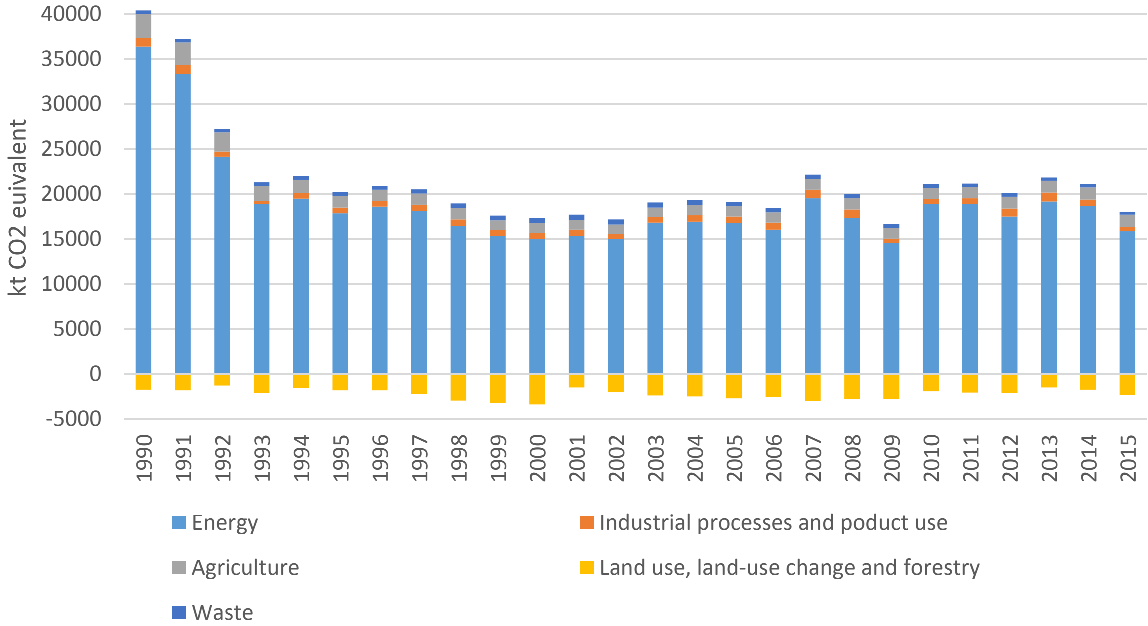

Figure 2.4. Greenhouse gas emission trends, by sectors, kt CO_2 eq.

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

2.2.1. Trends in Energy (CRF 1)

Estonia's emissions from the Energy sector are divided into the following categories: Fuel combustion, including Energy industries; Manufacturing industries and construction; Transport; Other sectors; Other; and Fugitive emissions from fuels. The share of emissions by category is presented in Figure 2.5.

The Energy sector is the main source of GHG emissions in Estonia. In 2015 the sector contributed 87.9% of all emissions, totalling 15 863.86 kt CO_2 equivalent. 99.9% of emissions in the sector originated from fuel combustion – just 0.1% were from fugitive emissions.

Energy related CO_2 emissions varied mainly in relation to the economic trend, the energy supply structure and climate conditions. The decrease of GHG emissions between 1990 and 1993 is related to major structural changes in the economy after Estonia regained its independence from the Soviet Union. A small increase of emissions in 1994 is related to the growing energy demand in the transport sector. After that the emissions from the Energy sector were quite steady (slight decrease until 2002). In 2003 the emissions increased mainly due to the export of the oil shale based electricity. The big increase of emissions between 2006 and 2007 is related to the overall economic upturn and the decrease of emissions between 2007 and 2009 to the overall economic downfall. Since 2009 the GHG emissions are strongly related to the volume of exported electricity that is mainly produced from oil shale.

Emissions from the Energy sector decreased by 56.4% compared to 1990 (incl. Energy industries – 58.2%; Manufacturing industries and construction – 80.1%; Transport – 6.2%; Other sectors – 62.6%; Other – 38.3% and Fugitive emissions from fuels – 69.1%). This major decrease was caused by structural changes in the economy after 1991 when Estonia regained its independence. There has been a drastic decrease in the consumption of fuels and energy in energy industries (closing of factories), agriculture (reorganisation and dissolution of collective farms), transport (the proportion of new and environmentally friendly cars has increased and the number of agricultural machines has decreased), households (energy saving) etc. The overall progression of GHG emissions in the Energy sector in CO_2 equivalent is presented in Figure 2.5.

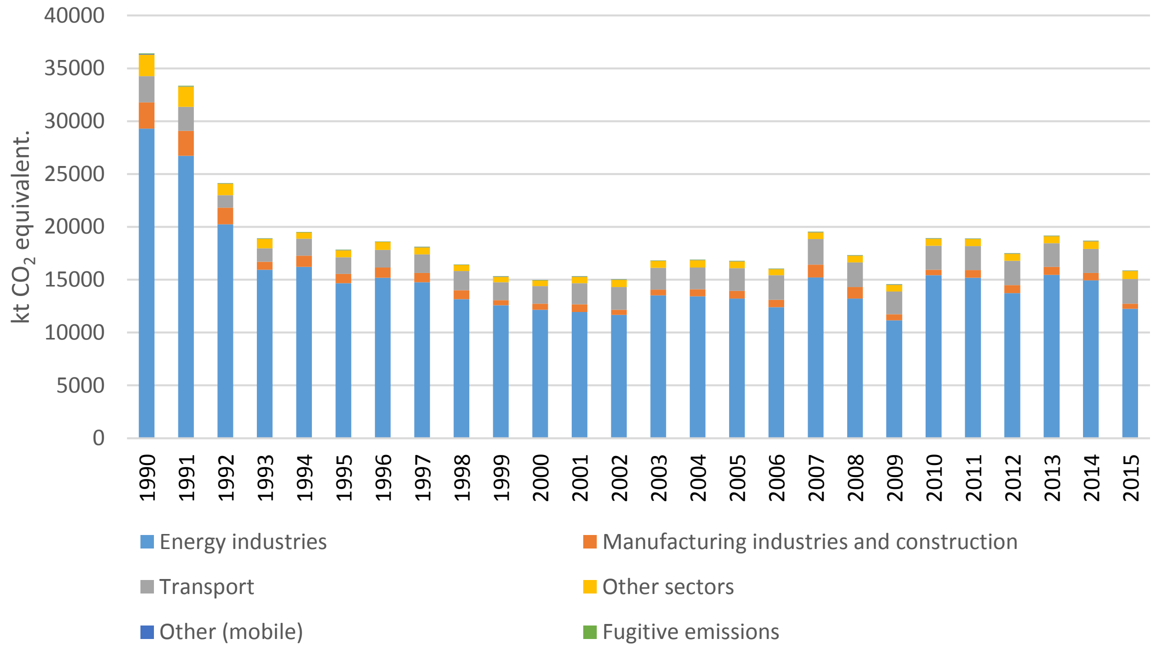

Figure 2.5. Trend in emissions from Energy sector 1990–2015, kt CO_2eq.

2.2.2. Trends in Industrial processes and product use (CRF 2)

Estonia's GHG emissions from the Industrial processes and product sector are divided into the following categories:

- Mineral industry (emissions from cement, lime, glass production and other process uses of carbonates);
- Chemical industry (historically ammonia and carbamide were produced);
- Non-energy products from fuels and solvent use (CO_2 emissions from lubricant and paraffin wax use and urea based catalysts for motor vehicles, as well as NMVOC emissions from solvent use and road paving with asphalt);
- Product uses as substitutes for ODS (HFC emissions from refrigeration and air conditioning, foam blowing, fire protection and aerosols);
- Other product manufacture and use (SF_6 emissions from electrical equipment, SF_6 and PFC emissions from other product use and N_2O emissions from product uses).

Additionally Estonia reports indirect CO_2 emissions calculated from NMVOC emissions from CRF category 2.D.3.

The share of emissions by category in CO_2 eq. is presented in Figure 2.6.

In 2015 the Industrial processes and product use sector contributed 2.84% of all GHG emissions in Estonia, totalling 512.92 kt CO_2 eq. with indirect CO_2 (and 497.04 kt CO_2 eq. without indirect CO_2). The most significant emission sources were CO_2 emissions from cement production at 40%, and HFC emissions from refrigeration and air conditioning at 43% of total emissions from the sector (with indirect CO_2). Compared to 2014, the emissions from Industrial processes and product use (with indirect CO_2) decreased by 27.5% in 2015. This decrease in emissions is caused temporary lower output of mineral industry because of economic slowdown.

Industrial CO_2 emissions have fluctuated strongly since 1990, reaching their lowest level in 1993. The decrease in emissions during the early 1990s was caused by the transition from a planned economy to a market economy after 1991 when Estonia regained its independence. This led to lower industrial production and to an overall decrease in emissions from industrial processes between 1991 and 1993. In 1994 the economy began to recover and production increased. The decrease in emissions in 2002 and 2003 was caused by the reduction in ammonia production, as the only ammonia factory in the country was being reconstructed. The sudden increase in emissions in 2007 was mainly caused by an increase in cement production, as the only cement factory renovated its third kiln. In 2009 the industrial processes sector was affected by the recession. Decline in production was mainly due to insufficient demand on both the domestic and external markets. Increase in 2011 emissions was caused by increase of cement production. CO_2 emissions raised in 2012 and 2013, because a power plant temporarily used large amounts of limestone for flue gas desulphurisation.

The overall progression of GHG emissions in the Industrial processes and product use sector in CO_2 eq. is presented in Figure 2.6.

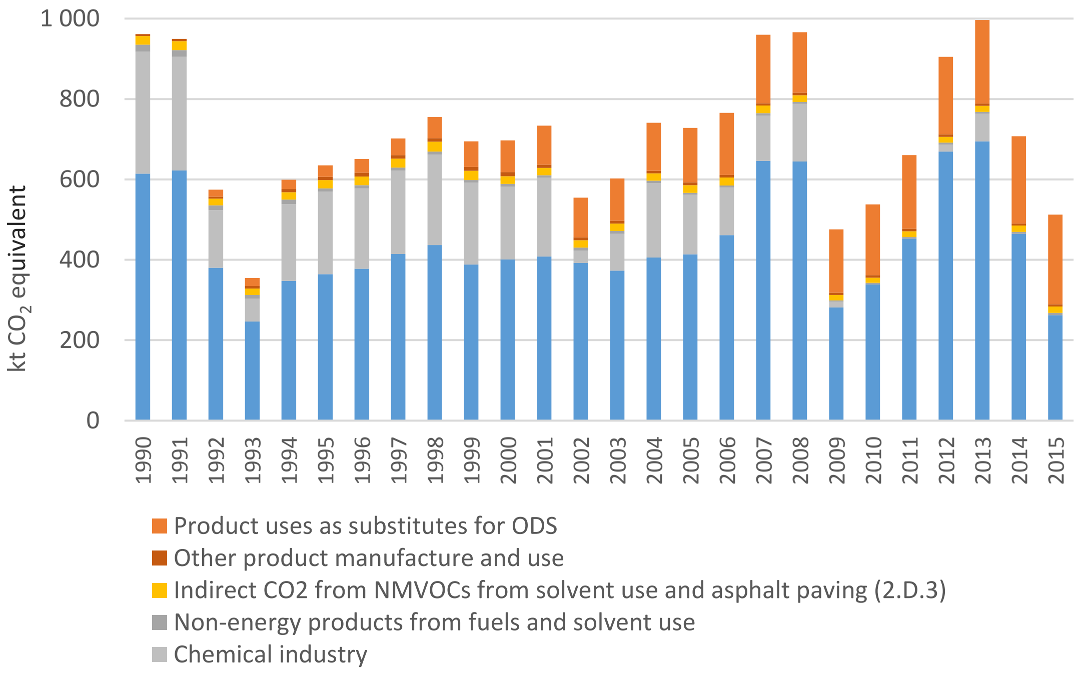

Figure 2.6. Trend in emissions from Industrial processes and product use sector, 1990–2015, kt CO_2 eq.

2.2.3. Trends in Agriculture (CRF 3)

Agricultural GHG emissions in Estonia consist of CH_4 emissions from Enteric fermentation of domestic livestock, N_2O emissions from Manure management systems, direct and indirect N_2O emissions from Agricultural soils, CO_2 emissions from Liming and Urea application to agricultural soils. Direct N_2O emissions include emissions from synthetic fertilizers, emissions from animal waste, compost and sludge applied to agricultural soil, emissions from crop residues and cultivation of organic soils and emissions from urine and dung deposited by grazing animals. Indirect N_2O emissions include emissions due to atmospheric deposition and leaching and run-off. The trend in emissions in CO_2 eq. by category is presented in Figure 2.7.

The total GHG emissions reported in the Agricultural sector of Estonia were 1 337.6 kt CO_2 eq. in 2015. The sector contributed about 7.4%[6] to the total CO_2 eq. emissions in Estonia (Figure 2.4). In 2015 the emissions from enteric fermentation decreased 3.5% and from manure management 6.8% compared to the previous year due to a fall in the numbers of dairy cattle and swine. The dairy industry has suffered a decline in production due to economic sanctions imposed by Russia on EU starting from August 2014. Consequently the number of dairy cattle in 2015 dropped 5.2% in comparison with 2014. The number of swine has fallen 16% in Estonia as a result of the outbreak of African swine fever in the region in 2015.

Emissions from agricultural soils and enteric fermentation of livestock were the major contributors to the total emissions recorded in the sector – 48% and 40% respectively.

As a result of the markets of the former Soviet Union collapsing in the early 1990's, Estonia was left with a large excess supply of agricultural produce. Western markets remained closed to Estonian agricultural products, mostly for two reasons – high customs barriers and non-compliance of our products with the requirements and practices abroad. Producer prices in Estonia fell to a level up to 50% lower than prices on world markets and became insufficient to cover production costs[7]. All of which led to rapid decline of agricultural production in Estonia and which explains why the emissions from the Agricultural sector have declined by 49.9% by 2015 compared with the base year (1990). Between 2002–2008, the most important driving force for Estonian agriculture was the EU accession and the application of accompanying supporting EU's common agricultural policy which significant effect appeared a few years before joining[8]. The positive impact on the agricultural production manifested years preceding the EU accession, is reflected in the turnover of a downward GHG emissions trend that began in the 1990's.

The overall progression of GHG emissions in the Agriculture sector is presented in Figure 2.7.

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[6] GHG emissions related to LULUCF sector are not included.
[7] http://www.estonica.org/en/The_rural_economy_in_Estonia_until_2001/Crisis_in_agriculture_in_the_1990s/.
[8] Estonian Universtity of Life Sciences. (2011). *Maaelu arengu aruanne.*

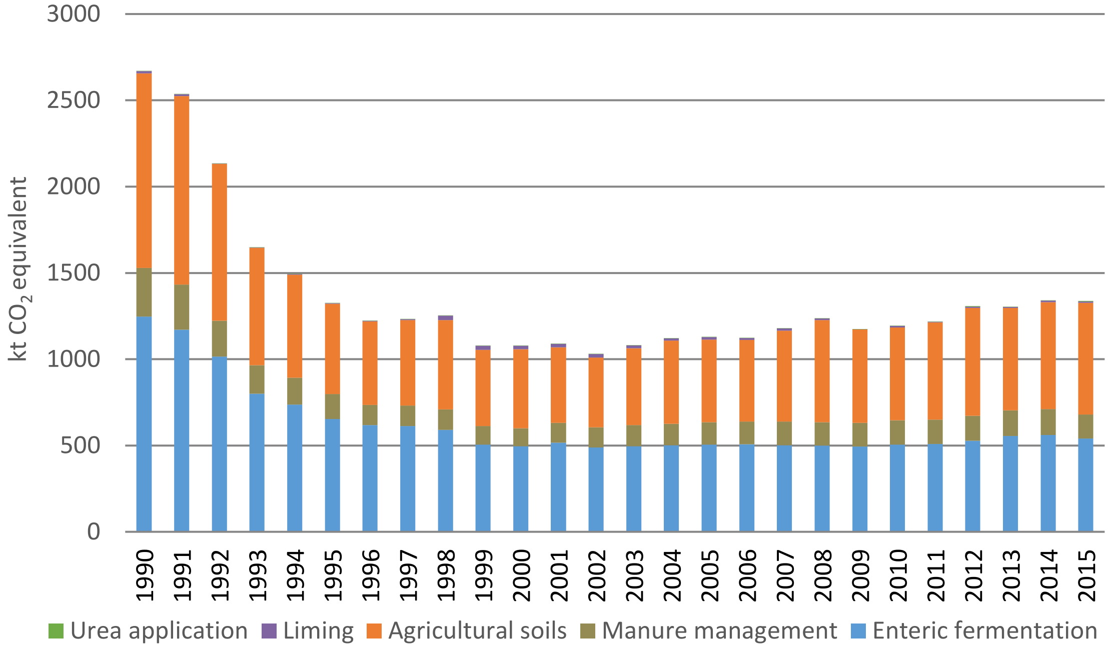

Figure 2.7. Trend in emissions from Agriculture sector, 1990–2015, kt CO_2 eq.

2.2.4. Trends in Land use, land-use change and forestry (CRF 4)

The LULUCF sector, acting as the only possible sink of greenhouse gas emissions in Estonia, plays an important role in the national carbon cycle. Emissions and removals from the LULUCF sector are divided into the following categories: Forest land; Cropland; Grassland; Wetlands (peatland); Settlements; Other land and Harvested wood products (HWP). Each category, except HWP, is further divided into 'land remaining' and 'land converted to' subcategories.

The share of LULUCF sector emissions and removals by each land use category during the time period 1990–2015 is presented in Figure 2.8. In 2015 the LULUCF sector acted as a CO_2 sink, totalling uptake of 2359.2 kt CO_2 equivalent. Compared to the base year (1990), uptake of CO_2 in LULUCF sector has increased by 36% and compared to the previous year (2014), 34.4%. The main driver behind the LULUCF sector sink is harvest rates, expanding settlements area, Harvested wood products and emissions from organic soils. A key driver behind the harvest trend has been the socio-economic situation in Estonia.

The majority of CO_2 removals in the LULUCF sector comes from the biomass increment in forest land remaining forest land and land converted to forest land subcategories. In 2015, forest land and HWP were the only net sink categories.

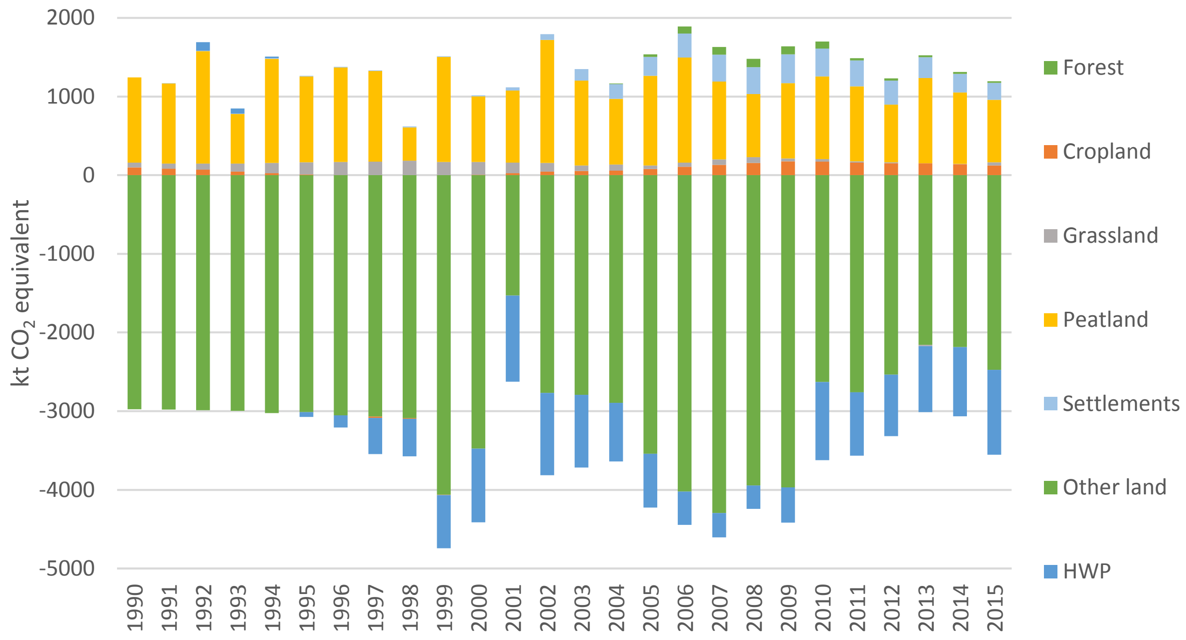

Figure 2.8 Trend in emissions from land use, land-use change and forestry sector 1990–2015, kt CO_2eq.

2.2.5. Trends in Waste (CRF 5)

Estonia's GHG emissions from Waste sector covers solid waste disposal sites which include solid municipal and industrial waste as well as domestic and industrial sludge. The Waste sector also covers GHG emissions which include both CH_4 and N_2O emissions from biogas burnt in a flare waste incineration without energy recovery and open burning of waste, biological treatment of solid waste and wastewater treatment and discharge from domestic and industrial sector. CO_2 emission is reported from non-biogenic incineration without energy recovery. The share of emissions by each category is presented in Figure 2.9.

Compared to the base year of 1990, the amount of CO_2 eq. emission emitted in 2015 is 11.8% lower, compared to 2014, the CO_2 eq. decreased about 4.2%. The total emission from Waste sector has been is in decreasing trend in recent years.

In 2015 Waste sector contributed 1.8% of all GHG emissions, totalling 326.08 kt CO_2 eq. Solid waste disposal is the highest contributed to total emissions in the waste sector in Estonia and is, compared to the base year of 1990, in decreasing trend with 12.4%. CO_2 equvalent emissions emitted from incineration and open burning of waste has decreased about 58.2% and Wastewater treatment and discharge decreased 41.1%. On the other hand, emission from Biological treatment of solid waste has increased 2 113.8%. Burning biogas in a flare is taking place since 1999 and it is connected with the number of active plants. The increase of burning biogas in a flare since 1999 is 1.5%.

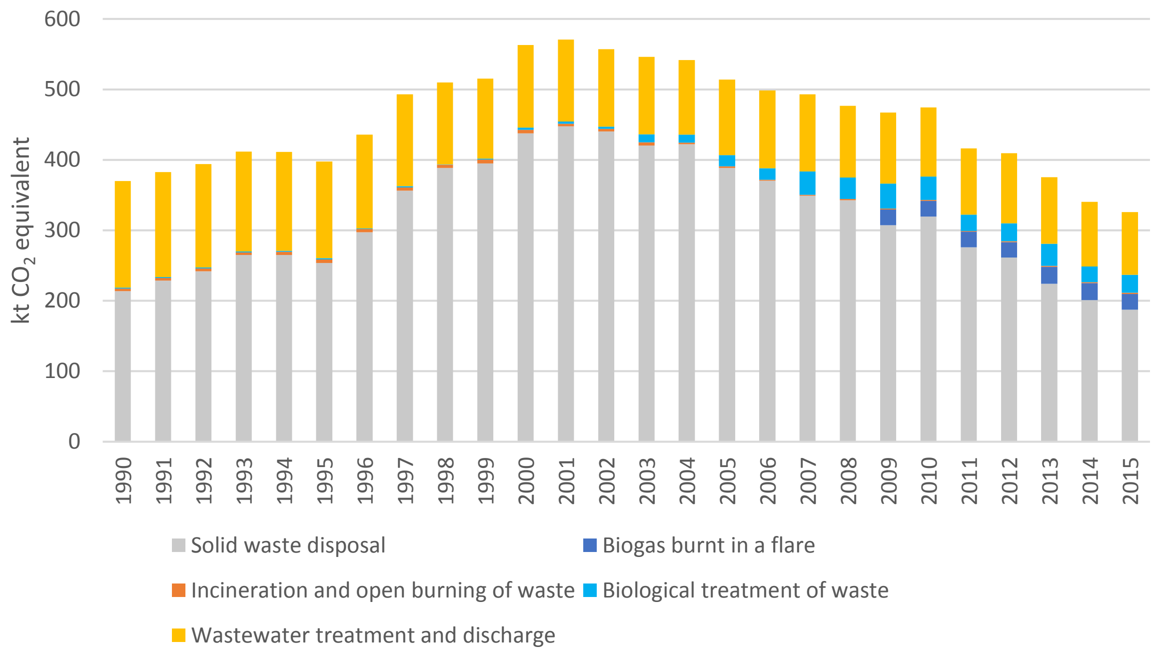

Figure 2.9. Trends of GHG emissions in the waste sector by source categories in 1990–2015, kt CO_2 eq.

As seen from the Figure 2.9 GHG emissions from Waste sector are in decreasing trend. The lowest CO_2 eq. emissions occurred in 2015, which was mainly connected to decreasing amount of waste deposited on landfills. Low CO_2 eq. emissions in 1995 are related to decrease CH_4 emissions originating from paper and sludge disposal. The highest CO_2 eq. emission in 2000–2001 is related to significant increase in emissions mainly from Solid waste disposal. Increasing trend of emission until 2001 is linked to the high amount deposited organics and food waste which were deposited due to low rate of waste sorting. Emissions from waste incineration have been marginal during the whole period compared to other activities involved. The decrease of GHG emissions from Waste sector after 2004 is connected to the increasing amount of CH_4 recovery from landfills. Emission decrease starting from 2008 is connected with the financial crisis during 2007–2008. Financial crisis did not affect the Waste sector immediately, because companies had a prepared raw material reserve. The total CO_2 eq. in 2013 decreased significantly compared to previous years, mainly because of the change in the national currency, which raised prices in the country and therefore reduced consumption habits and waste generation. Also, the opening of Iru waste incineration plant in 2013 had a decreasing effect on the amount of deposited waste trend since 2010.

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

In 2015, Article 3.3 activities were a net source in Estonia. The total net emissions were estimated at 6.81 kt CO_2 eq. Afforestation and reforestation resulted in a net removal of -177.80 kt CO_2 eq. and Deforestation a net emission of 184.61 kt CO_2 eq. (Table ES.3). Areas subject to AR and D were 59 382 and 19 589 ha, respectively by the end of 2015. Forest management, under Article 3.4, was a net sink with total uptake of -2 438.32 kt CO_2 eq (without HWP).

On AR and FM areas, non-CO_2 emissions related to wildfires are estimated (Table 2.1). CO_2 emissions from fires are included in the biomass estimates due to the stock-change method used. On D areas, emissions from wildfires are not provided, since all biomass present on forest land before deforestation is assumed to be lost after the land-use change.

Table 2.1. KP-LULUCF areas (kha) and emissions by gas (kt)

Afforestation/reforestation	**2013**	**2014**	**2015**
Area, kha	59.09	59.35	59.38
CO_2, kt	-147.67	-164.40	-177.80
AR Biomass burning			
Area, kha	0.99	3.17	0.50
CH_4, kt	$1.4 \bullet 10^{-4}$	$1.5 \bullet 10^{-4}$	$1.5 \bullet 10^{-4}$
N_2O, kt	$1.3 \bullet 10^{-6}$	$1.5 \bullet 10^{-6}$	$1.5 \bullet 10^{-6}$
AR total CO_2 eq., kt	-147.67	-164.40	-177.80
Deforestation			
Area, kha	19.09	19.40	19.59
D total CO_2 eq., kt	280.97	210.24	184.61
ARD TOTAL CO_2 kt	133.31	45.84	6.81
Forest management			
Area, kha	2 360.65	2 361.03	2 361.32
CO_2, kt	-2 086.10	-2 148.62	-2 438.32
FM biomass burning			
Area, ha	31.86	52.25	43.78
CH_4, kt	$7.62 \bullet 10^{-5}$	$1.51 \bullet 10^{-3}$	$1.10 \bullet 10^{-4}$
N_2O, kt	$7.50 \bullet 10^{-7}$	$1.48 \bullet 10^{-5}$	$1.08 \bullet 10^{-6}$
FM	-2 086.10	-2 148.58	-2 438.32
FM total with HWP CO_2 eq., kt	-2924.46	-3031.17	-3518.52

3. ENERGY (CRF 1)

3.1. Overview of the sector

The Energy sector is the main source of greenhouse gas emissions in Estonia. In 2015, the Energy sector contributed about 87.9% of total emissions, totalling 15 863.86 kt of CO_2 equivalent (see Figure 3.1). Compared to the base year 1990, the emissions were about 56.4% below that level (36 397.39 kt CO_2 eq.). Most of the Energy sector emissions – 99.9% originate from Fuel combustion and only 0.1% are contributed by Fugitive emissions.

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

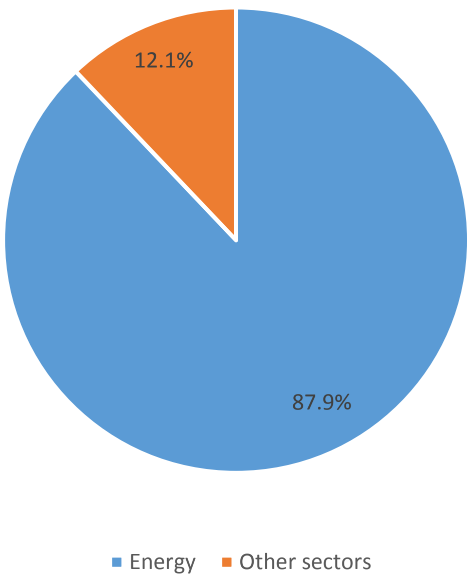

Figure 3.1. Emissions from the Energy sector compared to the total emissions in 2015,%

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

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

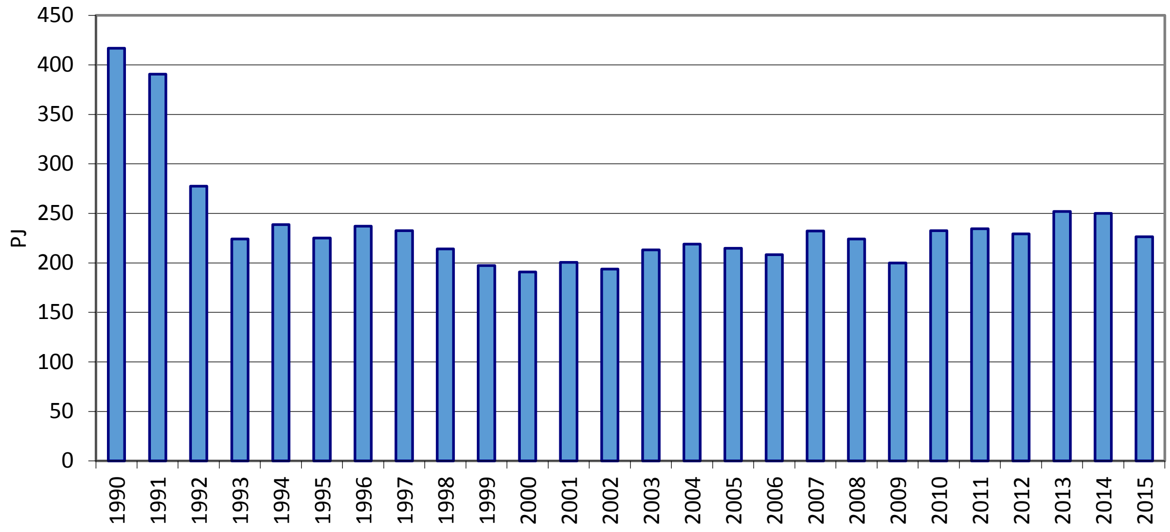

Figure 3.2. Development of total primary energy supply in Estonia in 1990–2015, PJ (Source: Statistics Estonia)

In 2015 the supply of primary energy was 226.2 PJ, of which oil shale formed 71% and wood and municipal wastes together – 16.7%. Other fuels had smaller shares – natural gas 7.0%, oil products 4.5%, peat 0.6% and col 0.4%. The total primary energy supply decreased about 9% in 2015 compared to the previous year (see Figure 3.2).

The structure of primary energy supply in 1990 is presented in Figure 3.3 and the structure of primary energy supply in 2015 is presented in Figure 3.4.

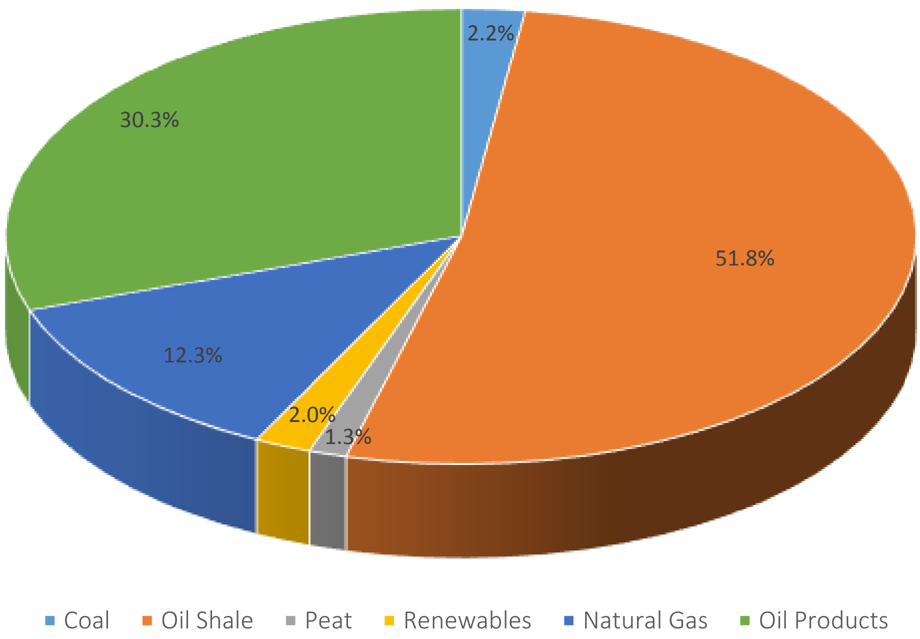

Figure 3.3. Structure of primary energy supply in Estonia in 1990, %

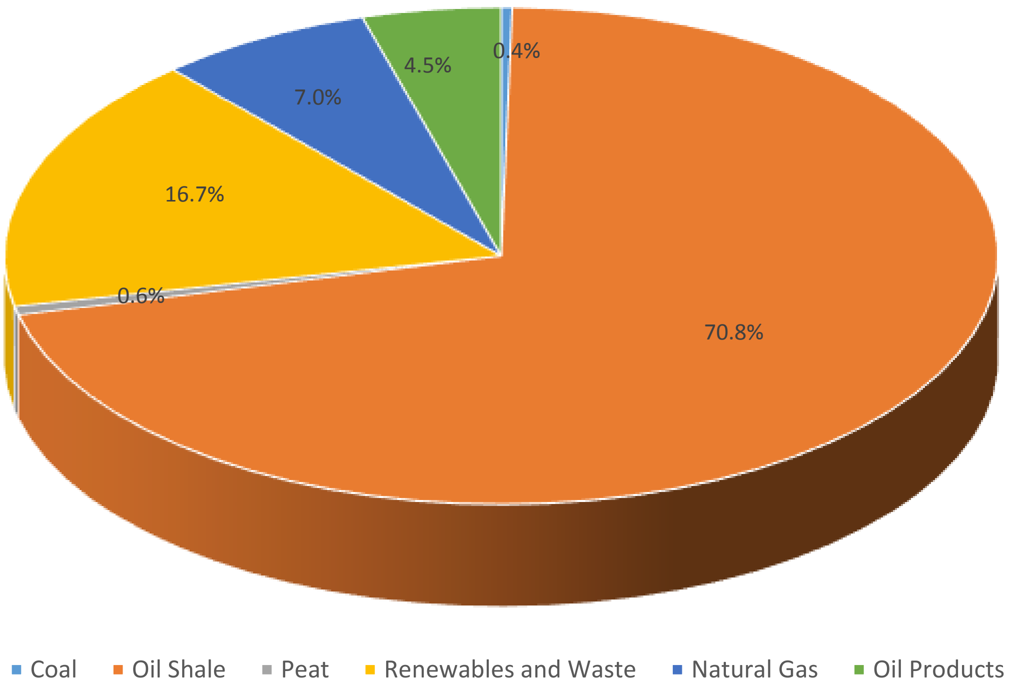

Figure 3.4. Structure of primary energy supply in Estonia in 2015, %

In previous years, Estonia had one of the fastest-growing economies in Europe, but in 2013 the Estonian economy experienced a significant slowdown. The GDP growth in real terms was only 0.8%. In 2014 the GDP of Estonia grew more than in the previous year and its economic growth fastened. The GDP growth in real terms was 2.1%. In 2015 GDP growth has once again slowed down as it was only 1.4%. Final consumption of energy decreased about 0.7% compared to 2014.

Domestic fuels have a large share in Estonia's total energy resources and in the balance of primary energy which is mainly based on oil shale. The majority of oil shale is consumed in power plants and as raw material for shale oil. Biomass is used in boilerhouses and in the residential sector. Natural gas is also used in boilerhouses (Figure 3.4).

Emissions from the Energy sector by subcategory in 1990–2015 are presented in Figure 3.5.

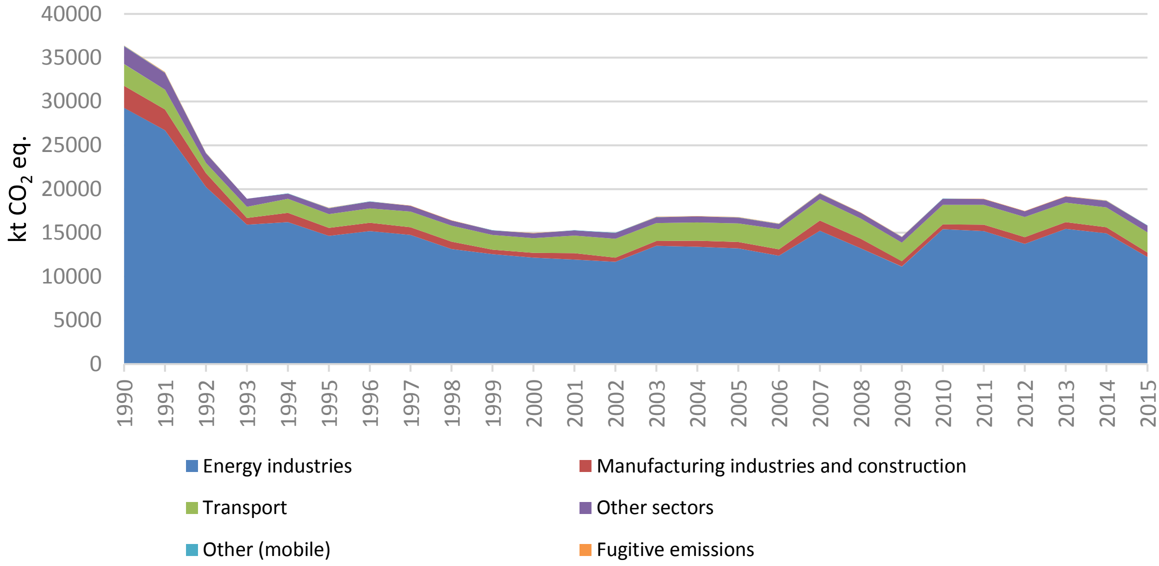

Figure 3.5. Emissions from the Energy sector by subcategory in 1990–2015, kt CO_2 eq.

The trend of fuel consumption in Energy sector in 1990–2015 is presented in Figure 3.6.

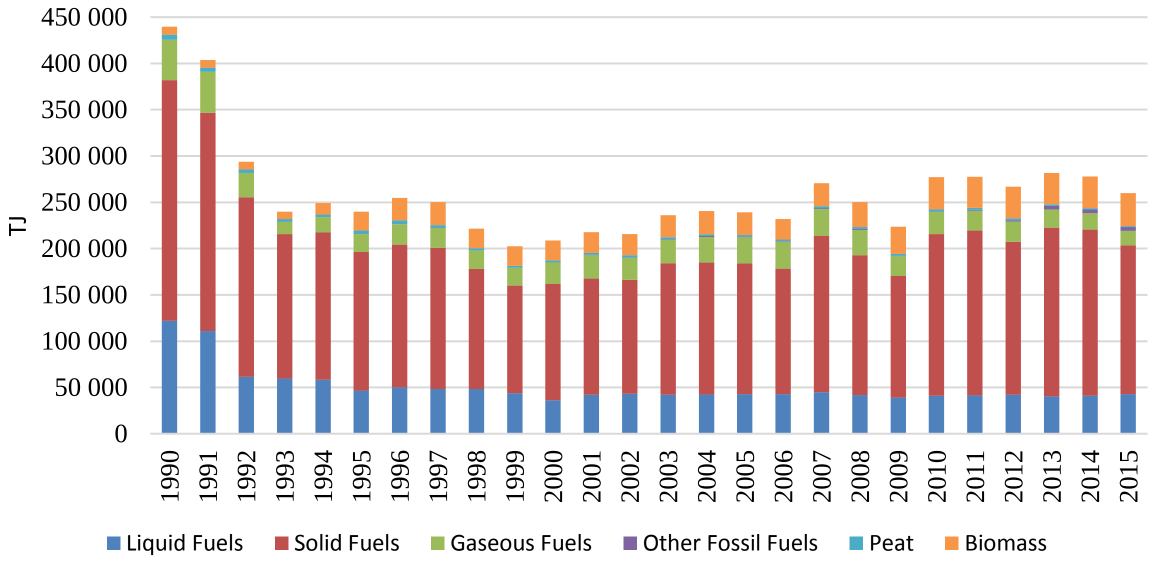

Figure 3.6. Fuel consumption in Energy sector in 1990–2015, TJ

Table 3.1. Emissions from the Energy sector in 1990, 1995, 2000, 2005 and 2010–2015 by greenhouse gas, kt

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1 Energy total, CO_2 eq.	36 397.39	17 855.16	14 974.85	16 787.35	18 939.30	18 887.78	17 496.63	19 181.24	18 691.23	15 863.86
1.A Fuel Combustion, CO_2 eq.	36 347.12	17 831.23	14 947.62	16 754.50	18 916.19	18 866.94	17 474.95	19 158.89	18 673.75	15 848.33
1.A Fuel Combustion, CO_2	36 093.48	17 597.02	14 731.45	16 534.97	18 649.19	18 620.41	17 222.14	18 905.20	18 413.54	15 589.05
1.A Fuel Combustion, CH_4	5.49	6.13	5.41	4.97	6.33	5.67	5.90	5.84	5.78	5.68
1.A Fuel Combustion, N_2O	0.39	0.27	0.27	0.32	0.37	0.35	0.35	0.36	0.39	0.39
1.B Fugitive Emissions, CO_2 eq.	50.27	23.93	27.23	32.85	23.11	20.84	21.68	22.35	17.47	15.53

Three greenhouse gases are emitted from Energy sector, carbon dioxide (CO_2), small amounts of methane (CH_4) and nitrous oxide (N_2O) (Table 3.1). Energy related CO_2 emissions vary mainly according to the energy supply structure and climate conditions. The export of electricity also has an essential role, because the main share of electricity in Estonia is produced from oil shale. As suggested in the IPCC 2006 Guidelines, the emissions in the Energy sector are divided into emissions from Fuel combustion (CRF 1.A) and Fugitive emissions from fuels (CRF 1.B). Emissions from the Energy sector in 1990–2015 by greenhouse gas are presented in Table 3.1.

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

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

- CRF 1.A 1 – Energy industries;
- CRF 1.A 2 – Manufacturing industries and construction;
- CRF 1.A 3 – Transport;
- CRF 1.A 4 – Other sectors (including Commercial, Residential and Agriculture/forestry/fishing sectors);
- CRF 1.A 5 – Other/military fuels.

Reported greenhouse gas emissions, used methods and type of emission factors are listed in Table 3.2.

Table 3.2. Reported emissions, calculation methods and type of emission factors for the subcategory Fuel combustion in the Estonian GHG Inventory

CRF	Source	Emissions reported	Method	Emission factor
1.A.1	Energy industries	CO_2	T1, T2, T3	D, CS, PS
		CH_4	T1, T2	D, CS
		N_2O	T1, T2	D, CS
1.A.2	Manufacturing industries and construction	CO_2	T1, T2, T3	D, CS, PS
		CH_4	T1, T2	D, CS
		N_2O	T1, T2	D, CS
1.A.3	Transport	CO_2	T1, T2	D, CS
		CH_4	T1, T2, T3	D, CS
		N_2O	T1, T2, T3	D, CS
1.A.4	Other sectors	CO_2	T1, T2	D, CS
		CH_4	T1, T2	D, CS
		N_2O	T1, T2	D, CS
1.A.5	Other	CO_2	T2	CS
		CH_4	T1	D
		N_2O	T1	D

Quantitative overview

CO_2 emissions from Fuel combustion (15 589.05 kt) accounted for 98.3% of the Energy sector's total emissions and 86.4% of total greenhouse gas emissions in 2015.

The share of CH_4 emissions from Fuel combustion (141.92 kt CO_2 eq.) was 0.9% in 2015, mainly due to the incomplete combustion of wood fuels (small combustion). N_2O emissions from Fuel combustion are relatively small (117.36 kt CO_2 eq.) accounting for about 0.7%. N_2O emissions emissions mainly originate from Energy industries and different Transport subsectors.

The emissions from Fuel combustion are presented in Table 3.3.

Table 3.3. Emissions from Fuel combustion in Estonia in 1990, 1995, 2000, 2005 and 2010–2015, kt

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1.A Fuel combustion total, CO_2 eq.	36 347.12	17 831.23	14 947.62	16 754.50	18 916.19	18 866.94	17 474.95	19 158.89	18 673.75	15 848.33
1.A.1 Energy industries, CO_2 eq.	29 281.48	14 655.02	12 144.17	13 208.69	15 432.26	15 190.54	13 723.24	15 468.65	14 936.02	12 237.23
1.A.2 Manufacturing industries and construction, CO_2 eq.	2 506.62	897.28	580.39	725.31	512.80	726.83	773.39	744.37	706.01	497.63
1.A.3 Transport, CO_2 eq.	2 477.19	1 584.36	1 682.11	2 150.88	2 261.03	2 269.41	2 294.76	2 240.16	2 264.43	2 323.82
1.A.4 Other sectors, CO_2 eq.	2 037.62	665.29	523.79	634.29	668.59	660.04	661.72	672.92	734.13	762.39
1.A.5 Other, CO_2 eq.	44.20	29.27	17.16	35.33	41.51	20.11	21.85	32.79	33.17	27.26

Methods

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

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

Key Categories

The key categories in 2015 by level and trend (Tier 1 and Tier 2) are presented in Table 1.3

3.2.1. Comparison of the Sectoral approach and the Reference approach

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

In the 2017 inventory submission, the difference of CO_2 emissions between RA and Sectoral approach (SA) was 3.6%. The differences between RA and SA have been greatly reduced since the last submission.

Differences in solid and liquid fuel consumption between RA and SA are caused by the fact that a lot of secondary fuels are used in final consumption (SA): shale oil, semi coke and oil shale gas – all made from oil shale, etc. For the last three years, solid fuel consumptions of SA and RA have been similar, with a difference up to 2.5% (in earlier years, the difference has been more substantial due to statistical differences, however Estonia is working on improving this issue). This is due to the fact, that Statistics Estonia has improved its methodology in the recent years for presenting data on oil shale. These two datasets are comparable because in SA and RA theoretically the same amount of oil shale has to be consumed. However, the amounts of emitted CO_2 are different, because SA considers the fact that some of the oil shale is turned into shale oil and this process has a smaller CEF (carbon emission factor) than the combustion of oil shale (since some of the carbon is transferred into shale oil). RA does not take this into account, and so all carbon of oil shale is calculated as it had been combusted. Consequently RA Solid fuels emissions are greater than in SA.

An opposite effect takes place for Liquid fuels. Shale oil has a substantial part in Estonia's liquid fuels. As the production of secondary fuels (which shale oil is) is not counted for in RA and Estonia exports most of its produced shale oil and this causes a negative apparent consumption of shale oil, the apparent consumption of liquid fuels is substantially smaller in RA than in SA. This also causes smaller CO_2 emissions for liquid fuels in RA. The smaller emissions from Liquid fuels and greater emissions from Solid fuels roughly cancel each other out. Finally, only a small difference remains between SA and RA due to smaller statistical differences.

3.2.2. International bunker fuels

International bunkers cover International aviation and Navigation according to the 2006 IPCC Guidelines.

In 2015, GHG emissions from International bunkering were 968.39 kt CO_2 equivalent, including Marine bunkers 894.03 kt CO_2 equivalent and Aviation bunkers 74.37 kt of CO_2 equivalent.

GHG emissions from International navigation increased throughout the period of 2005–2007. After 2007 a decline lasted until 2011. Due to the methodology change in activity data by Statistics Estonia, the fuel consumption Marine bunkering, the emissions increased about two times in 2012 compared to 2011. In 2013, the emissions increased 4.9% compared to the previous year. In 2014 the emissions decreased about 23.4% compared to 2013. The decreasing trend continues in 2015, the emissions decreased about 9.6% compared to 2014.

The trend of emissions in International aviation has been pretty stable, small increases of GHG emissions in 2005 and 2007 were caused by lower bunker fuel price in Estonia. In 2011, the emissions from Aviation bunkering declined about 9% compared to previous year. Emissions from Aviation bunkering increased about 10% in 2012 compared to 2011. In 2013, the emissions from Aviation bunkering decreased about 22.9% compared to 2012. In 2014 the amount of GHGs emitted from Aviation bunkering rose about 41.4% compared to 2013. In 2015, however, the emissions from Aviation bunkering fell 39.7% compared to 2014.

The trend of GHG emissions from International bunker fuels are presented in Figure 3.7. As can be seen from the figure, fuel consumption decreased in aviation bunkering. This decrease was mainly caused by a decrease in cargo and mail services by air transport. Marine bunkering also saw a decrease in passenger traffic and in the average gross tonnage of vessels.

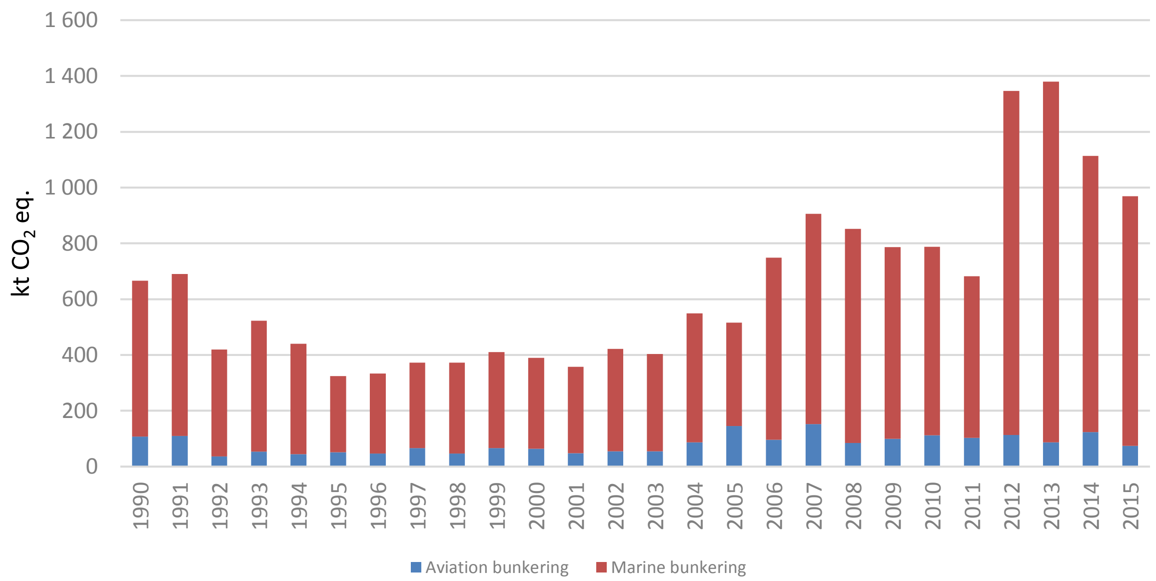

Figure 3.7. Emissions from International bunkers in 1990–2015, kt CO_2 equivalent

The emissions are calculated using the 2006 IPCC methodology and country-specific emission factors. Fuel consumption data on Marine bunkering is obtained from the energy statistics and it includes fuel sales to ships abroad. Statistics Estonia obtains this data from the international trade database according to a relevant merchandise code. Activity data used in the calculations for Domestic and International aviation (landing and take off cycles, fuel consumption) is obtained from the Estonian Environment Agency.

Category-specific recalculations

There were recalculations in the Aviation bunkering sector due to revising of emissions factors (see Table 3.5). Emission factor comparison has been compiled in Table 3.4.

Table 3.4. Comparison of the emission factors of CO_2, CH_4 and N_2O in Aviation bunkering

	CO_2	**CH_4**	**N_2O**
Cruise			
2016	3 150.0 kg/t	0.0 kg/t	0.1 kg/t
2017	70 000 kg/TJ	0 kg/TJ	2 kg/TJ
LTO			
2016	3 150.0 kg/t	0.5 kg/t	0.1 kg/t
2017	3 160 kg/t	5 kg/TJ	2 kg/TJ

Table 3.5. Differences of GHG emissions between 2017 and 2016 submissions in Aviation bunkering, kt CO_2 eq.

Year	**Differences between 2017 and 2016 submissions**
1990	-1.101
1991	1.388
1992	-0.058
1993	-0.403
1994	-1.028
1995	-3.468
1996	-1.178
1997	-2.196
1998	-0.839
1999	-1.341
2000	-1.318
2001	-1.399
2002	-1.110
2003	-1.245
2004	-3.174
2005	-2.236
2006	-1.790
2007	-3.073
2008	-1.512
2009	-1.942
2010	-2.246
2011	-1.904
2012	-2.143
2013	-1.921
2014	-3.014

3.2.3. Feedstocks and Non-energy use of fuels

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

- 1.AD.2 Lubricants;
- 1.AD.3 Bitumen;
- 1.AD.5 Natural gas;
- 1.AD.10 Other/Oil shale.

Activity data on lubricants and bitumen consumption is received from Statistics Estonia (Joint Questionnaire that Statistics Estonia sends to IEA annually). Data on natural gas that is used for the category non-energy use, is taken from the national energy balance sheet. Activity data on oil shale reported in the CRF 1.AD is calculated on the basis of plant-specific data. This reported amount consists of oil shale semi coke – the by-product of shale oil production which contains a small amount of organic matter (carbon). Oil shale semi-coke is stored in the oil shale waste dumps (carbon stored).

Natural gas for non-energy purposes was used for ammonia production and is reported in the CRF category 2.B.1. Natural gas was only used in the company Nitrofert AS. In 2010 and 2011 the factory was temporarily closed down due to low ammonia price in the World market. In 2012 the ammonia production factory was reopened and during 2013 it was closed again and has remained closed ever since.

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

3.2.4. Energy industries and Manufacturing industries and construction (CRF 1.A.1 and CRF 1.A.2)

3.2.4.1. Category description

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

In 2015, the category Energy industries (1.A.1) contributed 77.1% of Energy sector emissions, totalling 12 237.23.50 kt of CO_2 equivalent (see Table 3.3) and about 67.8% of total GHG emissions. Compared to the base year 1990, the emissions were about 58.2% lower (29 281.48 kt CO_2 eq.).

The emissions from Energy industries by relevant subcategories and gases in 1990–2015 are presented in the Table 3.6. The Figure 3.8 presents the trend of GHG emissions from Energy industries by relevant subcategories in 1990 to 2015.

In general, the trend of GHG emissions in Energy industries follows the trend of fuel consumption. In 2015, the emissions of Energy industries decreased by 58.2% compared to 1990. The decrease of GHG emissions in Electricity and heat production sub-sector was 62.2%. This big decrease was caused by the structural changes in the economy after 1991, when Estonia regained its independence. There has been a drastic decrease in the consumption of fuels and energy in Energy industries (closing of the factories, decrease of electricity import, etc.). At the same time GHG emission trend of Other energy industries (1.A.1.c) has increased about 13 times compared to 1990 due to enlarged export volumes of shale oil.

Since 2013 a waste incinerator plant was opened in Estonia. Since then emissions can be observed from Other fuels in Energy industries sector. In 2015 149.44 kt CO2 eq. of emissions were emitted from that plant – Iru Waste Incinerator.

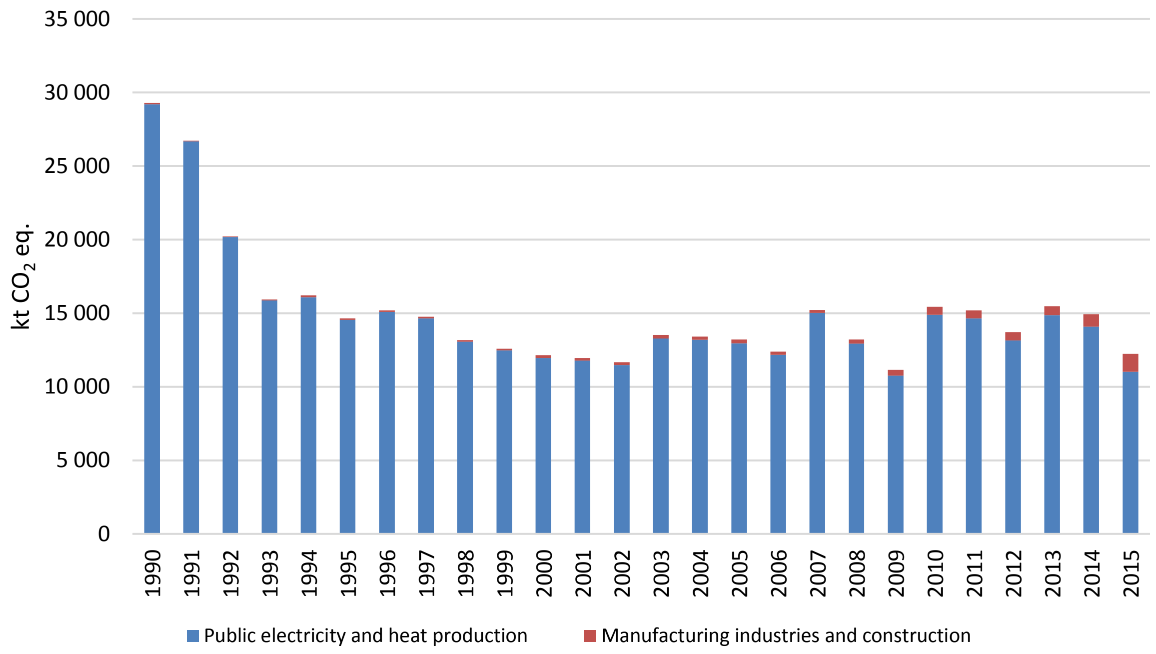

Figure 3.8. Trend of GHG emissions from Energy industries by relevant sub-categories in 1990–2015, kt CO_2 eq.

In 2015, the gross production of electricity was 10 417 GWh – about 16.3% lower compared to 2014 (12 444 GWh). The main reason behind the decreased production was the increase of electricity imports from Finland. Import from Finland represented 96.8% of total electricity imports in 2015. The export of electricity decreased from 6 484 GWh in 2014 to 6 377 GWh in 2015 (about 1.7%). Export to Latvia represented about 95.3% share of total electricity exports.

In Estonia renewable energy is generated from wind and biomass and also in hydroelectric plants. Since electricity generation in wind parks has increased rapidly, the proportion of renewable energy in energy production has increased. In 2015, the production of electricity from wind energy increased about 18.4% compared to 2014.

In 2015 the production of heat decreased about 3.4% compared to 2014. About 53.6% of heat was produced by heating plants and their total heat production decreased about 4.7% compared to the previous year. About 46.4% of heat was produced in power plants. About half (44.1%) of the total heat produced by heating plants was generated from natural gas and about a third (39.8%) from wood fuel. The production of heat from natural gas in boilerhouses decreased about 21.0% compared to 2014. On the other hand, the production of heat from wood increased 11.6%.

Coal, wood, natural gas and liquid fuels were imported in 2015 to Estonia. Imports of natural gas decreased about 11.1% compared to 2014. The imports of motor gasoline decreased 7.1% while imports of diesel increased about 3.7% compared to the previous year. The imports of coal decreased about 90.9% compared to 2014.

In 2015, the Manufacturing industries and construction contributed about 3.2% of Energy sector emissions, totalling 497.63 kt of CO_2 equivalent and about 2.8% of total GHG emissions.

The emissions from Manufacturing industries and construction by relevant subcategories and GHGs in 1990–2015 are presented in Table 3.6 and Figure 3.10. Compared to 1990, the emissions decreased by 80.1% in 2015. This big decrease was caused by the structural changes in the economy after 1991, when Estonia regained its independence.

To follow the structure of CRF tables, all Manufacturing industries and construction sub-sectors are presented in the following CRF sub-categories: 2.a Iron and steel, 2.b Non-ferrous metals, 2.c Chemicals, 2.d Pulp, paper and print, 2.e Food processing, beverage and tobacco and 2.f Non-metallic minerals and 2.g Other. The shares of GHG emissions of relevant Manufacturing industries and constructions subcategories in 2015 are presented in the Figure 3.9.

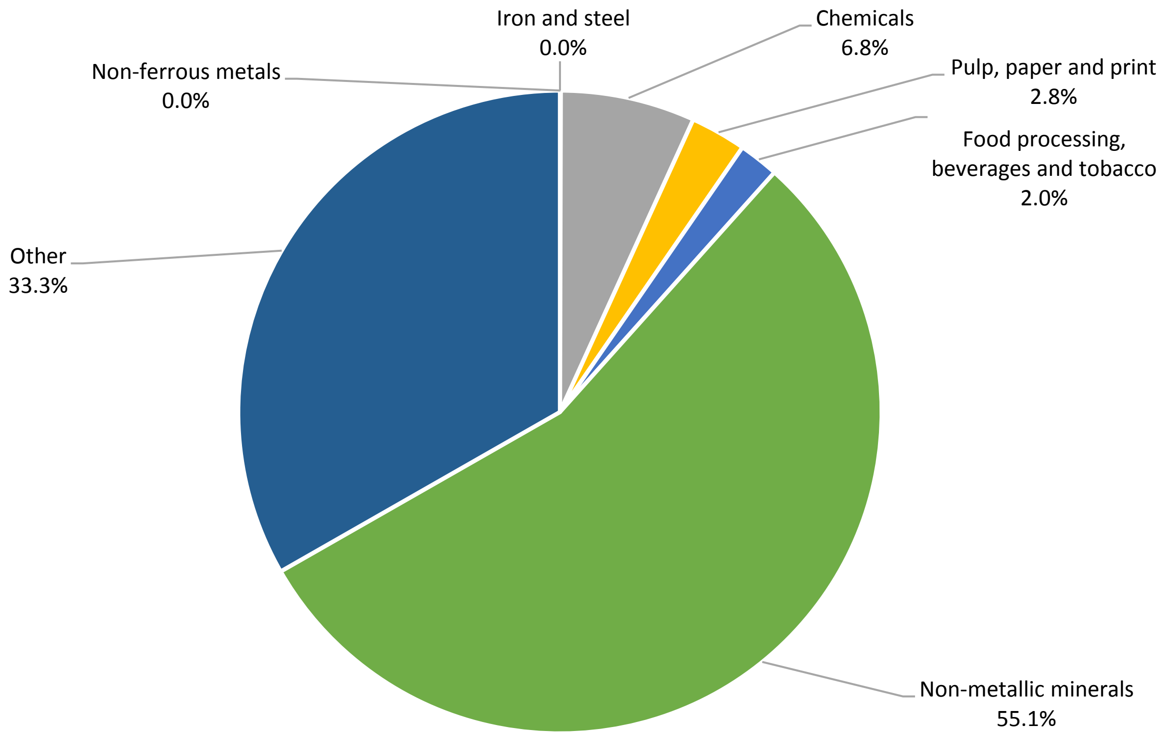

Figure 3.9. The share of GHG emissions from Manufacturing industries and construction by relevant sub-categories in 2015, %

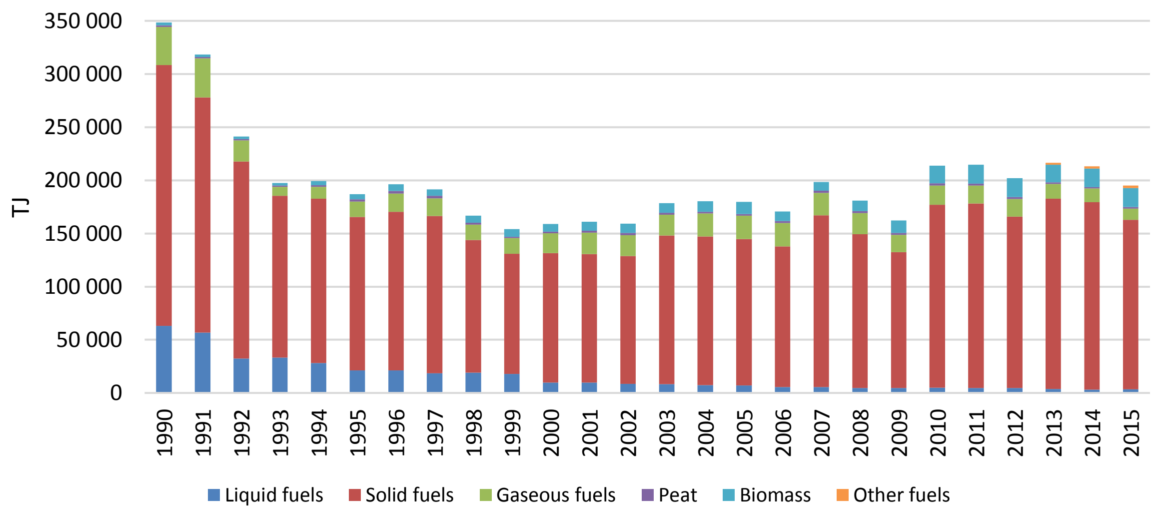

Figure 3.10. Trend of GHG emissions from Manufacturing industries and construction by relevant sub-categories in 1990–2015, kt CO_2 eq.

The trend of GHG emissions from the CRF category 1.A.2.a Iron and steel in 1990–2015 is presented in Figure 3.11.

In Estonia, the share of the CRF sub-category 1.A.2.a Iron and steel is very small and in the last three years there have been no emissions at all. The category '1.A.2.a Iron and steel' consists mainly from factories using fuel for manufacturing goods from imported iron and steel. Since raw material (iron and steel) for this industry was imported from Russia, then after regaining its independence in 1991 all iron and steel using factories were closed. In 1994 those factories started working again. As the production of goods depends from the raw material supply and final production export possibilities, the production decrease in 1997–1999 was directly caused by economic crisis in Russia at the same period. The production stabilized in 2000 up to 2006 and the decrease of emissions in 2007 to 2009 is connected with the last economic depression. In 2010 the emissions of GHG increased to the 2008 level due to upturn of export possibilities of the sector. In 2011 the emissions dropped drastically due to decreased fuel consumption in Iron and steel industry. In 2012, the emissions stayed on the same level as in 2011. Starting from 2013 GHG emissions have not occurred in this category as no fuels have been used.

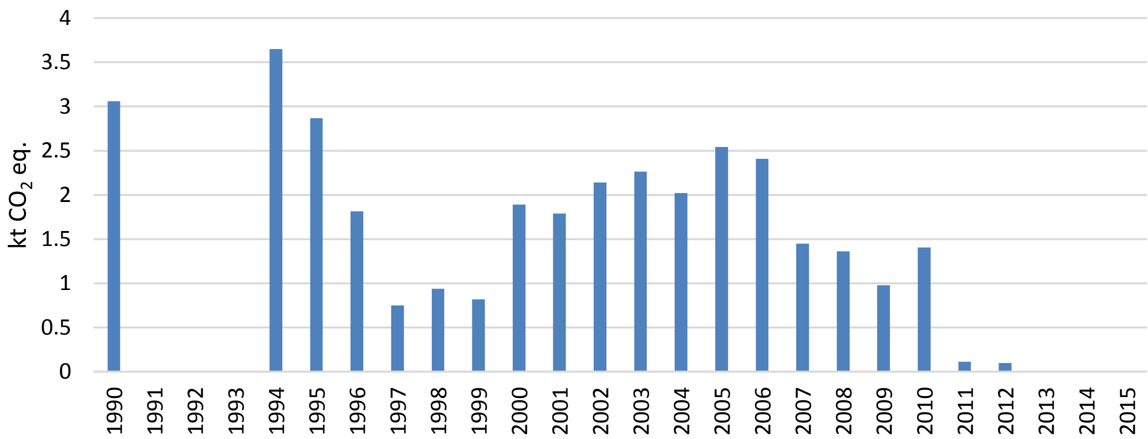

Figure 3.11. Trend of GHG emissions from Iron and steel in 1990–2015, kt CO_2 eq.

The trend of GHG emissions of the CRF category 1.A.2.b Non-ferrous metals in 1990–2015 is presented in Figure 3.12.

The Non-ferrous metal sub-sector is very small in Estonia consisting of 2–3 enterprises only. The big increase of GHG emissions in 2007 comparing with previous years is connected with fuel consumption increase and is probably caused by same large order(s) for some of these enterprises. The share of the CRF sub-category 1.A.2.b Non-ferrous metals is very small forming 0.04% of the Manufacturing industries GHG emissions in 2015 (see Figure 3.9). In 2015 the emissions from Non-ferrous metals were only 0.20 kt CO_2 equivalent. The shape of the GHG emission trend follows the trend of fuel consumption in the sub-category.

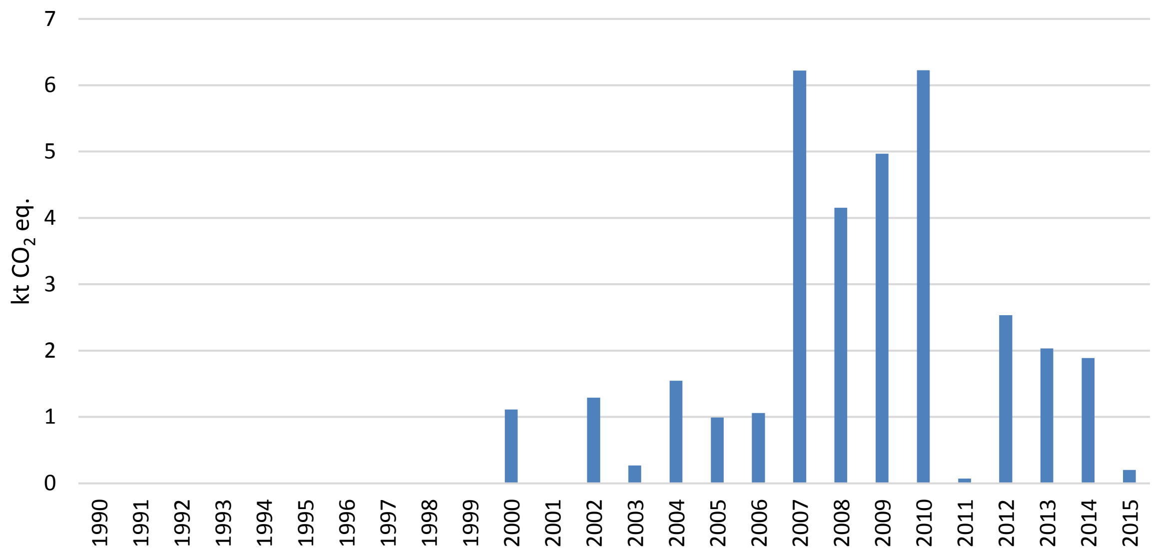

Figure 3.12. Trend of GHG emissions from Non-ferrous metals in 1990–2015, kt CO_2 eq.

The trend of GHG emissions of the CRF category Chemicals in 1990–2015 is presented in Figure 3.13.

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

The share of the CRF sub-category 1.A.2.c Chemicals sub-sector forms about 6.8% of the Manufacturing industries GHG emissions in 2015 (see Figure 3.9).

The first decrease in the trend of GHG emissions in 1992/1993 was caused by privatisation of chemical enterprises after regaining independence in 1991 and by transition from eastern markets to the western markets. The second big decrease in 1999 is caused by extensive restructuring in the Estonian biggest chemical enterprise – Kiviter AS. The main product of the Kiviter was shale oil (a liquid fuel made from oil shale), but since 1999 shale oil production is reported under the Energy sector not under chemical industry as earlier. Only the products of oil shale industry by-products like formalin, toluene, etc are still under chemical industry. In 2002 and 2009 the production of Nitrofert was very small and in 2010 and 2011 the factory was temporarily closed down due to low ammonia prices in world market. In 2012, the ammonia production factory Nitrofert was reopened. Since the shape of the GHG emission trend follows the trend of fuel consumption, then the fluctuations of the trend are determined by the ammonia export possibilities of the chemical factory Nitrofert. In 2014 the production facilities of Nitrofert AS were closed again, so the overall emissions are noticeably lower. The plant has not been opened since.

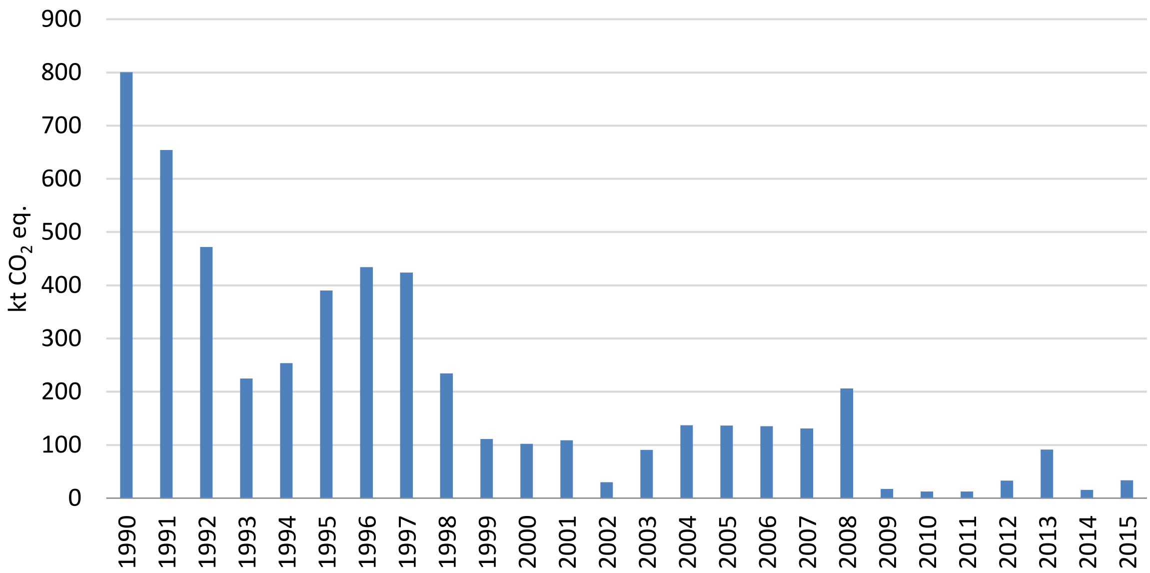

Figure 3.13. Trend of GHG emissions from Chemicals in 1990–2015, kt CO_2 eq.

The trend of GHG emissions of the CRF category Pulp, paper and print in 1990–2015 is presented in Figure 3.14.

The share of the CRF sub-category 1.A.2.d Pulp, paper and print is small, forming about 2.8% of the Manufacturing industries GHG emissions in 2015 (see Figure 3.9).

There are only a few major pulp and paper factories in Estonia: Horizon Tselluloosi and Paberi AS (Horizon Pulp and Paper Ltd, former Kehra paper factory), Kohila Paber AS (Kohila paper factory) and Räpina Paberivabrik AS (Räpina paper factory). In 2006 a new aspen pulp factory Estonian Cell AS was commissioned. There was no pulp and paper production in 1990–1991 since the big Tallinn Pulp and Paper factory was closed in the end of 1980s and all the small factories were not yet privatized.

In 1992–1998 the production of paper fluctuated because of a standstill of some factories. This was caused by ownership changes. During 1999–2003 the production of paper grew every year compared to the previous year. In 2004 manufacturing of wood pulp fell. In 2005 manufacturing of paper and paper products increased due to lively investment and growth of export. In 2009 the production of paper decreased again due to the economic depression. In 2010 manufacturing of paper and paper products increased again due growth of export. The decrease of emissions in 2011 compared to 2010 and the increase of emissions in 2012 compared to 2011 are related to declining consumption of natural gas. In 2013, the emissions decreased about 12% compared to 2012. In 2014, the emissions decreased about the same amount as the previous year, about 15% compared to 2013. However, in 2015 a big increase in emissions occurred. The emissions increased 279.1% compared to the previous year. The relative growth was quite large, however the absolute growth is quite insignificant compared to the overall emissions of Estonia. The increase took place mostly due to the increased usage of natural gas.

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

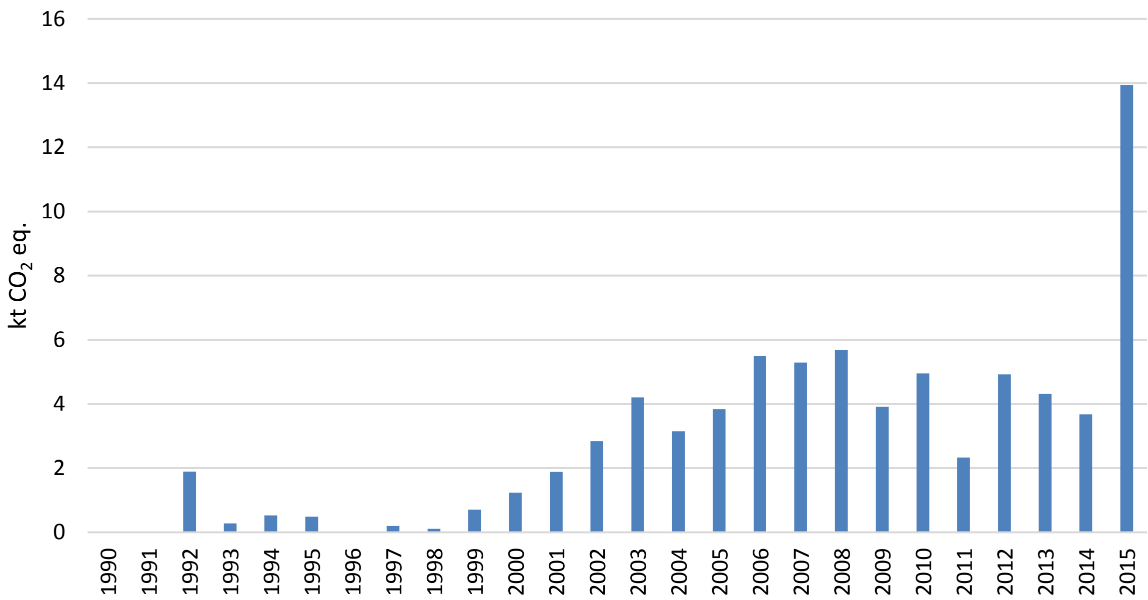

Figure 3.14. Trend of GHG emissions from Pulp, paper and print in 1990–2015, kt CO_2 eq.

The trend of GHG emissions of CRF category Food processing, beverages and tobacco in 1990–2015 is presented in Figure 3.15.

The share of the CRF sub-category 1.A.2.e Food processing, beverage and tobacco is small, forming about 2.0% of the Manufacturing industries GHG emissions in 2015 (see Figure 3.9).

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

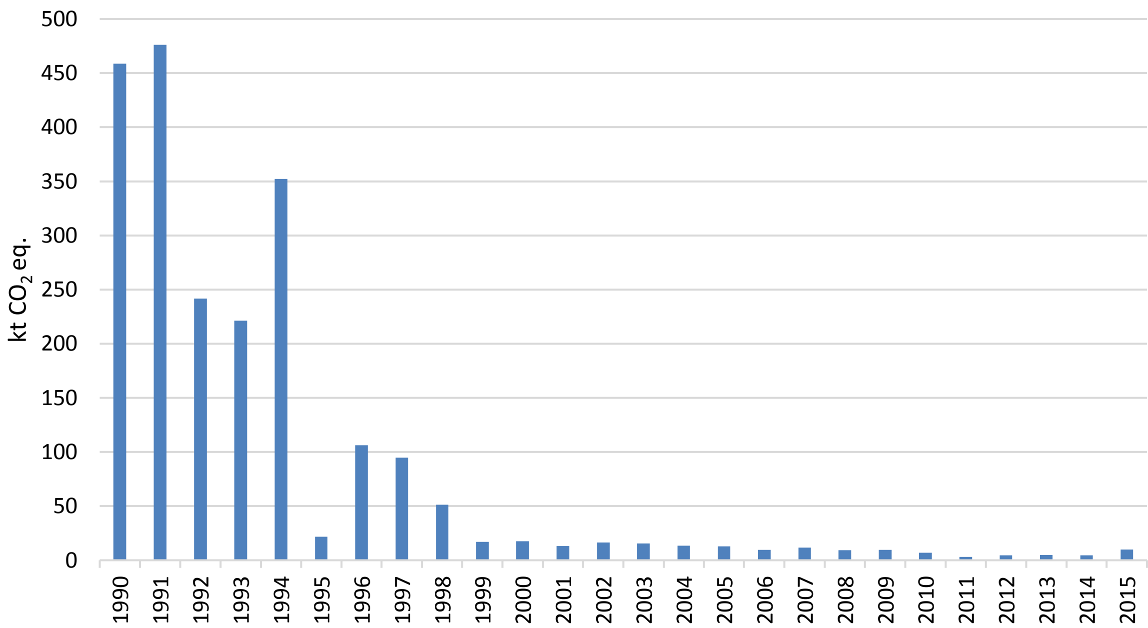

Figure 3.15. Trend of GHG emissions from Food processing, beverages and tobacco in 1990–2015, kt CO_2 eq.

The trend of GHG emissions of CRF category Non-metallic minerals in 1990–2015 is presented in Figure 3.16.

The share of CRF sub-category 1.A.2.f Non-metallic minerals is the biggest in Manufacturing industries and construction forming 55.1% in 2015. The main share of GHG emissions in this sub-category come from cement production. Therefore the trend of GHG emissions follows the trend of fuels used in cement production. In 2015, the emissions decreased about 47.2% compared to 2014 due to a disadvantageous cement market.

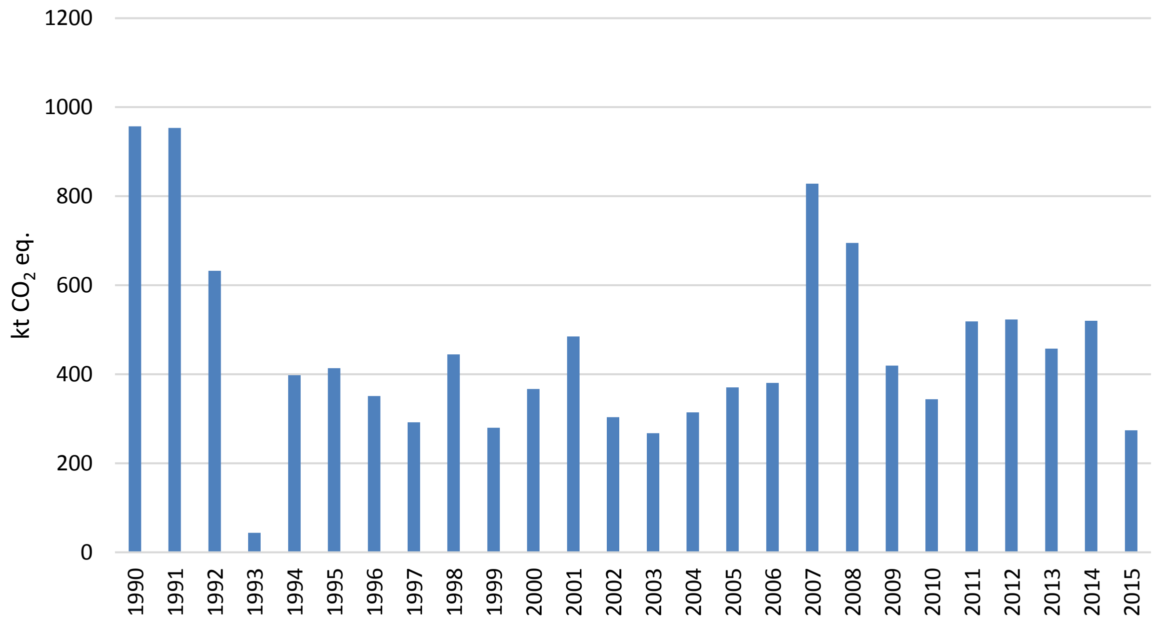

Figure 3.16. Trend of GHG emissions from Non-metallic minerals in 1990–2015, kt CO_2 eq.

The trend of GHG emissions of CRF category Other in 1990–2015 is presented in Figure 3.17.

The share of the CRF sub-category 1.A.2.g Other was about 33.3% in 2015 (see Figure 3.9).

In Estonia, the Manufacturing industries and construction sector's sub-category 1.A.2.f Other includes following sub-sectors: 'Production of transport equipment'; 'Machinery'; 'Mining and quarrying'; 'Production of wood and wood products construction'; 'Textile, leather and clothing industry' and 'Other industry'. In general, the shape of the GHG emission trend follows the trend of fuel consumption of the sector. The fluctuations of the trend are determined by the export possibilities of the sectors factories. The decrease of emissions in 2009 and 2010 is connected with economic depression which started in 2008. Despite the upturn of economy in some branches of manufacturing industries the total volume of output in the manufacturing industry decreased in 2010. There still was a recession in the construction market, which caused a low demand for building materials in the domestic and international markets. This was the main reason of the decline of the emissions. 2011, GHG emissions increased about 38.4% compared to 2010. This was due to the overall economic upturn. In 2012, the emissions increased about 8.2% compared to 2011. The increase was caused by increased consumption of natural gas and liquid fuels. In 2013, the emissions decreased 9.9% compared to the previous year. In 2014, there was about a 12.7% decrease in emissions compared to 2013. Emissions slightly increased (3.2%) in 2015 compared to 2014.

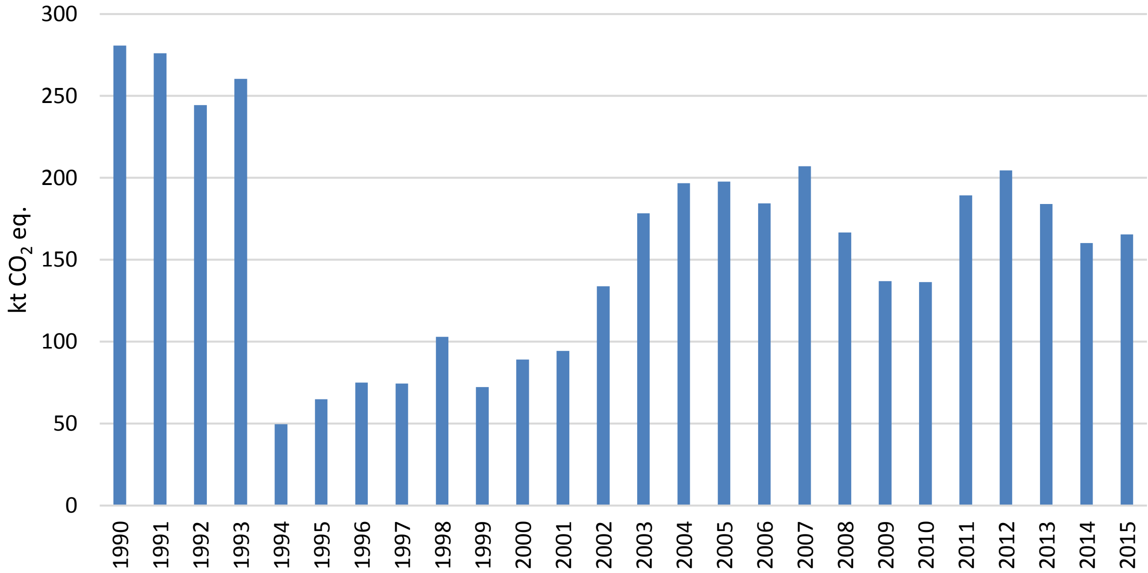

Figure 3.17. Trend of GHG emissions from Other in 1990–2015, kt CO_2 eq.

The values of CO_2 IEFs of liquid and solid fuels are fluctuating due to changes in the contribution of different liquid and solid fuels in these fuel groups over time.

The emissions from Energy industries are presented in Table 3.6 and the emissions from Manufacturing industries and construction are presented in Table 3.7.

Table 3.6. GHG emissions from Energy industries by relevant subcategories and gases, kt

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1.A.1 Energy industries, CO_2 eq.	29 281.48	14 655.02	12 144.17	13 208.69	15 432.26	15 190.54	13 723.24	15 468.65	14 936.02	12 237.23
1.A.1 Energy industries, CO_2	29 256.08	14 637.41	12 126.43	13 177.78	15 391.87	15 146.85	13 681.32	15 423.76	14 889.90	12 188.33
1.A.1 Energy industries, CH_4	0.30	0.23	0.25	0.36	0.51	0.56	0.55	0.56	0.60	0.63
1.A.1 Energy industries, N_2O	0.06	0.04	0.04	0.07	0.09	0.10	0.09	0.10	0.10	0.11
1.A.1.a Public electricity and heat production, CO_2 eq.	29 195.20	14 546.83	11 960.30	12 959.83	14 888.32	14 643.73	13 145.79	14 871.00	14 087.96	11 026.11
1.A.1.c Manufacture of solid fuels and other energy industries, CO_2 eq.	86.28	108.19	183.87	248.86	543.93	546.82	577.45	597.66	848.06	1 211.12

Table 3.7. GHG emissions from Manufacturing industries and construction by relevant subcategories and gases, kt

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1.A.2 Manufacturing industries and construction, CO_2 eq.	2 506.62	897.28	580.39	725.31	512.80	726.83	773.39	744.37	706.01	497.63
1.A.2.a Iron and steel, CO_2 eq.	3.06	2.87	1.89	2.54	1.40	0.11	0.10	0.00	0.00	0.00
1.A.2.b Non-ferrous metals, CO_2 eq.	0.00	0.00	1.11	0.99	6.23	0.07	2.53	2.03	1.89	0.20
1.A.2.c Chemicals, CO_2 eq.	806.83	393.29	102.48	136.87	12.81	12.63	33.26	91.36	15.49	33.65
1.A.2.d Pulp, paper and print, CO_2 eq.	0.00	0.48	1.24	3.84	4.95	2.33	4.93	4.31	3.68	13.94
1.A.2.e Food processing, beverages and tobacco, CO_2 eq.	458.77	21.69	17.43	12.71	7.01	3.19	4.56	4.76	4.61	10.01
1.A.2.f Non-metallic minerals, CO_2 eq.	957.19	413.95	367.09	370.66	344.05	519.12	523.35	457.83	520.02	274.30
1.A.2.g Other, CO_2 eq.	280.78	64.99	89.15	197.69	136.35	189.38	204.66	184.08	160.32	165.52

3.2.4.2. Methodological issues

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

For imported fuels, which belong to key categories, mainly Tier 2 approach has been applied. For domestic fuels – oil shale, shale oil, oil shale semi-coke, oil shale semi-coke gas and generator gas and peat – Tier 2 and Tier 3 approaches are used.

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 (about 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[9].

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[9].

From the point of view of greenhouse gas emissions it is important that during combustion of pulverised oil shale CO_2 is formed not only as a burning product of organic carbon, but also as a decomposition product of the ash carbonate part. Therefore, the total quantity of carbon dioxide increases up to 25% in flue gases of oil shale[9].

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

The first CFBC power unit (215 MW_{el}) started at the Eesti Power Plant in 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 MW_{el}) started at the Narva Power Plants in 2004. The successful operation of the new CFBC units allows continuing the construction of additional units. A new CFBC power unit (300 MW_{el}) was connected to the Estonian electricity network in 2015.

A formula for the calculation of Estonian (pulverised combustion) oil shale carbon emission factor, taking into consideration the decomposition of its ash carbonate part and CO_2 binding at ash fields is presented as Equation 3.1.

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[9] Ots, A. (2004). Põlevkivi põletustehnika. Tallinn: Tallinna Raamatutrükikoda, page 833.

Equation 3.1

$$CEF_{oil\ shale} = \frac{10 \cdot \left[C_t^r + k \cdot (CO_2)_M^r \cdot \frac{12}{44}\right]}{Q_i^r} \left[\frac{tC}{TJ}\right]$$

Where:

$CEF_{oil\ shale} =$ carbon emission factor of oil shale, tC/TJ;
$Q_i^r =$ lower heating value oil shale, MJ/kg;
$C_t^r =$ carbon content of oil shale, %;
$(CO_2)_m^r =$ mineral carbon dioxide content of oil shale, %;
$K=$ decomposition rate of ash carbon part (k = 0.64 for pulverised combustion of oil shale).

In 2017, the Regulation of Minister of Environment on "Calculation methods of the amount of CO_2 discharged into ambient air" was updated. According to the Annex 2 of this regulation, the carbon emission factors for oil shale combustion in power plants are:

- $CEF_{oilshalePC}$ = 27.85 tC/TJ;
- $CEF_{oilshaleCFB}$ = 26.94 tC/TJ.

It means that for National GHG Inventories emissions of CO_2 from pulverised combustion and circulating fluidised bed combustion boilers are calculated separately. These values are used for most years. When available, more accurate plant-specific emission factors are used. The ranges of these are presented in Table 3.10.

Shale Oil

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

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

The technology of processing oil shale in **vertical retorts** with a gaseous heat carrier (GHC) is a universal technology and suitable for retorting high-calorific oil shale. The vertical retort is a metal vessel lined on the 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 a gaseous heat carrier. By influence of gases, oil shale is warmed and dried up and after achieving a needed temperature for retorting, the organic part of oil shale starts to decompose quickly. 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. Cleaned generator gas is delivered to heating boilers for burning. Thermal processing of oil shale in vertical retorts takes place without any contact with the ambient atmosphere; therefore no pollutants are emitted[10]. As GHC plants have no direct emissions from the shale oil production process, its CEF is effectively 0. This causes the IEF of Energy industries to be very low (69.41 t CO_2/TJ in 2015)

In **Solid Heat Carrier installation (SHC),** hot oil shale dust as a heat carrier is used. Pre-dried fine-grained oil shale with hot oil shale dust (800 ^oC) is delivered to a horizontal rotating reactor where during just a few minutes the retorting process is occurring. The mixture of heat carrier with oil and water vapours moves into dust separation chamber. Oil vapours and gas are sent to the condensing chamber where the condensed oil is separated and semi-coke gas is sent for burning to power plant. Mixture of semi-coke and dust will delivered to an aero fountain combustor chamber, where semi-coke is burned and flue gases separated. The flue gases are used for drying and pre-heating of raw oil shale in the dryer and then they are completely emitted into the atmosphere. The dust is then delivered to ash fields, although a part of it is delivered back to the reactor[10].

In 2015, 63.15 PJ of oil shale was consumed for shale oil production in total but processing of 42.88 PJ of oil shale caused direct CO_2 emissions at the plants (see Table 3.8). This occurs because of a difference in technologies. Namely, no CO_2 is emitted directly from gas generator type plants. However CO_2 is emitted in solid heat carrier type plants.

Table 3.8. Oil shale consumption for shale oil production by different technologies, PJ

Year	Solid Heat Carrier			Total	Gas generators		Total	Total
	Narva	VKG	Kiviõli	in SHC	VKG	Kiviõli	in gas generators	Oil shale
1990	3.24	NO	NO	3.24	21.56	5.55	27.11	**30.36**
1991	1.77	NO	NO	1.77	19.05	5.24	24.29	**26.06**
1992	2.57	NO	NO	2.57	18.22	5.26	23.47	**26.05**
1993	4.20	NO	NO	4.20	20.09	5.44	25.53	**29.73**
1994	4.75	NO	NO	4.75	18.14	5.00	23.14	**27.89**
1995	4.31	NO	NO	4.31	20.14	5.35	25.49	**29.81**
1996	4.58	NO	NO	4.58	21.42	5.37	26.79	**31.38**
1997	5.15	NO	NO	5.15	21.22	5.47	26.69	**31.84**
1998	4.35	NO	NO	4.35	13.14	4.34	17.49	**21.83**
1999	4.14	NO	NO	4.14	9.75	0.47	10.23	**14.37**
2000	5.86	NO	NO	5.86	13.57	5.30	18.87	**24.73**
2001	6.24	NO	NO	6.24	15.38	5.29	20.67	**26.91**
2002	6.74	NO	NO	6.74	16.13	5.52	21.65	**28.38**
2003	7.66	NO	NO	7.66	16.93	5.49	22.42	**30.08**
2004	8.13	NO	NO	8.13	17.63	4.69	22.32	**30.44**
2005	8.87	NO	NO	8.87	17.78	4.21	22.00	**30.86**
2006	8.40	NO	NO	8.40	19.73	4.17	23.90	**32.30**
2007	7.96	NO	NO	7.96	20.72	4.26	24.98	**32.94**
2008	10.85	NO	NO	10.85	19.99	3.87	23.86	**34.70**
2009	13.07	NO	NO	13.07	20.45	4.04	24.49	**37.56**
2010	14.74	2.22	0.20	17.15	21.15	4.10	25.25	**42.40**
2011	13.39	5.48	0.54	19.41	21.28	3.93	25.21	**44.62**
2012	15.13	6.00	0.31	21.44	21.18	3.86	25.04	**46.48**
2013	15.59	6.43	0.18	22.20	21.45	3.96	25.42	**47.61**

[10] J. Soone. S. Doilov (2003). Sustainable utilisation of oil shale resources and comparison of contemporary technologies used for oil shale processing. Oil Shale, Vol. 20. No. 3S. pages 311-323.

Year	Solid Heat Carrier			Total	Gas generators		Total	Total
	Narva	VKG	Kiviõli	in SHC	VKG	Kiviõli	in gas generators	Oil shale
2014	18.76	9.37	0.35	28.48	21.35	4.18	25.53	**54.01**
2015	23.86	18.61	0.40	42.88	15.36	4.91	20.27	**63.15**

Oil shale gases

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) is called as generator gas. Also gas gasoline is produced as a by-product fuel in oil shale production. In Table 3.9 semi-coke gas and generator gas production data for different shale oil plants are presented.

Table 3.9. Semi-coke gas and generator gas production by shale oil plants, PJ

Year	Solid Heat Carrier			Total	Gas generators		Total	Total
	Narva	VKG	Kiviõli	in SHC	VKG	Kiviõli	in gas generators	Oil shale gas
1990	0.70	NO	NO	0.70	2.82	0.39	3.20	**3.90**
1991	0.37	NO	NO	0.37	2.47	0.37	2.84	**3.21**
1992	0.54	NO	NO	0.54	2.52	0.41	2.94	**3.48**
1993	0.70	NO	NO	0.70	2.65	0.42	3.07	**3.77**
1994	0.91	NO	NO	0.91	2.74	0.41	3.14	**4.05**
1995	0.90	NO	NO	0.90	2.69	0.46	3.15	**4.05**
1996	1.00	NO	NO	1.00	2.91	0.43	3.34	**4.34**
1997	1.05	NO	NO	1.05	2.85	0.42	3.27	**4.32**
1998	0.92	NO	NO	0.92	1.30	0.35	1.66	**2.58**
1999	0.79	NO	NO	0.79	1.20	0.04	1.24	**2.03**
2000	1.04	NO	NO	1.04	1.75	0.43	2.17	**3.21**
2001	1.26	NO	NO	1.26	1.97	0.47	2.44	**3.70**
2002	1.26	NO	NO	1.26	2.15	0.49	2.64	**3.90**
2003	1.32	NO	NO	1.32	2.27	0.48	2.74	**4.06**
2004	1.48	NO	NO	1.48	2.28	0.48	2.76	**4.24**
2005	1.59	NO	NO	1.59	2.26	0.53	2.78	**4.38**
2006	1.62	NO	NO	1.62	2.66	0.55	3.21	**4.83**
2007	1.53	NO	NO	1.53	2.92	0.54	3.46	**4.99**
2008	2.00	NO	NO	2.00	2.79	0.50	3.29	**5.28**
2009	2.40	NO	NO	2.40	2.88	0.50	3.38	**5.78**
2010	2.83	0.34	0.03	3.12	3.02	0.52	3.77	**6.89**
2011	2.75	0.94	0.08	3.77	2.63	0.52	3.15	**6.92**
2012	2.99	1.08	0.06	4.13	2.81	0.51	3.32	**7.45**
2013	2.73	0.92	0.03	3.68	2.91	0.54	3.45	**7.13**
2014	3.18	1.38	0.06	5.20	2.84	0.59	3.43	**8.63**
2015	4.17	2.88	0.09	7.14	1.78	0.59	2.37	**9.51**

CO_2 emissions from the combustion of different oil shale gases are calculated separately and included into CRF category CRF 1.A.1.a Public electricity and heat production/Solid fuels (see also Annex 3).

CO_2 emission factors and other parameters

Carbon emission factors, oxidation factors and net calorific values used in the emission calculations are presented in Table 3.10 below.

Table 3.10. Carbon emission factors, oxidation factors and net calorific values by fuels

Fuels	NCV average	Unit	CEF, tC/TJ	Oxidation factor	Source of emission factor
Liquid fuels					
LPG	45.5	GJ/t	17.3	1	CS (Estonia)
Gasoline (for non-road transport)	44	GJ/t	19.85	1	CS (Estonia)
Light Fuel Oil	42.5	GJ/t	20.18	1	CS (Estonia)
Shale Oil (heavy fraction)	39.2	GJ/t	21.1	1	CS, MoE 2017
Shale Oil (light fraction)	42.2	GJ/t	20.2	1	CS (Estonia), MoE 2017
Diesel Oil	42.3	GJ/t	19.92	1	CS (Estonia)
Residual Fuel Oil (heavy fuel oil)	40.15	GJ/t	21.02	1	CS (Estonia)
Solid fuels					
Coal	27.14	GJ/t	25.74	1	CS (Estonia)
Coke Oven Coke	28.5	GJ/t	29.02	1	CS (Estonia)
Oil Shale CFB (Fludised Bed Combustion)	8.9	GJ/t	26.42 – 27.25	0.98	PS (Estonia)
Oil Shale PC (Pulverised Combustion)	8.9	GJ/t	27.76 – 29.14	0.98	PS (Estonia)
Milled Peat	9.7	GJ/t	28.9	1	D, IPCC 2006
Sod Peat[11]	12	GJ/t	27.82	1	FI (Finland)
Peat Briquette	16	GJ/t	26.45	1	FI (Finland)
Oil Shale semi-coke gas (SHC technology, Narva Enefit 140 plant)	45.4	GJ/1000 m^3	18.79	0.995	PS (Estonia)
Oil Shale semi-coke gas (SHC technology, Narva Enefit 280 plant)	41.73	GJ/1000 m^3	20	0.995	PS (Estonia)
Oil Shale semi-coke gas (VKG Petroter I plant)	35.73	GJ/1000 m^3	19.3	0.995	PS (Estonia)
Oil Shale semi-coke gas (VKG Petroter II plant)	35.64	GJ/1000 m^3	19.15	0.995	PS (Estonia)
Oil Shale generators gas (VKG Petroter III plant)	35.64	GJ/1000 m^3	19.17	0.995	PS (Estonia)
Oil Shale semi-coke gas (Kiviõli plant)	34.31	GJ/1000 m^3	18.51	0.995	PS (Estonia)
Oil Shale generator gas (Kiviõli plant)	2.49	GJ/1000 m^3	46.18	0.995	PS (Estonia)
Oil Shale generator gas (VKG plant)	3.64	GJ/1000 m^3	42.15	0.995	PS (Estonia)
Gas Gasoline	44	GJ/t	19.88	0.99	CS (Estonia)
Waste Oils (CRF 1A2f)	16	GJ/t	20.1818	1	PS, Kunda Nordic Cement
Other Fossil based Solid Waste (MSW) (CRF 1A2f)	19	GJ/t	21.8182	1	PS, Kunda Nordic Cement
Plastic Waste (CRF 1A2f)	21	GJ/t	20.4545	1	PS, Kunda Nordic Cement
Municipal solid waste (CRF 1A1a)	9.4 – 10.5	GJ/t	16.15	1	PS, Iru incineration plant

[11] A processed form of peat that is compressed into small (40 – 70 mm) pieces.

Fuels	NCV average	Unit	CEF, tC/TJ	Oxidation factor	Source of emission factor
Gaseous fuels					
Natural Gas	33.6	GJ/1000 m^3	15.07	1	CS (Estonia)
Biomass fuels					
Solid Biomass (solid, includes e.g. firewood, wood chips, sawdust pellets, briquettes, etc.)	6.9 – 16.9	GJ/t	30.5	1	D, IPCC 2006
Black Liquor	13.4	GJ/t	26	1	D, IPCC 2006
Biogas (landfill gas and biogas from wastewater treatment)	17.4	GJ/1000 m^3	14.89	1	D, IPCC 2006

D - IPCC default value; CS – country specific; PS – plant specific; EE – expert estimation

CH_4 and N_2O emission factors of different fuels are presented in Table 3.11 below.

Table 3.11. CH_4 and N_2O emission factors by fuel, kg/TJ

Fuels	Energy Industry		Manufacturing Industry		Source
	CH_4	N_2O	CH_4	N_2O	
Liquid fuels					
LPG (Liquefied Petrol Gas)	1	0.1	1	0.1	D, IPCC 2006
Gasoline	3	0.6	3	0.6	D, IPCC 2006
Gasoil (light fuel oil)	3	0.6	3	0.6	D, IPCC 2006
Gasoil (for non-road use)	3	0.6	3	0.6	D, IPCC 2006
Shale Oil	3	0.6	3	0.6	D, IPCC 2006
Diesel Oil	3	0.6	3	0.6	D, IPCC 2006
Residual Fuel Oil (heavy fuel oil)	3	0.6	3	0.6	D, IPCC 2006
Recycled Waste Oil	30	0.6	30	0.6	D, IPCC 2006
Solid fuels					
Coal	1	1.5	10	1.5	D, IPCC 2006
Coke Oven Coke			10	1.5	D, IPCC 2006
Oil Shale $_{PC}$[9]	0	0	10	1.5	CS, A.Ots/ D, IPCC 2006
Oil Shale $_{FBC}$[*]	0	0.82	10	1.5	CS, EE/ D, IPCC 2006
Milled Peat	1	1.5	2	1.5	D, IPCC 2006
Sod Peat	1	1.5	2	1.5	D, IPCC 2006
Peat Briquette	1	1.5	2	1.5	D, IPCC 2006
Oil Shale Gases (semi-coke gas and generator gas)	1	0.1	1	0.1	D, IPCC 2006 (of natural gas)
Waste Oils			30	4	
Other Fossil based Waste (MSW)			30	4	D, IPCC 2006
Plastic Waste			30	4	D, IPCC 2006
Municipal Solid Waste	30	4			
Gaseous fuels					
Natural Gas	1	0.1	1	0.1	D, IPCC 2006
Biomass fuels					

Fuels	Energy Industry		Manufacturing Industry		Source
	CH_4	N_2O	CH_4	N_2O	
Solid Biomass (solid, includes e.g. firewood, bark, chips, sawdust and other industrial wood residues, pellets and briquettes)	30	4	30	4	D, IPCC 2006
Black Liquors	3	2			D, IPCC 2006
Biogas (landfill gas and biogas from wastewater treatment)	1	0.1			D, IPCC 2006

* *Expert estimation*

Emission factors of indirect greenhouse gases from Fuel combustion

The NO_x, CO and NMVOC emission factors used in the Estonian inventory are from different sources. If possible, a country-specific emission factor is used, if not, the EMEP/EEA Guidebook 2013 is used as a source. However the data on the oil shale direct combustion plants is plant-specific, so an average emission factor is provided in the following tables. The emission factors are presented in Table 3.12, Table 3.13 and Table 3.14.

Table 3.12. NO_x emission factors from Fuel combustion (kg/TJ)

	Coal	*Natural Gas*	*Heavy Fuel Oil*	*Gas Oil*	*Biomass*	*Oil Shale*	*Peat*
Energy industries	200	100	250	513	100	79.02	300
Manufacturing and construction	173	60	513		100	110	300
Other sectors	200	60	51		100	110	300

Table 3.13. CO emission factors from Fuel combustion (kg/TJ)

	Coal	*Natural Gas*	*Heavy Fuel Oil*	*Gas Oil*	*Biomass*	*Oil Shale*	*Peat*
Energy industries	100	40	100	100	200	0.88	100
Manufacturing and construction	931	50	66		700	87	650
Other sectors	5 000	26	57		5 009	5000	5000

Table 3.14. NMVOC emission factors from Fuel combustion (kg/TJ)

	Coal	*Natural Gas*	*Heavy Fuel Oil*	*Gas Oil*	*Biomass*	*Oil Shale*	*Peat*
Energy industries	1.5	2.5	3	1.5	48	0	100
Manufacturing and construction	88.8	2.5	25		48	60	100
Other sectors	600	1.9	0.69		271.58	600	600

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, is received from the Energy Department of Statistics Estonia. This data is also presented in the database of SE and added to the *Estonian National Inventory Report 1990–2015 (Annex 3).* Some detailed data (i.e. technology specific – pulverised and fludised bed combustion of oil shale consumption in Narva power plants; shale oil and semi-coke gas production by the Narva Oil Plant) are obtained from the energy company Eesti Energia AS. Data on oil shale, shale oil and semi-coke and generator gas consumption in Kiviõli and VKG Oil Plants are obtained directly from the oil plants.

Fuel consumption in Energy industries (CRF 1.A 1) and Manufacturing industries and construction (CRF 1.A 2) in 1990–2015 are presented in Figure 3.18, Figure 3.19 and Table 3.15.

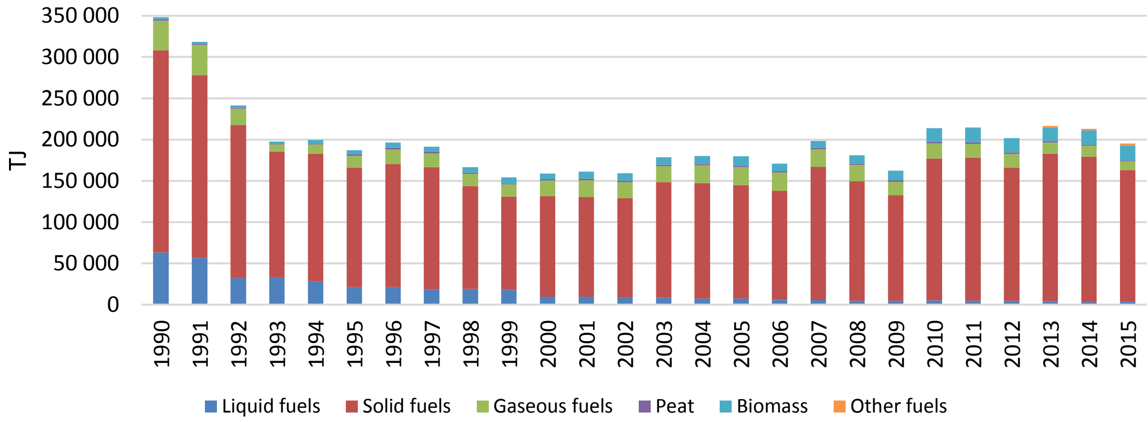

Figure 3.18. Trend of fuel consumption in Energy industries, TJ

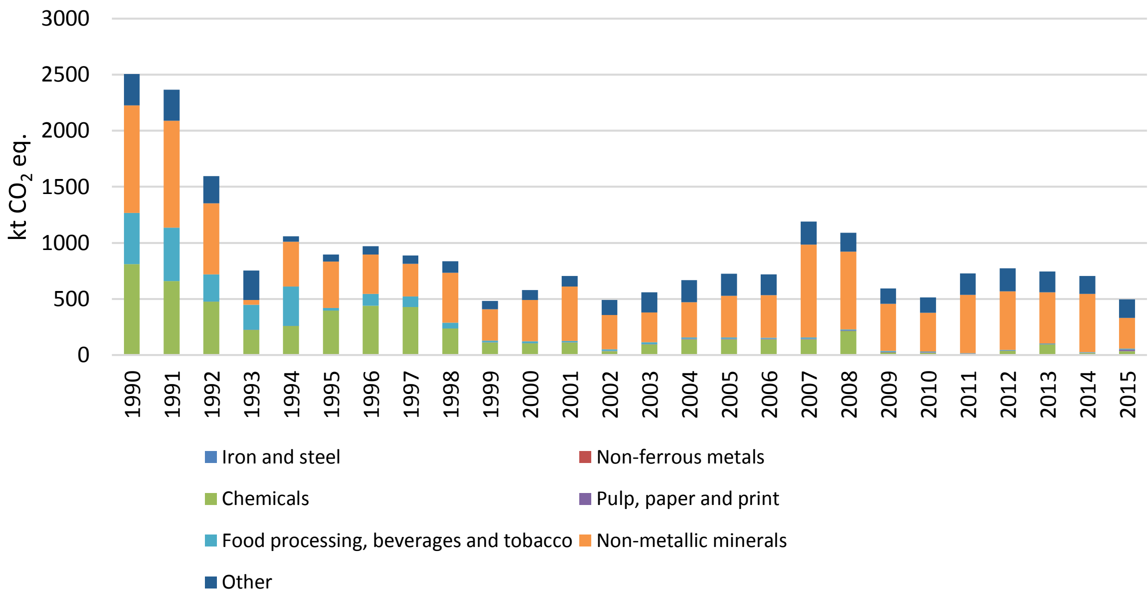

Figure 3.19. Trend of fuel consumption in Manufacturing industries and construction, TJ

Table 3.15. Fuel consumption in Energy industries and Manufacturing industries and construction in 1990, 1995, 2000, 2005, 2010–2015, TJ

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1.A.1 Energy industries total	348 336	186 962	158 819	179 623	213 630	214 671	201 928	216 482	213 155	195 061
Liquid Fuels	63 128	21 247	9 705	7 167	5 001	4 518	4 526	3 731	3 273	3 452
Solid Fuels	245 187	144 403	121 732	137 639	171 865	173 797	161 428	179 062	176 134	159 513
Gaseous Fuels	35 808	14 302	18 872	21 914	18 273	16 624	16 530	13 740	13 084	10 559
Peat	1 770	2 027	1 340	1 463	2 178	1 861	1 854	1 492	1 232	1 226
Biomass	2 443	4 983	7 170	11 440	16 313	17 871	17 590	16 523	17 351	17 914
Other Fuels[12]	NO	NO	NO	NO	NO	NO	NO	1 934	2 081	2 397
	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
1.A.2 Manufacturing industries and construction total	27 080	9 649	7 559	10 121	6 889	9 017	9 857	10 846	9 190	8 464
Liquid Fuels	10 464	1 996	1 306	2 227	1 717	2 131	2 352	2 037	1 865	2 234
Solid Fuels	11 172	4 417	3 139	2 608	2 552	3 861	3 611	2 640	3 225	1 261
Gaseous Fuels	5 099	3 058	2 929	4 206	1 553	1 663	2 186	3 165	1 480	1 602
Peat	96	24	38	139	4	5	0	1	1	1
Biomass	249	154	139	331	499	236	255	1 124	530	1 911
Other Fuels[13]	0	0	8	610	564	1 121	1 454	1 879	2 089	1 455

[12] Municipal solid waste; combusted in Iru waste incinerator since construction in 2013

[13] Waste oils, Other fossil based waste (MSW) and Plastics; Combusted in Kunda Nordic Cement plant since 2000

3.2.4.3. Uncertainties and time series consistency

Uncertainty evaluation of CO_2 emissions has been conducted for four fuel types used in Estonia in 2015 liquid, solid, gaseous 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[14].

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 2015 by using available estimates and the combination of available measured data;

Data has been obtained from database of Statistics Estonia.

In estimation of uncertainty two main components has 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 given as Equation 3.2:

Equation 3.2

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

Where:

u_e = uncertainty of emissions;
u_{AD} = uncertainty of activity data;
u_{EF} = uncertainty of emission factor.

In obtaining expanded uncertainty the coverage factor *k*=2 has been used to provide approximately 95% confidence level of the results (see Equation 3.3):

Equation 3.3

$$U_E = 2 \cdot u_E$$

Where:

U_E= expanded uncertainty.

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

- Liquid Fuels

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

- Solid Fuels

[14] Metrosert AS report: Uncertainty Estimation of CO_2 emission in the Estonian National Greenhouse Gas Inventory, April 2007, Tallinn, Estonia.

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

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

The uncertainty factors of carbon emission factors and activity data due to fuel combustion are presented in Table 3.16. The largest uncertainty contribution of 60% is caused by incomplete data of emission factor of other fuels (waste fuels).

Table 3.16. Estimated relative uncertainties of CO_2 emission due to Fuel combustion in Estonia in 2015[15]

GHG Source and Sink Categories	Gas	Uncertainty of activity data, %	Uncertainty of emission factor, %	Combined relative uncertainty, %
1.A. Fuel combustion				
Liquid Fuels	CO_2	1.7	1.8	2.5
Solid Fuels	CO_2	3.3	38.9*	39.0
Gaseous Fuels	CO_2	1.4	3.6	3.9
Other Fuels*	CO_2	5	60	60.2

*The uncertainty of the emission factors of the solid fuels category 1.A.1a is significantly lower – 2.39%.

In estimation of uncertainties in CH_4 and N_2O the IPCC default values for activity data (5% and 10%) and for CH_4 emission factors (25%–150%) were used. In estimation of N_2O emission factor uncertainties (50%–125%) IPCC default and some Finnish values were used (see Table 3.17).

Table 3.17. Summary of uncertainty estimates for CH_4 and N_2O emission factors and activity data (95% confidence interval)

Source and Sink	GHG	Activity data uncertainty U_A	Emission factor uncertainty U_E	Reference U_A, U_E
1.A.1 Energy industries				
Liquid, solid and gaseous fuels	CH_4	5%	50%	**U_A** – IPCC GPG, Table 2.6, p. 2.41 **U_E** – IPCC GPG, Table 2.5, p. 2.41
	N_2O	5%	60%	**U_A –** IPCC GPG, Table 2.6, p. 2.41 **U_E –**Finnish[16]

[15] IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories.
[16] Finnish NIR 1990–2012.

Source and Sink	GHG	Activity data uncertainty U_A	Emission factor uncertainty U_E	Reference U_A. U_E
Biomass	CH_4	5%	60%	**U_A –** IPCC GPG, Table 2.6, p. 2.41 **U_E –** Finnish[16]
	N_2O	5%	60%	**U_A –** IPCC GPG, Table 2.6, p. 2.41 **U_E –** Finnish[16]
1.A.2. Manufacturing industries and constructions				
Liquid, solid and gaseous fuels	CH_4	5%	50%	**U_A** – IPCC GPG, Table 2.6, p. 2.41 **U_E** – IPCC GPG, Table 2.5, p. 2.41
	N_2O	5%	60%	**U_A** – IPCC GPG, Table 2.6, p. 2.41 **U_E** – Finnish[16]
Biomass	CH_4	5%	60%	**U_A** – IPCC GPG, Table 2.6, p. 2.41 **U_E** – Finnish[16]
	N_2O	5%	60%	**U_A –** IPCC GPG, Table 2.6, p. 2.41 **U_E –** Finnish[16]
Other Fuels	CH_4	5%	60%	**U_A –** IPCC GPG, Table 2.6, p. 2.41 **U_E –** Finnish[16]
	N_2O	5%	60%	**U_A –** IPCC GPG, Table 2.6, p. 2.41 **U_E –** Finnish[16]
1.A.3. Transport				
Liquid and solid fuels	CH_4	5%	40%	IPCC GPG .... p. 2.49
	N_2O	5%	50%	IPCC GPG .... p. 2.49
Biomass	CH_4	5%	100%	**U_A** – IPCC GPG, Table 2.6, p. 2.41 **U_E** – Finnish[16]
	N_2O	5%	150%	**U_A** – IPCC GPG, Table 2.6, p. 2.41 **U_E** – Finnish[16]
1.A.4. Other sectors				
Liquid, solid and gaseous fuels	CH_4	5%	50%	**U_A** – IPCC GPG, Table 2.6, p. 2.41 **U_E** – IPCC GPG, Table 2.5, p. 2.41
Solid and gaseous fuels	N_2O	5%	50%	**U_A** – IPCC GPG, Table 2.6, p. 2.41 **U_E** – Finnish[16]
Liquid fuels	N_2O	5%	75%	**U_A** – IPCC GPG, Table 2.6, p. 2.41 **U_E** – Finnish[16]
Biomass	CH_4	10%	150%	**U_A** – IPCC GPG, Table 2.6, p. 2.41 **U_E** – Finnish[16]
	N_2O	10%	150%	**U_A** – IPCC GPG, Table 2.6, p. 2.41 **U_E** – Finnish[16]
1.B. Fugitive emissions from fuels				
1.B.2.b Natural gas	CH_4	10%	25%	IPCC GPG .... p. 2.92

As the Good Practice Guidance does not give CH_4 emission factors uncertainty estimations (U_E) for biomass, and also for N_2O emission factors (U_E) for biomass and fossil fuels, those factors have been taken from the Finnish 2012 national inventory.

Detailed uncertainty estimations by categories are presented in Annex 2.

3.2.4.4. Category-specific QA/QC and verification

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

Fuel consumption data in natural units (in tons or thousand cubic meters, etc) and fuel consumption data in energy units (in TJ-s) are available in the statistical database on the website of Statistics Estonia (www.stat.ee). Year average net calorific values of fuels are received from Statistics Estonia by a special request. Before entering the fuel consumption data into emission calculation tables the expert first checks the current year data by multiplying fuel amounts in natural units with NCV and compare the results with fuel consumption data in TJ-s presented in the statistical database. Sometimes there are some small differences due to the rounding of values. The second step is to check all activity data on previous years because Statistics Estonia sometimes corrects old data. The third step is the checking of national energy balance data with IEA data. IEA uses constant NCV-s for fuels but National energy data in TJ-s are calculated using year specific NCV-s. Some differences are also in reporting of heat produced. In IEA statistics only fuels used for sold heat produced by district heating power plants and auto-producers are reported in Energy conversion sector, but fuels used for heat production by auto-producers and used by themselves (own consumption) is reported under the final consumption. In the National energy balance only fuels used for heating technological processes is reported under the final consumption of fuels of the sector.

After the fuel consumption data, emission factors of fuels will be checked. If there is some new research on estimation of country specific emission factors available, all necessary corrections will be made for whole time series.

In the 2017 inventory submission Energy sector CO_2 emissions were compared against the emissions of European Union Emission Trading Scheme (EU ETS) enterprises (for the year 2015). The consistency of EU ETS data and the inventory submission has been improved since the 2016 submission. Notably, the methodology of the calculation of the emissions of shale oil production has been improved in the inventory. Inventory compilers receive additional information from shale oil producers which makes inventory emissions data more precise and reliable. Secondly, Estonia is working on unifying the oil shale combustion data presented in the EU ETS and in the energy balance of Statisticzs Estonia.

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

3.2.4.5. Category-specific recalculations

For the year 2014 in 1A1a some activity data of other fuels (municipal waste) has been updated. Also, the activity data of oil shale combustion has been updated for the years 2005 – 2015 according to relevant EU ETS enterprises. Estonia is also working on unifying EU ETS oil shale combustion data with the data of Statistics Estonia. Oxidation factors have been updated in nearly all categories due to the Regulation of Minister of Environment on “Calculation methods of the amount of CO_2 discharged into ambient air” was updated to be in accordance eith the 2006 IPCC Guidelines. The methodology of 1A1c has been enhanced. Namely, the emission factors of shale oil production have been recalculated according to more precise plant specific data. For 1A2d, the combustion of biogas has been added to 2014. The differences are presented in Table 3.18.

Table 3.18. Differences between 2017 and 2016 submissions, kt CO_2 equivalent

Year	Differences between 2017 and 2016 submissions, kt CO2 equivalent*								
	1A1a	**1A1c**	**1A2a**	**1A2b**	**1A2c**	**1A2d**	**1A2e**	**1A2f**	**1A2g**
1990	410.19	21.19	-0.002	0.000	6.45	0.000	-0.26	11.75	0.10
1991	375.12	11.57	0.000	0.000	5.26	0.000	-0.23	11.16	0.08
1992	306.09	16.97	0.000	0.000	3.53	0.008	-0.05	7.83	1.70
1993	231.02	27.66	0.000	0.000	1.65	0.001	-0.10	0.21	4.10
1994	241.72	31.24	-0.001	0.000	1.79	0.001	-0.21	6.80	0.05
1995	219.04	28.36	0.000	0.000	2.99	0.002	0.04	6.56	0.04
1996	224.21	30.17	-0.001	0.000	3.39	0.000	-0.04	5.87	0.04
1997	221.63	33.82	-0.001	0.000	3.39	0.000	-0.04	4.46	0.05
1998	200.04	28.50	-0.001	0.000	1.51	0.000	-0.01	7.18	-0.01
1999	193.81	27.21	-0.001	0.000	0.47	0.001	0.02	4.16	0.02
2000	189.07	38.43	0.000	-0.001	0.44	0.004	0.03	4.27	0.03
2001	182.82	41.04	-0.001	0.000	0.47	0.008	0.02	3.97	0.06
2002	177.99	44.31	0.000	0.005	0.11	0.010	0.01	3.51	0.06
2003	213.31	50.48	0.001	0.000	0.36	0.015	0.01	2.90	0.12
2004	188.70	53.46	0.000	0.007	0.56	0.012	0.03	3.14	0.44
2005	754.67	58.36	0.003	0.004	0.56	0.012	0.03	4.66	0.47
2006	672.73	55.22	0.004	0.004	0.55	0.019	0.02	3.60	0.30
2007	1266.96	52.63	0.000	0.014	0.53	0.016	0.02	8.02	0.27
2008	542.64	71.58	0.002	0.015	1.20	0.020	0.01	4.74	0.23
2009	369.27	86.00	0.000	0.014	0.07	0.012	0.01	2.85	0.13
2010	1064.39	126.85	0.000	0.010	0.02	0.018	0.01	2.64	0.15
2011	492.33	157.55	0.000	0.000	0.02	0.010	0.00	4.67	0.90
2012	453.88	181.27	0.000	0.000	0.10	0.016	0.01	4.34	0.81
2013	-24.26	153.15	0.000	-0.001	0.36	0.015	0.02	2.72	0.83
2014	-272.68	264.02	0.000	-0.001	0.03	0.015	0.01	2.75	0.28

3.2.4.6. Category-specific planned improvements

There are no category-specific planned improvements.

3.2.5. Transport (CRF 1.A.3)

An efficient transport system is an important prerequisite for economic and social development. Transport also has an important social function – to satisfy movement needs. In the Estonian economy, transport and its support activities account for about 9% of total employment. In 2015 the amount of registered vehicles increased, the amount of railway passengers increased, but the amount of goods transported by rail decreased. While passenger travel by sea increased, the amount of goods transported decreased.

3.2.5.1. Category description

In 2015, the greenhouse gas emissions from Transport sector amounted to 2 323.82 kt CO_2 equivalent. The share of the Transport sector of the Energy sector was 14.6% and of the total greenhouse gas emissions approximately 12.9% in 2015.

Emissions from Transport include all domestic transport sectors (see Table 3.19):

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

Table 3.19. Reporting categories in the Transport sector

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

Emission trends from Transport sector by subcategories are given in Figure 3.21. In Figure 3.20 emissions from the Transport sector are given by greenhouse gases.

CO_2 emission trend decreased strongly after 1991. The reason of the decrease was the rapid increase of fuel prices after regaining independency in Estonia in 1991 and also difficulties in fuel supply. Estonia imported in the beginning of 1990s all transport fuels from Russia. The bottom was reached in year 1992 and after that increase has been fairly constant reaching the 1990 emission level in 2007. The increase has happened mainly in the road transport. In 2010 emissions from transportation sector increased comparing with previous year. The reason for this increase was the perking up of the economic environment after economic depression in 2008 and 2009. In 2011, the emissions grew about 0.4% compared to 2010. This increase took place mainly due to decrease in number of public transport users and the increase of transported goods on road transport. In 2012, the emissions stayed about the same level as in 2011 (increase of 1.1%). Emissions decreased about 2.4% in 2013 compared to 2012. In 2014 emissions increased about 1.1% compared to the previous year. In 2015 there was slight increase in emissions again. The emissions increased 2.6% compared to 2014.

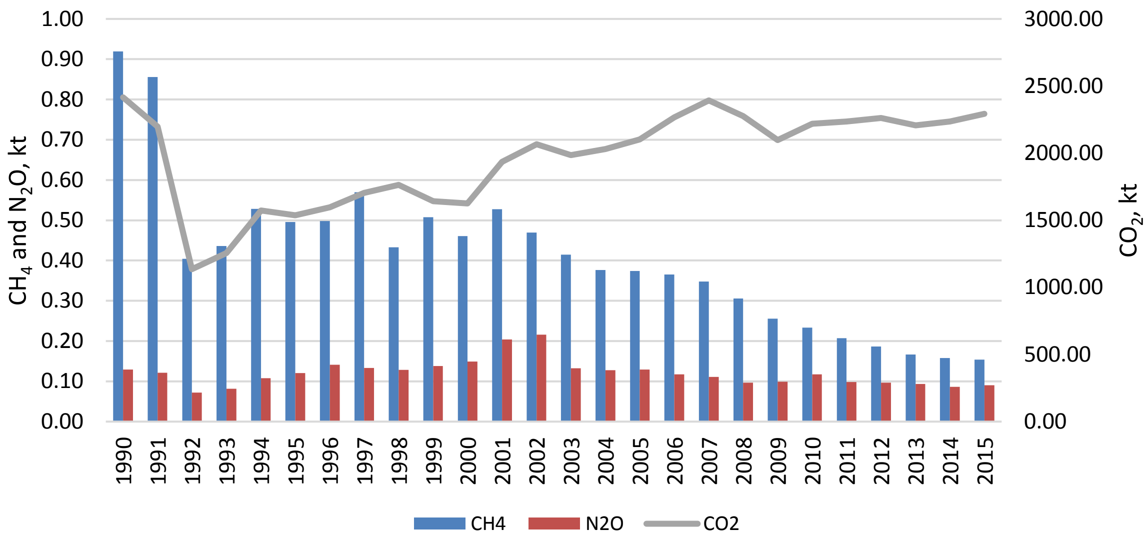

Figure 3.20. Emissions from Transport sector by greenhouse gas in 1990–2015, kt

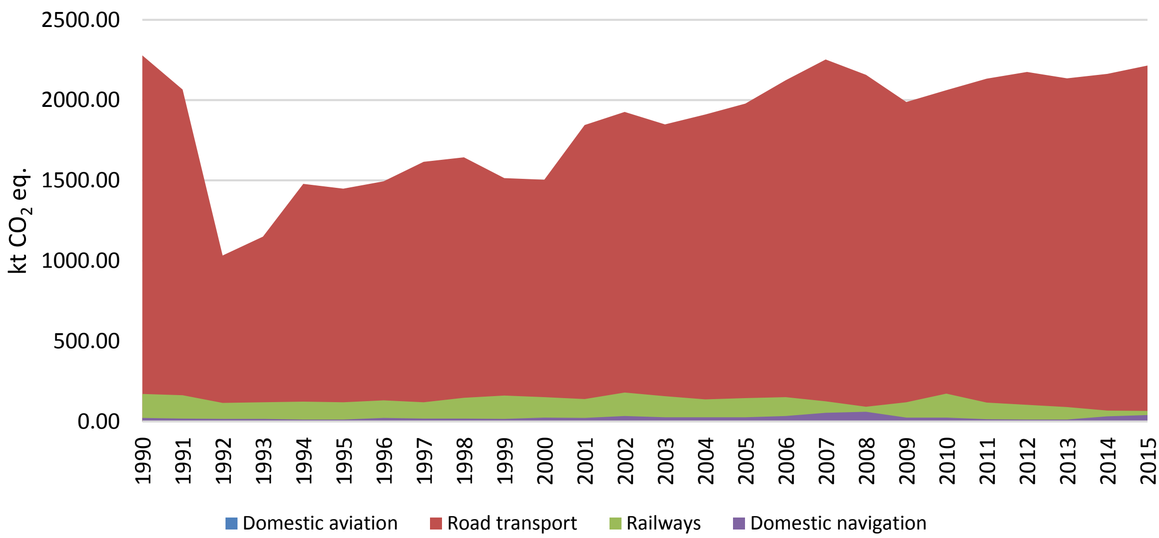

Figure 3.21. Emissions from Transport sector by subcategory in 1990–2015, kt CO_2 eq.

Road transportation is the most important emission source in Transport sector covering 95.4% of sector's emissions (see Figure 3.21). The fuel consumption and the emissions from the Transport sector are presented in Table 3.20 and

Table **3.21**.

Table 3.20. Emissions from the Transport sector by subcategories, kt

	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
1.A.3 Transport, CO_2 eq.	2 477.19	1 584.36	1 682.11	2 150.88	2 261.03	2 269.41	2 294.76	2 240.16	2 264.43	2 323.82
1.A.3.a Civil aviation, CO_2	5.52	3.24	2.40	1.70	1.76	2.67	3.34	1.20	1.24	1.24
1.A.3.b Road transport, CO_2	2 234.50	1 412.30	1 465.08	1 946.69	2 039.40	2 112.18	2 153.54	2 113.16	2 140.57	2 192.85
1.A.3.c Railways, CO_2	153.93	108.15	135.61	129.64	155.60	105.44	91.82	81.11	61.17	59.41
1.A.3.d Domestic navigation, CO_2	21.79	12.31	23.17	24.92	23.36	14.70	12.66	12.72	31.71	39.63
1.A.3 Transport, CH_4	0.92	0.50	0.46	0.37	0.23	0.21	0.19	0.17	0.16	0.15
1.A.3 Transport, N_2O	0.13	0.12	0.15	0.13	0.12	0.10	0.10	0.09	0.09	0.09

Table 3.21. Fuel consumption in Transport sector, TJ

	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
1.A.3.a Civil aviation										
Aviation gasoline	78	46	34	24	24	37	47	16	17	17
1.A.3.b Road transport										
Gasoline	21 405	10 527	11 872	12 249	11 745	11 144	10 695	9 967	10 151	10 033
Diesel Oil	9 500	8 989	8 540	14 795	16 302	17 868	18 935	19 018	19 162	20 043
LPG	139	17	10	8	5	6	5	7	10	8
1.A.3.c Railways										
Coal	119	39	6	NO	NO	NO	NO	NO	NO	NO
Diesel oil	1 951	1 425	1 842	1 774	2 125	1 442	1 255	1 110	837	814
1.A.3.d Domestic navigation										
Diesel oil	298	168	316	341	319	201	173	174	434	543

3.2.5.2. Civil aviation

The number of passengers, who passed through airports in 2015 increased compared to 2014. The passenger traffic volume of Estonian airports was over 2.2 million persons, which is 8% more than in 2014. Tallinn Airport had 7.5% more passengers in 2015 compared to the previous year. Most of the passengers were serviced on scheduled flights. Over 2 million passengers were transported on international flights and over 41 thousand passengers were transported on domestic flights (14% more than in 2014). There were more scheduled flights per week than the year before. Compared to 2014, cargo and mail services through airports also decreased 22.9%, amounting to just over 16 thousand tons.

At the end of 2015, the Register of Estonian Civil Aircraft included 170 units of aircraft.

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

Table **3.21**).

The share of the Civil aviation from the Transport sector was only 0.05% and the amount of emissions was 1.26 kt of CO_2 equivalents in 2015. The corresponding figure was 5.58 kt CO_2 equivalent in 1990.

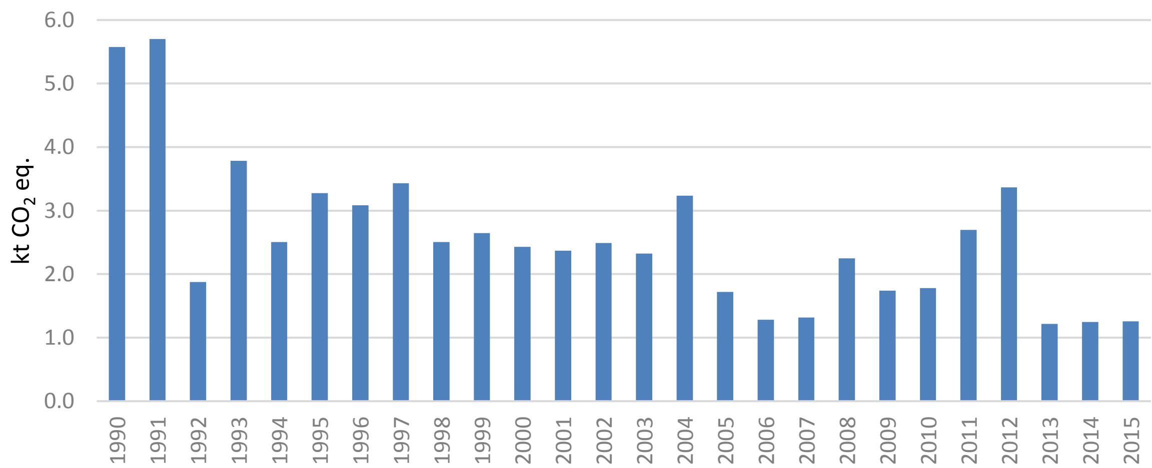

Figure 3.22. GHG emissions from Civil aviation in 1990–2015, kt CO_2 eq.

Methods

For estimation of emissions from Civil aviation the Tier 2 approach is used. Operations of aircraft are divided into LTO and Cruise phases. The Tier 2 approach breaks the calculation of emissions from aviation into the following steps using Equation 3.4, Equation 3.5 and Equation 3.6:

Equation 3.4

1. *Total Emissions = LTO Emissions + Cruise Emissions*

Equation 3.5

2. *LTO Emissions = Number of LTOs * Emission Factor of LTOs*

Equation 3.6

3. *Cruise Emissions = (Total Fuel Consumption – LTO Fuel Consumption) * EF Cruise*

Activity data

The activity data on aviation gasoline used in Civil aviation is obtained from Statistics Estonia. In the National Energy Balance aviation fuel is not presented separately for national and international flights, but this data still exists in the database of Statistics Estonia. Ministry of the Environment asks every year the detailed data on aviation fuel use for GHG inventory submission. Data is collected from different fuel supply companies by special statistical questionnaire 'Transport Fuels' where fuel use has to be reported separately for national and international use.

To separate the fuel consumption further into landing and take-off (LTO) phase and the cruise phase Estonia uses the following principle: for the LTO phase, fuel consumed is based on representative aircraft type group data. The energy use by aircraft is calculated for both domestic and international LTOs by multiplying the LTO fuel consumption factor for each representative aircraft type by the corresponding number of LTOs (Equation 3.7). The cruise energy use is estimated as the difference between the total fuel use from aviation fuel sale statistics and the total calculated LTO fuel use (Equation 3.8).

Equation 3.7

$$LTO_{\text{Fuel Consumption}} = \text{Number of LTOs}_{\text{by aicraft type}} * \text{Fuel Consumption per LTO}_{\text{by aicraft type}},$$

Equation 3.8

$$Cruise_{\text{Fuel Consumption}} = Total_{\text{Fuel Consumption}} - LTO_{\text{Fuel Consumption Cruise}},$$

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

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

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

A complete calculations has been carried out by Estonian Environment Agency for the years 1992–2015. An extrapolation has been made for 1990 and 1991 (see Table 3.22).

Table 3.22. Number of LTO cycles

Year	Domestic LTO	International LTO
1992	2 249	5 247
1993	2 398	5 595
1994	2 366	5 520
1995	3 754	8 760
1996	4 819	11 243
1997	4 516	10 537
1998	4 922	11 484
1999	4 672	10 901
2000	4 778	12 303
2001	4 255	10 408
2002	8 720	15 894
2003	8 025	14 040
2004	6 243	15 868
2005	7 740	17 907
2006	7 219	15 460
2007	7 958	17 078
2008	8 212	20 501
2009	7 598	14 122
2010	7 637	14 855
2011	8 320	17 344
2012	8 692	21 811
2013	7 924	16 672
2014	7 508	16 775
2015	8 097	18 087

Emission factors and other parameters

Cruise and LTO emission factors of the CO_2, CH_4, N_2O used in the calculation of emissions from national aviation are aquired from the IPCC 2006 Guidelines

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

LTO emission factors of the NOx, CO, NMVOC and SO_2 used in the calculation of emissions from national aviation are taken from the EMEP/EEA air pollutant emission inventory guidebook 2009 (chapter: 1.A.3.a Aviation, table 3–3, p.18) and other referred sources in guidebook (IPCC, FOCA, ICAO engine database etc). The share of different aircraft types varies every year and due to that the average emission factor changes from year to year. In the Table 3.23 is presented average emission factors for 2015 emission calculations.

Table 3.23. Emission factors used in the calculations of emissions from Civil aviation (1.A.3.a)

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
Cruise[17]	70 000 kg/TJ	0 kg/TJ	2 kg/TJ	10.3 kg/t	2.0 kg/t	0.1 kg/t	1.0 kg/t

[17] EMEP/EEA air pollutant air emission inventory guidebook, Table 3-3, p.18 (average fleet).

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
LTO	3 160 kg/t	5 kg/TJ	2 kg/TJ	6.0 kg/t	103.3 kg/t	5.1 kg/t	0.0 kg/t

Emission factors in kg per ton of aviation gasoline are converted to kg/TJ using net average calorific value of aviation gasoline. The results for 2015 are presented in Table 3.24.

Table 3.24. Emission factors from Civil aviation (1.A.3.a)

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
	t/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
Cruise	70	0	2.0	239.5	46.5	2.3	18.6
LTO	73.5	5	2.0	139.5	2 402.3	118.6	20.9

3.2.5.3. Road transport

Road transport (CRF 1.A.3.b) includes all transportation on the roads in Estonia. The types of vehicles with combustion engines are: passenger cars, vans, buses, lorries, motorcycles and mopeds. The category does not cover farm and forest tractors driving occasionally on the roads because they are included in the CRF category 1.A.4.c Agriculture/forestry/ fisheries.

Road transport is the most important emission source in the Transport sector. The emissions from Road transportation were 2 216.08 kt CO_2 equivalent in 2015, it is about 95.4% of total Transport sector emissions and 14.0% of the Energy sector. In 2015 the GHG emissions of the Road transport sector were about 2.8% lower than in 1990 (2 278.78 kt CO_2 eq.).

The trend of CO_2 emissions follows in general the fuel consumption trend in the Road transportation sector. The total emissions of Road transport can be observed on Figure 3.23. The lowest emission level in the Road transportation was achieved in 1992/1993, it was caused by rapid increase of fuel prices after regaining independency in 1991 and also with difficulties in fuel supply (in the beginning of 1990s Estonia imported all transport fuels from Russia). The second decrease in the emission trend was in 1999/2000 and it was connected with an economic crisis in Russia (fuel supply problems). In 2007 the emissions from Road transport were on the level of 1990, but since 2008 a small decrease of emissions (in 2008/2007 about 6% and in 2009/2008 about 7%) started which reflects the overall economic depression in Estonia. In 2011, GHG emissions from Road transportation increased about 3.5% compared to 2010. Similarly, the emissions increased about 2.0% in 2012 compared to 2011. In 2013 the emissions decreased about 1.9% compared to previous year because there was an overall decrease of fuels used in the road transport sector. In 2014 the emissions increased about 1.3% compared to 2013 because of an increase in fuel consumption. The year 2015 continued with an increase of 2.5% compared to the previous year, mainly due to the increased use of diesel fuel.

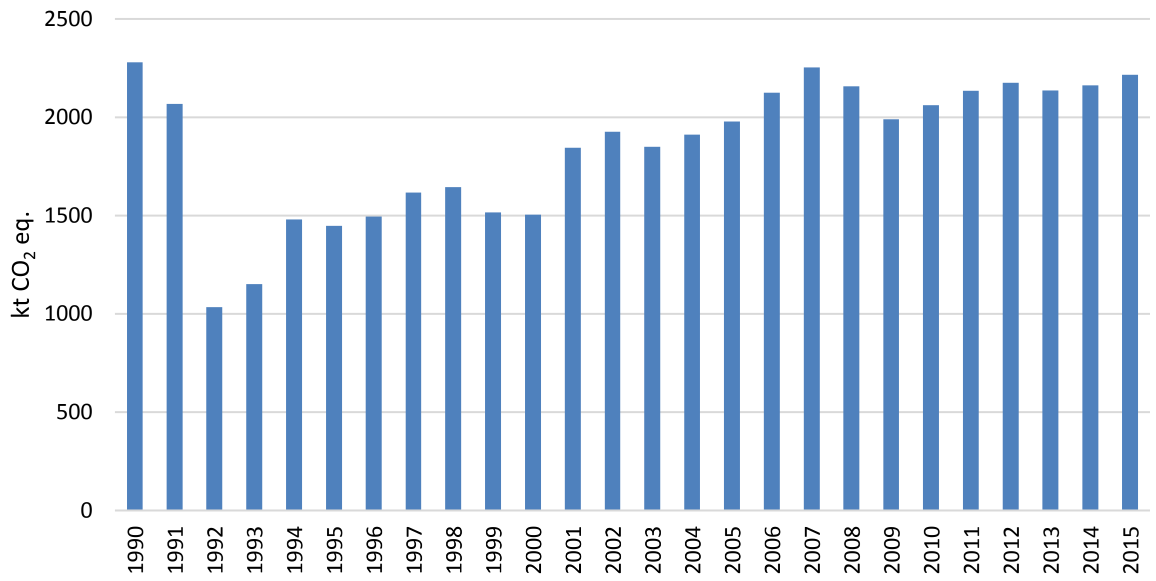

Figure 3.23. Emissions from the Road transport in 1990–2015, kt CO_2 eq.

Methods

Emissions from Road transport are estimated using the 2006 IPCC Tier 2 methodology for CO_2 emissions and the COPERT model in accordance with the 2006 IPCC Tier 3 methodology for CH_4 and N_2O emissions. COPERT model is also used for calculation of SO_2, CO, NOx and NMVOC emissions. CH_4 and N_2O emissions from combustion of LPG in Road transport are calculated using the IPCC Tier 1 methodology since the COPERT model does not include LPG.

In the current inventory report the emissions of CO_2 is calculated on basis of the amounts and type of fuel combusted and its carbon content. The *Tier 2* approach calculates CO_2 emissions by multiplying the estimated fuel sold with a country-specific emission factor. This approach can be expressed as in Equation 3.9:

Equation 3.9

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

Where:

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

The emission equation of Tier 3 of CH_4 and N_2O which is described in the Equation 3.10:

Equation 3.10

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

Where:

Emission =	emission of CH_4 or N_2O, kt CO_2 eq.;
$EF_{a.b.c.d}$ =	emission factor, kg/km;
$Distance_{a.b.c.d}$ =	distance traveled (VKT) during thermally stabilized engine operation phase for a given mobile source activity, km;
$C_{a.b.c.d}$ =	emissions during warm-up phase (cold start);
a =	fuel type (e.g. diesel, gasoline, etc);
b =	vehicle type;
c =	emission control technology (such as uncontrolled, catalytic converter, etc);
d =	operating conditions (e.g. urban or rural road type, climate, or other environmental factors).

N_2O and CH_4 emissions are calculated for gasoline and diesel vehicles separately. The kilometrage (km/y) of each automobile type and model on different road types and in different speed classes are multiplied with corresponding CH_4 and N_2O emission factor. Calculations are made by using COPERT 4 model, which is based on EMEP/EEA air pollutant emission inventory guidebook – 2013 sector 1.A.3.b Road transport[18]. The calculation model COPERT is located in the Estonian Environment Agency. Also a validation of fuel and mileage statistics is performed and data is adjusted if necessary.

COPERT is a software tool used world-wide to calculate air pollutant and GHG emissions from road transport. The development of COPERT is coordinated by the European Environment Agency, in the framework of the activites of the European Topic Centre for Air Pollutant and Climate Change Mitigation. Necessary input data for the model in order to calculate emissions: number of vehicles, annual mileage per vehicle, annual statistical fuel consumption, speed (urban, rural, highway), driving share (urban/rural/highway), monthly minimum and maximum temperatures, monthly reid vapo pressure (RVP) etc. COPERT contains 240 individual vehicle types. The vehicle classes are defined by the vehicle category (passenger car, light duty vehicle, etc.) fuel type, weight class, environmental class and in some instances the engine type and/or the emission control technology (e.g. "Euro" standards). Estonia divides its vehicle stock into 110 vehicle types.

QA/QC on input data collection of COPERT model includes: vehicle data and annual mileage per vehicle are collected from the Estonian Road Administration. Meteorological data is provided by Estonian Weather Service and data pertaining to fuel consumption by Statistics Estonia. QA/QC plan consists of six parts:

1) stakeholder engagement (stakeholders – e.g. suppliers of data, reviewers, recipients);
2) data collection, which includes activity data collection; before using activity data, common statistical quality checking related to the assesment of trends is carried out;
3) data manipulation (common statistical quality chekcing is carried out);
4) inventory compilation;
5) reporting;
6) archiving.

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

[18] EMEP/EEA air pollutant emission inventory guidebook – 2013 1.A.3.b.i-iv Exhaust emissions from road transport. [WWW] http://www.eea.europa.eu/publications/emep-eea-guidebook-2013/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-road-transport (13.03.2016).

the emission factor values are differentiated per vehicle category and Euro standard. N_2O emission factors depend on vehicle category and also on fuel sulphur content[18].

Activity data

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

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

In Table 3.26 the number of vehicles, in Table 3.27 road traffic mileage and in Figure 3.24 road traffic mileage per vehicle in 1990–2015 are presented.

There has been a small amount of biofuels used in Estonia in recent years, but the share has been very small (less than 1%), taking into account the energy content. The data on biofuels production and inland consumption are received from the Estonian Environment Agency. The biofuel consumption figures in PJ are reported in Table 3.25.

Table 3.25. Consumption of bioethanol and biodiesel in Estonia in 2005–2015, TJ

	Bioethanol consumption	**Biodiesel consumption**
2005	NO	0.17
2006	NO	1.23
2007	0.02	0.56
2008	2.15	3.15
2009	0.15	1.82
2010	6.86	3.57
2011	5.93	0.72
2012	5.63	NO
2013	4.78	NO
2014	7.75	0.0004
2015	4.00	NO

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

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

Table 3.26. Number of vehicles in Estonia, thousand vehicles

	Passenger cars	**Buses**	**Lorries and special vehicles**	**Motorcycles and Mopeds**	**Trailers**	**Total Vehicles**
1990	241	8	68	106	17	**440**
1991	261	9	77	100	16	**463**
1992	284	8	75	100	36	**503**
1993	317	9	74	97	37	**534**
1994	338	6	54	2	17	**417**
1995	383	7	66	3	24	**483**

	Passenger cars	Buses	Lorries and special vehicles	Motorcycles and Mopeds	Trailers	Total Vehicles
1996	407	7	71	5	29	**519**
1997	428	7	77	5	33	**550**
1998	451	6	81	6	36	**580**
1999	459	6	81	7	37	**590**
2000	464	6	82	7	38	**597**
2001	407	6	81	7	37	**538**
2002	401	5	80	7	37	**530**
2003	434	5	83	8	40	**570**
2004	471	5	86	9	43	**614**
2005	494	5	86	10	46	**641**
2006	554	5	93	13	53	**718**
2007	524	4	80	15	53	**676**
2008	552	4	83	18	60	**717**
2009	546	4	81	19	62	**712**
2010	553	4	81	20	66	**724**
2011	574	4	84	21	70	**753**
2012	602	4	88	23	75	**792**
2013	629	5	92	25	80	**831**
2014	653	5	97	27	85	**867**
2015	677	5	102	29	91	**904**

Table 3.27. Road traffic mileage in Estonia, million km/y

	Cars	Vans	Lorries	Buses	MC+Mopeds	Vehicles total
1990	5 601	687	1 363	221	317	**8 189**
1991	5 612	668	1 020	176	230	**7 706**
1992	2 278	347	678	105	230	**3 638**
1993	2 620	378	679	152	223	**4 052**
1994	4 225	422	679	165	5	**5 496**
1995	3 880	447	631	211	8	**5 177**
1996	4 172	495	657	194	10	**5 528**
1997	4 396	555	725	199	13	**5 888**
1998	3 165	456	839	226	10	**4 696**
1999	4 012	512	709	193	15	**5 441**
2000	4 126	505	725	175	16	**5 547**
2001	5 271	729	844	167	16	**7 027**
2002	5 177	873	871	182	17	**7 120**
2003	5 219	825	764	177	19	**7 004**
2004	5 420	958	767	175	33	**7 353**
2005	5 802	959	724	174	11	**7 670**
2006	6 451	950	767	172	19	**8 359**

	Cars	Vans	Lorries	Buses	MC+Mopeds	Vehicles total
2007	6 990	978	777	184	28	**8 957**
2008	6 829	966	817	178	30	**8 820**
2009	6 547	727	677	142	27	**8 120**
2010	6 456	764	829	152	27	**8 228**
2011	6 460	778	845	154	25	**8 262**
2012	6 715	860	888	154	34	**8 651**
2013	6 737	853	799	163	44	**8 596**
2014	7 029	887	771	153	28	**8 868**
2015	7 413	800	759	167	65	**9 204**

The number of vehicles increased between 1991 and 1992 by 8.6% while the kilometers driven decreased by 52.8%. This increase in number of vehicles, but in the same time decrease in mileage is due to the fact, that Estonia regained its independence in 1991. Before that, only people with special permits could buy a vehicle. In 1992, no permits were needed, therefore everyone could buy a vehicle. Still, there was a shortage of motor fuels and the prices were very high. Therefore there was a large decrease in the mileage of vehicles.

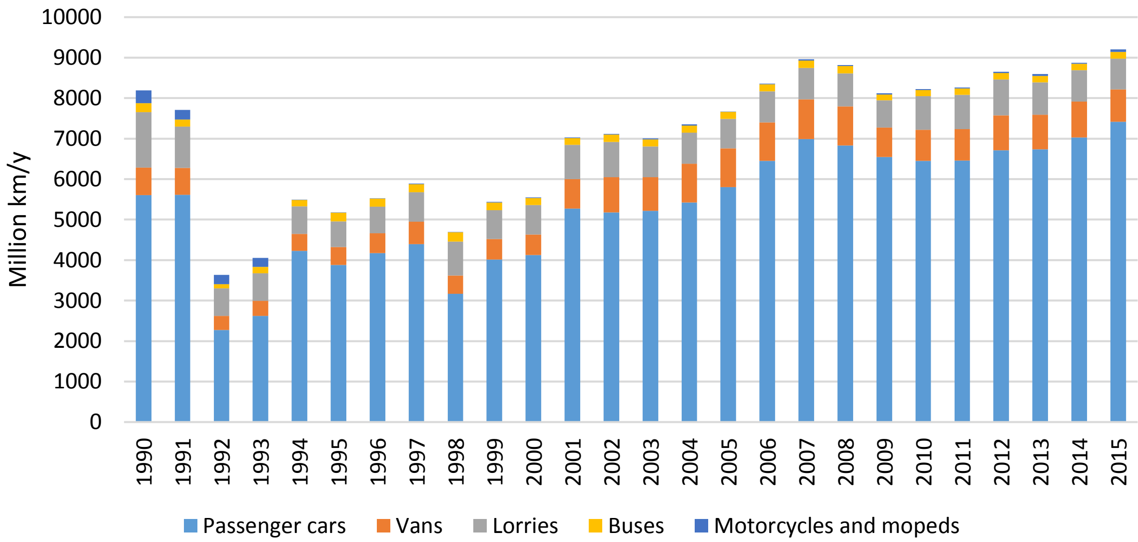

Figure 3.24. Road traffic mileage per vehicle type in 1990–2015, million km/y

Emission factors and other parameters

CO_2 emission factors of Gasoline, LPG and Diesel oil for Road transportation are presented in Table 3.28. In 2013 Estonia developed its own country specific CEF calculation methodology for Gasoline, LPG and Diesel oil for Road transportation. The CEFs for these fuels are calculated using weighted average method using CEFs of countries, that Estonia imports its fuel from. Since there was no import data for the years 1990–1994, then these values are calculated based on the data of 1995–1997. All submissions since then are based on these CEFs

Table 3.28. Carbon emission factors, tC/TJ, CH_4 emission factors, kg/TJ and N_2O emission factors, kg/TJ for fuels used in Road transport

Year	Gasoline			Diesel			LPG		
	CEF	CH_4 EF	N_2O EF	CEF	CH_4 EF	N_2O EF	CEF	CH_4 EF	N_2O EF
1990	19.50	39.10	2.25	20.01	7.52	2.54	17.72	1.00	0.10
1991	19.50	40.58	2.38	20.01	7.28	2.45	17.72	1.00	0.10
1992	19.50	39.90	2.18	20.01	7.46	2.53	17.72	1.00	0.10
1993	19.50	39.79	2.77	20.01	7.54	2.37	17.72	1.00	0.10
1994	19.50	37.69	3.99	20.00	7.35	2.24	17.72	1.00	0.10
1995	19.51	40.00	5.55	20.02	7.48	2.34	17.83	1.00	0.10
1996	19.49	36.91	6.49	20.01	7.37	2.49	17.83	1.00	0.10
1997	19.52	38.72	5.46	20.01	7.24	2.43	17.79	1.00	0.10
1998	19.60	28.32	4.16	20.01	7.51	2.58	17.77	1.00	0.10
1999	19.55	36.74	5.19	20.01	7.37	2.33	17.75	1.00	0.10
2000	19.27	32.79	6.46	20.01	7.18	2.19	17.72	1.00	0.10
2001	19.34	31.52	9.51	19.97	6.78	1.89	17.75	1.00	0.10
2002	19.71	28.85	9.92	19.96	6.47	1.82	17.76	1.00	0.10
2003	19.79	26.25	4.56	19.97	6.19	1.64	17.76	1.00	0.10
2004	19.79	23.81	4.65	19.95	5.88	1.66	17.75	1.00	0.10
2005	19.27	23.05	4.44	19.95	5.52	1.59	17.75	1.00	0.10
2006	19.03	20.85	2.76	19.94	4.76	1.66	17.73	1.00	0.10
2007	19.06	18.95	2.54	19.94	4.18	1.74	17.62	1.00	0.10
2008	19.19	16.47	2.39	19.95	4.23	1.89	17.52	1.00	0.10
2009	19.40	15.59	2.29	19.91	3.40	1.86	17.56	1.00	0.10
2010	19.77	14.67	2.21	19.89	2.99	1.84	17.47	1.00	0.10
2011	19.78	13.70	2.10	19.92	2.60	1.84	17.29	1.00	0.10
2012	19.61	12.76	1.93	19.96	2.29	2.08	17.59	1.00	0.10
2013	19.80	12.26	1.76	19.94	2.02	2.29	17.30	1.00	0.10
2014	19.88	11.51	1.55	19.95	1.77	2.39	17.31	1.00	0.10
2015	19.85	11.44	1.52	19.92	1.57	2.51	17.30	1.00	0.10

The amounts of fuels imported in 2015 are presented in Table 3.29.

Table 3.29. Imported fuel amounts in 2015 by country

Gasoline (1000 l)		Diesel (kg)		LPG (kg)	
EU	43	**Belarus**	10 626 069	**China**	134
Belarus	20 798	**Belgium**	647 350	**Denmark**	3 355 030
Finland	201 062	**Canada**	5	**EU**	4 840 078
Germany	2 470	**China**	32	**Finland**	287
Italy	300	**EU**	1 340	**France**	2 620
Lithuania	299 688	**Finland**	171 025 520	**Germany**	7 075
Netherlands	4 588	**Germany**	2 339	**Greece**	123
Russia	4 961	**Lithuania**	404 721 235	**Italy**	2 739
Sweden	85	**Netherlands**	7	**Latvia**	2 156 369
UK	2 617	**Russia**	25 021 356	**Lithuania**	365 960
		Singapore	41	**Netherlands**	163
		Sweden	4 884	**Norway**	1 646 862
		Switzerland	1 238	**Republic of Korea**	223
		UK	10	**Russia**	9 638 526
		Undefined	929	**Sweden**	1 900 023

Gasoline (1000 l)		Diesel (kg)		LPG (kg)	
		USA	6 519 021	**UK**	1 789 205
				Undefined	335 664

* For countries, for whom CEF data was not available, the default CEFs have been used.

Oxidation factors for all fuels in Road transportation are equal to 1. The NCVs for the fuels used in road transport are the following: diesel – 42.3 GJ/kg, LPG – 45.5 GJ/kg and gasoline 33 GJ/litre.

The CEFs used for the calculation of the country-specific CO_2 emission factor for Estonia in 2015 are presented in Table 3.30.

Table 3.30. Carbon emission factors used in the calculation of the country-specific CO_2 emission factor for Liquid fuels in Road transport, tC/TJ

	Gasoline	Diesel	LPG
EU		20.20	
Belarus	18.90	20.21	17.20
Belgium		20.13	
Canada		19.15	
China		20.20	17.20
Denmark			17.21
EU			
Finland	19.88	19.99	17.20
France			17.80
Germany	19.93	20.19	17.87
Greece			17.43
Italy	20.00		17.89
Latvia			17.03
Lithuania	19.90	19.88	17.84
Netherlands	19.64	20.26	18.19
Norway			17.75
Republic of Korea			17.20
Russia	19.89	20.14	17.21
Singapore		20.20	
Sweden	19.64	19.64	17.75
Switzerland			
UK	19.09		17.64
Undefined		20.2	17.2
USA		19.12	

The CO_2 emission factor for bioethanol is 0.698 t CO_2/t and for biodiesel 0.978 t CO_2/t.

For bioethanol and biodiesel, the CH_4 and N_2O emission factors of 3 kg/TJ and 0.6 kg/TJ respectively are used (2006 IPCC emission factors for gasoline and diesel). CH_4 and N_2O emission are calculated using COPERT model. CH_4 and N_2O emission factors used in COPERT are described in the EMEP/EEA air pollutant emission inventory guidebook, Chapter 1.A.3.b Road transport GB2013. Since different EURO class vehicles have different emission factors, then the CH_4 and N_2O emissions are highly dependent on the share of vehicles used in road transportation.

3.2.5.4. Railway

New trains started to run on Estonian railways in 2013 after several years of railway reconstruction. There were 288 locomotives, 19 electric railcars, 52 diesel railcars, 283 passenger wagons and 21 501 freight wagons registered in the State Railway traffic Register at the end of 2015.

Rail transport enterprises carried 28.0 million tonnes of goods in 2015. 11.3 million tonnes of transit goods were carried by rail – of these, 5.8 million tonnes were refined oil products and over 4.6 million tonnes were chemical products.

Railway transportation in Estonia is a small emission source in Transport sector. The emissions of Railway transportation were 66.43 kt of CO_2 equivalent in 2015. The share of GHG emissions from Railway transport was about 2.9% of the total Transport sector emissions. In 1990 the corresponding figure was 170.82 kt CO_2 equivalent.

All non-electric locomotives use diesel oil in Estonia. From 1990 to 2002 also coal burning locomotives were used in Estonia. They were not used from 2003 to 2005. There was some use in 2006, but since then coal-powered trains have not been used.

Compared to other countries, the Rail transport of passengers in Estonia is used seldom and also the rail network density (in meters per km^2) is one of the smallest in Europe.

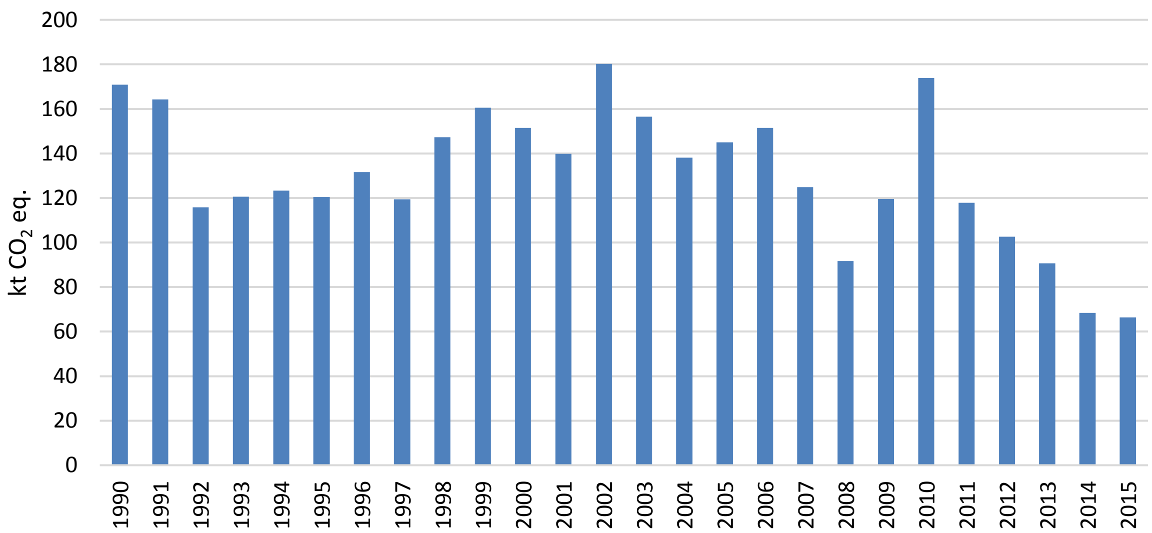

Figure 3.25. Emissions from Railways in 1990–2015, kt CO_2 eq.

The trend of CO_2 emissions follows in general the fuel consumption trend in the Rail transportation sector (Figure 3.25). The Rail transport is used mostly for transport of goods. The lowest emission level in the Rail transportation before the year 2015 was achieved in 2008, it was caused by rapid decrease of amount of goods carried by Estonian transport enterprises. The decrease in the goods transported by rail that started in 2007 has kept falling and the freight turnover was at the same level as it was ten years ago. The rail passanger traffic was disturbed due to a major reconstruction of railways in 2008. In 2009 the volume of transit goods inceased by 8% compared to 2008 and in 2010 by 11% compared to 2009. Compared to 2010, 20% more goods were posted abroad by rail and 40% more goods were received from abroad in 2011. In 2012, almost 8% less goods was carried by rail transport enterprises then in 2011. In 2013 the emissions decreased about 11.6% compared to 2012 due to the decrease in cargo turnover. In 2014 the amount of emissions decreased again, about 25% compared to 2013. This was caused by a sharp decrease in the carriage of goods by rail. The emissions reported in 2015 are the lowest ever estimated, due to ongoing decreasing in the carriage of goods by rail.

Methods

Emissions from Railways are calculated by multiplying the estimated fuel (diesel oil, coal) consumption with a country-specific emission factor (IPCC 2006 Tier 2).

Activity data

The activity data on fuel consumption used in Railways is obtained from Statistics Estonia and is presented in Table 3.21.

Emission factors and other parameters

CO_2 emissions from Railway transportation are calculated using the country-specific carbon emission factors of Coal and Diesel Oil. These emission factors are calculated using the weighted average method using CEFs of countries, that Estonia imports these fuels from. Emission factors of CH_4, and N_2O used in the calculation of emissions from Railway transportation are taken from the 2006 IPCC Guidelines, emission factors of NOx, CO and NMVOC for coal from EMEP/EEA Guidelines and SO_2 EF is country specific (an expert estimation). The used emission factors are presented in Table 3.31.

Table 3.31. Emission factors used in the calculation of emissions from Railways

Fuel	GHG	EF	Source
Diesel Oil	CO_2	19.92 tC/TJ	CS, Estonia
	CH_4	4.15 kg/TJ	IPCC 2006
	N_2O	28.6 kg/TJ	IPCC 2006
	NOx	52.4 kg/t	EMEP/EEA Guidelines
	CO	10.7 kg/t	EMEP/EEA Guidelines
	NMVOC	4.65 kg/t	EMEP/EEA Guidelines
	SO_2	141.2 kg/t	CS, EE
Coal	CO_2	25.69 tC/TJ	CS, Estonia
	CH_4	2 kg/TJ	IPCC 2006, Vol.2, Chapter 3, Table 3.4.1
	N_2O	1.5 kg/TJ	IPCC 2006, Vol.2, Chapter 3, Table 3.4.1
	NOx	173 kg/TJ	EMEP/EEA Guidelines
	CO	931 kg/TJ	EMEP/EEA Guidelines
	NMVOC	88.8 kg/TJ	EMEP/EEA Guidelines
	SO_2	1 028 kg/TJ	CS, EE

**EE – expert estimation*

3.2.5.5. Domestic navigation

The Estonian Register of Ships listed 108 sea craft (gross tonnage 100 or more) and 33 inland waterway vessels at the end of 2015. 15 ships (gross tonnage 100 or more) were listed in the register of bareboat character ships.

Domestic navigation in Estonia is also a small emission source in Transport sector. The emissions of Domestic navigation were 40.05 kt of CO_2 equivalent in 2015 (1.7% of the total Transport sector emissions). In 1990 the corresponding figure was 22.02 kt CO_2 equivalent.

Emissions from deep sea fishing are not included in the reporting for national navigation.

The trend of GHG emissions from Domestic navigation is presented in Figure 3.26. In the years 2006, 2007 and 2008 there was an increase in the emissions from Domestic navigation because there was a rapid increase of passenger traffic volume of sea transport enterprises.

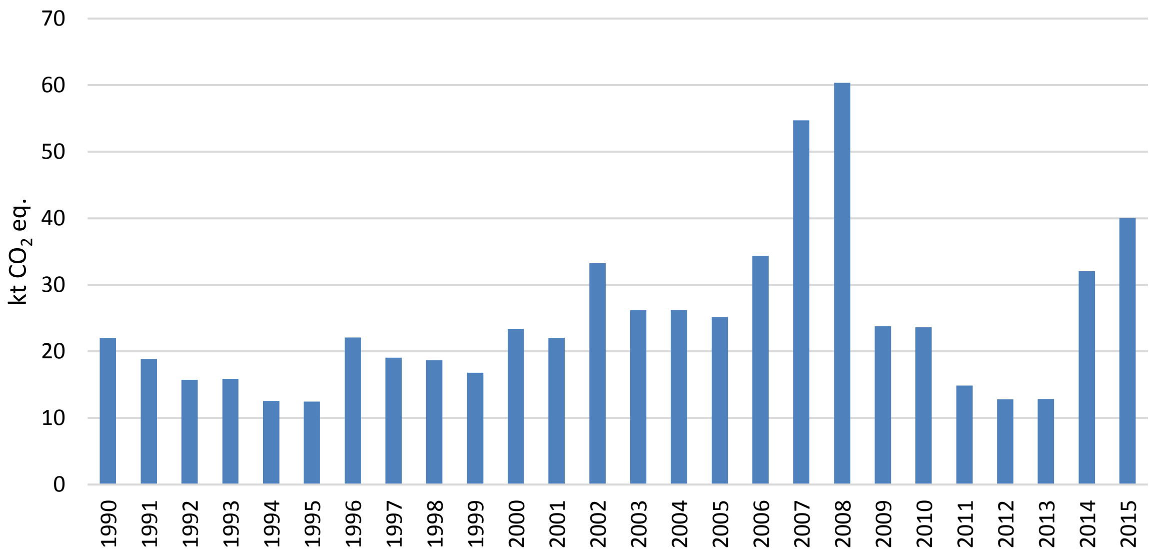

Figure 3.26. Emissions from Domestic navigation in 1990–2015, kt CO_2 eq.

Methods

Emissions of Domestic navigation are calculated by multiplying the estimated fuel (diesel oil) consumption with a country-specific emission factor (2006 IPCC Tier 2).

Activity data

The activity data on fuel consumption used in Domestic navigation are obtained from the Statistics Estonia and presented in

Table 3.21. Statistics Estonia acquires the amounts of fuel used from relevant reports that are presented by water transport companies to Statistics Estonia.

Emission factors and other parameters

CO_2 emissions from Domestic navigation are calculated using the country-specific carbon emission factor Diesel Oil. This emission factor is calculated using the weighted average method using CEFs of countries, that Estonia imports this fuel from. CH_4 and N_2O emission factors for diesel oil and coal and NOx, CO and NMVOC EF for diesel oil used in the calculation of emissions are taken from the IPCC 2006 Guidelines. NOx, CO and NMVOC EF for coal are taken from the EMEP/EEA Guidelines, SO_2 EFs are country specific. All emission factors are presented in Table 3.32.

Table 3.32. Emission factors used in the calculation of emissions from Domestic navigation

Fuel	GHG	EF	Source
Diesel Oil	CO_2	19.92 tC/TJ	CS, Estonia
	CH_4	7 kg/TJ	IPCC 2006
	N_2O	2 kg/TJ	IPCC 2006
	NOx	9.4 kg/t	EMEP/EEA Gudelines
	CO	573.9 kg/t	EMEP/EEA Gudelines
	NMVOC	181.5 kg/t	EMEP/EEA Gudelines
	SO_2	141.2 kg/TJ	CS, EE

**EE – expert estimation*

3.2.5.6. Category-specific recalculations

Due to revised 1A3a emission factors, the category 1A3a has been recalculated (see Table 3.34). Revised emission factors are presented in Table 3.33. In all the other categories oxidation factors were updated according to the updated Regulation of Minister of Environment on "Calculation methods of the amount of CO_2 discharged into ambient air". In addition the country-specific CO_2 emission factors were updated with a more accurate carbon conversion factor specified in the previously mentioned regulation.

Table 3.33. The comparison of previous and current emission factors in 1A3a

	CO_2	CH_4	N_2O
Cruise			
2016	3 150.0 kg/t	0.0 kg/t	0.1 kg/t
2017	70 000 kg/TJ	0 kg/TJ	2 kg/TJ
LTO			
2016	3 150.0 kg/t	0.5 kg/t	0.1 kg/t
2017	3 160 kg/t	5 kg/TJ	2 kg/TJ

Table 3.34. Differences between 2017 and 2016 submissions, kt CO_2 eq

Year	Differences between 2017 and 2016 submissions, kt CO2 equivalent*			
	1A3a	1A3b	1A3c	1A3d
1990	-0.156	-1.626	-0.112	-0.016
1991	-0.029	-1.474	-0.108	-0.014
1992	-0.036	-0.738	-0.076	-0.011
1993	-0.101	-0.821	-0.079	-0.011
1994	-0.106	-1.053	-0.081	-0.009
1995	-0.296	-1.028	-0.079	-0.009
1996	-0.137	-1.059	-0.086	-0.016
1997	-0.177	-1.147	-0.078	-0.014
1998	-0.088	-1.172	-0.096	-0.013

Year	Differences between 2017 and 2016 submissions, kt CO2 equivalent*			
	1A3a	1A3b	1A3c	1A3d
1999	-0.095	-1.076	-0.105	-0.012
2000	-0.091	-1.066	-0.099	-0.017
2001	-0.111	-1.300	-0.091	-0.016
2002	-0.070	-1.360	-0.117	-0.024
2003	-0.065	-1.322	-0.102	-0.019
2004	-0.160	-1.367	-0.090	-0.019
2005	-0.030	-1.417	-0.094	-0.018
2006	-0.015	-1.526	-0.099	-0.025
2007	-0.019	-1.620	-0.081	-0.039
2008	-0.061	-1.552	-0.060	-0.043
2009	-0.022	-1.431	-0.078	-0.017
2010	-0.021	-1.484	-0.113	-0.017
2011	-0.077	-1.537	-0.077	-0.011
2012	-0.106	-1.567	-0.067	-0.009
2013	-0.012	-1.538	-0.059	-0.009
2014	-0.011	-1.558	-0.045	-0.023

***** Positive value means that in the 2016 submission the emissions have increased when compared to the 2015 submission. Negative value means decrease in emissions.

3.2.5.7. Category-specific planned improvements

There are currently no category-specific improvements planned.

3.2.6. Other sectors (CRF 1.A.4) and Other (CRF 1.A.5)

3.2.6.1. Category description

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

- 1.A.4.a Commercial/institutional
- 1.A.4.b Residential (Households)
- 1.A.4.c Agriculture/forestry/fisheries

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

In 2015, emissions of the CRF sub-category CRF 1.A.4 Other sectors were 762.39 kt in CO_2 equivalent, it is about 4.8% of the Energy sector’s emissions and 4.2% of total GHG emissions in Estonia. Corresponding emissions were 2 037.62 kt CO_2 equivalent in 1990 (see Figure 3.27 and Table 3.38).

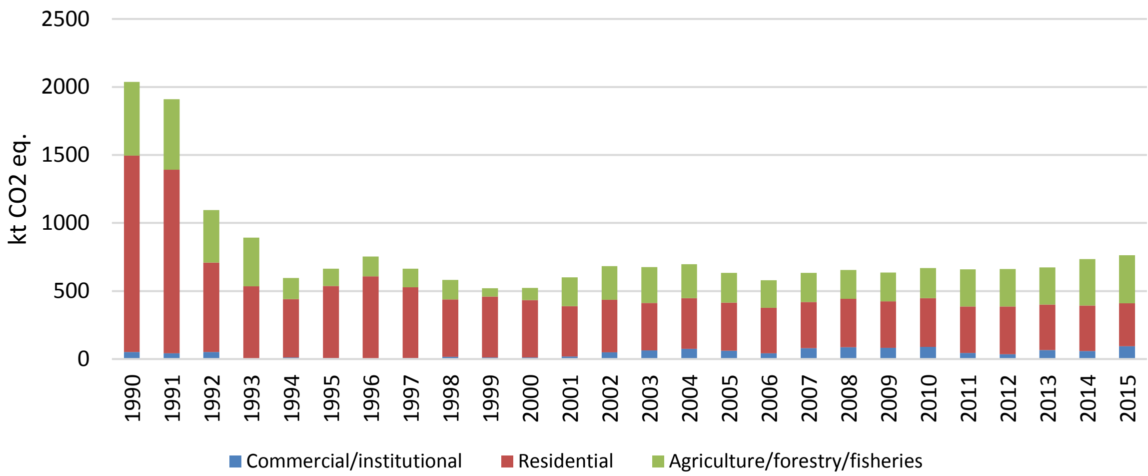

Figure 3.27. Trend of GHG emissions from Other sectors, kt CO_2 equivalent

The sub-category CRF 1.A.4.a contains GHG emissions from Commercial and institutional subsectors including: wholesale and retail trade; repair of motor vehicles; hotels and restaurants; financial intermediation; real estate, renting and business activities; public administration and defence; compulsory social security; education; health and social work; other community, social and personal service activities, fuel terminals etc.

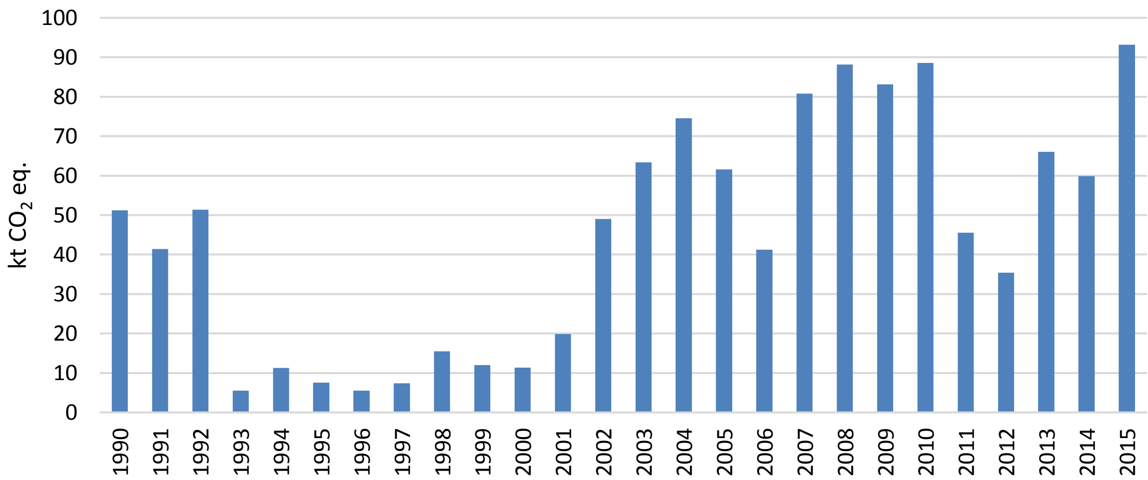

Figure 3.28. Trend of GHG emissions from Commercial/institutional, kt CO_2 eq.

The decreasing trend of GHG emissions in Commercial/institutional in the beginning of 90s (since 1993 up to 2000) is logical and reflects the general economic development trend after regaining independence in 1991. The increase of emission trend in 2001 is connected with big growth of some sub-sectors like financial intermediation; real estate, hotels and restaurants, etc. The rapid decrease in 2006 was caused by structural changes of used fuels – use of wood fuels decreased about 72% and the use of liquid fuels decreased about 73% when at the same time the use of gaseous fuels increased by 12% compared to 2005. From 2007 to 2010 the GHG emission trend was quite stable (see Figure 3.28). In 2011 the decreased use of natural gas in commercial/institutional led to decrease of GHG emissions. GHG emissions decreased about 48.5% compared to previous year. Similarly in 2012, the emissions decreased about 22%

compared to 2011 due to decreased consumption of natural gas. In 2013, the emissions increased about 87% compared to 2012. The increase was mainly due to increased use of natural gas. In 2014, the emissions decreased 9.4% compared to the previous year. The decrease was mostly caused by a decreased use of coal in the Commercial/institutional sector. In 2015, the emissions of Commercial/institutional were the highest ever estimated so far, increasing 55.5% compared to 2014. The increase can mostly be attributed to an increase in the use of natural gas and shale oil.

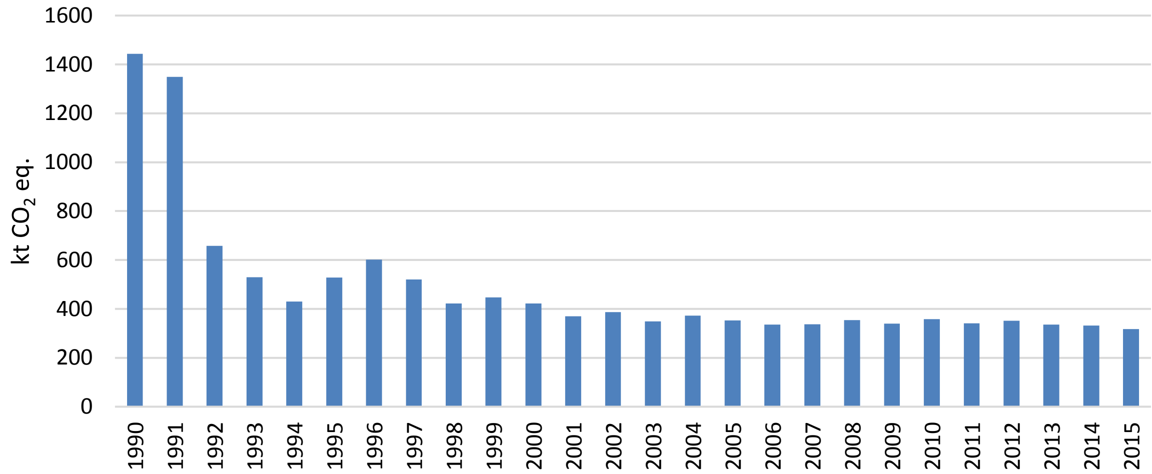

Figure 3.29. Trend of GHG emissions from Residential, kt CO_2 eq.

The category 1.A.4.b includes GHG emissions from fuel combustion in households. The overall trend of GHG emissions is decreasing and follows the fuel consumption trend of the sector. The decreasing trend is logical because of energy efficiency and saving measures, renovation of houses, building more new houses, etc. But the most important reason for the decrease of GHG emissions is a big change in the fuel consumption structure in the Residential sector. Consumption of fuel oils decreased rapidly after 1991 but consumption of wood fuels increased in last year more than three times compared to 1990/1991 (see Figure 3.29).

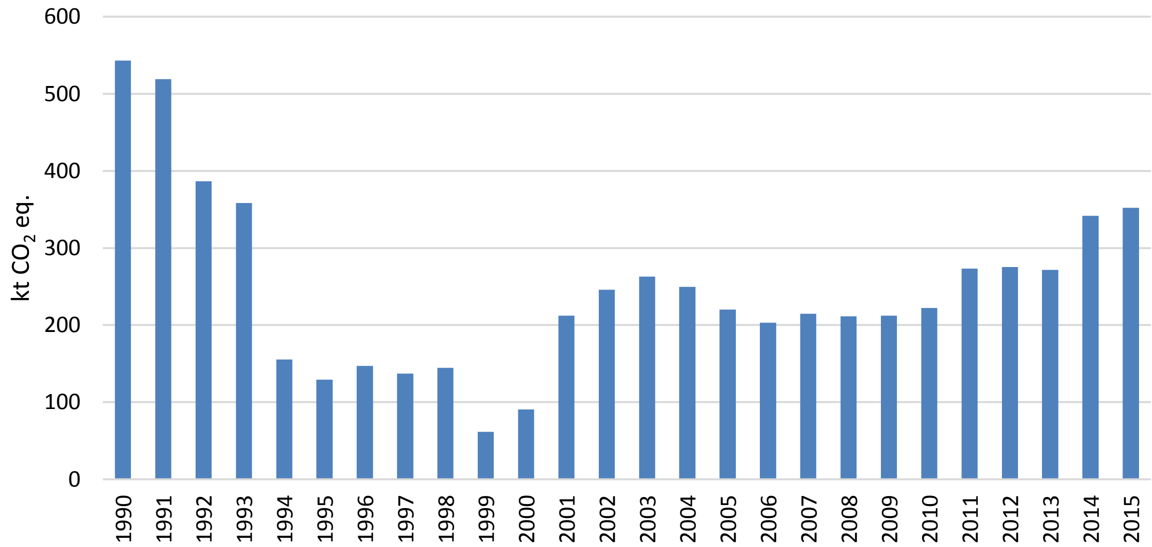

Figure 3.30. Trend of GHG emissions from Agriculture/forestry/fisheries, kt CO_2 eq.

Under category 1.A.4.c Agriculture, GHG emissions from fuel combustion in agriculture, fishing and hunting are reported. The trend of GHG emissions follows the fuel consumption trend of the sector and reflects the whole sector development trend. The number of farms decreased since 1994 drastically and reached the bottom in 1999. Since 2002 the production in agriculture stabilized and small fluctuation in different years is explained mainly with different weather conditions (see Figure 3.30). The increase of emissions in 2011 is explained with the growth in production of agricultural products, since the use of fuels also increased. In 2012 and 2013, the emissions stayed about the same level as in 2011. In 2014 there was a rise in emissions again, about 26% compared to the previous year. This was related to a 45% increase in diesel consumption. In 2015 there was a moderate increase in emissions yet again, the emissions increased 3.0% compared to the previous year, due to increased fuel consumption.

The values of CO_2 IEFs of liquid and solid fuels are fluctuating due to changes in the contribution of different liquid and solid fuels in these fuel groups over time.

Sub-category CRF 1.A.5 includes emissions from other mobile sources. The emissions of the CRF 1.A.5 were 27.26 kt CO_2 equivalent in 2015, it is about 0.2% of the Energy sector's emissions and 0.2% of total GHG emissions in Estonia. Corresponding emissions were 44.20 kt of CO_2 equivalent in 1990. The emissions can be observed in Table 3.39.

3.2.6.2. Methodological issues

Methods

Emissions from sub-categories CRF 1.A.4 and CRF 1.A.5 are calculated using the 2006 IPCC methodology.

Activity data

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

The fuel consumption data by main fuel groups for CRF 1.A.4 are presented in Table 3.40 and Figure 3.31. Fuel consumption data in CRF 1.A.5 is presented in Table 3.41.

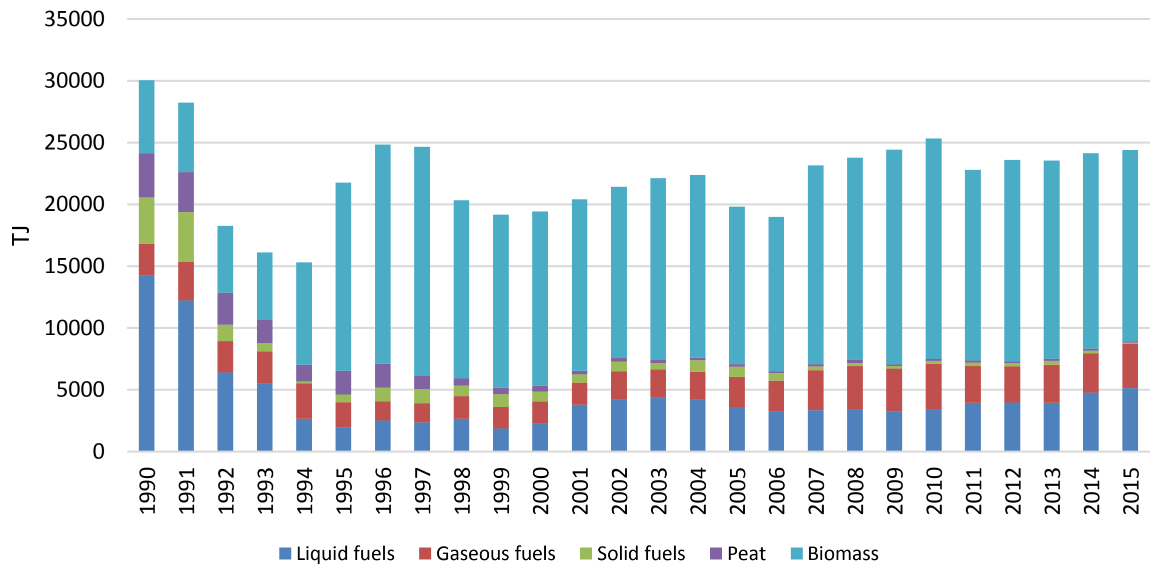

Figure 3.31. Fuel consumption in CRF 1.A.4 Other sectors, TJ

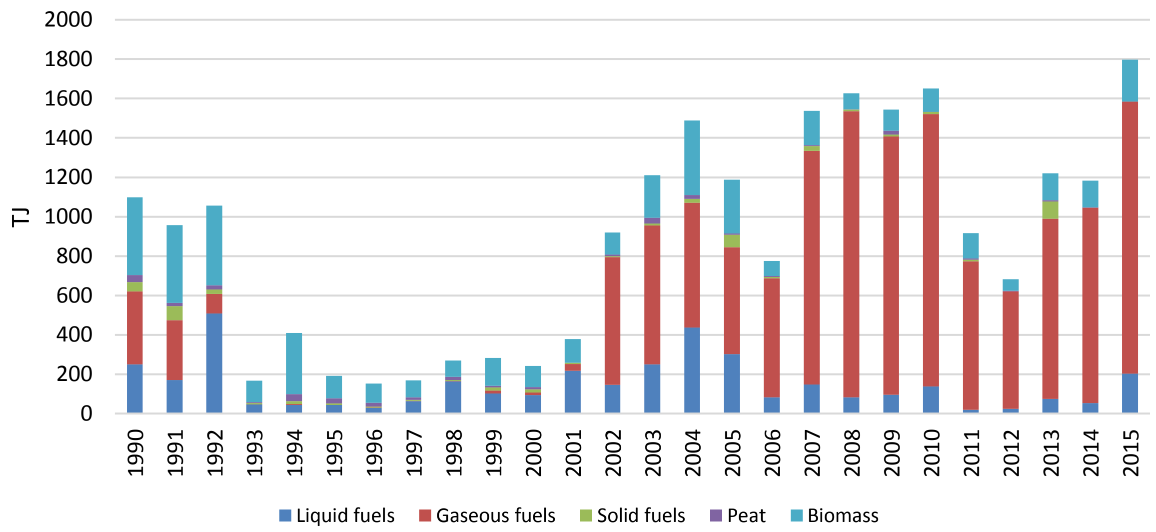

Figure 3.32. Fuel consumption in Commercial/institutional sector, TJ

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

Consumption of other fuels: liquid, solid and biomass fuels were more stable, some fluctuations are in the liquid fuel consumption trend in 1992, 2001 and 2004 (see Figure 3.32).

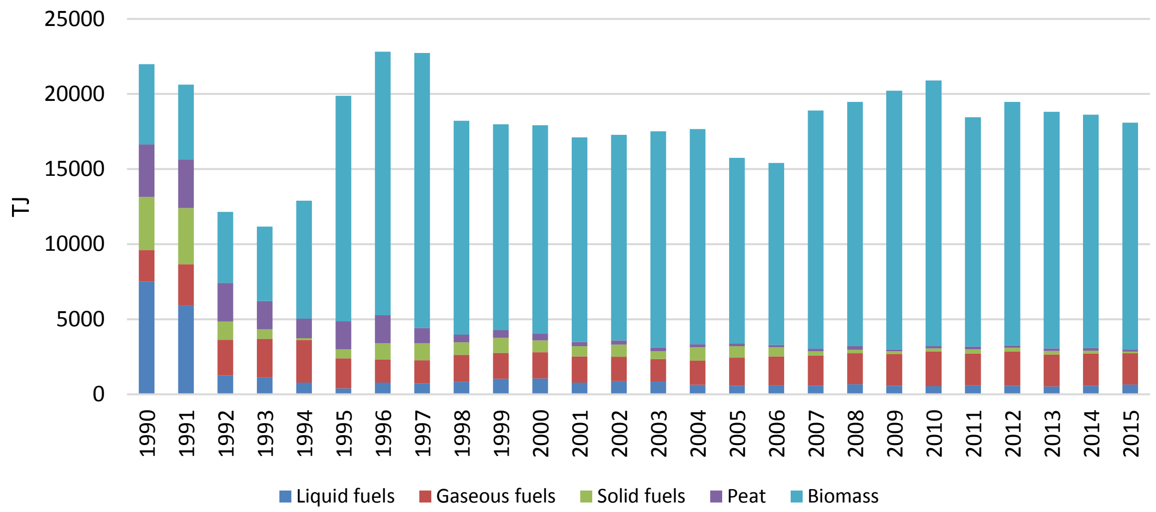

Figure 3.33. Fuel consumption in Residential, TJ

In Figure 3.33 the fuel consumption trend by main fuel groups of the Residential sector is presented. The most dominating fuel of the sector is biomass (used for space heating). The big increase of the values of biomass on Figure 3.33 is most likely caused by the methodologies used to estimate household fuel use in the post controlled economy Estonia, as there were great changes occurring in the economy of the country while collected data might have been slightly incomplete. The increase of the biomass consumption trend in 1996/1997 is connected with the methodology change of the SE and decreases in 2005/2006 with warm winters. Since 2007 the use of biofuels in residential sector had been slightly increasing. Due to warmer-than-average winter, the use of biomass in households for heating decreased in 2011 compared to 2010. In 2012, the use of biomass in residential sector increased about 6.2% compared to the previous year. In 2013 the use of biomass decreased about 2.8% compared to 2012. In 2014 there was a 1.2% decrease in the use of biomass compared to the previous year. In 2015 the use of biomass decreased 2.7% compared to 2014.

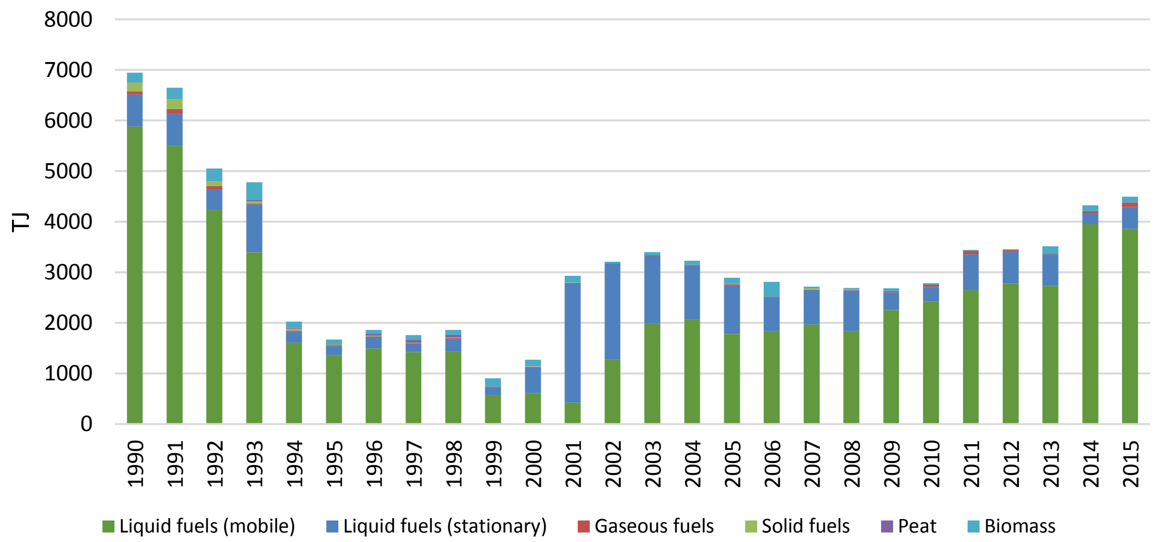

Figure 3.34. Fuel consumption in Agriculture/forestry/fisheries, TJ

In Figure 3.34 the fuel consumption trend by main fuel group of the Agriculture/forestry/fisheries sector is presented. The main fuel group in agriculture is liquid fuels, the other fuel groups have a small share in the sector and the consumption trend has been quite stable since 2001. The amount of liquid fuels used in agriculture decreased since 1990 up to 1999 almost 60%, mostly due to the decreasing of whole agricultural production caused by the structural changes in the economy after 1991 when Estonia became independent. After 2000 the agricultural production started to increase, bringing the increase of liquid fuel consumption with it. Fuel consumption has been quite stable through the years 2005–2010. Due to growth in production of agricultural products, the use of liquid fuels also increased in 2011. In 2012 and 2013, the GHG emissions stayed at the same level as in 2011. Compared to the last three years' stability, there was a big increase of fuel use in 2014 compared to the previous year. Fuel consumption increased about 23% compared to 2013. The year 2015 was similar to the previous year concerning fuel consumption.

Emission factors and other parameters

Both, IPCC default and national (country specific) emission factors are used.

For LPG, Light Fuel Oil, Diesel Oil, Gasoline, Residual Fuel Oil and Coal Estonia uses the country-specific weighted average CEFs.

For CH_4 and N_2O Estonia uses IPCC 2006 default emission factors. The used CH_4 and N_2O emission factors are presented in Table 3.35.

Table 3.35. CH_4 and N_2O emission factors for small combustion of fuels, kg/TJ

	CH_4	N_2O	Source
Oil	10	0.6	2006 IPCC
LPG	5	0.1	2006 IPCC
Natural Gas	5	0.1	2006 IPCC
Coal (commercial)	10	1.5	2006 IPCC
Coal (residential, agriculture)	300	1.5	2006 IPCC
Oil Shale (commercial)	10	1.5	2006 IPCC
Oil Shale	300	1.5	2006 IPCC
Peat/Peat Briquette (commercial)	10	1.4	2006 IPCC
Peat/Peat Briquette (residential, agriculture)	300	1.4	2006 IPCC
Wood	300	4	2006 IPCC

Under the CRF category 1.A.4.c Agriculture/Mobile emissions from off-road agricultural transport are estimated. In Table 3.36 emission factors of motor fuels used for off-road transportation and fishing and leasure boats are presented.

Table 3.36. Emission factors for Agricultural off-road fuels, kg/TJ

	CO_2 (tC/TJ)	CH_4	N_2O	NOx	CO	NMVOC	Source
Motor Gasoline	19.03-19.88	80	2	1 200	1 000	200	IPCC2006, Chapter 3, Table 3.3.1 (CEF: Estonian Country-Specific)
Diesel Oil	19.94-20.02	4.15	28.6	1 200	1 000	200	IPCC2006, Chapter 3, Table 3.3.1 (CEF: Estonian Country-Specific)

In the Table 3.37 emission factors used in calculation of emissions from CRF 1.A.5 are presented.

Table 3.37. Emission factors for CRF 1.A.5, kg/TJ

	CO_2 (t C/TJ)	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**	**Source**
Motor Gasoline	19.03-19.88	3.8	5.7	600	8 000	1 500	IPCC2006, Chapter 3, Table 3.2.3. (CEF: Estonian Country-Specific)
Diesel Oil	19.94-20.02	3.9	3.9	800	8 000	1 500	IPCC2006, Chapter 3, Table 3.2.3; (CEF: Estonian Country-Specific)

Table 3.38. Emissions from Other sectors (incl. Commercial/institutional, Residential and Agriculture/forestry/fisheries), kt

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1.A.4 Other sectors, CO_2 eq.	**2 037.62**	**665.29**	**523.79**	**634.29**	**668.59**	**660.04**	**661.72**	**672.92**	**734.13**	**762.39**
1.A.4.a Commercial/institutional, CO_2 eq.	51.20	7.56	11.31	61.56	88.53	45.58	35.40	66.05	59.89	93.19
1.A.4.b Residential, CO_2 eq.	1 443.38	528.38	421.68	352.72	357.79	341.32	350.87	335.38	332.33	316.98
1.A.4.c Agriculture/forestry/fisheries, CO_2 eq.	543.04	129.36	90.80	220.01	222.28	273.14	275.44	271.49	341.91	352.22

Table 3.39. Emissions from CRF 1.A.5 Other, kt

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1.A.5 Other total, CO_2 eq.	44.20	29.27	17.16	35.33	41.51	20.11	21.85	32.79	33.17	27.26

Table 3.40. Fuel consumption in CRF 1.A.4 Other Sectors, TJ

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1.A.4 Other Sectors	**30 039**	**21 746**	**19 435**	**19 826**	**25 337**	**22 804**	**23 607**	**23 546**	**24 132**	**24 386**
Liquid fuels	14 269	1 980	2 270	3 606	3 390	3 958	3 981	3 949	4 779	5 145
Solid fuels	3 746	637	800	842	220	294	238	325	200	119
Gaseous fuels	2 552	2 010	1 779	2 434	3 722	2 955	2 926	3 066	3 178	3 554
Peat	3 534	1 910	466	208	152	184	171	175	169	110
Biomass	5 938	15 209	14 120	12 736	17 853	15 413	16 291	16 031	15 806	15 458

Table 3.41. Fuel consumption in CRF 1.A.5 Other, TJ

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1.A.5 Liquid Fuels	596	393	230	475	557	270	294	441	446	367

3.2.6.3. Category-specific recalculations

In all categories oxidation factors were updated according to the updated Regulation of Minister of Environment on “Calculation methods of the amount of CO_2 discharged into ambient air”. In addition the country-specific CO_2 emission factors were updated with a more accurate carbon conversion factor specified in the previously mentioned regulation. The differences can be seen in Table 3.42.

Table 3.42 Differences between 2017 and 2016 submissions, kt CO2 eq

Year	Differences between 2015 and 2014 submissions, Gg CO2 equivalent*			
	1A4a	1A4b	1A4c	1A5
1990	0.068	-0.389	-0.342	-0.032
1991	0.056	-0.152	-0.315	-0.039
1992	0.024	0.255	-0.174	-0.025
1993	0.005	0.465	-0.148	-0.008
1994	-0.004	0.560	-0.045	-0.008
1995	-0.004	0.297	-0.056	-0.021
1996	-0.002	0.120	-0.077	-0.012
1997	-0.003	0.174	-0.074	-0.010
1998	-0.010	0.304	-0.077	-0.013
1999	-0.004	0.260	-0.035	-0.013
2000	-0.004	0.281	-0.053	-0.012
2001	-0.004	0.306	-0.150	-0.013
2002	0.145	0.258	-0.167	-0.011
2003	0.162	0.259	-0.171	-0.014
2004	0.135	0.280	-0.140	-0.020
2005	0.107	0.345	-0.128	-0.025
2006	0.140	0.376	-0.130	-0.023
2007	0.285	0.420	-0.133	-0.022
2008	0.339	0.418	-0.080	-0.008
2009	0.304	0.445	-0.096	-0.021
2010	0.320	0.490	-0.107	-0.030
2011	0.178	0.442	0.358	-0.014
2012	0.140	0.484	0.267	-0.016
2013	0.210	0.449	0.278	-0.023
2014	0.236	0.450	-0.066	-0.024

* Positive value means that in the 2017 submission the emissions have increased when compared to the 2016 submission. Negative value means decrease in emissions.

3.2.6.4. Category-specific planned improvements

Currently there are no category-specific improvements planned.

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

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

Oil shale is mined for energy generation and shale oil production in Estonia. There are no coal mines in Estonia.

Unlike coal mines, there are no CH_4 emissions from oil shale mines, because methane is non-existent in Estonian Oil Shale (see the Explanation Letter from the Department of Mining of The Tallinn University of Technology in Annex 3).

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

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

3.3.2.1. Category description

Estonia reports CO_2 and CH_4 emissions from Natural gas transmission and distribution. Natural gas is imported into Estonia from Russia and from the Inchukalns underground gas storage in Latvia. AS Eesti Gaas has two gas metering stations on the border of Estonia (in Värska and in Karksi) where the volumes of imported gas are measured. Gas is distributed to customers through gas pipelines, distribution stations and gas pressure reducing stations.

Map of natural gas distribution network in Estonia is presented in Figure 3.35.

Figure 3.35. Natural gas distribution network in Estonia

In 2015, fugitive emissions from oil and natural gas were 0.03 kt CO_2 and 0.62 kt CH_4 (total of 15.53 kt CO_2 eq.). It is about 0.10% of the Energy sector's emissions and 0.09% of total GHG emissions in Estonia. Corresponding emissions were 50.27 kt CO_2 equivalent in 1990.

3.3.2.2. Methodological issues

The equation for calculating CH_4 emissions from oil and gas activities is presented as Equation 3.11:

Equation 3.11

$$Emissions = \frac{Activity\ \cdot EF}{10^6}$$

Where

Emissions = CH_4 emissions, kt
Activity = activity data of natural gas activities, PJ;
EF = emission factor of fugitive emissions from natural gas activities, kg/PJ.

Activity data

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

Emission factors and other parameters

CO_2 and CH_4 emission factors for calculating emissions from Natural gas distribution are taken from the IPCC 2006 Guidelines (developed countries).

Emissions from natural gas storage are not occurring due to the fact that there are no natural gas storage facilities in Estonia. Estonia uses storage facilities located in Latvia.

3.3.2.3. Quantitative overview

Table 3.43 includes CO_2 and CH_4 emissions from Natural gas distribution. In Table 3.44 CO_2 and CH_4 emissions from Natural gas transmission are shown. In Table 3.45 CO_2 and CH_4 emissions from Oil and Gas activities are presented.

Table 3.43. CO_2 and CH_4 emissions from Natural gas distribution

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Natural gas distribution CO_2, kt	0.09	0.04	0.05	0.06	0.04	0.04	0.04	0.04	0.03	0.03
Natural gas distribution CH_4, kt	1.89	0.90	1.03	1.24	0.87	0.78	0.82	0.84	0.66	0.59
Natural gas distribution total, kt CO_2 eq.	47.43	22.58	25.70	30.99	21.80	19.66	20.45	21.09	16.49	14.66

Table 3.44. CO_2 and CH_4 emissions from Natural gas transmission

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Natural gas transmission CO_2, kt	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0005
Natural gas transmission CH_4, kt	0.11	0.05	0.06	0.07	0.05	0.05	0.05	0.05	0.04	0.04
Natural gas transmission total, kt CO_2 eq.	2.84	1.35	1.54	1.86	1.31	1.18	1.23	1.26	0.99	0.88

Table 3.45. CO_2 and CH_4 emissions from Oil and Gas activities

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Natural gas transmission and distribution total, kt CO_2 eq.	50.27	23.93	27.23	32.85	23.11	20.84	21.68	22.35	17.47	15.53

3.3.2.4. Uncertainties and time-series consistency

To estimate the uncertainties of this category, the IPCC Tier 1 method was used.

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

3.3.2.5. Category-specific recalculations

There were no category-specific recalculations.

3.3.2.6. Category-specific planned improvements

There are currently no category-specific planned improvements.

3.4. CO_2 transport and storage (CRF 1.C)

Up to 2015, no CO_2 transport and storage has been used in Estonia.

4. INDUSTRIAL PROCESSES AND PRODUCT USE (CRF 2)

4.1. Overview of the sector

Greenhouse gas emissions from Industrial processes and product use contributed 2.84% to the total anthropogenic greenhouse gas emissions in Estonia in 2015 (Figure 4.1), totalling 512.92 kt CO_2 equivalent with indirect CO_2 and 497.04 CO_2 equivalent without indirect CO_2.

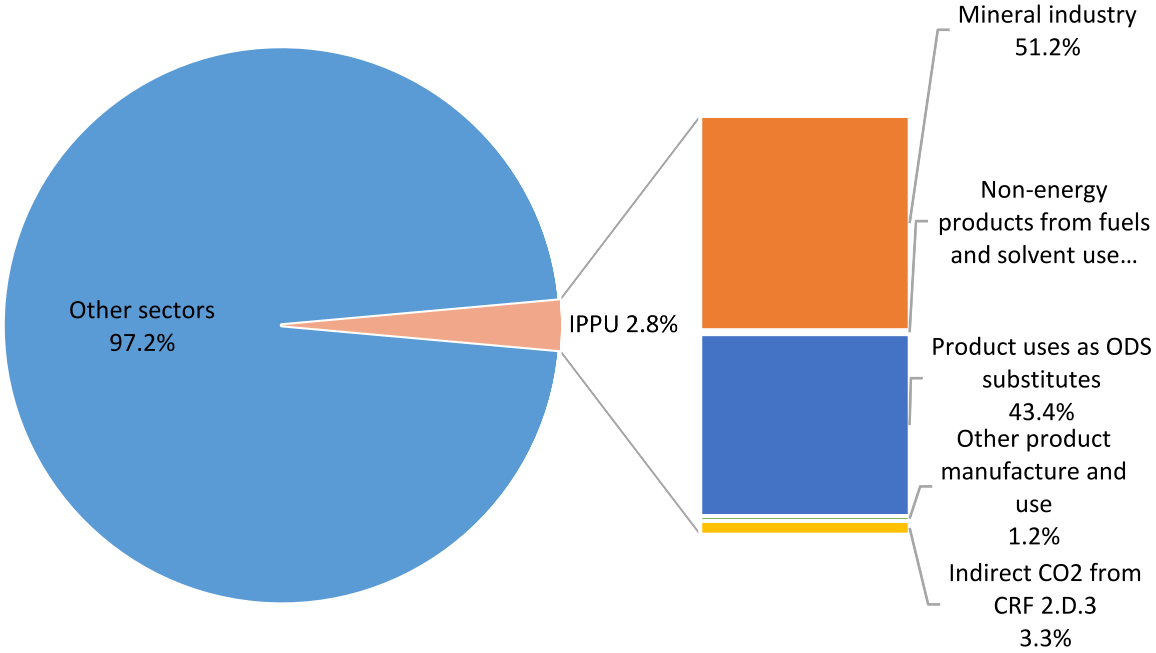

Figure 4.1. Emissions from Industrial processes and product use compared with total emissions in 2015, %

Estonia's emissions from the Industrial processes and product use sector are divided into following emission categories:

- Mineral industry (CRF 2.A) including CO_2 emissions from cement, lime and glass production, other process uses of carbonates (ceramics, other uses of soda ash and limestone use for flue gas desulphurisation);
- Historical chemical industry's emissions (CRF 2.B) – CO_2 emissions from ammonia production;
- Non-energy products from fuels and solvent use (CRF 2.D) including CO_2 emissions from use of 1) lubricants and 2) paraffin waxes and 3) urea based catalysts for motor vehicles, NMVOC emissions from solvent use and road paving with asphalt;
- Product uses as substitutes for ODS (CRF 2.F) including HFC emissions from refrigeration and air conditioning, foam blowing agents, fire protection and aerosols;
- Other product manufacture and use (CRF 2.G) including SF_6 emissions from electrical equipment, SF_6 and PFC emissions from other product use and N_2O emissions from product uses;

- Other (CRF 2.H) including NOx, CO, NMVOC and SO_2 emissions from pulp and paper and NMVOC emissions from food and beverages; and
- Indirect CO_2 emissions calculated from NMVOC emissions from CRF 2.D.3.

Reported greenhouse gas emissions, used methods and type of emission factors are listed in Table 4.1.

Table 4.1. Reported GHG emissions, calculation methods and type of emission factors for Industrial processes and product use sector in 2015

CRF	Source	Emissions reported	Method	Emission factor
2.A	Mineral industry	CO_2	T1, T2, T3	D, PS
2.A.1	Cement production	CO_2	T2	PS
2.A.2	Lime production	CO_2	T2	PS
2.A.3	Glass production	CO_2	T3	PS
2.A.4	Other process uses of carbonates	CO_2	T1, T2, T3	D, PS
2.D	Non-energy products from fuels and solvent use	CO_2	D,T1,T2	D
2.D.1	Lubricant use	CO_2	T1	D
2.D.2	Paraffin wax use	CO_2	T1	D
2.D.3	Other - Use of urea based catalytic converters for motor vehicles	CO_2	T2	D
2.D.3	Use of solvents; Road paving with asphalt	Indirect CO_2	D	D
2.F	Product uses as substitutes for ODS	HFCs	T2	CS
2.F.1	Refrigeration and air conditioning	HFCs	T2	CS
2.F.2	Foam blowing agents	HFCs	T2	CS
2.F.3	Fire protection	HFCs	T2	CS
2.F.4	Aerosols	HFCs	T2	CS
2.G	Other product manufacture and use	N_2O	T2	CS
		SF_6	T3	CS
2.G.1	Electrical equipment	SF_6	T3	CS
2.G.2	SF_6 and PFCs from other product use	SF_6	T3	CS
2.G.3	N_2O from product uses	N_2O	T2	CS

Compared to 2014, the emissions from Industrial processes and product use (with indirect CO_2) decreased by 27.5 % in 2015. This decrease in emissions is caused by temporarily decreased output of mineral industry. The reason is economic slowdown.

Regarding chemical industry (2.B) – ammonia production has been completely ceased since 2014 and the operators have no plans to restore production in near future.

As for more distant history – industrial CO_2 emissions have fluctuated strongly since 1990 (Figure 4.2 and Table 4.2) reaching their lowest level in 1993. The decrease in emissions during the early 1990s was caused by the transition from a planned economy to a market economy after 1991 when Estonia regained its independence. This led to lower industrial production and to an overall decrease in emissions from industrial processes between 1991 and 1993. In 1994 the economy began to recover and also the production increased. Since 1995 (the base year for F-gases under the Kyoto Protocol) emissions of F-gases have significantly increased. The decrease in emissions in 2002 and 2003 was caused by the reduction in ammonia production, as the only ammonia factory in the country was being reconstructed. The sudden increase in emissions in 2007 was mainly caused by an increase in cement production, as the only cement factory renovated its third kiln. In 2009 the industrial processes sector was affected by the recession. Decline in production was mainly due to insufficient demand on both the domestic and external markets. Increase in 2011 emissions was caused by increase of cement production. CO_2 emissions rose in 2012 and 2013, because a power plant used large quantities of limestone for flue gas desulphurisation.

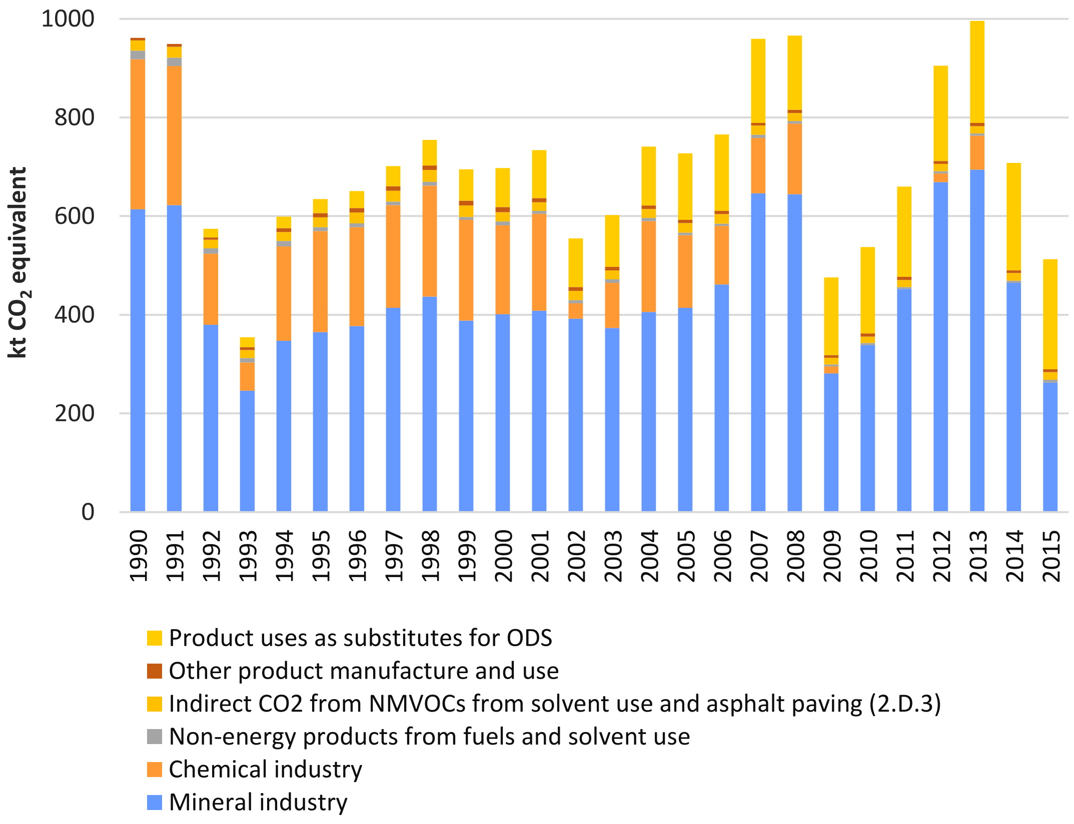

Figure 4.2. Emissions from Industrial processes and product use in Estonia in 1990–2015 (with indirect CO_2), kt CO_2 equivalent

Table 4.2. Trend in the greenhouse gas emissions from Industrial processes and product use, kt CO_2 equivalent

	1990	1992	1993	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO_2																				
Mineral industry	614.3	380.1	246.2	364.6	401.0	408.4	391.9	373.2	405.9	414.0	461.3	646.3	644.4	281.3	338.7	452.7	669.4	694.5	464.5	262.7
Chemical industry	308	145	58	208	181	195	31	92	185	146	118	111	142	14	NO	NO	17	69	NO	NO
Non-energy products from fuels and solvent use (without indirect CO_2)	17.4	11.5	9.1	7.5	7.4	6.1	7.0	7.2	6.4	5.1	4.4	6.3	5.4	3.8	4.2	4.0	4.6	4.4	4.7	5.5
Indirect CO_2 from solvent use and road paving with asphalt	20.9	17.1	16.1	20.6	19.2	17.8	18.8	18.4	18.3	19.1	20.0	18.7	16.5	13.5	12.9	14.0	14.6	15.2	15.7	15.7
N_2O																				
Other product manufacture and use	5.4	4.5	4.6	5.4	7.5	6.5	5.8	5.8	5.9	5.9	5.1	4.5	4.7	4.3	4.6	4.7	4.2	3.9	3.2	3.8
HFCs	NO	17.5	20.0	28.5	79.1	97.2	98.8	104.9	119.3	135.0	154.6	170.4	150.4	157.5	175.5	183.3	193.2	207.3	217.5	222.8
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.09	0.08	0.05	NO	NO	NO	NO	NO	NO	NO
SF_6	NO	0.09	1.39	3.07	2.61	1.67	1.38	1.27	1.04	1.03	1.10	0.92	1.29	1.38	1.73	1.77	1.88	2.03	2.10	2.25
Total (with indirect CO_2)	**965.7**	**576.3**	**355.3**	**637.4**	**697.6**	**733.1**	**555.1**	**603.0**	**741.4**	**726.4**	**764.4**	**957.7**	**964.3**	**475.9**	**537.6**	**660.5**	**904.4**	**996.0**	**707.7**	**512.9**
Total (without indirect CO_2)	**944.8**	**559.14**	**339.22**	**616.8**	**678.4**	**715.3**	**536.3**	**584.6**	**723.1**	**707.3**	**744.2**	**939.0**	**947.8**	**462.4**	**524.7**	**646.5**	**889.90**	**980.8**	**692.0**	**497.0**

Key categories

Key categories in Industrial processes and product use in 2015 by level (L) and trend (T) are summarised in Table 4.3 in accordance with IPCC Tier 1 method.

Table 4.3. Key categories in Industrial processes and product use (CRF 2) in 2015 (without LULUCF)

Source category	**Gas**	**Criteria**
CRF 2.A.1 Cement production	CO_2	Level
CRF 2.A.2 Lime production	CO_2	Level, Trend
CRF 2.B.1 Ammonia production	CO_2	Trend
CRF 2.F.1.a Commercial refrigeration	HFCs	Level, Trend
CRF 2.F.1.c Industrial refrigeration	HFCs	Level, Trend
CRF 2.F.1.d Refrigerated vehicles	HFCs	Trend
CRF 2.F.1.e Mobile Air-Conditioning - Passenger cars	HFCs	Trend
CRF 2.F.1.f Stationary and Room Air-Conditioning	HFCs	Trend

4.2. Mineral industry (CRF 2.A)

In this category Estonia reports non-fuel emissions from

- Cement production (2.A.1);
- Lime production (2.A.2);
- Glass production (2.A.3);
- Other process uses of carbonates (2.A.4)
  - Ceramics (2.A.4.a) – bricks and tiles, lightweight gravel;
  - Other uses of soda ash (2.A.4.b); and
  - Other (2.A.4.d), which is use of limestone for flue gas desulphurisation at power plant.

CO_2 emissions from Mineral industry have fluctuated since 1990 (Table 4.4 and Figure 4.3) having the lowest value in 1993, after what the trend of CO_2 emissions have stabilized (except a rise in 2007–2008 and sudden decrease in 2009). The decrease in the emissions during early 1990's was caused by the transition from planned economy to market economy after 1991 when Estonia became independent. This led to decrease in industrial production, and to an overall decrease in emissions from Mineral industry between 1991 and 1993. In 1994 the economy began to recover and also production increased. Increase in 2007–2008 emissions was caused by increase of cement production. In 2009, Mineral industry sector was affected by the economic recession. Decline in production was mainly caused by the insufficient demand both in domestic and external markets. Increase in 2010 and 2011 emissions was caused by increase of cement production. CO_2 emissions increased in 2012 and 2013, because a power plant used limestone for flue gas desulphurisation. Since 2014 they use novel integrated desulphurization (NID) which uses lime as reagent. In 2015 emissions from Mineral industry were 43% lower than in 2014 because of temporarily decreased output of mineral industry, mainly cement industry because of decreased market demand.

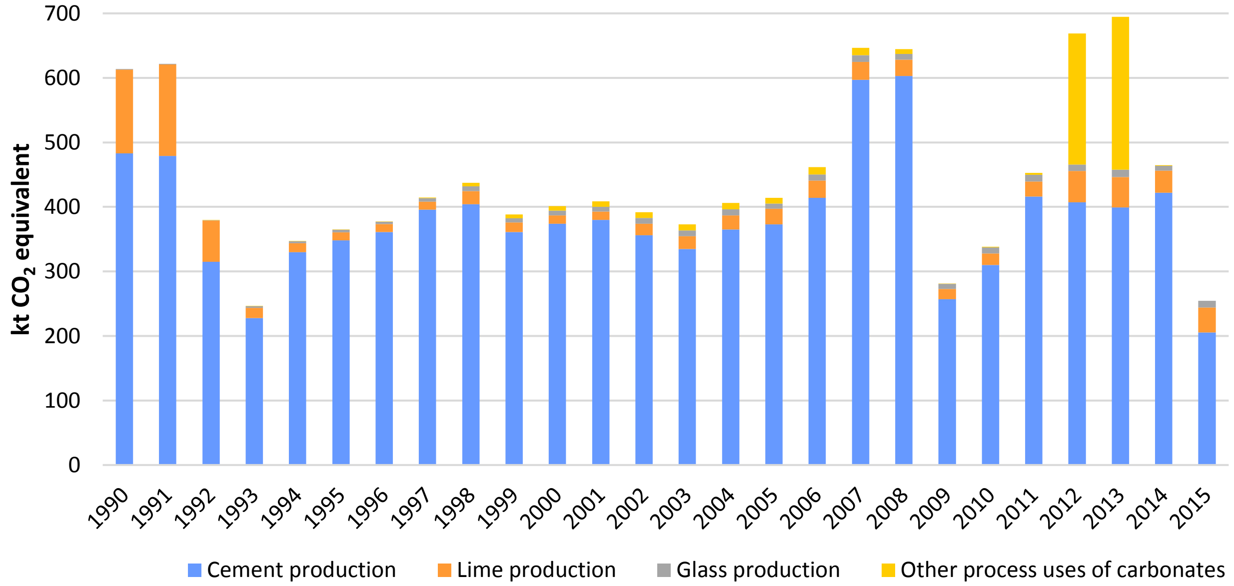

Figure 4.3. CO_2 emissions from Mineral industry in Estonia in 1990–2015, kt

Table 4.4. CO_2 emissions from Mineral industry, kt

	1990	1992	1993	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2.A.1 Cement production	483	315	228	348	374	380	356	335	365	373	414	597	603	257	310	416	407	399	422	206
2.A.2 Lime production	130	64	16	12	13	13	18	20	22	24	27	28	25	16	18	23	49	47	34	39
2.A.3 Glass production	1.2	0.8	2.3	4.0	7.4	7.3	8.7	8.9	9.2	8.1	9.3	10.5	8.7	7.7	9.7	10.9	9.8	11.4	7.7	10.0
2.A.4.a Ceramics	NA	0.01	0.03	0.05	6.0	7.6	7.7	8.9	9.3	8.5	10.9	10.9	7.4	0.5	0.7	2.1	2.4	2.7	0.6	1.0
2.A.4.b Soda ash use	0.3	0.1	0.1	0.3	1.1	1	0.9	0.4	0.6	0.4	0.7	0.5	0.3	0.1	0.1	0.5	0.3	0.2	0.2	0.2
2.A.4.d Other - Use of limestone for flue gas desulphurisation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	200.8	233.8	NO	7.2
Total	**614.3**	**380.1**	**246.2**	**364.6**	**401.0**	**408.4**	**391.9**	**373.2**	**405.9**	**414.0**	**461.3**	**646.3**	**644.4**	**281.3**	**338.7**	**452.7**	**669.4**	**694.5**	**464.5**	**262.7**

4.2.1. Cement production (CRF 2.A.1)

4.2.1.1. Source category description

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

In Estonia, there is only one plant producing clinker and cement. Cement is produced by standard wet process. The clinker burning process takes place in rotary kilns. Dust caught with rotary kilns electric filters is partly directed into kiln and partly into dust silo. In production process the most important fuels are oil shale, coal and refuse-derived fuel.

Limestone containing small amounts of organic carbon (byproduct of oil shale mining) was one of raw materials in 2014.

SO_2 emissions from cement production are also reported in the CRF. These emissions are calculated by the plant and reported to the air pollution database OSIS.

4.2.1.2. Methodological issues

Methods

Emissions from cement production were calculated using method compliant with Tier 2 method (Equation 4.1) from the IPCC 2006 Guidelines[19].

Equation 4.1

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

Activity data, emission factor and CKD correction factor is given by cement plant. All measurements and calculations are done according to Regulation (EU) No 601/2012 on the monitoring and reporting of greenhouse gas emissions and verified according the Directive 2003/87/EC. The plant operators calculate emissions with Cement CO_2 and Energy Protocol (software from World Business Council for Sustainable Development).

Tier 2 method assumes that all of the CaO is from a carbonate source (e.g. $CaCO_3$).

Emission factors

Emission factors used in calculating the emissions from cement production are provided by the plant. Emission factors vary slightly due to the parameters (i.e. amount of kiln dust, CaO and MgO content of the clinker) affecting them from year to year.

Emission factors from cement production are based on the actual CaO and MgO contents of clinker. CO_2 from organic carbon is taken into account when calculating $EF_{clinker}$. Cement kiln dust and by pass dust as well as the amounts of CaO and MgO that are already calcinated before the process (and therefore do not cause emissions) are taken into account at plant.

[19] IPCC 2006 Guidelines, Volume 3, Chapter 2: Mineral Industry, page 2.9, equation 2.2.

Activity data

In calculating the emissions from cement production the amount of clinker produced annually is used as activity data. The data on clinker production, kiln dust (not recycled to the kiln) and CO_2 emitted from both materials was received directly from the plant throughout the time series. The CKD correction factor calculation done by the plant is compliant with the Tier 2 method from IPCC 2006 Guidelines[20].

Each year has a different CKD correction factor mainly due to different quantities of cement kiln dust, but also calcination rate of CKD and CaO content of the clinker are slightly different in different years. The calcination rate of CKD was 82% in years 1990–2006, and 79% in years 2007–2015.

Data on clinker production as well as CKD correction factors between 1990–2015 are available in Table 4.5.

Table 4.5. Activity data and emission factors for clinker production

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
2.A.1 Cement													
Clinker production, kt	790	773	517	378	540	571	591	651	659	590	620	629	590
$EF_{clinker}$, t/t	0.549	0.557	0.548	0.542	0.549	0.547	0.546	0.543	0.546	0.546	0.538	0.538	0.538
CKD correction factor	1.113	1.113	1.113	1.113	1.113	1.113	1.121	1.121	1.121	1.121	1.121	1.122	1.122

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Clinker production, kt	560	623	635	705	1 043	1 040	449	537	719	715	691	720	356
$EF_{clinker}$, t/t	0.538	0.542	0.547	0.547	0.546	0.548	0.548	0.549	0.549	0.549	0.549	0.56	0.558
CKD correction factor	1.113	1.081	1.073	1.073	1.048	1.058	1.046	1.054	1.054	1.039	1.051	1.046	1.034

4.2.1.3. Uncertainties and time-series consistency

The uncertainties of activity data and emission factors of clinker as well kiln dust production was provided by the plant operators. The uncertainty of activity data is 0.024%, the uncertainty of emission factor is 0.50%.

The uncertainty of emission factor took into account possible errors in chemical analyses of clinker and kiln dust.

4.2.1.4. Category-specific QA/QC and verification

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

Activity data was compared with the data from Statistics Estonia to exclude possibility of other cement production plants. The completeness of the category was also checked from the Estonian Air Pollution Sources Information System.

[20] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.13, equation 2.5.

The emissions of 2005–2015 have been compared with EU ETS data. Differences between those two figures have been very small (please see Table 4.6).

Table 4.6. Differences between EU ETS and GHG inventory data on emissions from cement production, %

Year	CO_2 emissions reported in GHG inventory, kt	Difference between ETS and GHG inventory data, %
2005	372.88	0.00
2006	413.70	0.00
2007	596.72	0.00
2008	602.72	0.00
2009	257.00	0.00
2010	310.43	0.00
2011	416.12	0.00
2012	407.44	0.00
2013	399.05	0.00
2014	421.88	0.00
2015	205.61	0.00

4.2.1.5. Category-specific recalculations

No category-specific recalculations have been done.

4.2.1.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.2.2. Lime production (CRF 2.A.2)

4.2.2.1. Source category description

CO_2 emissions from lime production are due to calcination of calcium and magnesium carbonates at high temperatures. In Estonia there are currently three lime production plants, from which one is responsible for 79% of the Estonia's lime production.

4.2.2.2. Methodological issues

Methods

Emissions from lime production are calculated by multiplying emission factors with activity data). Activity data are collected mainly directly from the industry but in the earlier years (1990–1996) industrial statistics have also been used. Two lime plants provide their emission factors they use for their emission reports to EU-ETS. Emission factor for historical plants in 1990–1996 is based on IPCC's default factors.

The methods for calculating emissions from lime production are consistent with the Tier 2 level method (Equation 4.2) from IPCC 2006 Guidelines[21].

Equation 4.2

$$CO_2\ emissions\ = \sum_i \left(EF_{lime,i} \bullet M_{l,i} \bullet CF_{lkd,i} \bullet C_{h,i}\right)$$

Where:

CO_2 emissions =	emissions of CO_2 from lime production, tonnes;
$EF_{lime,i}$ =	emission factor for lime of type *i*, tonnes CO_2/tonne lime;
$M_{l,i}$ =	lime production of type *i*, tonnes;
$CF_{lkd,i}$ =	correction factor for LKD for lime of type *i*, dimensionless;
$C_{h,i}$ =	correction factor for hydrated lime of the type *i* of lime, dimensionless;
i =	each of the specific lime types.

Emission factors

There are four different emission factors used to calculate emissions from lime production.

1. For historical lime plants in 1990–1996 IPCC default value for lime emission factor 0.7665 is used.
2. Two plants who have to submit their EU-ETS reports are calculating emission factors 1) on basis of chemical analyses of carbonate content or 2) using values from national regulation as allowed by the Monitoring and Reporting Regulation (EU) No 601/2012. The Regulation of Minister of Environment on calculation methods of the amount of CO_2 discharged into ambient air[22] stipulates emission factor 0.7857. This emission factor is appropriate for producing lime from Estonian limestone which has high calcium content and contains maximally 3% magnesium oxide.

   From the biggest plant emission factor based on actual CaO and MgO content has been available since 2005. As this emission factor differs strongly from default emission factor, emission factors for 1990–2004 are established as a mean value from emission factors in 2005–2008.
3. Third, smallest lime plant has been estimating their emission factor since 1994.

Correction factor for lime kiln dust is 1 in case of both bigger lime plants.

Operator of one plant explained that all products that leave the kiln are sold and is already taken into account when calculating CO_2 emissions. One part of dust is returned to kiln and other part is sold as product. Product of low quality is sold for filling mines. In the environmental permit of the plant (number L.KKL.LV-20971[23]) it is explained: lime kiln dust is captured in different stages of production by flue gas filters, bag filters and aspiration system much more efficiently than required by BREF[24]. This is in compliance with fact that in their annual waste report the plant reports no mineral waste. The environmental permit and e-mail from the plant operators can be provided to reviewers on request.

[21] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.21, equation 2.6.
[22] https://www.riigiteataja.ee/akt/129122016063, visited on 06.01.2017.
[23] Database of Estonian environmental permits https://eteenus.keskkonnaamet.ee/?page=avalik_stat_koond&act=avalik_info&u=20130115112432 06.01.2017.
[24] http://eippcb.jrc.ec.europa.eu/reference/BREF/clm_bref_0510.pdf visited on 07.01.2016.

In the other plant kiln dust is caught into very effective filters and returned to kiln. Some kiln dust and inferior lime is weighed together with limestone chippings and burned together with fuel in boiler of an CHP. The operator confirms that CO_2 emission from calcination process of inferior lime (including kiln dust) is accounted in in their EU-ETS report together with emission from limestone use for flue gas desulphurization. In GHG inventory it is accounted under subcategory 2.A.4.d.

Correction factor of hydrated lime is 1, because all plants gives data on produced quicklime before it is hydrated.

According to the IPCC 2006 Guidelines(Equation 4.3)[25]:

Equation 4.3

$$EF_{lime} = 0.85 \cdot EF_{high\ calcium\ lime} + 0.15 \cdot EF_{dolomitic\ lime}$$

$EF_{lime} = 0.85 \cdot 0.75 + 0.15 \cdot 0.86 = 0.7665$. This value is applied to those companies that were closed before 1996, as no better data is available.

Activity data

Activity data (Table 4.7) for lime production is collected mainly directly from the industry and taken partly from industrial statistics (1990–1996). Since 1997 there have been two lime producing plants in Estonia and therefore activity data is collected directly from the industry (1997–2014). From 1990–1996 there were more producing plants and therefore industrial statistics have also been used. From 1990–1996 activity data is collected on one hand directly from plants producing lime nowadays, on the other hand industrial statistics have been used to calculate emissions from plants closed during 1990–1996.

Data on lime production as well as emission factors between 1990–2015 are available in Table 4.7.

Table 4.7 Activity data and emission factors for lime production

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
2.A.2 Lime													
Lime production, kt	185	207	92	21	18	16.8	17.4	18.9	31.6	23.4	19.9	19.9	28.3
IEF_{lime}, t/t	0.7	0.68	0.69	0.74	0.75	0.74	0.71	0.64	0.64	0.64	0.64	0.64	0.64

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Lime production, kt	30.7	34.3	37.2	41.5	43.4	39.5	24.2	26.9	35.8	71.8	69.5	48.8	54.5
IEF_{lime}, t/t	0.64	0.64	0.65	0.64	0.64	0.64	0.66	0.66	0.65	0.68	0.68	0.70	0.71

4.2.2.3. Uncertainties and time-series consistency

The uncertainty of tonnes of produced lime is 0.72%. This is combined uncertainty of two largest lime producer´s output.

[25] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.22, equation 2.8.

The default value of EF uncertainty - 2% - is used for lime production[26].

4.2.2.4. Category-specific QA/QC and verification

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

The completeness of the category was checked from the Estonian Air Pollution Sources Information System, database of environmental permits and EU-ETS reports. No other lime production plants were found.

Lime production reported in GHG inventory was compared with data from Statistics Estonia. Statstical data was somewhat larger number. The reason can be that some companies have reported imported lime as “product”.

The emissions from plants submitting EU ETS reports have been compared with EU ETS data. Differences between emissions reported to EU ETS and GHG inventory have been 0.02% at the most (please see Table 4.8).

Table 4.8. Differences between EU ETS and GHG inventory data on emissions from lime production, %

Year	Difference between ETS data and GHG inventory emissions, %
2005	0.00
2006	0.00
2007	0.00
2008	0.00
2009	0.02
2010	0.00
2011	0.00
2012	0.00
2013	0.00
2014	0.00
2015	0.00

4.2.2.5. Category-specific recalculations

No category-specific recalculation have been done.

4.2.2.6. Category-specific planned improvements

There are no planned category-specific improvements.

[26] IPCC 2006 Guidelines,Volume 3, Chapter 2, Table 2.5.

4.2.3. Glass production (CRF 2.A.3)

4.2.3.1. Source category description

Under this category, Estonia reports CO_2 emissions from flat glass and container glass production. Currently only container glass is produced in Estonia and there is one production plant. The plant started to produce container glass in 1992, and flat glass was produced in Estonia from 1990 to 1996.

4.2.3.2. Methodological issues

Methods

There are two methods in use for calculating CO_2 emissions from glass production.

1. For flat glass production Tier 1 method according to the IPCC 2006 Guidelines [27] is used (Equation 4.4).

According to the Tier 1 method:

Equation 4.4

$$CO_2\ emissions\ = M_g \bullet EF \bullet (1 - CR)$$

Where:

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

Tier 1 method was used since carbonates used in flat glass manufacturing are not known and only national-level production statistics was available.

2. For container glass production Tier 3 method[28] is used (Equation 4.5).

Equation 4.5

$$CO_2\ emissions\ = \sum_i (M_i \cdot EF_i \cdot F_i)$$

Where:

M_i =	weight or mass of the carbonate i consumed, tonnes;
EF_i =	emissions factor for the particular carbonate i, tonnes CO_2/tonne carbonate;
F_i =	fraction calcination achieved for the carbonate i, fraction

Activity data (1993–2015) was collected directly from glass producing company.

Emissions from coke that is a component of the glass batch are accounted in addition to carbonate materials.

[27] IPCC 2006 Guidelines, Volume 3, Chapter 2, equation 2.10.
[28] IPCC 2006 Guidelines, Volume 3, Chapter 2, equation 2.12.

Emission factors

Emission factors for calculating emissions from limestone use are based on the actual $CaCO_3$, $MgCO_3$ content of limestone and this data is provided by the plant. The plant operators provided exact carbonate content of limestone for the years 2006–2015. The plant operators estimated, that the carbonate content of the limestone used in 1992–2005 was approximately the same as in the later years. Therefore average values of the $CaCO_3$ and $MgCO_3$ contents of the limestone used in 2006–2012 were applied for 1992–2005. Emission factors of $CaCO_3$, $MgCO_3$ and Na_2CO_3 are the ones from IPCC 2006 Guidelines[29] and are based on stoichiometric ratios. Emission factor for limestone is then: EF_{CaCO3} • part of $CaCO_3$ in limestone + EF_{MgCO3} • part of $MgCO_3$ in limestone.

Emission factors for calculating emissions from flat glass production are based on the IPCC default factors[30]. For the calculation of CO_2 emissions from flat glass, emission factor 0.20 t of CO_2 per tonne of glass is used.

Emission factors for coke are provided by the plant and are based on the carbon content of the coke.

Activity Data

The consumption of limestone, sodium carbonate and coke has been used as activity data when calculating emissions from container glass production. Activity data was collected directly from glass producing plant (Table 4.9).

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

Data on glass production as well as emission factors between 1990–2015 are available in Table 4.9.

Table 4.9. Activity data and emission factors for container and glass production

2.A.3 Glass	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Container glass production, kt	NO	NO	0.6	10.8	20.6	27.9	35	53	57.9	53.6	59.1	59.2	56.1
Limestone consumption, kt	NO	NO	0.15	1.71	3.2	3.86	4.15	7.96	8.2	7.9	8.99	9.65	8.79
IEF, t/t	NA	NA	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434
Sodium carbonate consumption, kt	NO	NO	0.31	2.4	2.58	2.9	3.8	5.1	9.13	7.0	8.1	7.35	11.65
$EF_{default}$, t/t	NA	NA	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415
Coke consumption, kt	NO	NO	1	3.7	8.2	9.9	11	29.7	28.6	32.5	34.9	24.9	26.8
IEF, t/t	NA	NA	3.667	3.667	3.667	3.667	3.667	3.667	3.667	3.667	3.667	3.667	3.667

[29] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.7, table 2.1.
[30] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.29, equation 2.13.

2.A.3 Glass	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Flat glass production, kt	12.3	12	5.9	5.5	8.5	11.2	0.02	NO	NO	NO	NO	NO	NO
$EF_{default}$ x (1 - CR), t/t	0.1	0.1	0.1	0.1	0.1	0.1	0.1	NA	NA	NA	NA	NA	NA

2.A.3 Glass	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Container glass production, kt	61.9	66.8	62.1	70.5	76	65.7	63	81.6	81.4	73.9	84	64	88
Limestone consumption, kt	8.97	9.46	8.64	10.37	11.85	9.82	7.9	11.17	12.41	10.90	12.74	7.99	11.35
IEF, t/t	0.434	0.434	0.434	0.436	0.432	0.431	0.437	0.441	0.432	0.434	0.433	0.435	0.44
Sodium carbonate consumption, kt	11.9	12.0	10.2	11.38	12.74	10.47	9.89	11.25	13.04	11.95	13.97	10.13	11.91
$EF_{default}$, t/t	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415
Coke consumption, kt	29.6	37.8	36.3	21.9	36.3	28.5	27.9	18.8	23.5	25.5	28.6	18.9	22.9
IEF, t/t	3.667	3.667	3.667	3.667	3.667	3.667	3.667	3.667	3.667	3.667	3.192	3.192	3.192
Flat glass production, kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
$EF_{default}$ x (1 - CR), t/t	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

4.2.3.3. Uncertainties and time-series consistency

The activity data uncertainty was estimated by the plant at ±1.1%. Uncertainty of the emission factor is estimated at ±1% as suggested in IPCC 2006 Guidelines[31].

4.2.3.4. Category-specific QA/QC and verification

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

The completeness of the category was checked from the Estonian Air Pollution Sources Information System and no other glass production plants were found. The environmental report of the glass plant from OSIS was compared to the GHG inventory data and no discrepancies were found.

Data on produced glass provided by the plant was compared with data on produced glass from Statistics Estonia. According Statistics Estonia a little less glass was produced in 2015 than the glass plant reported for GHG inventory and EU-ETS. It can be concluded that there are no other glass production plants in Estonia.

The CO_2 emission from glass production and amounts of raw materials used as reported in 2017 submission was compared with respective data from EU-ETS. The amounts of limestone, soda ash and coke were identical in ETS and GHG inventory.

[31] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.31.

4.2.3.5. Category-specific recalculations

No category-specific recalculations have been done.

4.2.3.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.2.4. Other process uses of carbonates (CRF 2.A.4)

Other process uses of carbonates (CRF category 2.A.4) consists of

- 2.A.4.a Ceramics
- 2.A.4.b Other uses of soda ash
- 2.A.4.d Other – Limestone use for flue gas desulphurisation

4.2.4.1. Ceramics (CRF 2.A.4.a)

Subcategory 2.A.4.a Ceramics consists of

- Bricks and roof tiles production
- Lightweight gravel production

Process-related CO_2 emissions result from the calcination of carbonates in the clay or additives, e.g limestone filler. Carbonates are heated to high temperatures in a kiln, producing oxides and CO_2.

Emissions from different ceramic products are aggregated in the CRF. The emissions from different brick producers are calculated according to Tier 1 (small producers) and Tier 2 method (large producer). Emissions from lightweight gravel are calculated according to Tier 1 method of IPCC 2006 Guidelines. The data collection and processing is described by different products (for transparency).

4.2.4.1.1. Bricks and roof tiles production

Source category description

In Estonia there have been multiple plants that have produced either bricks, roof tiles or both. In recent years there is one producer with large market share.The output has been fluctuating a lot, because of fluctuations of export demand.

Methodological issues

Methods

Emissions from ceramic bricks and roof tiles production were calculated using Tier 1 and Tier 2 methodology from the IPCC 2006 Guidelines[32]. According to the Tier 1 method (Equation 4.6):

Equation 4.6

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

[32] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.34.

Where:

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

and Tier 2 method (Equation 4.7):

Equation 4.7

$$CO_2\ emissions = M_{ls} \bullet EF_{ls} + M_d \bullet EF_d$$

Where:

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

Emission factors

Emission factors for calculating emissions from limestone and dolomite use are based on the IPCC default factors[33]. For the calculation of CO_2 emissions from limestone use, emission factor 0.43971 t of CO_2 per tonne of limestone is used. For the calculation of CO_2 emissions from dolomite use, emission factor 0.47732 t of CO_2 per tonne of dolomite is used.

Activity data

Mass of carbonates in consumed clay has been used as an activity data when calculating CO_2 emissions from small brick plants.

The emissions from large plant are calculated on the basis of limestone filler which is the same way the plant calculates its emissions. For calculation on basis of limestone filler the exact $CaCO_3$ content of limestone filler is provided by the plant. The $MgCO_3$ content is negliglible.

In Table 4.10 is the total mass of carbonates on which CO_2 emissions are calculated. This includes the precise amounts of limestone filler used by one producer and amounts that are estimated by Tier 1 method for other producers.

Data on the amount of clay and limestone filler used in bricks production was directly collected from the plants from 1992 to 2015. The amount of clay consumed in bricks production in 1990–1992 was calculated by multiplying production with a default loss factor of 1.1. In 1993, only two small plants produced ceramic bricks in Estonia. Data on the amount of clay used in production of roof tiles has been directly collected from the plant since 1997 (production of ceramic roof tiles began in 1997).

As no other information was available, default carbonate content of 10 percent was applied for clays used by small producers. It was assumed that 85 percent of carbonates consumed are limestone and 15 percent of carbonates consumed are dolomite[34].

[33] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.7, table 2.1.
[34] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.36.

For the years 1992–2015 data about bricks production was directly collected from the plants. The amounts of bricks produced between years 1990–2000 were taken from industrial statistics for one company. Data on production of ceramic roof tiles was received directly from the plant for all the years (Table 4.10).

Data on ceramics production as well as emission factors between 1990–2015 are available in Table 4.10.

Table 4.10. Activity data and emission factors for bricks and tiles and lightweight gravel production.

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
2.A.4.a Ceramics													
Production of ceramics, kt including:	251.1	255.2	129.2	0.7	47.9	28.8	29.9	33.9	99.9	110	119.6	154.8	164
Production of bricks and tiles kt	251.1	255.2	129.2	0.7	47.9	28.8	29.9	33.9	23.7	31.4	32.7	49.7	57.5
Emissions from bricks and roof tile production, Gg	NO	NO	0.007	0.033	0.051	0.051	0.029	0.008	0.017	0.014	0.014	0.101	0.329
EF of bricks and roof tiles, t/t	NO	NO	$5 \cdot 10^{-5}$	0.046	0.001	0.002	0.001	$2 \cdot 10^{-4}$	$7 \cdot 10^{-4}$	$5 \cdot 10^{-4}$	$4 \cdot 10^{-4}$	0.002	0.006
Production of lightweight gravel kt	NO	NO	NO	NO	NO	NO	NO	NO	76.2	78.6	86.9	105.1	106.5
Emissions from lightweight gravel production, Gg	NO	NO	NO	NO	NO	NO	NO	NO	4.7	5.0	6.0	7.5	7.4
EF of lightweight gravel, t/t	NO	NO	NO	NO	NO	NO	NO	NO	0.062	0.063	0.069	0.071	0.069
High-calcium limestone consumption for all ceramics (limestone filler + 85% of carbonate component of some type of clay) , kt	NO	NO	0.01	0.06	0.10	0.10	0.06	0.01	8.32	8.58	9.48	11.66	11.90
$EF_{default}$ t/t ($CaCO_3$)	$EF_{default}$ t/t ($CaCO_3$) 0.43971 was used for all years												
Dolomite consumption (15% of carbonate component of some type of clay), kt	NO	NO	0.002	0.011	0.017	0.017	0.010	0.003	2.309	2.503	3.804	5.162	5.214
EFdefault t/t ($CaMg(CO_3)_2$)	$EF_{default}$ t/t ($CaMg(CO_3)_2$) 0.47732 was used for all years												

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2.A.4.a Ceramics													
Production of ceramics, kt including:	182.6	191.7	184.6	206.2	256.6	215	25.6	38.3	61.7	55.6	56.6	43.0	33.4
Production of bricks and tiles kt	64.9	66.4	69.0	80.3	148.0	119.8	25.6	38.3	61.7	55.6	56.6	43.0	33.4
Emissions from bricks and roof tiles production, Gg	0.329	0.428	0.653	1.149	3.138	1.588	0.531	0.705	2.072	2.374	2.726	0.569	0.951
EF of bricks and roof tiles, t/t	0.005	0.006	0.01	0.014	0.021	0.013	0.021	0.018	0.034	0.043	0.048	0.013	0.029
Production of lightweight gravel kt	117.7	125.3	115.6	125.9	108.6	95.2	NO	NO	NO	NO	NO	NO	NO
Emissions from lightweight gravel production, Gg	8.5	8.9	7.9	9.8	7.7	5.8	NO	NO	NO	NO	NO	NO	NO
EF of lightweight gravel, t/t	0.0724	0.0710	0.0681	0.0778	0.071	0.061	NO	NO	NO	NO	NO	NO	NO
High-calcium limestone consumption for all ceramics (limestone filler + 85% of carbonate component of some type of clay), kt	14.19	15.15	14.13	17.48	19.02	12.44	1.21	1.60	4.71	5.40	6.20	1.29	2.16
$EF_{default}$ t/t ($CaCO_3$)	$EF_{default}$ t/t ($CaCO_3$) 0.43971 was used for all years												

Uncertainties and time-series consistency

The uncertainty of emission factor for this category is relatively low. The largest producer estimated the total uncertainty to be about 2%. The uncertainty of activity data is estimated at ±1% (by supplier of limestone filler) and consists of uncertainty of limestone weighing.

The emission factor uncertainty was estimated at ±1.7%, which consists mainly of the uncertainty of chemical analysis for carbonate content.

The total uncertainty is ±2%. The effect of uncertainties of small producers's emissions on the total uncertainty is very minimal.

Category-specific QA/QC and verification

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

For completeness check Estonian database of environmental permits and air emissions data system for point sources (OSIS) were checked and no other plants were found.

The activity data was compared with the data from Statistics Estonia, but some plants are providing aggregated data on their production and imports to Statistics Estonia.

Category-specific recalculations

No category-specific recalculations were done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.2.4.1.2. Lightweight gravel production

Source category description

In lightweight gravel production process-related CO_2 emissions result from the calcination of carbonates in the clay. Carbonates are heated to high temperatures in a kiln, producing oxides and CO_2. In lightweight gravel production plant dolomite is used as a flux. Therefore, CO_2 emissions occur from carbonates in the clay as well from dolomite used as a flux. In 2009–2015, there was no production of lightweight gravel in Estonia.

Methodological issues

Methods

Emissions from lightweight gravel production were calculated using Tier 1 methodology from the IPCC 2006 Guidelines (Equation 4.8)[35]. According to the Tier 1 method:

Equation 4.8

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

[35] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.34

Where:

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

Emission factors

Emission factors for calculating emissions from limestone and dolomite use are based on the IPCC default factors[36]. For the calculation of CO_2 emissions from limestone use, emission factor 0.43971 t of CO_2 per tonne of limestone is used. For the calculation of CO_2 emissions from dolomite use, emission factor 0.47732 t of CO_2 per tonne of dolomite is used.

Activity data

Mass of carbonates consumed has been used as an activity data when calculating CO_2 emissions from lightweight gravel production (see Table 4.10). Data about the amount of clay used for lightweight gravel production was directly collected from the plant from 1998 to 2008. As no other information was available, default carbonate content of 10 percent was applied for clays. It was assumed that 85 percent of carbonates consumed are limestone and 15 percent of carbonates consumed are dolomite[37].

Data on production of lightweight gravel was received directly from the plant for all the years, 1998–2008 (Table 4.10).

Uncertainties and time-series consistency

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

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

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

Category-specific QA/QC and verification

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

For completeness check Estonian database of environmental permits and air emissions data system for point sources (OSIS) were checked and no other plants that have emitted CO_2 from ceramic products were found.

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[36] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.7, table 2.1.
[37] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.36.

The activity data could not have been compared with the data from Statistics Estonia, because Statistics Estonia cannot provide separate data on lightweight gravel production for confidentiality reasons.

Category-specific recalculations

No source-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.2.4.2. Other uses of soda ash (CRF 2.A.4.b)

4.2.4.2.1. Source category description

In addition to glass production soda ash (= sodium carbonate) is used for:

1. rare earth metals separation and production;
2. electrolyte neutralisation in acid lead batteries scrap processing.

The use of soda ash in rare earth metals separation and rare metals production started in 1970 in Estonia. The use of soda ash in electrolyte neutralisation process started in 2003 in Estonia.

4.2.4.2.2. Methodological issues

Methods

Emissions from soda ash use are calculated by multiplying emission factors with the amount of used soda ash. Activity data are gathered directly from the industries. The method for calculating emissions from soda ash use is consistent with the Tier 3 method according to the IPCC 2006 Guidelines (Equation 4.9)[38].

Equation 4.9

$$CO_2\ emissions = \sum_i (M_i \bullet EF_i \bullet F_i)$$

Where

CO_2 emissions = emissions of CO_2 from other process uses of carbonates, tonnes;
M_i = mass of carbonate consumed, tonnes;
EF_i = emission factor for the carbonate, tonnes CO_2/tonne carbonate;
F_i = fraction calcination achieved for the particular carbonate i, fraction.

Emission factors

[38] 2006 IPCC Guidelines, Volume 3, Chapter 2, page 2.36

For the calculation of CO_2 emissions from soda ash use, the default emission factor 0.41492 t of CO_2 per tonne of soda ash is used[39].

Activity data

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

Data on soda ash use between 1990–2015 are presented in Table 4.11.

Table 4.11. Activity data and emission factors for soda ash use

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
2.A.4.b Soda ash use													
Soda ash use, kt	0.74	0.61	0.32	0.22	0.63	0.61	0.68	1.41	2.47	2.15	2.7	2.33	2.26
EF default (Na_2CO_3), t/t	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Soda ash use, kt	0.99	1.33	0.89	1.58	1.13	0.67	0.32	0.35	1.25	0.6	0.53	0.43	0.46
EF default (Na_2CO_3), t/t	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415

4.2.4.2.3. Uncertainties and time-series consistency

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

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

The uncertainty of activity data is estimated at ±3% as suggested in the IPCC 2006 Guidelines[40].

4.2.4.2.4. Category-specific QA/QC and verification

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

New environmental permits issued in 2016 were checked from relevant Estonian database and none of them contained emissive soda ash use.

Cross-check of total soda ash use included in the inventory against the total national soda ash imports was not made this year, because a significant part of soda ash used in industries is not emitting CO_2.

4.2.4.2.5. Category-specific recalculations

No category-specific recalculations have been done.

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[39] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.7, table 2.1.
[40] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.39, section 2.5.2.2.

4.2.4.2.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.2.4.3. Other – Limestone use for flue gas desulphurisation (CRF 2.A.4.d)

4.2.4.3.1. Source category description

Limestone was used by:

1. one of Estonian oil shale firing power plant for flue gas desulphurisation only in 2012 and 2013 (afterwards the operator replaced this desulphurization technology with novel integrated desulfurization (NID) technology using burnt lime);
2. other two power plants in 2015 (very small quantities)

The limestone is byproduct from oil shale mining and therefore may contain organic carbon which is oxidised to CO_2. Vast majority of the CO_2 comes from $MgCO_3$ and $CaCO_3$ of the limestone.

4.2.4.3.2. Methodological issues

Methods

Emissions from limestone use for flue gas desulphurisation are calculated by multiplying the amount of carbonates (e.g $CaCO_3$) and organic carbon in limestone with respective emission factors and oxidised fractions. Activity data are gathered directly from the industry. The method for calculating emissions from limestone is consistent with the Tier 3 level method according to IPCC 2006 Guidelines[41].

Emission factors

Calculation methods for emission factors are slightly different in case of each of the three power plants, but all are based on carbonate content of the limestone.

Methods are adapted from verified EU-ETS reports from these three plants and differences in methods are because 1) burning processes are very different (e.g temperatures) and 2) Regulation (EU) No 601/2012 allows different methods for emission factor calculations.

The plant which used large quantities of limestone has done chemical analyses for determination of $CaCO_3$, $MgCO_3$ and organic carbon content of limestone. For CO_2 from $CaCO_3$ the default emission factor of 0.43971 t CO_2 per tonne and for $MgCO_3$ the respective default emission factor 0.52197 t CO_2/t is used[42]. The oxidised fraction is provided by the plant and is 100% (because of high-temperature burning). For CO_2 from oxidation of organic carbon, the emission factor is based on relation of molecular weights of carbon dioxide and carbon (44/12=3.66667) and data on the oxidised fraction is provided by the plant.

One of the smaller plants has determined carbonate content of limestone by chemical analysis and takes into account a plant-specific oxidation factor of the carbonates (because of low-temperature burning).

[41] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.36.
[42] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.7, table 2.1.

Operator of the other smaller plant has also done laboratory analysis to determine mineral as well as organic carbon content of limestone. They use default oxidation factor best suitable for their burning process as stipulated in a national regulation ("Calculation methods of CO_2 emitted to ambient air")[43].

Activity data

Activity data on limestone use was provided by the three power plants.

Data on limestone use for flue gas desulphurisation in 2012–2013 and 2015 is presented in CRF Reporter.

4.2.4.3.3. Uncertainties and time-series consistency

The uncertainty of activity data is estimated by the plants at ±0.1%.

The uncertainty of emission factor depends on accuracy of chemical analysis. The emission factor uncertainty in 2015 was estimated to be ±2% which is in the middle of the range of default values (1–3%) suggested by IPCC 206 Guidelines[44].

4.2.4.3.4. Category-specific QA/QC and verification

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

The Estonian Air Pollution Sources Information System and EU-ETS reports were checked to find out if there are other plants that use limestone for flue gas desulphurisation, but none were found. Actually there are not many companies operating big power plants in Estonia which use oil shale products for fuel.

CO_2 emission reported in the CRF were compared with emissions reported to EU ETS. The differences (%) are reported in the Table 4.12. Difference in 2015 year's emissions is because different emission factor calculation methods of different companies were harmonized (more information in paragraph 4.2.4.3.2 Emission factors).

Table 4.12. Comparison of the CO_2 emissions from using limestone for flue gas desulphurization at power plant reported in GHG inventory and EU ETS

Year	CO_2 emissions reported in GHG inventory, kt	Difference with EU ETS data, %
2012	200.77	0.00
2013	233.79	0.00
2015	7.19	18.8%

4.2.4.3.5. Category-specific recalculations

No category-specific recalculations have been done.

[43]https://www.riigiteataja.ee/akt/129122016063; visited on 10.01.2017.
[44] IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.39.

4.2.4.3.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.3. Chemical industry (CRF 2.B)

4.3.1. Ammonia production (CRF 2.B.1)

4.3.1.1. Source category description

This category of the inventory includes the non-fuel emissions from natural gas used for ammonia production. In Estonia there is only one ammonia production plant.

In 2015 no production took place in the ammonia plant because production was not profitable any more. The plant operator has no plans to reopen the plant in near future.

Regarding earlier years: CO_2 emissions from ammonia production have decreased considerably since 1990, having the lowest values in 1993, 2002 and 2009. The decrease in the emissions during early 1990's was caused by the transition from planned economy to a market economy after 1991 when Estonia became independent. This led to decrease in industrial production, and to an overall decrease in emissions from industrial processes between 1991 and 1993. In 1994 the economy began to recover and production started to increase, emissions stabilized till 2002 and 2003, when there was sudden decrease in emissions. In 2002, 2003 and 2008 there were reconstructions of the plant that strongly affected production. The lowest point in production and also in emissions was in 2009. In 2009, the plant temporarily stopped production at the beginning of February. In 2010–2011, there was no production of ammonia in Estonia. The plant started ammonia production beginning of December in 2012 and produced until September 2013.

4.3.1.2. Methodological issues

Estonia is accounting under Industrial processes and product use sector only the natural gas used as feedstock for primary steam reforming. The amount of natural gas combusted is reported under Energy sector 1.A.2.c. The reason for such accounting is that it would be very difficult to subtract the combusted gas from energy balance. In the energy balance data provided by Statistics Estonia there is no split by single plants.

Emissions of CO_2 will depend on the amount and composition of gas used in the technological process and whether and how much carbon is captured in produced urea.

A part of the CO_2 from ammonia production is captured for urea (carbamide) production. The most part of CO_2 captured in urea is subtracted as following:

1. Since 2015 year's submission the carbon dioxide captured in urea which was sold in Estonia as fertiliser, is subtracted from emissions. It is accounted under Agriculture sector, 3.H. Urea application together with imported urea that was used as fertilizer.
2. In current submission CO_2 captured in produced urea that was exported thereafter was subtracted. The most part of the produced urea was exported each year. Imported urea solutions that are used as catalysts in motor vehicles exhaust gas systems, are accounted under subsector 2.D.3 Other.

Methods

Estonia uses method Tier 3 in calculating CO_2 emissions from ammonia production (Equation 4.10)[45].

According to the Tier 3 method:

Equation 4.10

$$CO_2\ emissions = \sum_i (TFR_i \bullet CCF_i \bullet COF_i \bullet 44/12) - R_{CO2}$$

Where:

TFR_i = total fuel requirement for fuel type i, GJ;
CCF_i = carbon content factor of the fuel type i, kg C/GJ;
COF_i = carbon oxidation factor of the fuel type i, fraction;
R_{CO2} = CO_2 recovered for downstream use (urea production, CO_2 capture and storage (CCS)), kg.

The plant-specific consumption of CO_2 for urea production is 0.75 t CO_2/t urea.

Emission factors

Emission factors were calculated by dividing CO_2 emissions (without subtracting recovered amounts) from technological process with amount of ammonia produced.

Emissions are calculated based on amount of natural gas used as feedstock and carbon content of gas. Carbon content of gas is provided by industry directly to the inventory compilers. Amount of gas feedstock is provided by industry to Statistics Estonia and from Statistics Estonia to inventory compilers. The emission factors for calculations of CO_2 emissions from ammonia production are plant specific throughout time series. In Estonia, ammonia production emission factors are, depending on the year, between 1.277–1.516 t CO_2/tonne NH_3 produced.

The carbon content of the gas is calculated by the gas supply network operator using the results of monthly gas compositional analyses. The carbon content is determined at gas parameters at 0 degrees Celsius and 1 atmosphere of pressure and recalculated to 20 degrees and 1 atm pressure for emission calculations.

For carbon oxidation factor the default value 1 is used.

Activity data

The annual ammonia production figures 1990–2013 have been provided by the production plant. Consumption of natural gas feedstock in millions m^3 at 1 atm pressure and 20 degrees C and in terajoules (TJ) in the years 1990–2003 and 2005-2013 has been provided by the production plant to Statistics Estonia. This data is included into energy balance (category “non-energy use of fuels”) by Statistics Estonia. Concerning gas feedstock quantity used in 2004 the plant provided retrospectively corrected data to the inventory compiler however no correction have been made concerning statistical data. Corrected gas feedstock quantity for the year 2004 were used in the GHG inventory.

The plant also provided data on amount of urea exported and also the urea sold in Estonia as fertiliser in the years 2003–2013, but data on 1990–2003 was not available.

[45] IPCC 2006 Guidelines, Volume 3, Chapter 3, page 3.13.

- It was assumed, that urea sold in Estonia as fertiliser every year between 1990–2003 constituted the same percent from total production of urea each year as the average of the years 2004–2009.
- It was assumed, that urea exported every year between 1990–2003 constituted the same percent from total production of urea each year than in 2003–2005.

Activity data, emission factors and CO_2 emissions from ammonia production in 1990–2015 are in Table 4.13.

Table 4.13. Activity data (and its differences to statistical data), emission factors and CO_2 emissions from ammonia production in 1990–2015

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
2.B.1													
Ammonia production, kt	294	270	140	55	180	201	203	206	211	199	177	183	47
Amount of natural gas used as feedstock, million m^3	227	218	109	43	141	148	147	145	146	139	124	133	34
Amount of natural gas used as feedstock TJ	7657	7361	3665	1440	4736	4978	4930	4859	4899	4674	4166	4459	1152
Difference between natural gas feedstock AD (TJ) to statistical data %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carbon content of natural gas t C/TJ	15.1	15.2	15.1	15.1	15.1	15.5	15.0	15.0	15.1	15.0	15.2	15.2	15.1
$EF_{ammonia}$, t/t (recovered amounts subtracted)	1.4	1.5	1.4	1.5	1.5	1.4	1.3	1.3	1.3	1.3	1.3	1.4	1.3
CO_2 captured in produced urea subtracted from emissions kt	116.4	108.3	56.8	21.9	67.9	74.7	69.1	56.0	41.9	54.1	50.7	52.4	32.4
CO_2 emission from ammonia production, kt (recovered amounts not included)	307.7	301.2	145.4	57.9	194.2	207.8	202.8	211.4	228.4	203.1	180.8	195.4	31.3

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Ammonia production, kt	98	202	213	211	202	209	23	NO	NO	17	121	NO	NO
Amount of natural gas used as feedstock, million m^3	74	145	146	146	140	145	16	NO	NO	13	83	NO	NO
Amount of natural gas used as feedstock TJ	2413	4871	4915	4912	4715	4872	538	NO	NO	448	2789	NO	NO

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Difference between natural gas feedstock AD (TJ) to statistical data %	0.0	-6.9	0.0	0.0	0.0	0.0	0.0	NO	NO	0.0	0.0	NO	NO
Carbon content of natural gas t C/TJ	15.5	15.1	15.0	15.1	15.0	15.1	15.1	NA	NA	14.8	15.1	NA	NA
$EF_{ammonia}$, t/t (recovered amounts subtracted)	1.4	1.3	1.3	1.3	1.3	1.3	1.3	NO	NO	1.4	1.3	NO	NO
CO_2 captured in produced urea subtracted from emissions kt	45.2	84.9	124.8	153.7	149.0	127.5	15.5	NO	NO	7.6	85.8	NO	NO
CO_2 emission from ammonia production, kt (recovered amounts not included)	92.2	184.5	146.4	117.6	110.6	141.6	14.2	NO	NO	16.6	68.6	NO	NO

4.3.1.3. Uncertainties and time-series consistency

The uncertainty of activity data is provided by the plant and it was ±1% in 2013. The uncertainty of emission factor is determined mainly by carbon content of natural gas and uncertainty of weighing carbamide which carbon is substracted from emissions. For carbon content uncertainty the same uncertainty value for natural gas carbon content as in energy sector – ±3.6% – is used. Uncertainty of weighing carbamide is 2% according to the plant operator. The carbon oxidation coefficient has negligible uncertainty. The uncertainty of EF is $\sqrt{(3.6^2+2^2)}$= 4.1%. Total uncertainty was $\sqrt{(1^2+4.1^2)}$ = 4.2% in 2013.

4.3.1.4. Category-specific QA/QC and verification

In 2016 a complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

The emissions of 2008–2013 have been compared with EU ETS reports. The differences in quantities of natural gas used as feedstock (converted to 20 degrees C and 1 atm) were 0.5% or less on 2008-2009 and 2013. In 2012 the difference was 2.5% because consumption of natural gas was very small and statistical data is rounded to millions m^3. Quantitative comparison can be provided to the ERT on request.

The completeness of the category was checked from the Estonian Air Pollution Sources Information System and no other ammonia production plants were found.

The UNFCC Review Team asked to provide background data sources that inform estimates of natural gas used as fuel in ammonia plants. Background data sources are plant operator and beforementioned data sources used for quality control: 1. ETS and 2. Estonian Air Pollution Sources Information System.

The UNFCC Review Team also asked Estonia to provide outcome of the comparison between operator data on gas feedstock AD and the allocation of non-energy use of fuels in the energy balance from Statistics Estonia. The differences in gas feedstock AD that Statistics Estonia used in energy balance non-energy use of fuels and that is used for GHG inventory 2.B.1 are included into table 4.13. For 1990-2003 and 2005-2013 Estonia uses data provided by operator to Statistics Estonia and for that dataset there are no differences. The difference is in the year 2004, because plant operator retrospectively corrected gas quantity – recalculated from 0 degrees C and 1 atm to 20 degrees C and 1 atm. In GHG inventory the corrected gas amount is used for emission calculation.

4.3.1.5. Category-specific recalculations

For this submission amounts of natural gas used as feedstock that the plant has given to Statistics Estonia were used as basis for emission calculations for the years 1990-2003 and 2005-2013. 2004 emissions are calculated on the basis of corrected gas amount provided by the plant and rounded to millions m^3 (the same way as statistical data is rounded). This recalculations are done with the harmonization with energy balance data.. Corrected quantities of natural gas feedstock and changes in emissions thereof can be found in Table 4.14.

Table 4.14. Recalculations of CO_2 emissions from ammonia production.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
2.B.1													
Amount of natural gas feedstock, million m^3 in current submission	227	218	109	43	141	148	147	145	146	139	124	133	34
Amount of natural gas feedstock, million m^3 in previous submission	225.2	208	107.8	42.35	139.3	146.4	145	142.9	144.1	139.4	123.9	133.4	33.9
CO_2 emission from ammonia production, kt (recovered amounts not included) in current submission	307.7	301.2	145.4	57.9	194.2	207.8	202.8	211.4	228.4	203.1	180.8	195.4	31.3
CO_2 emission from ammonia production, kt (recovered amounts not included) in previous submission	303.6	282.4	143.5	57.0	191.3	205.3	199.9	208.1	224.9	203.9	180.6	196.1	31.1

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Amount of natural gas feedstock, million m^3 in current submission	74	145	146	146	140	145	16	0	0	13	83	NO	NO
Amount of natural gas feedstock, million m^3 in previous submission	73.6	144.795	146.679	146.616	140.878	145.843	16.001	NO	NO	13.328	82.568	NO	NO
CO_2 emission from ammonia production, kt (recovered amounts not included) in current submission	92.2	184.5	146.4	117.6	110.6	141.6	14.2	NO	NO	16.6	68.6	NO	NO
CO_2 emission from ammonia production, kt (recovered amounts not included) in previous submission	91.4	184.1	147.6	118.7	112.3	143.2	14.2	NO	NO	17.2	68.7	NO	NO

Category-specific planned improvements

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

4.4. Non-energy products from fuels and solvent use (CRF 2.D)

This category includes:

- 2.D.1 – CO_2 emissions from use of lubricants (industrial and motor oils) during their use time;
- 2.D.2 – CO_2 emissions from paraffin waxes;
- 2.D.3 Other – CO_2 emissions from urea based catalysts for motor vehicles;
- 2.D.3 – NMVOC emissions from 1. use of solvents and 2. use of bitumen/asphalt paving. Indirect CO_2 emissions are calculated from NMVOC emissions from this category and reported under 2.D.3 on the row of CO_2 emissions.

CO_2 emissions from lubricants, paraffin waxes and urea based catalytic converters for motor vehicles are shown in Figure 4.4.

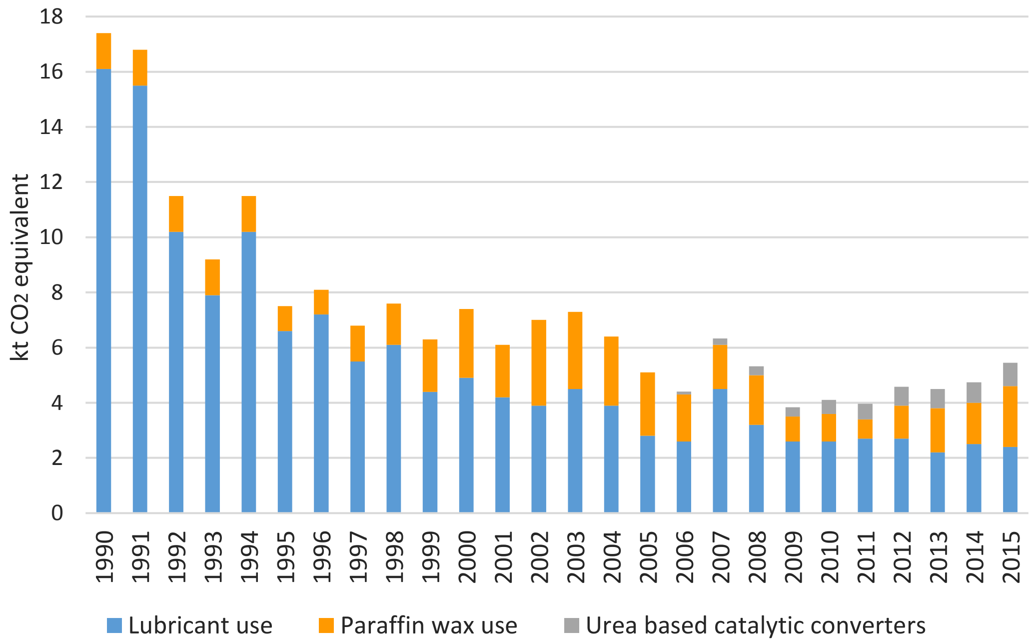

Figure 4.4. CO_2 emissions from Non-energy products from fuels and solvent use in Estonia in 1990–2015, kt

In Figure 4.5 are shown the indirect CO_2 emissions from NMVOCs from 1. use of solvents and 2. use of bitumen/asphalt paving.

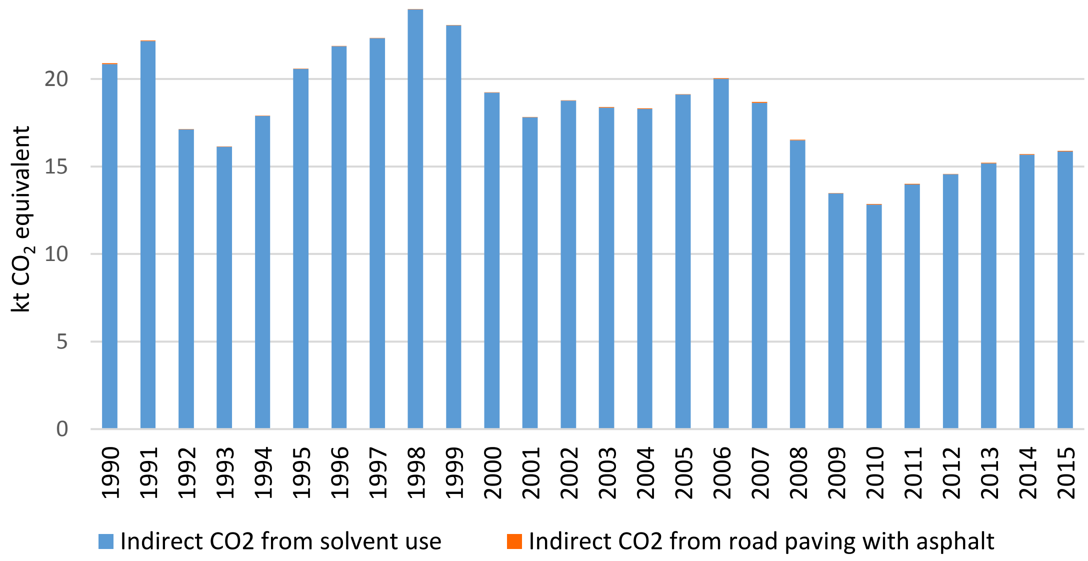

Figure 4.5. Indirect CO_2 emissions from subcategories Solvent use and Road paving with asphalt in Estonia in 1990–2015, kt

4.4.1. Lubricant use (CRF 2.D.1)

4.4.1.1. Source category description

Lubricant use is covering industrial and motor oils and greases that were produced from fossil fuels. This paragraph is about emissions from primary use of lubricants in industry, households and vehicles. The lubricants that are lost during primary use are oxidised and result in CO_2 emissions. The waste oils that are incinerated are accounted under Energy sector´s sectoral approach.

4.4.1.2. Methodological issues

Method

Emissions from lubricants were calculated according to Tier 1 method according to IPCC 2006 Guidelines (Equation 4.11)[46]. Total consumption of solid and liquid lubricants (TJ) is multiplied with emission factor. The emission factor is based on default values of carbon content and oxidation during use (ODU) factor[47].

Equation 4.11

$$CO_2\ emissions\ = \sum (LC \bullet CC_{lubricant} \bullet ODU_{lubricant}) \bullet 44/12$$

Where:

CO_2 emissions = CO_2 emissions from lubricants, tonne CO_2;
LC = total lubricant consumption, TJ;

[46] IPCC 2006 Guidelines, Volume 3, Chapter 5, page 5.7.
[47] IPCC 2006 Guidelines, Volume 3, Chapter 5, page 5.9, section 5.2.2.2

$CC_{Lubricant}$ = carbon content of lubricants (default), tonne C/TJ (= kg C/GJ);
$ODU_{Lubricant}$ = ODU factor (based on default composition of oil and grease), fraction;
44/12 = mass ratio of CO_2/C.

In 2015 the apparent consumption of lubricants was 4.11 kt and the emission from this category (2.D.1) was 2.42 kt CO_2 equivalent.

Activity Data

Data on production of lubricants in 1990–2015 was provided by Statistics Estonia. No production of motor and industrial oils was present in Estonia during 1990–2015 according to Statistics Estonia and Eurostat Prodcom database.

The apparent consumption of lubricants was calculated with formula: import-export, as no lubricant production occurred.

The quantities in tonnes were converted into TJ using the default net calorific value – 40.2 TJ/kt from IPCC 2006 Guidelines[48].

Activity data on lubricants is presented in Table 4.15.

Emission factors

According to the Tier 1 the weighted average ODU factor 0.2 for lubricants as a whole is used[49].

The default carbon content for lubricants - 20.0 t C/TJ - was applied[50].

4.4.1.3. Uncertainties and time-series consistency

Uncertainty of activity data (international trade) was estimated to be 5% by Statistics Estonia, which is the same value as suggested in the IPCC 2006 Guidelines (section 5.2.3.2).

For ODU the default uncertainty of 50% was used.

For carbon content coefficient the default uncertainty of ±3% was used.

4.4.1.4. Category-specific QA/QC and verification

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

All possible CN 8 digit codes for lubricants were checked to make sure that all relevant lubricants were included (waste oils were not included).

The number of vehicles with 2-stroke engines was estimated using the data from Estonian traffic registry. Approximately 10 000 motor scooters (a large part of them are with 2-stroke engines) are registered in Estonian traffic registry. It was concluded that the use of lubricants in 2-stroke engines is marginal.

[48] IPCC 2006 Guidelines, Volume 2, Chapter 1, page 1.18, table 1.2.
[49] IPCC 2006 Guidelines, Volume 3, Chapter 5, page 5.9, table 5.2.
[50] 2006 IPCC Guidelines, Volume 2, Chapter 1, page 1.21, table 1.3.

4.4.1.5. Category-specific recalculations

No category-specific recalculations have been done.

4.4.1.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.4.2. Paraffin wax use (CRF 2.D.2)

4.4.2.1. Source category description

The category includes such products as candles, petroleum jelly, paraffin waxes and other waxes, including ozokerite. Most of CO_2 emissions derive when the waxes or derivatives of paraffins are combusted during use (e.g. candles). Production of candles from paraffin waxes is taking place in Estonia. No production of paraffin waxes has taken place.

In Estonia, there is one candle producer which started in 1997 and has been responsible for vast majority of total candle production in Estonia since 1998. Before 1998 there was another candle producer which closed in 1998. Candle production in Estonia has multiplied after 2005 and approximately 90% of turnover are exports.

4.4.2.2. Methodological issues

Method

Emissions from paraffin waxes were calculated according to Tier 1 method according to IPCC 2006 Guidelines (Equation 4.12)[51], because no sufficient data on oxidation factors of different paraffin wax products was found.

Total consumption of paraffin waxes (TJ) is multiplied with emission factor.

Equation 4.12

$$CO_2\ emissions = PW \bullet CC_{wax} \bullet ODU_{wax} \bullet 44/12$$

Where:

CO_2 emissions =	CO_2 emissions from waxes, tonne CO_2;
PW =	total wax consumption, TJ;
CC_{wax} =	carbon content of paraffin wax (default), tonne C/TJ (= kg C/GJ);
ODU_{wax} =	ODU factor for paraffin wax, fraction;
44/12 =	mass ratio of CO_2/C.

In 2014 the apparent consumption of paraffin waxes (including candles) was 3.80 kt and the emission from this category (2.D.2) was 2.24 kt CO_2 equivalent.

Activity data

According to Statistics Estonia no production of paraffin waxes took place in Estonia, but production of candles from paraffin waxes. The data on candle production in 2006–2015 was provided by Statistics Estonia and was validated with data and estimates from the largest candle

[51] IPCC 2006 Guidelines,Volume 3, Chapter 5, page 5.11, equation 5.4.

producer. No data was available for the years 1990–2005 and therefore average apparent candle consumption (import-export) of the years 2006–2013 was used for the years 1990–2005.

The apparent consumption of paraffin waxes was calculated basically with formula: import-export+production. The amounts of paraffin waxes which were processed into candles were excluded because the consumption of candles was already accounted and the exported candles do not contribute to Estonia's emissions.

Data on import and export of paraffin waxes for the years 1995–2015 was provided by Statistics Estonia. For the years 1990–1995 the average import and export data from the years 1995–1999 was used for calculating the apparent consumption.

The quantities of total consumed paraffin waxes in tonnes were converted into TJ using the default net calorific value – 40.2 TJ/kt[52].

Activity data on paraffin waxes is presented in Table 4.15.

Emission factors

Default oxidation factor (ODU) of 0.2 and carbon content 20.0 kg C/GJ were applied according to IPCC 2006 Guidelines.

4.4.2.3. Uncertainties and time-series consistency

Uncertainty of activity data on paraffin wax consumption is estimated to be ca 20% for the years 2007–2015[53]. For earlier years the uncertainty of activity data is estimated to be 50%, because the emissions were calculated on estimates.

For carbon content coefficient the default uncertainty of ±5 percent was used.

The applied default ODU factor 0.2 has an uncertainty of about 100%.

4.4.2.4. Category-specific QA/QC and verification

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

All possible CN 8 digit codes for paraffin waxes were checked to make sure that all of them were included.

Data on candle production was given by Statistics Estonia as well by the largest candle producer. The beforementioned data from both sources was compared. The comparison confirmed that the production of other candle producers is marginal. The largest candle producer gave the same estimation. This comparison cannot be presented in NIR because of confidentiality issues.

4.4.2.5. Category-specific recalculations

No category-specific recalculations have been done.

4.4.2.6. Category-specific planned improvements

There are no planned category-specific improvements.

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[52] IPCC 2006 Guidelines, Volume 2, Chapter 1, page 1.18, table 1.2.
[53] IPCC 2006 Guidelines, Volume 3, Chapter 5, page 5.13 section 5.3.3.2.

Table 4.15. Activity data, emission factors and emissions concerning lubricants, paraffin waxes and urea based catalytic converters for motor vehicles

	1990	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2.D.1 Use of lubricants, kt	27.3	17.3	13.3	17.3	11.2	12.2	9.4	10.4	7.5	8.4	7.1	6.6	7.6	6.7	4.8	4.4	7.6	5.5	4.4	4.5	4.6	4.5	3.7	4.3	4.1
Use of lubricants, TJ	1098	696	536	696	449	491	376	417	303	336	284	265	304	267	191	176	305	221	175	180	184	182	148	173	165
CO_2 emission kt	16.1	10.2	7.9	10.2	6.6	7.2	5.5	6.1	4.4	4.9	4.2	3.9	4.5	3.9	2.8	2.6	4.5	3.2	2.6	2.6	2.7	2.7	2.2	2.5	2.4
$EF_{lubricants}$, t/t	0.5896 for all the years																								
2.D.2 Use of paraffin waxes, kt	2.2	2.2	2.2	2.2	1.6	1.5	2.2	2.6	3.2	4.2	3.3	5.3	4.7	4.2	3.8	2.9	2.7	3.1	1.5	1.8	1.1	2.1	2.7	2.5	3.8
Use of paraffin waxes, TJ	88	88	88	88	63	59	87	103	128	167	133	212	189	167	154	116	108	123	60	71	46	85	107	100	153
CO_2 emission kt	1.3	1.3	1.3	1.3	0.9	0.9	1.3	1.5	1.9	2.5	1.9	3.1	2.8	2.5	2.3	1.7	1.6	1.8	0.9	1.0	0.7	1.2	1.6	1.5	2.2
$EF_{paraffin\ waxes}$, t/t	0.5896 for all the years																								
2.D.3 Use of urea based catalytic converters for motor vehicles kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.4	1.0	1.3	1.4	2.1	2.4	2.9	2.9	3.1	3.4
CO_2 emission kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.1	0.2	0.3	0.3	0.5	0.6	0.7	0.7	0.7	0.9
$EF_{catalytic\ converters}$ t/t	0.2383 for all the years																								
Sum of CO_2 emissions from 2.D1-2.D.3, kt (excl. indirect CO_2)	17.4	11.5	9.1	11.5	7.5	8.1	6.8	7.6	6.3	7.4	6.1	7.0	7.2	6.4	5.1	4.4	6.3	5.4	3.8	4.2	3.9	4.6	4.4	4.7	5.5

4.4.3. Other (CRF 2.D.3)

The subsector 2.D.3 covers:

- Other – CO_2 emissions from urea based catalytic converters for motor vehicles;
- NMVOC and indirect CO_2 emissions from use of solvents and other products;
- NMVOC and indirect CO_2 emissions from road paving with asphalt.

4.4.3.1. Other- Urea based catalytic converters for motor vehicles

Source category description

Directive 2005/55/EC introduced Euro IV maximum limit of NOx for exhaust gases of new heavy vehicles with diesel engines registered after 01.10.2006. Euro V applied for new heavy vehicles registered since 01.10.2009 and Euro VI since 31.12.2013.

Regulation 692/2008/EC and Regulation (EU) 2016/427 of 10 March 2016 implement requirements on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6). New light vehicles brought to market and registered after 1st September 2015 have to meet strict limits of exhaust NO_x and need catalyst system. Euro 6 upper limit on NO_x is over 2 times less than Euro 5 upper limit.

SCR is the dominant technology at least in the market of trucks - 75% of sales[54]. Larger trucks have been equipped with SCR+EGR (exhaust gas recirculation).

Summary reaction of urea in SCR systems (Equation 4.13):

Equation 4.13

$$4NO + 2(NH2)2CO + O2 = 4N2 + 4H2O + 2CO2$$

Methodological issues

Tier 2 method from IPCC 2006 Guidelines was used[55].

Activity data consists of

- diesel fuel consumption of vehicles; and
- consumption of urea solution per fuel consumption.

As for average consumption of urea solution per fuel consumption IPCC 2006 Guidelines suggest default value 1–3% of diesel fuel consumption[52].

Emission factor consists of concentration of urea in it (purity), stoichiometrical coefficient of conversion of C in urea into CO_2.

[54] https://www.eionet.europa.eu/events/Copert%20training/Presentation%205.

[55] IPCC 2006 Guidelines, Volume 2, Chapter 3 page 3.12.

Methods

According to the Tier 2 methodology[55]:

Equation 4.14

$$Emission = Activity \times 12/60 \times Purity \times 44/12$$

Where:

12/60 = stoichiometrical coefficient of carbon in urea;
44/12 = stoichiometrical coefficient of conversion of carbon to CO_2.

Emission factors

The emission factor is the concentration of urea in solution (32.5%) multiplied with 0.73333 - stoichiometrical coefficient for conversion of C from urea into CO_2 (44/60). EF = 0.325 x 0.73333 = 0.238332255.

Activity data

Data on diesel fuel consumption by new vehicles complying with Euro standards was compiled by Estonian Environment Agency (EtEA). EtEA has obtained data on diesel fuel consumption from Statistics Estonia and vehicle data (passenger cars, light and duty vehicles, buses, motorcycles) and annual mileage per vehicle from the Estonian Road Administration.

Until 2015 only heavy vehicles have been accounted and in 2015 also light vehicles.

Default average consumption of urea solution per fuel consumption is 1–3%. Estonia uses 3% when calculating emissions because Estonia wholesalers of catalyst fluid say it is not under 3%.

Uncertainties and time-series consistency

1. Uncertainty of activity data consists of

- uncertainty of diesel fuel consumption which is 1.7% according to a country-specific study[56] done by Estonian Central Office of Metrology; and
- uncertainty of consumption of urea solution per diesel fuel unit. The default average consumption of urea solution per fuel consumption is 1–3%[57]. Assuming that the average value is somewhere in higher end of this range as told by Estonian fuel wholesalers, the uncertainty is estimated to be about 30%.

  The combined uncertainty of activity data is $\sqrt{(1.7^2+30^2)}=30\%$

2. Uncertainty of emission factor depends mainly on uncertainty of urea concentration in catalyst fluid. It is assumed that the concentration range matches the quality standard for aqueous ISO 22241-1:2006 Diesel engines -- NO_x reduction agent AUS32 -- Part 1:Quality requirements which suggests that concentration in 32.5 ± 0.7%. Therefore the emission factor is 0.7%.

The total uncertainty of emissions from catalysts for motor vehicles is therefore: $\sqrt{(0.7^2+30^2)}=30\%$.

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[56] AS Metrosert (Estonian Central Office of Metrology) (2007). Uncertainty estimation of CO2 emission in Estonian national greenhouse gas inventory in 2004. Report.
[57] IPCC 2006 Guidelines, Volume 2, Chapter 3, page 3.12.

Category-specific QA/QC and verification

Estimated consumption of urea catalyst solutions has been validated by comparison with external trade data from Statistics Estonia. Only CN code 31021090 was considered relevant and data from enterprises whose occupation was related to transport or wholesale of chemicals excluding agricultural chemicals. The data from Statistics Estonia was similar to the estimation used in national submission.

Category-specific recalculations

No category-specific recalculations were done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.4.3.2. Solvent use

4.4.3.2.1. Source category description

The use of solvents and products containing solvents result in emissions of non-methane volatile organic compounds (NMVOCs) when emitted into the atmosphere. Indirect CO_2 emissions are calculated from NMVOCs.

Estonia reports in the CRF also CO and SO_2 emissions from a few industrial processes using solvents (e.g. canola oil production).

Use of solvents and other products covers emissions from:

SNAP 0601: Paint application;

SNAP 0602: Degreasing, dry cleaning and electronics;

SNAP 0603: Chemical products manufacturing or processing

SNAP 0604: Other use of solvents and related activities. Including such activities as 'enduction' (i.e. coating) of glass wool and mineral wool, printing industry, fat and oil extraction, uses of glues and adhesives, wood preservation, domestic solvent use (other than paint application) and vehicle underseal treatment and vehicle dewaxing.

SNAP 0606: Use of tobacco (SNAP 060602).

Under categories paint application (SNAP 0601), degreasing and dry cleaning (SNAP 0602), chemical products, manufacture and processing (SNAP 0603) and other (SNAP 0604) Estonia reports indirect greenhouse gas emissions (NMVOCs) and indirect CO_2 emissions from NMVOC emissions (please see Table 4.16).

The NMVOC and indirect CO_2 emissions from solvent by EMEP/EEA Air pollutant emission inventory's NFR code are shown Table 4.16. Indirect CO_2 emissions from paint application (SNAP 0601) and other use of solvents (SNAP 0604) contributed the main share of total emissions from the sector – 44.5% and 36.3% respectively (see Figure 4.6).

Table 4.16. Reported emissions from Solvent use in Estonia in 2015

SNAP	NRF	Source	Emissions
0601	2D3d	Coating (paint) application	NMVOC, indirect CO_2
0602	2D3e	Degreasing	NMVOC, indirect CO_2

SNAP	NRF	Source	Emissions
0602	2D3f	Dry cleaning	NMVOC, indirect CO_2
0603	2D3g	Chemical products, manufacture and processing	NMVOC, indirect CO_2, CO
0604	2D3h	Printing industry	NMVOC, indirect CO_2,
0604	2D3a	Domestic solvent use (other than paint application)	NMVOC, indirect CO_2
0604	2D3i	Other solvent use	NMVOC, indirect CO_2, SO_2
0606	2G	Other product use	NMVOC, indirect CO_2, CO

Emissions from the Solvent use sector have decreased by 31.6% compared to base year 1990. The main category where a decrease in NMVOC emissions have occurred in later years is domestic solvent use (other than paint application) (NFR 2D3a under SNAP 0604) and this is caused by decrease of population.

The fluctuation of total NMVOC emissions in the period 1990–2015 has mostly occurred due to the welfare of the economic state of the country. The decrease in the emissions between 1992 and 1993 was due to the economic crisis what was conditioned by the fall of the Soviet Union and the independence of the Estonian Republic. Between 1993 and 1998 the economic growth induced the growing usage of NMVOC containing paints in decorative and industrial coating application. At the end of 1998 the world was struck by the economic crisis, which affected the construction sector and as a consequence the usage of decorative coatings also. From 2001 the economy turned again into growth until in 2008 the world suffered the economic depression. Because of that, compared with the year 2007, the NMVOC emissions and indirect CO_2 emissions respectively decreased in 2008 and 2009 (see Figure 4.6 and Table 4.17).

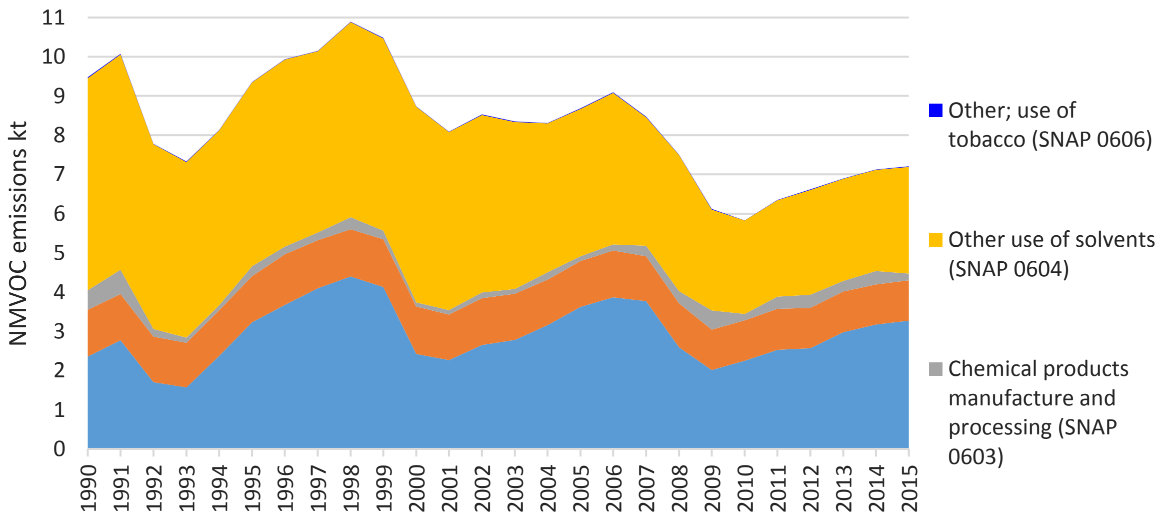

Figure 4.6. Total NMVOC emissions from Solvent use, kt

Table 4.17. Emissions from Solvent use and road paving with asphalt in 1990–2015, kt

		NMVOC emissions from Solvent use, kt																								
		1990	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
2D3a	Domestic solvent use including fungicides	4.07	4.03	3.91	3.83	3.75	3.69	3.64	3.61	3.57	3.63	3.22	2.81	2.42	2.02	1.63	1.62	1.61	1.61	1.60	1.60	1.60	1.59	1.58	1.58	1.58
2D3d	Coating application s	2.35	1.70	1.57	2.37	3.22	3.67	4.09	4.40	4.12	2.42	2.26	2.65	2.78	3.15	3.62	3.87	3.76	2.59	2.01	2.25	2.53	2.57	2.97	3.17	3.27
2D3e	Degreasing	1.18	1.15	1.12	1.14	1.16	1.26	1.22	1.18	1.17	1.16	1.12	1.13	1.11	1.10	1.10	1.13	1.09	1.07	1.00	1.02	1.03	1.02	1.00	0.98	1.00
2D3f	Dry cleaning	0.01	0.01	0.01	0.02	0.02	0.03	0.00	0.02	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.02	0.01	0.02	0.01	0.04	0.04	0.03
2D3g	Chemical products	0.50	0.20	0.13	0.14	0.25	0.20	0.19	0.31	0.22	0.11	0.11	0.15	0.13	0.18	0.13	0.16	0.26	0.31	0.50	0.16	0.31	0.34	0.27	0.34	0.18
2D3h	Printing	0.08	0.05	0.06	0.09	0.13	0.13	0.17	0.21	0.22	0.25	0.27	0.32	0.39	0.47	0.74	0.66	0.45	0.76	0.20	0.35	0.34	0.46	0.46	0.46	0.43
2D3i	Other solvent use	1.26	0.63	0.50	0.54	0.81	0.95	0.81	1.15	1.11	1.11	1.06	1.39	1.45	1.30	1.38	1.59	1.22	1.10	0.76	0.42	0.52	0.63	0.56	0.55	0.67
2G	Other product use	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total NMVOC from solvent use kt		**9.5**	**7.8**	**7.3**	**8.1**	**9.4**	**9.9**	**10.2**	**10.9**	**10.5**	**8.7**	**8.1**	**8.5**	**8.4**	**8.3**	**8.7**	**9.1**	**8.5**	**7.5**	**6.1**	**5.8**	**6.4**	**6.6**	**6.9**	**7.1**	**7.2**
Indirect CO_2 emissions from NMVOCs from Solvent use, kt																										
Indirect CO_2 kt		**20.9**	**17.1**	**16.1**	**17.9**	**20.6**	**21.9**	**22.3**	**24**	**23.1**	**19.2**	**17.8**	**18.8**	**18.4**	**18.3**	**19.1**	**20**	**18.7**	**16.5**	**13.5**	**12.9**	**14**	**14.6**	**15.2**	**15.7**	**15.9**

NMVOC emissions from asphalt paving kt	**0.03**	**$3\cdot10^{-3}$**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**
Indirect CO_2 emissions from NMVOCs from asphalt paving, kt																								
Indirect CO_2 kt	**0.05**	**$4\cdot10^{-3}$**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	**0.02**	**0.01**	**0.03**	**0.02**	**0.03**	**0.03**	**0.04**	**0.04**	**0.04**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.04**

4.4.3.2.2. Methodological issues

The compiling of NMVOC emission data from the Solvent use sector is performed at the Estonian Environment Agency. The air pollutant's inventory is carried out to meet the obligations of UNECE CLRTAP.

NMVOC emission estimations from solvent use are based on several data sources and methods. Emissions from point sources are gathered from the web-based air emissions data system for point sources (OSIS) and the emissions for diffuse sources are calculated from the data received and gathered from Statistics Estonia and Eurostat using international emission factors and expert opinions. The main database of emission factors is the EMEP/EEA Guidebook 2013.

Indirect CO_2 emissions from Solvent use were calculated using methodology from the IPCC 2006 Guidelines (Equation 4.15)[58]. According to the method:

Equation 4.15

$$CO_2\ emissions\ =\ Emissions_{NMVOC}\ \bullet\ \%\ carbon\ in\ NMVOCs\ by\ mass\ \bullet\ 44/12$$

It was assumed that the average carbon content of NMVOCs is 60% by mass for all categories under the sector of Solvent use according to the IPCC 2006 Guidelines.

4.4.3.2.3. Uncertainties and time-series consistency

As Estonia has developed a detailed inventory for these sources, therefore the uncertainty of activity data is estimated to be the default value of 25% (as suggested in the IPCC 2006 Guidelines[59]).

Uncertainties of indirect CO_2 from solvent use were estimated on the basis of uncertainties of respective NMVOC emissions. The uncertainty of activity data is estimated to be the default value of 25% as suggested in the IPCC 2006 Guidelines[59]. For CO_2 emission factor uncertainty the default value of 10% was used. The uncertainty of emission factor took into account the fact that the default fossil carbon content fraction of NMVOC is 60% by mass, and can vary between 50–70%.

4.4.3.2.4. Category-specific QA/QC and verification

Normal statistical quality checking related to the assessment of magnitude and trends is carried out. Calculated emissions and emission data from the OSIS database are compared to the previous years in order to detect calculation errors, errors in the reported data or in allocation. The reasons behind any fluctuation in the emission figures are studied. The data reported and entered into the OSIS database by operators are firstly checked by specialists from the Estonian Environmental Board and then by the specialists in the Estonian Environment Agency.

4.4.3.2.5. Category-specific planned improvements

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

4.4.3.2.6. Category-specific recalculations

No category-specific recalculations have been done.

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[58] IPCC 2006 Guidelines, Volume 1, Chapter 7, page 7.6, box 7.2.
[59] IPCC 2006 Guidelines, Volume 3, Chapter 5, page 5.17, section 5.5.4.

4.4.3.3. Road paving with asphalt

4.4.3.3.1. Source category description

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

NMVOC emission from road paving with asphalt was 0.023 kt.

Indirect CO_2 emissions from road paving with asphalt – 0.038 kt.

NMVOC and indirect CO_2 emissions in 1990-2015 are shown in Table 4.17

4.4.3.3.2. Methodological issues

Methods

NMVOC emissions from road paving with asphalt were calculated using Tier 1 default approach from the renewed EMEP/EEA Guidebook 2013 (Equation 4.16).

According to the Tier 1 method:

Equation 4.16

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

Where:

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

Indirect CO_2 emissions from road paving with asphalt were calculated using methodology from the IPCC 2006 Guidelines[58] (according Equation 4.15).

Activity data

The annual weight of asphalt produced for road paving was used as activity data when calculating NMVOC emissions from this source category. Activity data was received from the Estonian Asphalt Pavement Association for the years 1990–2015.

Emission factors

Default NMVOC factors are taken from EMEP/EEA Guidebook – 2013. For the calculations of NMVOC emissions from road paving with asphalt, emission factor 16 g of NMVOC per Mg of asphalt was used.

When calculating indirect CO_2 emissions from road paving with hot asphalt mix it was assumed that the average carbon content of NMVOCs is 45% which is between the default values of 40–50%.

4.4.3.3.3. Uncertainties and time-series consistency

The data on road paving with asphalt is deemed precise because the relevant association provided it. The uncertainty of activity data (production of hot asphalt mix) is estimated at

±10%. The uncertainty of NMVOC emission factor for total hot asphalt mix (batch and drum hot mix) production is estimated at ±100% as suggested in the IPCC 2006 Guidelines[60].

The uncertainty of average carbon content of NMVOCs is 10%. The combined emission factor of indirect CO_2 is $\sqrt{(100^2 \cdot 10^2)}$=101%.

4.4.3.3.4. Category-specific QA/QC and verification

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

4.4.3.3.5. Category-specific recalculations

No category-specific recalculations have been done.

4.4.3.3.6. Category-specific planned improvements

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

[60] IPCC 2006 Guidelines, Volume 3, Chapter 5, page 5.16, section 5.4.4.

4.5. Product uses as substitutes for ODS (CRF 2.F)

In 2015, greenhouse gas emissions under the category CRF 2.F product uses as substitutes for ODS amounted to 222.82 kt CO_2 equivalent, which is about 1.25% of the total greenhouse gas emissions in Estonia.

Under this category, Estonia reports HFC emissions from all refrigeration and air-conditioning equipment (CRF 2.F.1), HFC emissions from foam blowing and use of HFC-containing foam products (CRF 2.F.2), HFC emissions from fire extinguishers (CRF 2.F.3), and HFC emissions from aerosols (CRF 2.F.4).

The consumption of halocarbons 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. 2014 was the last year when import of HFC-s was free of quota limit. In 2013 and 2014 Estonian wholesalers imported much larger amounts F-gases than in previous years in order to sell the gases in future. In 2015 amount of HFC refrigerants placed on market in Estonia (in the meaning of Regulation (EU) No 517/2014) was not much higher than estimated consumption according to GHG inventory.

The total emissions of HFCs have increased significantly since 1993 (see Table 4.18 and Figure 4.7), especially HFC emissions from refrigeration and air-conditioning equipment, which is the major source of halocarbons in Estonia (see Figure 4.8).

As can be seen from Figure 4.8 HFC use has been halted two times – in year 2008 and in 2015. These halts resulted from restrictions of HFC use stipulated in Regulations (EU) No 842/2006 and (EU) No 517/2014 respectively. In 2008 one-component polyurethane foams with HFC-134a were banned. Large foam producers in Estonia replaced propellant HFC-134a with HFC-152a and hydrocarbons and emissions decreased sharply. The halt in emissions in 2015 is caused by forthcoming ban of Regulation 517/2014 on bringing on the market commercial refrigeration systems with HFCs. In 2015 no new commercial refrigeration systems with R-404A were built.

Today the second largest HFC emission sourc is still foam blowing (HFC-152a). All remaining sources are comparatively small emitters of fluorinated greenhouse gases.

Table 4.18. Actual emissions of HFCs in 1990–2015, kt CO_2 equivalent

	1990	1991	1992	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
HFCs	NO	NO	18	28	35	41	52	63	79	97	99	105	119	135	155	170	150	158	176	183	193	207	218	223

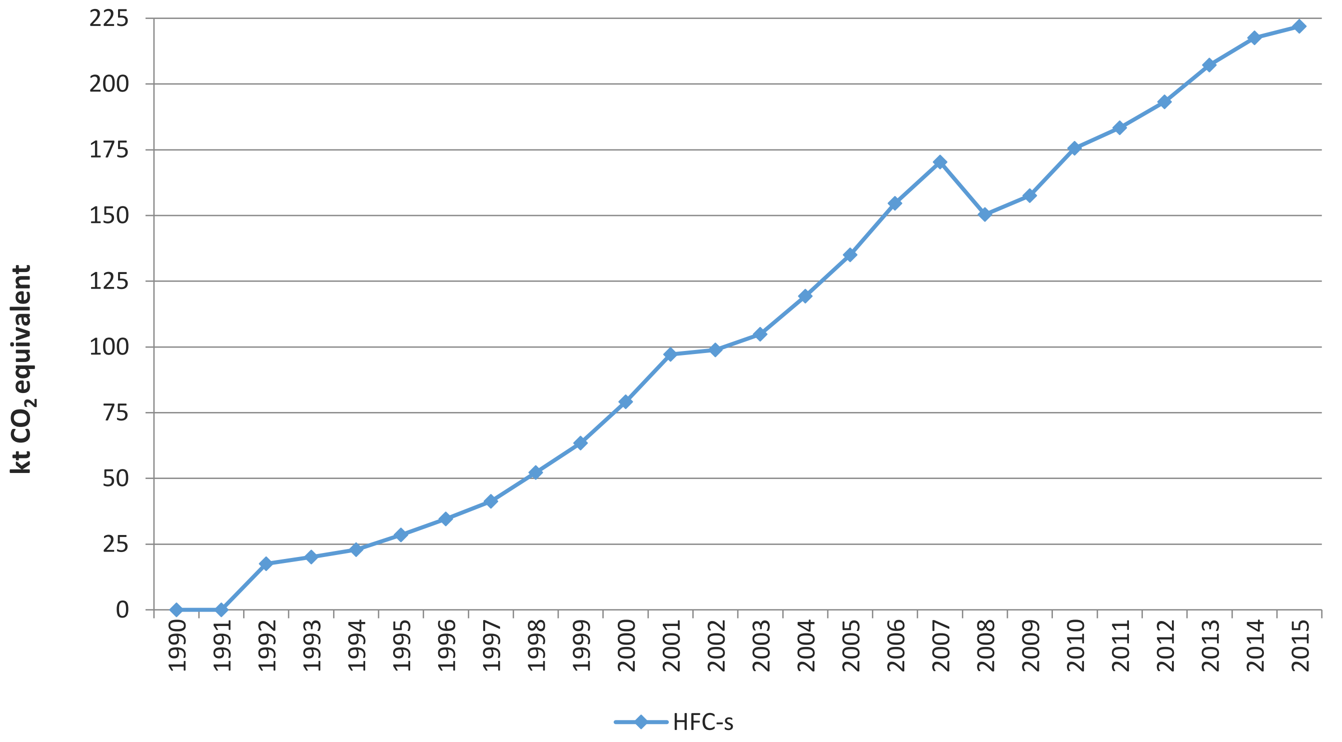

Figure 4.7. Actual emissions of HFCs in Estonia in 1990–2015, kt CO_2 equivalent

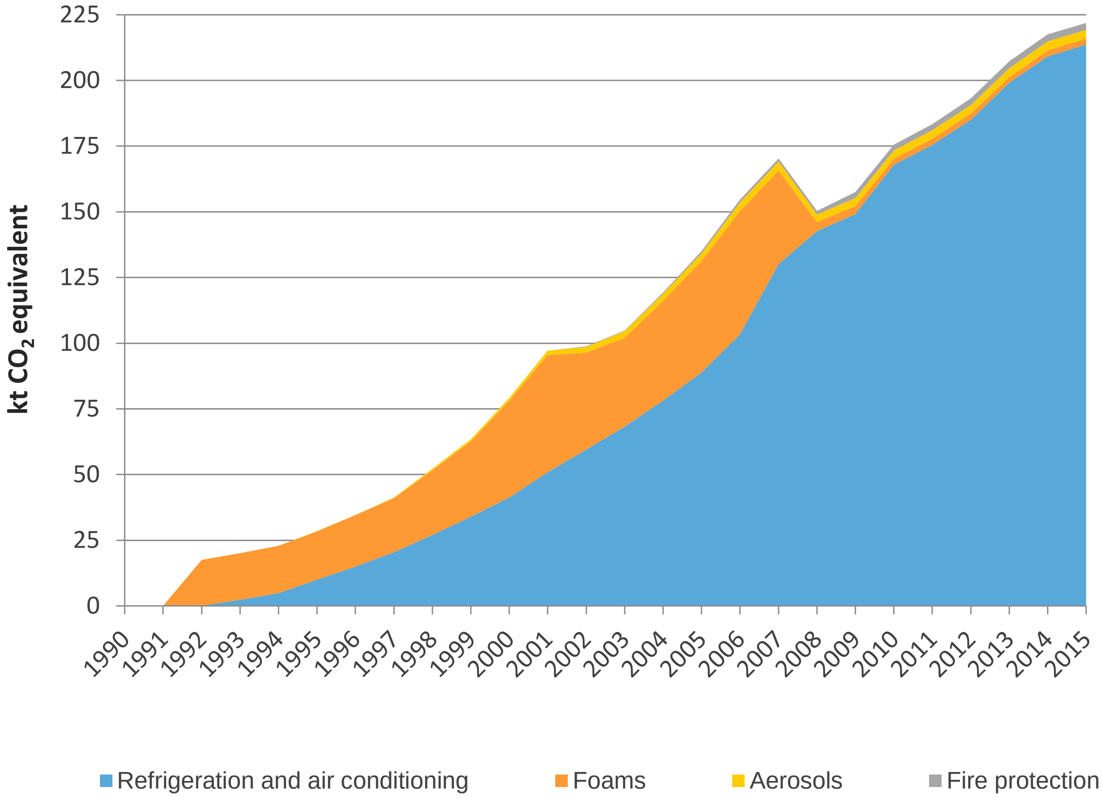

Figure 4.8. Actual emissions of HFCs by subcategory in Estonia in 1990–2015, kt CO_2 equivalent

In 2006, the first assessment of F-gas consumption in Estonia based on results from the Twinning Project EE2005/IB/EN/01 'Enhancing the capacity to reduce the emissions of fluorinated greenhouse gases in Estonia' (Twinning project between the Estonian Ministry of Environment and the German Ministry for the Environment, Nature Conservation and Nuclear Safety) was made. Within the project all sectors of possible F-gas consumption as described in the IPCC Guidelines for National Greenhouse Gas Inventories (2006 edition) were investigated. Experts had to start from zero with emissions estimation from Consumption of Halocarbons and SF_6. IPCC 2006 methodology was selected for Estonia due to it was appropriate with regard to the Estonian situation and the possibilities to get basic data. IPCC 2006 Guidelines have been also chosen as they reflect the most recently available knowledge on F-gases and the 2006 Guidelines allow for more complex modelling approaches, particularly at higher tiers.

The methods developed during Twinning Project are used until today and the validity of methods is evaluated each year with quality assessment activities.

The research has been bottom-up orientated. Manufacturers of and traders with F-gas containing goods, domestic and international suppliers of the Estonian market as well as consumers of such goods in industry and tertiary sector and the F-gas trade itself are the main sources of information, including experts from domestic and international companies, from associations, from academia and from public institutions (e.g. statistical office, car register, ship register etc.). Data collection and examination of data quality is carried out in a direct contact with the sources and from databases. By this activity data, emission factors and emissions are determined methodologically as far as possible in a country specific way (Tier 2a and Tier 3 according to IPCC 2006 guidelines).

Quality control of activity data, emission factors and data on measured emissions was made by the data collecting experts from the Estonian Environmental Research Centre.

4.5.1. Refrigeration and air conditioning (CRF 2.F.1)

Refrigeration and air-conditioning (RAC) are responsible for about 96% of the Estonian F-gas emissions (214.63 kt CO_2 equivalents). The big sub sectors are:

a) Commercial refrigeration (refrigeration units for supermarkets and smaller shops, restaurants etc.);

b) Domestic refrigeration (fridges and freezers for domestic use);

c) Industrial refrigeration (refrigeration units in the food and other industries);

d) Transport refrigeration (refrigerated vehicles and reefer containers);

e) Stationary air-conditioning (heat pumps and room air-conditioning systems); and

f) Mobile air-conditioning (AC systems for passenger cars, trucks, buses, ships, railcars, wheel tractors/mobile machinery).

4.5.1.1. Commercial refrigeration (CRF 2.F.1.a)

4.5.1.1.1. Source category description

Commercial refrigeration and its main sub sector, supermarkets, is one of the big application sectors of fluorinated refrigerants and emissions in Estonia. This category distinguishes between:

- Supermarkets and other food retail shops with mostly on-site assembled centralized systems; small shops and institutions with comparable refrigeration units (only one compressor and/or less than 15 kg refrigerant; including standalone equipment as well as plus and/or minus compartments of refrigeration systems); main HFC refrigerant is still R-404A, but also HFC-134a (mostly in standalone equipment).
- Refrigeration equipment for restaurants, hotels, pubs, canteens etc. (mostly small stand alone equipment for kitchens and cold rooms, on average 350 g/device); HFC-refrigerants: 55% R-134a, 39% R-404A and 6% other refrigerants (R-422A, R-422D, R-437A).
- Stand alone or plug-in equipment (mostly vending machines for shops, filling stations etc., on average 250 g R-134a/device).

The Commercial refrigeration sector is dominated by the refrigerants R-404A, which make 90.8% of the 2015 HFC stock (mostly used in supermarket systems) and R-134a (about 8.2%, mainly used in vending machines, small shops and restaurants). However very little new equipment with R-404A has been installed in 2015 and 2016 since supermarket chains are aware of service ban on equipment with R-404A stipulated in Regulation (EU) No 517/2014.

Other HFC refrigerants (R-407C, R-422A, R-422D etc.) are of less importance at the moment.

Estonian refrigeration equipment in general is quite modern. The biggest sector with older included second hand equipment (older than 15 years) is the small shop sector.

The number of food retail supermarkets in Estonia – hypermarkets, supermarkets, discounters, department stores – was according to the Estonian Traders Association about 600, the number of small commercial and public customer orientated service institutions with refrigeration equipment (like small shops, medical institutions, hotels, restaurants, canteens etc.) according to other statistical sources more than 10 000. This includes according to expert calculation from refrigeration service companies about 7 000 small shops with less than 3 kg refrigerant charge plus about 4 000 hotels, bars, restaurants, pubs, canteens etc. The number of vending machines for cooling of beverages and other goods (stand alone equipment) was calculated at about 15 000 units.

4.5.1.1.2. Methodological issues

Supermarkets and small shops: The refrigeration systems of supermarkets and small shops are maintained by specialised service companies. Most of them install and service the systems, some are specialised on service activities. Activity data (stock, new installations in 2015, refilling data) was collected partly from national database of F-gas equipment set up according Regulation 517/2014 and partly from service companies. The 2015 stock data (85.424 tons HFC) had to be completed by the estimation of the stock (additional 6.64 tons). This estimated amount should cover small shops HFC stock which is much under-represented in database. The estimation is conservative and low with the aim not to overestimate the stock (the country specific emission rate EF_{op} is calculated higher [15%], see below).

Total amount of HFC refrigerants was 92.043 t of HFC for the 2015 stock of supermarkets and small shops. This amount is about the same as 91.82 tonnes reported in 2016 year's submission for 2014.

Restaurants etc.: The companies installing and servicing refrigeration equipment for restaurants, canteens and similar institutions did not provide stock data. The respective stock was estimated based on a number of 4 000 possible clients with on average three devices with refrigerant charge 350 g/device resulting in about 4.2 tons HFC-refrigerant. The percentage of R-404A is estimated by Estonian experts at 39% (1.659 tons), the percentage of HFC-134a at 55% (2.289 tons). Other HFC refrigerants (R-422A, R-422D, R-437A) are only of less importance.

The number of vending machines in Estonia (15 000 à 250 g refrigerant) was extrapolated on basis of data from the two biggest manufacturers of beer and other beverages delivering such machines to Estonian shops. The HFC-charge amounts to 3.830 tons R-134a and 0.152 tons R-404A.

The lifetime of refrigeration systems for supermarkets and small shops including kitchen systems in Estonia is according to experts from the mentioned companies on average about 15 years (vending machines shorter, 5–10 years). As 1993 was the starting point of using R-134a in commercial refrigeration, based on 15 years lifetime, first decommissioning emissions occurred in 2008. The amount of R-134a, R-404A and R-407C filled in new equipment in 2000 was decommissioned according to 15 years lifetime in 2015.

Emissions: The service companies provided 2015 stock data and refilling data of their clients. Seven service companies provided complete refilling data in addition to data on stocks–refilling ratio 13.7%. However operating emission factor 15% is used as in previous submissions because the difference 1.3 (15–13.7=1.3) is very small compared to allowed uncertainty.

An EF_{op} of 15% is applied to all sectors covering emissions from operating and servicing, except vending machines. The vending machines in Estonian market are modern and should be very tight; the emission rate EF_{op} is estimated at 1.5%/year. These emission factors are in the range of the IPCC 2006 Guidelines (10–35% for medium and large commercial refrigeration and 1–15% for standalone commercial refrigeration)[61].

The EF_{manu} (filling of new equipment) is estimated at a low value of 0.5%, which is likewise in accordance with the IPCC 2006 Guidelines[62].

The EF_{disp} (disposal loss factor) is estimated at a value of 50%. The disposal emission factor is based on IPCC 2006 Guidelines[62] estimates of recovery efficiency and estimates from service companies. 50% of the refrigerant from disposed equipment is recovered.

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

- Country specific EF_{manu} (filling): 0.5%;
- Country specific operating emission factor EF_{op}: 15% (vending machines: 1.5%);
- Country specific disposal emission factor EF_{disp}: 50%.

The total quantity of HFC filled into new commercial refrigeration equipment in 2015 was a tiny 230 kg of R-404A. The manufacturing emissions from this filling are 1.14 kg. The HFC stock amounts to 100.219 tons (90.94 tons R-404A, 8.22 tons R-134a and small amounts of R-407C, R-410A, R-422A, R-422D R-437A, R-417A). The stock emissions are in total 14.49 tons. The largest part of them is HFC-404A (13.62 tons) and HFC-134a (0.72 tons). Amount of HFC-404A, HFC-134a and R-407C filled in new equipment in 2000 was decommissioned according to 15 years lifetime in 2015. The amount of fluid remained at products at decommissioning amounts to 3.672 tons of R-404A, 0.633 tons of R-134a and small amount of other refrigerants; tons HFCs total. The disposal emissions are in total 2.17 tons (1.836 tons of R-404A, 0.316 tons of R-134a and small amount of other refrigerants).

The CO_2 equivalent of all 2015 HFC emissions is 62.561 kt (62561 tons).

4.5.1.1.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the IPCC 2006 Guidelines.

The UN of the three activity data ‘Filled in new manufactured products’, ‘HFC stock in operating systems’ and ‘Remained in products at decommissioning’ is estimated ± 20% (0.2). The combination of this value with the respective emission factors (± 10%) results in the UN of manufacturing, operating and disposal HFC emissions of ± ~22%.

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[61] Information about the development of the PLF for commercial refrigeration was included as the recommendation of the UNFCCC review team.

[62] IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

4.5.1.1.4. Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

4.5.1.1.5. Category-specific recalculations

No category-specific recalculations have been done.

4.5.1.1.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.5.1.2. Domestic refrigeration (CRF 2.F.1.b)

4.5.1.2.1. Source category description

Refrigerators (fridges and freezers) for domestic use that are containing HFC are not manufactured in Estonia but were imported from 1993–2009 (new and second hand). To some degree R-134a was used as refrigerant and as foam insulating gas. R-134a as refrigerant was introduced by industry at the end of 1993 as replacement for CFC-12. In the following years, its replacement by R-600A (isobutane) started in some countries (Germany) but not in all countries in Europe and North-America. According to Estonian experts there has been no import of domestic refrigerators with refrigerant R-134a since 2009. The share of HFC-134a in the stock is estimated to be below 10% and in disposed refrigerators ca 30%.

4.5.1.2.2. Methodological issues

In 2015 Estonia had – according to the statistical office – about 597 300 households. The number of domestic refrigerators is estimated at 591 924 and the number of newly imported fridges/freezers in 2015 is estimated at 67 843 (data from importers and EES Ringlus [Estonian Association for Recycling of Electrical and Electronic Equipment]). The stock of HFC-134a containing fridges/freezers is based on estimation of HFC-134a containing fridges/freezers decommissioned in 2015 which in turn is estimated via lifetime. Lifetime of domestic refrigeration equipment in Estonia is estimated by wholesalers to be 15 years.

Emission factors: EES Ringlus estimated that about 6% of the original charge has already emitted by the time that fridges/freezers are collected for recycling. The annual operating emission rate is, following this information, 0.4%/year (EF_{op}). This country specific emission factor is within the value range 0.1–0.5% given by IPCC 2006 Guidelines[63].

The number of refrigerators decommissioned per annum can be calculated (based on 15 years lifetime) at 34 939 from which 16 039 are collected by the recycling companies and sent for treatment to foreign countries; the remaining 18 900 are disposed without refrigerant recovery. According to EES Ringlus experts estimates, the percentage of illegally disposed fridges/freezers is not as high in reality and could be ca 40%. This the number of fridges/freezers disposed without refrigerant recovery in 2015 would be ca 13 976. EES Ringlus assumed (i) that 30% of these 13 976 non-collected refrigerators contain R-134a, and (ii) that in each of

[63] IPCC 2006 Guidelines,Volume 3, Chapter 7, table 7.9, page 7.52.

them 94% of the original 150 gram charge is left (6% already emitted), the disposal HFC-134a emissions are 610.1 kg ($EF_{disposal}$ = 100%).

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

- Country specific average refrigerant charge per unit: 150 g R-134a;
- Country specific operating emission factor: 0.4%.

The total 2015 amount of R-134a emissions is 0.615 tons (stock emissions: 5.257 kg, end-of-life emissions: 610.1 kg) representing 0.880 kt CO_2 equivalent.

4.5.1.2.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the IPCC 2006 Guidelines.

The data are based on direct information from industry, so that the UN of the activity data on the number of units (stock, annual importation, annual decommissioning) is estimated to be (± 20%). The UN of the emission factor is assessed ± ~10%, so that the combined UN of the emissions (operating and disposal) is estimated to be ± 22%.

4.5.1.2.4. Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

4.5.1.2.5. Category-specific recalculations

No category-specific recalculations have been done.

4.5.1.2.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.5.1.3. Industrial refrigeration (CRF 2.F.1.c)

4.5.1.3.1. Source category description

Industrial refrigeration is a big application sector of fluorinated greenhouse gases, mainly of HFC blend R-404A. The dominant application is the food industry (fish, meat, dairy, beverage industries, breweries, etc), which is Estonia's most important industrial sector. The food industry's output is staying the same in the last years. The HFC consumption of other industries (process cooling in plastics, printing, chemical industries etc.) is comparably small.

In contrast to commercial refrigeration, in industrial refrigeration non-HFC/HCFC refrigerants – especially NH_3 – play a major role than HFC. With regard to the HFC stock R-404A is the prevailing refrigerant with about 89.3%. Other HFC refrigerants (R-134a, R-407C, R-507A, R-410A, R-422A etc.) are of minor importance.

The refrigeration systems are very often served by bigger service companies; however, self-maintenance and cooperation with smaller (locally based) service companies is of more importance than in the supermarket and food retail sector.

4.5.1.3.2. Methodological issues

Information on potential HFC users in the food and other industries was compiled in cooperation with experts from refrigeration service companies specialized on industrial application. Food industry's basic data can be found in the statistics of the Veterinary and Food Board (VTA; www.vet.agri.ee) because companies wishing to handle foodstuff must be approved by the VTA.

Complete activity data (stock, new installations in 2015, refilling data) on the HFC refrigerant consumption was provided by six large service companies. Stock data was available from national database of F-gas equipment set up according Regulation (EU) No 517/2014.

As the refrigerant stock based on the data from service companies and national database covers the total stock to a certain part only, the remaining stock had to be estimated by inventory compilers in cooperation with national sector experts. The thus estimated percentage of HFC stock in industrial refrigeration is 5.92 tons or 9.2% of the total HFC stock (64.07 tons, reported and assessed).

The average lifetime of industrial refrigeration systems in Estonia is about 15 years or more, according to experts from the mentioned companies. As 1993 was the starting point of using R-134a in industrial refrigeration, based on 15 years lifetime, first decommissioning emissions occurred in 2008. The amount of R-404A, R-134a and R-407C filled in new equipment in 2000 was decommissioned according to 15 years lifetime in 2015.

Emissions: The service companies and the industrial companies surveyed by questionnaires were asked for 2015 stock and refilling data. Complete stock and refilling data for R-404A were available for 6 large service companies. Detailed research indicated that the refilling ratios of the individual companies range from 6 to 40%. The average refilling rate was 17.7% which is somewhat higher than previous years value of 15%. Still refilling rate of 15% is used when calculating operating emissions. The reason is that it is unlikely that leakage rates increase when stricter demands on service have been stipulated by law and higher refilling rate in 2015 was caused by smaller sample that was available. Difference in real refilling rate (17.7%) and the rate that was used in calculations (15%) fits well into uncertainty range (25%) and is actually ca 15%.

As in the case of commercial refrigeration the emission factor (EF_{op}) for the stock is country specific, i.e. is based on the average refilling ratio in the industry, with 15%. This emission factor is in the range of the IPCC 2006 Guidelines and IPCC Good Practice Guidance (7-25% of the stock).

The EF_{manu} (filling of new equipment) is estimated at a low value of 0.5%, which is likewise in accordance with the IPCC 2006 Guidelines and IPCC Good Practice Guidance. The EF_{disp} (disposal loss factor) is estimated at a value of 50%. The disposal emission factor is based on IPCC 2006 Guidelines[64] estimates of recovery efficiency and also estimates from service companies. 50% of HFC containing refrigerants are recovered.

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

- Country specific EF_{manu} (filling): 0.5%;
- Country specific operating emission factor EF_{op}: 15%;
- Country specific disposal emission factor EF_{disp}: 50%.

[64] IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

The total quantity of HFCs filled into new industrial refrigeration equipment in 2015 amounts to 1.99 tons R-404A (1.035 tons R-143a, 0.876 tons R-125 and 0.080 tons R-134a).

The manufacturing emissions from filling are 10.0 kg (0.00995 kt CO_2 eq).

The HFC stock amounts to 64.07 tons (57.27 tons R-404A, 2.91 tons R-407C, 1.37 tons R-134a and smaller amounts of R-507A, R-422A and D, R-417A, R-410A). The stock emissions total 9.61 tons (8.591 tons R-404A, 0.206 tons R-134a, 0.437 tons R-407C and smaller amounts of other refrigerants. CO_2 equivalent of these gases is 35.85 kt.

Amount of R-404A, R-134a and R-407C filled in new equipment in 2000 was decommissioned according to 15 years lifetime in 2015. The amount of fluid remained at products at decommissioning amounts to 3.12 tons of R-404A, 0.049 tons of R-134a, 0.101 tons of R-407C. The disposal emissions are in total 1.95 tons of HFC-s (7.421 kt CO_2 eq).

Total HCF emissions in 2015 are 11.57 t which CO_2 equivalent is 43.314 kt (43 314 tons).

4.5.1.3.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the IPCC 2006 Guidelines.

The UN of the three activity data ‘Filled in new manufactured products’, ‘HFC stock in operating systems’ and ‘Remained in products at decommissioning’ is estimated ± >25% (26%). This high value mainly results from the high share of estimations in the determination of total HFC stock. The combination of this value with the UN of the respective emission factors (± 15%) results in the UN of emissions of ± 30%.

4.5.1.3.4. Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

4.5.1.3.5. Category-specific recalculations

No category-specific recalculations have been done.

4.5.1.3.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.5.1.4. Transport refrigeration (CRF 2.F.1.d)

4.5.1.4.1. Refrigerated vehicles

Source category description

By 31.12.2015, 1 609 refrigerated vans and trucks and 1 706 refrigerated trailers were registered in Estonia. Most of these vehicles are second hand vehicles imported from Western Europe. A large part of the refrigeration units fitted to the imported second-hand trucks and trailers are empty and are charged with refrigerant within the country. Some new vehicles are fitted with refrigeration units first in Estonia, and as a consequence, first-filled in the country.

The refrigerants in use are R-134a in case of vans and smaller trucks, and the blend R-404A in case of bigger trucks and of trailers.

Methodological issues

The Estonian Motor Vehicle Registration Centre provided a list of all refrigerated vehicles registered at the end of 2015, subdivided in weight classes (N1, N2, and N3 according to 2001/16/EC), makes, models and production years dating back to 1995 and beyond.

Information on the types of refrigeration units of the Estonian vehicles, the HFC-types they are charged with, the refrigerant charges, the emissions and the frequency of refilling is based on information provided by three biggest service companies for refrigerated vehicles, both linked to the leading international manufacturers of refrigeration units for trucks and trailers. The service companies provide the amount of refrigerants filled into empty/new equipment and estimates on average refrigerant charges and refilling rates.

Vans and smaller trucks (class N1 and half of class N2 according to 2001/16/EC) run R-134a systems (average charge 2.0 kg/unit), bigger trucks (half of class N2 and the class N3) run R-404A systems (average charge 5.8 kg/unit). For trailers an average charge of 8.0 kg R-404A is supposed. Charges of newly filled equipment are provided directly by service companies and are smaller than average.

The Estonian experts estimate the emissions at first domestic filling (empty units of imported new and second-hand vehicles) at 1%, which is in accordance with the IPCC 2006 Guidelines[65]. These emissions are equated to the CRF emission category 'emissions from manufacturing'. The annual losses from the operating systems (emissions from stocks) including service emissions on refilling amount to average 30% (EF_{op} – operating emission factor) of the refrigerant stock in the refrigerated vehicles. This country specific emission factor is within the value range given by IPCC 2006 Guidelines[39]. Disposal emission factor is based estimates from service companies and is at the high end of IPCC 2006 Guidelines estimates[39].

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

- Country-specific average refrigerant charges per unit (for estimating the stock): weight classes N1 and half N2: 2 kg; N3 and half weight class N2: 5.8 kg; trailers: 8.0 kg;
- Country-specific manufacturing emission factor: 1%;
- Country-specific operating emission factor: 30%;
- Country-specific disposal emission factor: 30%.

The total 2015 quantity of HFCs filled in empty units of refrigerated vehicles in Estonia amounts to 1.67 kg R-134a and 565.7 kg R-404A, the 'manufacturing' emissions on these first fills are 0.017 kg R-134a and 5.66 kg 404A. The HFC stock in refrigerated vehicles amounts to 764.7 kg R-134a and 20 138 kg R-404A; the stock emissions are 229.4 kg R-134a and 6 041 kg R-404A. The amount of fluid remained at products at decommissioning amounts to 638.64 kg of R-404A and 153.23 kg of R-134a. The disposal emissions are 45.939 kg R-134a and 191.59 kg R-404A. The lifetime for refrigerated vehicles is according to experts about 10 years.

[65] IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

The HFC emissions from refrigerated trucks and vans total 276.29 kg HFC-134a and 6 238.71 kg R-404A. CO_2 equivalent of these emissions is about 24.857 kt.

Uncertainties and time-series consistency

The emissions uncertainty was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the 2006 IPCC Guidelines.

The uncertainty of the two activity data 'First fill of empty systems' and 'HFC stock in operating vehicles' is estimated ± 8.5%, which is the combination of the individual uncertainty of a) total registrations (new or operating) by weight categories in 2015 (± 1%), b) refrigerant charges (± 6%) and c) refrigerant split into R-134a and R-404A (± 6%).

The combination of the uncertainty of new fill or of stock (± 8.5%) with the uncertainty of the respective emission factors (± 5%) results in the uncertainty of both manufacturing and operating HFC emissions of ± 10%.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.1.4.2. Reefer containers

Source category description

Reefer containers are being transported on sea ships around the world, and HFC emissions from their refrigeration systems do not occur inside a particular country. As a consequence, it is plausible to attribute the emissions of the worldwide reefer container fleet to a particular nation according to the share of this country in world trade. Estonia's share in the world trade in 2015 amounted according to the Statistical Office to 0.083%, so that it is responsible of 0.083% of HFC stock and HFC emissions of the worldwide reefer container fleet.

Methodological issues

The starting point of the estimation is not country-specific but worldwide data. As this data was already available in the German F-gas inventory, own research on worldwide HFC stock and emissions was not necessary. Only the share of Estonia in the world trade had to be identified.

The worldwide HFC stock was estimated in three steps:

1. Annual number of 20 feet units (new manufactured, decommissioned, total stock) from World Cargo News Online[66];
2. Refrigerant charge per set (6 kg of R-134a or 4 kg of R-404A; from German F-gas inventory);
3. HFC-split between R-134a and R-404a (80% to 20%; from German F-gas inventory).

The emissions of R-134a and R-404A are calculated by means of emission factors. The operating emission factor is 10%[67]. The disposal emission factor is 30%, which lies at the upper boundary of the range given in IPCC Good Practice Guidance. (Manufacturing emissions are not distributed by world trade shares but are estimated in the (few) countries of container manufacturing).

Method according to IPCC 2006 Guidelines: Tier 2a with international default EF.

The 2015 HFC stock emissions from reefer containers attributable to Estonia are 501.11 kg R-134a and 106.70 kg R-404A.

The 2015 emissions from the decommissioning of reefer containers attributable to Estonia are 65.17 kg R-134a and 9.5 kg R-404A.

The lifetime for reefer containers is according to experts about 14 years. According to product lifetime of 14 years, first decommissioning emissions of R-134a occurred in 2007 and R-404A in 2011.

Total emissions from reefer containers amount 566.2 kg R-134a and 116.2 kg R-404A. This is 1.265 kt CO_2 equivalent.

Uncertainties and time-series consistency

The emissions uncertainty was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the 2006 IPCC Guidelines.

The uncertainty of the basic activity data 'worldwide HFC stock' is the same as in the German inventory: ± 8.4%, which is the combination of the individual uncertainty of a) number of units (± 3%), b) HFC-charges (± 5%), c) HFC-split (± 6%).

The uncertainty of the Estonia share in world trade is estimated ± 3%, and the uncertainty of the operating emission factor ± 5%. The combined uncertainty of the HFC emissions (both 134a and 404A) can be calculated ± 10%.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

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[66] http://www.worldcargonews.com/htm/nf20151206.795565.htm

[67] http://ozone.unep.org/Assessment_Panels/TEAP/Reports/RTOC/RTOC2002.pdf

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.1.5. Mobile air-conditioning (CRF 2.F.1.e)

4.5.1.5.1. Passenger cars

Source category description

In 2015, there were about 676 593 passenger cars in traffic register of Estonia. In Western Europe systematic air-conditioning of passenger cars with the refrigerant HFC-134a had started in 1994. As lifetime of passenger cars is estimated to be 12 years, most of cars are supposed to have air conditioner. Since 1 January 2017 the air conditioning systems of new types of M1 and N1 category vehicles must be filled with a refrigerant that have GWP 150 or less according to the Directive 2007/46/EC (MAC Directive) and the most common refrigerant is HFC-1234yf. New cars with HFC-1234yf already were marketed in Estonia in 2013–2014. Therefore the proportion of new cars with HFC-134a containing air conditioner is lower than in previous years. The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on car makes and models and refrigerant type. The refrigerant charge of passenger car MAC systems ranges from 0.39 kg to 1.24 kg, the emission rate is estimated 10%.

Methodological issues

The Estonian Road Administration provided a list of all passenger cars registered at the end of 2015, subdivided in production years (dating back to 1994 and beyond). No official data about air-conditioning were obtainable.

MAC data depends on specific car models. While making the 2006 investigation a model for estimating the MAC data for the registration years 1994–2005 was elaborated and applied. This model was based on the fact that the predominant origin of the Estonian cars is Western Europe (Germany is the biggest source of second hand cars in Estonia), suggesting the conjecture that the average MAC data of the Estonian car park does not significantly differ from the analogous West European figures. The quantitative model composition of the Estonian registration year 2006 did not differ much from quantitative 2006 model composition of the German car park. Also the cars registered in 2013 and 2014 in Estonia were checked with Germany’s respective list and the same car models constituted the majority of new registrations. As a result it emerged that the Estonian average figures indeed only marginally deviate from the German ones.

This substantial congruence in the 2006 and 2013–2014 MAC figures made the assumption plausible that such congruence also exists for the previous and the next registration years. Consequently, the German average figures were applied to respective registration years in the Estonian car park. This approach allows that the individual Estonian registration years do not need to be divided into the numerous models they consist of.

HFC-134a charges and quota for 2015 were given by German experts from Öko-Recherche GmbH.

For new cars with HFC-134a the German quota 85.11% was used. Incomplete data about HFC-134a quota was also provided by some Estonian car importers: few importers of prevailing car brands imported a large percentage cars with HFC-1234yf already in 2014 while others still imported most cars with HFC-134a. This incomplete data was used for quality assessment.

The Estonian MAC quotas are considered equal to the German MAC quotas, the Estonian MAC charges are considered 2% smaller than the analogous German charges.

The emissions from the refrigerant stock in the car park are estimated applying the leakage rate established in the 2003 EU study (Schwarz & Harnisch, 2003)[68], which the authors of this study claim to be representative of EU countries.

Different types of vehicles have different product life factor (PLF). PLF for different types of vehicles (passenger cars, trucks, buses, ships, railcars, wheel tractors and mobile machinery) that have mobile air-conditioning is calculated as follows:

actual emissions from stocks / amount of fluid in operating systems (average annual stocks) • 100.

Total PLF for mobile air-conditioning category is calculated as follows:

total actual emissions from stocks / total amount of fluid in operating systems (average annual stocks) • 100.[69]

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

- Country-specific average refrigerant charge: 548 grams;
- Emission factor: 10%, which is in accordance with the IPCC 2006 Guidelines 2006[70];
- MAC quotas: In the total fleet, the MAC quotas vary by the production years;
- Disposal emission factor 50% is based on IPCC 2006 Guidelines[70] estimates of recovery efficiency and estimates from service companies.

The total HFC-134a stock in passenger car MACs in Estonia amounts to to 144.942 tons in the year 2015. The HFC-134a emissions from the Estonian passenger car fleet in 2015 total 14.494 tons (10%), the CO2 equivalent of which is 20 727 tons.

The amount of HFC-134a in the passenger cars MACs disposed in 2015 was estimated 11 149 kg. Disposal emissions from the Estonian passenger car fleet in 2015 total 5 575 kg (EF=50%), the CO2 equivalent of which is 7 972 tons.

The CO2 equivalent of all 2015 HFC emissions is 28 698 tons (28.70 kt).

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the IPCC 2006 Guidelines was applied.

The UN of the basic activity data 'HFC stock' is estimated ± 8.5%, which is the combination of the individual UN of a) total registrations in 2006 (± 1%), b) MAC quotas (± 6%), c) refrigerant charges (± 6%) – with most quotas and charges being taken from Germany.

The combination of the UN of the stock (± 8.5%) with the UN of the operating emission factors (± 5%) result in the UN of the HFC emissions of ± 10%.

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[68] Schwarz, W. and J. Harnisch, 2003: Establishing the Leakage Rates of Mobile Air Conditioners. Report prepared for DG Environment of the European Commission, Ecofys, Öko-Recherche and Ecofys, Frankfurt, Germany.

[69] Information about the development of the PLF for different types of vehicles that have mobile air conditioning was included as the recommendation of the UNFCCC review team.

[70] IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.1.5.2. Trucks

Source category description

In 2015, there were about 101 769 trucks of the weight classes (according to 2002/16/EC) N1, N2, and N3 in traffic registry of Estonia, more than a half of which are newer than 12 years (their approximate lifetime). In Western Europe systematic air-conditioning of trucks with the refrigerant HFC-134a had started in 1994/95. As a consequence, more than of half Estonian trucks are potentially air-conditioned. Equipment of these younger vehicles with air-conditioners is relatively high – 80–100% of new trucks depending on category. The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on truck makes and models. The refrigerant charge of truck MAC systems ranges from 0.75 kg to 1.2 kg, the emission rate is 10–15% depending on the weight class.

Methodological issues

The Estonian Road Administration provided a list of all trucks registered at the end of 2015, subdivided in weight classes (N1, N2, and N3), makes, models and production years dating back to 1995 and beyond. No official data about air conditioning were available.

As the 2006 investigation results had showed congruence between Estonian and German passenger car fleets and their MAC data (based on the high share of imported used vehicles from Germany) the following approach was applied to establish necessary truck MAC data. The German F-gas inventory treats the MAC quotas and charges of certain truck models as representatives of their respective weight classes and extrapolates their specific figures to the total N1, N2, and N3 trucks in the country. The same truck models as in Germany were identified in the Estonian truck park for each weight category (N1, N2, N3). The German MAC quotas and refrigerant charges of these representative models were applied to the same models in the Estonian truck fleet. The total values of N1, N2 and N3 trucks in Estonia result from extrapolation of the particular model values pursuant to the share that these models have in the total Estonian fleet, by the three different weight classes N1, N2 and N3.

In 2015, the German MAC quotas and refrigerant charges for trucks were adapted and their suitability for Estonian truck fleet was verified with incomplete data from Estonian truck sellers.

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

- Country-specific average refrigerant charges: weight class N1: 0.75 kg; weight class N2: 1.0 kg; and weight class N3: 1.2 kg.
- Emission factors (Schwarz, 2007)[71]: weight class N1: 10%; weight classes N2 and N3: 15%, which are likewise in accordance with the IPCC 2006 Guidelines[70] and IPCC Good Practice Guidance[72].
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.
- Disposal emission factor 50% is based on IPCC 2006 Guidelines[73] estimates of recovery efficiency and estimates from service companies.

The total HFC-134a stock in truck MACs in Estonia amounts to 28 397.3 kg in the year 2015. The HFC-134a emissions from the Estonian truck fleet in 2015 total 3 468.2 kg, the CO_2 equivalent of which is 4 959.6 tons.

The amount of HFC-134a in the truck MACs disposed in 2015 was estimated 2 184 kg. Disposal emissions from the Estonian truck fleet in 2015 total 1 092.20 kg (EF=50%), the CO_2 equivalent of which is 1 562 tons.

The CO_2 equivalent of all 2015 HFC emissions is 6 521.4 tons (6.52 kt).

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the IPCC 2006 Guidelines was applied.

The UN of the basic activity data 'HFC stock' is estimated ± 8.5%, which is the combination of the individual UN of a) total registrations by weight categories in 2006 (± 1%), b) MAC quotas (± 6%), c) refrigerant charges (± 6%) – with quotas and charges being taken from Germany.

The combination of the UN of the stock (± 8.5%) with the UN of the operating emission factors (± 5%) results in the UN of the HFC emissions of ± 10%.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

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[71] Schwarz, W. (2007). Establishing the Leakage Rates of Mobile Air Conditioners in Heavy Duty Vehicles (070501/2005/422963/MAR/C1). Part I trucks, and part II buses. Prepared for the European Commission (DG Environment).

[72] IPCC 2000 Good Practice Guidance and Uncertainty Management, Chapter 3, table 3.23, page 3.110.

[73] IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

4.5.1.5.3. Buses

Source category description

In 2015, about 3 661 buses were operated in Estonia. A large part of the Estonian bus fleet consists of second-hand vehicles from Western Europe. In Western Europe large-scale air-conditioning of buses with the refrigerant HFC-134a had started in 1995. Majority of Estonian buses were built from 1995 onwards and are therefore potentially equipped with HFC containing A/C. Proportion of the newer buses with air-conditioners is relatively high (e.g. ca 71% of buses initially registered in 2011–2015). The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on whether a bus is a city, intercity or a tourist bus. City buses can be subdivided into single and articulated buses; intercity and tourist buses are usually single vehicles, with a small part of tourist buses being double-deckers. The refrigerant charge of bus MAC systems is large, ranging from 7 kg to 20 kg, the emission rate is high mainly because of the up to 50 metres long refrigerant piping.

Methodological issues

The Estonian Road Administration provided a list of all buses registered at the end of 2015 (M3 category), subdivided in makes, models and production years dating back to 1992 and beyond. Data on the city-intercity-tourist bus split were not included, nor are there official data available about air conditioning.

Several big national and local bus operators were interviewed about the MAC data of their own fleet and of the countrywide bus fleet. The data they provided on average quota on intercity and tourist buses largely match the data of Western Europe (Schwarz, 2007)[74] in consequence of the extensive importation of second-hand vehicles from there.

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

- Country-specific average refrigerant charges: Single buses (city, intercity, tourist): 11 kg; articulated buses and double deckers: 18 kg.
- Country-specific emission factors: Single buses (city, intercity, tourist): 1.5 kg/a; Articulated buses and double deckers: 3 kg/a, which are likewise in accordance with the IPCC 2006 Guidelines[75] and IPCC Good Practice Guidance.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years. For intercity and tourist buses German quota was used and for city buses Estonian quota.
- Disposal emission factor 50% is based on IPCC 2006 Guidelines estimates[73] of recovery efficiency and estimates from service companies.

The total HFC-134a stock in bus MACs in Estonia amounts to 12 847 kg in the year 2015. The operating emissions from the Estonian bus fleet in 2015 total 1 887 kg (of HFC-134a), the CO_2 equivalent of which is about 2 698 tons.

[74] Schwarz, W. (2007). Establishing the Leakage Rates of Mobile Air Conditioners in Heavy Duty Vehicles (070501/2005/422963/MAR/C1). Part I trucks, and part II buses. Prepared for the European Commission (DG Environment).
[75] IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

The amount of HFC-134a in the bus MACs disposed in 2015 was estimated 988 kg. Disposal emissions from the Estonian bus fleet in 2015 total 494.1 kg (EF=50%), the CO_2 equivalent of which is 707 tons.

The CO_2 equivalent of all 2015 HFC emissions is 3 405 tons (3.405 kt).

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the IPCC 2006 Guidelines was applied.

The UN of the basic activity data 'HFC stock' is estimated ± 8.7%, which is the combination of the individual UN of a) total registrations in 2011 (± 1%), b) bus split (± 5%), c) MAC quota (± 5%), d) refrigerant charge (± 5%).

The combination of the UN of the stock (± 8.7%) with the UN of the operating emission factor (± 5%) results in the UN of the HFC emissions of ± 10%.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.1.5.4. Ships

Source category description

Usually, merchant ships >100 Gross Tonnage (GT) are equipped with air-conditioning systems and provision refrigeration, tugs with air-conditioning only, and fishing vessels >18 m with refrigeration. Ship air-conditioning with HFC started from 1996 onwards substituting HCFC-22. Refrigerants in use are HFC-407C, HFC-404A, HFC-427A, HFC-407A and HFC-134a as the new standard refrigerant[76]. Other HFC refrigerants (HFC-507A, HFC-410A, HFC-422A, HFC-422D) are of minor importance. Most HFC-refrigerants are used for air-conditioning (R-134a); a smaller part is used for provision cooling (R-134a, R-404A, R-407C). The cooling and freezing systems of most Estonian deep-sea freezer trawlers operate without HFC (refrigerant: ammonia).

[76] Schwarz, W., Rhiemeier, J. M. (2007). The analysis of the emissions of fluorinated greenhouse gases from refrigeration and air conditioning equipment used in the transport sector other than road transport and options for reducing these emissions: Maritime, Rail, and Aircraft Sector (07010401/2006/445124/MAR/C4). Prepared for the European Commission.

Methodological issues

Ships under Estonian flag with GT 100 or more and fishing vessels >18 m are listed in the Estonian Ship Register (Estonian Maritime Authority). Data on AC and provision cooling systems of these ships were collected from the operating companies, additionally data on all ferries of the two relevant Estonian ferryboat companies. The data on type of refrigerant, charge and refilling in 2015 were provided directly by the ship owners. The estimation of the stock emissions is based on average refilling rate.

The ship owners also provided data on HFC containing fire extinguishers, which are accounted under CRF category 2.F.3 Fire protection.

According to Estonian Maritime Administration tugboats >100 GT have no air-conditioning devices.

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

- Country-specific HFC refrigerant stock: total 9 374 kg, thereof 6 031.2 kg R-134a; 3 298 kg R-404A; 695.5 kg R-407C, 24 kg R-427A, 408 kg R-407A, 37.7 kg R-410A.
- Country-specific stock emissions (refills): total 3 146.8 kg which is 33% of the stock. EF of 30% (average of previous years) is used for emission calculation, which is in accordance with the IPCC Good Practice Guidance.
- Country-specific decommissioning emissions factor: 50%. Disposal emission factor 50% is estimated with data from waste collecting companies.

Stock emissions (all HFC substances together) are 7 134 tons (7.134 kt).

No equipment was decommissioned.

The CO_2 equivalent of total emissions is 7 134 tons (7.134 kt).

Uncertainties and time-series consistency

The data on refills are reliable and complete. As a consequence, the uncertainty of the HFC emissions is estimated ± 5%.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.1.5.5. Railcars

Source category description

In 2015, there were 178 railcars and engines of the Estonian fleet equipped with a working air conditioner. All railcars were purchased as new in 2013–2015.

The relevant MAC properties (refrigerant charge, leakage rate) do not depend on the type of the railcars. The refrigerant charge of railcar MAC systems ranges from 11 kg to 30 kg.

Methodological issues

Estonian Technical Surveillance Authority was contacted to establish the size of the countrywide fleet. For obtaining MAC data all three local rail operators involved in passenger transport were interviewed. Dining cars, sleeping cars and coaches of international trains having much higher charges (30 kg) than standard cars (average 11.25 kg). Average charge in engines MAC is 1.3 kg. The old MAC systems can release 20 grams of refrigerant per operating hour, but refilling rate of newer cars is much less.

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

- Country-specific average refrigerant charges: 30 kg/a of R-134a for cars of international trains, 11.25 kg for standard cars and 1.3 kg/a of R-134a (engines).
- Country-specific emission factors: calculation based on annual losses of R-134a and the amount of refrigerant stock leads to the implied emission factor of 5.77% for all railcars in 2015, which is in accordance with the IPCC Good Practice Guidance[77].

The total HFC-134a stock in railcar MACs in Estonia amounts to 1 409.7 kg in the year 2015. The HFC-134a emissions from the Estonian railcars in 2015 amount 81.4 kg, the CO_2 equivalent of which is 116.4 tons (0.12 kt).

Uncertainties and time-series consistency

The emissions uncertainty was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the IPCC 2006 Guidelines was applied.

The uncertainty of the basic activity data 'HFC stock' is estimated ± 3%, which is the combination of the individual uncertainty of a) number of operating vehicles with air conditioning in 2006 (± 0%), and b) refrigerant charges (± 3%).

The combination of the uncertainty of the stock (± 3%) with the uncertainty of the operating emission factors (± 5%) results in the uncertainty of the HFC emissions of ± 5.8%.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

[77] IPCC Good Practice Guidance 2000, Chapter 3, page 3.110, table 3.23.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.1.5.6. Wheel tractors and mobile machinery

Source category description

First agricultural machines (wheel tractors, combine harvesters) equipped with mobile air-conditioners on Estonian market were manufactured in 1997/1998. With regard to construction machines (excavators, loaders) and other mobile machinery (forestry vehicles, roadwork machines) A/C equipment appeared later, in 2000. The equipment quota of the new agricultural machines has been estimated to be 75% since 2005. In 2015, there were about 28 360 wheel tractors and 7 601 mobile machinery in traffic register of Estonia, over a half of which were manufactured in 2005 and later. Air-conditioning of these machines is rapidly growing. The refrigerant in use is HFC-134a. The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on the type and purpose of a specific machine. The refrigerant charge of tractors and mobile machinery MAC systems ranges from 1.0 kg to 2.0 kg. The emission rate is high due to powerful vibration of these machines causing amongst others the connections in the MAC system to become loose.

Methodological issues

The Estonian Road Administration provided a list of all wheel tractors and mobile machinery registered at the end of 2015. Official data about air-conditioning of the vehicles were not available.

Estonian tractor importers gave incomplete data on A/C quota and charges. The average charges and quotas of Estonian agricultural machines match the respective values of Western Europe. The authors of this report taking into account the particularities of the Estonian vehicle fleet estimated the amount of leakages and refills.

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

- Country-specific average refrigerant charges: wheel tractors, construction machines, forestry and roadwork machines 1.0 kg/a; combine harvesters: 1.6 kg/a.
- Country-specific emission factors: wheel tractors 20% (EF is in the range of the IPCC 2006 Guidelines and IPCC Good Practice Guidance); combine harvesters, construction machines, forestry and roadwork machines 25%, which is likewise in accordance with the IPCC Good Practice Guidance.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.

In 2015 the total HFC-134a stock in tractor and mobile machinery MACs in Estonia amounts to 15 427 kg. The HFC-134a emissions from the entire Estonian fleet total 3 265.1 kg (21.16%) the CO_2 equivalent of which is about 4 669.1 tons (4.67 kt).

The amount of HFC-134a in the tractor/mobile machinery MACs disposed in 2015 was estimated 884 kg. Disposal emissions from the Estonian fleet in 2015 total 237 kg (EF=20%), the CO_2 equivalent of which is 0.339 kt.

The CO_2 equivalent of all 2015 HFC emissions is 5 008.5 tons (5.0085 kt).

Uncertainties and time-series consistency

The emissions uncertainty was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the IPCC 2006 Guidelines was applied.

The uncertainty of the basic activity data 'HFC stock' is estimated ± 14.5% for every vehicle type, which is the combination of the individual uncertainty of a) total registrations by vehicle types in 2006 (± 3%), b) MAC quotas (± 10%), c) refrigerant charges (± 10%).

The combination of the uncertainty of the stock (± 14.5%) with the uncertainty of the operating emission factors (± 10%) results in the uncertainty of the HFC emissions of ± 17.6%.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

Activity data and emissions have been recalculated for years 2010–2014, because some of the wheel tractors were not accounted previously in these years. HFC stock in tractors and mobile machinery A/C-s, emissions and increase in emissions in comparison with previous submission are presented in Table 4.19.

Table 4.19. Recalculations of emissions from work machinery

Year	HFC-134a stock in operating work machinery, t	Emissions, kt CO_2 eq.	Increase in emissions, kt CO_2 eq.
2014	14.7408	3.3446	0.7006
2013	14.0477	3.2175	0.5632
2012	13.3015	3.0140	0.3750
2011	12.3035	2.7850	0.2228
2010	11.4443	2.5918	0.0742

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.1.6. Stationary air-conditioning (CRF 2.F.1.f)

4.5.1.6.1. Heat pumps

Source category description

The use of heat pumps with HFC refrigerants – ground and air heat pumps – started in Estonia in 1995. Ground heat pumps generally operate with HFC-407C, air heat pumps with HFC-410A. In general, heat pumps are imported to the country and already charged with refrigerant. Only a small number of ground heat pumps was manufactured and filled with refrigerant in Estonia itself.

Methodological issues

The leading experts of the Estonian Heat Pump Association provided information on heat pumps in Estonia. In order to avoid double counting, the classification of heat pumps on the one hand and stationary respective room air-conditioning systems on the other hand was discussed together with experts from the Estonian Refrigeration Association. According to the experts the stock of installed heat pumps in Estonia amounts to approx. 119 375 systems in 2015 (13 115 ground, 105 346 air and 914 other heat pumps), 15 010 of them were installed in 2015. It is assumed that heat pumps which reach end of lifetime (15 years) are decommissioned each year. The average charge was estimated at 2.0 kg for ground, air to water and other HP, 1.0 kg refrigerant for air to air HP. The discussion with Estonian experts resulted in emission factors for manufacturing (EF_{manu}) of 2.0%, which lies above the value range proposed in IPCC 2006 Guidelines and IPCC Good Practice Guidance (0.2–1%); for operating systems (EF_{op}) of 2.5%, which is in accordance with the IPCC 2006 Guidelines[78] and IPCC Good Practice Guidance[79]. The disposal emission factor is 30.0%, which lies in the upper part of the range proposed in IPCC 2006 Guidelines. The disposal emission factor takes into account estimates from service companies. It is estimated that 70% of the refrigerant is recovered.

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

- Country-specific EF_{manu}: 2%;
- Country-specific EF_{op}: 2.5%;
- Country-specific EF_{disp}: 30%.

The domestic consumption filled in new ground HP is 640 kg R-407C, the manufacturing emissions 12.8 kg R-407C. The 2015 operating stock amounts to 28 058 kg R-407C (ground and other HP) and 111 216 kg R-410A (air HP). The 2015 operating emissions total 0.702 tonnes R-407C and 2.780 tonnes R-410A. The amount of fluid remained in HP at decommissioning was 300 kg R-407C and 200 kg R-410A. The 2015 disposal emissions in total 90 kg R-407C and 60 kg R-410A.

All global warming emissions together amount to 7 356.0 t CO_2 equivalent (7.356 kt).

[78] IPCC 2006 Guidelines, Volume 3, chapter 7, page 7.52, table 7.9.
[79] IPCC Good Practice Guidance 2000, Chapter 3, page 3.106, table 3.22.

Uncertainties and time-series consistency

Öko-Recherche experts assessed the emissions uncertainty pursuant to approach 1 of the IPCC 2006 Guidelines. The data on heat pumps are deemed precise because the relevant associations, companies and experts for heat pumps and refrigeration systems in Estonia, provided them.

The uncertainty of the three activity data 'Filled in new manufactured products', 'HFC stock in operating systems' and 'Remained in products at decommissioning' is estimated at ± 9%. The emission factors are estimated ± 5%. The combination of the uncertainty of the three activity data with the uncertainty of the emission factors results in the uncertainty of the HFC emissions of ± 10.3%.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.1.6.2. Stationary and room air-conditioning

Source category description

Stationary and room air-conditioning systems including chillers, ventilation and split systems are generally imported. Split systems are imported with HFC charge, newly installed chillers and ventilation systems are first-filled inside the country. In these cases emissions from filling (manufacturing) have to be considered. Refrigerants in use for chillers are HFC-134a, R-407C and lately also R-410A to some extent. Refrigerants for ventilation systems and split systems are R-407C and R-410A.

Methodological issues

The 2015 newly installed systems, the total 2015 equipment stock, the refrigerant charges by weight and HFC types, and the EF for domestic manufacturing and operating stock were determined in cooperation with the experts from the Estonian Refrigeration Association and companies (manufacturers, traders, service companies) belonging to this association. As mentioned in the heat pump section, the heat pumps on the one hand, and stationary and room air conditioning systems on the other hand were discussed together with the Estonian Heat Pump Association to avoid double counting. The interviews revealed for 2015 the following numbers of operating systems: 926 chillers, 5 230 ventilation systems and 30 000 split systems. The EF_{manu} (first filling loss) was established at 20g/system for chillers (0.019%) and 40g/system (factor: 0.24%) for ventilation systems, the EF_{op} (Product Life Factor) at 1% (chillers), 10.5% (ventilation systems) and 2% (split systems). Chillers and split systems are industrially manufactured and tighter than ventilation systems that are assembled on site. Although the emission factor of chillers estimated by the national experts is deemed too low compared with values discussed in other countries, there is currently no more reliable data available. Emissions factors of ventilation systems and split systems are in the range of the IPCC 2006 Guidelines[80]. The country-specific emission factor used for disposal (EF_{disp}=30%), is at the high end of the range proposed in IPCC 2006 Guidelines[54]. Disposal emission factor is based on IPCC 2006 Guidelines estimates of recovery efficiency and estimates from service companies.

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

- Country-specific EF_{manu}: 0.019% (chillers) and 0.24% (ventilation);
- Country-specific EF_{op}: 1% (chillers), 10.5% (ventilation) and 2% (split);
- Country-specific EF_{disp}: 30%;
- Country-specific recovery percentage: 70%.

Manufactoring emissions in 2015 are: 13.42 kg of R-134a, 70.84 kg of R-32 and 71.14 kg of R-125.

The operating stock amounts to 92.92 t R-134a, 54.32 t R-32 and 55.99 t R-125. Operating emissions: 3.858 t R-134a, 3.296 t R-32 and 3.42567 t R-125.

As 1995 was the starting point of using HFCs in stationary air-conditioning equipment, first decommissioning emissions occurred in 2010. Disposal emissions in 2015: 1.507 t R-134a 0.421 t of HFC-32 and 0.455 t of HFC-125.

All global warming emissions together amount to 23.51 kt CO_2 equivalent (23 510 t CO_2 equivalent).

Uncertainties and time-series consistency

Öko-Recherche experts assessed the emissions uncertainty pursuant to approach 1 of the IPCC 2006 Guidelines. The relevant associations, companies and experts in Estonia very roughly estimated the data on stationary AC systems, especially on emission factors of split systems and chillers.

The uncertainty of the activity data HFC consumption and stock is estimated at ± 15%. The uncertainty of the ventilation emission factors is ± 10%. The uncertainty of the EF for chillers and split systems are more uncertain (± 26%); they are supposed to be too low. The combination of the uncertainty of stock/consumption with the uncertainty of the (given) emission factors results in the uncertainty of the HFC emissions of ± 30% (chillers, splits), and ± 18% (ventilation systems).

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

[80] IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.2. Foam blowing agents (CRF 2.F.2)

4.5.2.1. Closed cells (CRF 2.F.2.a)

4.5.2.1.1. PU insulation panels

Source category description

In 2015 HFC blown and containing insulation panels made of polyurethane rigid foam were neither manufactured nor used in Estonia. Imported products had been used in the past. In 2001, one Estonian company manufacturing PU sandwich panels (consisting of facings and a rigid polyurethane foam core) had substituted the blowing agent CFC directly by the water/CO_2 reaction. The only manufacturer of industrially prefabricated insulation panels for buildings (some type of sandwich element) combining PU spray foam with polystyrene changed in 2004 from the blowing agent HCFC-141b to CO_2/water and methyl formate. From 1998 onwards, a certain amount of PU sandwich elements manufactured with HFC-134a as blowing agent had been imported from abroad. Although the use of these products in Estonia stopped in 2006, the HFCs enclosed in the foam cells of these panels form a small bank that is a source of emissions in the long run.

Methodological issues

The present bank of HFC-134a as insulating gas in imported sandwich elements was assessed by a model (because the import/export data from the Estonian customs only indicate origin and total weight of sandwich elements without information on the insulating gases). The model is based on information from the Statistics Estonia (annual import of sandwich elements minus export), Estonian experts/importers (average quota of imported sandwich elements with PU-core 1998–2001: 15%, 2002–2006: 40%), and foreign manufacturers of sandwich elements (average quota of PU-foam with HFC-134a: 1998/99: 100%, 2000: 50%, 2001: 10%, 2002ff: 5%; PU core: 30% of the sandwich elements weight). As a result, the bank of HFC containing PU panels (about 760 t) in 2006 was estimated to contain approx. 230 tons PU with HFC-134a with the HFC-134a content in the foam-stock of 6.75%[81].

The annual use-phase HFC-134a emissions from the bank (EF_{op}) are estimated according to experts from manufacturing companies at 0.5%, which is likewise in accordance with the IPCC 2006 Guidelines[82] and IPCC Good Practice Guidance.

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

- Country specific EF_{op}: 0.5%.

The 2015 Estonian HFC-134a bank in PU insulation panels amounts to 14.701 tons, the annual use-phase emissions are 0.0735 tons (105.1 tons or 0.105 kt CO_2 equivalent).

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[81] The panels are manufactured according to experts with 7.5% HFC-134a; after a first year loss (FYL) of 10% during and after manufacturing 6.75% of the blowing agent remain within the foam.
[82] IPCC 2006 Guidelines,Volume 3, Chapter 7, page 7.37, table 7.7.

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the IPCC 2006 Guidelines was applied.

The UN of the basic activity data 'HFC stock' is estimated at ± >10% because it is based on both official statistical data and expert judgment.

The combination of the UN of the stock (± >10%) with the UN of the operating emission factor (± 10%) results in the UN of the HFC emissions of ± 14%.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.2.1.2. Spray and injection PU foam

Source category description

This sector of on-site insulation with spray respectively injection foam blown with HFC-365mfc (with HFC-227ea add-on to reduce the flammability) is small. However, there must not only use-phase emissions be considered but also emissions upon manufacturing until year 2008. The manufacturing emissions are relatively high because the foaming process is an open application. It should be mentioned that HFC-free (water based) PU spray foam systems are also in use, namely for in-site insulation of buildings and soil-laid heating pipes, up to some tons/year. In 2009–2015, there was no production of HFC containing spray and injection PU foam in Estonia.

Estonia has searched for enterprises who insulate buildings with spray polyurethane foam and manufacturers of polyurethane (PU) foam products. We contacted 6 enterprises who insulate buildings with spray PU foam and none of them reported any HFCs. They use air as propellant.

Methodological issues

In the EU, for on-site applied foam the hardly inflammable blowing agent HCFC-141b was no longer permitted as of 2004 at the latest. Difficulties with alternative blowing agents arose from two sides. On the one hand the application of HFC-365mfc is not trivial from a technical point of view. On the other hand the manufacturer of this fluid could not satisfy the demand for HFC-365mfc in 2004 because of problems in his production plant. As a consequence, in the EU the HCFC-141b was still in use after 2004 - according to PU system suppliers also in Estonia.

Until 2008, one company in Estonia used HFC-365mfc/HFC-227ea (in addition to a small amount of HFC-134a) as blowing agent for on-site applied PU foam. HFC quota in this mixture: HFC-365mfc = 93%, HFC-227ea = 7%.

According to chemical suppliers, the HFC content in the spray foam system before application is 7.5%. On application (manufacturing), a blowing agent loss (EF_{manu}) must be considered which includes two HFC fractions: one released directly upon application and another being released within one year after application. Both fractions together are called first year loss (FYL). The FYL amounts to 20%; 80% of the original blowing agent remain in the foam cells during the use-phase[83]. The product life factor (EF_{op}) is according to chemical suppliers 1%.

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

- Country specific EF_{manu}: 20%;
- Country specific EF_{op}: 1%.

In 2015 the stock constituted of 258 kg HFC-365mfc, 33 kg HFC-227ea and 30 kg HFC-134a. Stock emissions: 2.58 kg HFC-365mfc, 0.33 kg HFC-227ea and 0.3 kg HFC-134a.

Total global warming emissions: 3.54 t CO_2 equivalent (0.0035 kt).

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The UN of the basic activity data ‘HFC consumption’ is estimated at ± >10% because it is based on sales data and expert judgment. The combination of the UN of the consumption (± >10%) with the UN of the manufacturing emission factor (FYL) of ± 10% results in the UN of the HFC emissions of ± 14%.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

The companies which insulate buildings with PU spray and injection foam were asked if they used HFCs. No company used HFCs in their product, but air or water instead.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

[83] In contrast to the IPCC 2006 Guidelines (p. 7.35: FYL 10%), in this report an FYL of 20% is used (Krähling/Solvay 2002: 15% loss on manufacturing, 5% additional loss within the first year).

4.5.2.1.3. XPS insulation foam

Source category description

The 2015 basic research showed that XPS foam was not manufactured in Estonia whereas imported XPS board for thermal insulation was of some importance in the country. Inventory compilers checked websites of imported foam products that are sold in markets for construction/gardening goods and found information that no HFCs are used. The European manufacturers have stepwise shifted from HCFC blowing agents to HFC-134a/152a and to CO_2. The main XPS suppliers to the Estonian market are using CO_2. One international manufacturer currently using both CO_2 and HFC-134a blowing agents supplies the Estonian market from a Scandinavian factory with CO_2 blown foam. From 2001 to 2006, this company sold a considerable amount of HFC-134a containing XPS panels to Estonia where these panels were used. It is generally accepted that in case of HFC-134a some 27% of the blowing agent release to the atmosphere on manufacturing (EF_{manu} = 27%). As a consequence, 73% of the blowing agent remains in the panels as insulating cell gas, in the long term. Thus, in Estonia an HFC bank in the XPS board stock was considered as a source of domestic emissions.

Methodological issues

Seven international chemical companies gave data on the XPS foam market in Estonia. Based on this information, both the year-on-year growth in the domestic XPS-foam bank and the HFC content in the annual sales quantities were assessed for the 2001–2005 periods. From 12.5% (2001) a gradual decrease in the HFC-134a content to 0% (2006) was established, resulting in 5% HFC content of the final 2006 XPS stock (72 000 m^3 XPS, thereof 3 600 m^3 HFC-containing XPS). As the HFC quantity used for the production of one m^3 XPS foam is known (3.3 kg), the HFC bank was calculated from the volume of XPS sold to Estonia. A use-phase emission factor (EF_{op}) of 0.66% was applied to this long-term bank of enclosed HFC-134a. Country specific EF_{op} is lower than the value given in IPCC Good Practice Guidance, 0.75%.

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

- Country specific EF_{op}: 0.66%;
- 2015 HFC-134a bank: 8.17 tons;
- 2015 use-phase emissions: 54 kg (0.66%) which is 77.61 t (0.078 kt) CO_2 equivalent.

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts.

No official statistical data on the XPS board consumption in Estonia is available. Thus the annual sales and the current stock of XPS foam with HFC-134a had to be calculated with sector experts. The UN of the activity data 'HFC stock' is estimated at ± 20%. The uncertainty of the emission factor is estimated 10% so that the UN of the annual use-phase emissions is ± 22.36%.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for IPPU sector according to IPCC Tier 1 method.

Environmental permits database and air pollution point sources database were checked for XPS producers. No XPS production plants were found.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.2.2. Open cells (CRF 2.F.2.b)

4.5.2.2.1. One component PU foam

Source category description

Estonia is amongst the biggest polyurethane one-component foam (OCF) producers in EU. To a considerable part, the propellant gases in the foam cans are HFCs (HFC-152a) that are added to halogen-free flammable gases. By far most of the domestically used fluorinated greenhouse gases (HFCs) are imported for filling million of OCF cans that are, on their part, predominantly exported, especially to Eastern Europe. There is, however, also a considerable domestic market for OCF, which is supplied by both domestic manufacturers and – to lesser degree – foreign companies. Due to the restrictions of the previous F-gas Regulation (EU) No 842/2006 on marketing HFCs in OCF both Estonian producers, in 2008, have stopped marketing OCF with HFC-134a in EU, using mainly hydrocarbons instead, but also HFC-152a for some special applications. In 2010–2012, one Estonian producer manufactured OCF with HFC-134a as propellant, but all products were located outside the EU markets. In 2013 and 2014, HFC-134a was not used in OCF production and no emissions occurred.

Methodological issues

The following data was collected for emission estimation from manufacturing and use of OCF:

1. Number of cans (in terms of 750 ml volume) with HFC as blowing agent manufactured in Estonia, average amount of HFC per can, emissions on filling;
2. Number of OCF cans (in terms of 750 ml content) with HFC as blowing agent sold to the Estonian market, average amount of HFC propellant per can.

Information sources:

- The two Estonian companies manufacturing OCF within the country and selling OCF to the Estonian market.
- Wholesalers selling HFC-152a containing OCF to the Estonian market.

The EF_{manu} (0.51%) is based on information from the two domestic manufacturers. As to the application of OCF, it is assumed that all HFC is emitted from the cans in the year of the OCF use. In contrast to the method of the IPCC 2006 Guidelines but in accordance with other submissions under the UNFCCC it is assumed that all use-phase emissions occur in the year of sale (use and disposal occurring promptly after sale). The row 'stock' in CRF Reporter is equated to the HFC content of OFC cans sold to the Estonian market and used in relevant year. Hence only emissions from manufacturing and use (= stock) are entered in the CRF table, no emissions from disposal. EF_{op} is 100%, which is higher than the value given in IPCC Good Practice Guidance and IPCC 2006 Guidelines (95%).

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

- Country specific EF_{manu}: 0.51% (HFC-152a);
- Country specific EF_{op}: 100%;
- Manufacturing emissions: 3.10 tons HFC-152a or 384.4 t CO_2 equivalent;
- Stock = use-phase emissions: 13.78 tons HFC-152a or 1 708.72 t CO_2 equivalent.

The HFC emissions from manufacturing and from stock total to 2.09312 kt CO_2 equivalent.

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. As the domestic and foreign manufacturers themselves provided all the relevant data, the data uncertainty is estimated low. The uncertainty of the annual HFC consumption and – consequently – use-phase emissions by quantity and HFC type is ± 15%. The same value applies to the manufacturing emissions.

Source-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Emissions of HFC-152a from OCF manufacturing were cross-checked against reports from Estonian air emissions data system for point sources (OSIS) and no significant differences were found.

For completeness check Estonian database of environmental permits and OSIS were checked for other foam producers. No other foam producers which would use HFCs were found.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.2.2.2. PU integral skin foam

Source category description

In Estonia the PU Integral Skin Foam production started in 2004 with HFC-365mfc. Beforehand, ozone-depleting HCFC-141b was used; it is no longer allowed from 2004 onwards. All blowing agent applied on manufacturing is supposed to emit to the atmosphere the same year. Until 2009, one company in Estonia used HFC-365mfc and HFC-227ea for manufacturing of a very small amount of PU integral skin products. In 2010–2015, PU Integral Skin Foam was neither manufactured nor used in Estonia.

Methodological issues

For manufacturing of PU integral skin foam small quantities (1–2%) of HFC are added as auxiliary blowing agent in order to improve product quality. As integral skin is open-cell foam, upon foaming the blowing agent is released almost completely within one year (according to the industrial foam system supplier). The EF manu (First Year Loss) is 100%. This means methodologically that there is no need for estimating an HFC bank and operating emissions from this bank. Information on the consumption of HFC-365mfc was provided by the manufacturer of integral skin products in Estonia. The EF_{manu} is likewise in accordance with the IPCC 2006 Guidelines (page 7.33). IPCC Good Practice Guidance default emission factor is 95%, which is lower than country-specific emission factor.

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

- Country specific EF_{manu}: 100%.

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The UN of the activity and emissions data ‘HFC consumption’ is estimated at only ± 3% because it is based on information of the only user.

Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.5.3. Fire protection (CRF 2.F.3)

In Estonia different types of HFC are used for substituting halons in fire protection (flooding equipment): mostly HFC 227ea (FM-200), the blend FS49C2 (R-866) consisting of HFC-134a, HFC-125 and CO_2, and furthermore HFC-23.

4.5.3.1. Source category description

F-gases are more expensive than environmentally friendlier substances for fire fighting in indoor flooding systems (e.g. nitrogen, argon). The latter are characterized as overpressure gases. Compared to them, the advantage of F-gases is their lower pressure: The pressure of FM 200 (HFC-227ea) in the piping is about one fifth of the pressure of argon. This makes the F-gases suitable for flooding systems of smaller rooms where the higher pressure of e.g. argon could cause damages. However popularity of F-gases in fire protection systems has a decreasing trend and in last few years very little new systems were installed. F-gases for fire fighting are still popular on aircraft and some military vehicles.

F-gases for fire fighting are brought to Estonia in closed cylinders from European manufactories. Installation is carried out by connecting the cylinder with the piping system. The cylinder has, according to the supplying companies, no valve outside but only inside so that a mistake upon installation (e.g. opening of the wrong valve) is hardly possible. In case of false alarm or fire the whole charge of the cylinder is blown out. Refilling in site does normally not take place. Emptied cylinders are replaced by full cylinders.

4.5.3.2. Methodological issues

Data on the amount of the three mentioned HFC-based fluids for fire protection in the 2015 stock was provided directly by four companies dealing with fire protecting systems incl. maintenance; by one supplier of fire fighting agents who submitted the basic data (stock) of eight additional clients. Additional data was extracted from database set up according Regulation No 517/2014. According to experts from these companies no other companies were active in this field. The first HFC installation dates back to 2000.

According to IPCC 2006 Guidelines the annual emissions from installed flooding systems are in the range of 2 ± 1 percent of the installed base. As there are no detailed indications on operating emissions from flooding systems in Estonia for a longer period, an EF_{op} of 2% is applied to the bank. Emissions upon filling/refilling (EF_{manu}) are not calculated. According to the long lifetime of flooding systems (15–20 years) and the possibilities of recovery we do not assume end-of-life emissions.

Method Tier 2a according to IPCC 2006 Guidelines, using IPCC default EF_{op}.

- Operating emission factor EF_{op}: 2%.

In Estonia, the total 2015 quantity of F-gases in installed fire fighting systems amounted to 32.60 t (23.31 t HFC-227ea, 3.117 t HFC-23 and 6.705 kg FS49C2 (R866), the latter containing 8% CO_2 in mixture with HFC-134a and HFC-125). The emissions from this stock are calculated 2 percent: 62.34 kg HFC-23, 13.4 kg HFC-125, 110.0 kg HFC-134a and 466.2 kg HFC-227ea. The CO_2 equivalent of all 2015 HFC emissions is about 2.63 kt (2 628 tons).

4.5.3.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the IPCC 2006 Guidelines.

The data are based on direct information from industry, so that the UN of the data on the different HFC stocks can be estimated comparably low (± 10%). The UN of the emission factor is assessed ± ~10%, so that the combined UN of the emissions is estimated ± 14%.

4.5.3.4. Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

4.5.3.5. Category-specific recalculations

No category-specific recalculations have been done.

4.5.3.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.5.4. Aerosols (CRF 2.F.4)

4.5.4.1. Metered dose inhalers (CRF 2.F.4.a)

4.5.4.1.1. Source category description

Under the category of Metered Dose Inhalers (MDI) with HFCs of pharmaceutical grade two aerosol applications are discussed: aerosols for the treatment of asthma/COPD (chronic obstructive pulmonary diseases) and aerosols for natural medicine.

4.5.4.1.2. Methodological issues

The domestic manufacturer provided the data on manufacturing, domestic consumption and export of MDIs for natural drug products including the emissions rate from manufacturing (EF_{manu} = 2%). Use-phase emissions: The number of MDIs for both anti-asthma and natural medicines sold to the domestic market in 2015 (production + import - export) is the stock of the same year 2015. As the consumption of the products follows the purchase immediately, annual stock and the annual emissions are the same size. HFC-134a is completely exhaled after inhalation so that 100% is the appropriate value for the use-phase emission factor, which is likewise in accordance with the IPCC 2006 Guidelines and IPCC Good Practice Guidance.

2015 year's sales figures and HFC content of the MDIs (asthma/COPD) and other pharmaceutical products were provided by the Estonian Medical Board and information on HFC content per device was provided by respective companies.

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

- Country specific EF_{manu}: 2%;
- Country specific EF_{op}: 100%;
- Natural medicines: The 2015 domestic consumption of HFC-134a was 1.05 tons (manufacturing emissions: 31.5 kg), of which 0.968 tons were sold to the domestic market, resulting in use-phase emissions of the same amount.
- Anti-Asthma MDIs: The 2015 domestic market was 1 293 kg, with the same quantity of emissions.
- Overall emissions: 2.292 tons HFC-134a or 3 277tons CO_2 equivalent (3.28 kt).

4.5.4.1.3. Uncertainties and time-series consistency

The emissions uncertainty was assessed by the Öko-Recherche experts according to approach 1 of the IPCC 2006 Guidelines.

The data are based on direct information from manufacturers and from trade departments in industry, so that the activity data domestic production and domestic market are deemed highly reliable. As a consequence, the uncertainty of the emissions (manufacturing and use-phase) is estimated ± 10%.

4.5.4.1.4. Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

4.5.4.1.5. Category-specific recalculations

No category-specific recalculations have been done.

4.5.4.1.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.5.4.2. Technical aerosols (CRF 2.F.4.b)

4.5.4.2.1. Source category description

HFC-134a is used as propellant in some technical aerosols like solvent and cleaning sprays, but in recent years HFC-free sprays with alternative gases are marketed in Estonia. Regulation (EU) No 842/2006 banned bringing on the market of novelty aerosols such as signal horns for sport events or hunting. The Estonian manufacturer stopped producing signal horns in 2009. Solvent and cleaning sprays with HFC-134a were imported until 2010.

4.5.4.2.2. Methodological issues

In 2010, the use of HFC-134a in solvent and cleaning sprays stopped in Estonia due to the supplier exchange and changes in product prescription.

As in MDIs, the HFC-consumption for freezing spray in 2009 is equated to emission in the same year 2009 (EF_{op} 100%), which is in accordance with the IPCC 2006 Guidelines and IPCC Good Practice Guidance.

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

- Country specific EF_{op}: 100%;
- Country specific charge of aerosol cans: 12.9 g.

4.5.4.2.3. Uncertainties and time-series consistency

The emissions uncertainty was assessed by the Öko-Recherche experts according to approach 1 of the IPCC 2006 Guidelines.

The data are based on direct information from industry, so that the uncertainty of the activity data on the number of units and on charges can be estimated low (± 10%). The same uncertainty value applies to the emissions because the emission factor is 100%.

4.5.4.2.4. Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

4.5.4.2.5. Category-specific recalculations

No category-specific recalculations have been done.

4.5.4.2.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.6. Other product manufacture and use (CRF 2.G)

This category includes:

- SF_6 emissions from Electrical equipment (CRF 2.G.1);
- SF_6 emissions from Accelerators (CRF 2.G.2b), historic SF_6 and PFC emissions from Sport shoes and SF_6 emissions from Car tyres (CRF 2.G.2.d); and
- N_2O emissions from Medical and other applications (CRF 2.G.3.a) and from Propellant for aerosol products (CRF 2.G.3.b).

Emissions from category Other product manufacture and use are shown in Figure 4.9.

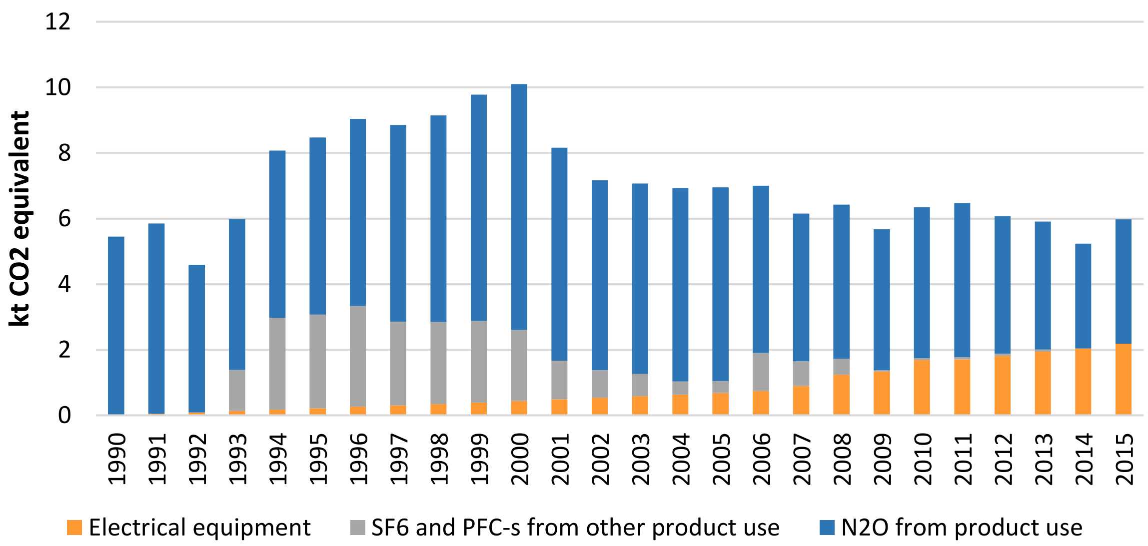

Figure 4.9. Emissions from Other product manufacture and use in Estonia in 1990–2015, kt CO_2 equivalent

4.6.1. Electrical equipment (CRF 2.G.1)

4.6.1.1. Source category description

SF_6 is used as an arc quenching and insulating gas in high-voltage (110–380 kV) and medium-voltage (6–35 kV) switchgear (GIS) and control gear. In Estonia the use of SF_6 in this sector started in 1991 (high-voltage) and 1999 (medium-voltage), respectively. The equipment is not manufactured within the country. Medium-voltage GIS (distribution equipment) operate with low over-pressure and little gas quantities of only some kg/system. They are already SF_6

charged when imported and are hermetically closed (‘sealed for life’). High-voltage GIS (transmission equipment) with a higher operating pressure (up to 7 bar) and bigger gas quantities (‘closed for life’) have to be replenished in their lifetime. They are imported with a transport filling and are filled up in site (on site erection).

4.6.1.2. Methodological issues

Estonian companies of electrical power distribution provided data on their equipment, on their SF_6 consumption in total and on refilling during the last year. The refilling data of the HV equipment reported from different power suppliers ranged from 0.1% to 0.7%/year. In case of MV-GIS no losses occurred according to the companies. The main operator of HV-GIS estimated the EF_{manu} (topping up of imported HV-GIS within the country) 0.1%. The EF_{op} of HV- and MV-GIS used in this report is based on the default emission factors of the IPCC 2006 Guidelines with 0.7% (high voltage) and 0.1% (medium voltage) per year, respectively.

Method according to IPCC 2006 Guidelines: Tier 3.

- Country specific EF_{manu} (manufacturing emission factor, on site erection): 0.1%;
- EF_{op} (according to IPCC GL): 0.7% (HV), 0.1% (MV).
- Disposal emission is estimated to be 2% of initial quantity[84].

Manufacturing emissions amount to 1.44 kg. Total stock emissions: 94.28 kg. Disposal emissions 0.2 kg (of 10 kg collected from disposed equipment).

Total global warming emissions: 2 187 t CO_2 equivalent (2.19 kt).

4.6.1.3. Uncertainties and time-series consistency

Öko-Recherche experts assessed the emissions uncertainty (UN) pursuant to approach 1 of the IPCC 2006 Guidelines. As the activity data are based on direct information from industry, their UN is estimated low: ± 3%. The UN of the default emission factors is ± 10% (IPCC 2006 GL, Tier 3). The combined UN of the emissions is ± ~10.4%.

4.6.1.4. Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

[84] http://www.ecofys.com/files/files/esi-sf6_finalreport_edition11_100701_v01.pdf

4.6.1.5. Category-specific recalculations

No category-specific recalculations have been done.

4.6.1.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.6.2. SF_6 and PFCs from Other product use (CRF 2.G.2)

4.6.2.1. Accelerators (CRF 2.G.2.b)

4.6.2.1.1. Source category description

Under this source category, Estonia reports emissions of SF_6 from radiotherapy devices. Two hospitals in Estonia use SF_6 insulated radiotherapy equipment (oncology), in one hospital there are three devices. The three devices in one hospital are in same size, device in another hospital is in different size. Other applications – e.g. SF_6 insulated particle accelerators or gas impregnation of power capacitors – do not occur in Estonia.

4.6.2.1.2. Methodological issues

Data on charge and use-phase losses were directly submitted from the medical operators. The operators calculated the emission rate of all equipment at 10% a year. In 2015 there was no new equipment.

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

- Country specific EF_{op}: 10.0%.
- Disposal emissions are estimated to be ca 5% which is in the same magnitude as in case of switchgear.

The 2015 stock of SF_6 totals 27.2 kg, the 2015 operating emissions 2.72 kg. Disposal emissions were 0.1 kg (of 2 kg SF_6 collected from one accelerator during repair).

Global warming emissions: 64.296 t CO_2 equivalent (0.064 kt).

4.6.2.1.3. Uncertainties and time-series consistency

The data are based on estimation of the operators. The emissions uncertainty is estimated ± 30%.

4.6.2.1.4. Category-specific QA/QC and verification

The data for this report was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

4.6.2.1.5. Category-specific recalculations

No category-specific recalculations have been done.

4.6.2.1.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.6.2.2. Adiabatic properties: Shoes and Tires (CRF 2.G.2.d)

Under this category aggregated SF_6 from both Shoe soles and Car tires are reported in this years's CRF tables. PFC emissions occured only from Shoe soles in Estonia in the past.

4.6.2.2.1. Sport shoes

Source category description

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

Methodological issues

Data on the Estonian market of sport shoes with PFC gas cushion were provided by the manufacturer. New footwear on the Estonian market has been clear of SF_6 from July 2003 onwards; final disposal emissions occurred in 2006; PFC-stock, PFC quantity for disposal/PFC disposal emissions have been calculated for 2003–2007, and 2006–2008, respectively.

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

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

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the IPCC 2006 Guidelines.

The data are based on direct information from industry, so that the UN of the activity data 'sales in year 2005' and 'emissions in 2008' can be estimated comparably low (± 10%).

Category-specific QA/QC and verification

The data for this category was collected within the framework of the Twinning Project EE2005/IB/EN/01. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.6.2.2.2. Car tires

Source category description

In Estonia, SF_6 has never been filled into car tires. This, however, was practice in Germany in the 1990s to some extent. As a considerable part of the Estonian passenger cars are imported second hand vehicles from Germany, SF_6 in tires came also to Estonia. The gas is assumed to be released completely to the atmosphere on disposal three years after the filling (IPCC 2006 Guidelines) or one year after importation.

Methodological issues

The Öko-Recherche archives include the time series from 1990 for the annual number of German cars whose tires were filled with SF_6 (one car = four tires = 1 kg), in comparison to the total number of cars registered in Germany in the same year. This quota was some 0.3% in 1992–1995, 0.17% to 0.08% (1996–1998), and negligible from 1999.

Applying these quotas to the annual number of Estonian cars imported from Germany, 1992–1998, the disposal emissions of SF_6 from the tires of these cars arise (1 kg per car). The simplified assumption is that in a particular year the imported cars show the same SF_6 quota as the cars in Germany in the same year. The disposal emissions from tire dismantling are assumed to arise one year after importation (two years are assumed to be the running time in Germany).

The annual number of used cars imported from Germany varied about 20 000 in the 1992–1998 period. Assuming this yearly number constant, rough estimation of the SF_6 emissions in Estonia can be given.

Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the IPCC 2006 Guidelines. The activity data are rated reliable and uncertainty estimated comparably low (± 10%).

Category-specific QA/QC and verification

The data for this category was collected within the framework of the Twinning Project EE2005/IB/EN/01. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

Category-specific recalculations

No category-specific recalculations have been done.

Category-specific planned improvements

There are no planned category-specific improvements.

4.6.3. N_2O from product uses (CRF 2.G.3)

4.6.3.1. Medical applications (CRF 2.G.3.a)

4.6.3.1.1. Source category description

Under this source category, Estonia reports N_2O emissions from the use of N_2O in medical and other applications. N_2O emissions from aerosol cans are reported under category Propellant for pressure and aerosol products.

4.6.3.1.2. Methodological issues

N_2O emissions from the category Medical application are calculated by the Estonian Environmental Research Centre. N_2O emissions from N_2O used in medical and other applications are estimated taking into account the amount of N_2O sold to Estonian market. Activity data was collected directly from the companies importing N_2O for medical use and other applications to Estonia from 1992 to 2015. Activity data for 1990–1991 was estimated based on the surrogate data method. It is assumed that all N_2O sold to Estonian market in a year is used in the same year. According to the IPCC 2006 Guidelines[85], it is assumed that none of the administered N_2O is chemically changed by the body and therefore emission factor of 1.0 was applied.

4.6.3.1.3. Uncertainty and times-series consistency

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

The data are based on direct information from companies importing N_2O to Estonia and selling it to Estonian market so that the uncertainty of activity data is estimated low: ± 5%. The uncertainty of emission factor is assumed to be extremely small and is estimated at ± 2%.

4.6.3.1.4. Source-specific QA/QC and verification

The data for this category was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

4.6.3.1.5. Category-specific recalculations

No category-specific recalculations have been done.

4.6.3.1.6. Category-specific planned improvements

There are no planned category-specific improvements.

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[85] IPCC 2006 Guidelines, Volume 3, Chapter 8, page 8.36.

4.6.3.2. Propellant for pressure and aerosol products (CRF 2.G.3.b)

4.6.3.2.1. Source category description

Under this source category, Estonia reports N_2O emissions from aerosol cans.

4.6.3.2.2. Methodological issues

N_2O emissions from the category Propellant for pressure and aerosol products are calculated by the Estonian Environmental Research Centre. N_2O containing aerosol cans are not produced in Estonia but imported and sold to Estonian market. Total quantity of N_2O supplied to Estonian market was obtained from distributors of N_2O products. From 2007–2016 aerosols with N_2O as propellant were sold to Estonian market by one company. Number of cans sold and N_2O content in each can was obtained from this company. According to the IPCC 2006 Guidelines[85], none of the N_2O is reacted during the process and all of the N_2O is emitted to the atmosphere resulting in the emissions factor of 1.0 for this source.

4.6.3.2.3. Uncertainty and times-series consistency

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

The data are based on direct information from company distributing N_2O products in Estonia, the uncertainty of activity data is estimated low: ± 5%. The uncertainty of emission factor is assumed to be extremely small and is estimated at ± 2%.

4.6.3.2.4. Source-specific QA/QC and verification

The data for this category was collected by the expert of Estonian Environmental Research Centre. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Industrial processes and product use sector according to IPCC Tier 1 method.

4.6.3.2.5. Category-specific recalculations

No category-specific recalculations have been done.

4.6.3.2.6. Category-specific planned improvements

There are no planned category-specific improvements.

4.7. Other production (CRF 2.H)

4.7.1. Category description

This source category includes the NMVOC emissions from the Pulp and paper (CRF 2.H.1) and Food industries (CRF 2.H.2). In addition, NO_x, CO and SO_2 emissions from Pulp and paper are reported under 2.H Other production. The non-fuel based CO_2 emissions from pulp and paper industry are estimated to be negligible in Estonia. All N_2O emissions from the pulp and paper and food industry are reported as fuel based emissions under CRF 1.

4.7.2. Methodological issues

Data on NMVOC emissions from the pulp and paper and food industry is adapted from Estonian Environment Agency.

Emissions data from these branches of industry are based on facilities data and only NMVOC emissions from the food industry are calculated as diffuse sources on the basis of statistical data and renewed EMEP/EEA Guidebook 2013 default emission factors. Activity data of the years 1990–1994 is obtained from the annual proceeding of Statistics Estonia 'Industry' and of the years 1995–2015 from the electronic database on the website of Statistics Estonia.

4.7.3. Category-specific QA/QC and verification

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

The activity data from air pollution database OSIS was compared with the data from Statistics Estonia. The number of pulp and paper plants was checked from Estonian database of environmental permits of enterprises, from newspapers and internet.

4.7.4. Category-specific recalculations

No category-specific recalculations have been done.

4.7.5. Category-specific planned improvements

There are no planned category-specific improvements.

5. AGRICULTURE (CRF 3)

5.1. Description and quantitative overview

5.1.1. Overview of the sector

The total GHG emissions reported in the Agricultural sector of Estonia were 1 337.6 kt CO_2 eq in 2015. The sector contributed about 7.4%[86] to the total CO_2 eq. emissions in Estonia (Figure 5.1). In 2015 the emissions from Enteric fermentation decreased 3.5% and from Manure management 6.8% compared to the previous year due to a fall in the numbers of dairy cattle and swine. The dairy industry has suffered a decline in production due to economic sanctions imposed by Russia on EU starting from August 2014. Consequently the number of dairy cattle in 2015 dropped 5.2% in comparison with 2014. The number of swine has fallen 15% compared to 2014 in Estonia as a result of the outbreak of African swine fever in the region in 2015.

Estonia's agricultural GHG emissions consist of

- CH_4 emissions from enteric fermentation of domestic livestock (for 16 sub-categories of livestock);
- CH_4 and direct and indirect N_2O emissions from manure management systems;
- direct and indirect N_2O emissions from agricultural soils. (Direct N_2O emissions include emissions from synthetic fertilizers, emissions from animal waste, compost and sludge applied to agricultural soil, emissions from crop residues, cultivation of organic soils and emissions from urine and dung deposited by grazing animals. Indirect N_2O emissions include emissions due to atmospheric deposition and leaching and run-off);
- liming; and
- urea application.

Enteric fermentation of livestock and direct emissions from agricultural soils were the highest contributors to the total emissions from the Agricultural sector (Figure 5.1).

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

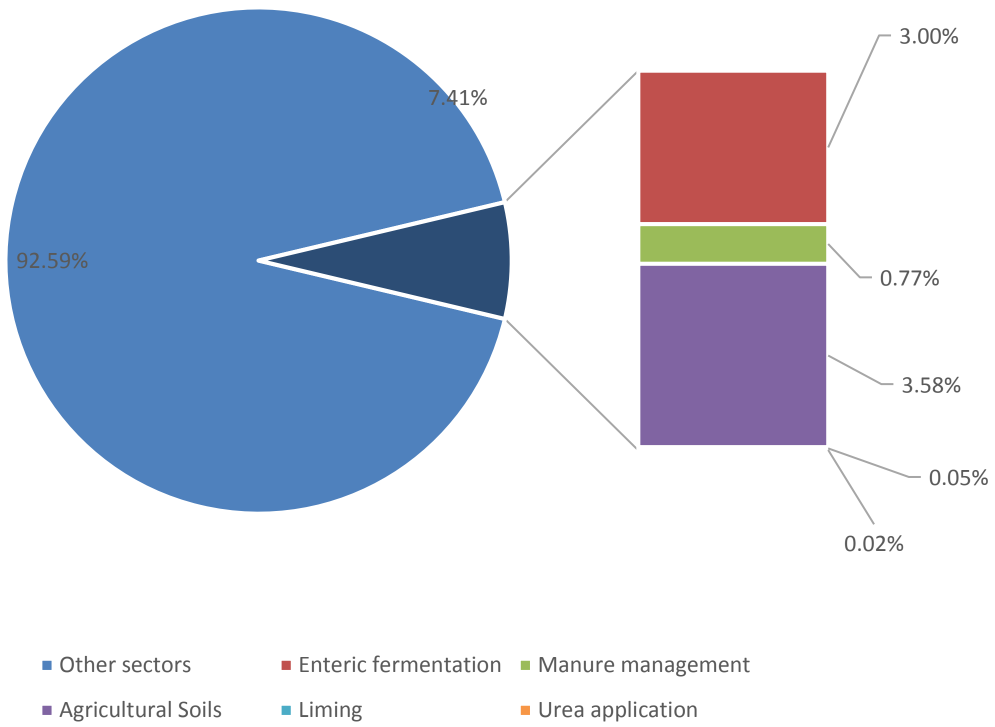

Figure 5.1. Emissions from Agriculture compared to total CO_2 eq. emissions in 2015, %

As a result of the markets of the former Soviet Union collapsing, Estonia was left with a large excess supply of agricultural produce. Western markets remained closed to Estonian agricultural products, mostly for two reasons – high customs barriers and non-compliance of our products with the requirements and practices abroad. Producer prices in Estonia fell to a level up to 50% lower than prices on world markets and became insufficient to cover production costs[87]. All of which led to rapid decline of agricultural production in Estonia.

The OECD review of agricultural policies in Estonia in 1986–1996 stated: "Farmers were lacking in both working capital and investment capital. Agriculture was considered to be a high-risk sector with a low rate of return on capital. Furthermore, borrowing was complicated due to an underdeveloped banking system. The period of 1992–1993, which was a period of major macro-economic reforms and dramatic, sometimes even chaotic reorganization, ended with the agricultural sector being subjected to hidden taxes of 50% on the average. In 1996–2001, as a result of low producer prices and small subsidies, investments in Estonian agriculture amounted to 11% in respect of the value added which is 2.5 to 3 times less than in most European countries (25–30%). According to international monitoring[88], in Central and Eastern European countries, total agricultural production decreased most in Bulgaria where it fell 55% during the years 1990–2000, followed by Estonia with 54%[87].

Between 2002 and 2008, the most important driving force for Estonian agriculture was the EU accession and the application of accompanying supporting EU's common agricultural policy which significant effect appeared a few years before joining[89]. The positive impact on the

[87] http://www.estonica.org/en/The_rural_economy_in_Estonia_until_2001/Crisis_in_agriculture_in_the_1990s/
[88] Situatsionsbericht 2002, DBV, Bonn.
[89] Estonian Universtity of Life Sciences. (2011). *Maaelu arengu aruanne.*

agricultural production manifested years preceding the EU accession, is reflected in the turnover of a downward GHG emissions trend that began in the 90's.

Consequently, CO_2 eq. emissions from the Agricultural sector declined 50% by 2015 compared with the base year (i.e. 1990), mostly due to decrease in livestock population and quantities of synthetic fertilizers and manure applied on agricultural fields (Figure 5.2, Table 5.1).

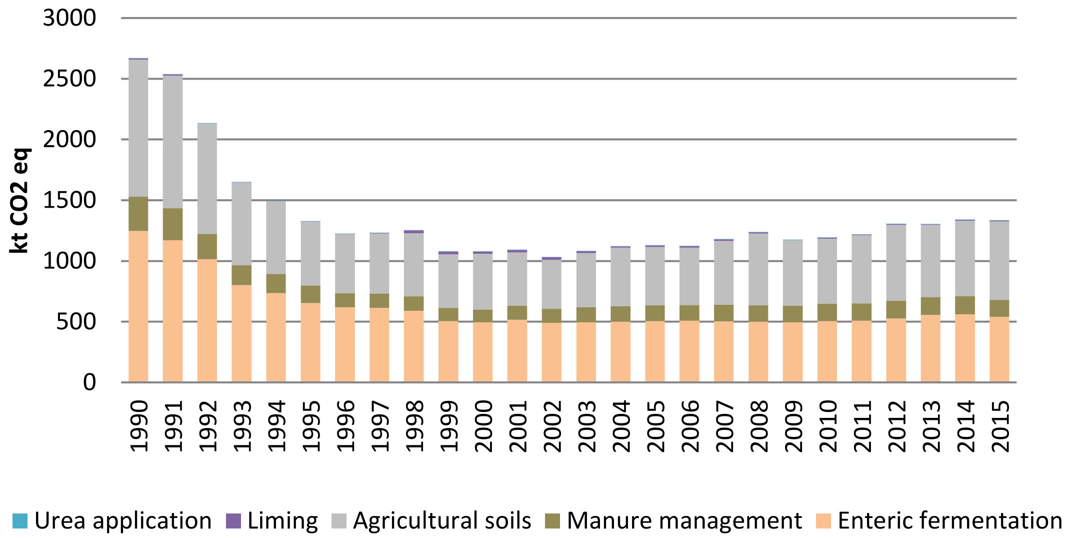

Figure 5.2. Trends in emissions by categories in Estonia in 1990–2015, kt CO_2 eq.

Table 5.1. Estonia's agricultural GHG emissions by sources in 1990–2015, kt

Year	Enteric fermen-tation	Manure management		Agricultural soils Direct	Agricultural soils Indirect	Liming	Urea application	Total GHG emissions			Total CO_2 eq emissions
	CH_4	CH_4	N_2O[90]	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O	CO_2	CO_2 eq
1990	49.88	5.87	0.45	3.00	0.79	12.11	1.00	55.75	4.24	13.11	2 669.72
1991	46.85	5.39	0.43	2.90	0.76	11.17	0.93	52.24	4.09	12.10	2 536.99
1992	40.61	3.99	0.36	2.42	0.62	2.60	0.49	44.60	3.41	3.09	2 133.81
1993	32.02	3.13	0.29	1.84	0.44	2.38	0.20	35.15	2.57	2.58	1 647.88
1994	29.45	3.12	0.27	1.63	0.38	2.16	0.66	32.57	2.27	2.81	1 493.58
1995	26.14	2.92	0.24	1.42	0.32	3.59	0.64	29.07	2.00	4.23	1 326.10
1996	24.76	2.21	0.21	1.33	0.29	3.65	0.59	26.97	1.83	4.24	1 223.66
1997	24.51	2.27	0.21	1.36	0.30	5.76	0.48	26.78	1.87	6.24	1 232.17
1998	23.59	2.32	0.20	1.42	0.32	24.95	0.36	25.90	1.94	25.31	1 252.49
1999	20.18	2.08	0.19	1.21	0.27	25.84	0.46	22.26	1.67	26.30	1 079.50
2000	19.81	2.11	0.17	1.26	0.28	19.41	0.43	21.92	1.71	19.85	1 078.02
2001	20.62	2.28	0.20	1.20	0.27	20.83	0.45	22.90	1.67	21.28	1 090.55
2002	19.56	2.38	0.19	1.11	0.24	18.83	0.28	21.95	1.55	19.11	1 029.38
2003	19.80	2.59	0.20	1.21	0.28	16.85	0.39	22.39	1.69	17.24	1 081.34
2004	20.05	2.64	0.20	1.31	0.31	12.43	0.65	22.69	1.82	13.08	1 121.78
2005	20.22	2.76	0.20	1.31	0.30	13.44	1.41	22.98	1.81	14.84	1 129.09
2006	20.31	2.85	0.20	1.29	0.30	12.24	0.76	23.15	1.78	13.00	1 123.75
2007	20.09	3.11	0.20	1.42	0.34	11.90	1.55	23.20	1.97	13.45	1 179.45
2008	20.02	3.05	0.20	1.59	0.39	9.56	0.18	23.06	2.18	9.74	1 236.16
2009	19.80	3.11	0.20	1.46	0.35	1.20	0.22	22.91	2.01	1.42	1 173.28
2010	20.21	3.26	0.20	1.45	0.35	9.37	0.01	23.47	2.00	9.37	1 192.37
2011	20.34	3.26	0.20	1.52	0.37	3.93	1.13	23.59	2.09	5.06	1 218.35
2012	21.07	3.34	0.21	1.69	0.41	6.98	2.75	24.41	2.31	9.74	1 307.40
2013	22.21	3.39	0.21	1.60	0.39	6.11	0.37	25.59	2.21	6.47	1 303.52
2014	22.41	3.42	0.22	1.67	0.41	8.29	2.47	25.83	2.30	10.76	1 341.93
2015	21.62	3.12	0.21	1.75	0.43	8.29	2.95	24.74	2.38	11.24	1 337.62

[90] N_2O emissions include Indirect N_2O emissions from manure category.

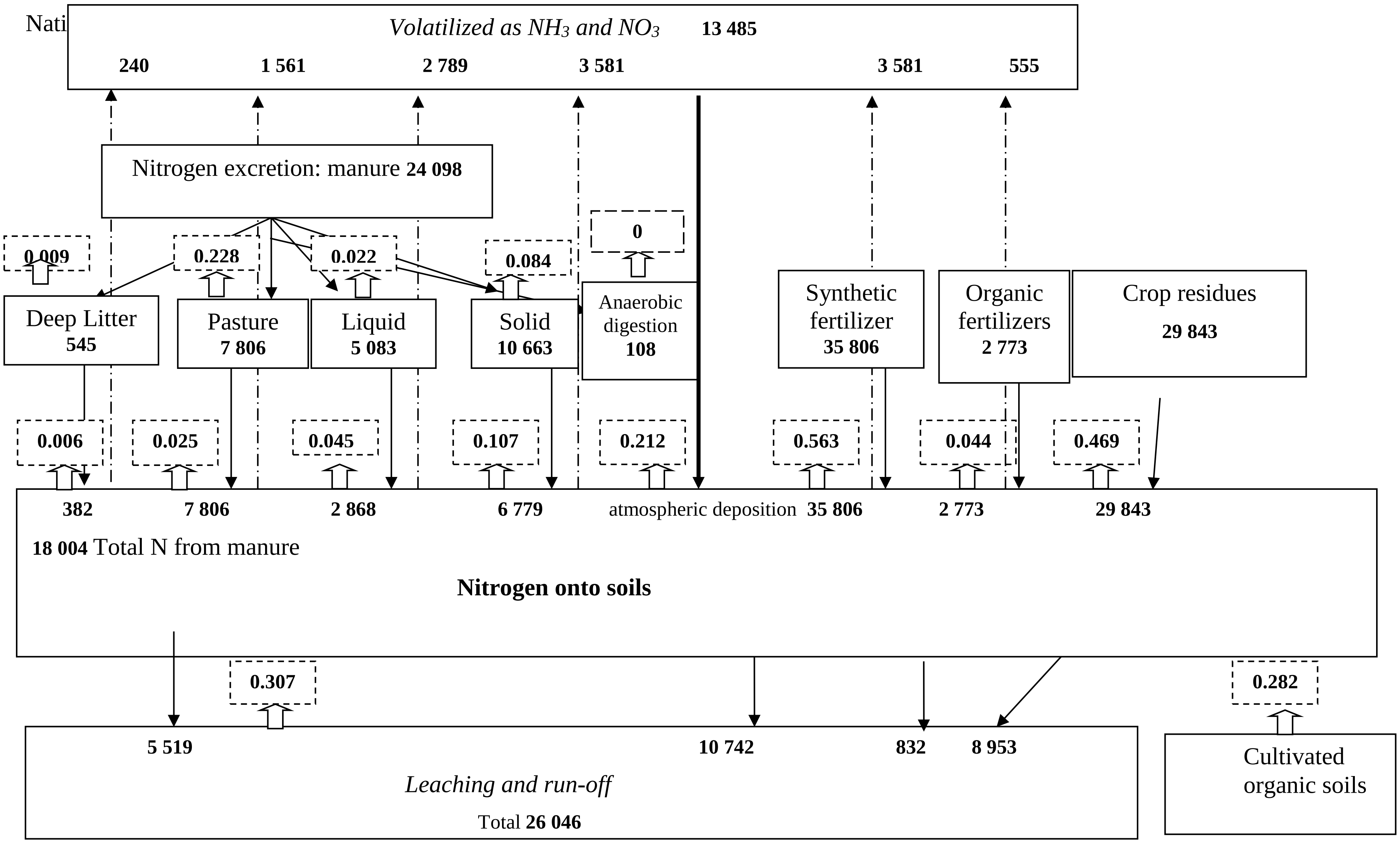

Figure 5.3. Nitrogen flow balance of Estonia's agriculture in 2015 (the scheme was adopted from Finland's NIR (2009)) (Bulk arrows stand for emissions, thin arrows for N flow. Nitrogen amounts are in Mg/year and emissions (fragmental line) in kt/year)

Results of the nitrogen balance of Estonia in 2015 are presented in Figure 5.3. The total amount of nitrogen excreted with manure was 24 098 tonnes in 2015; 37% of the total nitrogen volatilized as N-NH_3 and N-NO_3, the rest of the amount (18 004 tonnes) entered into soils. Solid storage manure management system (MMS) was the main source of N_2O emissions from manure management in Estonia. Nitrogen contained in synthetic fertilizers applied on agricultural soils made up 35 806 tonnes of and from crop residues 29 843 tonnes of nitrogen. Amounts of nitrogen contained in other sources, which were accounted under the agricultural sector, were noticeably lower than amounts of nitrogen excreted with manure and contained in fertilizers and crop residues. The total amount of nitrogen that volatized as NH_3 and NO_3 was 13 485 tonnes, N_2O emissions due to atmospheric deposition and losses from manure management were 0.212 kt; N_2O emissions from nitrogen leaching and run-off were 0.307 kt in Estonia.

5.1.2. Category description and methodology

The *tier 1* and *tier 2* approaches were implemented to estimate GHG emissions from the Agriculture sector in Estonia. In Table 5.2 the results of the *tier 1* key-category analysis are represented. The results of the *tier 2* approach are available in Chapter. A list of methods and emission factors employed in the estimates for each sub-category of the Agriculture sector is presented in Table 5.2. Rice is not cultivated in Estonia. Savannah areas do not exist in Estonia.

Several recalculations were carried out to improve quality of the inventory in the following sub-sectors of the Agriculture sector:

- CH_4 emissions form cattle enteric fermentation and manure management;
- CH_4 emissions from swine manure management;
- N_2O emissions from cattle and swine manure management;
- N_2O emissions from animal manure applied to soils and from grazing animals;
- N_2O emissions from compost application on agricultural soils;
- N_2O emissions from crop residues left on the fields;
- N_2O emissions from organic soils cultivation;
- CO_2 emissions from liming; and
- CO_2 emissions from urea fertilizer application.

Table 5.2. Methods and emission factors used to estimate GHG emissions of the Agriculture sector

	CO_2		CH_4		N_2O		Key category	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	LULUCF sector is not included	LULUCF sector is included
3.A. Enteric fermentation								
1. Cattle								
a. Cows, bulls and heifers (2 years and over)								
Dairy cattle			T2	D, CS			L	L, T
Non-dairy cattle							L, T [91]	L
…Mature females			T2	D, CS				
…Mature males			T2	D, CS				
b. Bovine animals (ages between 1 and 2 years)			T2	D, CS				
c. Calves (6-12 months old)			T2	D, CS				
d. Calves (0-6 months old)			T2	D, CS				
2. Swine								
a. Piglets, live weight less than 20 kg			T2	D, CS				
b. Young pigs, live weight 20 - <50 kg			T2	D, CS				
c. Fattening pigs, live weight								
50 - <80 kg			T2	D, CS				
80 - <110 kg			T2	D, CS				
110 kg or more			T2	D, CS				
d. Breeding pigs, live weight 50 kg and more			T2	D, CS				
3. Sheep			D,T1	D				
4. Goats			T1	D				
5. Horses			T1	D				
6. Poultry			NA	NA				
7. Fur farming			T1	OTH				
8. Rabbits			NA	NA				
3.B. Manure management								
1. Cattle								

[91] Mature non-dairy cattle and young cattle were grouped and considered in the context 'Non-Dairy Cattle' category.

	CO_2		CH_4		N_2O		Key category	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	LULUCF sector is not included	LULUCF sector is included
a. Cows, bulls and heifers (2 years and over)								
Dairy cattle			T2	D, CS			T	T
Non-dairy Cattle								
Mature females			T2	D, CS				
Mature males			T2	D, CS				
b. Bovine animals (ages between 1 and 2 years)			T2	D, CS				
c. Calves (6-12 months old)			T2	D, CS				
d. Calves (0-6 months old)			T2	D, CS				
2. Swine								
a. Piglets, live weight less than 20 kg			T2	D, CS				
b. Young pigs, live weight 20 - <50 kg			T2	D, CS				
c. Fattening pigs, live weight								
50 - <80 kg			T2	D, CS				
80 - <110 kg			T2	D, CS				
110 kg or more			T2	D, CS				
d. Breeding pigs, live weight 50 kg and more			T2	D, CS				
3. Sheep			D,T1	D				
4. Goats			T1	D				
5. Horses			T1	D				
6. Poultry			T1	D				
7. Fur farming			T1	D				
8. Rabbits			T1	D				
9. Indirect N_2O Emissions			T1,T2	D, CS				
3.C. Rice cultivation			NA	NA				
3.D. Agricultural soil								
1. Direct N_2O Emissions From Managed Soils								
1. Inorganic N Fertilizers					T1	D	L, T	L, T
2. Organic N Fertilizers								
a. Animal Waste Applied to Soils					T1	D	L	L

	CO_2		CH_4		N_2O		Key category	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	LULUCF sector is not included	LULUCF sector is included
b. Sewage sludge Applied to Soils					T1	D		
c. Compost Applied to Soils					T1	D		
3. Urine and Dung Deposited by Grazing Animals					CS,T2	D	L	L
4. Crop Residues					T1	D	L, T	L, T
5.Mineralization/ Immobilization Associated with Loss/Gain of Soil Organic Matter					NA	NA		
6. Cultivation of Histosols					T1	D	L, T	L, T
3. Indirect Emissions								
a. Atmospheric Deposition					T1	D	L	
b. Leaching and Run-off					D,T1	D	L, T	L, T
3.E. Prescribed burning of savannas			NA	NA	NA	NA		
3.F. Field burning of agricultural residues			NA	NA	NA	NA		
3.G Liming	D,T1	D						
3.H Urea application	T1	D						

T1 – Tier 1; T – Tier 2; D – IPCC default; CS – Country-specific; NO – Not occurring; NA – Not applicable; OTH – Other.

5.1.3. References – sources of information

The estimations were carried out based on approaches presented in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Activity data were obtained from Estonian national statistics, default emission factors (EFs) were taken from the IPCC Guidelines and country-specific EFs were calculated based on country-specific data. The list of institutions directly and indirectly involved in the inventory process is presented in Table 5.3.

Table 5.3. List of institutions (datasets) involved in the emission inventory for the Agricultural sector

References	Link	Data, activity
Estonian Environmental Research Centre (EERC)	http://www.klab.ee/en/	- activity data handling; - estimation of emissions; - reporting (CRF tables, NIR).
Statistics Estonia – Agricultural Statistics (SE)	http://www.stat.ee/en	- collection and reporting of data on livestock population, quantities of crop produced and amounts of fertilizers and carbonate lime applied to fields.

Estonian Animal Recording Centre (EARC)	https://www.jkkeskus.ee/jkk/en.html	- collection and reporting of data on milk production, fat content in milk; - collection of data on dairy cattle population by dairy-cattle breed.
Estonian Environment Agency (EtEA)	http://www.keskkonnaagentuur.ee/	- providing data on areas of organic soils under cultivation. - collection and reporting of data on amounts of sludge used on agricultural fields.
Estonian Agricultural Board	http://www.pma.agri.ee/index.php?main=1	- sales records of lime fertilizers

5.1.4. Livestock characterization

Estonia's livestock population decreased by 2015 in comparison with the base year: the number of dairy cattle decreased by 68%: from 280.7 thousand heads to 90.6 thousand heads (Figure 5.4, Figure 5.5, Figure 5.6), the number of non-dairy cattle decreased from 477.1 thousand heads in 1990 to 165.6 thousand heads in 2015 (Figure 5.4, Figure 5.6). The total number of swine decreased by 58%, i.e. from 859.9 thousand heads in 1990 to 304.5 thousand heads in 2015 (Figure 5.4, Figure 5.7). The population of horses decreased from 8.6 thousand heads in 1990 to 6.3 thousand heads in 2015 – by 27% (Figure 5.4). The number of sheep decreased by 38% – from 138 thousand heads in 1990 to 85.9 thousand heads in 2015. However, the population of goats increased from 1.8 thousand heads to 5 thousand from 1990 to 2015 (Figure 5.4). The poultry population decreased by 67% by 2015 compared to the base year – from 6 536.5 thousand heads in 1990 to 2 161.8 thousand heads in 2015.

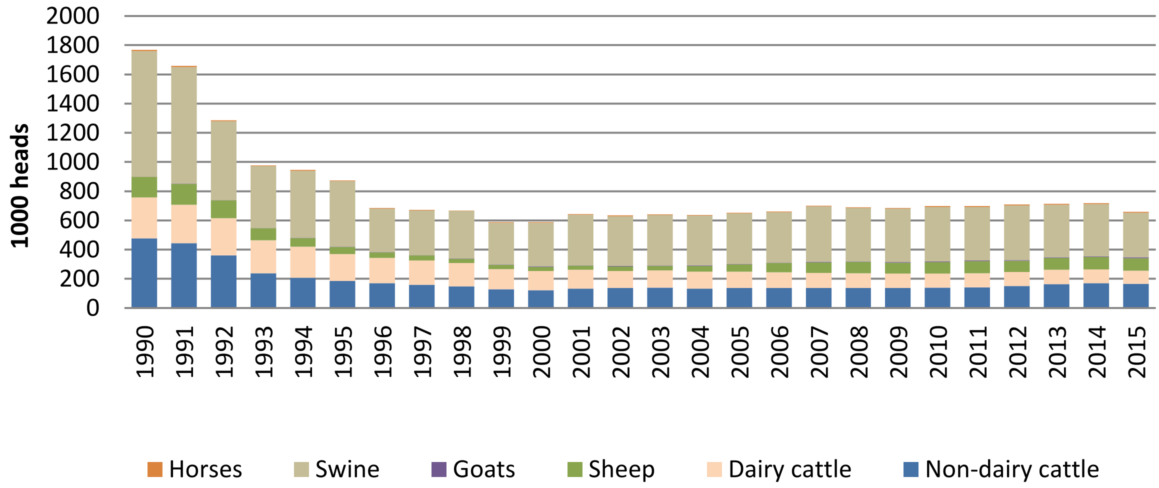

Figure 5.4. Population of livestock in Estonia in 1990–2015 (December 31st), 1000 heads

The data on mature non-dairy cattle population were collected and reported by SE according to two methodologies employed: for 1990–1998 – livestock population data have been reported for two sub-categories (bovine animals and mature males) and for 1999–2014 – the population of three sub-categories of non-dairy mature cattle was reported by SE (bovine animals, mature males and females). In order to guarantee consistency in activity data used, data of 1990–1998 were updated based on the assumptions applied in the 2010 submission, results are illustrated in (Figure 5.6, Annex A.3.2_I).

In the 2013 submission, in order to take into account a recommendation made by the ERT (see ARR2011, para 70) and to calculate emissions from enteric fermentation and manure management of calves aged between 0–6 months, further development and changes were applied to activity data on cattle population – to calves (less than 1 year). Currently, Estonian statistics do not collect separately data on calve population (0–6 months), data are collected and reported on the population of calves less than 1 year old. Hence, population of calves 0–6 months old was separated from the total population of calves based on the data on number of calves born in each quarter (it was applied that about 50% of the total population of calves (0–12 months) are calves less than 6 months old for the entire time-period). GHG emissions from enteric fermentation and manure management were estimated for calves 0–6 months old and calves 6–12 months old.

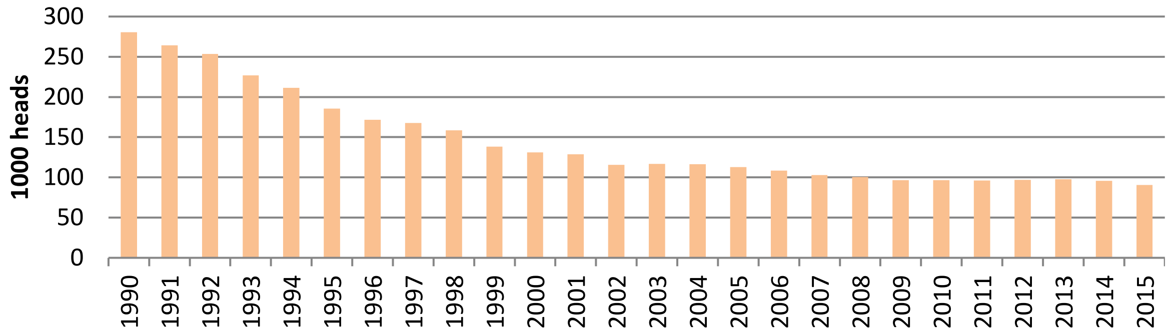

Figure 5.5. Population of dairy cattle in Estonia in 1990–2015, 1000 heads

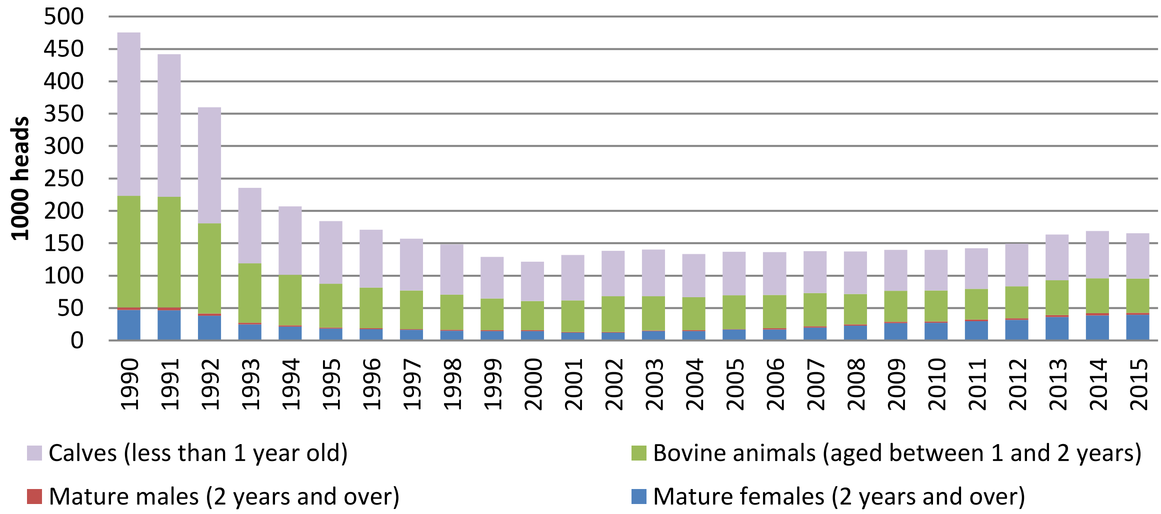

Figure 5.6. Population of non-dairy cattle in Estonia in 1990–2015, 1000 heads

Activity data on swine population in 1990–1998 were updated in the 2009 submission. Since, the number of swine population for 1990–1998 has been reported for three sub-categories of swine (breeding sows, fattening pigs and young swine); however, the number of swine population for 1999–2008 has been reported for six sub-categories of swine (piglets, with live weight less than 20 kg; young pigs, with live weight 20–<50kg; pigs, with live weight 50–<80kg, 80–<110kg and 110 kg and more; and breeding sows). Therefore, based on the average structure of swine population (by categories) of 1999–2008, activity data on swine population in 1990–1998 were recalculated for six sub-categories instead of three reported earlier (Figure 5.7, Annex A.3.2_I).

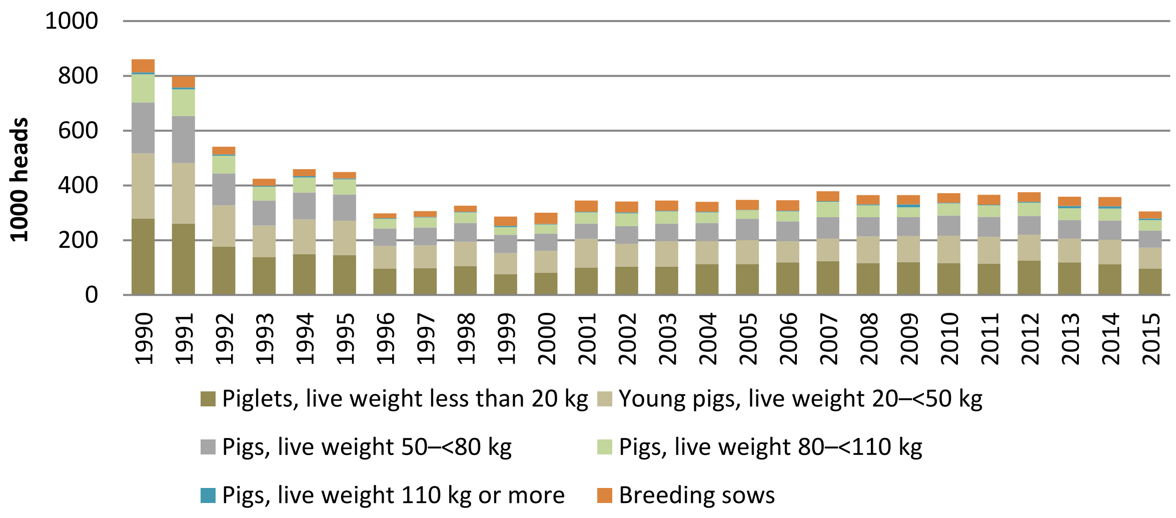

Figure 5.7. Population of swine in Estonia in 1990–2015, 1000 heads

Population of fur animals remarkably decreased by 1999 compared to 1990 due to absence of markets. In 1998, Estonian fur farmers established a relationship with colleagues from Nordic countries. The new partners provided Estonian farmers with valuable assistance regarding breeding programmers, improving basic herds, etc.[92]. Since 2000, the number of fur animals has started slightly to increase. Nowadays, a major share of the production of Estonian fur farming is exported[93].

The activity data used in the estimations in the 2017 submission differ from those reported in the FAO statistic dataset due to different methods of data reporting (Table 5.4). In the framework of the FAO datasets, the data on livestock population is reported according the following methodology – the total number of live animal is given for the year ending 30 September (e.g. number of live animals enumerated in a given country any time between 1 October and 30 September of the following year should be considered for the later year). According to the methodology established in SE, total number of live animal is presented for the year ending 31 December. The data of SE were used in the estimates of the 2017 submission.

Seasonal births or slaughters may cause the population size to expand or contract at different times of the year, which will require the population numbers to be adjusted accordingly. Annual average populations are estimated in various ways, depending on the available data and the nature of the animal population. In the case of static animal populations (e.g., dairy cows, breeding swine, layers), estimating the annual average population may be as simple as obtaining data related to one-time animal inventory data.

[92] Saveli, 2004
[93] Estonica, 2010

However, estimating annual average populations for a growing population (e.g., meat animals, such as broilers, turkeys, beef cattle, and market swine) requires more evaluation. Most animals in these growing populations are alive for only part of a complete year. Animals should be included in the populations regardless if they were slaughtered for human consumption or die of natural causes[94]. In Estonian GHG inventory annual average population Equation 5.1 has been used in estimates of the annual average of livestock population for broiler chickens, fur animals killed for fur and broiler rabbits.

Equation 5.1

$$AAP = Days\_alive \times \frac{NAPA}{365}$$

Where:

AAP = annual average population;
NAPA= number of animals produced annually.

The annual average livestock populations reported in the CRF tables and their trends are provided in (Table 5.4).

Sheep and goats

The SE has been producing four censuses of aggregated sheep and goat numbers per year since 2007. The surveys are conducted in March, June, September and December. The quarterly mean total is adjusted according to the ratio of sheep and goats for the separately collected sheep and goat data in December. Preceding years population numbers, when the statistics are gathered in the framework of a once a year census, the annual average population is adjusted according to the calculated annual average population of 2007–2015. The data used in the calculations of average yearly population of sheep and goats is presented in Annex A.3.2.

The annual average population for a year t was calculated with Equation 5.2 by using the chronological mean of censuses, as follows:

Equation 5.2

$$NoA = (NoA_{March} + NoA_{June} + NoA_{Sep} + NoA_{Dec})/4$$

Where:

NoA = chronological mean of the annual population of a livestock category in a year [1 000 head];
NoA_{March} = population of a livestock category in March [1 000 head];
NoA_{June} = population of a livestock category in June [1 000 head];
NoA_{Sep} = population of a livestock category in September [1 000 head];
NoA_{Dec} = population of a livestock category in December [1 000 head].

Poultry

The average population of poultry is based on the statistical data of layers, number of poultry for slaughter, dead and perished birds, other hens and roosters and other poultry. For the years that number of layers was not available, total production of eggs and production per layer was

[94] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, p.10.8.

used for the calculations. Average life cycle of Estonian broiler is 42 days[95] which was used in the estimation of average annual population using Equation 5.1. The data used in the calculations of average yearly poultry population is presented in Annex A.3.2.

Fur animals

For the estimation of average annual population of fur animals statistical data of seasonal births and the number of animals killed for fur was used.

December-March is the time of the year that farmers focus on bringing mink (both male and female) into good breeding condition. In preparation for breeding, mink are positioned within the barns depending on the breeding system practiced on the farm. Most farms breed a ratio of 4–5 females for every male[96]. Gestation varies from 40–70 days (due to a delayed implantation). Major birthing of minks takes usually place in the end of April. Litters range in size from 2 to 10, but five or six is typical. Most mink are graded in November or early December, depending on color-type and sex.

Foxes are bred once a year and the breeding season of the silver fox is from January to March. Pregnancy lasts for 54 days and a litter of 1 to 9 young (average of 3/litter) is born during March-May[97]. Average fertility rate for Ltd. Balti Kasrusnahk in 2005 was of 3.8/litter[98]. The vixen nurses her youngs for about 6 weeks and the litters are weaned in May and June. Winter fur development begins in August and the fur is prime for pelting in November and December. Foxes are polygamous, so farms breed a ratio of 8–10 females for every male. The data used in the calculations of average yearly fur animals population is presented in Annex A.3.2.

Rabbits

1990–2000

For the years 1990–2000 the number of rabbits originate from the records of agricultural production statistics according to the leading expert of Statistics Estonia. These data primarily represent rabbits kept in private households. There was practically no industrial level farming of rabbits in collective farms, later rabbits in homesteads accrued.

2001–2015

In the period of 2001–2015 only one census for the total number of rabbits has been conducted (July 2001). Following surveys have covered only the number of breeding females in compliance with the EU regulation 1166/2008[99] or the respective earlier regulations.

Breeding females without young and breeding males are usually kept on their own in separate cages. Each female will have around five to eight litters of eight to ten young per year[100]. Breeding rabbits are usually kept until around 18 to 36 months of age. For every male farms usually breed 8–10 females. These characteristics were taken as presumptions upon which annual average population of rabbits was estimated.

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[95] http://www.pkpk.ee/sites/default/files/linnukasvatus_i.pdf
[96] http://www.eau.ee/~alo/karusloomad/mingid/?Minkide_sigimine/Poegimine
[97] http://www.fur.ca/FF_canadian_fur_farming.php
[98] http://www.eau.ee/~alo/karusloomad/rebased/?Rebased
[99] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:321:0014:0034:EN:PDF
[100] http://www.rabbitfarm.planet.ee/kasulikinfo.html

Table 5.4. The number of livestock population in Estonia in 1992–2015, in accordance with SE (as of December 31)) and the FAO datasets, 1000 heads[101]

Year	Cattle		Pigs		Sheep		Goats		Horses		Poultry	
	SE	FAO	SE	FAO	SE	FAO	SE	FAO	SE	FAO	SE	FAO
1992	613.0	708.3	541.1	798.6	121.5	141.9	1.2	NR	6.6	7.8	3 418.1	5 704
1993	462.6	614.6	424.3	541.1	82.2	124.2	1.1	NR	5.2	6.6	3 226.1	3 500
1994	418.3	463.2	459.8	424.3	60.0	83.3	1.5	NR	5.0	5.2	3 129.7	3 272
1995	369.7	419.5	448.8	459.8	48.2	61.5	1.6	NR	4.6	5.0	2 911.3	3 178
1996	342.4	370.4	298.4	448.8	37.6	49.8	1.6	NR	4.2	4.6	2 324.9	2 962
1997	325.0	343.0	306.3	298.4	33.9	39.2	1.7	NR	4.2	4.2	2 602	2 380
1998	306.7	325.6	326.4	306.3	28.7	33.9	2.1	1.7	3.9	4.2	2 635.7	2 650
1999	267.3	307.5	285.7	326.4	28.2	28.7	2.7	2.1	3.9	3.9	2 461.8	2 684
2000	252.8	267.3	300.2	285.7	29.0	28.2	3.2	2.7	4.2	3.9	2 366.4	2 462
2001	260.5	252.8	345.0	300.2	28.8	29	3.6	3.2	5.5	4.2	2 294.9	2 366
2002	253.9	260.5	340.8	345.0	29.9	28.8	3.9	3.6	5.3	5.5	2 096.3	2 295
2003	257.2	253.9	344.6	340.8	30.8	29.9	3.5	3.9	5.8	5.3	1 945.2	2 096
2004	249.8	257.2	340.1	344.6	38.8	30.8	2.9	3.5	5.1	5.8	2 183.0	1 945
2005	249.5	249.8	346.5	340.1	49.6	38.1	2.8	2.9	4.8	5.1	1 878.7	2 183
2006	244.8	249.5	345.8	346.5	62.7	49.6	3.3	2.8	4.9	4.8	1 638.7	1 879
2007	240.5	244.8	379.0	345.8	72.4	62.7	4.0	3.3	5.3	4.9	1 477.6	1 638
2008	237.9	240.5	364.9	379.0	78.2	72.4	3.6	4.0	5.3	5.3	1 757.3	1 477
2009	234.7	237.9	365.1	364.9	76.5	78.2	3.9	3.6	5.4	5.3	1 792.2	1 758
2010	236.3	234.7	371.7	365.1	78.6	76.5	4.1	3.9	6.8	5.4	2 046.4	1 793
2011	238.3	236.3	365.7	371.7	83.9	78.6	4.3	4.1	6.5	6.8	2 032.9	2 047
2012	246.0	238.3	375.1	365.7	76.8	83.9	4.6	4.3	6.2	6.5	2 170.9	2 033
2013	261.4	246.0	358.7	375.1	81.8	76.8	5.0	4.6	6.3	6.2	2 139.2	2 171
2014	264.7	261.4	357.9	358.7	85.2	81.8	4.6	5.0	6.3	6.3	2 339.6	2 139
2015	256.2	264.7	304.5	357.9	85.9	85.2	5.0	4.6	6.3	6.3	2 161.8	2 340

NR – the data are not reported by the FAO

5.1.5. NMVOC and NO_x emissions

NMVOC emission from Manure management and NO_x emission originating from Agricultural soils have been reported in the CRF (Table 5.5). The emissions are in compliance with the data submitted under the Convention on Long-Range Transboundary Air Pollution in the Estonian Informative Inventory Report 1990–2015. Under the Agriculture sector NOx emission from Agricultural soils and NMVOC emissions from Manure management decreased by 46% and 55% respectively compared to the base year (1990). The decrease in air pollution is mainly the result of rapid economic changes in the 1990's. Emission calculations from Manure management and Agricultural soils are based mainly on the Tier 1 method from the renewed EMEP/EEA Guidebook 2016. In order to calculate swine and dairy cattle NMVOC emissions from Manure management Tier 2 method was applied. For further insight regarding the trends and activity data and methodology applied for NMVOC and NOx emission estimations, see Estonian Informative Inventory Report 1990–2015 submitted under the Convention on Long-Range Transboundary Air Pollution[102].

[101] SE, 2015; FAOSTAT, 2015.
[102] Estonian Informative Inventory Report 2015, Ch. 5 Agriculture (NFR 3).

Table 5.5. NMVOC and NOx emissions originating from Agriculture sector reported in the CRF, kt

	NOx	**NMVOC**
1990	2.88	10.30
1991	2.34	9.42
1992	2.34	7.74
1993	1.21	5.96
1994	1.05	5.44
1995	0.77	4.91
1996	0.67	4.28
1997	0.83	4.29
1998	1.00	4.27
1999	0.80	3.67
2000	0.91	3.56
2001	0.80	3.89
2002	0.68	3.84
2003	0.98	4.05
2004	1.04	4.09
2005	0.87	4.04
2006	0.98	4.00
2007	1.14	3.96
2008	1.55	4.00
2009	1.25	3.99
2010	1.29	4.09
2011	1.29	4.21
2012	1.43	4.32
2013	1.48	4.33
2014	1.53	4.58
2015	1.54	4.61

5.2. Enteric fermentation (CRF 3.A)

5.2.1. Category description

Methane is emitted as a by-product of 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 methane is then eructated or exhaled by the animal. Within livestock, ruminant livestock (cattle, buffalo, sheep, and goats) are the primary source of emissions. Pigs are non-ruminant animals and convert a smaller proportion of feed intake into methane than ruminants.

Around 95% of the CH_4 emissions arising from animal husbandry in Estonia are caused by cattle. Dairy cattle livestock was the main contributor to CH_4 emissions from cattle enteric fermentation in Estonia in 2015 (Table 5.12). The number of dairy cows which has been decreasing in Estonia over the last 20 years has been around 95.6–97.9 thousand in the last years. The decrease in 2015 dairy cattle population compared to the year before is the result of Russia's economic sanctions against the EU. The growth in CH_4 emissions in the recent years are the result of increased milk production per cow and the growing numbers of beef cattle. The number of the total CO_2 eq. emissions from enteric fermentation of Estonian livestock made up 40% from the total CO_2 eq. emissions of the Agricultural sector in Estonia in 2015. CH_4 emissions from enteric fermentation in 2015 were 57% lower than the emissions of the base year due to decrease in number of livestock population (Table 5.6, Figure 5.8).

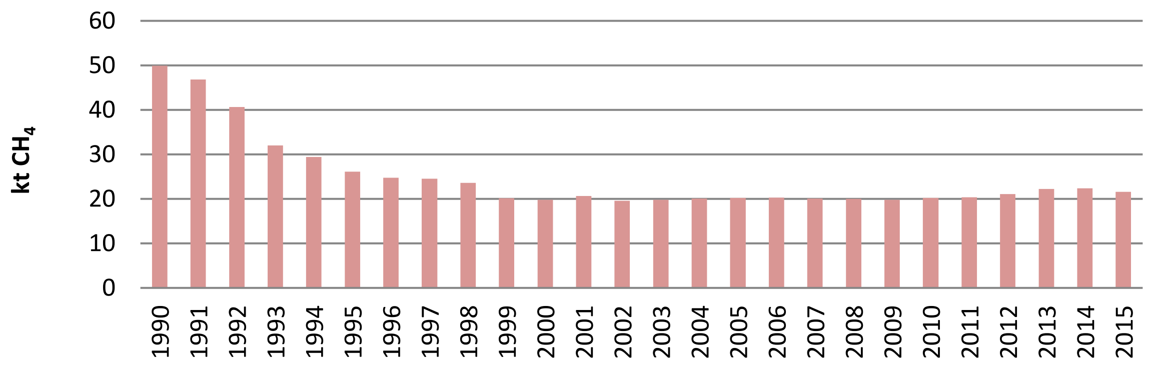

Figure 5.8. Enteric fermentation CH_4 emissions from Estonia's livestock in 1990–2015, kt

Table 5.6. CH_4 emissions from Enteric fermentation by animal type in 1990–2015 in Estonia, kt

Year	Cattle	Swine	Sheep	Goats	Horses	Poultry	Rab-bits	Fur animals	Total CH_4, kt
1990	47.60	0.83	1.27	0.01	0.15	NE	NE	0.02	49.88
1991	44.61	0.77	1.29	0.01	0.14	NE	NE	0.02	46.85
1992	38.81	0.52	1.13	0.01	0.12	NE	NE	0.02	40.61
1993	30.73	0.41	0.76	0.01	0.09	NE	NE	0.02	32.02
1994	28.34	0.45	0.55	0.01	0.09	NE	NE	0.01	29.45
1995	25.16	0.43	0.44	0.01	0.08	NE	NE	0.01	26.14

Year	Cattle	Swine	Sheep	Goats	Horses	Poultry	Rab-bits	Fur animals	Total CH_4, kt
1996	24.03	0.29	0.35	0.01	0.08	NE	NE	0.01	24.76
1997	23.80	0.30	0.31	0.01	0.08	NE	NE	0.01	24.51
1998	22.91	0.32	0.26	0.01	0.07	NE	NE	0.01	23.59
1999	19.53	0.30	0.26	0.02	0.07	NE	NE	0.01	20.18
2000	19.13	0.31	0.27	0.02	0.08	NE	NE	0.01	19.81
2001	19.89	0.34	0.26	0.02	0.10	NE	NE	0.01	20.62
2002	18.81	0.35	0.28	0.03	0.10	NE	NE	0.01	19.56
2003	19.04	0.35	0.28	0.02	0.10	NE	NE	0.01	19.80
2004	19.20	0.33	0.39	0.02	0.09	NE	NE	0.01	20.05
2005	19.32	0.34	0.44	0.02	0.09	NE	NE	0.01	20.22
2006	19.30	0.34	0.55	0.02	0.09	NE	NE	0.01	20.31
2007	18.92	0.38	0.65	0.02	0.10	NE	NE	0.01	20.09
2008	18.81	0.36	0.72	0.02	0.10	NE	NE	0.01	20.02
2009	18.58	0.36	0.73	0.02	0.10	NE	NE	0.01	19.80
2010	18.92	0.37	0.77	0.02	0.12	NE	NE	0.01	20.21
2011	19.07	0.36	0.75	0.02	0.12	NE	NE	0.01	20.34
2012	19.83	0.37	0.73	0.03	0.11	NE	NE	0.01	21.07
2013	21.04	0.36	0.66	0.03	0.11	NE	NE	0.01	22.21
2014	21.22	0.36	0.69	0.02	0.11	NE	NE	0.01	22.41
2015	20.46	0.30	0.71	0.03	0.11	NE	NE	0.01	21.62
%, 2015	94.63	1.41	3.26	0.12	0.52			0.05	100

5.2.2. Enteric fermentation of cattle

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

The *Tier 2* method of IPCC 2006 (Equations 5.3–5.12) was used to estimate CH_4 emissions from enteric fermentation of dairy cattle and mature non-dairy and young cattle (bovine cattle, calves 0–6 months and 6–12 months). In the 2013 submission, two key recalculations were performed: namely, population of calves (less than 1 year old) was split into two groups: calves 0–6 months old and calves 6–12 months old. Methane emissions from enteric fermentation were estimated separately for these two groups of calves (a recommendation of ERT, see ARR2011, para 70). In addition, reporting way of emissions in the CRF reporter was changed: CH_4 emissions from enteric fermentation of bovine animals were excluded from 'Mature cattle' category and included and reported under 'Young cattle' category.

Net energy for maintenance – Net energy required to keep the animals in energy equilibrium (Equation 5.3)

Equation 5.3[103]

$$NE_{mj} = C_{f\ j} \times (weight_j)^{0.75}$$

[103] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.3, p. 10.15.

Where:

NE_{mji} =Net energy for maintenance by *j* category of cattle; MJ/head/day;
Weight = Live weight of *j* category of cattle, kg.

Equation 5.4[104]

$$Cf\ (in\ cold)\ = Cf_i +\ 0.0048\times(20-℃)$$

Where:

Cf = Coefficient for calculating NEm (Table 5.7);
℃ = mean daily temperature during winter season.

Table 5.7. C_f coefficient[105]

Animal category	C_{fi}
Cattle (non-lactating)	0.322
Cattle (lactating)	0.386
Cattle (bulls)	0.370

Net energy for activity for animals (Equation 5.5)

Equation 5.5[106]

$$NE_{aj} = C_a\times NE_{mj}$$

Where:

NE_{aj} = Net energy intake by *j* category of cattle, MJ/head/day;
C_a = Coefficient corresponding to animal's feeding situation (Table 5.8);
NE_m = Net energy required for maintenance by *j* category of cattle (Equation 5.3).

Table 5.8. Activity coefficients corresponding to animal's feeding situation[107]

Feeding 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	0.00
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 (Equation 5.6)

Equation 5.6[108]

$$NE_g = 22.02\times(\frac{BW}{C\times MW})^{0.75}\times WG^{1.097}$$

[104] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.2, p.10.13.
[105] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10.4, p. 10.16.
[106] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.4, p. 10.16.
[107] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10.4, p.10.16.
[108] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.6, p. 10.17.

Where:

NE_{gji}=	Net energy for growing by *j* category of cattle, MJ/head/day;
BW=	Average live body weight of the animals in the population, kg;
WG=	Weight gain by *j* category of cattle, kg per day;
C=	a coefficient with a value of 0.8 for females, 1.0 for castrates and 1.2 for bulls;
MW =	the mature live body weight of an adult female in moderate body condition, kg.

Net energy for lactation – energy for lactation

Equation 5.7[109]

$$Ne_{li} = kg\_of\_milk/day_i \times (1.47 + 0.40 \times Fat_i)$$

Where:

NE_{li} =	Net energy for lactation by dairy cattle, MJ/head/day;
Fat =	Fat content of milk, %.

Net energy for pregnancy

Equation 5.8[110]

$$NE_{pregnancy} = C_{pregnancy} \times NE_m$$

Where:

$NE_{pregnancy}$ =	net energy required for pregnancy, MJ/head/day;
$C_{pregnancy}$=	pregnancy coefficient = 0.1[(111)];
NE_m=	net energy required by the animal for maintenance, MJ/head/day

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

Equation 5.9[112]

$$REM = 1.123 - \left(4.092 \times 10^{-3} \times DE_{ji}\%\right) + \left(1.126 \times 10^{-5} \times \left(DE_{ji}\%\right)^2\right) - 25.4/DE_{ji}\%$$

Where:

REM =	Ratio of net energy available in a diet for maintenance to digestible energy consumed for *j* category of cattle;
DE_{ji} =	Digestible energy expressed as a percentage of gross energy for *j* category of cattle;

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

Equation 5.10[113]

$$REG = 1.146 - \left(5.160 \times 10^{-3} \times DE_{ji}\%\right) + \left(1.308 \times 10^{-5} \times \left(DE_{ji}\%\right)^2\right) - 37.4/DE_{ji}\%$$

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[109] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.8, p. 10.18.
[110] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.13, p. 10.20.
[111] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10.7, p. 10.20.
[112] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.14, p. 10.20.
[113] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.15, p.10.21.

Where:

REG = Ratio of net energy available for growth in a diet to digestible energy consumed for *j* category of cattle;

Gross energy for cattle

Equation 5.11[114]

$$GE = \frac{(NE_{mji} + NE_{feedji} + NE_{workji} + NE_{pregnancyj})\times(\frac{100}{DE_{ji}\%})}{(NE/DE)_{ji} + (NE_{gji}/\{NE_g/DE\}_{ji})}$$

Where:

GE = Gross energy intake by *j* category of cattle, MJ/head/day;
NE_m = Net energy required by the animal for maintenance by *j* category of cattle, MJ/head/day;
NE_a or N_{feed} = Net energy for animal activity by *j* category of cattle, MJ/day
NE_l = Net energy for lactation by dairy cattle, MJ/head/day;
NE_{work} = Net energy for work by *j* category of cattle[115], MJ/head/day;
NE_p or $NE_{pregnancy}$= Net energy required for pregnancy by dairy cattle, MJ/head/day;
NE_g = Net energy needed for growth by *j* category of cattle, MJ/head/day;
DE = Digestible energy as percentage of gross energy of *j* category of cattle%;

Methane emission factor from livestock category

Equation 5.12 [116]

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

Where:

EF = Methane emissions from enteric fermentation of *j* category of cattle, kg CH_4/year;
GE = Gross energy intake by *j* category of cattle, MJ/head/day;
Y_m = Methane conversion rate, which is the factor of gross energy in feed converted to methane.

Main data sources used in the estimations of CH_4 EF for Enteric fermentation by sub-categories of cattle:

Weight, kg – data on weight of dairy-cattle were calculated based on data of EARC, an expert judgment on weight of main categories of dairy-cattle and from scientific literature (Table 5.11, Annex A.3.2_III);

Milk production per day, kg/day – a source of data is SE (Annex A.3.2_II);

Fat content of milk, % - data were obtained from EARC;

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[114] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.16, p.10.21.
[115] Net energy for work was not calculated.
[116] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.21, p.10.31.

Percentage of cows that give birth in a year, % – data were employed from EARC (Annex A.3.2_II);

Feed digestibility, % – data were used from Kaasik et al., 2002;

Methane conversion rate, Y_m % (IPCC Guidelines.

Table 5.9) – the values of Ym of mature dairy and non-dairy cattle and bovine animals were used from the 2006 IPCC Guidelines.

Table 5.9. Methane conversion rate, %[117]

Cattle category	Ym, %
Mature dairy cattle	6.5
Mature non-dairy cattle	
…Mature males (2 years and over)	6.5
…Mature females (2 years and over)	6.5
Young cattle	
…Bovine animals (aged between 1 and 2 years)	6.5
…Calves (6-12 months)	6.5
…Calves (0-6 months)	3.25

Value of *Ym* for calves (0–6 months) was estimated taking into account feed intake diet of animals and development conditions of rumen: namely, the development of rumen of calves is complete between the 7th and 9th week of life, but may take several additional weeks[118], which stipulate markedly lower methane emissions. Additionally, consumption of milk (only) assumes zero methane emissions from the rumen[119]. In Estonia, it was investigated that calves get milk and milk substitute until the age of 3 months, which assume zero emissions from enteric fermentation; at the age of 3–6 months, calves feed on mineral fodder[120]. Hence, it was assumed that methane conversion rate of calves (0–6 months) is 3.25%, the rate was estimated as arithmetic mean based on the rate of calves between 0 and 3 months (which is zero) and from 3 to 6 months (Ym is 6.5%).

Values of CH_4 EFs estimated for Enteric fermentation of dairy cattle are presented in Table 5.11.

The values of CH_4 EFs for Enteric fermentation of non-dairy cattle (mature and young) are presented in Table 5.10.

Table 5.10. CH_4 EF of Enteric fermentation of non-dairy cattle in 2015, kg CH_4/head/year

Livestock category of non-dairy cattle	Emission factor, kg CH_4/head/year
Mature males (2 years and over)	75
Mature females (2 years and over)	59
Bovine animals (aged between 1 and 2 years)	61
Calves (6-12 months)	40
Calves (0-6 months)	7

117 IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10.12, p.10.30.
118 German NIR, 2012.
119 IPCC 2006 Vol.4, Ch.10: Emissions from Livestock and Manure Management, p.10.30.
120 Lehtsalu et al., 2010.

The values of CH_4 EF have increased in the period of 1990–2015, mainly, due to increased milk production per cow (Table 5.11). Figure 5.11 illustrates the trend of annual changes in CH_4 EFs for dairy cattle, milk yield per cow and number of dairy cattle population in relation to the base year (1990 = 1).

Table 5.11. Weight, milk yield per cow and fat content of milk, gross energy intake and enteric fermentation CH_4 EFs for dairy cattle in 1990–2015 (Annex A.3.2_II)

Year	Weight of dairy-cattle, kg/head	Fat content of milk, %	Milk yield per cow, kg/head/yr	Gross energy intake, MJ/head/day	Emission factor, kg CH_4/head/yr
1990	544.9	4.09	4 164	237	101
1991	545.1	4.06	3 968	231	99
1992	545.3	3.98	3 530	220	94
1993	545.6	4.00	3 322	215	92
1994	545.7	4.01	3 455	219	93
1995	545.8	4.08	3 588	223	95
1996	545.9	4.21	3 809	231	99
1997	546.1	4.21	4 210	241	103
1998	546.3	4.26	4 456	248	106
1999	546.5	4.23	4 171	239	102
2000	546.7	4.29	4 660	252	107
2001	546.8	4.31	5 152	264	113
2002	546.9	4.29	5 138	264	113
2003	547.0	4.31	5 176	265	113
2004	546.9	4.27	5 528	274	117
2005	546.9	4.21	5 886	282	120
2006	546.9	4.17	6 285	292	124
2007	547.0	4.15	6 484	296	126
2008	547.1	4.12	6 781	303	129
2009	547.2	4.14	6 838	305	130
2010	547.3	4.11	7 021	309	132
2011	547.4	4.10	7 168	312	133
2012	547.5	4.04	7 526	319	136
2013	547.5	4.00	7 990	330	141
2014	547.5	4.00	8 233	336	143
2015	547.5	3.94	8 442	339	145
IPCC default					
EE[121]	550[(122)]		2 555		99[(123)]
WE	600		5 986		117

121 EE – Eastern Europe, WE – Western Europe.

122 IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management. Table 10A.1, p.10.72.

123 IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10.11, p. 10.29.

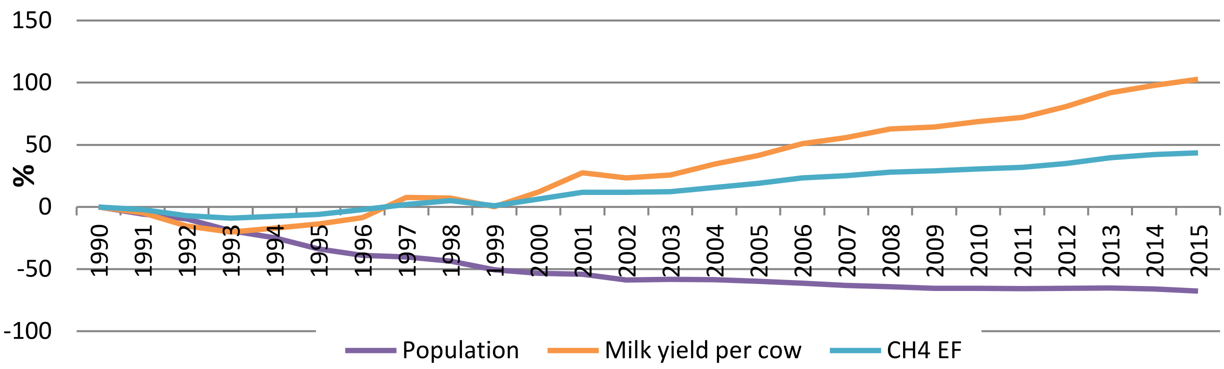

Figure 5.9. The changes in dairy cattle population, milk yield per cow and CH_4 EF in the period of 1990–2015 in relation to the base year (1990), %

5.2.2.2. Quantitative overview – CH_4 emissions from enteric fermentation of cattle in 2015

The total CH_4 emissions from enteric fermentation of cattle were 20.46 kt in 2015. Dairy cattle livestock was the main contributor to CH_4 emissions from cattle enteric fermentation in Estonia in 2015 (Table 5.12). The number of dairy cows which has been decreasing in Estonia over the last 20 years has been 95.5–96.7 thousand in the last years. In 2015 the dairy industry faced a decline in production due to economic sanctions imposed by Russia on EU starting from August 2014. Consequently, the number of dairy cattle in 2015 dropped 5.2% in comparison with 2014. The continuous growth of CH_4 emissions per dairy cow has been contributed by yearly increase of milk production per cow. CH_4 emissions from cattle enteric fermentation decreased 57% in 2015 compared with the base year.

Table 5.12. CH_4 emissions from Enteric fermentation of cattle in 1990–2015 in Estonia, kt

	Cattle[124]			
Year	**Dairy cattle**	**Other mature cattle**	**Growing cattle**	**Total, CH_4 kt**
1990	28.30	3.06	16.23	47.60
1991	26.07	3.07	15.47	44.61
1992	23.76	2.48	12.57	38.81
1993	20.80	1.65	8.29	30.73
1994	19.69	1.42	7.23	28.34
1995	16.59	1.22	6.35	25.16
1996	16.93	1.16	5.94	24.03
1997	17.25	1.07	5.48	23.80
1998	16.80	0.99	5.12	22.91
1999	14.10	0.98	4.45	19.53
2000	14.05	0.95	4.13	19.13
2001	14.48	0.80	4.60	19.88
2002	13.02	0.80	4.98	18.81
2003	13.21	0.92	4.90	19.04

[124] CH_4 emissions are reported according to the classification of the CRF reporter, since Option B was implemented to report emissions from enteric fermentation of cattle.

Year	Cattle[124]			Total, CH_4 kt
	Dairy cattle	Other mature cattle	Growing cattle	
2004	13.59	0.97	4.65	19.20
2005	13.54	1.06	4.72	19.32
2006	13.48	1.14	4.68	19.30
2007	12.99	1.33	4.61	18.92
2008	12.95	1.49	4.36	18.81
2009	12.57	1.61	4.39	18.58
2010	12.71	1.81	4.40	18.92
2011	12.78	1.95	4.34	19.07
2012	13.17	2.10	4.56	19.83
2013	13.77	2.36	4.90	21.04
2014	13.69	2.54	4.98	21.22
2015	13.11	2.55	4.80	20.46
%, 2015	64.1	12.4	23.5	100

5.2.3. Enteric fermentation of swine

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

The *Tier 2* method (Equations 5.13–5.16) was used to estimate CH_4 emissions from Enteric fermentation of swine. The estimation was carried out for the main sub-categories of pigs broken down by weight of animals Table 5.13 methane conversion factors were taken from the 2006 IPCC Guidelines, ratios of feed digestibility were obtained from a study by A. Kaasik[125].

Gross energy intake by swine

Equation 5.13[126]

$$GE_j = ME_j / DE_j$$

Where:

GE = Gross energy intake by *j* swine category, MJ/head/day;
DE = Digestible energy as percentage of gross energy of *j* category of swine, %;

Equation 5.14[127]

$$ME_j = 2.0 \times w_j^{0.63}$$

Where:

ME_j = Energy intake for maintenance and growth of *j* swine category, MJ/head/day;
w_j = Live weight of *j* category, kg.

[125] Kaasik et al., 2002.
[126] Oll *et al*., 1991; Turnpenny *et al*., 2001.
[127] Oll *et al*., 1991; Turnpenny *et al*., 2001.

Methane emission factor from livestock category

Equation 5.15[128]

$$CH_4 Emission = EF_j \times population_j / (10^6 kg/Gg)$$

Where:

CH_4 $Emission_j$ = Methane emissions from Enteric fermentation from *j* category of swine, kt CH_4/year;

Equation 5.16[129]

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

Where:

GE = Gross energy intake, MJ/head/day;
Y_m = Methane conversion rate, which is the factor of gross energy in feed converted to methane.

Table 5.13 demonstrates CH_4 emission factors for each category of swine and the IPCC default EF for swine recommended for developed countries. Implied emission factors for swine enteric fermentation for the entire time-series are presented in Figure 5.10.

Table 5.13. Methane emission factors for swine enteric fermentation, kg CH_4/head/year

Swine category	Emission factor, kg CH_4/head/year	
	calculated	IPCC default[130]
Total		1.5
Piglets, live weight less than 20 kg	0.39	
Young pigs, live weight 20–<50 kg	0.87	
Fattening pigs		
…live weight 50–<80 kg	1.36	
…live weight 80–<110 kg	1.73	
…live weight 110 kg or more	1.90	
Breeding pigs, live weight 50 kg or more	1.49	

[128] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.19, p. 10.28.
[129] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.21, p.10.31.
[130] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10.10, p.10.28.

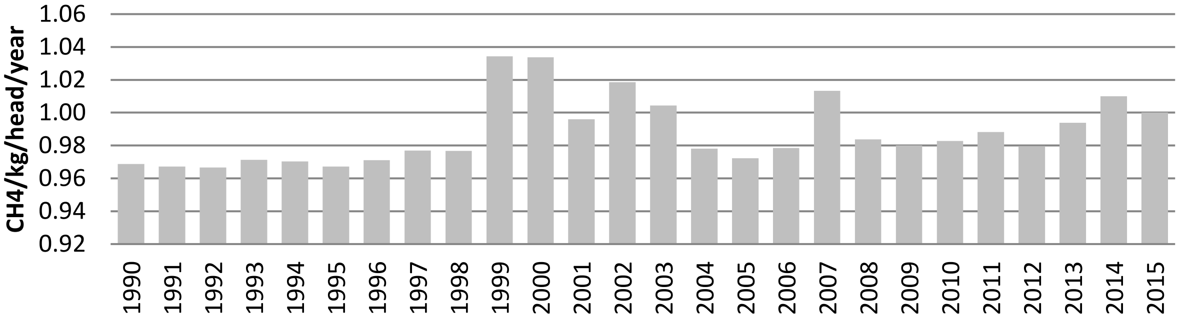

Figure 5.10. Implied emission factor (IEF) of swine enteric fermentation in 1990–2015, CH_4 kg/head/year

5.2.3.2. Quantitative overview – CH_4 emissions from enteric fermentation of swine in 2015

The total CH_4 emissions from swine enteric fermentation were 0.30 kt in 2015. The emissions decreased by 63% since the base year due to decreasing population of swine (Figure 5.11). The main reason for this is the decline in pork production in Estonia compared to the base year. The lowest point in pork production was in 1999 when the production constituted only 26% of the production in 1990. During 2002–2010 Estonian swine population started to slowly recover and grew 0.8–0.9% per year. The number of swine fell 15% compared to 2014 in Estonia as a result of the outbreak of African swine fever in the region in 2015.

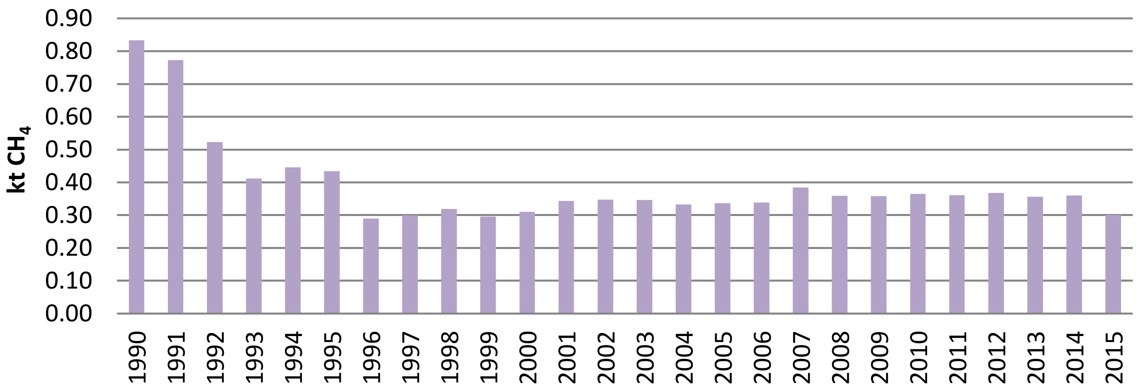

Figure 5.11. CH_4 emissions from Enteric fermentation of swine in 1990–2015 in Estonia, kt

5.2.4. Enteric fermentation of other livestock

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

The *Tier 1* of IPCC 2006 (Equation 5.17) was used to estimate CH_4 emissions from Enteric fermentation of other livestock.

Equation 5.17[131]

$$CH_4Emission = EF_j \times population_j / (10^6 kg/Gg)$$

Where:

CH_4 Emission$_j$ = Methane emissions from Enteric fermentation from j category of animals, kt CH_4/year;
EF_j = Methane emission factor for *j* category of animals, CH_4 kg/head/year;
Population$_j$ = Number of *j* category of animals, head.

CH_4 emission factors, recommended by the 2006 IPCC Guidelines for developed countries, were used to estimate CH_4 emissions from Enteric fermentation of sheep, goats and horses (Table 5.14). The emission factors for fur animals were provided by a Finnish expert in the Agriculture sector (Sanna Pitkänen, personal communication).

Table 5.14. Enteric fermentation methane emission factors, kg CH_4/head/year[132]

Livestock category	**Emission factor, kg CH_4/head/year**
Sheep	8
Goats	5
Horses	18
Poultry	Not estimated
Fur animals	0.1[133]
Rabbits	Not estimated

5.2.4.2. Quantitative overview – CH_4 emissions from enteric fermentation of other livestock categories in 2015

The total CH_4 emissions from Enteric fermentation of other livestock were 0.86 kt in 2015. CH_4 emissions declined by 41% by 2015 in comparison with the base year due to a decrease in number of other livestock population (Figure 5.12).

[131] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.19, p. 10.28.
[132] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10.10 (developed countries), p.10.28.
[133] For fur animals, Norwegian emission factor was used (0.1 kg/animal/year). The emission factor was derived by scaling the emission factor of swine based on comparison between the average weights of swine and fur animals. Swine were assumed to be similar to fur animals with regard to digestive system and feeding. Norwegian fur animals emission factor has been developed for the reporting purposes of similar fur animals as Estonia. The species of the reported Norwegian fur animals include foxes and minks as in Estonia.

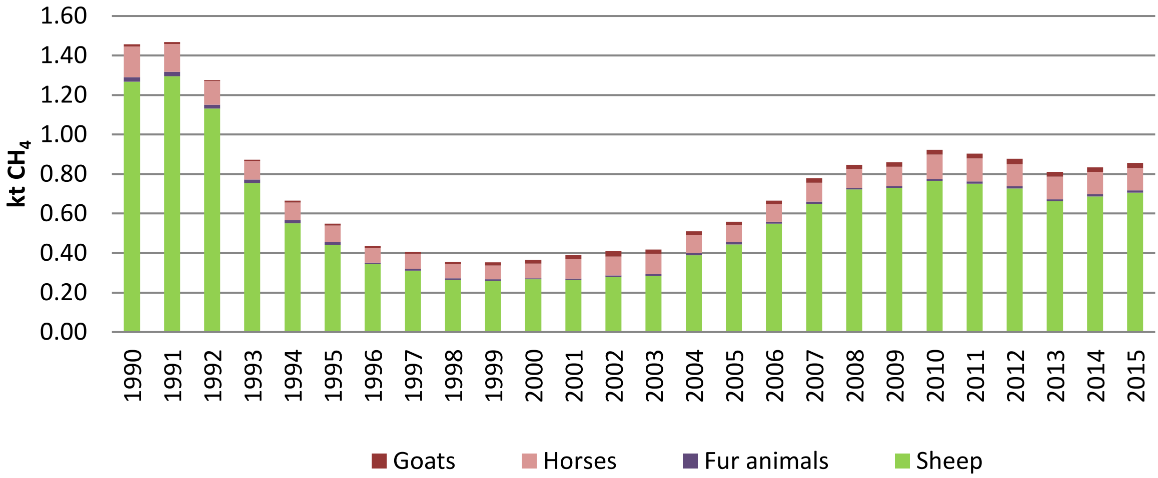

Figure 5.12. CH_4 emissions from Enteric fermentation of other livestock categories in 1990–2015, kt

5.2.5. Uncertainties and time-series consistency

The estimation of CH_4 emissions from Enteric fermentation of cattle and swine were carried out based on the *Tier 2* approach with Estonian activity data and default factors obtained from the IPCC Guidelines. The *Tier 1* method was used to estimate CH_4 emissions from other livestock: goats, horses, sheep and fur animals.

Uncertainty rates of activity data are not calculated in Estonia. The data were obtained from (Rypdal and Winiwarter, 2001), where uncertainties of activity data (livestock population) are presented for a few countries: Austria (±10%), Norway (±5–10%), the Netherlands (<±5%), USA (±2%). The experiences of Austria were used to calculate uncertainties in emissions from Enteric fermentation of livestock (Table 5.15). The uncertainty in CH_4 emission factors for livestock categories (sheep, goats, horses, fur animals) is reported to be ±40%[134].

Table 5.15. Estimated values of uncertainties used in the Agriculture sector

Input	**Uncertainty**	**References**
Activity data		
Estonia's livestock population (cattle, swine, sheep, goats, horses, poultry and fur animals)	± 10%	Rypdal and Winiwarter, 2001
Emission factors		
Enteric fermentation (CH_4) (cattle, swine)	± 20%	IPCC, 2006. Agriculture. pp. 10.33
Enteric fermentation (CH_4) (sheep, goats, horses, fur animals)	± 40%	

134 IPCC. (2000). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

In spite of the fact that the *Tier 2* method is used in the calculation of emissions from cattle and swine, the default uncertainty rate was taken as ±20% due to lack of uncertainty analysis performed to estimate uncertainty rates of each parameter (Table 5.15).

5.2.6. Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.2.3.

The QC/QA plan for the Enteric fermentation subsector includes the QC activities described in the IPCC 2006 Guidelines Volume 1, Chapter 6 and the activities listed in Volume 4, Chapter 10[135]. The activities are carried out every year during the inventory. The QC check list is used during the inventory.

5.2.7. Category-specific recalculations

The calculations in swine and cattle sub-categories were previously performed on a county level which involved several intermediate calculations which were ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are immediately performed on a country-level using weighed average country-specific activity data which is in line with the IPCC guidelines. The change in calculation approach brought about a reevaluation of used activity data along with some miscalculation errors detected and corrected in working tables, which lead to recalculations under the enteric fermentation subsector. The renewed emissions are presented in Table 5.16.

Table 5.16. Reported CO_2 eq. emissions in 2016 and 2017 submissions in Enteric fermentation category, kt

Enteric Fermentation	1990	1995	2000	2005	2010	2011	2012	2013	2014
2017 submission	1 247.1	653.5	495.2	505.5	505.3	508.5	526.8	555.2	560.3
2016 submission	1 251.1	637.2	493.3	505.8	505.6	508.8	527.0	555.3	560.7

5.2.8. Category-specific planned improvements

Cattle activity data in different subcategories is currently under revision.

5.3. Manure management (CRF 3.B)

5.3.1. CH_4 emissions from manure management

CH_4 is produced from the decomposition of the organic matter remaining in the manure under anaerobic conditions. CH_4 emission rates from Manure management directly depend on the manure management system and temperature[136].

CH_4 emissions (recalculated to CO_2 eq.) from Manure management formed 5.8% in the total agricultural emissions in Estonia in 2015.

[135] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, pp. 10.33-34.

[136] IPCC. (2000). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

The largest contributor in 2015 to the CH_4 emissions in manure management was the cattle sub-category and in 1990 the swine sub-category. The total CH_4 emissions from livestock manure management were 3.12 kt in Estonia in 2015, the emissions declined by 47% by 2015 in comparison with the base year (Table 5.17, Figure 5.13). The main reason for this is the decline in pork production in Estonia compared to the base year. The lowest point in pork production was in 1999 when the production constituted only 26% of the production in 1990.

Table 5.17. CH_4 emissions from Manure management in 1990–2015 in Estonia, kt

Year	Cattle	Swine	Sheep	Goats	Horses	Poultry	Fur animals	Rabbits	Total
1990	1.75	3.76	0.03	0.0003	0.013	0.15	0.16	0.007	5.87
1991	1.64	3.42	0.03	0.0003	0.012	0.13	0.16	0.007	5.39
1992	1.43	2.27	0.03	0.0002	0.010	0.10	0.14	0.008	3.99
1993	1.15	1.76	0.02	0.0002	0.008	0.08	0.12	0.008	3.13
1994	1.06	1.86	0.01	0.0002	0.008	0.07	0.10	0.007	3.12
1995	0.94	1.81	0.01	0.0003	0.007	0.06	0.09	0.006	2.92
1996	0.90	1.20	0.01	0.0002	0.007	0.05	0.04	0.005	2.21
1997	0.90	1.24	0.01	0.0003	0.007	0.05	0.06	0.004	2.27
1998	0.87	1.32	0.01	0.0003	0.006	0.06	0.06	0.004	2.32
1999	0.74	1.23	0.01	0.0004	0.006	0.05	0.05	0.003	2.08
2000	0.72	1.29	0.01	0.0005	0.007	0.04	0.03	0.005	2.11
2001	0.75	1.40	0.01	0.0005	0.009	0.06	0.04	0.008	2.28
2002	0.81	1.44	0.01	0.0007	0.008	0.06	0.05	0.007	2.38
2003	1.01	1.43	0.01	0.0005	0.009	0.06	0.07	0.006	2.59
2004	1.11	1.38	0.01	0.0005	0.008	0.06	0.07	0.004	2.64
2005	1.20	1.40	0.01	0.0004	0.007	0.05	0.09	0.007	2.76
2006	1.28	1.41	0.01	0.0005	0.008	0.05	0.07	0.006	2.85
2007	1.34	1.62	0.02	0.0006	0.008	0.04	0.08	0.005	3.11
2008	1.41	1.50	0.02	0.0005	0.008	0.05	0.06	0.004	3.05
2009	1.46	1.50	0.02	0.0006	0.008	0.05	0.07	0.004	3.11
2010	1.56	1.54	0.02	0.0006	0.011	0.06	0.07	0.003	3.26
2011	1.57	1.52	0.02	0.0006	0.010	0.06	0.08	0.003	3.26
2012	1.63	1.54	0.02	0.0007	0.010	0.06	0.08	0.003	3.34
2013	1.72	1.50	0.02	0.0007	0.010	0.06	0.08	0.004	3.39
2014	1.72	1.52	0.02	0.0006	0.010	0.07	0.08	0.004	3.42
2015	1.66	1.28	0.02	0.0007	0.010	0.07	0.08	0.004	3.12
%, 2015	53.13	41.15	0.54	0.02	0.32	2.18	2.54	0.13	100

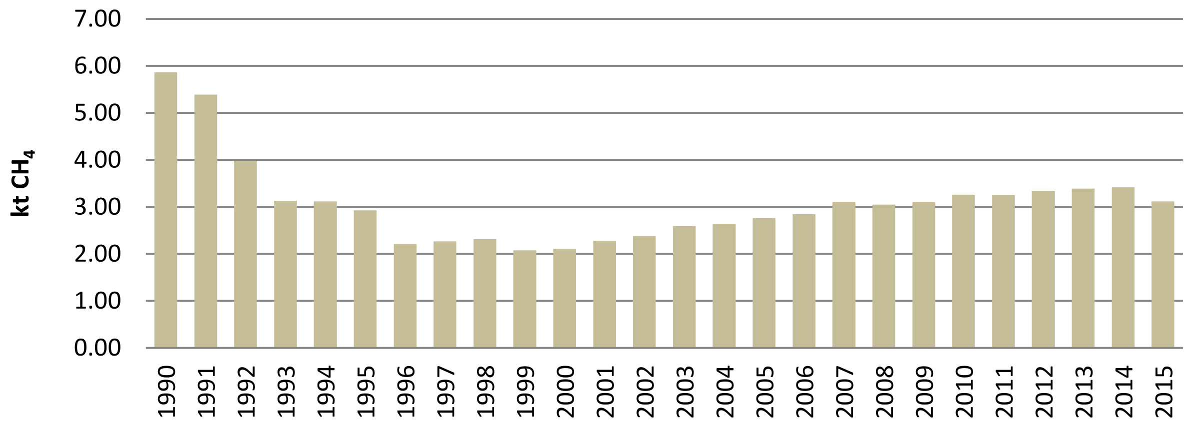

Figure 5.13. CH_4 emissions from Estonia's livestock manure management in 1990–2015, kt

5.3.1.1. Cattle manure management

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

CH_4 production from manure of dairy cattle and non-dairy cattle was estimated based on the algorithm presented in the IPCC 2006 using country-specific data and IPCC default factors (Equation 5.18-5.20).

Equation 5.18[137]

$$CH_4\_Emission_j = EF_j \times Population_j / (10^6 kg/Gg)$$

Where:

CH_4 Emissions$_j$ = Methane emissions from Manure management of *j* category of cattle, kt CH_4/year;
EF_j = Methane emission factor for *j* category of cattle, kg CH_4/head/year;
$Population_j$ = The number of head in *j* category of cattle, heads.

Equation 5.19[138]

$$EF_j = VS_j \times {}^{365\ days}/_{yr} \times B_{oj} \times 0.67\ {}^{kg}/_{m^3} \times \sum_{nK} MCF_{nK} \times MS\%_{jK}$$

Where:

EF_j = Annual methane emission factor for *j* category of cattle kg;
VS_j = Volatile solid excreted for *j* category of cattle, kg;
Bo_j = Maximum CH_4 producing capacity for manure produced by *j* category of cattle, kg of VS (Table 5.18);
MCF_{nk} = CH_4 conversion factors for each manure management system *n* by climate region k;

[137] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management. Equation 10.22, p. 10.37.
[138] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management. Equation 10.23, p. 10.41.

MS_{njk} = Fraction of animal species/category *j*'s manure handled using manure system *n* in climate region *k*.

Equation 5.20[139]

$$VS = [GE \times (1 - (DE\%)/100) + (UE \times GE)][((1 - ASH)/18.45)]$$

Where:

VS_j= volatile solid excretion per day on a dry-matter weight basis of *j* category of cattle, kg DM/day;
GE_j = daily gross energy intake per head of *j* category of cattle, MJ/day; 1 dm kg – 18.45 MJ;
DE_i = digestible energy of the feed for *j* category of cattle, % (Table 5.18);
ASH = Ash content of the manure as a percentage, % (8%);
(UE x GE) = urinary energy expressed as fraction of GE. Typically 0.04 GE can be considered urinary energy excretion by most ruminants.

Table 5.18. Parameters used in the estimates

Cattle category	Feeding situation	Digestibility of feed, %[140]	Bo, m^3 CH_4/kg VS
Mature cattle[141]			
...Dairy	Stall fed	67	0.24
...Non-dairy cattle:			
…...Mature females	Pasture/Range	62	0.17
…...Mature males	Pasture/Range	63	0.17
Bovine animals (aged between 1 and 2 years)	Pasture/Range	63	0.17
Calves (6-12 months old)	Pasture/Range	63	0.17
Calves (0-6 months old)	Stall feed	63	0.17

The module on MMS (Annex A.3.2_IV) and CH_4 EFs employed in the estimations are presented in Table 5.19. The country-specific CH_4 EFs are higher than IPCC default CH_4 EFs, because the amount of manure stored in the liquid/slurry system, is higher than IPCC default share (for Eastern Europe).

Table 5.19. Manure management system usage, methane conversion factors (MCFs) and manure management emission factors for dairy cattle in 2015 in Estonia

	Manure management system, %			Emission factor, kg CH_4/head/yr
	Liquid/Slurry	Solid Storage	Pasture/Range	
Estonian average	24.09	36.3	39.7	12.98
EE[142]	17.5	60	18	11.0

[139] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management. Equation 10.24, p. 10.42.
[140] Kaasik, A., Leming, R., Remmel, T., (2002) Toitainete (N, P, K) kadu veise- ja seakasvatuses. Agraarteadus XIII/4, 201–211.
[141] IPCC 2006, Vol. 4, Ch.10: Emissions from Livestock and Manure Management. Dairy Cows – Table 10A.1 and 10A.4, pp. 10.72, 10.77; Other Cattle – Table 10A.2 and 10 A.5, pp. 10.73,10.7 (for Eastern European countries).
[142] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10A-4, p.10.77.

	Manure management system, %			Emission factor, kg CH_4/head/yr
	Liquid/Slurry	Solid Storage	Pasture/Range	
		+2.5[143] +2.0[144]		
MCFs[145], %	10	2	1	

Estonia uses MCF 10% for the liquid/slurry MMS in the inventory as the common spread practice is not to cover the liquid manure storage units in Estonia allowing thereby crust formation. Although no official national statistics is gathered on a consistent basis about the covering of manure storage facilities, this statement is confirmed by the leading specialists of the Estonian Environmental Research Centre, who conduct air quality measurements in farms on a regular basis and hold a good overview of the common conditions concerning manure storage facilities. This opinion has been seconded by other specialists, in contact with local farmers from relevant environmental institutions, who agree that in case of using a higher MCF would cause an overestimation of CH_4 emissions.

Implied CH_4 EFs have increased since 1990, due to changes in technology of dairy cattle housing (Figure 5.14). The transition from tie-stall housing technology to loose-housing technology launched in Estonian farms in the beginning of 2000's, that stipulated a switch from solid storage MMS to liquid/slurry MMS in dairy cattle farms (Figure 5.14; see also Annex A.3.2_IV).

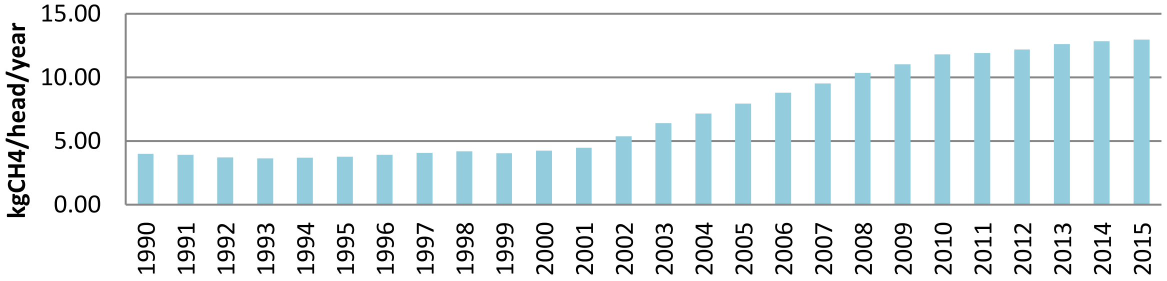

Figure 5.14. Implied CH_4 emission factor for dairy-cattle manure management system in 1990–2015, kg CH_4/head/year

It was assumed that MMS usage for manure storage of mature non-dairy cattle has not changed over the whole period of reporting – tie stall housing technology with solid storage MMS was mostly applied in cattle breeding holdings. Hence, a share of non-dairy cattle manure stored to solid storage MMS made up 56% and about 44% of time, mature non-dairy cattle spent on pasture. In 2015 CH_4 EFs applied in the estimations of mature non-dairy cattle were: mature males – 2.32 kg CH_4/head/year and mature females – 1.86 kg CH_4 per head/year.

143 Daily spread
144 Other
145 IPCC 2006 Volume 4 Chapter 10: Emissions from Livestock and Manure Management, Table 10.17, p.10.45.

MMSs used to store animal waste generated by bovine cattle (young cattle) and by calves (6–12 months) and CH_4 EFs in Estonia are presented in Table 5.20 (see also Annex A.3.2_IV).

Table 5.20. Manure management system usage, methane conversion factors and manure management emission factors for growing cattle in 2015 in Estonia

	Manure management system, %				EFs, kg CH_4/head/year	
	Liquid/ Slurry	Solid Storage	Deep litter	Pasture/ Range	Bovine animals	Calves (6-12 months old)
Estonian average	5.2	42.3	14.7	37.8	5.10	3.35

CH_4 IEFs for young cattle have slightly changed over 1990–2015 (Figure 5.15), because of the shifts in the housing technology – from tie stall housing to loose-housing, from solid storage MMS to liquid/slurry MMS and deep litter MMS.

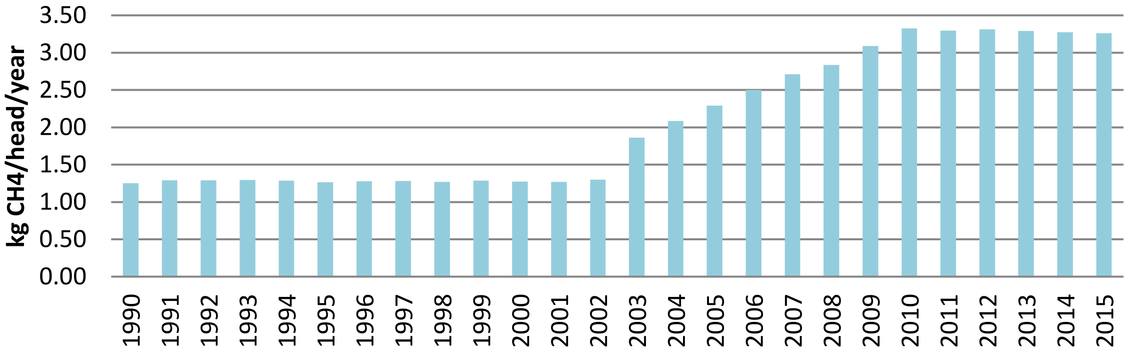

Figure 5.15. Implied CH_4 emission factor for young cattle MMS in 1990–2015, kg CH_4/head/year

Calves (0–6 months) are kept in individual or group boxes, which corresponds to solid storage MMS. Hence, the ratio of manure stored in solid MMS is 56%; in the summer period calves are kept on pasture or at an outside yard, which can be defined as pasture, range (44%). EF for manure management of calves (0–6 months old) was estimated to be 0.42 kg CH_4/head/year for the entire time period.

5.3.1.1.2. Quantitative overview – CH_4 emissions from cattle manure management in 2015

The total CH_4 emissions from cattle manure management were 1.66 kt in Estonia in 2015, the emissions decreased by 5.8% by 2015 in comparison with the base year (Table 5.21).

Table 5.21. CH_4 emissions from cattle manure management activities in 1990–2015 in Estonia, kt

Year	Dairy cattle	Mature non-dairy cattle	Growing cattle	Total emissions
1990	1.12	0.10	0.53	1.75
1991	1.03	0.10	0.50	1.64
1992	0.94	0.08	0.41	1.43

Year	Dairy cattle	Mature non-dairy cattle	Growing cattle	Total emissions
1993	0.82	0.05	0.27	1.15
1994	0.78	0.05	0.24	1.06
1995	0.70	0.04	0.21	0.94
1996	0.67	0.04	0.19	0.90
1997	0.68	0.03	0.18	0.90
1998	0.67	0.03	0.17	0.87
1999	0.56	0.03	0.15	0.74
2000	0.56	0.03	0.14	0.72
2001	0.58	0.03	0.15	0.75
2002	0.62	0.03	0.16	0.81
2003	0.75	0.03	0.23	1.01
2004	0.83	0.03	0.24	1.11
2005	0.89	0.03	0.27	1.20
2006	0.95	0.04	0.29	1.28
2007	0.98	0.04	0.31	1.34
2008	1.04	0.05	0.32	1.41
2009	1.07	0.05	0.34	1.46
2010	1.14	0.06	0.37	1.56
2011	1.15	0.06	0.36	1.57
2012	1.18	0.07	0.38	1.63
2013	1.24	0.08	0.41	1.72
2014	1.23	0.08	0.42	1.72
2015	1.18	0.08	0.40	1.66
%, 2015	70.9	4.9	24.2	100

5.3.1.2. Swine manure management

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

Methane production from the manure of swine by sub-categories was estimated based on the algorithm described in Chapter 5.2.3.1.

Methane conversion factors and the use of different systems of manure management for swine manure storage are presented in Table 5.22.

Table 5.22. Parameter used in the estimates

	Feed digestibility, %[146]	VS, kg/h/d	Bo, m^3 CH_4/kg VS[147]	MCF, %[148]
Piglets, live weight less than 20 kg	85	0.09	0.45	0.6

[146] Kaasik, A., Leming, R., Remmel, T., (2002) Toitainete (N, P, K) kadu veise- ja seakasvatuses. Agraarteadus XIII/4, 201–211.
[147] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10A-7 and 10A-8, pp.10.80-10.81.
[148] IPCC 1996. Agriculture. Reference Manual. Table A-4, pp. 4.35.

	Feed digestibility, %[146]	**VS, kg/h/d**	**Bo, m^3 CH_4/kg VS[147]**	**MCF, %[148]**
Young pigs, live weight 20–<50 kg	85	0.20	0.45	0.6
Fattening pigs				
…live weight 50–<80 kg	80	0.41	0.45	0.6
…live weight 80–<110 kg	80	0.51	0.45	0.6
…live weight 110 kg or more	80	0.56	0.45	0.6
Breeding pigs, live weight 50 kg or more	80	0.44	0.45	0.6

Table 5.23. MMS usage, methane conversion factor and Manure management emission factors for swine in 2015 in Estonia

	Manure management system, %				Emission factor, kg CH_4/head/year					
					Piglets, live weight less than 20 kg	Young pigs, live weight 20–<50 kg	Fattening pigs…			Breeding pigs, live weight 50 kg or more
	Liquid/ Slurry	Anaerobic Digestion	Solid storage	Pasture, Range			...live weight 50–<80 kg	...live weight 80–<110 kg	…live weight 110 kg or more	
	76.1	3.8	19.8	0.3	1.39	3.07	6.24	7.92	8.69	6.82
EE[149]	3[(150)]		13.7 +24.7+24. 7+5.7[(151)]		3					4
MCFs[152], %	17	17	2	1						

[149] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Tables 10A-7 and 10A-8, pp.10.80-81.
[150] Lagoons.
[151] 13.7% - Dry lot, 24.7% – Pits less than 1 month and more than 1 month, 5.7% – Other.
[152] IPCC 2006 Volume 4 Chapter 10: Emissions from Livestock and Manure Management, Table 10.17, p.10.45.

The algorithm and dataset used to develop the country-specific module on MMS in Estonia was described in Annex A.3.2_IV and the results are presented in Table 5.23. MCF related to each type of MMS and CH_4 EFs related are reported in the same table.

Covering of pig slurry storage units is uncommon practice in Estonia. Although no official national statistics is gathered on a consistent basis about the covering of manure storage facilities, this statement is confirmed by the leading specialists from Estonian Environmental Research Centre in contact with local farmers from relevant environmental institutions. In 2016 and 2017 submissions liquid manure management MCF value of 17% for pigs has been used in calculations instead of 10% used in the previous submissions, as the formation of a crust cover for uncovered pig slurry is highly unlikely.

Emission estimations concerning anaerobic digestion of manure submitted by Estonia before the 2016 submission, was not in line with the 2006 IPCC GL. As the IPCC 2006 GL do not provide clear and verified instructions on how to correctly estimate the before mentioned emissions, Estonia has applied a conservative MCF value of 17% as for the undigested pig slurry[153]. Obviously, the MCF should be lower for anaerobically digested slurry compared to non-treated slurry, but currently little data is available to estimate an MCF corresponding to the Estonian agricultural conditions. Because of this, the reduction of CH_4 emission is not included in this year inventory. However, research activities are ongoing and hopefully eventually can be used to estimate an MCF for biogas treated slurry.

Implied CH_4 emission factors for swine manure management system have slightly changed in the period of 1990–2015 due to changes in the structure of swine population. Values of IEFs are reported in Figure 5.16.

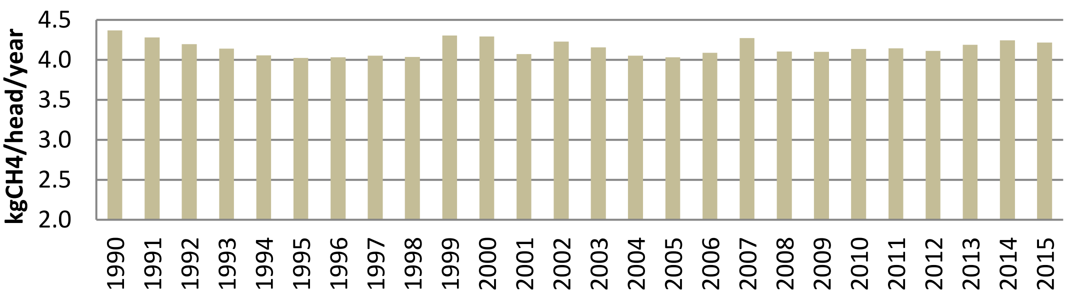

Figure 5.16. Implied CH_4 emission factor for swine manure management system in 1990–2015, kg CH_4/head/year

5.3.1.2.2. Quantitative overview – CH_4 emissions from swine manure management in 2015

The total CH_4 emissions from swine manure management were 1.28 kt in Estonia in 2015 (Figure 5.17). The emissions decreased by 66% by 2015 in comparison with the base year due to decrease in number of swine population.

153 The same approach using the unreduced CH_4 estimates was used by our Danish colleagues in the 2015 Danish NIR.

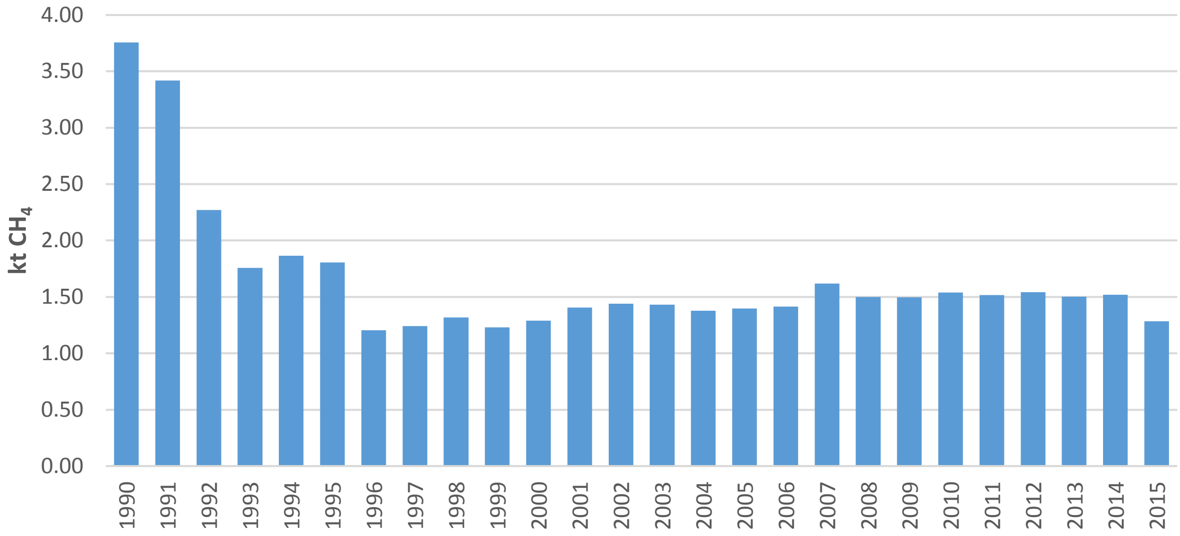

Figure 5.17. CH_4 emissions from swine MMSs in 1990–2015 in Estonia, kt

5.3.1.3. Other livestock manure management

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

CH_4 emissions from Manure management for other livestock were calculated in accordance with the equation (5.18) using activity data on the population of livestock and the default IPCC emission factors.

The module on MMS for sheep, goats and horse livestock categories was developed based on grazing-period of animals (Annex A.3.2_IV). Animal wastes generated by livestock categories are stored in 'solid manure management system' (Table 5.24).

Table 5.24. Manure management system usage and methane emission factors from Manure management of other livestock categories[154]

Livestock category	Manure management system, %		Emission factor[155], kg CH_4/head/year
	Solid storage	Pasture/Range	
Sheep	50.68	49.32	0.19
Goats	50.68	49.32	0.13
Horses	58.90	41.10	1.56
Poultry[156]	98.54	1.46	
...Broilers			0.02
...Layers and other chickens			0.03
...Other Poultry			0.055

[154] The module was applied only in the estimation of N_2O emissions from manure management of other livestock, since CH_4 emission from manure management was estimated based on Tier 1 of the IPCC Guidelines.
[155] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management (developed countries, cool climate region), Tables 10.15-16, pp. 10.40-41.
[156] Data of 2011.

Livestock category	Manure management system, %		Emission factor[155], kg CH_4/head/year
	Solid storage	Pasture/Range	
Fur animals	100	-	
…Foxes and Raccoon			0.68
…Minks			0.68
Rabbits	100	-	0.08

5.3.1.3.2. Quantitative overview – CH_4 emissions from manure management other livestock categories in 2015

The total CH_4 emission from manure management system of other livestock categories was 0.18 kt in Estonia in 2015 (Figure 5.18). The emission declined by 50% by 2015 in comparison with the base year due to decrease in the number of other livestock population.

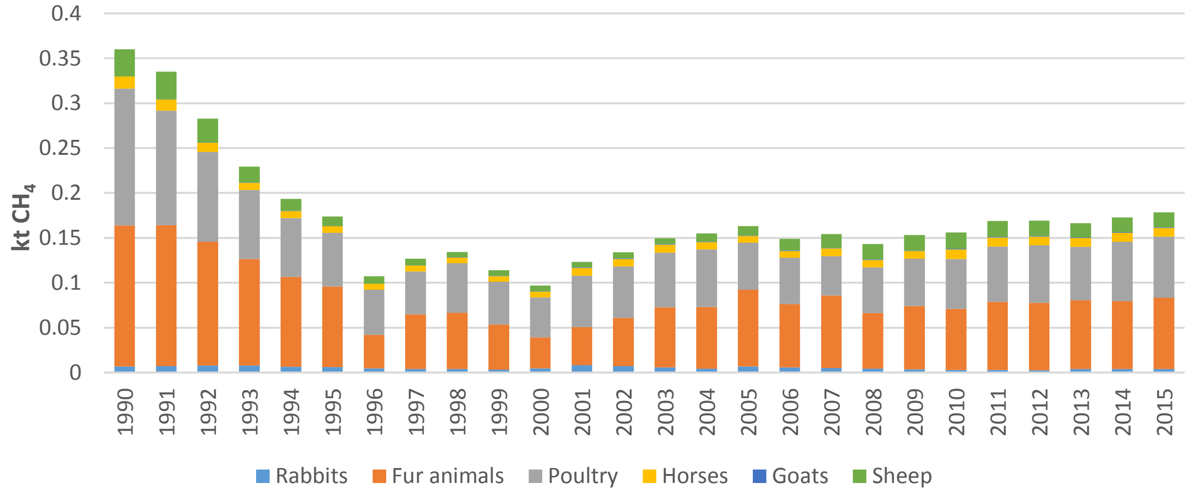

Figure 5.18. CH_4 emissions from other livestock MMSs in 1990–2015 in Estonia, kt

5.3.1.4. Category-specific recalculations

The calculations in swine and cattle Manure management sub-categories were previously performed on a county level that involved several intermediate calculations which were ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are immediately performed on a country-level using weighed average country-specific activity data in line with the IPCC guidelines. The change in calculation approach brought about a reevaluation of used activity data along with some miscalculation errors detected and corrected in working tables, which lead to recalculations in CH_4 emissions under the Manure management subsector. The recalculated emissions are presented in Table 5.25.

Table 5.25 Reported CH_4. emissions in 2016 and 2017 submissions in Manure management category, kt

Manure management	1990	1995	2000	2005	2010	2011	2012	2013	2014
2017 submission	5.87	2.92	2.11	2.76	3.26	3.26	3.34	3.39	3.42
2016 submission	5.80	2.89	2.10	2.71	3.19	3.18	3.28	3.36	3.38

5.3.1.5. Category-specific planned improvements

Developing a methodology suitable for Estonian conditions to estimate reduced CH_4 emissions from anaerobically digested slurry.

5.3.2. Direct N_2O emissions from manure management

5.3.2.1. 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[157].

5.3.2.2. Cattle manure management

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

The key methodology used for the estimation of N_2O emissions from Manure management was the *Tier 2* method (Equations 5.21–5.22).

Equation 5.21[158]

$$N_2O_{D(mm)} = \sum_{(S)} \{[\sum_{(T)} N_{(T)} \times Nex_{(T)} \times MS_{(T,S)}] \times EF_{3(S)}\}$$

Where:

$N_2O\text{-}N_{D\,(mm)}$ = Direct N_2O emissions from Manure management in the country, kg N_2O/year;
$N_{(T)}$ = Number of head of livestock species *j* in the country;
$Nex_{(T)}$ = Annual average N excretion per head of livestock species *j* in the country, kg N/head/year;
$MS_{(T,S)}$ = Fraction of total annual excretion for each livestock species *T* that is managed in manure management system *S* in the country;
$EF_{3(S)}$ = N_2O emission factor for manure management system *S* in the country, kg N_2O-N/kg N in manure management system *S*;
S= Manure management system;
T = Species of livestock.

The data on livestock population by categories were obtained from database of SE (Annex A.3.2_I). Nitrogen excretion factors for all categories of cattle were calculated based on nitrogen balance described in Equation 5.22[159]:

Equation 5.22

$$N_{excreta_j} = N_{feed_j} - (N_{milk} + N_{weight\_gain} + N_{embryo})_j$$

Where:

$N_{excreta\_j}$ = Nitrogen excreted per *j* category of cattle, kg/head/year;

[157] Jun *et al.*, 2003

[158] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.25, p.10.54.
[159] BAT manual for intensive cattle farming, http://www.ippc.envir.ee/docs/PVT/PVT_Veised-t2iendatud111007.pdf.

N_{feed_j} = Nitrogen consumption with feed by *j* category of cattle, kg/head/year;
N_{milk_j}= Nitrogen absorbed in milk, kg/head/year;
$N_{weight\ gain\_j}$= Nitrogen retained for growth per *j* category of cattle, kg/head/year;
N_{embryo_j} = Nitrogen required to support embryo development, kg/head/year.

Nitrogen contained in feed consumed by different categories of cattle was calculated taken into account the values of gross intake (kg/head/yr), the algorithm is described in Chapter 5.2.2.1 and average rates of nitrogen content in animal feed (Annex A.3.2_V). N_{milk}, N_{gain} and N_{embryo} were estimated as follows[160]:

N_{milk} = kg milk protein per cow per year / 6.38

N_{gain} = kg weigh gain per head per year * nitrogen content in body weight

N_{embryo} = kg calf * nitrogen content in embryo

The values of nitrogen content in milk, body weight and embryo are reported in (Annex A.3.2_V). Values of average milk protein content in Estonia in 1990–2015 were obtained from EARC[161].

Table 5.26. Weight, milk yield per cow and protein content of milk in 1990–2015 (Annex A.3.2_II)

Year	Weight of dairy-cattle, kg	Milk yield per cow, kg/head/yr	Protein content of milk, g/kg	Nitrogen excretion rate, kg N/head/yr
1990	544.9	4 164	3.22	85
1991	545.1	3 968	3.25	83
1992	545.3	3 530	3.14	81
1993	545.6	3 322	3.11	80
1994	545.7	3 455	3.15	81
1995	545.8	3 588	3.17	82
1996	545.9	3 809	3.20	84
1997	546.1	4 210	3.15	87
1998	546.3	4 456	3.18	89
1999	546.5	4 171	3.15	94
2000	546.7	4 660	3.28	89
2001	546.8	5 152	3.31	100
2002	546.9	5 138	3.27	101
2003	547.0	5 176	3.30	101
2004	546.9	5 528	3.31	103
2005	546.9	5 886	3.34	105
2006	546.9	6 285	3.32	108
2007	547.0	6 484	3.36	108
2008	547.1	6 781	3.36	110
2009	547.2	6 838	3.37	111
2010	547.3	7 021	3.36	112
2011	547.4	7 168	3.39	112

[160] Standard Values for Farm Manure. DIAS report no. 7.(1997). (eds. H.D. Poulsen, V. F. Kristensen). p. 160.
[161] Results of animal recording in Estonia in 1997–2013. Annual Reports. Available at: https://www.jkkeskus.ee/jkk/piimaveised/statistika/aastaaruanded.html.

Year	**Weight of dairy-cattle, kg**	**Milk yield per cow, kg/head/yr**	**Protein content of milk, g/kg**	**Nitrogen excretion rate, kg N/head/yr**
2012	547.5	7 526	3.39	114
2013	547.6	7 990	3.38	116
2014	547.6	8 233	3.37	118
2015	547.5	8 442	3.30	120
IPCC default				
EE[162]	550	2 555		96.4[163]
WE	600	5 986		105.1

The trend in (implied) nitrogen excretion rates reported in the CRF are presented in Table 5.26.

The calculation of nitrogen excretion rates for non-dairy cattle categories were performed based on the algorithm presented by equation (5.22). The N excretion rates are reported in Table 5.27.

Table 5.27. Nitrogen excretion rates of non-dairy cattle in 2015, kg N/head/year

Livestock category of non-dairy cattle	**Nitrogen excretion rate, kg N/head/yr**
Mature males (2 years and over)	79.5
Mature females (2 years and over)	44.3
Bovine animals (aged between 1 and 2 years)	58.1
Calves (6–12 months)[164]	18.7
Calves (0–6 months)	4.4

5.3.2.2.2. Quantitative overview – Nitrogen excretion by cattle livestock in 2015

The total quantity of nitrogen generated by cattle was 16 714 tonnes in Estonia in 2015. The allocation of nitrogen excreted among different types of MMS is presented in Table 5.28.

Table 5.28. The allocation of the quantity of nitrogen (in manure) excreted by cattle, kg

Year	Liquid system	Solid storage	Deep litter	Pasture range and paddock	Total nitrogen
1990	-	21 976 676	-	17 152 527	39 129 203
1991	-	20 760 017	-	16 202 940	36 962 958
1992	-	18 339 362	-	14 313 649	32 653 011
1993	-	14 692 257	-	11 467 128	26 159 385
1994	-	13 472 207	-	10 514 893	23 987 099
1995	-	11 892 687	-	9 282 097	21 174 784
1996	-	11 313 603	-	8 830 129	20 143 733
1997	-	11 151 609	-	8 703 695	19 855 304
1998	-	10 654 112	-	8 315 405	18 969 517
1999	-	9 787 645	-	7 639 138	17 426 783

162 IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10A.1, p.10.72.
163 IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10.19, p.10.59.
164 2-round production cycle was applied for calves (0-6 months and 6-12 months).

Year	Liquid system	Solid storage	Deep litter	Pasture range and paddock	Total nitrogen
2000	-	8 803 566	-	6 871 076	15 674 642
2001	-	9 671 906	-	7 548 804	17 220 710
2002	463 002	8 706 605		7 156 766	17 220 710
2003	988 275	8 381 493	173 278	6 899 797	16 442 842
2004	1 298 904	8 129 713	217 845	6 869 188	16 515 650
2005	1 573 456	7 816 436	274 635	6 787 185	16 451 712
2006	1 843 771	7 499 184	325 097	6 695 942	16 363 993
2007	2 040 478	7 049 411	373 120	6 468 670	15 931 678
2008	2 285 309	6 697 793	395 455	6 330 201	15 708 758
2009	2 486 777	6 371 580	451 666	6 199 469	15 509 492
2010	2 771 517	6 236 331	503 497	6 254 015	15 765 361
2011	2 766 156	6 268 095	494 970	6 274 902	15 804 123
2012	2 831 696	6 495 174	521 024	6 487 214	16 335 108
2013	2 942 664	6 876 347	558 577	6 843 046	17 220 633
2014	2 919 884	6 944 185	566 263	6 886 509	17 316 841
2015	2 803 334	6 715 545	545 430	6 649 801	16 714 111

5.3.2.3. Swine

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

Activity data on swine population were obtained from national statistics, a method used in the estimation was employed from the IPCC Guidelines (Chapter 6.3.3.1). Nitrogen excretion rates were taken from the Regulation of the Minister of the Environment no 8, 25.03.2014[165] (Table 5.29). Applied emission factors are indicated in Table 5.34.

Table 5.29. Average N excretion factors used in the estimates, kg N/head/year

Swine category	Nitrogen excretion rate, kg N/head/year	IPCC default, kg N/head/year
Piglets, live weight less than 20 kg	4.5	
Young pigs, live weight 20–<50 kg	8.7	
Fattening pigs		
…live weight 50–<80 kg	10.6	
…live weight 80–<110 kg	10.6	
…live weight 110 kg or more	10.6	
Breeding pigs, live weight 50 kg or more	25.1	
Swine[166]		
...Market (average 50 kg)		10
...Breeding (average 180 kg)		30

[165] https://www.riigiteataja.ee/aktilisa/1280/3201/4033/KKM_m8_lisa.pdf#.
[166] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10.19, p.10.59.

Nitrogen (implied) excretion factors reported in the CRF are demonstrated in Figure 5.19.

The rate has slightly changed over the entire time-series due to the changes in the structure of swine population.

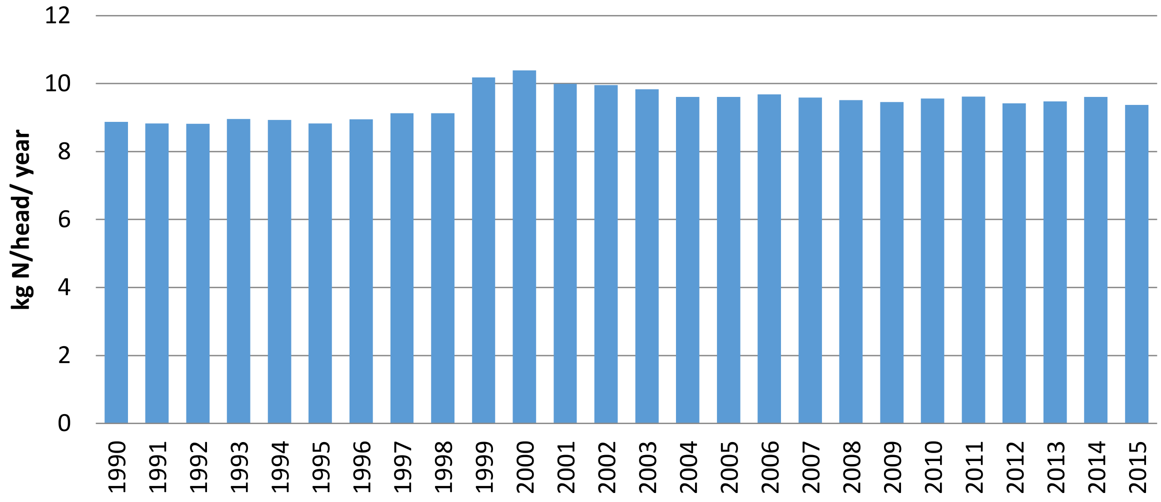

Figure 5.19. Implied swine nitrogen excretion factor reported in the CRF for 1990–2015, kg N/head/year

5.3.2.3.2. Quantitative overview – Nitrogen excretion by swine in 2015

The total quantity of nitrogen generated by pigs was 2 854 tonnes in Estonia in 2015. The allocation of nitrogen excreted among different types of manure management system is presented in Table 5.30. As the formation of a crust cover for uncovered pig slurry is highly unlikely, then in the 2016 and 2017 submission Estonia has applied a value of 0 kg N_2O-N (kg N ex)$^{-1}$ in order to estimate N_2O emissions from pig slurry management.

Table 5.30. The allocation of amount of nitrogen (contained in manure) excreted by pigs and stored in different types of MMSs, kg N/year

Year	Liquid system	Solid storage	Pasture, range and paddock	Digesters	Total nitrogen
1990	6 670 662	961 630	-	-	7 632 292
1991	6 030 274	1 019 443	-	-	7 049 718
1992	3 990 957	778 467	-	-	4 769 424
1993	3 110 137	691 211	-	-	3 801 348
1994	3 282 471	822 906	-	-	4 105 376
1995	3 157 170	805 988	-	-	3 963 158
1996	2 119 262	550 823	-	-	2 670 086
1997	2 211 251	585 035	-	-	2 796 285
1998	2 346 322	631 783	-	-	2 978 105
1999	2 283 479	625 660	-	-	2 909 138
2000	2 440 085	680 193	-	-	3 120 278
2001	2 687 276	761 998	-	-	3 449 274

Year	Liquid system	Solid storage	Pasture, range and paddock	Digesters	Total nitrogen
2002	2 651 392	742 192	-	-	3 393 585
2003	2 655 686	733 803	-	-	3 389 488
2004	2 568 598	700 514	-	-	3 269 112
2005	2 622 813	705 934	-	-	3 328 747
2006	2 540 649	702 492	-	104 273	3 347 414
2007	2 790 219	754 138	479	89 246	3 634 083
2008	2 605 214	711 539	1 427	152 266	3 470 445
2009	2 605 651	698 470	3 101	144 911	3 452 134
2010	2 706 373	704 173	10 561	134 471	3 555 577
2011	2 676 360	696 363	10 443	132 980	3 516 146
2012	2 688 936	699 636	10 493	133 604	3 532 668
2013	2 588 026	673 380	10 099	128 590	3 400 095
2014	2 618 402	681 283	10 217	130 100	3 440 002
2015	2 172 016	565 138	8 475	107 920	2 853 549

5.3.2.4. Other livestock

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

Activity data on other livestock population were obtained from national statistics, the module on MMS was used from Table 5.24 and nitrogen excretion rates (Table 5.31) were obtained from the IPCC 2006 Guidelines.

Table 5.31. Nitrogen excretion rates per head of animal, kg N/head/year

Livestock category[167]	Nitrogen excretion rate, kg N/head/year
Poultry	
...Layers (1.8 kg)	0.39
...Broilers (0.9 kg)	0.36
...Other chickens (1.8 kg)	0.54
...Other poultry (4.75 kg)	1.36
Sheep (65 kg)	21
Goats (40 kg)	19
Horses (550 kg)	60
Fur farming	
…Foxes and Raccoon	12.09
…Minks	4.59
Rabbits	8.1

[167] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10.19, p.59; average weight Table 10A-9, p.10.82.

5.3.2.4.2. Quantitative overview – Nitrogen excretion by other livestock in 2015

The total amount of nitrogen generated by other livestock was 4 530 tonnes in 2015. The breakdown of the quantity of nitrogen excreted by other livestock categories is reported in Table 5.32.

Table 5.32. Nitrogen (in manure) excreted by other livestock categories, kg N/year

Year	by livestock category					
	Sheep	**Goats**	**Horses**	**Poultry**	**Fur animals**	**Rabbits**
1990	3 384 094	39 151	517 935	2 480 871	1 698 267	696 219
1991	3 455 219	41 319	469 755	2 098 033	1 698 267	736 695
1992	3 018 710	23 921	397 485	1 572 516	1 571 687	778 272
1993	2 015 761	23 921	313 170	1 220 760	1 445 107	780 864
1994	1 471 358	32 629	301 125	1 067 322	1 318 527	658 368
1995	1 181 989	36 965	277 035	970 376	1 305 070	607 541
1996	922 044	34 797	252 945	791 000	558 536	457 472
1997	831 317	36 965	252 945	763 201	979 507	384 855
1998	703 800	45 673	234 878	881 815	967 032	404 222
1999	691 543	58 718	234 878	748 604	811 867	334 028
2000	711 166	69 575	252 945	702 657	558 840	486 518
2001	706 255	78 284	331 238	905 218	618 150	844 765
2002	745 501	102 205	319 193	924 202	711 471	719 888
2003	755 302	76 116	349 305	987 185	770 979	595 002
2004	1 039 077	67 987	307 148	1 039 895	787 464	425 112
2005	1 183 911	58 493	289 080	843 714	869 862	676 301
2006	1 464 568	67 464	295 103	844 880	721 711	590 514
2007	1 732 093	83 760	319 193	713 246	835 626	504 727
2008	1 925 440	77 593	319 193	848 143	513 745	430 985
2009	1 946 857	86 881	325 215	874 720	572 923	357 242
2010	2 044 630	93 347	409 530	935 590	554 574	283 492
2011	2 006 281	90 001	391 463	1 051 295	617 490	272 128
2012	1 941 561	101 794	373 395	1 078 361	610 740	260 755
2013	1 765 254	94 449	379 418	1 002 033	622 726	400 869
2014	1 832 920	86 619	379 418	1 104 821	614 999	400 861
2015	1 882 116	95 888	379 418	1 127 496	644 563	400 861

5.3.3. Indirect N_2O emissions from Manure management

Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NO_x. Nitrogen is also lost through runoff and leaching into soils from the solid storage of manure at outdoor areas, in feedlots and where animals are grazing in pastures. Pasture losses are considered separately in Agricultural soils category.

5.3.3.1. N losses due to volatilization from manure management

Tier 1 method (Equations 5.23–5.26) of the IPCC 2006 Guidelines[168] was applied to estimate indirect N_2O emissions from manure management due to volatilization:

Equation 5.23

$$N_2O_{G(mm)} = (N_{volatilization-MMS} \times 〚EF〛\_4) \times 44/28$$

Where:

$N_2O_{G(mm)}$= indirect N_2O emissions due to volatilization of N from Manure management in the country, kg N_2O yr^{-1};

EF_4 = emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg N_2O-N (kg NH_3-N + NO_x-N volatilised)$^{-1}$; default value is 0.01 kg N_2O-N (kg NH_3-N +NO_x-N volatilised)$^{-1}$.

Equation 5.24

$$N_{volatilization-MMS} = \sum_S \left[\sum_T \left[\left(N_T \times Nex_T \times MS_{T,S} \right) \times \left(\frac{Frac_{GasMS}}{100} \right)_{T,S} \right] \right]$$

Where:

$N_{volatilization\text{-}MMS}$ = amount of manure nitrogen that is lost due to volatilization of NH_3 and NOx, kg N yr^{-1};

$N_{(T)}$ -= number of head of livestock species/category *T* in the country;

$Nex_{(T)}$ = annual average N excretion per head of species/category *T* in the country, kg N $animal^{-1}$ yr^{-1};

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

$Frac_{GasMS}$ = percent of managed manure nitrogen for livestock category *T* that volatilises as NH_3 and NO_x in the manure management system *S*, %.

Estonia uses default values for $Frac_{GasMS}$ detailed in Table 5.33.

[168] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, pp.10.54-56.

Table 5.33. N loss from MMS due to volatilisation of N-NH_3 and N-NOx (%) by MMS[169]

Animal type	**Manure management system (MMS)**	**N loss from MMS due to volatilisation of N-NH3 and N-NOx (%) $Frac_{GasMS}$**
Swine	Liquid/Slurry	48% (15-60)
	Solid storage	45% (10-65)
Dairy cow	Liquid/Slurry	40% (15-45)
	Solid storage	30% (10-40)
Poultry	Poultry with litter	40% (10-60)
Other cattle	Solid storage	45% (10-65)
	Deep bedding	30% (20-40)
Other	Solid storage	12% (5-20)

5.3.3.2. N losses due to leaching from manure management systems

Tier 2 methodology for estimation of N losses due to leaching from manure management systems is applied and the respective IPCC 2006[170] equations are used:

Equation 5.25

$$N_2O_{L(mm)} = \left(N_{leaching-MMS} \times EF_5\right) \times \frac{44}{28}$$

Where:

$N_2O_{L(mm)}$ = indirect N_2O emissions due to leaching and runoff from Manure management in the country, kg N_2O yr^{-1};

EF_5 = emission factor for N_2O emissions from nitrogen leaching and runoff, kg N_2O-N/kg N leached and runoff (default value 0.0075 kg N_2O-N (kg N leaching/runoff)$^{-1}$;

Equation 5.26

$$N_{leaching-MMS} = \sum_S \left[\sum_T \left[\left(N_T \times Nex_T \times MS_{T,S}\right) \times \left(\frac{Frac_{leachMS}}{100}\right)_{T,S}\right]\right]$$

Where:

$Frac_{leachMS}$ = percent of managed manure nitrogen losses for livestock category *T* due to runoff and leaching during solid and liquid storage of manure (typical range 1–20%).

Leaching and run-off of manure nutrients is prevented, when the manure storage facility is compacted and sealed. According to an expert opinion of Estonian University of Life Sciences leakage may be presumed for 70% of solid manure storage in 1990's, as most of the manure was kept in manure stacks.

[169] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management pp.10.56
[170] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, pp.10.56-57.

The leak-tightness of manure storage facilities was studied in a 2010 survey[171] conducted by Ltd. Estonian, Latvian & Lithuanian Environment. The survey was carried out in Pandivere and Adavere-Põltsamaa nitrate vulnerable zones in farms with over 10 livestock units. 44 farms that were entities to an environmental permit were visited during the inventory.

The results of the inventory showed that leakage was notable in case of solid manure storage. Leaching and run-off appeared to be a problem for 23% of solid storage facilities. In case of liquid manure storage, no leaking facilities were detected. It should be noted that leakage was determined by visual inspection and on the ground of records. The latter was used for the assessment of leakage probability. This kind of approach does not ensure 100% accurate results, but does provide a ground for making assumptions. Therefore, the existence of more leaking manure storage facilities than detected by the inventory compilers, was likely. The majority of liquid manure storage facilities are newer than 10 years and constructed according to respective project requirements (circular drainage, manholes etc). Hence, leak-tightness of liquid manure storage facilities should thereby be provided.

Corrected by the number of livestock, leaching and run-off is calculated for 32% of solid manure in 2010 and it is assumed to be the same for the following years. The leakage percentages for the years 2000–2009 have been found via interpolation.

The value of $Frac_{leachMS}$ = 5% is taken from the *Best Available Technique manual for intensive cattle farming*[172] for Estonian farmers.

5.3.4. Quantitative overview – N_2O emissions from manure management systems in Estonia in 2015

The total quantity of nitrogen generated by livestock and stored in solid, liquid and deep litter types of MMSs or used for biogas production was 16 292 kt in 2015 (Table 5.35). 0.114 kt of direct and 0.093 kt of indirect N_2O emissions (Table 5.36) occurred from the stored manure. The breakdown of emission factors used to estimate N_2O emissions released from different types of manure management systems are reported in Table 5.34. The fall in N_2O emissions from Manure management are tracked down to changes in MMS structure and the shrinking of animal husbandry compared to 1990 emissions.

Table 5.34. Emission factors of manure management practice

Manure management system	EF_3 (kg N_2O-N/kg Nitrogen excreted)
Liquid system (with natural crust cover)	0.005
Liquid system (without natural crust cover)	0
Solid storage	0.005
Deep bedding (no mixing)	0.01
Anaerobic digester	0

[171] ELLE *Manure management and storage inventory in nitrate vulnerable zone in farms with over 10 livestock units, 2010, pp. 56-58*, http://www.envir.ee/sites/default/files/ntas6nnikukitlusearuanneelle230710.pdf.
[172] *BAT manual for intensive cattle farming*, p.26, Table 16, http://www.ippc.envir.ee/docs/PVT/PVT_Veised-t2iendatud111007.pdf.

Table 5.35. Total nitrogen (in manure) excreted by livestock and direct N_2O emissions from manure management systems in Estonia during 1990–2015

Year	Nitrogen excreted, tonnes					N_2O emissions, kt				
	Liquid/ Slurry	Solid storage	Deep Litter	Digesters	Total	Liquid/ Slurry	Solid storage	Deep Litter	Digesters	Total [173]
1990	6 670 662	29 771 283	-	-	36 441 945	-	0.234	-	-	0.234
1991	6 030 274	28 290 496	-	-	34 320 770	-	0.222	-	-	0.222
1992	3 990 957	24 762 653	-	-	28 753 610	-	0.195	-	-	0.195
1993	3 110 137	20 005 974	-	-	23 116 111	-	0.157	-	-	0.157
1994	3 282 471	18 241 283	-	-	21 523 753	-	0.143	-	-	0.143
1995	3 157 170	16 327 879	-	-	19 485 050	-	0.128	-	-	0.128
1996	2 119 262	14 276 634	-	-	16 395 896	-	0.112	-	-	0.112
1997	2 211 251	14 425 136	-	-	16 636 387	-	0.113	-	-	0.113
1998	2 346 322	14 024 201	-	-	16 370 523	-	0.110	-	-	0.110
1999	2 283 479	12 798 035	-	-	15 081 514	-	0.101	-	-	0.101
2000	2 440 085	11 749 477	-	-	14 189 562	-	0.092	-	-	0.092
2001	2 687 276	13 359 526	-	-	16 046 802	-	0.105	-	-	0.105
2002	3 114 394	12 391 268		-	15 505 662	0.004	0.097	-	-	0.101
2003	3 643 960	12 068 353	173 278	-	15 885 592	0.008	0.095	0.003	-	0.105
2004	3 867 501	11 796 470	217 845	-	15 881 817	0.010	0.093	0.003	-	0.106
2005	4 196 270	11 689 676	274 635	-	16 160 581	0.012	0.092	0.004	-	0.109
2006	4 384 420	11 290 524	325 097	104 273	16 104 314	0.014	0.089	0.005	-	0.108
2007	4 830 696	10 953 209	373 120	89 246	16 246 272	0.016	0.086	0.006	-	0.108
2008	4 890 523	10 391 559	395 455	152 266	15 829 802	0.018	0.082	0.006	-	0.106
2009	5 092 429	10 083 738	451 666	144 911	15 772 743	0.020	0.079	0.007	-	0.106
2010	5 477 891	10 025 347	503 497	134 471	16 141 205	0.022	0.079	0.008	-	0.108
2011	5 442 516	10 183 091	494 970	132 980	16 253 556	0.022	0.080	0.008	-	0.110
2012	5 520 632	10 384 523	521 024	133 604	16 559 783	0.022	0.082	0.008	-	0.112
2013	5 530 690	10 726 790	558 577	128 590	16 944 647	0.023	0.084	0.009	-	0.116
2014	5 538 286	10 926 410	566 263	130 100	17 161 059	0.023	0.086	0.009	-	0.118
2015	4 975 350	10 663 164	545 430	107 920	16 291 865	0.022	0.084	0.009	-	0.114

[173] N_2O emissions from ‘Pasture/range and paddock’ were considered under Direct soil emissions.

Table 5.36. Indirect N_2O emissions from Manure management 1990–2015

Year	N losses due to volatilization from manure management, kt N_2O	N losses due to leaching from manure management systems, kt N_2O	Total Indirect N_2O emissions from Manure management, kt N_2O
1990	0.204	0.012	0.217
1991	0.192	0.012	0.203
1992	0.155	0.010	0.166
1993	0.122	0.008	0.130
1994	0.115	0.008	0.123
1995	0.105	0.007	0.111
1996	0.089	0.006	0.095
1997	0.089	0.006	0.095
1998	0.088	0.006	0.094
1999	0.081	0.005	0.087
2000	0.077	0.005	0.082
2001	0.086	0.005	0.091
2002	0.085	0.004	0.089
2003	0.087	0.004	0.091
2004	0.087	0.004	0.091
2005	0.088	0.003	0.091
2006	0.088	0.003	0.091
2007	0.089	0.003	0.092
2008	0.088	0.002	0.091
2009	0.088	0.002	0.090
2010	0.091	0.002	0.093
2011	0.092	0.002	0.094
2012	0.094	0.002	0.096
2013	0.096	0.002	0.098
2014	0.097	0.002	0.099
2015	0.091	0.002	0.093

5.3.5. Uncertainties and time-series consistency

CH_4 emissions from Manure management were calculated based on activity data and emission factors.

Uncertainties in estimates of CH_4 emissions from sheep, goats, horses and poultry manure management are reported in (IPCC, 2006) (Table 5.37).

Emission factors for cattle and swine were calculated using IPCC default parameters (volatile solids, CH_4 producing capacity, methane conversion factors, manure management system).

N_2O emissions from livestock manure management were calculated based on activity data (livestock population), nitrogen excretion factors (Nex, kg/head/year) were calculated based on nitrogen balance of animals and N emission factor related to manure management system. In spite of the use of nitrogen balance, default uncertainty rates for Nex (by categories of livestock) were used from the IPCC Guidelines.

IPCC nitrogen emission factors default uncertainty estimates for all systems of manure management used in Estonia's estimates of N_2O emissions from animal manure are reported in Table 5.37.

Uncertainties associated with indirect N_2O emission factors are presented in Chapter 5.5.5 discussing indirect N_2O EF uncertainty of Agricultural soils. Default IPCC 2006 uncertainty ranges for total N losses ($Frac_{LossMS}$)[174] are implemented in the estimates.

Table 5.37. Estimated values of uncertainties used in Agriculture sector

Input	**Uncertainties**	**References**
Activity data		
Estonia's livestock population (cattle, swine, sheep, goats, horses, poultry and fur animals)	± 10%	Rypdal and Winiwarter, 2001
Emission factors		
Manure management (CH_4) (cattle, swine)	± 20%	IPCC, 2006. Agriculture. p. 10.48
Manure management (CH_4) (sheep, goats, horses, fur animals)	± 30%	IPCC, 2006. Agriculture. p. 10.48
Manure management (N_2O)	-50... +100	IPCC, 2006. Agriculture. p. 10.66
…Nitrogen excretion factor (Nex)	± 50%	IPCC, 2006. Agriculture. p. 10.66
…Anaerobic lagoon	-±25... ±50	IPCC, 2006. Agriculture. p. 10.67
…Liquid system	-±25... ±50	IPCC, 2006. Agriculture. p. 10.67
…Solid storage	-±25... ±50	IPCC, 2006. Agriculture. p. 10.67
…Pasture/range and paddock	-±25... ±50	IPCC, 2006. Agriculture. p. 10.67
…Other systems (deep litter, poultry manure with bedding,, anaerobic digestion)	-±25... ±50	IPCC, 2006. Agriculture. p. 10.67

5.3.6. Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.2.3.

The QC/QA plan for the Manure management subsector includes the QC activities described in the IPCC 2006 Guidelines Volume 1, Chapter 6 and the activities listed in Volume 4, Chapters 10.4.5 and 10.5.6. The activities are carried out every year during the inventory. The QC check list is used during the inventory.

5.3.7. Category-specific recalculations

Below follows an overview of improvements implemented since the 2016 submission that resulted in minor recalculations mainly under cattle and swine manure management subsectors.

The calculations in swine and cattle Manure management sub-categories were previously performed on a county level that involved several intermediate calculations which were

[174] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Table 10.23, p. 10.67 (Range of $Frac_{LossMS}$).

ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are immediately performed on a country-level using weighed average country-specific activity data which is in line with the IPCC guidelines. The change in calculation approach brought about a reevaluation of used activity data along with some miscalculation errors detected and corrected in working tables, which lead to recalculations in N_2O emissions under the Manure management subsector. The renewed emissions are presented in Table 5.38.

Table 5.38. Reported N_2O. emissions in 2016 and 2017 submissions in Manure Management category, kt

Manure management	1990	1995	2000	2005	2010	2011	2012	2013	2014
2017 submission	0.451	0.240	0.174	0.200	0.201	0.203	0.208	0.214	0.217
2016 submission	0.477	0.249	0.181	0.200	0.209	0.211	0.217	0.224	0.226

5.3.8. Category-specific planned improvements

Until 2016 NH_3 and NO_x emissions submitted under the Convention on Long-Range Transboundary Air Pollution in the Estonian Informative Inventory Report 1990–2013, were estimated according to the EMEP/EEA guidebook Tier 1 methodology. Estonia is planning to adopt the Tier 2 methodology also in the GHG inventory during the next submissions for indirect N_2O emissions due to NO_x and NH_3 volatilization and is making an effort to increase co-operation between the two different institutions compiling the separate inventories and harmonize the emission estimates.

The animal waste management system data are planned to be renewed and updated by the following submission.

5.4. Direct N_2O emissions from managed soils (CRF 3.D.1)

N_2O is produced naturally in soils through the microbial processes of nitrification and denitrification. A number of agricultural activities add nitrogen to soils, increasing the amount of nitrogen available for nitrification and the amount of N_2O[175].

The following agricultural activities influence N flows in agricultural soils:

- synthetic fertilizers;
- animal excreta nitrogen used as fertilizer;
- sewage sludge application on agricultural soils;
- compost application on agricultural soils;
- crop residues;
- cultivation of high organic content soils; and
- urine and dung deposited by grazing animals.

[175] IPCC. (2000). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

5.4.1. Category description

Even though the cereal production in Estonia has revived following the EU accession to 1990 levels, the volume of production of livestock products has not achieved the level of 20 years ago. Accordingly, N_2O emissions decreased by 42% by 2015 in comparison with the base year due to decrease in number of livestock population (i.e., amount of animal manure applied on agricultural soils and emissions from grazing animals) and due to decline in quantity of fertilizers applied on agricultural land (Figure 5.20). In 2015 the main contributor to the direct N_2O emissions from agricultural soils was the use of synthetic fertilizers (32%), followed by emissions originating from crop residues left on the fields (27%) and as a result of the cultivation of organic soils (16%), emissions from animals grazing constituted 13% and the use of organic fertilizers 11% (Figure 5.21). The total direct N_2O emissions from Agricultural soils were 1.7 kt in Estonia in 2015.

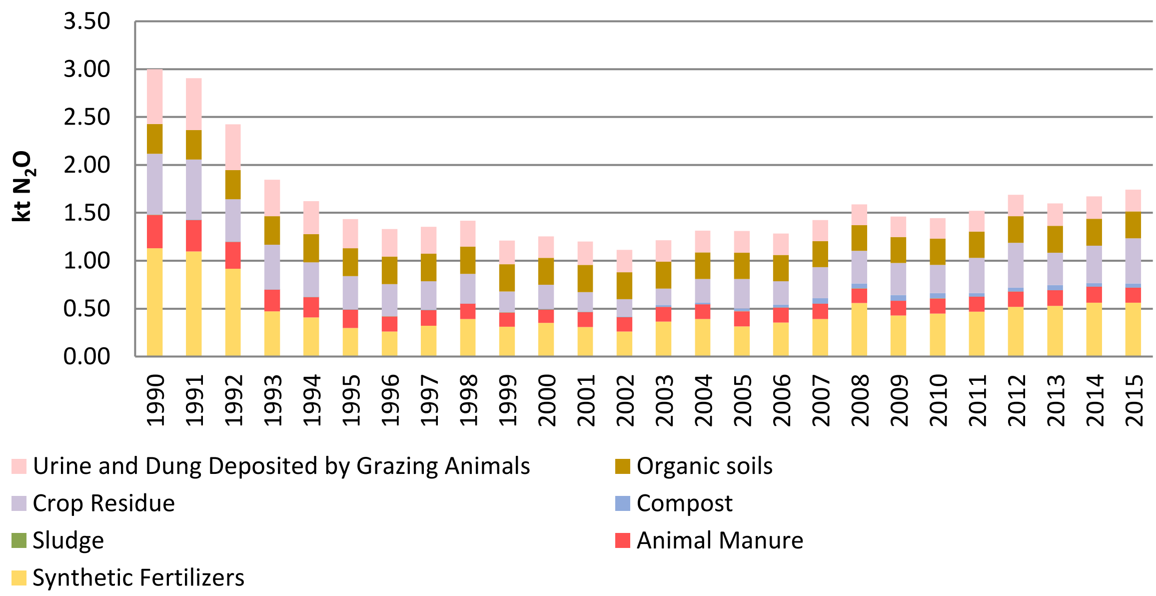

Figure 5.20. Direct N_2O emissions from Agricultural soils in Estonia in 1990–2015, kt

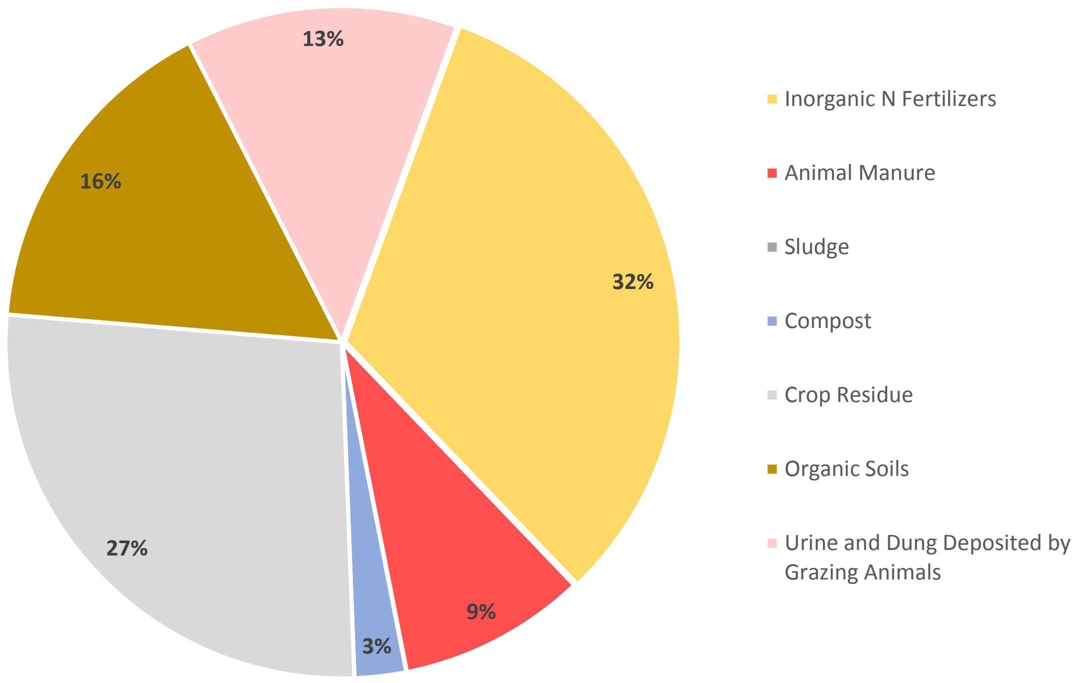

Figure 5.21. Direct N_2O emissions from Agricultural soils in Estonia in 2015, %

5.4.2. Activity data employed

Activity data on amount of synthetic fertilizers and compost applied on agricultural fields, crop production in Estonia were obtained from the datasets of Statistics Estonia. The data on amounts of sludge used on agricultural lands and the area of grasslands on mineral soils converted to cropland were received from Estonian Environment Agency. The data on areas of histosols under cultivation in Estonia were obtained in the framework of National Forest Inventory (Chapter 6 LULUCF).

Table 5.39. N_2O emission factors for Agricultural soils used in Estonian GHG Inventory

Category	**Emission factor**			**Source**
3.D.1 Direct N_2O emissions				
N additions from mineral fertilisers, organic amendments and crop residues, and N mineralised from mineral soil as a result of loss of soil carbon	EF_1	0.01	kg N_2O–N (kg N)-1	IPCC (2006), table 11.1
Temperate organic crop and grassland soils	EF2 CG, Temp	8	kg N_2O–N ha-1	IPCC (2006), table 11.1

Category	Emission factor			Source
Cattle (dairy, non-dairy and buffalo), poultry and pigs	EF3PRP, CPP	0.02	kg N_2O–N (kg N)-1	IPCC (2006), table 11.1
Sheep and 'other animals'	EF3PRP	0.01	kg N_2O–N (kg N)-1	IPCC (2006), table 11.1
3.D.2 Indirect N_2O emissions				
N volatilisation and re-deposition	EF4	0.01	kg N_2O–N (kg NH_3–N + NO_X–N volatilised)-1	IPCC (2006), Table 11.3
leaching/runoff	EF5	0.0075	kg N_2O–N (kg N leaching/runoff)	IPCC (2006), Table 11.3
Volatilisation from synthetic fertiliser	FracGASF	0.1	(kg NH_3–N + NOx–N) (kg N applied) –1	IPCC (2006), Table 11.3
Volatilisation from all organic N fertilisers applied , and dung and urine deposited by grazing animals	FracGASM	0.2	(kg NH_3–N + NOx–N) (kg N applied or deposited) –1	IPCC (2006), Table 11.3
N losses by leaching/runoff	FracLEACH(H)	0.3	kg N (kg N additions or deposition by grazing animals)-1	IPCC (2006), Table 11.3

5.4.3. N_2O emissions from inorganic fertilizer nitrogen applied to soils (CRF 3.D.1.1)

N_2O emissions are estimated from annual synthetic nitrogen applied to soils. The algorithm reported in IPCC 2006 was used to estimate nitrogen input into agricultural soils adjusted for volatilization.

$Frac_{GASF}$ = Fraction of total synthetic fertilizer nitrogen that is emitted as NO_x+NH_3, kg N/kg N (Table 5.39);

N_2O emissions into the atmosphere from using of synthetic nitrogen were calculated based on the Equation 5.27:

Equation 5.27

$$N_2O_{direct} = F_{SN} \times EF \times \frac{44}{28}$$

Where:

F_{SN} = Total use of synthetic fertilizer in country, kg N/year.

5.4.3.1. Quantitative overview – N_2O emissions from synthetic fertilizers applied to soils in 2015

The total N_2O emissions from synthetic fertilizers applied onto agricultural soils were 0.563 kt in Estonia in 2015 (Figure 5.22). As the methodology of data collection by the SE has changed and from now on SE is planning on using the data gathered by the Estonian Rural Economy Research in the framework of Centre Farm Accountancy Data Network (*FADN*) and reported to the European Commission. This alteration has created a delay of publishing the data of inorganic fertilizer use in 2015, hence the data of 2014 were applied to estimate 2015 N_2O emissions from the application of inorganic fertilizers to the soils. The emissions declined by 50% by 2015 in comparison with the base year due to the decrease in the amounts of synthetic fertilizers applied to agricultural fields, mostly on fields sown with cereals and forage crops (Figure 5.22, Annex A.3.2_VI).

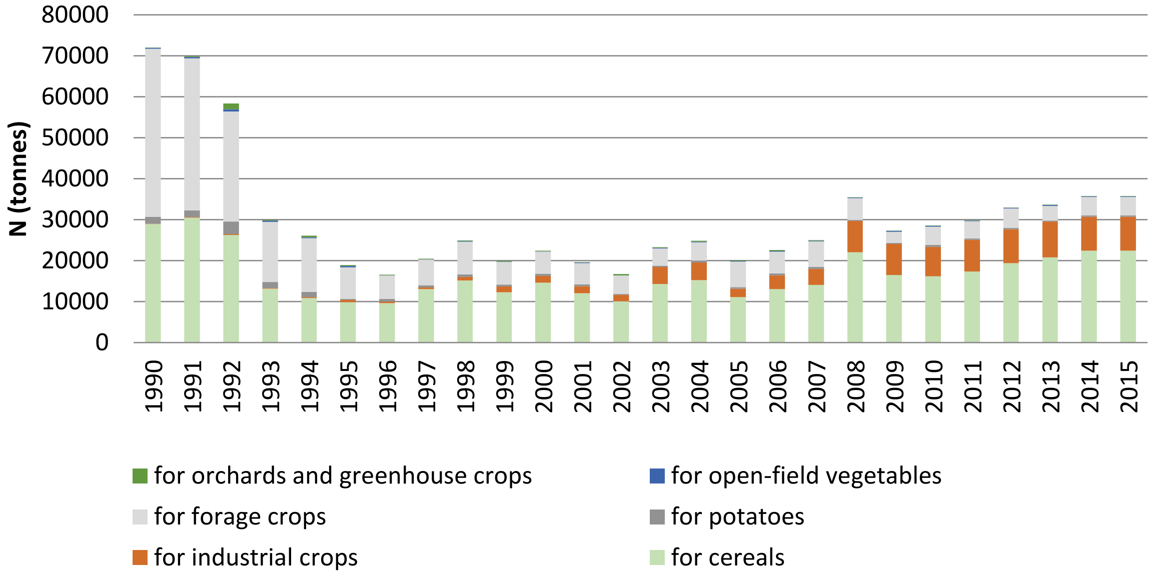

Figure 5.22. Quantity of synthetic fertilizers applied to agricultural soils in 1990–2015 in Estonia, N (tonnes)

5.4.4. N_2O emissions from animal manure applied to soils (CRF 3.D.1.2.a)

N_2O emits from agricultural soil through manure application to fields as organic fertilizer.

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

N_2O emission into the atmosphere from animal waste applied to agricultural fields as organic fertilizer was estimated according to the algorithm proposed by the IPCC 2006 (Equations 5.28–5.30):

Equation 5.28

$$N_2O_{direct} - N = F_{AM} \times EF_l$$

Equation 5.29[176]

$$F_{AM} = N_{MMS\ Avb} \times [1 - (Frac_{FEED} + Frac_{FUEL} + Frac_{CNST})]$$

Where:

EF_1 = emission factor;
F_{AM} = annual amount of animal manure N applied to soils, kg N yr^{-1};
$N_{MMS\ Avb}$ = amount of managed manure N available for soil application, feed, fuel or construction, kg N yr^{-1};
$Frac_{FEED}$ = fraction of managed manure used for feed;
$Frac_{FUEL}$ = fraction of managed manure used for fuel;
$Frac_{CNST}$ = fraction of managed manure used for construction.

Equation 5.30[177]

$$N_{MMS\ Avb} = \sum_S \left\{ \sum_{(T)} \left[\left[\langle N_{(T)} \times Nex_{(T)} \times MS_{(T,S)} \rangle \times \langle 1 - \frac{Frac_{LossMS}}{100} \rangle \right] + \left[N_{(T)} \times MS_{(T,S)} \times N_{beddingMS} \right] \right] \right\}$$

Where:

N_{MMS_Avb} = amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes, kg N yr^{-1};
$N_{(T)}$ = number of head of livestock species/category *T* in the country;
$Nex_{(T)}$ = annual average N excretion per animal of species/category *T* in the country, kg N animal^{-1} yr^{-1};
$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category *T* that is managed in manure management system *S* in the country, dimensionless;
$Frac_{LossMS}$ = amount of managed manure nitrogen for livestock category *T* that is lost in the manure management system *S*, %;
$N_{beddingMS}$ = amount of nitrogen from bedding (to be applied for solid storage and deep bedding MMS if known organic bedding usage), kg N animal^{-1} yr^{-1};
S = manure management system;
T = species/category of livestock.

Nitrogen from bedding material was not accounted for under animal manure applied to soils. The respective nitrogen is included in the nitrogen returned to soils as crop residues.

Nitrogen excreted per head of different categories of animals and per waste management systems was estimated in N_2O emissions from manure management chapter. IPCC default factors were used to estimate nitrogen input to Agricultural soils (Table 5.40).

Table 5.40. IPCC default factors used in the estimation of N_2O emissions from animal waste applied to soils

Factor	**Value**
$Frac_{FUEL}$	0.0 kg N/kg nitrogen excreted
$Frac_{FEED}$	0.0 kg N/kg nitrogen excreted

[176] IPCC 2006, Vol.4, Ch.11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, Equation 11.4, p.11.13.
[177] IPCC 2006, Vol.4, Ch.10: Emissions from Livestock and Manure Management, Equation 10.34, p.10.65.

Factor	Value
$Frac_{FUEL}$	0.0 kg N/kg nitrogen excreted
$Frac_{CONST}$	0.0 kg N/kg nitrogen excreted

5.4.4.2. Quantitative overview – N_2O emissions from animal manure applied to soils in 2015

The direct N_2O emissions from animal manure applied on agricultural soils were 0.158 kt in Estonia in 2015 (Figure 5.20). The emission decreased by 55% by 2015 compared to the base year, due to the decline in number of livestock population.

5.4.4.3. N_2O emissions from sewage sludge applied to soils (CRF 3.D.1.2.b)

Sludge from domestic wastewater treatment plants is used on agricultural land. Table 5.41 illustrates amounts of sewage sludge used for improvement of environmental situation (R10). Data for years 1999–2015 were obtained from datasets of EtEA.

The amounts of sewage sludge treated according R10 category in 1990–1998 were extrapolated based on rough assumption – about 50% of the total amount of generated sewage sludge was used for improvement of environmental situation (Table 5.41).

Since 2004, the amount of sewage sludge treated biologically has increased. However, the amounts of sewage sludge directly used for improvement of environmental situation have decreased (see also Chapter 7 Waste).

Table 5.41. Amounts of municipal sludge application on agricultural land, tonnes[178]

Year	R10
1990	7 434
1991	7 825
1992	8 237
1993	9 081
1994	14 306
1995	27 073
1996	30 041
1997	30 028
1998	12 724
1999	17 302
2000	26 489
2001	2 770
2002	4 048
2003	9 799
2004	1 025
2005	6 992
2006	12 285
2007	24 292
2008	18 948

[178] R10 of the European Waste Catalogue (2002) – Land treatment resulting in benefit to agriculture or ecological improvement.

Year	R10
2009	15 189
2010	23 663
2011	4 317
2012	4 193
2013	1 825
2014	6 114
2015	6 131

5.4.4.4. Methodology, data availability and sources, emission factors

The IPCC 2006 *Tier 1* (Equation 5.31) approach was employed in order to estimate N_2O emissions from sludge applied on agricultural land:

Equation 5.31

$$N_2O_{direct} = F_{SL} \times EF_1 \times \frac{44}{28}$$

Where:

F_{SL}= annual amount of sewage sludge N applied to soils, kg N yr^{-1};
EF_1= emission factor.

The factors used in the estimates are presented in Table 5.39 and Table 5.42.

Table 5.42. Parameters and factors used in the estimates

Factor	Value	
N content of sewage sludge[179]	4.9	% dry matter

5.4.4.5. Quantitative overview – N_2O emissions from sludge applied on agricultural land in 2015

The total N_2O emissions from sludge applied on agricultural land were 0.0005 kt in Estonia in 2015 (Figure 5.23).

[179] Final report, 2008

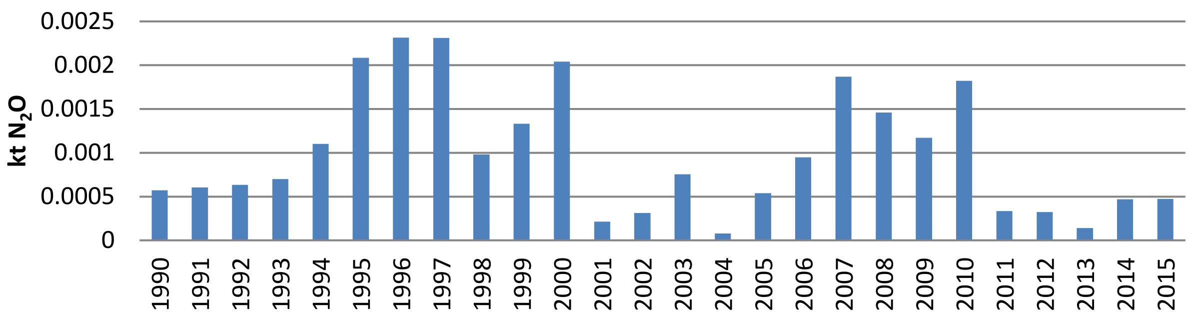

Figure 5.23. N_2O emissions from sewage sludge applied on agricultural land in Estonia in 1990–2015, kt

5.4.5. N_2O emissions from compost applied to soils (CRF 3.D.1.c)

In case of compost statistical data on usage is not collected and therefore could only be estimated. Quantity of biological treatment of waste (recovery code R3) in the waste database of the waste reporting of enterprises holding waste permits managed by Estonian Environment Agency is only available data concerning quantity of generation of compost. (Quantity of biological treatment of waste (recovery code R3o) in the database of the waste reporting of enterprises holding waste permits. These data refers to the compost produced by companies specialized on waste management).

As no data on use of compost are available, it was supposed, that all generated quantity of compost was also used at the same year (Table 5.43).

Table 5.43. Composted organic waste, 1 000 tonnes

Year	Composted organic waste
1990	6.775
1991	7.117
1992	7.477
1993	7.857
1994	8.256
1995	8.899
1996	6.004
1997	11.218
1998	2.027
1999	6.434
2000	19.010
2001	17.937
2002	16.359
2003	67.339
2004	65.600
2005	93.578
2006	97.332
2007	192.256
2008	179.204
2009	204.876

Year	Composted organic waste
2010	195.002
2011	133.383
2012	148.362
2013	183.237
2014	128.368
2015	149.984

5.4.5.1. Methodology, data availability and sources, emission factors

The IPCC 2006 *Tier 1* (Equation 5.32) approach was employed in order to estimate N_2O emissions from organic fertilizers applied to agricultural land:

Equation 5.32

$$N_2O_{direct} = F_{ON} \times EF_1 \times \frac{44}{28}$$

Where:

F_{ON} = annual amount of organic fertilizer N applied to soils, kg N yr^{-1};
EF_1 = emission factor.

The factors used in the estimates are presented in Table 5.39 and Table 5.44.

Table 5.44. Parameters used in the estimates

Factor	Value	
N content of compost[180]	1.83	% dry matter

5.4.5.2. Quantitative overview – N_2O emissions from compost applied on agricultural land in 2015

The total N_2O emissions from compost applied on agricultural land were 0.04 kt in Estonia in 2015 (Figure 5.24).

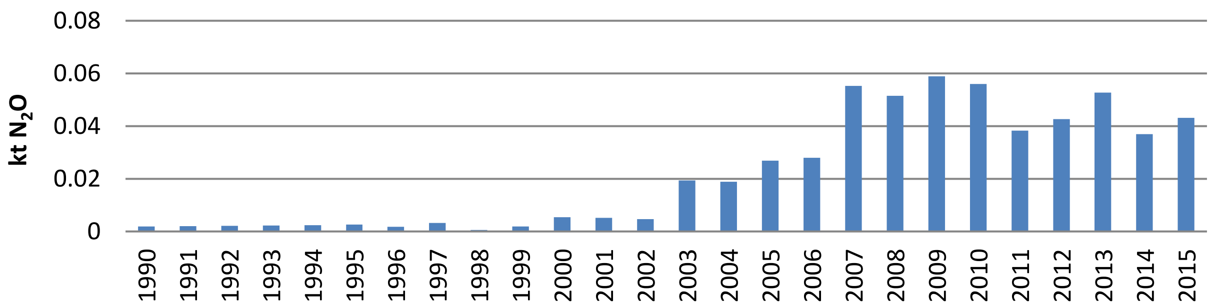

Figure 5.24. N_2O emissions from compost applied on agricultural land in Estonia in 1990–2015, kt

[180] Overview of Waste Compost production in Estonia, Annex 1 (2012).

5.4.6. N_2O emissions from urine and dung deposited by grazing animals (CRF 3.D.1.3)

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

The method reported in Chapter 5.4.2 was used to estimate N_2O emissions from animal pasture, range and paddock.

5.4.6.2. Quantitative overview – N_2O emissions from pasture, range and paddock in 2015

The total N_2O emissions from pasture, range and paddock made up 0.228 kt in 2015. The emission decreased by 60% compared to the base year due to decline in number of livestock population (Figure 5.25).

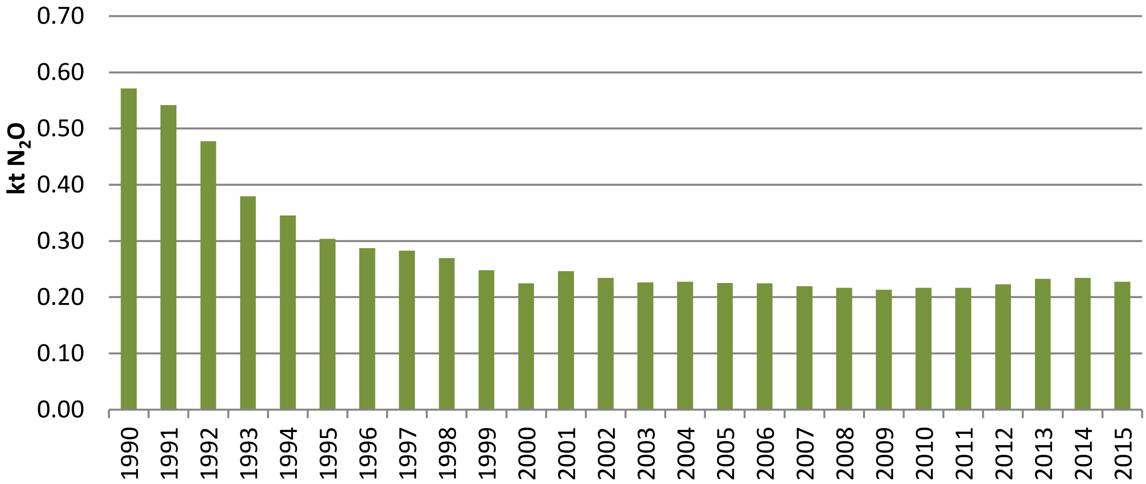

Figure 5.25. N_2O emissions from urine and dung deposited by grazing animals in 1990–2015, kt

5.4.7. N_2O emissions from nitrogen input from crop residues (CRF 3.D.1.4)

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

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

The IPCC Tier 1 (Equation 5.33) method was used to estimate emissions from crop residues returned to the soil

Equation 5.33[181]

$$F_{CR} = \sum_T \{Crop_T \times (Area_T - Area\ burnt_{(T)} \times C_f) \times Frac_{Renew(T)} \times [R_{AG(T)} \times N_{AG(T)} \times (1 - Frac_{Remove(T)}) + R_{BG(T)} \times N_{BG(T)}]\}$$

Where:

Data for $Frac_{Remove}$ is not available in Estonia, therefore no removal was assumed. Also as no agricultural burning practices have been carried out is Estonia, Area burnt $_{(T)}$ is considered to

[181] IPCC 2006, Vol.4, Ch.11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, Equation 11.6, p.11.14.

be zero. IPCC default values have been used for factors $R_{AG(T)}$, $N_{AG(T)}$, $R_{BG(T)}$ and $N_{BG(T)}$ available in table 11.2 in the IPCC 2006 Guidelines[182].

F_{CR} = annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually, kg N yr^{-1};
$Crop_{(T)}$ = harvested annual dry matter yield for crop *T*, kg d.m. ha^{-1};
$Area_{(T)}$ = total annual area harvested of crop *T*, ha yr^{-1};
Area burnt $_{(T)}$ = annual area of crop *T* burnt, ha yr^{-1};
$Frac_{Renew\,(T)}$ = fraction of total area under crop *T* that is renewed annually 15. For countries where pastures are renewed on average every X years,
$Frac_{Renew}$ = 1 /X. For annual crops $Frac_{Renew}$ = 1;
$R_{AG(T)}$ = ratio of above-ground residues dry matter (AGDM(*T*)) to harvested yield for crop *T* (Crop(*T*)), kg d.m. (kg $d.m.)^{-1}$, = AGDM(*T*) ● 1000 / Crop(*T*);
$N_{AG(T)}$ = N content of above-ground residues for crop *T*, kg N (kg d.m.) $^{-1}$;
$Frac_{Remove(T)}$ = fraction of above-ground residues of crop *T* removed annually for purposes such as feed, bedding and construction, kg N (kg $crop\text{-}N)^{-1}$;
$R_{BG(T)}$ = ratio of below-ground residues to harvested yield for crop *T*, kg d.m. (kg $d.m.)^{-1}$. If alternative data are not available, RBG(*T*) may be calculated by multiplying RBG-BIO by the ratio of total above-ground biomass to crop yield (= [(AGDM(*T*) ● 1000 + Crop(*T*)) / Crop(*T*)];
$N_{BG(T)}$ = N content of below-ground residues for crop *T*, kg N (kg $d.m.)^{-1}$;
T = crop or forage type.

Annual N_2O emissions from crop residues were calculated using the Equation 5.34.

Equation 5.34[183]

$$N_2O_{direct} = F_{CR} \times EF_1 \times \frac{44}{28}$$

Selected crop residue statistics and factors used in the algorithm to estimate emissions from crop residues are presented in Table 5.45.

Table 5.45. Factors used in the algorithm to estimate N_2O emissions from crop residues[184]

Factor	Unit
$Frac_{REMOVE}$	0 kg N/kg crop-N[185]
$Frac_{RENEW\ annual}$	1
$Frac_{RENEW\ herbacous}$	8
$Frac_{RENEW\ legumes}$	4

[182] IPCC 2006, Vol.4, Ch.11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, Table 11.2, pp.11.17-18.
[183] IPCC 2006, Vol.4, Ch.11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, Equation 11.1, p.11.7.
[184] Expert opinion of the Estonian Agricultural Research Centre.
[185] $Frac_R$ at value of 0 was applied because of a recommendation of the TERT (conducted in 2012).

5.4.7.2. Quantitative overview – N_2O emissions from crop-residues in 2015

In 2015, production of cereals was 1 535.3 thousand tonnes, maize – 230.8 thousand tonnes, potatoes – 117.2 thousand tonnes and legumes and fodder roots – 86.2 and 0.5 thousand tonnes, respectively (Figure 5.26–Figure 5.28) (data of SE, see also Annex A.3.2_VII). The inter-annual changes in crop production are explained by decline in the total sown area and by weather conditions (Annex A.3.2_VII). The sown area of cereals increased 5% compared to 2014. In total, cereals were grown on 350 400 hectares in 2015.

The share of winter crops in the sown area of cereals was 34% – much bigger than in the previous years. The hope of producing a higher yield of winter crops under good wintering conditions was justified in 2015. Winter wheat accounted for 28%, rye for 4%, spring barley for 37% and spring wheat for 21% of the total sown area of cereals. Compared to 2014, the sown area of winter wheat increased 21%, while the sown area of spring wheat decreased 2%. The sown area of rye decreased 7% year over year.

Thanks to favorable conditions for winter crops, cereal production was on a record-high level in 2015 – 1.5 million tonnes. The production was 26% bigger than in 2014. Wheat accounted for 53%, barley for 36%, oats for 4% and rye for 4% of the production of cereals.

The average yield of cereals was also at a record high in 2015 – 4 382 kilograms per hectare. Compared to 2014, there was a 19% rise in production. The average yield of winter cereals grew 24% year over year. The average yield of rye increased 19%, amounting to 3 823 kilograms per hectare, and the average yield of winter wheat grew 23% and amounted to 5 302 kilograms per hectare[186].

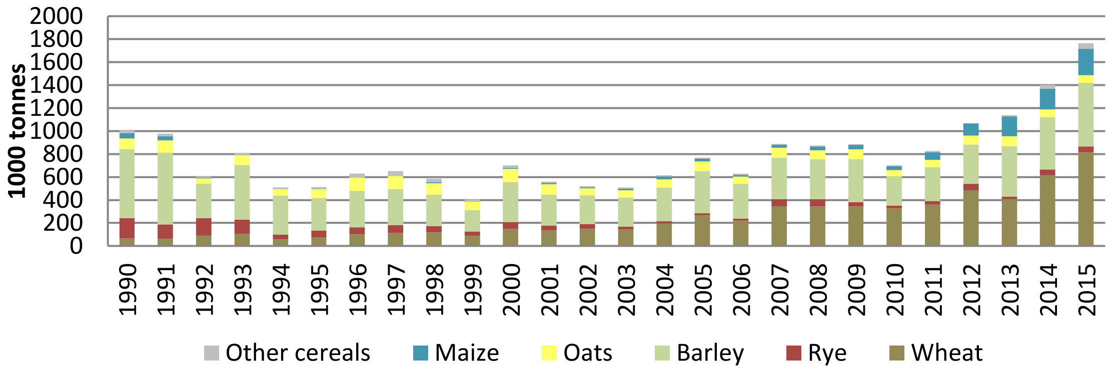

Figure 5.26. Cereals and maize production in 1990–2015 in Estonia, 1 000 tonnes

[186] Statistical Yearbook of Estonia 2015 https://www.stat.ee/90733

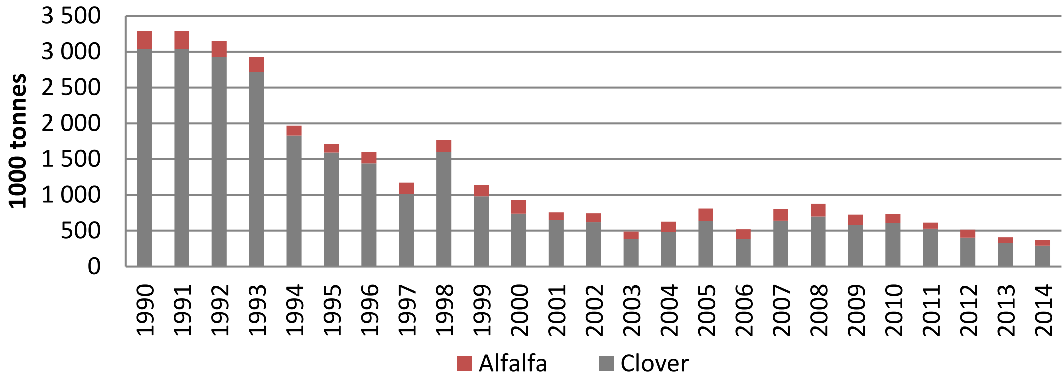

Figure 5.27. Clover and alfalfa production in 1990–2014 in Estonia, 1 000 tonnes

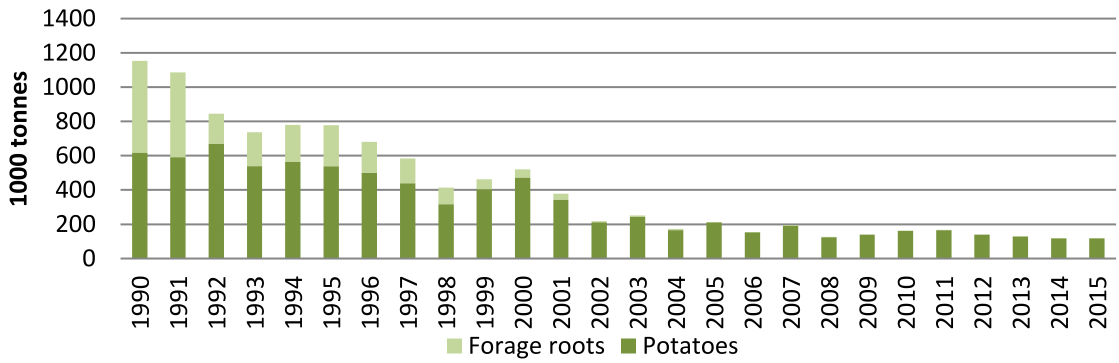

Figure 5.28. Potato and forage root production in 1990–2015, 1 000 tonnes

The total N_2O emissions from crop residues left on agricultural land was 0.469 kt in 2015 (Figure 5.29). The respective emissions have declined 26% compared with the base year 1990. The recuperation of crop production following the transition to market economy has been more prominent compared to animal husbandry. Increased crop production has been favored by the steady growth of cereals export in recent years.

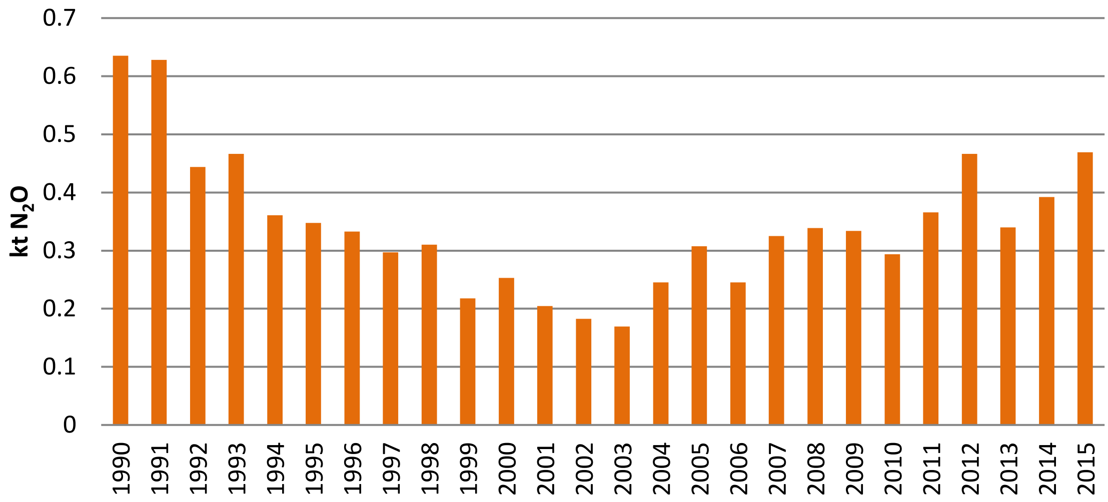

Figure 5.29. N_2O emissions from crop residues left on agricultural fields in 1990–2015 in Estonia, kt

5.4.8. N_2O emissions from mineralization/immobilization associated with loss/gain of soil organic matter (CRF 3.D.1.5)

No management changes in cropland remaining cropland have occurred in Estonia during 1990–2015, hence no emissions have been reported under this section.

5.4.9. N_2O emissions from organic soils cultivation (CRF 3.D.1.6)

N_2O emissions occur as a result of cultivation of organic soils due to enhanced mineralization of old, N-rich organic matter. The rate of N-mineralization is determined by N-quality of histosols, management practice and climatic conditions[187].

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

The 2006 IPCC *Tier 1* method was applied in order to estimate N_2O emissions from organic soils cultivation (Equation 5.35).

Equation 5.35

$$N_2O_{direct} = F_{OS} \times EF_{21} \times \frac{44}{28}$$

F_{OS} = area of cultivated organic soils, ha;

EF_2 = emission factor for organic soil mineralization due to cultivation, kg N_2O-N ha/year (Table 5.39).

[187] IPCC. (1997). Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

5.4.9.2. Quantitative overview – N_2O emissions from organic soils cultivated in 2015

N_2O emissions from cultivation of organic soils were 0.282 kt in 2015 in Estonia (Figure 5.30). The estimation was carried out based on the data received in the framework of National Forest Inventory (see Chapter 6 LULUCF).

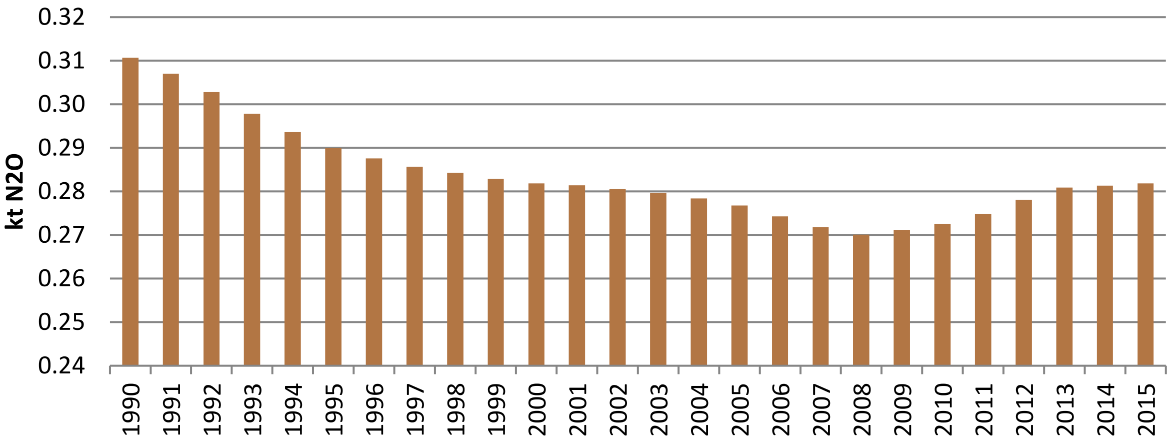

Figure 5.30. N_2O emissions from cultivation of organic soils in Estonia in 1990–2015, kt

5.4.10. Uncertainties and time-series consistency

The estimation of N_2O emissions from synthetic fertilizers used was 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 by Rypdal and Winiwarter[188]. 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[189]. No similar research has been carried out in Estonia, therefore the uncertainty of Finland was used in the estimates (Table 5.46).

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 0.0025–0.0225[190].

The estimation of N_2O emissions from animal manure applied and urine and dung deposited by grazing animals to soils was carried out based on activity data (amounts of nitrogen produced by livestock) and emission factors. Uncertainties of N generated were described in the 'Manure management' chapter above. Nitrogen emission factor was taken as IPCC default.

The estimation of N_2O emissions from N crop residue was 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).

188 Rypdal K., Winiwarter W. (2001). Uncertainties in greenhouses gas emission inventories – evaluation, comparability and implications. Environmental Science and Policy (4), pp. 107–116.
189 Monni, S. and Syri, S. (2003), Uncertainties in the Finnish 2001 Greenhouse Gas Emission Inventory. VTT Research Notes 2209. Otamedia Oy, Espoo. // www.vtt.fi/inf/pdf/ tiedotteet/2003/T2209.pdf.
190 IPCC. (1997). Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

Data on uncertainty of crop production, sewage sludge and compost application in Estonia are not available. In the second order draft of the LULUCF Good Practice Guidance, an uncertainty of < ±20% in the amount of organic waste used as fertilizer is given. In case of crop residues the uncertainty of Finland was used in the estimates (Table 5.46).

Table 5.46. Estimated values of uncertainties used in Agriculture sector

Input	Uncertainties	References
Activity data		
Estonia's Livestock Population (cattle, swine, sheep, goats, horses, poultry)	± 10%	Rypdal and Winiwarter, 2001
Synthetic Fertilizers (applied to agricultural soils) Cropland remaining Cropland - mineral soils Cropland remaining cropland-organic soils Sewage sludge, compost applied to soils Crop Residues	± 10% 33.24% 21.41% ±20% ±30%	Rypdal and Winiwarter, 2001 IPCC 2006; Kõlli et al., 2009 IPCC 2006 LULUCF GPG 2003 Monni et al.,2003
Emission factors		
EF_1 (mineral fertilizers, organic amendments, crop residues, N mineralised from soil as a result of loss of soil carbon), kg N_2O-N/kg N EF_2 for temperate organic crop and grassland soils, kg N_2O-N/ha EF_{3PRP} for cattle (dairy, non-dairy and buffalo), poultry and pigs, kg N_2O–N/ (kg N) $EF3_{PRP}$, SO for sheep and 'other animals' , kg N_2O–N / kg N	0.003–0.03 2–24 0.007–0.06 0.003–0.03	Table 11.1 of the 2006 IPCC Guidelines, pp. 11.11 Table 11.1 of the 2006 IPCC Guidelines, pp. 11.11 Table 11.1 of the 2006 IPCC Guidelines, pp. 11.11 Table 11.1 of the 2006 IPCC Guidelines, pp. 11.11

5.4.11. Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.2.3.

The QC/QA plan for the Agricultural soils subsector includes the QC activities described in the IPCC 2006 Guidelines Volume 1, Chapter 6 and the activities listed in Volume 4, Chapter 11.2.3. The activities are carried out every year during the inventory. The QC check list is used during the inventory.

5.4.12. Category-specific recalculations

- Direct N_2O emissions from animal manure applied to soils (CRF 3.D.1.2.a) and from urine and dung deposited by grazing animals (CRF 3.D.1.3) were revised due to recalculations under the Manure management subcategory (CRF 3.B) (see Chapter 5.4.7)
- Miscalculation errors were corrected in the working tables during the 2017 submission that resulted in recalculations under the Crop residues subsector.
- Activity data of composted biological waste were updated. Recalculations of the amount of composted biological waste are based on a research correcting waste classification for the IPCC Waste Model. The waste classification in Solid waste disposal and Biological treatment of solid waste is made on the same basis. For precise evaluation of uncertain waste types, an excerpt from JATS with company names and specific amounts was made (See also Chapter 7. Waste (CRF 5)).
- Cultivation of organic soils (CRF 3.D.1.6) – data on areas of organic soils cultivated were updated in the framework of the NFI (see Chapter 6 LULUCF).

The results of the recalculations are presented in Table 5.47.

Table 5.47. Reported CO_2 eq. emissions in 2016 and 2017 submissions from Agricultural soils, kt

Agricultural Soils	1990	1995	2000	2005	2010	2011	2012	2013	2014
2017 submission	1 128.5	523.8	458.3	480.2	536.3	562.9	625.5	593.5	620.9
2016 submission	1 083.8	507.4	427.6	424.2	496.3	502.6	565.4	547.7	592.4

5.4.13. Category-specific planned improvements

There are no planned category-specific improvements.

5.5. Indirect N_2O emissions from managed soils (CRF 3.D.2)

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[191].

5.5.1. Category description

Total indirect N_2O emissions from agricultural soils were 0.43 kt in 2015 (Figure 5.31). The emissions declined compared to the base year (1990) 46% by 2015 due to decrease in number of livestock population and synthetic and organic fertilizers application onto agricultural land.

[191] IPCC. (2000). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

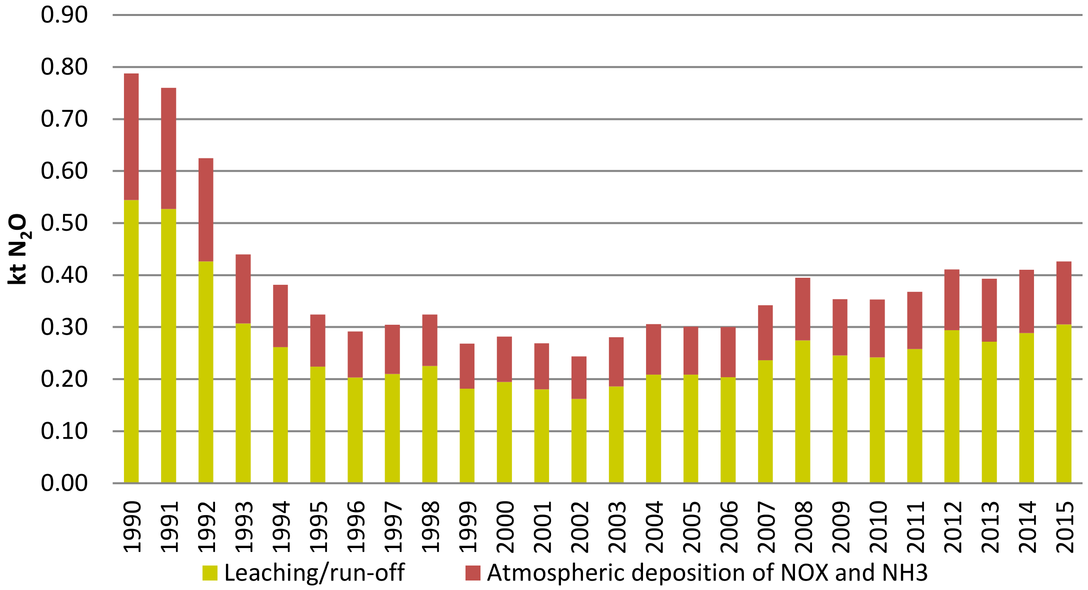

Figure 5.31. Indirect N_2O emissions from Agricultural soils in Estonia in 1990–2015, kt

5.5.2. Atmospheric deposition of NO_X and NH_4 (CRF 3.D.2.1)

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[192]. Total N_2O emissions from atmospheric deposition were 0.121 kt in 2015 in Estonia.

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

The *Tier 1* (Equation 5.36) method was used to estimate emissions from the Atmospheric deposition.

Equation 5.36[193]

$$N_2O_{(ATD)} - N = [(F_{SN} \times Frac_{GASF}) + ((F_{ON} + F_{PRP}) \times Frac_{GASM})] \times EF_4$$

Where:

$N_2O_{(ATD)}$–N = annual amount of N_2O–N produced from atmospheric deposition of N volatilised from managed soils, kg N_2O–N yr^{-1};

F_{SN} = annual amount of synthetic fertiliser N applied to soils, kg N yr^{-1};

$Frac_{GASF}$ = fraction of synthetic fertiliser N that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied)$^{-1}$;

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1};

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1};

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[192] IPCC. (2000). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.
[193] IPCC 2006, Vol.4, Ch.11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, Equation 11.9, p.11.21.

$Frac_{GASM}$ = fraction of applied organic N fertiliser materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied or deposited)$^{-1}$;
EF_4 = emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [kg N–N_2O (kg NH_3–N + NO_x–N volatilised)$^{-1}$].

5.5.3. Leaching/run-off of applied or deposited nitrogen (CRF 3.D.2.2)

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[194]. The total N_2O emissions from leaching and run-off were 0.305 kt in 2015 in Estonia.

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

The *Tier 1* method was used to estimate emissions from the atmospheric deposition (Equation 5.37).

Equation 5.37[195]

$$N_2O_{(L)} - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM} + F_{OS}) \times Frac_{LEACH-(H)} \times EF_5$$

Where:

$N_2O_{(L)–N}$ = annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs, kg N_2O–N yr^{-1};
F_{SN} = annual amount of synthetic fertiliser N applied to soils in regions where leaching/runoff occurs, kg N yr^{-1};
F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils in regions where leaching/runoff occurs, kg N yr^{-1};
F_{PRP} = annual amount of urine and dung N deposited by grazing animals in regions where leaching/runoff occurs, kg N yr^{-1};
F_{CR} = amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually in regions where leaching/runoff occurs, kg N yr^{-1};
F_{SOM} = annual amount of N mineralised in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management in regions where leaching/runoff occurs, kg N yr^{-1};
$Frac_{LEACH-(H})$ = fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N (kg of N additions)$^{-1;}$
EF_5 = emission factor for N_2O emissions from N leaching and runoff, kg N_2O–N (kg N leached and runoff)-1 (Table 5.39).

[194] IPCC. (2000). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.
[195] IPCC 2006, Vol.4, Ch.11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, Equation 11.10, p.11.21.

5.5.4. Uncertainties and time-series consistency

Atmospheric deposition

The estimation of N_2O emissions from Atmospheric deposition was carried out based on activity data (synthetic fertilizers, organic amendments applied to soils, urine and dung deposited by grazing animals) and emission factors.

Nitrogen (N_2O) emission factor was used from IPCC, 2006. IPCC Guidelines give the factor at 0.01 with a range 0.002–0.05.

Nitrogen leaching and run-off

The estimation of N_2O emissions from Nitrogen leaching was carried out based on activity data (synthetic fertilizers, organic amendments applied to soils, urine and dung deposited by grazing animals and crop residues) and emission factors (fraction of the synthetic fertilizers, organic amendments applied to soils, urine and dung deposited by grazing animals, crop residues and nitrogen lost to leaching and surface run-off and N_2O emission factor).

N_2O emission factor is reported from IPCC 2006 GL. The value of the factor is 0.0075 with a range 0.0005–0.025 (Table 5.48).

Table 5.48. Estimated values of uncertainties used in Agriculture sector

Input	**Uncertainties**	**References**
Emission factors and fractions		
Fraction of synthetic N fertilizers that volatilizes as NH_3 and NO_x	0.03–0.3	IPCC 2006, Table 11.3, p-11.24
Fraction of organic N fertilizers applied, and dung and urine deposited by grazing animals that volatilizes as NH_3 and NO_x	0.05–0.5	IPCC 2006, Table 11.3, p-11.24
Emission factor (Atmospheric deposition)	0.002–0.05	IPCC 2006, Table 11.3, p-11.24
Emission factor (N leaching and run-off)	0.0005–0.25	IPCC 2006, Table 11.3, p-11.24
Fraction of the fertilizer and manure nitrogen lost to leaching and surface run-off	0.1–0.8	IPCC 2006, Table 11.3, p-11.24

5.5.5. Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.2.3.

The QC/QA plan for the Agricultural soils subsector includes the QC activities described in the IPCC 2006 Guidelines Volume 1, Chapter 6 and the activities listed in Volume 4, Chapter 11.2.3. The activities are carried out every year during the inventory. The QC check list is used during the inventory.

5.5.6. Category-specific recalculations

Indirect N_2O emissions from agricultural soils were revised do to recalculations under the Manure management subcategory (CRF 3.B) (see Chapter 5.4.7). The results of the recalculations are presented in Table 5.47.

Data on cultivated areas of organic soils (CRF 3.D.1.6) were updated in the framework of the NFI (see Chapter 6 LULUCF). Improvements were implemented in the calculations under the crop residues sub-category which influenced the indirect N_2O emissions from managed soils category.

5.5.7. Category-specific planned improvements

There are no planned category-specific improvements.

5.6. Field burning of agricultural residues (CRF 3.F)

Since 2004, the burning of crop residues was prohibited by an Estonian law[196]. Until the 2015 submission the default value of the fraction of the crop-residue burned had been used in the estimates of emissions, since to date there were no reliable quantitative data developed. IPCC good practice guidance suggests that an estimate of 10% of residue burned may be appropriate for developed countries, but also suggests that the default values: "are very speculative and should be used with caution. The actual percentage burned varies substantially by country and crop type. This is an area where locally developed, country-specific data are highly desirable"[197].

As no other official records of agricultural burning of crop residues exist in Estonia, then for the reporting period of 1990–2004 an inquiry to the Estonian Ministry of Rural Affairs was made and according to their best knowledge no widespread practice of agricultural residues burning has taken place during the reporting period or has been marginal as the generation of agricultural residues in the form of litter is scant and often insufficient to cover the demand for it. In the 2017 submission notation key NO has been applied for the whole time-series. It is feasible that Estonia had been overestimating its emissions for 1990–2006 by applying the IPCC $Frac_{Burn}$ default value in the previous submissions.

5.7. CO_2 emissions from liming (CRF 3.G)

5.7.1. Category description

In Estonia, annual precipitation exceeds evapotranspiration, causing calcium and magnesium carbonates to leach out from the surface levels of soil by percolating water. As a result of the leaching carbonates, soil becomes deprived of calcium and magnesium. Over 22% of arable land soils in Estonia are calcium-deficient and acidificated. To eliminate calcium-deficiency in field soils, quick-acting fine dusty limes are mainly applied[198]. Total CO_2 emissions from lime

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[196] Põllumajandusministri määrus nr 5, 20.04.2004, nr 57, 20.04.2007 and nr 20, 23.02.2011.
[197] IPCC 2000, Ch.4: Agriculture, p.4.89.
[198] Loide, V. (2010). Relieving the calcium deficiency of field soils by means of liming, Agronomy Research 8 (Special Issue II), pp. 415–420.

applied on agricultural land were 8.3 kt in Estonia in 2015, from which CO_2 emission from dolomite were 1.1 kt and 7.2 kt from limestone (Figure 5.32). Compared to the previous year, total emission has remained the same, but the dolomite emission level has increased and limestone emission has decreased 7%.

During 1992–1997 CO_2 emissions was considerably lower due to the economic transition and agricultural production decline. In 1998 investments in Estonian agriculture increased and agricultural land area and applied amount of lime also increased. CO_2 emissions from 1999 has declined from 25.8 kt to 8.3 kt in 2015.

5.7.2. Methodology, emission factors and activity data employed

The *Tier 1* (Equation 5.38) method was used to estimate CO_2 emissions from the liming of croplands. Activity data on agricultural land areas on which lime was applied was obtained from the Estonian Ministry of Rural Affairs for the period 1990–2008. Data about liming is not implicit, since it is based on applied agricultural subsidies only and liming performed at a landowner's own expense is left out of the statistics. However, the scope of liming carried out at a landowner's own expense is considered to be marginal according to the Estonian Ministry of Rural Affairs. Data about the average quantity of lime applied per one hectare (5 t/ha) was taken from a report published by the Estonian Research Institute of Agriculture[199]. Since 2009, Statistics Estonia has been collecting detailed data about the area and applied amount of liming. The area of liming has fluctuated widely over the years, depending significantly on government subsidies.

Equation 5.38[200]

$$\Delta C_{CC\ Lime} = M_{Limestone} \times EF_{Limestone} + M_{Dolomite} \times EF_{Dolomite}$$

Where:

$\Delta C_{CC\ Lime}$ = annual C emissions from agricultural lime application, tonnes C yr^{-1};
M = annual amount of calcic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$), tonnes yr^{-1};
EF = emission factor, tonnes C (tonne limestone or dolomite)$^{-1}$; these are equivalent to carbonate carbon contents of the materials (12% for $CaCO_3$, 12.2% for $CaMg(CO_3)_2$).

In order to estimate the fractions of different fertilizer types used for neutralization of acidic soils resulting in CO_2 emissions, data reported by E. Turbas[201] for the time period of 1990–2001 and the sales records obtained from Estonian Agricultural Board for the years 2002–2014 were applied, as until 2015 Statistics Estonia collected only aggregated data for lime used on Estonian agricultural lands. The amount of lime fertilizers applied on agricultural soils are reported in Annex A.3.2_VII.5.

199 Järvan, M. (2005). Põldude lupjamine, Eesti Maaviljeluse Instituut, Saku.
200 IPCC 2006, Vol.4, Ch.11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, Equation 11.12, p.11.27.
201 Turbas, E. (2000). Muldade lupjamise mõtte ja lupjamistööde arengust Eestis, Eesti Maaülikool, Tartu.

The emissions resulting from limestone application were calculated using the sales records of clinker dust, chalk and powdered limestone. The fraction of $CaCO_3$ in the cement clinker dust (40.48%) was received by personal request from the Estonian cement factory.

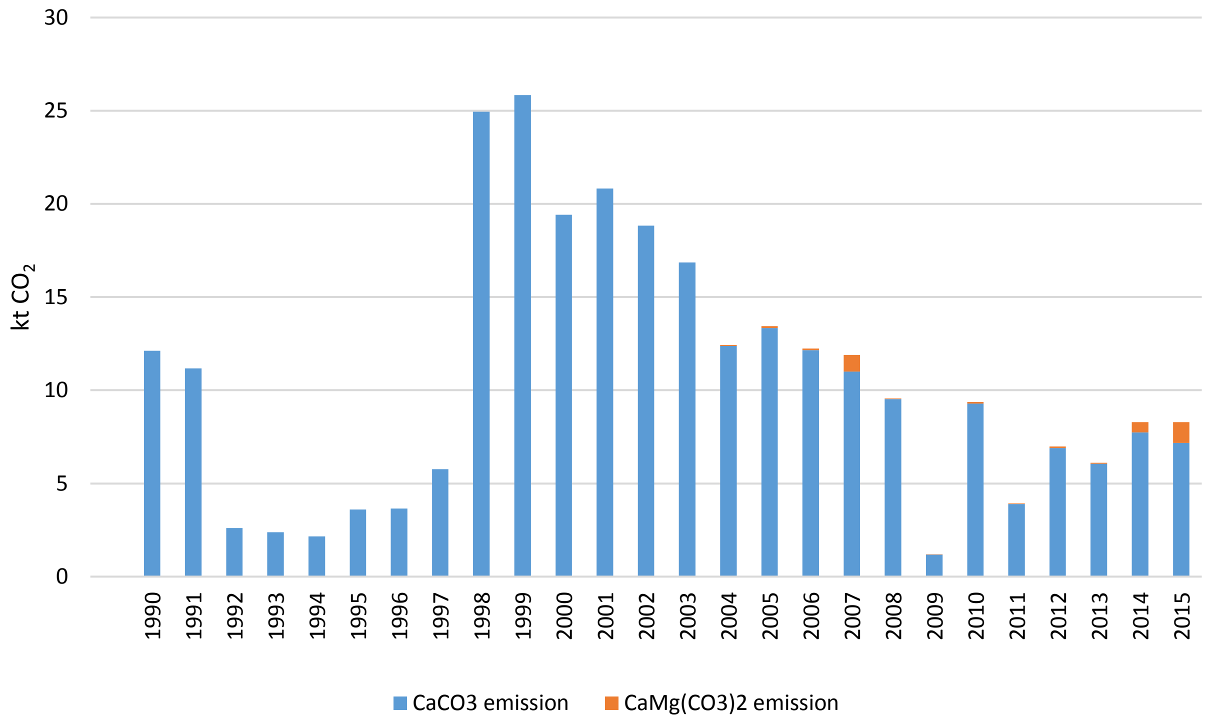

Figure 5.32. CO_2 emission from $CaMg(CO_3)_2$ and $CaCO_3$ in 1990–2015, kt

Yearly differences in the use of specific fertilizer type used for liming contribute to the CO_2 emission fluctuations in the time-series. No CO_2 emissions occur from the use of some lime fertilizers (oil shale ashes, ash) as they do not contain inorganic carbon (Table 5.49).

Table 5.49. Amounts of lime fertilizers applied on the fields 1990–2015, kt/yr

	1990	**1995**	**2000**	**2005**	**2010**	**2015**
Clinker dust	68	13.4	39.1	42.5	31.5	2.9
Chalk	NO	NO	NO	NO	NO	3.2
Powder limestone	NO	2.7	28.3	13.1	8.3	12.0
Oil shale ash	68	8.7	NO	NO	NO	9.3
Ash	NO	NO	NO	NO	7.9	2.2
Powder dolomite	NO	NO	NO	0.2	0.2	2.3
Total	136	24.8	67.4	55.8	47.9	31.9

5.7.3. Uncertainty and time series consistency

CO_2 emissions from liming are estimated according to and IPCC 2006. Activity data was obtained from the Estonian NFI, national statistics and the Ministry of Rural Affairs, emission factors were employed from the IPCC 2006 and uncertainties from GPG-LULUCF 2003. The uncertainty rates of activity data and the emission factors used are reported in Table 5.50.

Table 5.50. Uncertainties in Liming category

IPCC category		Uncertainties %		EF References
		Activity data[202]	Emission factors	
5.B\5(IV)	CO_2 emissions from agricultural lime application	29.15	50.00	LULUCF GPG 2003

5.7.4. Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.2.3.

The QC/QA plan for the Liming subsector includes the QC activities described in the IPCC 2006 Guidelines Volume 1, Chapter 6 and the activities listed in Volume 4, Chapter 11.3.5. The activities are carried out every year during the inventory. The QC check list is used during the inventory.

5.7.5. Category-specific recalculations

Compared with previous submission, type of lime applied to agricultural lands used in CO2 estimations were separated into calcic limestone ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$). This methodological change resulted in CO_2 emission recalculations using EF=12% for limestone and EF=12.2% for dolomite (Figure 5.33).

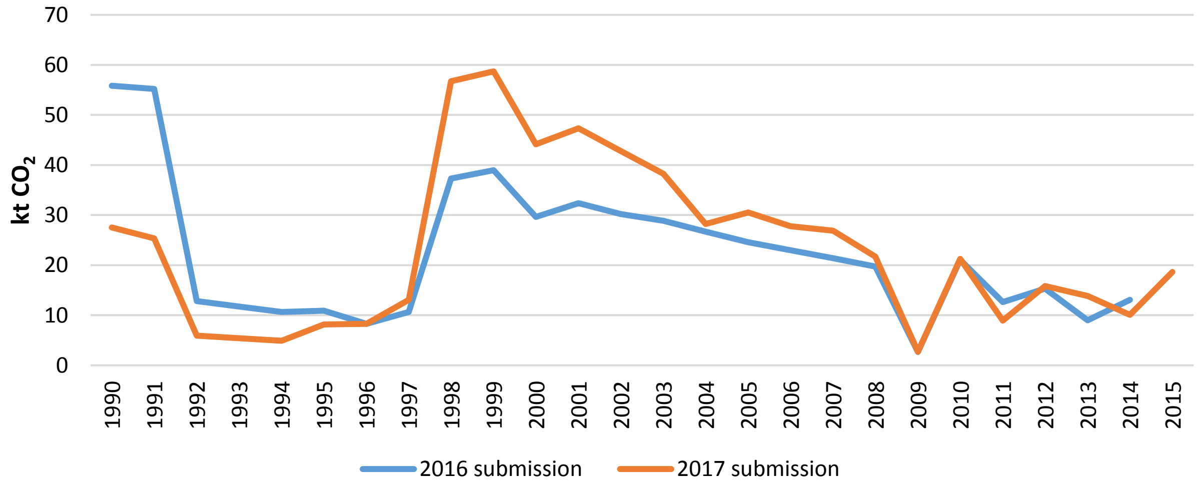

Figure 5.33. Results of the recalculations in Liming subcategory, kt

5.7.6. Category-specific planned improvements

There are no planned category-specific improvements.

[202]All activity data uncertainty estimates are obtained from NFI.

5.8. Urea application (CRF 3.H)

5.8.1. Category description

Adding urea to soils during fertilisation leads to a loss of CO_2 that was fixed in the industrial production process. Urea ($CO(NH_2)_2$) is converted into ammonium (NH_4+), hydroxyl ion (OH-), and bicarbonate (HCO_3-), in the presence of water and urease enzymes. Emissions range from 0.009 to 2.95 kt CO_2 per year (Figure 5.34).

5.8.2. Methodology, emission factors and activity data employed

Equation 5.39[203]

$$CO_2\ Emission = M \times EF \times \frac{44}{12}$$

Where:

CO_2–C Emission = annual C emissions from urea application, tonnes C yr^{-1} ;
M = annual amount of urea fertilisation, tonnes urea yr^{-1};
EF = emission factor, tonne of C (tonne of urea)$^{-1}$ IPCC 2006 GL default value of 0.20 is applied.

An approximate estimate of the amount of urea applied to soils on an annual basis is obtained using domestic production records and import/export data and Equation 5.39 (see also Annex A.3.2_VII.6). In compliance with the IPCC 2006 Guidelines it can be assumed that all urea fertilizer produced or imported annually minus annual exports is applied to soils[204]. Emission estimation were compiled on the basis of the only urea fertilizer producer LLC Nitrofert in Estonia and import-export statistical data provided by SA. In 2011, 2012 and 2014–2015 there was no production of urea fertilizers in Estonia nor did the records of SA show urea based fertilizer import activity, therefore emission estimations for the years with absent data have been made using urea fertilizer marketing data provided by the Estonian Agricultural Board.

[203] IPCC 2006, Vol.4, Ch.11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, Equation 11.13, p.11.32.
[204] IPCC 2006, Vol.4, Ch.11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, p.11.34.

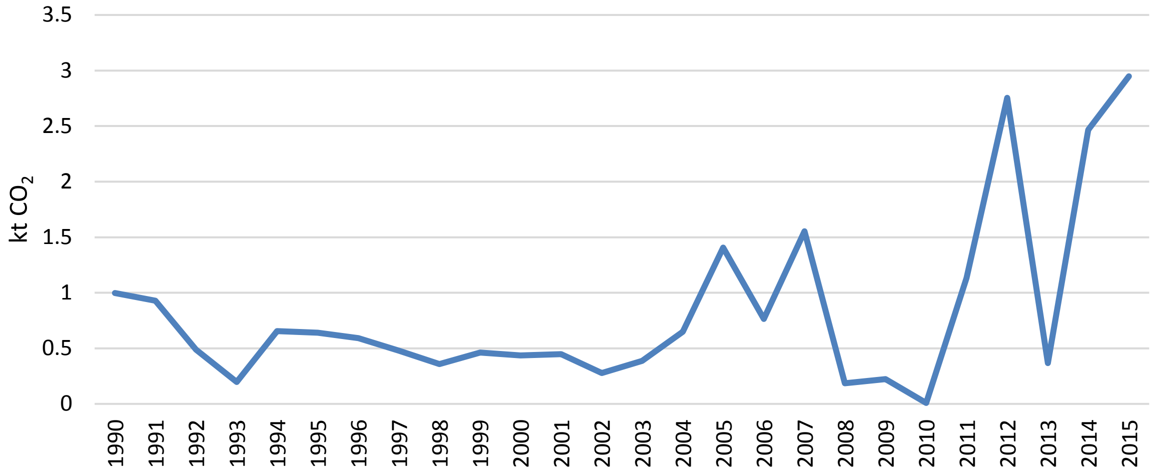

Figure 5.34. CO_2 emissions from urea fertilizer application, kt

5.8.3. Uncertainties and time-series consistency

For uncertainty of the emission factor, default values (-50%) associated with the EF specified in the 2006 IPCC Guidelines were applied. For activity data, 2% of weighing uncertainty for the urea fertilizer sales records of LLC Nitrofert were applied in the calculations.

5.8.4. Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.2.3.

The QC/QA plan for the Urea application subsector includes the QC activities described in the IPCC 2006 Guidelines Volume 1, Chapter 6 and the activities listed in Volume 4, Chapter 11.4.5. The activities are carried out every year during the inventory. The QC check list is used during the inventory.

5.8.5. Category-specific recalculations

In previous submissions CO_2 emissions were not reported" for 2011, 2012 and 2014. In the 2017 submission approximate CO_2 emissions have been estimated on the basis of urea-based fertilizers marketing data for 2011-2012 and 2014-2015. Updated emissions are presented in Table 5.51

Table 5.51. Reported CO_2 eq. emissions in 2016 and 2017 submissions in Urea application sub-category, kt

Urea application	2011	2012	2014
2017 submission	1.133	2.753	2.465
2016 submission	NO	NO	NO

5.8.6. Category-specific planned improvements

There are no planned category-specific improvements.

6. LAND USE, LAND USE CHANGE AND FORESTRY (CRF 4)

6.1. Overview of the sector

6.1.1. Description and quantitative overview

The methodology used to calculate emissions and removals from the Land use, land-use change and forestry sector follows the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006). Guidelines for LULUCF suggests the use of six top-level land categories (Forest land, Cropland, Grassland, Wetlands, Settlements, Other land), divided into Land remaining in the land-use category and Land converted to another land use category. Harvested wood products (HWP) constitute a component of the carbon cycle for which carbon stock changes can be estimated, based on national-level data. Since the 2011 submission, thearea of Estonia has been reported using *Approach 2* method that allows to track land-use transitions between categories.

In 2015, LULUCF sector acted as a CO_2 sink, resulting in net carbon uptake about 2 359.23 kt CO_2 equivalent, meaning that total removals arising from the sector exceed total emissions.

In the 2017 annual submission Estonia reports emissions and removals in the following subcategories:

- Forest land (CRF 4.A): emissions/removals from/by Forest land living biomass, dead wood, litter (only to FL), mineral and organic soils, non-CO_2 emissions from wildfires;
- Cropland (CRF 4.B): emissions from cultivated organic soils, mineral soils, emissions/removals from/by orchards' living biomass and N_2O emissions related to land conversion to cropland;
- Grassland (CRF 4.C): emissions/removals from/by grassland living biomass, dead wood, emissions from organic soils and non-CO_2 emissions from wildfires, emissions related to mineral soil and litter on land converted to grassland;
- Wetlands (CRF 4.D): CO_2, N_2O and CH_4 emissions from peat extraction, loss of living biomass and dead organic matter due to Forest land conversion to peatland/wetlands;
- Settlements (CRF 4.E): emissions related to Forest land, Cropland, Grassland and Other land conversion to settlements in living biomass, dead organic matter and soil carbon pools;
- Other land (CRF 4.F): emissions from Forest land, Cropland, Grassland and Wetlands conversion to other land; and
- Harvested wood products (CRF 4.G): emissions from Solid wood, Paper and paperboard and Semi-chemical wood pulp.

Estonia does not have currently country-specific emission factors for soils and litter for most of the land use categories. As an interim approach, carbon stock change estimates of these pools are based on emission factors from the Sweden National Inventory Report 2016[205]. Estonia has launched several projects aimed to get country-specific data regarding omitted pools for future submissions (see Chapters 6.2.6, 6.3.6 & 6.4.6 Category-specific planned improvements).

The *Tier 2* method has been applied to estimate carbon flows associated with living biomass and dead wood on land remaining and land-use change categories (Table 6.1) for the whole time series. Soil and litter estimates based on Swedish EF-s are also considered a *Tier 2* method. Country-specific emission factors were implemented for peatland emissions. Dead wood is estimated with the *Tier 2* method based on Estonia's own emission factors by Köster *et al.* (2015).

Table 6.1. Methods and emission factors used to estimate the emissions/removals of GHG in the LULUCF sector of Estonia

Greenhouse gases source and sink categories	CO_2		CH_4		N_2O	
	Method Applied	EF	Method Applied	EF	Method Applied	EF
A. Forest land						
Forest land remaining forest land	T1, T2	D, OTH, CS	NA	NA	NA	NA
Biomass burning	IE[206]	-	T2	D	T2	D
Land converted to forest land	T1, T2	D, OTH, CS	NA	NA	NA	NA
B. Cropland						
Cropland remaining cropland	T1, T2	D	NA	NA	NA	NA
Land converted to cropland	T1, T2	D	NA	NA	T1	D
C. Grassland						
Grassland remaining grassland	T1, T2	D, OTH, CS	NA	NA	NA	NA
Biomass burning	IE	-	T2	D	T2	D
Land converted to grassland	T1, T2	D, OTH, CS	NA	NA	NA	NA
D. Wetlands						
Wetlands remaining wetlands[207]	T2	CS	T2	CS	T2	CS
Biomass burning	IE	-	T2	D	T2	D
Land converted to wetlands	T2	CS	T2	CS	T2	CS
Non-CO_2 emission from drainage of soils and wetlands (Peatland)	T2	CS	T2	CS	T2	CS
E. Settlements						
Settlements remaining settlements[208]	NE	NA	NE	NA	NE	NA
Land converted to settlements	T2	OTH	NA	NA	NA	NA
F. Other land						
Other land remaining other land	NA	NA	NA	NA	NA	NA
Land converted to other land	T2	OTH	NA	NA	NA	NA
G. HWP						
Production approach	T2, T3	D, CS				

205 This approach is approved by ERT (FCCC/ARR/2012/EST para.94, 104; FCCC/ARR/2013/EST para. 63).
206 The stock-change method used for biomass estimates includes CO_2 loss from burning.
207 Wetlands are divided into unmanaged wetlands and peatland extraction. Emissions from unmanaged wetlands are not reported, since it is not mandatory according to IPCC GPG-LULUCF.
208 SS reporting is not mandatory.

EF – Emission Factor, NE – not estimated, NA – not applicable, IE – included elsewhere, T1 – *Tier 1* method , T2 – *Tier 2* method, T3 – *Tier 3* method, D – IPCC default, OTH – other, in the case of missing country-specific data, EF-s from Sweden were applied, CS – country specific.

The LULUCF sector inventory is carried out by the Estonian Environment Agency (EtEA), department of Data Management. Additionally, annual reports published by different institutions (EtEA, Ministry of Rural Affairs, Statistics Estonia (SE) etc.; see Table 6.2) have been used in the estimation of carbon fluxes related to the LULUCF sector.

Table 6.2. List of institutions (datasets) involved in the inventory of the LULUCF sector

References	Link	Abbreviation	Activity
Estonian Environment Agency	http://www.keskkonnaagentuur.ee/en	EtEA	- collecting and providing data for the National Forest Inventory - collecting and providing data on land use categories (Forest land, Cropland, Grassland, Wetlands, Settlements, Other land, HWP) - collecting and providing data on land use changes (including AR and D areas) - collecting and providing data on Forest land, Grassland and Cropland woody biomass and dead wood stocks - areas of peat extraction in 1990–2015 - wildfires inventory in field (started 2012) - area and amount of storm-damaged forest
Estonian Rescue Service; State Forest Management Centre	www.rescue.ee/ www.rmk.ee/en	ERS; SFMC	- collecting and publishing data on forest fires (location, type, cause etc)
Statistics Estonia	www.stat.ee/en	SE	- area of orchards - area of storm damaged forest - HWP foreign trade and production data
Estonian Peat Association	www.turbaliit.ee	-	- providing data on peat extraction
The Agricultural Research Centre; Estonian Crop Research Institute	www.pmk.agri.ee/en http://www.etki.ee/index.php/eng/	ARC; ECRI	- providing *know-how* for calculating Cropland mineral soil emissions
Estonian Land Board	www.maaamet.ee	ELB	- collecting and providing additional data on land areas

The areas of land use defined in accordance with the IPCC land use definitions are reported in Table 6.3. Peat extraction sites are a part of Wetlands and generally the area of Wetlands include both peatlands and inland water bodies if not stated otherwise.

Land-use changes are tracked on NFI sample plots that cover the whole country and are re-inventoried in every fifth year. Formerly, the NFI registered only the present type of land use, while starting from 2009, the transition of land-use is determined on each sample plot as well and assessed in retrospect for the past 20 years if necessary.

All area estimates are being re-estimated annually in the GHG inventory due to the method used by the National Forest Inventory (NFI). In 1999 the National Forest Inventory (NFI) was established, and since then the estimations are obtained from annual field inventory. To obtain data for the period 1990–1998 NFI data is extrapolated. The sampling design of the Estonian NFI and the method of estimation of land-use changes are described in subchapter 6.1.3. For the 2017 submission a large scale methodological updates and improvements were conducted. This improvement influenced the most the standing volume calculations for Forest land and for Grassland and a more thorough explanation is given in NFI Chapter 6.1.3.

Table 6.3. The area of different land use classes in 1990[209]–2015 (NFI), 1000 ha

	Forest land	**Cropland**	**Grassland**	**Unmanaged wetlands**	**Peatland (Wetlands)**	**Flooded wetlands**	**Settlements**	**Other land**
1989	2 316.2	1 112.8	306.2	404.8	16.1	6.2	313.6	57.6
1990	2 318.2	1 112.2	305.7	404.7	16.1	6.2	313.2	57.2
1991	2 321.5	1 110.7	305.0	404.7	16.1	6.2	312.9	56.5
1992	2 326.0	1 108.5	304.1	404.5	16.1	6.2	312.5	55.7
1993	2 331.7	1 105.1	303.4	404.3	16.1	6.2	312.1	54.6
1994	2 337.2	1 100.9	303.9	403.8	15.9	6.2	311.8	53.8
1995	2 342.9	1 095.9	304.8	403.3	15.8	6.2	311.6	53.0
1996	2 349.0	1 090.3	305.9	402.9	15.7	6.2	311.3	52.3
1997	2 355.2	1 083.9	307.8	402.6	15.5	6.2	311.0	51.4
1998	2 361.4	1 077.6	309.8	402.4	15.1	6.2	310.5	50.6
1999	2 368.1	1 071.7	311.0	402.3	14.8	6.2	309.9	49.4
2000	2 374.7	1 066.1	312.2	402.2	14.5	6.2	309.4	48.2
2001	2 380.6	1 061.5	313.0	401.9	14.0	6.2	309.1	47.1
2002	2 385.9	1 057.7	313.2	401.7	13.8	6.2	309.0	46.0
2003	2 391.4	1 054.2	312.4	401.4	13.6	6.2	309.5	45.0
2004	2 396.4	1 051.0	311.0	401.0	13.5	6.2	310.1	44.3
2005	2 401.2	1 048.4	308.7	400.8	13.4	6.2	311.0	43.9
2006	2 405.3	1 046.0	306.0	400.6	13.4	6.2	312.4	43.7
2007	2 409.0	1 044.0	303.0	400.3	13.5	6.2	314.0	43.6
2008	2 411.9	1 042.4	300.4	400.2	13.5	6.2	315.4	43.5
2009	2 414.0	1 041.4	297.6	400.0	13.7	6.2	317.0	43.5
2010	2 415.7	1 040.5	295.6	399.7	13.9	6.2	318.5	43.4
2011	2 417.4	1 039.7	294.0	399.6	14.0	6.2	319.5	43.1
2012	2 418.8	1 039.1	292.4	399.5	14.2	6.2	320.4	43.0
2013	2 419.7	1 038.8	291.0	399.5	14.4	6.2	321.0	42.9
2014	2 420.4	1 038.5	290.3	399.5	14.4	6.2	321.4	42.9
2015	2 420.7	1 038.3	289.7	399.5	14.4	6.2	321.7	42.9

[209] These are areas in the end of the year, e.g. 1989 is the area in 31.12.1989 and is applied as the initial area in 1990.

The net CO_2 emissions/removals of the Estonian LULUCF sector are presented in Figure 6.1. The main sink of CO_2 in Estonia is Forest land, constituting 51.9% of all LULUCF sector emissions in absolute values. Emissions and uptake from Forest land is predominantly determined by changes in forest growing stock.

Forest is the prevailing land-use category in Estonia. Due to the comparatively intensive use of forest resources, carbon flows derived from the forest category have the largest influence on the whole LULUCF sector's total carbon balance. From 1999 to 2004, the rate of logging was more than twice as high as in the previous 10 years and the harvest rate peaked in 2001, which can be explained by the outcome of land reform and the economic boom taking place in the early 2000s. In 1992, 2002 and 2006, extensive wildfires spread, having impact on the annual emissions of these years. Inter-annual variability in estimates is smoothed in the 2017 submission and further explanations are in the Chapter 6.1.3.

Figure 6.1, Figure 6.2 and Figure 6.3 show LULUCF sector emissions by gas during the period 1990–2015.

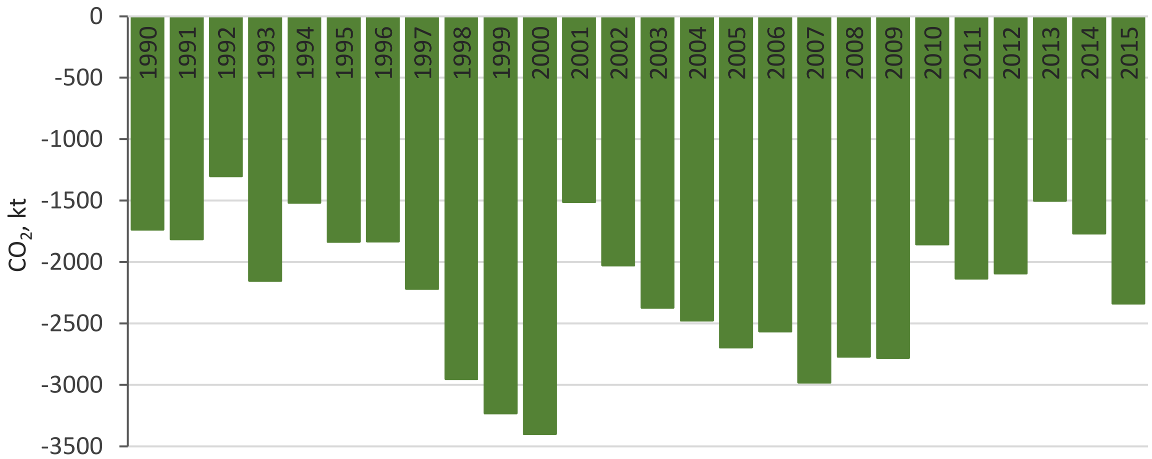

Figure 6.1. Annual change in emissions/removals of CO_2 from Estonian LULUCF sector in 1990–2015, CO_2 kt

Total quantities of CH_4 and N_2O emitted are presented in Figure 6.2 and Figure 6.3. CH_4 emissions originate from forest, grassland and wetland wildfires and peat extraction. N_2O emissions comprise emissions from Wildfires, Peatland management and Land conversion to cropland.

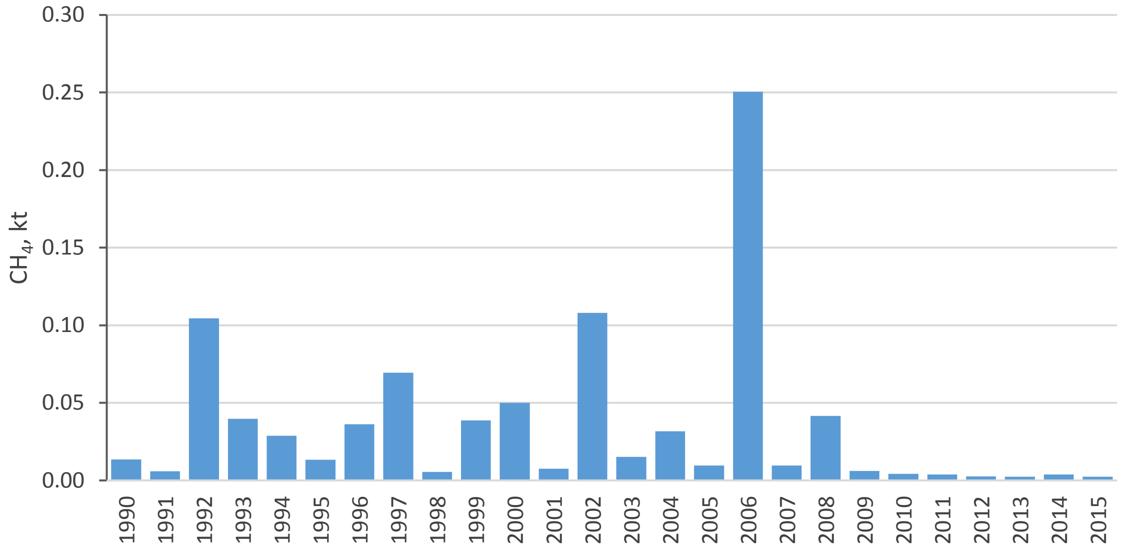

Figure 6.2. Emissions of CH_4 from the LULUCF sector in Estonia in 1990–2015, CH_4 kt

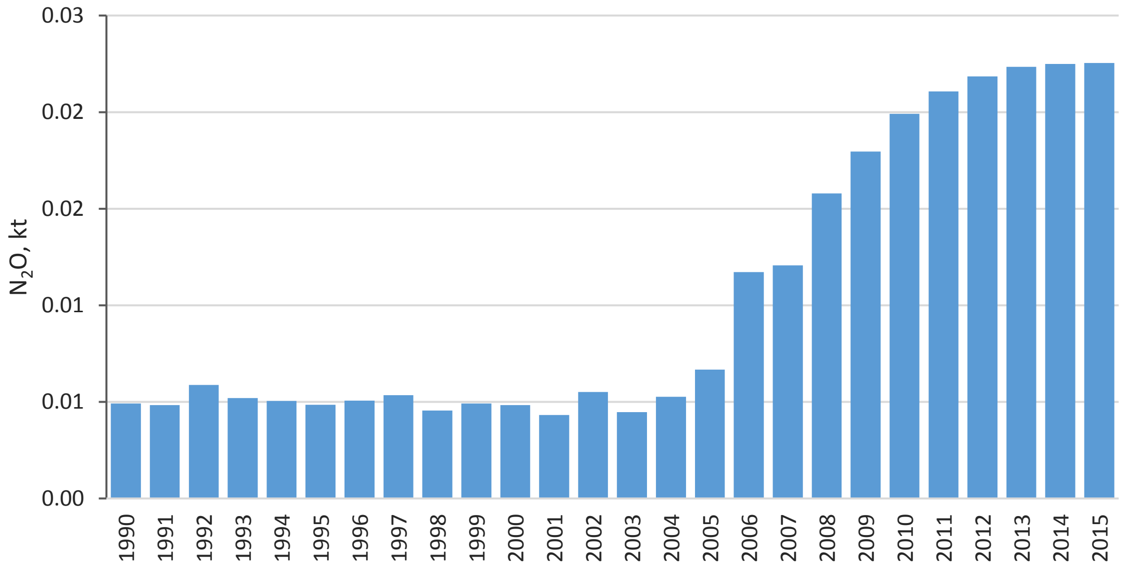

Figure 6.3. Emissions of N_2O from the LULUCF sector in Estonia in 1990–2015, N_2O kt

Large inter-annual differences in emissions of non-CO_2 gases are caused mainly by the unpredictable occurrence of Wildfires (see Chapter 6.8) and Land conversion to cropland (N_2O).

6.1.2. Land areas and land-use categories used in the Estonian inventory

LULUCF land categories presented in the inventory report are consistent with the land-use categories given in the IPCC LULUCF Guidelines (IPCC 2006) (Table 6.4). Area estimates for land-use categories are obtained from the NFI and carried out by the Forest Department of the Estonian Environment Agency.

The NFI is a systematic collection of forest information on randomly based sample plots that cover the whole country (Figure 6.4) and all land-use classes. The NFI also provides information on soils, distribution of mineral and organic soils as well as into drained and undrained land. The nationally classified NFI sample plots are reclassified into IPCC land-use categories (Table 6.6.6).

Table 6.4 gives an overview of land-use transitions between 31.12.1998 and 31.12.2015. The largest decrease in area has occurred among Croplands, most of which have turned into Grasslands due to lack of active management. Forest land has increased by 1.5% during the last 20 years. This change is mostly a result of reallocation of Grasslands to the Forest land category, when the tree crown cover of Grasslands exceeds 30% due to natural succession, then the land is counted as Forest land.

Table 6.4. The land-use change matrix for IPCC land-use categories from 31.12.1993 to 31.12.2015 (1 000 ha) Implementation of IPCC land-use categories in the Estonian inventory is described below.

	Initial						
Final	**FL**	**CL**	**GL**	**WL**	**SL**	**OL**	**Final area**
Forest land	2 296.6	41.2	49.4	10.4	7.7	15.3	2 420.7
Cropland	0.2	1 026.7	11.2	0.2	0.0	0.0	1 038.3
Grassland	6.5	39.7	240.3	0.6	1.6	1.1	289.7
Wetlands	2.4	0.0	0.6	415.6	1.3	0.0	420.1
Settlements	8.7	5.0	4.5	0.0	302.8	0.7	321.7
Other land	1.8	0.4	0.2	0.1	0.0	40.4	42.9
Initial area	**2 316.2**	**1 112.8**	**306.2**	**427.1**	**313.6**	**57.6**	4 533.5
Change since 1990	19.6	86.1	65.9	11.5	10.8	17.2	
Change 2014/1990%	4.3	-7.2	-5.7	-1.7	2.5	-34.2	

6.1.2.1. Forest land and definitions

Under the Kyoto Protocol, Parties are requested to make national parameter choices for the forest definition within the ranges allowed by Decision 16/CMP.1. Estonia established the 'definition of forest in the context of the Kyoto Protocol' in 2006 with the main parameters of the forest definition shown in Table 6.5. Estonia applies the same forest definition for both UNFCCC and KP reporting.

Table 6.5. Parameters for forest definition

Minimum tree crown cover	30%
Minimum land area	0.5 ha
Minimum tree height	2 m

The definition of forest has been amended several times in the Estonian Forest Act during the last 20 years. Since 2009 it stipulates forest land as land which meets at least one of the following requirements:

- forest land use is included in land cadastre; and
- has an area of 0.1 hectares of land, growing woody plants with a minimum height of 1.3 meters and the tree crown cover at least 30 percent.

To meet the requirements of UNFCCC and its Kyoto protocol reporting, the NFI is compiling statistical analyses based on both the national and the Kyoto Protocol definition of a forest regarding the minimum area of a forest. The NFI has been recording information on forests, which remain in the area between 0.1 ha and 0.5 ha due to the fact that criterion of 0.5 ha has been a minimum forest area in one of the earlier redactions of the Forest Act, thus there is activity data that is applicable for LULUCF reporting. The same information is used for estimating forest area according to the FRA (Forest Rights Act) definition.

The criterion of 1.3 m has caused some confusion in earlier greenhouse gas inventory reports; however it should be noted that it is not 'the minimum tree height' in context of the forest land definition. Actually, 1.3 m is the criteria for counting unstocked forest area as stocked forest. The minimum tree height *in situ* by the forest definition of the Forest Act is defined by tree species, the stand's age and site index. Thus, there is no constant criteria for tree height in the national definition. As there are no forest‒tree species in Estonia that could not reach the height of 2 m at maturity, the height criterion of the Kyoto Protocol forest definition has been met in NFI statistics.

All temporarily unstocked forest areas and regeneration areas which have yet to reach a crown density of 30 per cent and a tree height of 2 meters are also included as forest, as are areas which are temporarily unstocked as a result of human intervention such as harvesting, or natural causes (fires, etc.) but which are expected to revert to forest.

All forest land is considered managed in Estonia – the whole forest land in Estonia is or has been covered with forest management plans. In addition, protected forests are covered with the protection scheme.

6.1.2.2. Cropland

According to the definition used by the NFI, Cropland is 'arable land, area where annual or perennial crops are growing (incl. fallow, orchards, short-term and long-term cultural grasslands and temporary greenhouses)'. It does not include built garden land under 0.3 ha (that is included in Settlements).

Abandoned cropland is classified as Cropland until it has not lost arable land features – changes in soil and vegetation have not taken place and the land is still usable as cropland without the implementation of specific treatments.

The national definition corresponds to the IPCC classification.

6.1.2.3. Grassland

According to the national definition, this category includes rangelands and pasture land that is not considered Cropland nor Forest land: land with perennial grasses that is proper for mow and pasture, smaller fallows and former cultural grasslands that have lost arable land features and Grassland from wild lands (– 'natural grassland'). Overgrown wooded pasture with canopy cover between 30 and 50% is classified as Grassland or forest, depending on the main land-use purpose.

The national land cover class 'bushes' (– area covered with natural or wildered cultivated bush and shrub species where canopy cover is over 50%) is defined as IPCC Grassland[210].

6.1.2.4. Wetlands

Land permanently saturated by water and/or areas where the peat layer is at least 30 cm and the minimum potential tree height does not conform to the Forest land definition. It does include smaller bog holes.

The NFI Wetland areas are defined as IPCC Wetlands. Activity data is obtained from the NFI (for 1990–2015).

6.1.2.5. Settlements

Built-up areas, with roads, streets and squares, traffic and power lines, urban parks, industrial and manufacturing land, sports facilities, airports, legal waste down points, construction sites and buildings with up to 0.3 ha of garden yard (including permanent greenhouses), and open cast areas (except peat extraction areas) are reported under the Settlements land-use category (Table 6.3). Activity data on Settlements area is obtained from the NFI (for 1990−2015).

6.1.2.6. Other land

Land areas that do not fall into any of the other five land-use categories. Consistent with the IPCC Guidelines, this land-use category is used to allow the total of identified land areas to match the national area.

6.1.3. National Forest Inventory

The estimation of emitted/removed quantities of carbon is carried out based on data received in the process of the NFI. Until the 1990s, the national estimation of forest resources was based on stand-wise forest inventories. Regular inventories, every 10 years, were carried out on most of the forest land: state forest districts as well as the forests of collective and state farms. After independence was regained in Estonia in 1991, the ownership reform program was started. Part of it was land reform. Land, which had been unlawfully expropriated, was to be returned to its initial owners or to their descendants. Borders of the state forests were restored accordingly to the year 1940, and the remaining land was left for privatisation. Changes were carried out in forest survey too. The planned economy, which had existed for 50 years, was replaced by a market economy resulting in the intensive cutting of forests. As land reform was not quick enough (and is still continuing today), a situation arose such that valid, current information was available only for one-third of Estonian forests. Intensified forest management together with land reform created a need for new inventory methods.

The first National Forest Inventory covering the whole country commenced in 1999. With rather modest means the NFI is able to give a quite precise assessment of forest area, resources and cutting volume. The main objective of the NFI is to give a description of forests, but nowadays the NFI also gives information about subjects such as the distribution of land by land-use classes and the afforestation and growing stock of non-forest land etc.

[210] Area of bushes was reported under 'Other lands' until the 2009 submission. It was recommended by the ERT to include areas of bushes to 'Grassland' category.

In 2015 Estonian Land Board updated the coastline with Geographic information systems (GIS) data that lead to a total area increase of Estonia. Total land area of Estonia is updated to 45 335 km^2 (formerly known 45 227 km^2) and is used for NFI and GHG inventory starting from the 2017 submission.

Methodologically, the NFI is designed as an annual research effort, which, using optimal methods, must ensure the continuous updating of information and the forest database. An increased frequency network (starting from 2014)[211] of sample plots (Figure 6.4), covering the whole country, has been planned for five years with 20% or approximately 375 clusters (ca 5 500 sample plots) measured each year, so that permanent plots will be re-measured every 5 years. Point estimates of parameters are calculated using data from the sample plots and form the basis for inferences to the entire population.

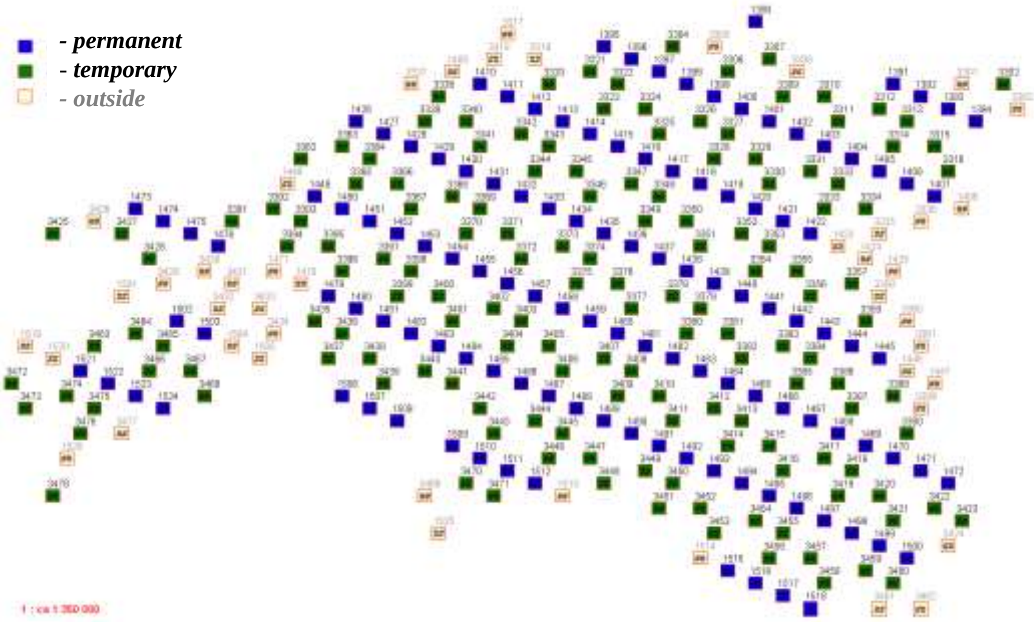

Figure 6.4. Cluster network of Estonian national forest inventory.

By 2001 the NFI assessments were used at the state level, as well as in compiling the strategic document "The Development Plan of Forestry until the Year 2010". Since that period the NFI has an important role in decision-making on the effective management of forests and future projections – in large-area forest management planning such as plan for cutting forests at the national level. At present, the actual themes of the NFI monitoring system include global carbon cycles and the observation of features related to the protection of biological diversity.

The Estonian NFI covers all land-use classes, including all forests and other wooded lands in all ownership groups, including protected areas. Assessments of the forest resource by the NFI have become the basis for national and international statistics in Estonia, such as the United Nations/FAO Forest Resources Assessment procedure, the Ministerial Conference on the Protection of Forests in Europe (MCPFE). The NFI also produces information on forest carbon pools and changes for the LULUCF reports under the United Nations Framework Convention on Climate Change.

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[211] In ARR2014, para 68, the ERT recommended to increase the sampling frequency

Statistical design of the Estonian NFI is a systematic sample without pre-stratification. No remote sensing is applied. The network of sample plots covers the whole country and is planned as a five-year cycle. The sampling grid is designed to meet the accuracy requirements at national level. The sampling intensity is the same throughout the whole country. The sample (cluster) distribution is based on a national 5-km x 5-km quadrangle grid, determined by the L-EST co-ordinates system.

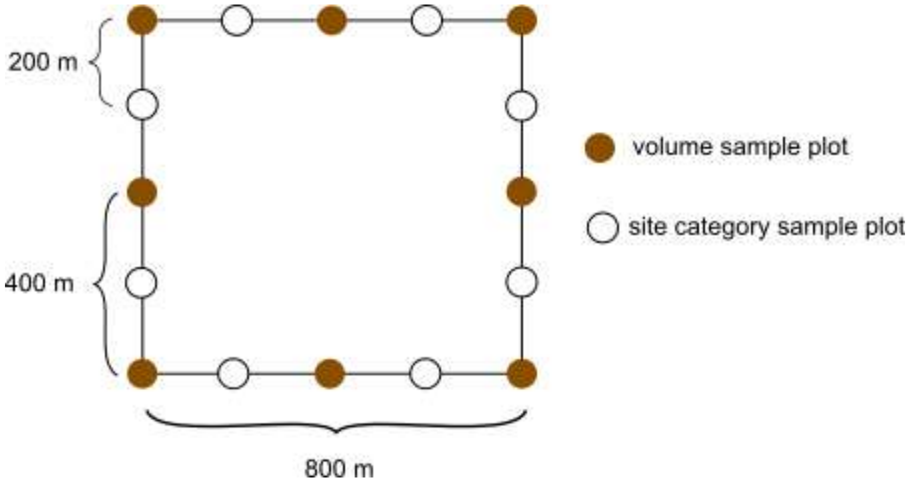

Figure 6.5. Estonian NFI cluster design.

Sample plots are organized into clusters (Figure 6.5) to increase the efficiency of the survey. An observation unit is an individual field plot that is the centre of sample circles with defined radii. The method of sampling with partial replacement is used. Plots are divided into permanent clusters and temporary clusters that form 800 x 800 metre squares. All the permanent clusters (sample plots) are re-measured every 5 years. The sample plot radius depends on the assessed variables, as well as their values, for example, tree diameter. In addition to plots with the main radii of 10 m and 7 m, where land-use class is determined, plots of other radii are also used.

All population units have equal probability of selection into the sample. The result is point estimates of multiple population parameters based on the measurement data. Although all NFI estimates are based on sampling, they are not absolute. Therefore, each estimate of a general parameter is always accompanied with a sampling error.

ERT has indicated several times[212,213,214] that Estonia needs to explore ways to reduce inter-annual variability in the carbon stock changes in living biomass. For the 2017 submission Estonia has implemented an improved average standing volume calculation that lead to significant recalculations of carbon stock changes in living biomass. Also an increased frequency sampling cycle data is being used for NFI calculations that further more change the overall outcome.

Starting from NFI 2015 average standing volume is calculated for every year based on 15-years trend. For previous submissions it was calculated based on five years measurements. Two

[212] ARR2012, para 98,

[213] ARR2013, para 66

[214] ARR2014, para 68

consecutive years are independent samples and average standing volume estimates have confidence intervals; therefore, the new methodology is statistically more accurate.

More detailed information about sampling scheme, design and density of sampling is described in the National Forest Inventories[215] (2010).

In order to collect data about land-use transitions, additional field studies started in 2009 in the framework of NFI. This methodology follows the example of the Finnish NFI. Collected data provides information on different land-use classes (origins retrospectively 20 years), the year of changes and also soil type. During land category registration, "LULUCF former land category" is registered on every sample plot if the land category has changed after base point (31.12.1989). The year of change is being estimated first directly in the field. Older maps and aerial photographs are used afterwards as supporting material to determine the exact year more accurately. Since 1999 there has been information available on permanent sample plots. The resulting data set is a matrix with previous and the current land-use classes in the timeline.

During field study soil types (mineral/organic) are also estimated. All sample plots are assessed with soil type ‚mineral' or ‚organic'. In case the former land category type differs from current one, soil type is estimated by the former land category.

The NFI determines more land categories than in the 2006 IPCC LULUCF, therefore some aggregation has been made, which is shown in Table 6.6. Not all national and IPCC land use categories have exact match, few national land-use categories can be forest land or grassland and it is specified in the field.

Table 6.6.6. National definitions for land-use categories and relevant land-use category defined in IPCC 2006

	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land
Forest land (M)	X					
Unstocked forest land (MM)	X					
Arable land (excluding PK, PR) (PM)		X				
Permanent crops (PK)		X				
Long-term cultural grassland (PR)		X				
Bushes (P)	X		X			
Natural grassland (RM)	X		X			
Swamp, bog (S)	X		X	X		
Inland water bodies (SV)				X		
Peat quarry (KT)				X		
Opencast pit (excl. KT) (K)					X	
Settlements (excl. T, TR) (A)					X	
Roads and railways (T)					X	
Lines, power lines etc. (TR)					X	
Unusable mineral land (KK)	X		X			X
Other land (Y)						X

[215] pp.177-183; http://www.springer.com/life+sciences/forestry/book/978-90-481-3232-4.

6.1.4. LULUCF cross-cutting issue: climate zones

According to GPG-LULUCF 2003 and IPCC 2006 Vol. 4, Estonia is near the transitional border of the boreal and cold temperate climatic zones, falling under the cold temperate moist climate designation. However, most recent reports (e.g. the State of Europe's Forests, 2011) and the statement by national biologists is that Estonian forest vegetation is typical to boreal forests, thus input values from the boreal zone is selected for Forest land category. Grasslands biomass parameters are also chosen from Boreal zone. All other land-use categories follow the default allocation by IPCC 2006.

The issue related to using emission factors from different climate zones was also raised by the Joint Research Centre of the European Commission during assistance[216] in 2013. Since soil, biomass and other parameter values for the abovementioned climate zones are significantly different, it may cause a large bias under land-use change estimates, when the lands are in different climate zones. However, this is not the case in the current report, as most land-use change emission factors for soil are obtained from the Swedish inventory report because Estonia does not currently have respective country-specific values. In some cases, e.g. Cropland mineral and organic soil, emission factors have the same value in both boreal and temperate zones[217].

Estonia assessed the impact of using temperate zone factors instead of the boreal zone for living biomass estimates[218]. The result was that CO_2 sink increased almost 2 fold, which is an obvious overestimation based on expert opinions and does not follow the UNFCCC recommended conservative approach. For those reasons, Estonia has decided to continue using boreal climate zone parameters in the Forest land category.

6.1.5. Key Categories

The key categories of the LULUCF sector are summarised in Table 6.7. The largest effect on the overall inventory was attributed by Forest land remaining forest land living biomass. The LULUCF sector constitutes 25% of the total inventory emissions in absolute values.

Table 6.7. Key categories in the LULUCF sector (CRF 4) in 2015 (Tier 1)

IPCC category		**Gas**	**Identification criteria**
4.A.1	Forest land remaining forest land - living biomass	CO_2	Level (1990, 2015), Trend
4.A.1	Forest land remaining forest land - mineral soils	CO_2	Level (1990, 2015), Trend
4.A.1	Forest land remaining forest land - organic soils	CO_2	Level (1990, 2015), Trend
4.A.1	Forest land remaining forest land - dead wood	CO_2	Level (1990, 2015), Trend
4.A.2.1	Cropland converted to forest land - mineral soil	CO_2	Level (2015), Trend
4.A.2.1	Cropland converted to forest land – dead wood	CO_2	Level (2015), Trend
4.A.2.2	Grassland converted to forest land - living biomass	CO_2	Level (2015), Trend
4.A.2.2	Grassland converted to Forest Land - dead wood	CO_2	Level (2015), Trend
4.A.2.2	Grassland converted to Forest Land - mineral soils	CO_2	Trend
4.B.1	Cropland remaining cropland - organic soils	CO_2	Level (1990, 2015), Trend
4.B.1	Cropland remaining cropland - mineral soils	CO_2	Level (1990, 2015), Trend

[216] ADMINISTRATIVE ARRANGEMENT Nº071201/2011/611111/CLIMA.A2 (Analysis of and proposals for enhancing, monitoring, reporting and verification of land use, land use change and forestry in the EU - LULUCF MRV).
[217] IPCC 2006, Vol 4 (AFOLU), Table 5.5 & Table 5.6, p. 5.17-5.19.
[218] Kaie Kriiska, LULUCF leading expert, Estonian Environment Agency, 2014.

IPCC category		Gas	Identification criteria
4.B.2.2	Grassland converted to cropland - mineral soils	CO_2	Level (2015), Trend
4.B.2.2	Grassland converted to cropland - organic soils	CO_2	Trend
4.C.1	Grassland remaining grassland - organic soils	CO_2	Level (2015), Trend
4.C.2	Land converted to grassland - mineral soils	CO_2	Level (2015), Trend
4.C.2	Land converted to grassland - organic soils	CO_2	Level (2015), Trend
4.C.2	Land converted to grassland - living biomass (excl. FL)	CO_2	Trend
4.C.2.1	Forest land converted to grassland – dead wood	CO_2	Trend
4.C.2.1	Forest land converted to grassland - living biomass	CO_2	Level (2015), Trend
4.D.1	Wetlands remaining wetlands\peatland - organic soils managed for peat extraction	CO_2	Level (1990, 2015), Trend
4.E.2.1	Forest land converted to settlements - living biomass	CO_2	Level (2015), Trend
4.E.2.1	Forest land converted to settlements – dead wood	CO_2	Level (2015), Trend
4.E.2.1	Forest land converted to settlements (min+org soils)	CO_2	Level (2015), Trend
4.E.2.2	Cropland converted to settlements - soils	CO_2	Level (2015), Trend
4.E.2.3	Grassland converted to settlements - soils	CO_2	Level (2015), Trend
4.G	Harvested wood products - Wood panels and sawnwood	CO_2	Level (2015), Trend
4.G	Harvested wood products - Semi-chemical wood pulp	CO_2	Trend

6.2. Forest land (CRF 4.A)

6.2.1. Category description

The Forest land category constitutes about 51.9% of all LULUCF sector emissions and removals. The net removal from Forest land was 2 475.37 kt CO_2 eq. in 2015 (Figure 6.6). Estimations include emissions and removals from living biomass, dead organic matter, mineral and organic soils and biomass burning.

Figure 6.6. Annual net change in CO_2 removals (-) from Forest land category in 1990–2015, kt CO_2 eq.

6.2.2. Methodological issues

The carbon stock change in category 4.A.1 Forest land remaining forest land is given by the sum of changes in above- and below-ground biomass, dead wood, litter, soils and harvested wood product. The algorithm employed in order to estimate carbon flows related to 'Forest land remaining forest land' is presented below:

Equation 6.1[219]

$$\Delta C_{LB_i} = (\Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{LI} + \Delta C_{SO} + \Delta C_{HWP})$$

Where:

ΔC_{LBi} = carbon stock change for a stratum of land-use category;
AB = above-ground biomass;
BB = below-ground biomass;
DW = deadwood;

[219] IPCC 2006, Vol 4 (AFOLU), Equation 2.3, p 2.7.

LI = litter;
SO = soils;
HWP = Harvested wood products.

Equation 6.1 is also used for calculations in land converted to Forest land subcategory.

6.2.2.1. Change in carbon stocks in living biomass

For estimating carbon stock changes in biomass under the Land remaining forest land category, the *Tier 2* approach and *Method 2* – the stock-difference method (Equation 6.2) was applied. The NFI annually provides data for growing stock and area for Forest land remaining forest land, also on Land converted to forest land.

It should be noted that the stock change method also comprises carbon loss from biomass burning, thus CO_2 emissions from burning are not presented separately, but included in general carbon stock change figures. However, CH_4 and N_2O emissions from biomass burning on forest areas have been estimated (Chapter 6.8).

A net carbon stock change is the output of the stock-difference method, therefore gains and losses are not listed separately neither in the CRF reporter nor in the NIR[220].

Equation 6.2[221]

$$\Delta C_{FF_{LB}} = \Delta C_B = (C_{t_2} - C_{t_1}) / (t_2 - t_1)$$

and

$$C = \sum_{i,j} \left\{ A_{i,j} \bullet V_{i,j} \bullet BCEF_{S_{i,j}} \bullet \left(1 + R_{i,j}\right) \bullet CF_{i,j} \right\}$$

Where:

ΔC_B = annual change in carbon stocks in biomass (the sum of above- and below-ground biomass) in Land remaining in the same category, tonnes C yr^{-1};
C_{t2} = total carbon in biomass calculated at time t_2, tonnes C;
C_{t1} = total carbon in biomass calculated at time t_1, tonnes C;
A = area of Land remaining in the same land-use category, ha;
V = merchantable growing stock volume, m^3 ha^{-1};
i = ecological zone i;
j = climate domain j;
$BCEF_S$ = biomass conversion and expansion factor for expansion of merchantable growing stock volume to above-ground biomass, tonnes above-ground biomass growth (m^3 growing stock volume)$^{-1}$ (Table 6.8); $BCEF_S = BEF_S \cdot D$;
R = ratio of below-ground biomass to above-ground biomass, tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$ (Table 6.9);
CF = carbon fraction of dry matter (default = 0.47), tonnes C (tonne d.m.)$^{-1}$.

Equation 6.2 is also used for the calculations of carbon stock changes in living biomass under the Land converted to forest land subcategory.

[220] In ARR2013, para 59, the ERT encouraged to separate carbon stock gains and losses except in cases where, due to the methods used, it is technically impossible.
[221] IPCC 2006, Vol 4 (AFOLU), Equation 2.8, p 2.12.

In Forest land category, the boreal climatic zone default IPCC parameter values are applied (see Chapter 6.1.4 for more information).

Table 6.8. Implemented values of $BCEF_S$[222]

Boreal	Growing stock level (m^3)			
Forest type	< 20	21-50	51-100	> 100
pines	1.20	0.68	0.57	0.50
firs and spruces	1.16	0.66	0.58	0.53
hardwoods	0.90	0.70	0.62	0.55
Weighted average $BCEF_S$	FL rem FL		0.56	
	CL to FL		0.97	
	GL to FL		0.68	
	WL to FL		1.01	
	SL to FL		0.98	
	OL to FL		0.98	

Weighted average $BCEF_S$ values were calculated for Land remaining forest land and for each land-use conversion to forest separately, depending on the distribution of tree species, age class and growing stock level.

Weighted average R values were calculated based on tree species distribution and above-ground biomass. Land converted to forest land subcategories were divided to human induced (CL to FL, WL to FL, SL to FL = AR) and natural regeneration (GL to FL, OL to FL) classes.

Table 6.9. Default values of root-to-shoot ratio R[223]

	Land remaining forest land		Land converted to forest land	
Domain	Above-ground biomass, t/ha	Root-shoot ratio R	Above-ground biomass, t/ha	Root-shoot ratio R
Boreal coniferous forest	> 75	0.24	< 75	0.39
Temperate, other broadleaf forest	75–150	0.23	< 75	0.46
Weighted average		0.236		Human induced 0.39 Natural 0.42

In order to ensure that actual carbon stock changes are reported, and not artefacts resulting from changes in area over time, ERT[224] recommended implementing calculations of carbon stock changes in the following sequence as set out in the IPCC good practice guidance for LULUCF (Chapter 4.2.3.2): i) for each given area the carbon stock change is first calculated as a

[222] IPCC 2006, Vol 4 (AFOLU), Table 4.5, p. 4.50.
[223] IPCC 2006, Vol 4 (AFOLU), Table 4.4, p. 4.49.
[224] ARR2012, para. 97.

difference of carbon stocks between times t_1 and t_2, ii) these stock changes are summed for all areas.

It was also a recommendation of ERT to implement $BCEF_S$ values from the IPCC 2006[225].

6.2.2.2. Annual change in carbon stock due to biomass changes in Forest land

In Estonia, total forest area increased 102.5 kilo hectares by 2015 in comparison to the base year. The distribution of the main tree species on Forest land remaining and Land converted to forest land is presented in Table 6.10.

Table 6.10. Distribution of tree species on FL rem FL and to FL[226]

Tree species	Land remaining forest land	Land converted to forest land	
		Human induced	Natural regeneration
Pinus sylvestris	0.315	0.43	0.18
Picea abies	0.238	0.53	0.11
Betula	0.220		
Populus tremula	0.078		
Alnus glutinosa	0.046		
Alnus incana	0.066		
Other	0.036	0.05 (mainly *Betula*)	0.7 (broadleaf)

In Table 6.11 the cumulative area and proportion of Land use changes to forest land in 2015 are shown, as well as applied emission factors for mineral and organic soils. In the case of missing or insufficient country-specific data, emission factors from the Sweden 2015 annual submission were implemented with the agreement of ERT[227].

Table 6.11. Cumulative Land use changes to forest land in 2015 and implemented soil emission factors[228]

Land-use change	kha	%	EF mineral soil kt C ha^{-1}	EF organic soil kt C ha^{-1}
Cropland→ Forest land	33.9	31%	-0.85	-6.1
Grassland→ Forest land	42.1	41%	-0.225	-0.3
Wetlands→ Forest land	9.1	8%	-	-0.3
Settlements→ Forest land	5.7	5%	0.158	-0.3
Other land→ Forest land	11.6	11%	0.158	-0.3
Total	102.5	100%		

225 ARR2012, para.126.
226 Sims, A. (Forest statistics by NFI, 2016).
227 ARR2012, para 94.
228 All EF-s for organic and mineral soils are taken from the Swedish 2015 annual submission, except CL→FL mineral soil, that is based on the Tier 1 method implemented with Estonia's country-specific data.

Data presented in Figure 6.7 characterizes carbon stock changes in living biomass under Land remaining forest land and Land converted to forest land in 1990–2015. The estimation for 1990–1998 is based on interpolated data, since no exhaustive forest statistics were carried out during these years. The National Forest Inventory that covers the whole country started in 1999. Harvest rate is the main driver behind the carbon stock and result of the biggest harvest rate in Estonia that was driven by the economic boom in Estonia. Significant changes compared to the previous submission are due to NFI recalculations that are explained in Chapter 6.1.3.

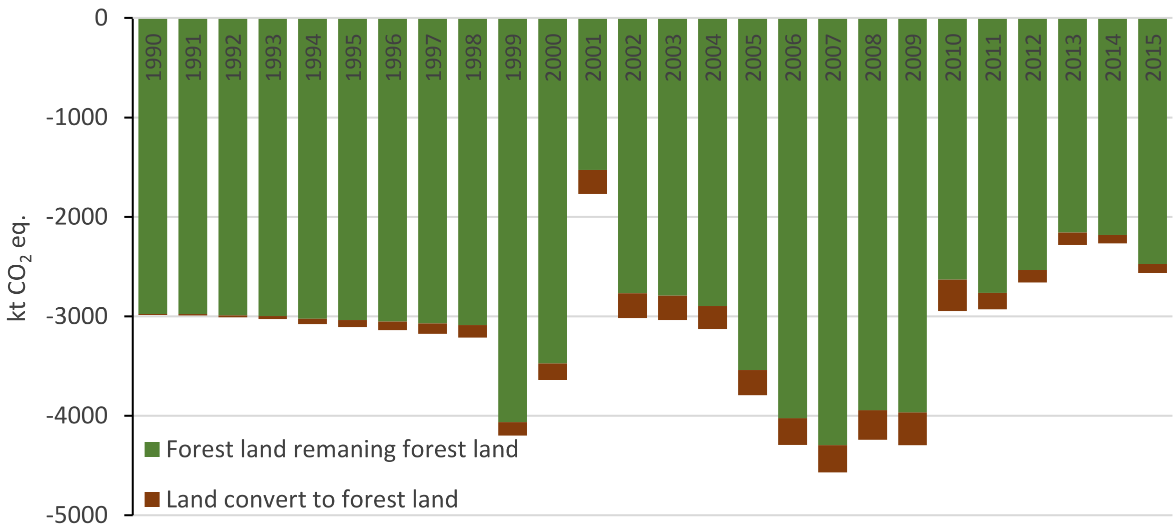

Figure 6.7. Annual carbon stock change in Forest land living biomass in 1990–2015, kt CO_2 eq.

6.2.2.3. CO_2 emissions/removals from/by dead wood

For estimating carbon stock changes in the dead wood pool, the *Tier 2* and stock change method was applied. The NFI annually provides data about the volume of dead wood for the entire forest area (Land remaining and conversion to forest land). Carbon stock change in the dead wood pool was calculated following Equation 6.3. The annual stock is first converted to stock per area, after which the equation can be applied in order not to confound the estimates of carbon stocks and stock changes due to differences in area. Also inter-annual fluctuations in the carbon stock changes in the dead wood pool were reduced by using smoothed data from NFI. Values of dead wood densities for different tree species were acquired from Köster *et al*, 2015[229].

Equation 6.3[230]

$$\Delta C_{FF_{DOM}} = \left[A \bullet \left(DOM_{t2} - DOM_{t1}\right)/T\right] \bullet CF$$

Where:

[229] Köster, K., Metslaid, M., Engelhart, J., Köster E. 2015. Dead wood basic density, and conventration of carbon and nitrogen for main tree species in managed hemiboreal forests. Forest Ecology and Management 354, p. 35-42.
[230] IPCC 2006, Equation 2.19, p 2.23.

$\Delta C_{FF\ DOM}$ =	annual change in carbon stocks in dead wood in Forest land remaining forest land, tonnes C yr^{-1};
A =	area of managed Forest land remaining forest land, ha;
DOM_{t1} =	dead wood stock at t_1 for managed Forest land remaining forest land, tonne d.m. ha^{-1};
DOM_{t2} =	dead wood stock at t_2 (the previous time) for managed Forest land remaining forest land, tonne d.m. ha^{-1};
T = (t_2-t_1) =	time period between time of the second stock estimate and the first stock estimate, yr;
CF =	carbon fraction of dry matter (default = 0.47), tonnes C (tonne d.m.)$^{-1}$.

Equation 6.3 is also used for estimating dead wood stock change in the Land converted to forest land subcategory.

Figure 6.8 illustrates annual dead organic matter stock changes on Land remaining forest land and Land converted to forest land. Significant changes compared to the previous submission are due to NFI recalculations that are explained in Chapter 6.1.3.

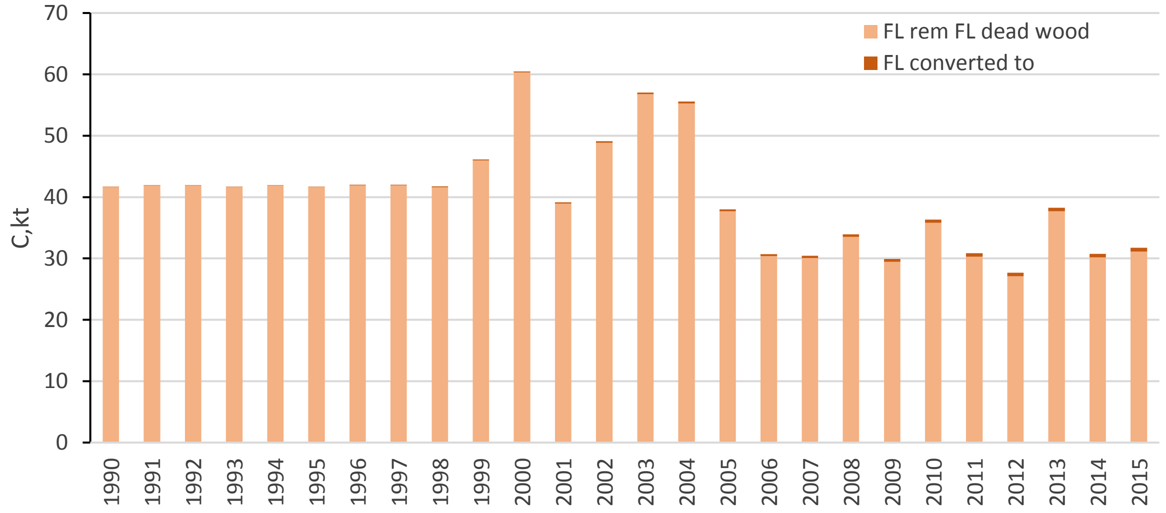

Figure 6.8. Net carbon stock change in forest dead organic matter pool 1990–2015, kt C

6.2.2.4. CO_2 emissions/removals from/by litter

Estonia does not have sufficient data regarding litter stocks, thus under Forest land remaining forest land, the *Tier 1* method was implemented, assuming that carbon stocks are in equilibrium, thus the changes in the litter pool are assumed to be zero. Under Land conversion to forest land, the emission factor from Sweden[231] (0.3 kt C ha^{-1} yr^{-1}) is used for litter, maintaining consistency between the Convention and KP-LULUCF reporting. It was also possible to apply the Swedish EF of litter on Land remaining forest land, but it would have resulted in a carbon increase in the pool. Therefore Estonia decided to implement a more conservative approach, i.e. *Tier 1*, assuming no change in the pool.

[231] Sweden NIR 2016, Annexes, Table A 3:2.11, p. 105

6.2.2.5. CO_2 emissions/removals from/by mineral forest soils

Due to insufficient country-specific data regarding carbon stock changes in forest mineral soil, the emission factor from Sweden[232] (0.14 kt C ha^{-1} yr^{-1}) was implemented for Land remaining forest land. For the conversion categories, EF-s from Sweden were applied as well (Table 6.11), except for Cropland conversion to forest land, where *Tier 1* and national SOC_{REF} stocks are applied (Table 6.13).

In 2015, there was a net increase in the carbon stock of forest mineral soils by 214.66 kt, of which 249.86 kt was contributed by Land remaining forest, whereas Land conversion to forest resulted a decrease of -35.20 kt carbon. On the whole, annual carbon sequestration has decreased by 13.8% since 1990 by forest mineral soil (Figure 6.9).

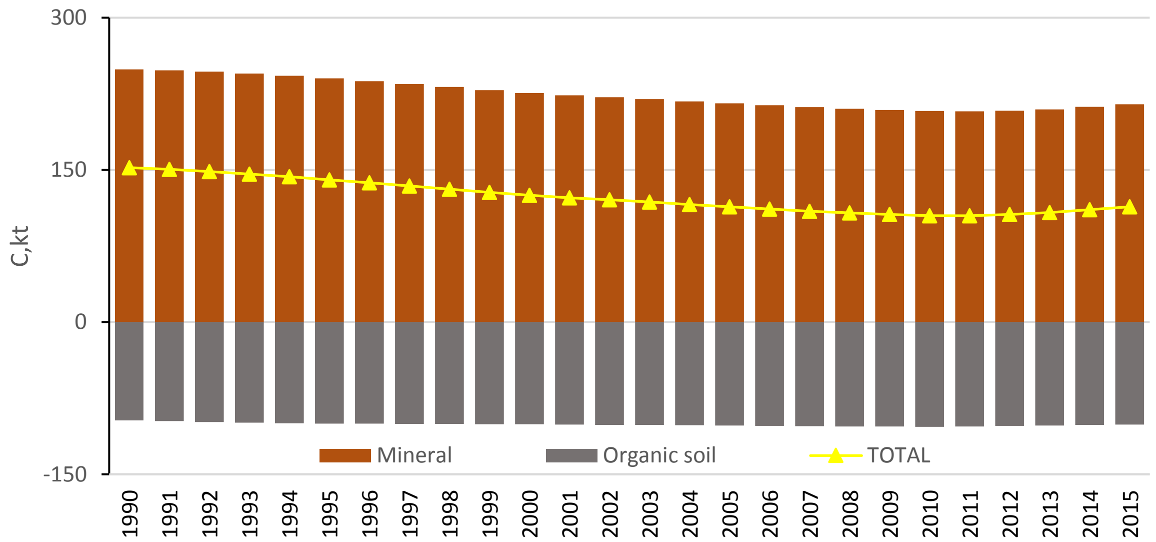

Figure 6.9. Annual stock change in Forest land mineral and organic soil pools 1990–2015, kt C

6.2.2.6. CO_2 emissions from drained organic forest soils

Equation 6.4 was applied for estimating carbon loss from drained organic forest soils.

Equation 6.4[233]

$$L_{Organic} = \sum_{c} (A \bullet EF)_c$$

Where:

$L_{Organic}$ = annual carbon loss from drained organic soils, tonnes C yr^{-1};
A = area of drained organic forest soils, ha;
EF = emission factor for CO_2 from drained organic forest soils, tonnes C ha^{-1} yr^{-1}

[232] The average implied emission factor of 1990–2014 in Sweden CRF tables 2016.
[233] IPCC 2006, Equation 2.26, p. 2.35.

Equation 6.4 is also used for calculating emissions from organic forest soils after Land transition to forest land.

ERT recommended Estonia to apply Swedish emission factors (Table 6.11) for drained organic forest soils, since default IPCC 2006 EF-s would likely cause underestimation of emissions[234]. Due to the fact that the EF-s in 2003 and 2006 LULUCF guidelines are the same, Estonia is going to keep using the Swedish emission factors.

Approximately 21% of all Estonian forest soils are organic soils, of which about 52% are drained according to NFI. Emissions from drained organic forest soils (Figure 6.9) have increased by 4.4% since 1990.

6.2.3. Uncertainty and time-series consistency

Uncertainties of activity data and emission factors are presented in Table 6.12.

Table 6.12. Uncertainties in Forest land category

IPCC category		Activity data %[235]	Emission factor %	EF References
4.A.1	Forest land remaining forest land - living biomass	1.16	46.95	IPCC 2003 & 2006[236]
4.A.1	Forest land remaining forest land - mineral soils	1.44	60.00	Sweden NIR 2015, p. 356
4.A.1	Forest land remaining forest land - organic soils	3.50	40.00	Sweden NIR 2015, p. 356
4.A.1	Forest land remaining forest land - dead wood	3.86	19.84	Köster *et al*. 2015
4.A.2.1	Cropland converted to forest land - living biomass	13.35	46.95	IPCC 2003 & 2006
4.A.2.1	Cropland converted to forest land - mineral soil	13.30	35.00	Kõlli *et al.* 2004 & 2009
4.A.2.1	Cropland converted to forest land - dead wood	13.84	19.84	Köster *et al*. 2015
4.A.2.2	Grassland converted to forest land - living biomass	12.04	46.95	IPCC 2003 & 2006
4.A.2.2	Grassland converted to forest land - mineral soils	12.03	60.00	Sweden NIR 2015, p. 356
4.A.2.2	Grassland converted to forest land - organic soils	45.46	40.00	Sweden NIR 2015, p. 356
4.A.2.2	Grassland converted to forest land - dead wood	12.59	19.84	Köster *et al*. 2015
4.A.2.3	Wetlands converted to forest land - living biomass	32.79	46.95	IPCC 2003 & 2006
4.A.2.3	Wetlands converted to forest land - organic soils	32.77	40.00	Sweden NIR 2015, p. 356

[234] ARR2012, para. 94.
[235] All activity data uncertainty estimates are obtained from NFI.
[236] Parameters were applied from the IPCC 2006. However due to lack of information in the IPCC 2006, the same EF uncertainty as in the GPG-LULUCF 2003 for calculating living biomass emissions was assumed.

IPCC category		Activity data %[235]	Emission factor %	EF References
4.A.2.3	Wetlands converted to forest land - dead wood	32.99	19.84	Köster *et al*. 2015
4.A.2.4	Settlements converted to forest land - living biomass	31.16	46.95	IPCC 2006
4.A.2.4	Settlements converted to forest land - mineral soils	34.17	60.00	Sweden NIR 2015, p. 356
4.A.2.4	Settlements converted to forest land - organic soils	67.96	40.00	Sweden NIR 2015, p. 356
4.A.2.4	Settlements converted to forest land - dead wood	31.37	19.84	Köster *et al*. 2015
4.A.2.5	Other land converted to forest land - living biomass	22.01	46.95	IPCC 2006
4.A.2.5	Other land converted to forest land - mineral soil	21.98	60.00	Sweden NIR 2015, p. 356
4.A.2.5	Other land converted to forest land - dead wood	22.32	19.84	Köster *et al*. 2015

6.2.4. Category-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for LULUCF sector according to the IPCC *Tier 1* method. The activities are carried out every year during the inventory. The QC check list is used during inventory.

Mineral soil reference carbon stocks and soil emission factors on land-use changes

Reference carbon stocks were calculated for forest land, cropland and grassland based on available national research data and publications. For verification purposes, obtained values were compared (Table 6.13) with the default SOC_{REF} values given in the IPCC 2006[237] calculated by applying default stock values according to soil type distribution on different land categories in Estonia.

Based on the difference in SOC_{REF} values and assuming default transition period of 20 years, mineral soil emission factors for land conversion from cropland to forest land (CF) and grassland to forest land (GF) were calculated. Obtained values were compared with respective EF-s of neighbouring countries - Finland and Sweden. There was less than a 2-fold difference between Estonian EF and Swedish EF for CF and 4.5-fold difference for GF emission factors, therefore only the country-specific CF emission factor was applied in the report calculations.

Table 6.13. Comparison of SOC_{REF} stocks estimated based on national publications and IPCC 2006

SOC_{REF} (Mg C ha^{-1})	Forest Land	Cropland	Grassland
National research data[238]	68.15	85.21	88.33

[237] IPCC 2006, Vol 4, Table 2.3, p 2.31.
[238] Kõlli et al, 2004, Organic Carbon Pools in Estonian Forest Soils, Baltic Forestry, Vol 10, No 1 (18), 19-26; Kõlli et al, 2009, Stocks of organic carbon in Estonian soils, Estonian Journal of Earth Sciences, 58, 2, 95-108; Kõlli et al, 2007, Organic matter of Estonian grassland soils, Agronomy Research, 5(2), 109-122.

IPCC 2006 default	74.36	85.37	75.88

6.2.5. Category-specific recalculations

The entire time series of activity data is annually recalculated for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated into overall activity data.

Soil emission factors were updated for Land remaining forest land.

In Table 6.14 changes in applied parameters and in Table 6.15 quantitative overview of recalculations is shown.

Table 6.14. Parameters used in Forest land category recalculations (15.06.2016 submission and 15.03.2017 submission)

Land use category	Parameter	2016 Submission		Source	2017 Submission		Source
Forest land remaining forest land	EF organic soil [kt C ha^{-1} yr^{-1}]	EF Sweden	-0.37	Sweden 2015, CRF (1990–2013 average)	EF Sweden	-0.37	Sweden 2016, CRF (1990–2014 average)
	EF mineral soil [kt C ha^{-1} yr^{-1}]	EF Sweden	0.16	Sweden 2015, CRF (1990–2013 average)	EF Sweden	0.14	Sweden 2016, CRF (1990–2014 average)

Table 6.15. Quantitative overview of recalculations, kt C (15.06.2016 submission/15.03.2017 submission)

		1990			1995			2000			2005			2010		
		Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**
Forest land remaining forest land	Living biomass	2 261.9	614.5	**-73**	2 686.1	614.3	**-77**	-612.8	690.0	**-213**	928.8	706.2	**-24**	1 123.7	443.9	**-60**
	Dead organic matter	63.8	41.6	**-35**	10.0	41.6	**316**	52.7	60.3	**14**	218.5	37.7	**-83**	182.7	35.8	**-80**
	Mineral soil	282.4	249.4	**-12**	282.1	249.3	**-12**	281.8	249.0	**-12**	281.2	248.5	**-12**	280.2	247.5	**-12**
	Organic soil	-79.7	-96.3	**21**	-79.3	-96.3	**21**	-79.0	-96.3	**22**	-78.5	-96.3	**23**	-77.8	-96.2	**24**
Land converted to forest land	Living biomass	0.2	2.8	**1433**	23.4	16.8	**-28**	78.8	53.8	**-32**	110.7	80.0	**-28**	212.7	97.4	**-54**
	Dead organic matter	1.3	0.7	**-48**	8.1	8.4	**3**	14.0	18.8	**35**	17.7	28.1	**58**	21.0	35.3	**69**
	Mineral soil	-1.2	-0.4	**-67**	-8.5	-9.0	**6**	-15.2	-23.1	**52**	-18.9	-32.9	**74**	-21.5	-39.4	**83**
	Organic soil	-0.1	-0.5	**500**	-0.8	-3.7	**389**	-1.4	-4.6	**234**	-2.0	-5.7	**187**	-2.7	-7.0	**157**
TOTAL Forest land net CO_2		-9 271.9	-2 967.4	**-68**	-10 711.2	-2 966.1	**-72**	1 030.4	-3 311.2	**-421**	-5 344.0	-3 285.9	**-39**	-6 300.6	-2 313.7	**-63**

6.2.6. Category-specific planned improvements

A number of improvements are required to be carried out in order to assure complete, transparent and accurate emission estimations for Forest land category.

The University of Life Sciences have a “Carbon and nitrogen cycling in drained forests” project in cooperation with State Forest Management Centre. This study can potentially provide useful information to estimate emissions for the non-mandatory land use categories and carbon pools: non-CO_2 emissions from drainage of forest soils. The University of Life Sciences also has a project about forest litter “Forest litter, research and modelling” that could help to make the estimation more complete and accurate. The project started in 2015 and will finish in 2018 resulting with county-specific litter model that is dependent on the main tree species and site type. The model will be used as an input for the calculations needed for greenhouse gas inventory.

Estonia was selected to participate in the Specific Contract (SC) 12 taskforce on harmonization of LULUCF inventories: modelling forest soil with Yasso. The Specific Contract 12 is a framework contract for the provision of forest data and services in support of the European Forest Data Centre. Estonia has some first results on modelling carbon stock change of forest mineral soils with Yasso07, but it will need some further research to provide data for the UNFCCC and Kyōto protocol reporting.

6.3. Cropland (CRF 4.B)

6.3.1. Category description

Total net CO_2 eq. emissions from cropland are presented in Figure 6.10. The cropland category includes emissions from mineral and organic soils, carbon stock changes in living biomass (orchards) and N_2O emissions related to land conversion to cropland. Emissions from organic soils are evened out by uptake by mineral soils, therefore inter-annual emission fluctuations in the cropland category are mainly caused by changes in living biomass.

Net CO_2 emissions from cropland were 125.2 kt and 100.9 kt, respectively in 2015 and 1990.

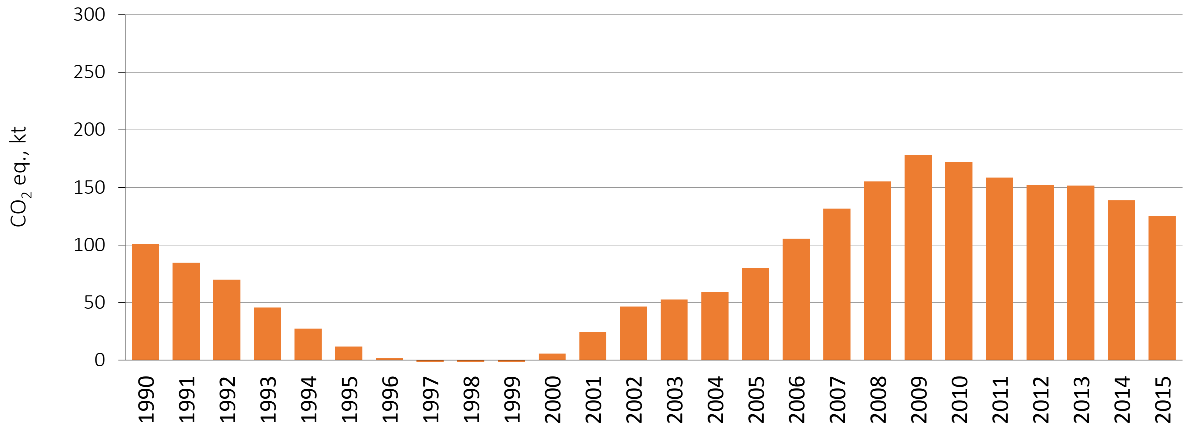

Figure 6.10. Total emissions (+)/ uptake (-) from Cropland category in 1990–2015, kt CO_2 eq.

The area of cropland (Figure 6.11) increased until the 1990s due to the propitious conditions in agricultural sector in Estonia. The biggest influences on the sector were the remarkable support provided by the early former Soviet Union, a large market and raw material basis, and a low market price for energy, which kept agriculture artificially alive. After Estonia regained its independence in 1991, these beneficial conditions were abolished[239]. From 1991 until 2005, an overall decline characterised Estonia's agriculture. Arable lands were abandoned due to the reduced demand for local food products, which was caused by the availability of cheap import goods as the result of opened markets. As from 2005, managing croplands has been increasing again due to increased investments and subsidiaries from the European Union to Estonian's agricultural sector, expansion of export opportunities and popularization of organic farming.

[239] Mäemets, M. (2006). An Outline of Agriculture in Estonia from the year 1990 until 2004, Bachelor's thesis, University of Tartu.

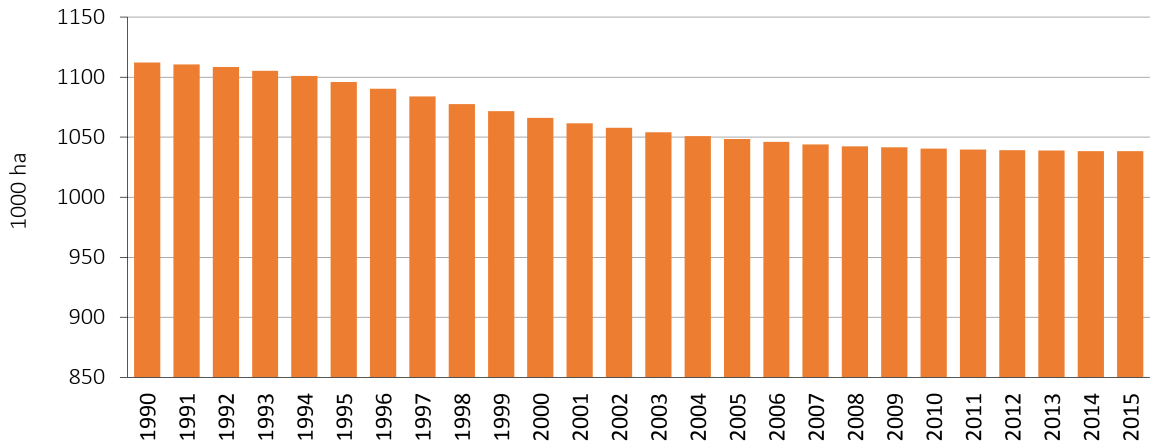

Figure 6.11. Cropland area in Estonia in 1990–2015, 1000 ha

Activity data used to estimate carbon fluxes related to cropland has been obtained from NFI (1990–2015).

6.3.2. Methodological issues

6.3.2.1. Change in carbon stocks in living biomass

In 2012, the Estonian Environment Information Centre (Estonian Environment Agency (EtEA)) launched a project in order to determine perennial woody crops biomass in croplands. The aim was to provide data about orchards' growing stock, which can be used in cropland living biomass carbon stock estimations. Sample plots were randomly selected representing main market gardens and privately owned orchards in Estonia. Fieldwork included determining tree species, age, density per area and measuring individual tree components: tree height, diameter at different heights, height until beginning of the crown and crown length. Measured variables were used as input data in the *Repola*[240] biomass function, which was implemented to estimate average aboveground, belowground and total biomass of orchards. The results are shown in Table 6.16.

Table 6.16. Average biomass stock on cropland orchards

	Living biomass stock, t d.m./ha
Total biomass	20.680
Aboveground	16.605
Belowground	4.075

Annual carbon stock change was calculated based on interannual area changes (Equation 6.5, *Tier 2*).

[240] Repola. J, Ojansuu, R. and Kukkola, M. (2007). Biomass functions for Scots pine, Norway spruce and birch in Finland, Working Papers of the Finnish Forest Research Institute, pp. 53.

Equation 6.5

$$\Delta C_{CC_{LB}} = \left[B_{total} \bullet \left(A_{t2} - A_{t1}\right)\right] \bullet CF$$

Where:

$\Delta C_{CC\ LB}$ = annual change in cropland (CL remaining CL and land converted to CL) perennial woody crops carbon stock, tonnes C yr^{-1};
B_{total} = total average biomass stock of orchards, t d.m./ha (Table 6.16);
A_{t1} = orchards area in previous year, ha;
A_{t2} = orchards area in current year, ha;
CF = carbon fraction of dry matter (default = 0.47), tonnes C (tonne d.m.)$^{-1}$.

The area of orchards is obtained from Statistics Estonia. The area of orchards has declined continuously, from 9 181 ha in 1990 to 3 601 ha in 2015, thus the carbon stocks in have been decreased as well as seen in Figure 6.12.

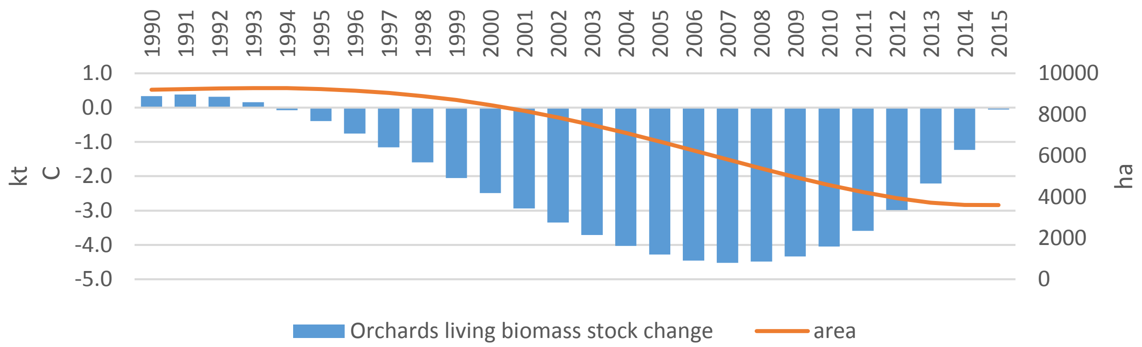

Figure 6.12. Area (ha) and annual change in cropland perennial woody crops (orchards) living biomass stock (kt C)

6.3.2.2. Mineral soils

In Table 6.17 the area and applied emissions factors of land remaining and converted to cropland are shown.

For mineral soils, *Tier 1* and Equation 6.6 is used to estimate change in soil organic carbon stocks. Cropland SOC_{REF} (Table 6.13) was estimated based on available national research data and publications. For verification purposes, obtained SOC_{REF} was compared with SOC_{REF} calculated according to IPCC 2006 default data (Cold, temperate moist climate).

Equation 6.6[241]

$$\Delta C_{Mineral} = \frac{\left(SOC_0 - SOC_{(0-T))}\right)}{D}$$

$$SOC = \sum_{c,s,i}\left(SOC_{REF_{c,s,i}} \bullet F_{LU_{c,s,i}} \bullet F_{MG_{c,s,i}} \bullet F_{I_{c,s,i}} \bullet A_{c,s,i}\right)$$

Where:

$\Delta C_{Mineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1};
SOC_0 = soil organic carbon stock in the last year of an inventory time period, tonnes C;
SOC_{0-T} = soil organic carbon stock at the beginning of the inventory time period, tonnes C;
D = default time period (20 years) for transition between equilibrium SOC values;
c = represents the climate zones, s the soil types, and I the set of management systems;
SOC_{REF} = the reference carbon stock, tonnes C ha^{-1} (Table 6.13);
F_{LU} / F_{MG} / F_I =stock change factors for land-use systems/management regime, input of organic matter, dimensionless[242];
A = land area of the stratum being estimated, ha.

EF for conversions to cropland was obtained by implementing IPCC *Tier 1* method, Equation 6.6.

Table 6.17. Cumulative land use changes to Cropland in 2015 and soil emission factors

Land-use	Area, kha	EF mineral soil kt C ha^{-1}	EF organic soil kt C ha^{-1}
Cropland remaining cropland	1 026.8	0.10[243]	-5.0
Forest land→ Cropland	0.2	-1.15	-
Grassland→ Cropland	11.2	-1.37	-5.0
Wetland→ Cropland	0.1	-	-5.0

Table 6.18 shows the share of different cropland management practices in Estonia (Estonian Research Institute of Agriculture).

Table 6.18. Proportions of cropland different management activities (ETKI, SE)

F_{LU}	Long term cultivated	Perennial/ Tree crop	Set aside (<20 yrs)	Total
Proportion of cropland area	0.740	0.007	0.253	1.00

[241] IPCC 2006 (Vol 4), Equation 2.25, p. 2.30.
[242] IPCC 2006 (Vol 4), Table 5.5, p. 5.17. (Temperate/Boreal)
[243] 1990–2014 average mineral soil EF.

F_{MG}	Full tillage	Reduced tillage	No-till	Total
Proportion of cropland area	0.5	0.4	0.1	1.00
F_I	Low	High with manure	Medium	Total
Proportion of cropland area	0.140	0.005	0.855	1.00

6.3.2.3. Organic soils

The *Tier 1* method was applied in order to estimate CO_2 emissions from cultivated organic soils.

Equation 6.7[244]

$$L_{Organic} = \sum_c (A \bullet EF)_c$$

Where:

$L_{Organic}$ = annual carbon loss from drained organic soils, tonnes C yr^{-1};
A = land area of drained organic soils in climate type *c*, ha;
EF = emission factor for climate type *c*, tonnes C ha^{-1} yr^{-1}.

Equation 6.7 was also used for calculations of organic soil emissions on the land converted to Cropland subcategory.

Default EF of 5.0 (tonnes C ha^{-1} yr^{-1}) from the IPCC 2006 Guidelines was applied for estimating the loss of soil carbon from drained organic cropland soils, whereby all cropland organic soil is considered drained in Estonia.

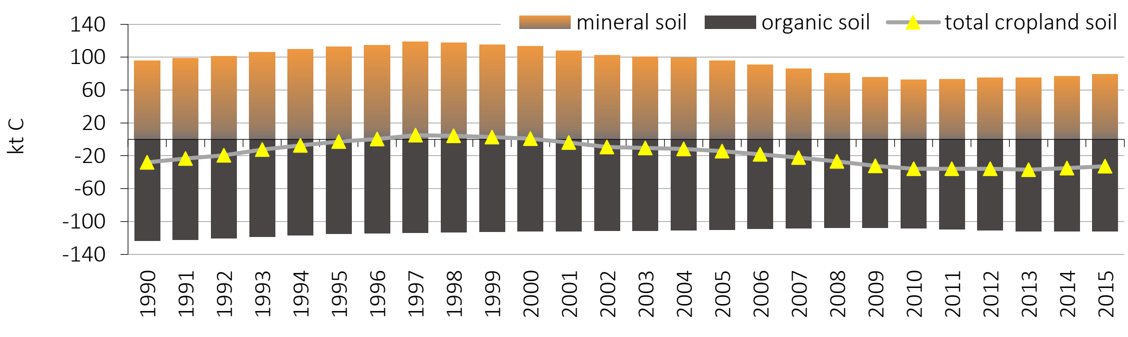

Figure 6.13. Annual stock change in Cropland mineral and organic soil pools 1990–2015, kt C

[244] IPCC 2006, Equation 2.6, p. 2.35.

Figure 6.13 illustrates annual carbon stock changes in cultivated cropland soils. In 2015, total CO_2 emissions from cropland soils were 119.5 kt, which is 15% more compared to 1990.

6.3.2.4. Nitrous oxide from mineral soils

Land conversion to cropland will result in emissions of N_2O from soils due to enhanced mineralization of soil organic matter. The *Tier 1* method (Equation 6.8) and the same emission factor (EF_l=0.0125 kg N_2O-N/kg N) that is used for direct emissions from agricultural land and the default C:N ratio [15 kg C (kg N)$^{-1}$] were applied.

Equation 6.8[245]

$$F_{SOM} = \sum_{LU}\left[\left(\Delta C_{Mineral,LU} \bullet \frac{1}{R}\right) \bullet 1000\right]$$

Where:

F_{SOM} = the net annual amount of N mineralised in mineral soils as a result of loss of soil carbon through change in land use or management, kg N
$\Delta C_{Mineral,LU}$ = average annual loss of soil carbon for each land-use type (*LU*), tonnes C
R = C:N ratio of the soil organic matter.
LU = land-use and/or management system type.

In 2015 11 240 ha of grasslands on mineral soils had been converted to cropland since 1990, resulting in N_2O emission of 18.2 tonnes.

6.3.3. Uncertainty and time series consistency

CO_2 emissions from cropland living biomass and organic soils are estimated according to IPCC 2006 (N_2O emissions, mineral and organic soils). Activity data was obtained from the Estonian NFI, national statistics and the Ministry of Rural Affairs, emission factors were employed from the IPCC 2006. The uncertainty rates of activity data and the emission factors used are reported in Table 6.19.

Table 6.19. Uncertainties in the Cropland category

IPCC category		Uncertainties %		EF References
		Activity data[246]	Emission factors	
4.B.1	Cropland remaining cropland - living biomass	39.27	46.95	NFI, SE, Repola (2007)
4.B.1	Cropland remaining cropland - mineral soils	2.31	50.00	IPCC 2006; Kõlli *et al*, 2009
4.B.1	Cropland remaining cropland - organic soils	18.13	90.00	IPCC 2006
4.B.2.2	Grassland converted to cropland - living biomass	29.15	46.95	IPCC 2006

[245] IPCC 2006, Equation 11.8, p. 11.16.
[246] All activity data uncertainty estimates are obtained from NFI.

IPCC category		Uncertainties %		EF References
		Activity data[246]	Emission factors	
4.B.2.2	Grassland converted to cropland - mineral soils	25.95	30.00	Kõlli *et al*, 2009
4.B.2.2	Grassland converted to cropland - organic soils	82.90	90.00	IPCC 2006
4.B.2.2	Grassland converted to cropland - (5III) mineral soils (N_2O)	25.95	50.00	IPCC 2006

6.3.4. Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level is presented in Section 1.2.3.

The QC/QA plan for the LULUCF sector includes the QC activities described in the IPCC 2006. The activities are carried out every year during the inventory and the QC check list is used during the inventory.

Country-specific cropland reference soil organic carbon stocks (SOC_{REF}) for mineral soils were compared with the estimates following IPCC 2006 methodology (Table 6.13) for verification purposes.

6.3.5. Category-specific recalculations

The entire time series of activity data is annually recalculated for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated into overall activity data.

In Table 6.20 a quantitative overview of recalculations has been shown.

6.3.6. Category-specific planned improvements

The Agricultural Research Centre of Estonia is conducting fieldwork and estimating carbon stock changes in cultivated mineral and organic soils.

Table 6.20. Quantitative overview of recalculations, kt C (15.06.2016 submission/15.03.2017 submission)

		1990			1995			2000			2005			2010		
		Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**
Cropland remaining cropland	Mineral soil	99.8	95.7	**-4**	113.3	112.5	**-1**	102.1	113.1	**11**	95.9	97.6	**2**	88.6	84.5	**-5**
	Organic soil	-124.4	-123.6	**-1**	-116.0	-114.9	**-1**	-113.0	-111.2	**-2**	-110.4	-109.2	**-1**	-107.5	-105.1	**-2**
Land converted to cropland	Living biomass	NO	NO	**-**	NO	NO	**-**	0.0	0.0	**0**	-18.1	-2.8	**-85**	-7.1	-5.6	**-21**
	Dead organic matter	NO	NO	**-**	NO	NO	**-**	0.0	0.0	**0**	-0.2	-0.1	**-68**	-0.2	-0.2	**12**
	Mineral soil	NO	NO	**-**	NO	NO	**-**	0.0	0.0	**0**	-4.3	-2.0	**-54**	-13.3	-12.0	**-10**
	Organic soil	NO	NO	**-**	NO	-0.4	**100**	-0.9	-0.9	**7**	-0.9	-0.9	**7**	-4.5	-3.3	**-27**
	N_2O	NO	NO	**-**	NO	NO	**-**	0.0	NO	**-100**	0.0	0.0	**-54**	0.0	0.0	**-10**
	TOTAL Cropland net CO_2	89.9	100.9	**12**	13.1	11.6	**-11**	52.1	5.5	**-89**	155.9	79.4	**-49**	177.3	167.6	**-5**

6.4. Grassland (CRF 4.C)

6.4.1. Category description

The spatial share of the grassland category is 6.4% of the overall Estonian area, ranking grasslands as the fourth largest land-use category after wetlands. By 2015, the area of grasslands decreased 5% compared to 1990s (Figure 6.14).

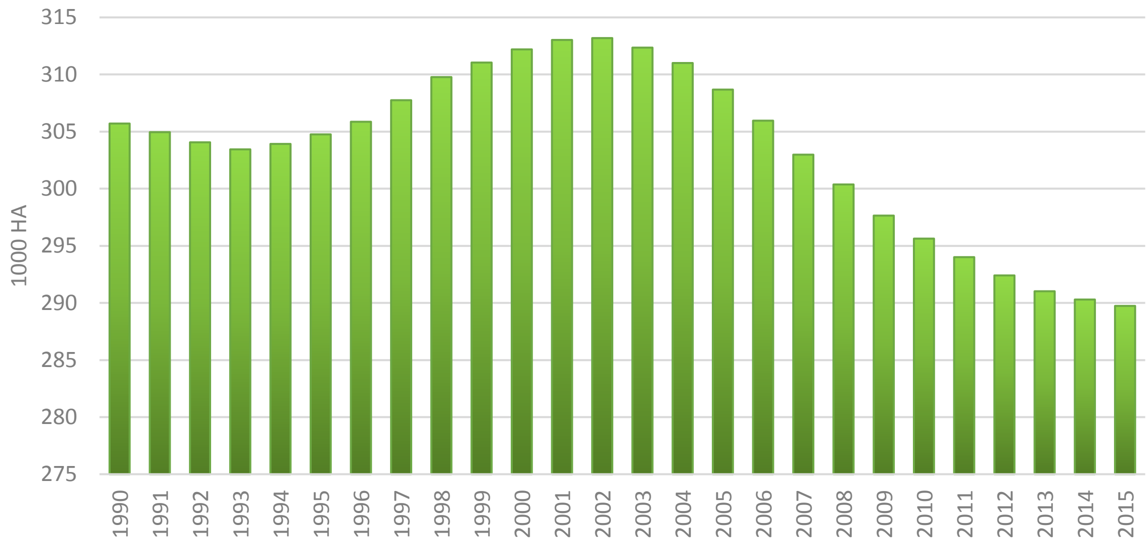

Figure 6.14. Grassland area in Estonia in 1990–2015, 1000 ha (SE, NFI)

The grassland category includes GHG emissions and removals from living biomass, mineral and organic soils, dead wood and loss of litter due to forest conversion to grasslands. Non-CO_2 emissions from biomass burning have also been estimated. The net emissions from Grassland were 37.6 kt CO_2 eq. in 2015 (Figure 6.15).

Grasslands have been both a net sink and source of GHG-s throughout the accounting period (Figure 6.15), depending mostly on the changes of living biomass. For the 2017 submission Estonia has implemented an improved average standing volume calculation that lead to significant recalculations of carbon stock changes in living biomass. Significant changes compared to the previous submission are due to NFI recalculations that are explained in Chapter 6.1.3. In the end of the 90s, fast biomass increase characterized grasslands, mostly caused by abandonment of old croplands. Due to natural succession, when the tree crown cover of grasslands exceeds 30%, the land is reallocated to the forest land category, which is the reason behind the decrease in grassland carbon uptake by biomass.

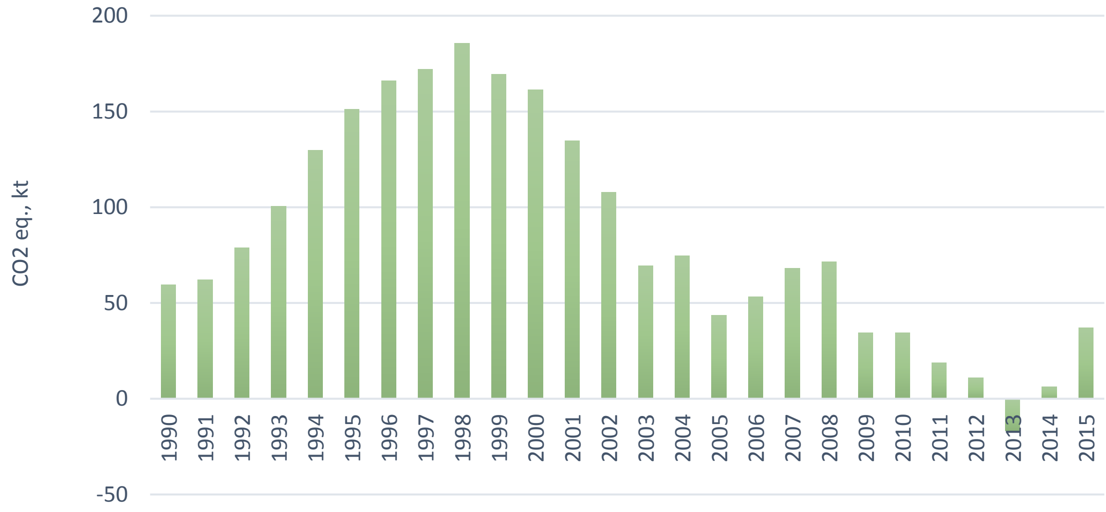

Figure 6.15. Annual CO_2 uptake (-)/emissions (+) from the Grassland category in 1990−2015, kt

6.4.2. Methodological issues

The carbon stock change in category 4.C Grassland remaining grassland and land converted to grassland is given by the sum of changes in living biomass, dead organic matter and soils (Equation 6.1).

6.4.2.1. Change in carbon stocks in living biomass

For estimating carbon stock changes in living biomass, the *Tier 2* approach and *Method 2* – the stock change method was used. The NFI provides annually updated data about the area and volume of growing stocks on grasslands. Biomass change is the difference between the biomass at year t_2 and year t_1 (see Equation 6.2). Parameters from IPCC 2006 (Table 6.21) were applied.

Table 6.21. Parameters used in Grassland living biomass estimations[247]

$BCEF_S$			R
Boreal	Growing stock level (m^3)		Above-ground biomass (t/ha)
	< 20	21-50	< 75
Pines	1.20	0.68	0.39
firs and spruces	1.16	0.66	
Hardwoods	0.90	0.70	0.46
Weighted average $BCEF_S$[248]	GL rem GL	0.76	0.45
	to GL	0.69…0.96	0.41

[247] IPCC 2006, Vol 4 (AFOLU), Table 4.4 & 4.5, p. 4.49-4.50.
[248] The weighted average $BCEF_S$ values are dependent on the distribution of tree species, age class and growing stock.

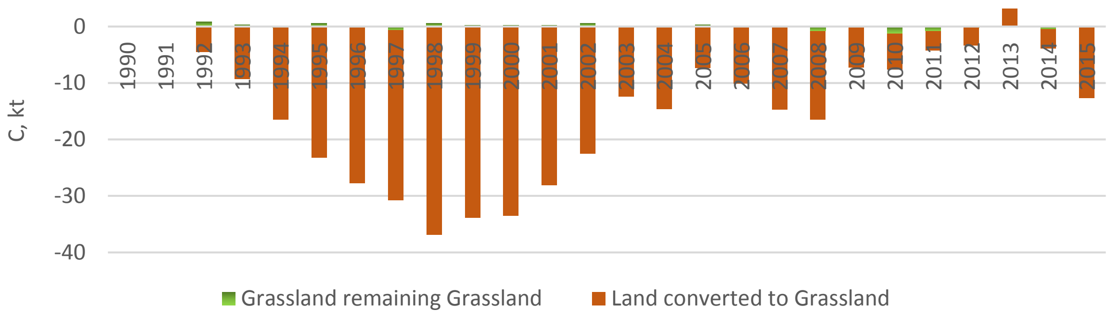

Figure 6.16. Carbon stock change in Grassland living biomass in 1990–2015, kt C

Figure 6.16 illustrates the annual change in living biomass carbon pool in the Grassland remaining grassland and Land converted to grassland subcategories.

The stock change method used for living biomass CSC calculations comprises also carbon loss from biomass burning. CH_4 and N_2O emissions from biomass burning on grassland areas are described in Chapter 6.8.

6.4.2.2. CO_2 emissions/removals from/by dead wood

The same method (*Tier 2*, stock-change method) and parameters were used for estimating carbon stock changes in the dead wood pool on grasslands as for forest land, more information can be found in chapter 6.2.2.3. The NFI estimates annually the volume of dead wood for the whole grassland area, data is provided for land remaining and land converted to Grassland subcategories. Figure **6.16**6.17 illustrates the annual change in dead organic matter pool in the Grassland remaining grassland and Land converted to grassland subcategories.

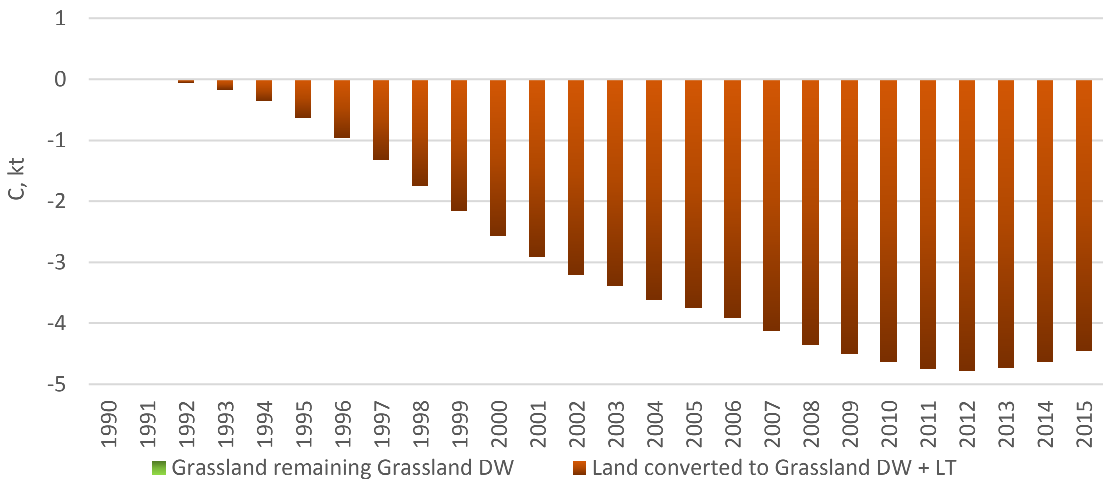

Figure 6.17. Annual change in Grassland dead organic matter pool in 1990–2015, kt C

6.4.2.3. CO_2 emissions/removals from/by litter

Estonia does not have sufficient country specific data regarding forest and grassland litter stocks, thus under Grassland remaining grassland, for the litter pool the *Tier 1* method was implemented, assuming that carbon stocks are in equilibrium so that the changes in the litter pool are assumed to be zero.

Under land conversion to grassland, the UNFCCC in-country review (2012) recommended the use of the litter emission factor from Sweden (Table 6.22) in order to avoid underestimation of emissions from deforestation (Forest land → Grassland) and assure consistency between the Convention and Kyoto Protocol reporting.

6.4.2.4. CO_2 emissions/removals from/by mineral soils

Reference soil organic carbon stock (Table 6.13) was calculated for grassland mineral soils based on national research and published data. *Tier 1* method and relative stock change factors from IPCC 2006[249] were applied to estimate annual stock changes in the Grassland remaining grassland category. Since grasslands are not actively managed in Estonia, nor are additional inputs added to grassland soil, all stock change factors (F_{LU}, F_{MG}, F_I) are equal to 1, hence no changes are assumed in the Grassland remaining mineral soil pool.

Emission estimates for land conversion to grassland are based on corresponding Swedish EF-s (*Tier 2*) (Table 6.22), except cropland conversion to grassland that was obtained by estimating differences in grassland and cropland stocks that were calculated by applying national SOC_{REF} and IPCC 2006 relative stock change factors, assuming 20 years of transition period (*Tier 1*).

Table 6.22. Cumulative land-use changes to Grassland in 2015, soil and litter emission factors[250]

Land-use	Kha	%	EF mineral soil kt C ha^{-1}	EF organic soil kt C ha^{-1}	EF litter kt C ha^{-1}
Grassland remaining grassland	245.7	-	-	-1.71	-
Forest land→ Grassland	6.0	14%	0.225	-1.506	-0.75
Cropland→ Grassland	35.0	80%	1.026	-6.100	NA
Wetlands→ Grassland	0.5	1%	-	-1.506	NA
Settlements→ Grassland	1.4	3%	0.026	-1.506	NA
Other land→ Grassland	1.1	3%	0.026	-1.506	NA
Total to GL	44.0	100%			

[249] IPCC 2006 (Vol 4), Table 6.2, p. 6.16.
[250] Sweden NIR 2016, Annexes, Table A 3:2.11, p. 105.

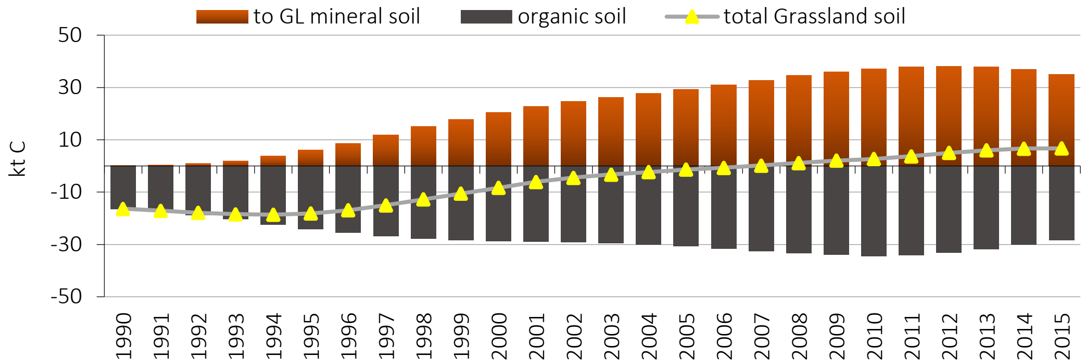

Figure 6.18. Annual stock change in Grassland mineral and drained organic soil pools 1990–2015, kt C

6.4.2.5. CO_2 emissions from organic soils

Figure 6.18 illustrates annual changes in grassland organic soils. *Tier 2* method and Equation 6.9 was implemented to estimate the loss of carbon from drained grassland soils. The emission factor from Sweden (Table 6.22) was implemented due to lack of country-specific data.

The total area of grassland organic soils and the sub-area of drained soils are obtained from the NFI database. The proportion of drained organic soils is about 27%. All organic soils falling under land converted to grassland are considered drained.

Equation 6.9[251]

$$L_{Organic} = \sum_{c} (A \bullet EF)_c$$

Where:

$L_{Organic}$ = annual carbon loss from drained organic soils, tonnes C yr^{-1};
A = land area of drained organic soils in climate type *c*, ha;
EF = emission factor for climate type *c*, tonnes C ha^{-1} yr^{-1}.

Emissions from grassland organic soils have increased by 42% compared to the base year.

6.4.3. Uncertainty and time series consistency

The uncertainty estimates related to the activity data and the emission factors are presented in Table 6.23.

[251] IPCC 2006, Equation 2.6, p. 2.35.

Table 6.23. Uncertainties in the Grassland category

IPCC category		Uncertainties %		EF References
		Activity data[252]	Emission factors	
4.C.1	Grassland remaining grassland – living biomass	13.71	46.95	IPCC 2006
4.C.1	Grassland remaining grassland – organic soils	12.78	25.00	Sweden NIR 2016, p. 382
4.C.1	Grassland remaining grassland – dead wood	53.44	19.84	Köster et al. 2015
4.C.2.1	Forest land converted to grassland - living biomass	37.29	46.95	IPCC 2006
4.C.2	Land converted to grassland – living biomass (excl. FL)	18.85	46.95	IPCC 2006
4.C.2	Land converted to grassland – mineral soils	12.59	25.00	Sweden NIR 2016, p. 382
4.C.2	Land converted to grassland – organic soils	40.93	25.00	Sweden NIR 2016, p. 382
4.C.2.1	Forest land converted to grassland - dead wood	31.07	19.84	Köster et al. 2015
4.C.2	Land converted to grassland – dead wood (excl. FL)	54.99	19.84	Köster et al. 2015

6.4.4. Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in chapter 1.2.3.

The QC/QA plan for the sector includes the QC activities described in the IPCC 2006 (p 6.43). The activities are carried out every year during inventory. The QC check list is used during the inventory.

Country-specific Grassland reference soil organic carbon stocks (SOC_{REF}) for mineral soils were compared with the estimates following IPCC 2006 methodology (Table 6.13) for verification purpose.

6.4.5. Category-specific recalculations

Activity data as well as growing stock and dead wood stock volumes are being updated and if necessary, corrected, each year.

In Table 6.24 a quantitative overview of recalculations has been shown.

6.4.6. Category-specific planned improvements

A project titled Applied research of greenhouse gases in the LULUCF sector in the framework of UNFCCC and Kyoto protocol reporting was launched in June 2013, funded by the

[252] All activity data references are obtained from NFI.

Environmental Investment Centre. One of the objectives of the project is to determine changes in grassland soil organic carbon stocks. Project activities include conducting fieldwork, resampling previous sample plots and estimating carbon stock changes in natural and semi-natural grassland soils. The aim is to develop country-specific emission factors for grassland soils.

Table 6.24. Quantitative overview of recalculations, kt C (15.06.2016 submission/15.03.2017 submission)

		1990			1995			2000			2005			2010		
		Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**
Grassland remaining grassland	Living biomass	38.2	0.0	**-100**	52.3	0.6	**-99**	45.7	0.2	**-99**	353.6	0.4	**-100**	-72.7	-1.2	**-98**
	Dead organic matter	-0.1	0.0	**-100**	0.1	0.0	**-100**	0.4	0.0	**-100**	13.7	0.0	**-100**	2.0	0.0	**-100**
	Organic soil	-27.5	-16.0	**-42**	-25.3	-15.5	**-39**	-24.8	-14.7	**-41**	-24.2	-14.2	**-42**	-22.9	-13.6	**-41**
Land converted to grassland	Living biomass	-2.9	0.0	**-100**	-29.3	-23.2	**-21**	-15.8	-33.5	**111**	-14.9	-7.3	**-51**	-7.1	-6.3	**-12**
	Dead organic matter	0.0	0.0	**-100**	-1.2	-0.6	**-48**	-2.6	-2.6	**-3**	-3.5	-3.7	**7**	-4.7	-4.6	**-2**
	Mineral soil	0.5	0.1	**-75**	10.3	6.1	**-41**	25.2	20.5	**-19**	33.3	29.3	**-12**	40.1	37.2	**-7**
	Organic soil	-2.3	-0.4	**-81**	-13.0	-8.7	**-33**	-17.3	-14.1	**-18**	-20.2	-16.5	**-18**	-23.4	-20.9	**-11**
	TOTAL Grassland net CO_2	-21.4	60.0	**-381**	22.3	151.5	**581**	-39.6	161.8	**-508**	-1238.9	44.0	**-104**	325.3	34.8	**-89**

6.5. Wetlands (CRF 4.D)

6.5.1. Category description

The area of wetlands cover 9% of Estonia's territory. Wetlands (including peatland and inland water bodies) decreased until the beginning of 1990s, since then the area has remained stable (Figure 6.19). A decrease in wetlands area has taken place mostly due to drainage of bogs and mires for agricultural and forestry purposes. Carbon fluxes related to Wetlands land category have been estimated for peat extraction sites and land conversion to wetlands/peatlands. Net CO_2 emissions from Wetland were 794.7 kt in 2015.

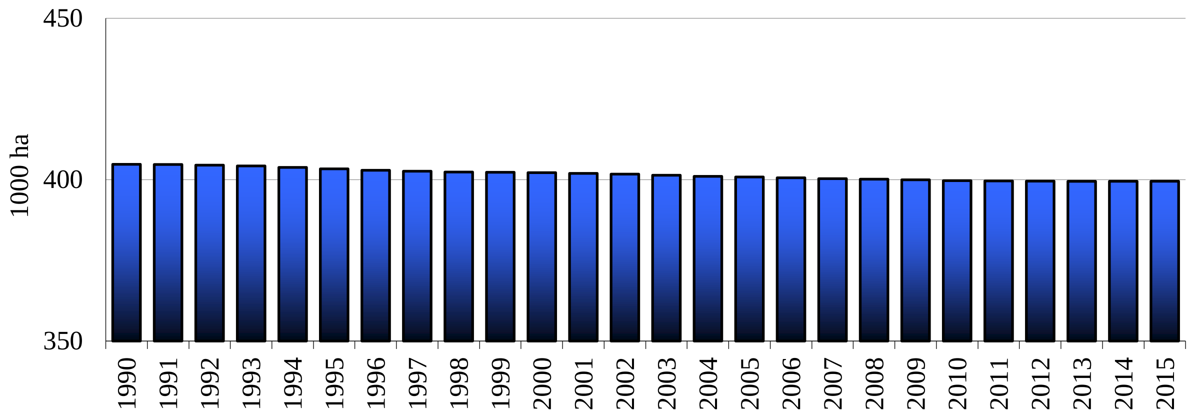

Figure 6.19. Area of Wetlands (including inland water bodies and peat extraction sites) in Estonia in 1990–2015, 1000 ha

Wetlands remaining wetlands are divided to unmanaged and managed wetlands. The unmanaged Wetlands consist of natural lakes and rivers, and bogs (excl. peat extraction sites/quarries) that do not fulfil the definition of forest land and are undrained (CRF 4.1). These changes have been made according to the ERT recommendation from the Report on the individual review of the annual submission of Estonia submitted in 2016[253].

In Estonia, peat is the third most-important indigenous fuel after oil shale and wood. A more detailed overview of usage of peat for energy production is provided under Energy sector (Chapter 3). The usage of horticultural peat is 2/3 of the Estonian peat production.

Activity data for the estimation of emissions related to peat extraction was obtained from NFI and the Estonian Peat Association. In 2015, the total area of managed peat extractions fields was 14 361 ha (Figure 6.20 & Figure 6.21). Peat extraction usually proceeds on the same production area during several years. After extraction the area is restored.

[253] Report on the individual review of the annual submission of Estonia submitted in 2016, p. 28.

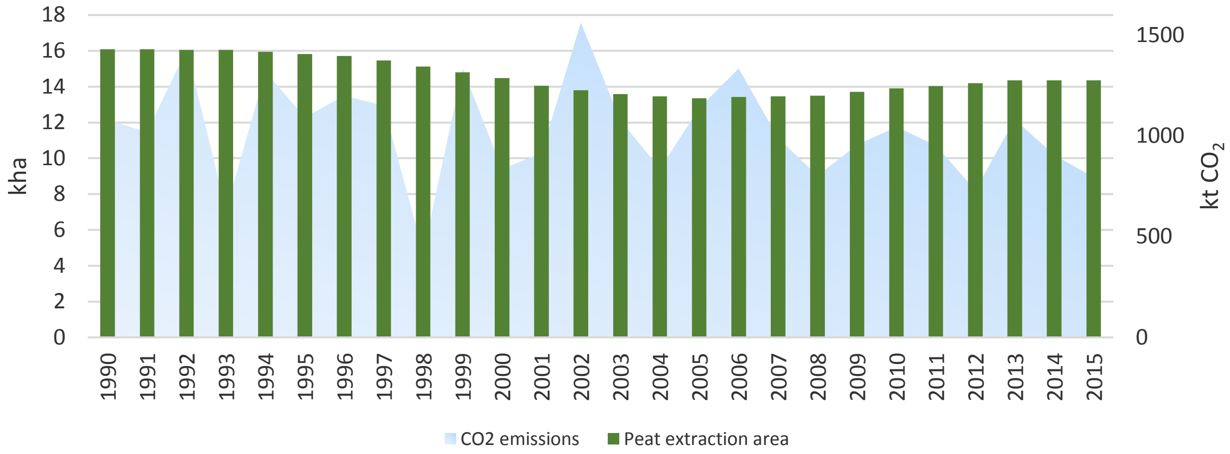

Figure 6.20. Total peatland area (kha) and emissions (kt CO_2) related to peat extraction

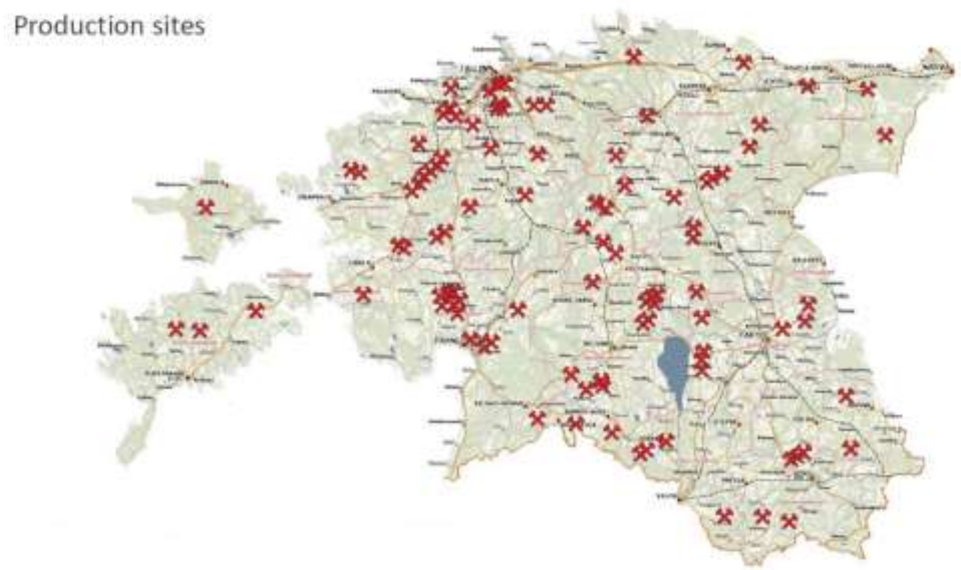

Figure 6.21. Peat production sites in Estonia

6.5.2. Methodological issues

6.5.2.1. Change in carbon stocks in living biomass and dead wood

Carbon loss in living biomass and dead organic matter pools after land conversion to wetlands/peat extraction sites (Table 6.25) was estimated using the *Tier 2*. It was assumed that all biomass will be lost after land use change. Average growing stock and dead wood volumes (NFI) in corresponding land remaining (eg land remaining forest land) categories were applied. Carbon loss from living biomass and DOM were -0.71 kt and -0.04 kt respectively in 2015 (Figure 6.22). Land change to wetlands and peat extraction sites has intensified since 2006, leading to growing emissions in the recent years. CO_2 emissions from horticultural use of peat is estimated according to IPCC 2006.

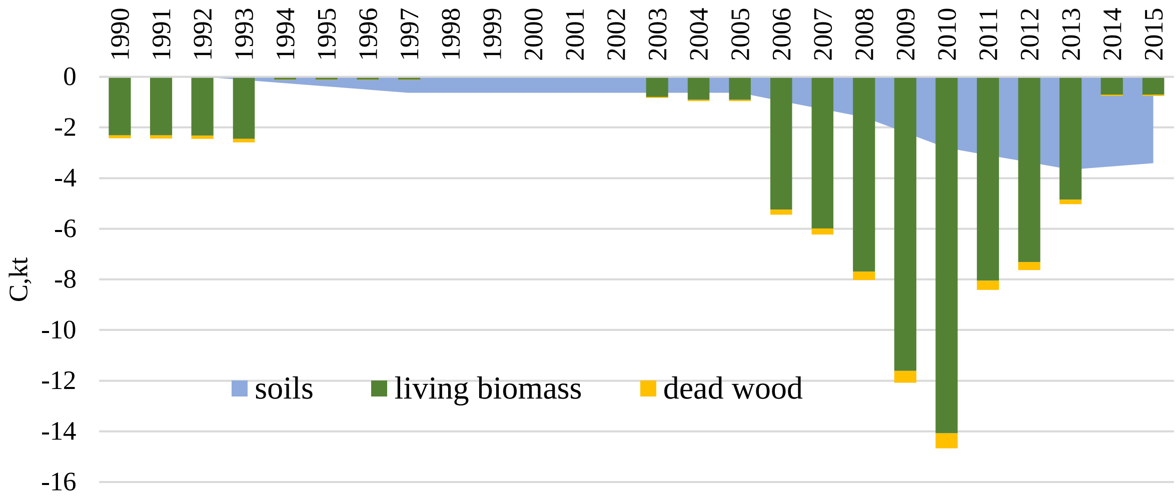

Figure 6.22. Carbon loss in living biomass, dead organic matter and soil after land conversion to wetlands and peat extraction sites in 1990–2015, kt C

6.5.2.2. Emissions from organic soils

In Table 6.25 land use changes to wetlands and peat extraction sites and applied emission factors are presented. Emission estimates are illustrated in Figure 6.20 and Figure 6.22.

Table 6.25. Cumulative land-use changes to Wetlands and peat extraction sites in 2015, soil and litter emission factors

Land-use change	kha	EF organic soil kt C ha^{-1}	EF litter [254] kt C ha^{-1}
Forest land→Wetlands	0.5	no emissions, soil C is not considered lost after LUC to unmanaged wetlands	-1.20
Grassand→Wetlands	0.5		NA
Peat extraction – Wetlands	0.0		NA
Settlements - Wetlands	1.3		NA
Other land→Wetlands	0.0		NA
Total to WL	2.3		
Forest land→Peat extraction	1.7	-1.741	-1.20
Wetlands→ Peat extraction	0.2		NA
Total to WL_{Peat}	2.0		
Flooded land→Flooded land	0.0	-	
Total to WL_f	0.0	-	

[254] Since there are no country-specific EF-s nor Swedish EF-s for land converted to Wetlands, the same litter emission factors as under land converted to Settlements was applied.

Tier 2 and Equation 6.10 was implemented for estimating CO_2 emissions from organic soils managed for peat extraction.

Equation 6.10[255]

$$CO_2\text{–}C_{WW_{peat_{off-site}}} = \frac{\left(Wt_{dry\_peat} \bullet Cfraction_{wt\_peat}\right)}{1000}$$

Where:

$CO_2\text{–}C_{WW\ peat\ off\text{-}site}$ = off-site CO_2–C emissions from peat removed for horticultural use, Gg C yr^{-1}
Wt_{dry_peat} = air-dry weight of extracted peat, tonnes yr^{-1}
$Cfraction_{wt\_peat}$ = carbon fraction of air-dry peat by weight, tonnes C (tonne of air-dry peat)$^{-1}$

Country-specific emission factors (Table 6.26) were applied for estimating emissions from peatland management.

Table 6.26. Emission factors for CO_2–C, N_2O–N and CH_4-C for active peatland management[256]

Annual soil efflux, median value [kg ha^{-1} yr^{-1}]	
CO_2-C	1 741
N_2O-N	0.19
CH_4-C	0.12

Equation 6.11 (*Tier 2*) was implemented for estimating CH_4 emissions from organic soils managed for peat extraction.

Equation 6.11[257]

$$Direct\ CH_4\ emissions_{WWpeat} = \left(A_{peatland} \bullet EF_{CH4}\right) \bullet \frac{16}{12} \bullet 10^{-6}$$

Where:

CH_4 emissions $_{WW\ peat}$ = emissions of CH_4, kt CH_4 yr^{-1};
$A_{peatland}$ = area of drained peatland soils, ha;
EF_{CH4} emission factor for actively managed peatland soils, kg CH_4–C ha^{-1} yr^{-1} (Table 6.26).

Equation 6.12 (*Tier 2*) was used for estimating N_2O emissions from drained peatlands.

255 IPCC 2006 Equation 7.5, p 7.11.
256 Salm *et al*. 2012. Emissions of CO_2, CH_4 and N_2O from undisturbed, drained and mined peatlands in Estonia. Hydrobiologia, vol 692, issue 1, p 41-55.
257 Equation adjusted after Equation 3a.3.7 in GPG-LULUCF, 2003, p. 3.283

Equation 6.12[258]

$$N_2O_{WW_{peatExtraction}} = \left(A_{peatRich} \bullet EF_{N_2O-N_{peatRich}}\right) \bullet \frac{44}{28} \bullet 10^{-6}$$

Where:

$N_2O_{WW_{peatExtraction}}$ = direct N_2O emissions from peatlands managed for peat extraction, Gg N_2O yr^{-1}
$A_{peatRich}$ = area of nutrient-rich peat soils managed for peat extraction, including abandoned areas in which drainage is still present, ha
EF_{N2O}= emission factor for actively managed peatland soils, kg N_2O–N ha^{-1} yr^{-1} (Table 6.26).

6.5.3. Uncertainty and time series consistency

The uncertainty rates related to the activity data and the emission factors used in the estimates are presented in Table 6.27.

Table 6.27. Uncertainties in the Wetlands category

IPCC category		Uncertainties %		EF References
		Activity data[259]	Emission factors	
4.D.1	Wetlands remaining wetlands\peatland - organic soils managed for peat extraction CO_2	22.84	50.00	Salm *et al*. 2012
4.D.2.1	Forest land converted to wetlands - living biomass	114.38	46.95	IPCC 2006
4.D.2.1	Forest land converted to wetlands - organic soils managed for peat extraction	64.49	50.00	Salm *et al*. 2012
4.D.2.1	Forest land converted to wetlands - dead wood	56.67	19.84	Köster et al. 2015
4.D.2.5	Wetlands converted to peatland - organic soils	64.49	50.00	Salm *et al*. 2012

6.5.4. Category-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for LULUCF sector according to the IPCC *Tier 1* method. The activities are carried out every year during the inventory. The QC check list is used during inventory.

Country-specific peat extraction soil emission factors were compared with IPCC 2013 default factors (Table 6.28).

[258] IPCC 2006 Equation 7.7, p 7.15.

[259] All activity data references are obtained from the NFI.

Table 6.28. Comparison of country-specific and IPCC 2013 drained peatland soil emission factors

EF (kg ha^{-1} yr^{-1})	CO_2-C	N_2O-N	CH_4-C
country-specific (Salm *et al*. 2012)	1 741	0.19	0.12
IPCC 2013 default	1 100-4 200[260]	-0.03 … 0.64[261]	1.6 … 11[262]

6.5.5. Category-specific recalculations

Updated activity data, growing stocks and dead wood volumes from the NFI was used for estimating carbon losses due to land conversion to wetlands and peatlands (Table 6.29).

Table 6.29. Quantitative overview of recalculations (15.06.2016 submission/15.03.2017 submission)

Wetlands TOTAL emissions, kt		**CO_2**	**CH_4**	**N_2O**
1990	**Previous submission**	1074.0	0.003	0.005
	Current submission	**1079.6**	0.003	0.005
	Difference %	**1**	**-3**	**-3**
1995	**Previous submission**	1097.9	0.003	0.005
	Current submission	**1091.3**	0.003	0.005
	Difference %	**-1**	**-7**	**-7**
2000	**Previous submission**	851.4	0.003	0.005
	Current submission	**835.2**	0.002	0.004
	Difference %	**-2**	**-15**	**-15**
2005	**Previous submission**	1183.9	0.003	0.005
	Current submission	**1138.5**	0.002	0.004
	Difference %	**-4**	**-23**	**-23**
2010	**Previous submission**	1048.4	0.003	0.006
	Current submission	**1045.5**	0.002	0.004
	Difference %	**0**	**-25**	**-25**

[260] 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Table 2.1, p 2.14.
[261] 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Table 2.5, p 2.34.
[262] 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Table 2.3, p 2.26.

6.5.6. Category-specific planned improvements

Updated NFI activity data will be used.

6.6. Settlements (CRF 4.E)

6.6.1. Category description

Settlements, including all built-up areas, cover about 7% of Estonia's territory. The area of settlements has been increasing continuously in Estonia (Figure 6.23) mainly on behalf of forest lands (Table 6.4). Carbon flows related to Settlements remaining settlements have not been calculated in the current submission due to lack of detailed data and also is assumed no change in carbon stocks in live biomass and that inputs equal outputs in mineral soils.

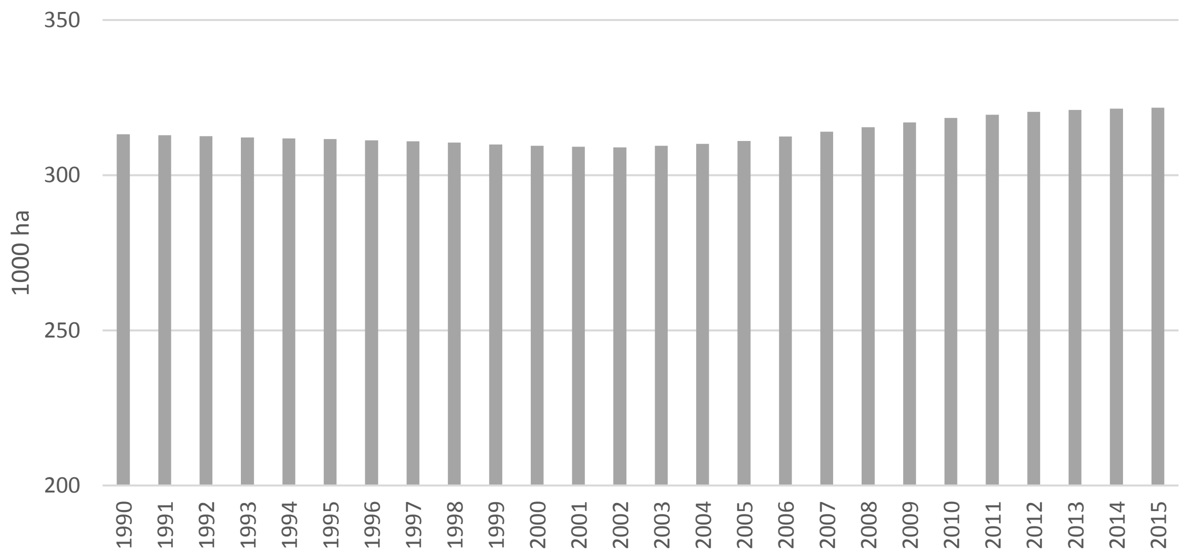

Figure 6.23. Area of Settlements in Estonia in 1990–2015, 1000 ha (SE, NFI)

6.6.2. Methodological issues

Emissions estimates were provided for forest land, cropland, grassland and other land conversion to Settlements (Figure 6.24). Total CO_2 emissions after land conversion to settlements were 214.1 kt in 2015.

Change in carbon stocks in living biomass and dead wood due to land conversion is estimated (using Equation 6.13) by multiplying the area converted annually to settlements by the difference in carbon stocks between biomass in the system prior to conversion and that in the settlements after conversion, assuming that all biomass will be lost (B_{AFTER}=0). Forest land and grassland living biomass and dead wood stocks prior the land-use change were obtained from the NFI.

Equation 6.13[263]

$$\Delta C_{CONVERSION} = \sum_{i} \{(B_{AFTER_i} - B_{BEFORE_i}) \bullet \Delta A_{TO\_OTHERS_i}\} \bullet CF$$

Where:

$\Delta C_{CONVERSION}$ = initial change in biomass carbon stocks on land converted to another land category, tonnes C yr^{-1};
B_{AFTERi} = biomass stocks on land type i immediately after the conversion, tonnes d.m. ha^{-1};
$B_{BEFOREi}$ = biomass stocks on land type i before the conversion, tonnes d.m. ha^{-1};
$\Delta A_{TO\_OTHERSi}$ = area of land use i converted to another land-use category in a certain year, ha yr^{-1};
CF = carbon fraction of dry matter, tonne C (tonnes d.m.)$^{-1}$;
i = type of land use converted to another land-use category

Due to missing country-specific soil emission factors, EFs from Sweden were implemented (Table 6.30). Since there were no EFs for land converted to Settlements for organic soils, mineral soils EF-s were applied.

Table 6.30. Cumulative land-use changes to settlements in 2015, soil and litter emission factors[264]

Land-use change	kha	EF mineral soil kt C ha^{-1}	EF organic soil kt C ha^{-1}	EF litter kt C ha^{-1}
Forest land→Settlements	8.7	-1.30	-	-1.20
Cropland→Settlements	5.0	-2.50	-	NA
Grassland→Settlements	4.2	-2.75	-	NA
Other land→ Settlements	0.6	-1.30	-	NA
Total	18.5			

263 IPCC 2006 (Vol 4), Equation 2.16, p. 2.20.

264 Emission factors were obtained from Sweden National Inventory Report 2016, Annexes, Table A3:2.11, p.105.

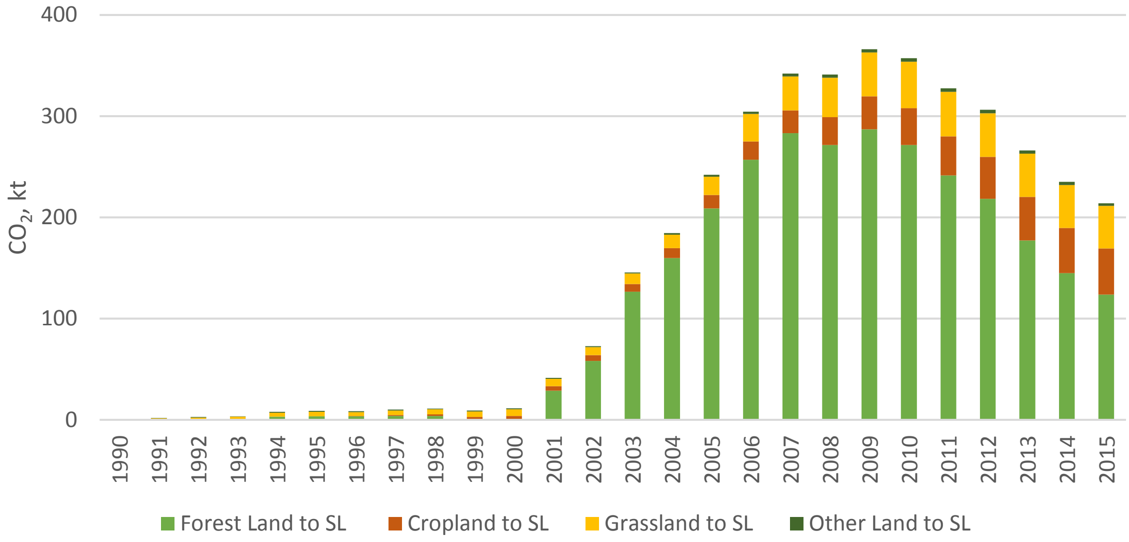

Figure 6.24. CO_2 emissions related to land conversion to settlements, 1990–2015, kt

6.6.3. Uncertainty and time series consistency

The uncertainty rates related to activity data and emission factors in the Settlements category are presented in Table 6.31.

Table 6.31. Uncertainties in the land converted to Settlements category.

IPCC category		Uncertainties %		EF References
		Activity data[265]	Emission factors	
4.E.2.1	Forest land converted to settlements - min+org soils	29.40	25.00	Sweden NIR 2016, p. 382
4.E.2.1	Forest Land converted to settlements – living biomass	29.42	46.95	IPCC 2006
4.E.2.1	Forest land converted to settlements – deadwood	29.65	19.84	Köster et al. 2015
4.E.2.3	Grassland converted to settlements – living biomass	43.64	46.95	IPCC 2006
4.E.2.3	Grassland converted to settlements – deadwood	67.62	19.84	Köster et al. 2015

6.6.4. Category-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for the LULUCF sector according to the IPCC *Tier 1* method. The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Chapter 1.2.3.

[265] All activity data uncertainty estimates are obtained from the NFI.

6.6.5. Category-specific recalculations

Updated activity data, growing stocks and dead wood volumes from the NFI were used for estimating carbon losses due to land conversion to Settlements.

In Table 6.32 a quantitative overview of recalculations has been shown.

Table 6.32. Quantitative overview of recalculations in the Settlements category (15.06.2016 submission/15.03.2017 submission)

to Settlements TOTAL emissions, kt		**CO_2**		**CO_2**
1990	Previous submission	1.30	**2005**	286.68
	Current submission	0.00		241.95
	Difference %	**-100**		**-16**
1995	Previous submission	7.37	**2010**	343.89
	Current submission	8.82		357.17
	Difference %	**20**		**4**
2000	Previous submission	39.14		
	Current submission	11.24		
	Difference %	**-71**		

6.6.6. Category-specific planned improvements

Updated data from the NFI for land-use changes will be used.

6.7. Other Land (CRF 4.F)

6.7.1. Category description

The Other land category includes all land that does not fall into the five previously described land-use categories.

6.7.2. Methodological issues

In the 2017 submission, emissions from forest land, cropland, grassland and wetlands to the Other land category were estimated (Figure 6.25) implementing Equation 6.13 and emission factors from the Sweden annual submission 2016 (Table 6.33). Conversion to other land has occurred since 2004 according to the NFI. Total emissions from land converted to other land were estimated at 23.4 kt CO_2 in 2015.

Table 6.33. Cumulative land-use changes to Other land in 2015, soil and litter emission factors

Land-use change	kha	EF mineral soil kt C ha^{-1} [266]	EF organic soil kt C ha^{-1}	EF litter kt C ha^{-1}
Forest land→Other land	1.8	-1.30	-	-1.20
Cropland→Other land	0.4	-2.50	-	NA
Grassland→Other land	0.2	-2.75	-	NA
Wetlands→Other land	0.1	-3.73	-	NA
Settlements→Other land	0.0	-1.30	-	NA
Total	2.5			

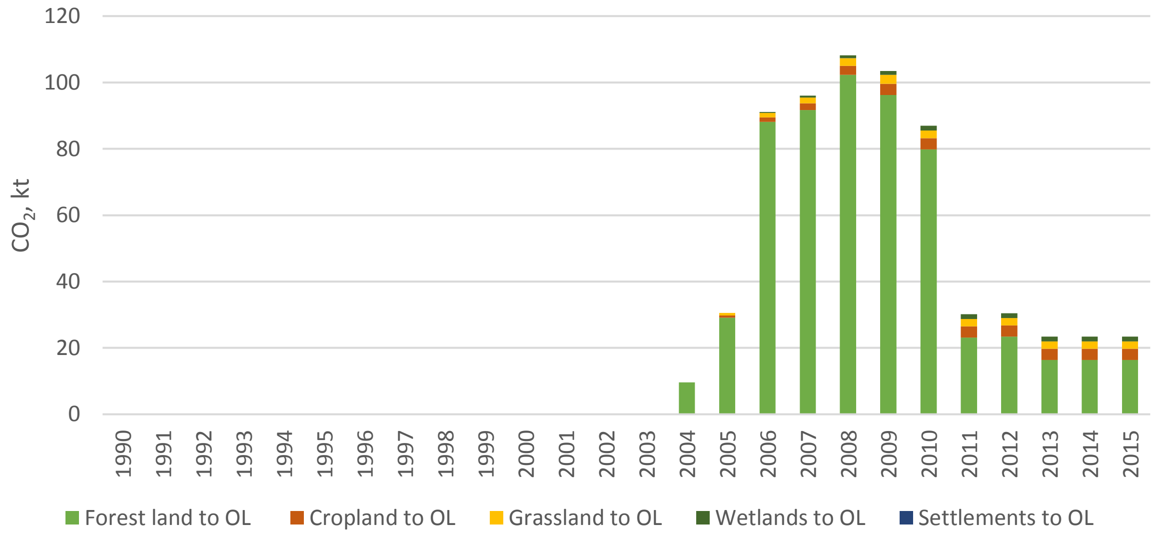

Figure 6.25. CO_2 emissions related to land-use changes to other land, 1990–2015, kt

6.7.3. Uncertainty and time series consistency

The uncertainty rates related to the activity data and the emission factors used in the estimates are presented in Table 6.34.

Table 6.34. Uncertainties used in the land converted to other land category

IPCC category	Uncertainties %	EF References

[266] Since there are no Swedish EFs for land converted to Other Land, the same emission factors as under land converted to Settlements were applied. The same EFs were implemented for mineral and organic soils.

		Activity data[267]	Emission factors	
4.F.2.1	Forest land converted to Other land – living biomass	67.97	46.95	IPCC 2006
4.F.2	Land converted to other land – soils	56.54	25.00	Sweden NIR 2016, p. 382
4.F.2.1	Forest Land converted to other land – dead wood	68.07	19.84	Köster et al. 2015

6.7.4. Category-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for the LULUCF sector according to the IPCC *Tier 1* method. The quality objectives and the QA/QC plan for the Estonian GHG inventory at the national level are presented in 1.2.3.

6.7.5. Category-specific recalculations

Updated activity data, growing stocks and dead wood volumes from the NFI were used for estimating carbon losses due to land conversion to Other Land.

In Table 6.35 a quantitative overview of recalculations has been shown.

Table 6.35. Quantitative overview of recalculations in the Other land category (15.06.2016 submission/15.03.2017 submission)

to Other land TOTAL emissions, kt		**CO_2**		**CO_2**
1990/1995	Previous submission	NO	**2005**	69.44
	Current submission	NO		30.59
	Difference %	**-**		**-56**
2000	Previous submission	NO	**2010**	36.99
	Current submission	NO		86.98
	Difference %	**-**		**135**

6.7.6. Category-specific planned improvements

Updated data derived from the NFI fieldwork for land-use changes will be used.

[267] All activity data uncertainty estimates are obtained from the NFI.

6.8. Non-CO_2 emissions from biomass burning (CRF 4 (V))

This category includes CH_4 and N_2O emissions from biomass burning on wooded lands after wildfires. CO_2 emissions caused by wildfires are included in living biomass emission estimates due to the stock change (stock-difference) method used for calculations, thus CO_2 emissions are not reported under the current category in order to avoid double accounting.

Controlled fires are not a common practice in Estonia. Furthermore the standpoint of the public and the national authorities is opposed to prescribed burnings. For example, pursuant to the Forest Act, local administrations shall implement measures to prevent forest fires, and according to the Estonian Fire Safety Act, it is forbidden to burn dead grass through the year.

6.8.1. Methodology, data availability and sources, emission factors

Information about wildfires is acquired from the Estonian Rescue Service (ERS), which reports the location and type of fire occurred. With the objective to improve and verify data and emissions related to wildfires, the Estonian Environment Agency started to inventory reported wildfires. Exact location (georeference, area), land use and affected biomass are determined during fieldwork. Wildfires reported in 2015 are indicated in Figure 6.10.

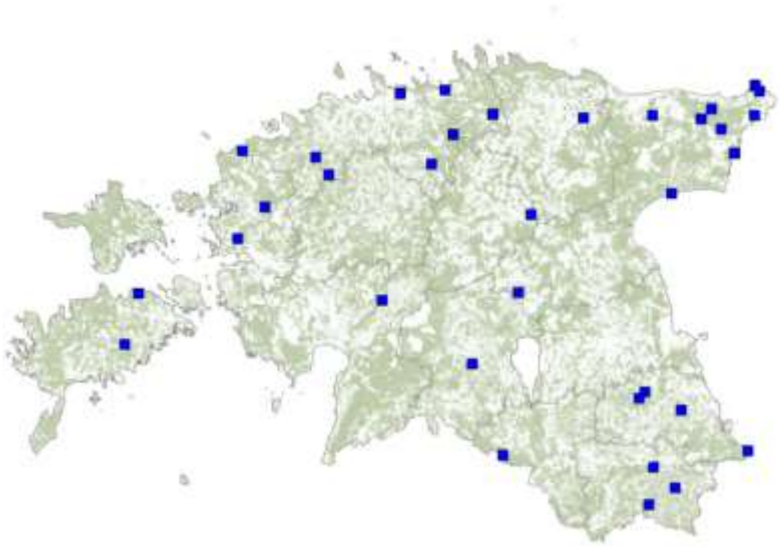

Figure 6.10. Reported wildfires in Estonia in 2015

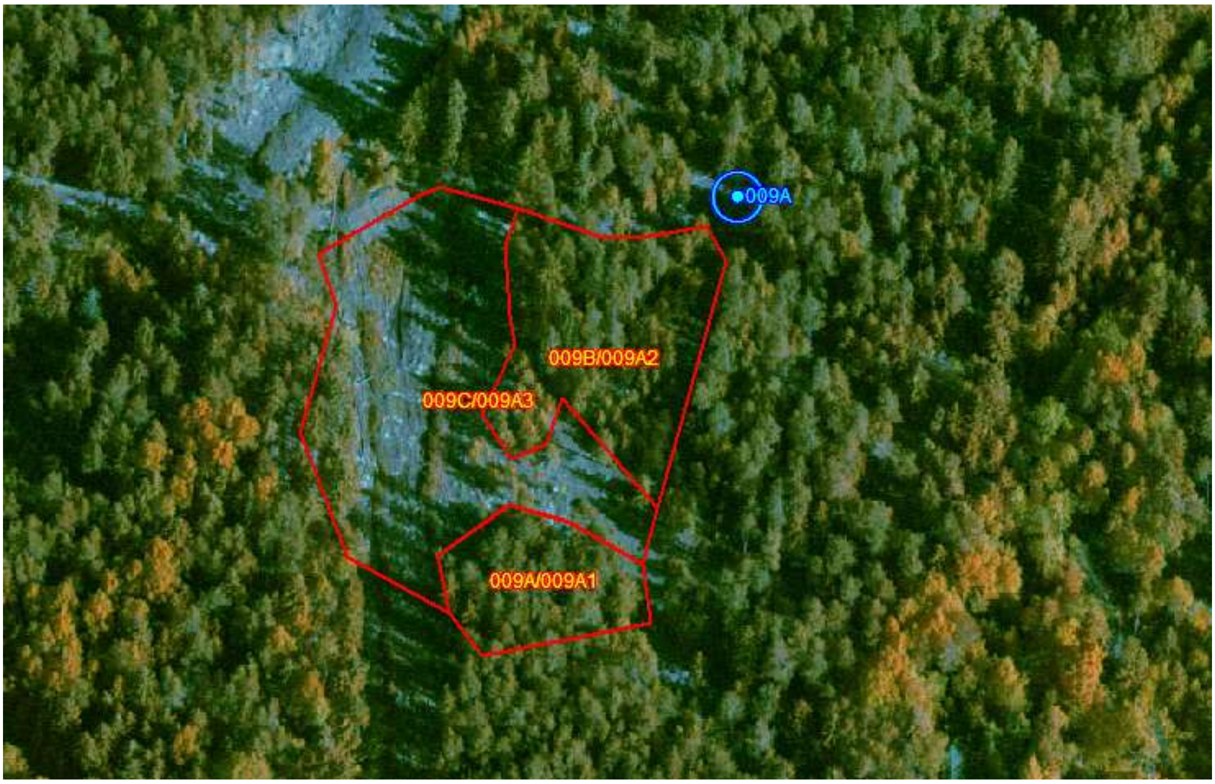

Figure 6.11. Reported fire location (blue circle), actual location (red border) and data analyses

Sometimes the location of wildfire reported by the ERS is imprecise, in which case EtEA field workers examine the nearby area and try to locate the place of fire (Figure 6.11). Detected burned area is separated into several land use categories if necessary.

The *Tier 2* method and Equation 6.14 was used to estimate the emissions of non-CO_2 greenhouse gases. Mass of available fuel and combustion efficiency is determined during fieldwork starting from 2013.

Equation 6.14[268]

$$L_{fire} = A \bullet M_B \bullet C_f \bullet G_{ef} \bullet 10^{-3}$$

Where:

L_{fire} = quantity of GHG released due to fire, tonnes of GHG;
A = area burnt, ha;
M_B = mass of 'available' fuel, kg dry matter ha^{-1};[269]
C_f = combustion efficiency (or fraction of the biomass combusted), dimensionless; from 1990–2012 applied value 0.15[270], starting from 2012 C is estimated during field inventory;
G_{ef} = emission factor, g (kg dry matter.)$^{-1}$.

268 IPCC 2006, Equation 2.27, p. 2.42.
269 from 1990-2012 year specific average forest biomass growing stock was used as basis for M_B.
270 IPCC 2006; Table 2.6, p. 2.46 (Boreal forest) surface fire.

Emission factors used for biomass burning emission calculations are shown in Table 6.36.

According to ERS and EtEA wildfires occurred only on 43.78 ha of forests and 28.37 ha of Grasslands in 2015 (Figure 6.12). Fluctuations in area burned are caused mainly by the weather conditions in different years (e.g. extremely hot and dry summers).

Table 6.36. Factors used for estimation of non-CO_2 greenhouse gas emissions from fires

	CH_4 Emission factor, D[271]	N_2O Emission factor, D
Forest land	6.1	0.06
Grassland and Wetlands	2.3	0.21

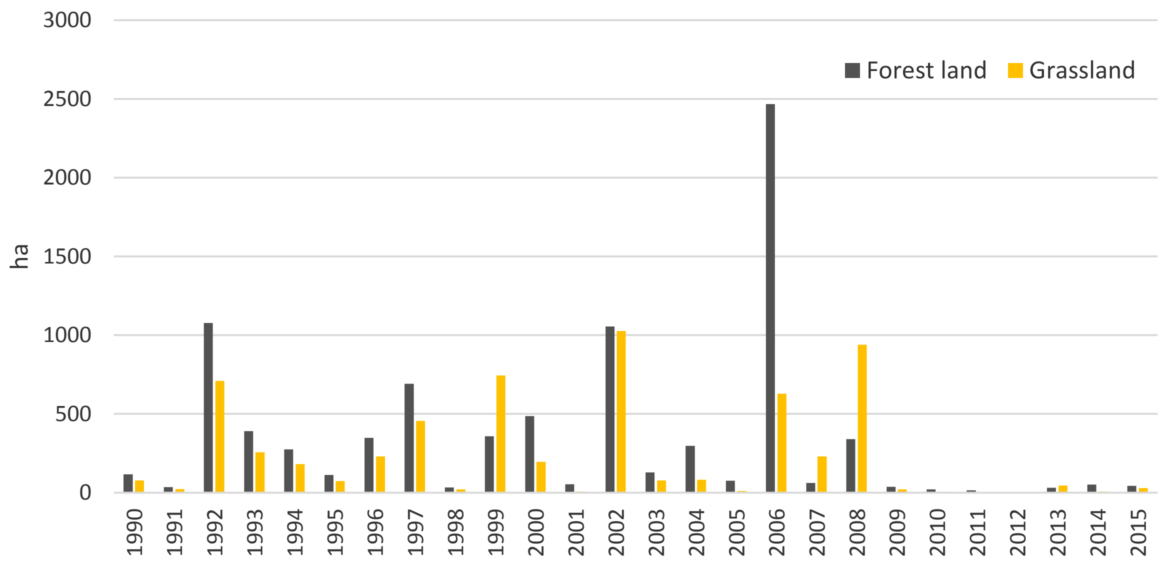

Figure 6.12. Annual area of Forest land and Grassland affected by fires in 1990−2015, ha

The total amount of CH_4 and N_2O released after wildfires was 0.11 t and 0.01 t respectively in 2015. Non-CO_2 emissions from Grassland wildfires are rather insignificant compared to Forest land, since there is approximately 10 times less growing biomass on Grasslands.

6.8.2. Uncertainties and time series consistency

Uncertainty estimates of CH_4 and N_2O emissions from wildfires were carried out based on 2006 IPCC guidelines. Activity data concerning area burnt was obtained from the Estonian Rescue Service and the Estonian Environment Agency. The uncertainty rates are shown in Table 6.37.

[271] IPCC 2006, Table 2.5 p. 2.47, Savanna and grassland, Biofuel burning.

Table 6.37. Uncertainties of non-CO_2 emission estimates from biomass burning

IPCC category	Uncertainties %		EF References
	Activity data[272]	Emission factors	
Biomass burning (CH_4)	34.50	70.00	LULUCF IPCC 2006, p. 4.7 Table 2.6 p. 2.48
Biomass burning (N_2O)	34.50	70.00	LULUCF IPCC 2006, p. 4.7 Table 2.6 p. 2.48

6.8.3. Category-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for the LULUCF sector according to the IPCC *Tier 1* method. The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Chapter 1.2.3.

Activity data obtained from the Estonian Rescue Service is verified and corrected if necessary during field inventory carried out by the Estonian Environment Agency.

6.8.4. Category-specific recalculations

No recalculations were made in the 2017 submission.

6.8.5. Category-specific planned improvements

Starting from October 2013, forest fires are inventoried by the Estonian Environment Agency, which determines the area and type of fire and estimates the fire damage on biomass (trees, dead organic matter) and soils.

[272] All activity data uncertainty estimates are obtained from the NFI.

6.9. Harvested wood products (CRF 4.G)

6.9.1. Category description

Harvested wood products is a key source of CO_2 removals and includes all wood products in use in Estonia. The carbon balance has been calculated using the production approach for HWP. HWP are divided into Solid wood products (sawnwood and wood panels), Paper products (paper and paperboard) and Semi-chemical wood pulp. The changes in roundwood stocks and their carbon balance are not taken into account in the reporting. The carbon balance of HWP in solid waste disposal sites is also excluded from the estimate. In Estonia HWP reporting starts from 1992 due to the lack of sufficient data regarding years 1990 and 1991.

Net emissions from the harvested wood products are calculated according to the chapter 2.8 from 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol[273]. CO_2 emissions due to roundwood production in deforested land are accounted using instantaneous oxidation method.

The net emissions in harvested wood products category in 2015 was -1 080.2 kt CO_2 and the net emissions during the reporting period are shown in Figure 6.13. Increases of removals in the harvested wood products are associated with increase of harvest rate. As a result of the estimated total HWP balance during periods when consumption is low (1992–1993), the HWP pool becomes a source of CO_2.

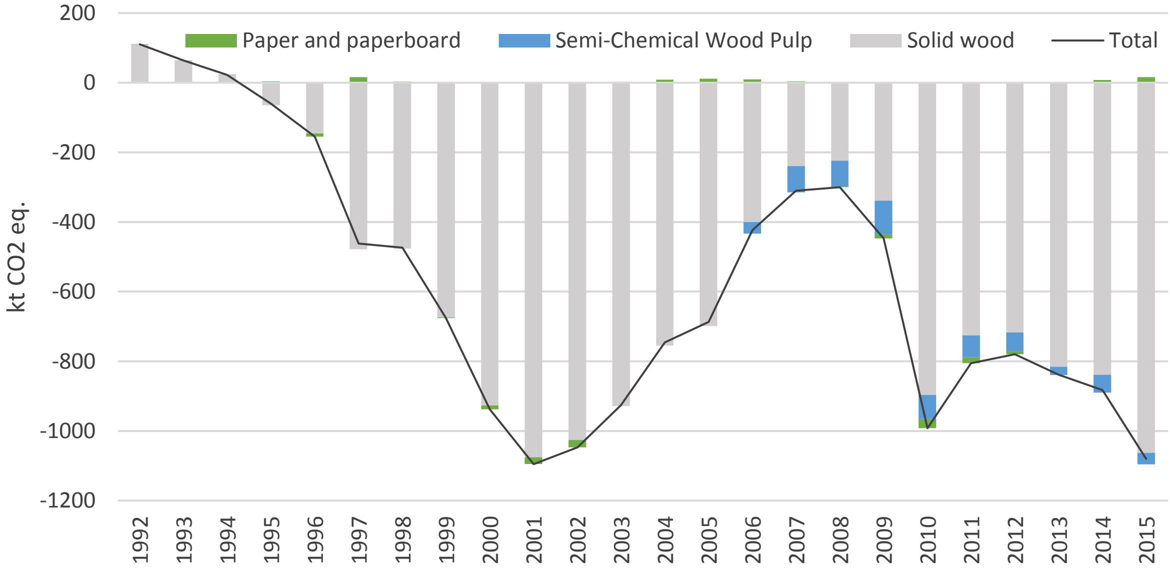

Figure 6.13. Net emissions of from HWP categories Solid wood, Paper and paperboard and Semi-chemical wood pulp in Estonia in 1992–2015, kt CO_2 eq.

[273] 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol, Chapter 2.8, p. 2.109-2.134.

6.9.2. Methodological issues

For calculating annual changes in carbon stocks and associated CO_2 emissions and removals from Harvested wood products (HWP) pool chapter 2.8 from 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol was applied. Estimation of annual fraction of feedstock for HWP originating from domestic harvest was calculated using equations 2.8.1–2.8.3.

Forestry data originates from National Forest Inventory (NFI) and foreign trade data comes from Statistics Estonia. In order to use equations 2.8.4–2.8.6 production data from Statistics Estonia was applied. Default conversation factors (Table 6.38) and half-lives from tables 2.8.1[274] and 2.8.2 were used to calculate Paper and paperboard and Solid wood removals with the *Tier 2* method. *Tier 3* method was used to calculate carbon stock and emission from Semi-chemical wood pulp with country specific C conversion factor (0.4275 kt C/m^3). Inherited emissions are included in the HWP estimations.

Table 6.38. Default conversion factors for default HWP categories and their subcategories

HWP categories	Density (kt/m^3)	Carbon fraction	C conversion factor (kt C / m^3)
Sawn wood (aggregate)	0.458	0.5	0.229
Coniferous sawnwood	0.45	0.5	0.225
Non-coniferous sawnwood	0.56	0.5	0.28
Wood-based panels (aggregate)	0.595	0.454	0.269
Hardboard (HDF)	0.788	0.425	0.335
Insulating board (Other board, LDF)	0.159	0.474	0.075
Fibreboard compressed	0.739	0.426	0.315
Medium-density fibreboard (MDF)	0.691	0.427	0.295
Particle board	0.596	0.451	0.269
Plywood	0.542	0.493	0.267
Veneer sheets	0.505	0.5	0.253
	(kt / kt)		(kt C / kt)
Paper and paperboard	0.9		0.386

274 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol, Chapter 2.8.3.1, p. 2.122.

6.9.3. Uncertainties and time-series consistency

The uncertainty rates related to the activity data and the emission factors used in the estimates are presented in Table 6.39.

Table 6.39. Uncertainties in HWP category

IPCC category	Uncertainties %		EF References
	Activity data[275]	Emission factors	
Wood panels and sawnwood	39	57	LULUCF IPCC 2006, p. 12.22 Table 12.6 Lamlom and Savidge, 2003
Paper and paperboard	30	57	LULUCF IPCC 2006, p. 12.22 Table 12.6 Lamlom and Savidge, 2003
Semi-chemical wood pulp	30	57	LULUCF IPCC 2006, p. 12.22 Table 12.6 Lamlom and Savidge, 2003

6.9.4. Category-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for the LULUCF sector according to the IPCC *Tier 1* method. The quality objectives and the QA/QC plan for the Estonian GHG inventory at the national level are presented in 1.2.3.

6.9.5. Category-specific recalculations

Activity data is being updated and if necessary, corrected, each year.

In Table 6.40 a quantitative overview of recalculations has been shown.

6.9.6. Category-specific planned improvements

There are currently no category-specific improvements planned.

[275] Activity data uncertainty estimates are obtained from the NFI and expert judgement.

Table 6.40. Quantitative overview of recalculations, kt C (15.06.2016 submission/15.03.2017 submission)

		1992			1995			2000			2005			2010		
		Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**	Previous submission	Current submission	**Difference %**
Harvested wood product	Solid wood	-30.3	-29.8	**-1**	17.7	17.6	**-1**	261.9	252.8	**-3**	117.6	190.6	**62**	242.9	244.6	**1**
	Paper and paperboard	-0.3	-0.2	**-25**	-1.1	-1.1	**5**	2.9	2.9	**-1**	-5.1	-3.2	**-38**	7.2	7.3	**1**
	Semi-Chemical Wood Pulp	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	17.8	18.8	**5**
TOTAL HWP net CO_2		112.5	110.3	**-2**	-61.2	-60.2	**-2**	-981.1	-937.5	**-4**	-421.0	-687.1	**63**	-977.6	-992.4	**2**

7. WASTE (CRF 5)

7.1. Overview of the sector

Waste management in Estonia is based on the EU and national legislation and National Waste Management Plan for years 2014 – 2020[276]. Main purpose of the national waste policy has been to reduce the volume of the waste deposited in landfills, enlarge the potential of recoverable waste and minimize the hazardousness of wastes to the limit. The National Waste Management Plan has a function of supporting Waste Act, which stipulates waste related requirements and rules.

Table 7.1 summarizes the data on approaches and emission factors employed in estimations of GHG emissions from each sub-category of the Waste sector. Due to lack of national research in order to use country-specific emission factors, the IPCC 2006 Guidelines default values have mostly been applied in calculations. The process of choosing among methods relies on the decision trees described in IPCC 2006 Guidelines.

Table 7.1. Methods and emission factors used in estimations of emissions from Waste sector

	Method applied/EF used		
GREENHOUSE GASES SOURCE AND SINK CATEGORIES	**CO_2**	**CH_4**	**N_2O**
5. WASTE			
5.A Solid waste disposal		T2/D	
5.B.1 Composting		T1/D	T1/D
5.C.1 Waste incineration	T2a/D	T1/D	T1/D
5.C.2 Open burning of waste	T1/D	T1/D	T1/D
5.D Wastewater treatment and discharge		T1/D	T1/D
5.E Biogas burnt in a flare		T2/CS	T2/CS

T1 – *Tier 1*method, T2 – *Tier 2* method, CS – country specific, D – IPCC 2006 default value.

CO_2 eq emission from Waste sector was 326.08 kt in 2015 and it covered 1.8% of the total GHG emission in 2015 (Figure 7.1).

[276] Waste Management Plan 2014–2020. Ministry of the Environment. [www] http://www.envir.ee/sites/default/files/riigi_jaatmekava_2014-2020.pdf (28.12.2016).

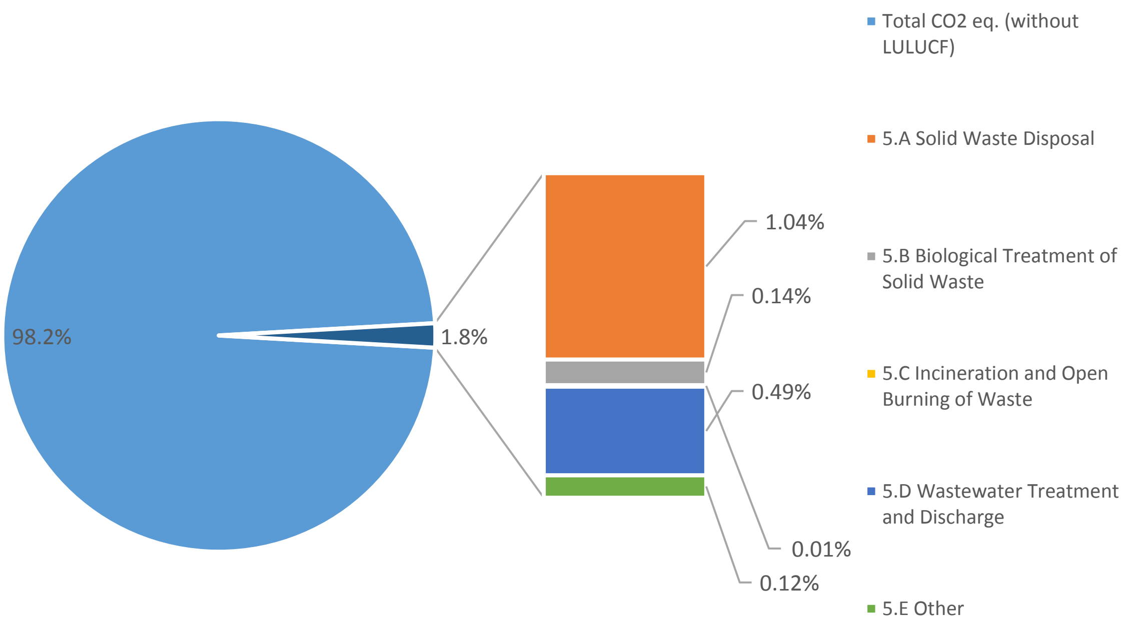

Figure 7.1. CO_2 eq emissions from the Waste sector compared to the total GHG emissions in Estonia in 2015, %

The total CO_2 eq emission from Waste sector (Figure 7.2) in 2015 decreased 4.2% compared to 2014. During recent years, the total emission is in decreasing trend. Compared to the base year of 1990, the amount of CO_2 eq emission emitted in 2015 is 11.8% lower. Compared with the base year, the CO_2 eq emissions from Solid waste disposal decreased 12.4%, CO_2 eq emissions emitted from Incineration and open burning of waste have decreased 58.2% and Wastewater treatment and discharge CO_2 eq emissions decreased 41.1%. On the other hand, the CO_2 eq emission from Biological treatment of solid waste have, compared to the base year of 1990 increased 2 113.8%. Burning biogas in a flare is taking place since 1999 and it is connected with the number of active plants. The increase of burning biogas in a flare since 1999 is 1.5%.

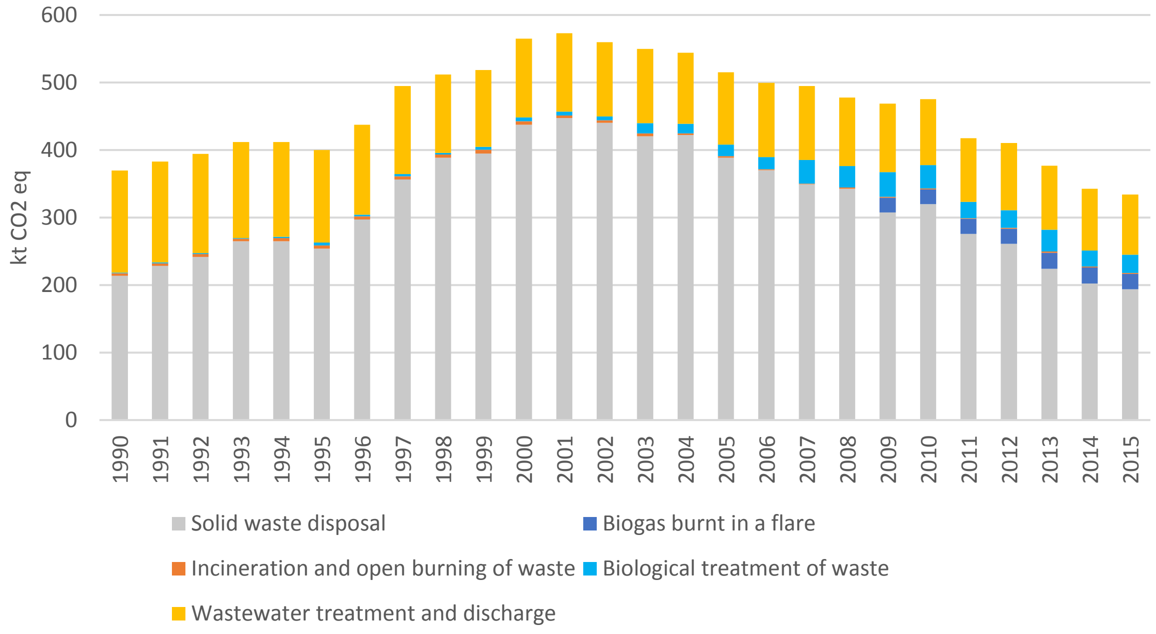

Figure 7.2. Trends of GHG emissions in the Waste sector by source categories in 1990–2015, kt CO_2 eq.

As seen from the Figure 7.2 and Table 7.2, the lowest GHG emissions from waste management occurred during 2015, which were mainly the result of decreasing rate of landfilling due to a functioning waste incineration plant. The highest CO_2 eq emission in 2001 were related to significant increase in emissions from Solid waste disposal. Emissions from Incineration and open burning have been marginal during the whole period compared to other activities involved. The emissions from Biological treatment of solid waste is generally in increasing trend as the amount of waste treated biologically is increasing. Starting from 2009, some Estonian landfills started biogas burning in a flare.

The fluctuations of the emission amounts are caused by the fluctuation of waste material that was biologically treated. Total CO_2 eq emissions in 2015 have decreased significantly compared to previous years.

NH_3 emission is based on the data reported in NEC/CLRTAP inventories by Estonian Environment Agency. The total NH_3 emission is presented in Figure 7.3 includes emissions from Solid waste disposal, Biological treatment of solid waste, Industrial waste incineration, Cremation, Industrial and domestic wastewater treatment and Other waste handling. The emissions are mainly calculated using actual emissions data reported by the companies and also using the EMEP/EEA Guidebook 2013[277].

[277] EMEP/EEA air pollutant emission inventory guidebook 2013. (2013). [www] http://www.eea.europa.eu/publications/emep-eea-guidebook-2013 (28.12.2016)

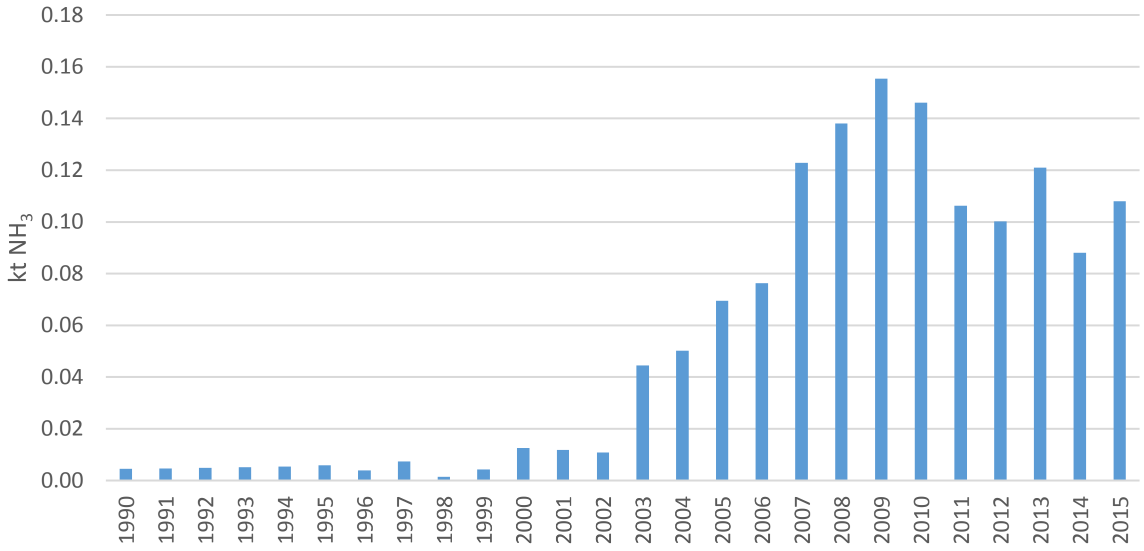

Figure 7.3. NH_3 emission from Solid waste disposal, Biological treatment of solid waste, Industrial waste incineration and Industrial and domestic wastewater treatment, kt

Table 7.2. GHG emissions from Waste sector in Estonia in 1990–2015, kt

Year	Solid waste disposal	Incineration and open burning of waste			Biological treatment of solid waste		Wastewater treatment and discharge			Biogas burnt in a flare		Total CO_2 eq. emissions
		non-biogenic			Composting		Domestic wastewater		Industrial wastewater			
	CH_4	CO_2	CH_4	N_2O	CH_4	N_2O	N_2O	CH_4	CH_4	CH_4	N_2O	CO_2 eq.
1990	8.55	2.25	0.05	0.0008	0.03	0.002	0.13	4.51	NO	NO	NO	369.90
1991	9.14	2.25	0.05	0.0008	0.03	0.002	0.13	4.43	NO	NO	NO	382.75
1992	9.68	2.45	0.05	0.0009	0.03	0.002	0.13	4.35	NO	NO	NO	394.18
1993	10.59	2.21	0.05	0.0007	0.03	0.002	0.12	4.29	NO	NO	NO	411.96
1994	10.60	2.60	0.06	0.0009	0.03	0.002	0.12	4.21	NO	NO	NO	411.06
1995	10.15	2.99	0.07	0.0010	0.04	0.002	0.11	4.15	NO	NO	NO	397.71
1996	11.88	2.46	0.07	0.0011	0.02	0.001	0.11	4.00	NO	NO	NO	435.77
1997	14.25	2.58	0.07	0.0011	0.04	0.003	0.11	3.94	NO	NO	NO	493.26
1998	15.54	2.65	0.07	0.0011	0.01	0.000	0.10	3.41	NO	NO	NO	509.66
1999	15.80	2.81	0.09	0.0012	0.03	0.002	0.10	3.37	NO	NO	NO	515.39
2000	17.50	2.82	0.08	0.0012	0.08	0.005	0.10	3.42	0.06	NO	NO	562.80
2001	17.90	2.21	0.05	0.0008	0.07	0.004	0.10	3.39	0.07	NO	NO	570.61
2002	17.60	2.38	0.06	0.0009	0.07	0.004	0.10	3.18	0.04	NO	NO	557.16
2003	16.82	2.64	0.06	0.0009	0.27	0.016	0.10	3.15	0.06	NO	NO	546.29
2004	16.89	1.39	0.03	0.0005	0.26	0.016	0.10	3.04	0.02	NO	NO	541.52
2005	15.54	1.46	0.03	0.0005	0.37	0.022	0.10	2.84	0.29	NO	NO	513.89
2006	14.81	0.69	0.02	0.0003	0.39	0.023	0.10	2.82	0.43	NO	NO	498.27
2007	13.97	0.66	0.02	0.0003	0.77	0.046	0.10	2.80	0.39	NO	NO	493.12
2008	13.71	1.10	0.02	0.0003	0.72	0.043	0.10	2.25	0.61	NO	NO	476.48

Year	Solid waste disposal	Incineration and open burning of waste			Biological treatment of solid waste		Wastewater treatment and discharge			Biogas burnt in a flare		Total CO_2 eq. emissions
		non-biogenic			Composting		Domestic wastewater		Industrial wastewater			
	CH_4	CO_2	CH_4	N_2O	CH_4	N_2O	N_2O	CH_4	CH_4	CH_4	N_2O	CO_2 eq.
2009	12.30	0.94	0.02	0.0003	0.82	0.049	0.10	2.24	0.60	0.85	0.0033	467.32
2010	12.79	0.84	0.02	0.0003	0.78	0.047	0.10	2.09	0.61	0.85	0.0033	474.20
2011	11.03	0.80	0.01	0.0002	0.53	0.032	0.10	2.08	0.47	0.85	0.0033	416.08
2012	10.45	0.86	0.02	0.0003	0.59	0.036	0.10	2.07	0.69	0.85	0.0033	409.58
2013	8.97	1.04	0.02	0.0003	0.73	0.044	0.10	2.02	0.55	0.91	0.0036	375.50
2014	8.05	0.97	0.02	0.0003	0.51	0.031	0.10	2.00	0.46	0.92	0.0036	340.27
2015	7.49	0.99	0.02	0.0003	0.60	0.036	0.10	1.97	0.38	0.86	0.0034	326.08

7.1.1. Key categories

Waste key categories in 2015 (without LULUCF) calculated with the *Tier 1* method are:

5.A	Solid waste disposal (CH_4)	L, T
5.B.1	Composting	T
5.D.1	Domestic wastewater (N_2O)	T
5.D.1	Domestic wastewater (CH_4)	L
5.E	Other (Biogas Burnt in a flare)	T

7.1.2. Uncertainty assessment

All calculated uncertainties of emission factors and activity data used are in accordance with methodology used in emission estimations, derived from IPCC 2006 Guidelines are using Equation 7.1. In Table 7.3 all categories comprised in uncertainty estimates are presented, detailed uncertainty values used in uncertainty assessment are presented under sub-categories' descriptions below.

Equation 7.1[278]

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \cdots + U_n^2}$$

Table 7.3. The combined uncertainties in Waste sector, %

Source category	**Gas**	**Combined uncertainty %**
5.A Solid waste disposal	CH_4	89%
5.B.1 Composting	CH_4	76%
5.B.1 Composting	N_2O	67%
5.B.2 Anaerobic digestion at biogas facilities	CH_4	96%
5.C.1 Waste incineration	CH_4	50%
5.C.1 Waste incineration	N_2O	100%
5.C.1 Waste incineration	CO_2	40%
5.C.2 Open burning of waste	CH_4	59%
5.C.2 Open burning of waste	N_2O	105%
5.C.2 Open burning of waste	CO_2	51%
5.D.1 Domestic wastewater	CH_4	90%
5.D.1 Domestic wastewater	N_2O	109%
5.D.2 Industrial wastewater	CH_4	62%
5.E Other (Biogas burnt in a flare)	CH_4	29%
5.E Other (Biogas burnt in a flare)	N_2O	19%

[278] IPCC 2006 vol 1, Chapter 3. Equation 3.1, p 3.28.

7.2. Solid waste disposal (CRF 5.A)

7.2.1. Source category description

In 2015, Estonia had 5 functioning landfills (Tallinn Recycling Center, Uikala, Väätsa, Torma and Paikre) classified as managed solid waste disposal sites and 1 landfill for construction waste. These landfills are fully conformed to environmental and technical requirements and standards and are capable to serve more than one county or service area. Due to the strict requirements which were established for waste landfilling, the number of landfills started decreasing from 157 landfills in 2001 to 5 landfills in 2015. Landfills closed for waste depositing were conditioned in accordance with the requirements by the end of 2015.

As seen from the Figure 7.4, the quantities of emitted methane from Solid waste disposal (SWD) are in decreasing trend with a stable level of recovered methane.

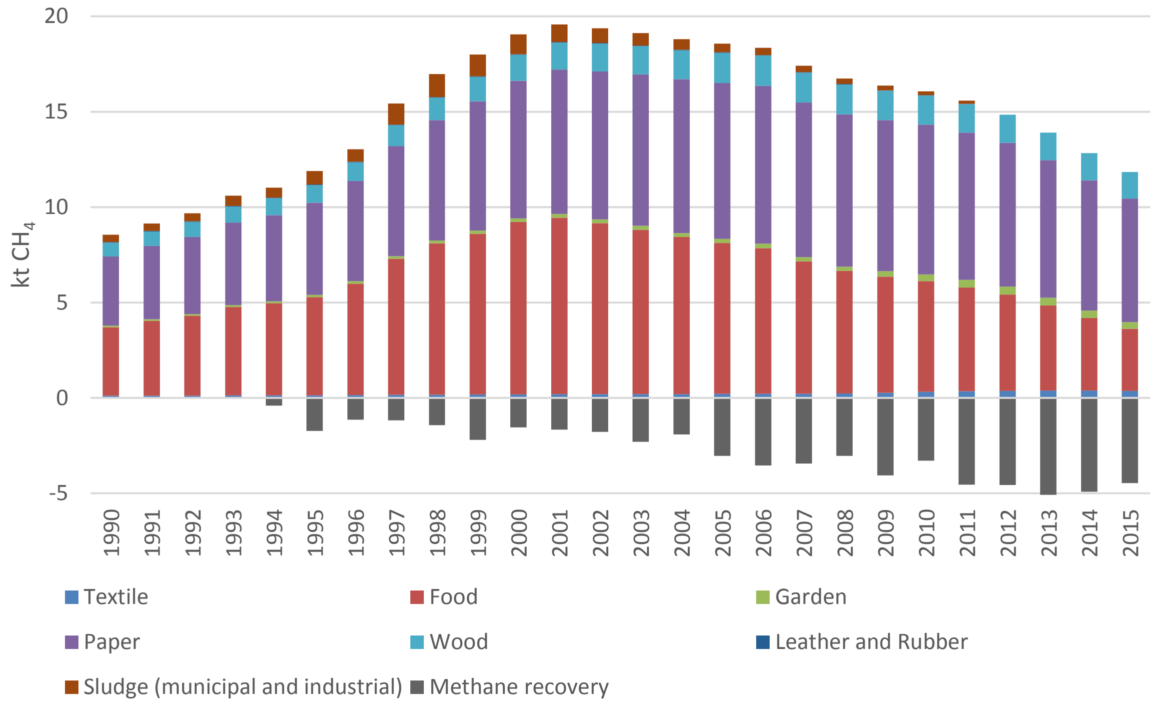

Figure 7.4. CH_4 emissions and recovery from landfills in Estonia in 1990–2015, kt

Estonia's total CH_4 emission from SWD onto landfills in 2015, was 7.49 kt (Figure 7.4). The driver for the decreasing trend in the total CH_4 emissions is the considerable amount of landfill gas recovered, waste incinerated in Iru waste incineration plant and the amount of waste recycled. Emissions from Iru waste incineration plant have been reported under Energy sector.

Table 7.4. Quantities of CH_4 emission and recovery from biodegradable solid waste disposed in landfills 1990–2015, kt

Year	Organic/ Food	Garden	Paper	Wood	Textile	Sludge (municipal+ industrial)	Leather	Recovery	Total CH_4 emission from SWDS
1990	3.6	0.1	3.6	0.7	0.1	0.4	0.03	0.0	8.55
1991	3.9	0.1	3.8	0.8	0.1	0.4	0.03	0.0	9.14
1992	4.2	0.1	4.0	0.8	0.1	0.4	0.03	0.0	9.68
1993	4.6	0.1	4.3	0.8	0.1	0.5	0.03	0.0	10.59
1994	4.8	0.1	4.5	0.9	0.1	0.5	0.04	-0.4	10.60
1995	5.1	0.1	4.8	0.9	0.1	0.7	0.04	-1.7	10.15
1996	5.8	0.1	5.3	1.0	0.1	0.6	0.04	-1.1	11.88
1997	7.1	0.1	5.8	1.1	0.2	1.1	0.04	-1.2	14.25
1998	7.9	0.2	6.3	1.2	0.2	1.2	0.04	-1.4	15.54
1999	8.4	0.2	6.8	1.3	0.2	1.1	0.04	-2.2	15.80
2000	9.0	0.2	7.2	1.4	0.2	1.0	0.03	-1.5	17.50
2001	9.2	0.2	7.6	1.4	0.2	0.9	0.03	-1.7	17.90
2002	9.0	0.2	7.8	1.5	0.2	0.8	0.03	-1.8	17.60
2003	8.6	0.2	7.9	1.5	0.2	0.7	0.03	-2.3	16.82
2004	8.2	0.2	8.1	1.5	0.2	0.6	0.03	-1.9	16.89
2005	7.9	0.2	8.2	1.6	0.2	0.5	0.03	-3.0	15.54
2006	7.6	0.2	8.3	1.6	0.2	0.4	0.03	-3.5	14.81
2007	6.9	0.2	8.1	1.6	0.2	0.3	0.03	-3.4	13.97
2008	6.4	0.2	8.0	1.6	0.2	0.3	0.03	-3.0	13.71
2009	6.1	0.3	7.9	1.5	0.3	0.2	0.03	-4.1	12.30
2010	5.8	0.4	7.8	1.5	0.3	0.2	0.03	-3.3	12.79
2011	5.4	0.4	7.7	1.5	0.3	0.2	0.03	-4.6	11.03
2012	5.0	0.4	7.5	1.5	0.4	0.1	0.03	-4.6	10.45
2013	4.5	0.4	7.2	1.4	0.4	0.1	0.02	-5.1	8.97
2014	3.8	0.4	6.8	1.4	0.4	0.1	0.02	-4.9	8.05
2015	3.3	0.3	6.5	1.4	0.4	0.1	0.02	-4.5	7.49

Figure 7.5.

Figure 7.5 is showing CH_4 emission from SWD with and without the energy recovery.

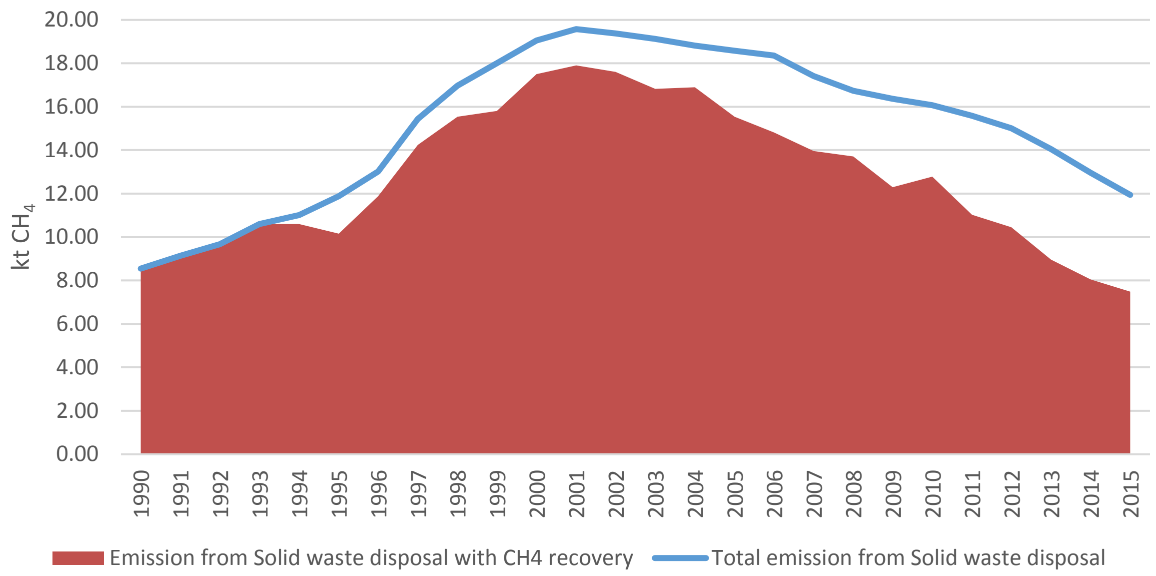

Figure 7.5. CH_4 emission from SWD with and without energy recovery, kt

7.2.2. Methodological issues

Activity data

Activity data for waste generation and depositing used in calculation is collected from Estonian Environment Agency (EtEA), who controls the accuracy of data reported by waste handling companies. The reported waste data is available in an online waste reporting system JATS[279]. JATS provides information about the whole waste stream including waste in the beginning of the year, imported waste, generated waste, recycling of waste, incineration of waste, composting biodegradable waste, exporting waste and the amount of waste which is left to stock in the end of the year. It is possible, that the amount of waste in the end of one year does not correspond with the amount of waste in the beginning of following year. This distinction a result of different aspects which include:

- Waste reporting obligation is new for the company- If company has it's waste permit enforced in 2015 than the amount of waste generated by this company will be included to the total amount of waste in the beginning of 2015 and is not included in the stock of waste in the end of 2014 (because this company did not have the waste reporting obligation in 2014).
- Company does not have to submit waste reports, because the waste reporting obligation has ended (company has changed profile of its activities etc)- If company's waste obligation has ended in 2014 then the amount of waste is counted in the stock in the end of 2014. In the beginning of 2015, these wastes are not included to the stock in the beginning of 2015 as these wastes will be given to other waste companies which will report the waste as 'received from the company'. This amount of waste will be accounted in total waste generation.

[279] Estonian Environment Agency Waste reporting system (JATS). [www] https://jats.keskkonnainfo.ee/main.php?public=1 (28.12.2016).

- The company has discovered that previous year's submitted data was in wrong units, than they are correcting the error in the beginning of the next year.
- The company is making an inventory at the beginning of the year and if it occurs that there have been any inconsistencies in the amounts reported by the end of previous year, then the company corrects the data in the beginning of the next year. If such changes have been made, it is tracked and there will be a comment about it in the online waste reporting system.

The matter of differneces of the activity data in the end of one year and in the beginning of the following year is a distinction of the national system, nevertheless all waste data has been considered while making emission calculations. The matter of activity data in the end of one year and in the beginning of the following year has been discussed with the National Audit Office of Estonia, who is aware of the current situation but has not suggested a method to enhance the reporting system.

EtEA started to collect data in accordance with the Estonian waste classification since 1992, however in 1999 the adapted classification system was changed and the European Waste Catalogue was employed. The data for 1990–1991 were interpolated based on the data of 1992–1998. The forecast function of the Excel software was used to calculate the quantities of waste generated in the period 1990–1991. Data on population and GDP is obtained from the dataset of the SE.

The quantity of total waste generation in 2015 was about 24.7 mln tonnes which is 11% higher than in 2014. The proportion of degradable and inert waste generation in 2015 is accordingly 3.7% and 95.3%. The proportion of separately collected waste is 1.1% of total waste generation. The annual trend of inert and degradable waste generated in Estonia in 1990–2015 is presented in Figure 7.6.

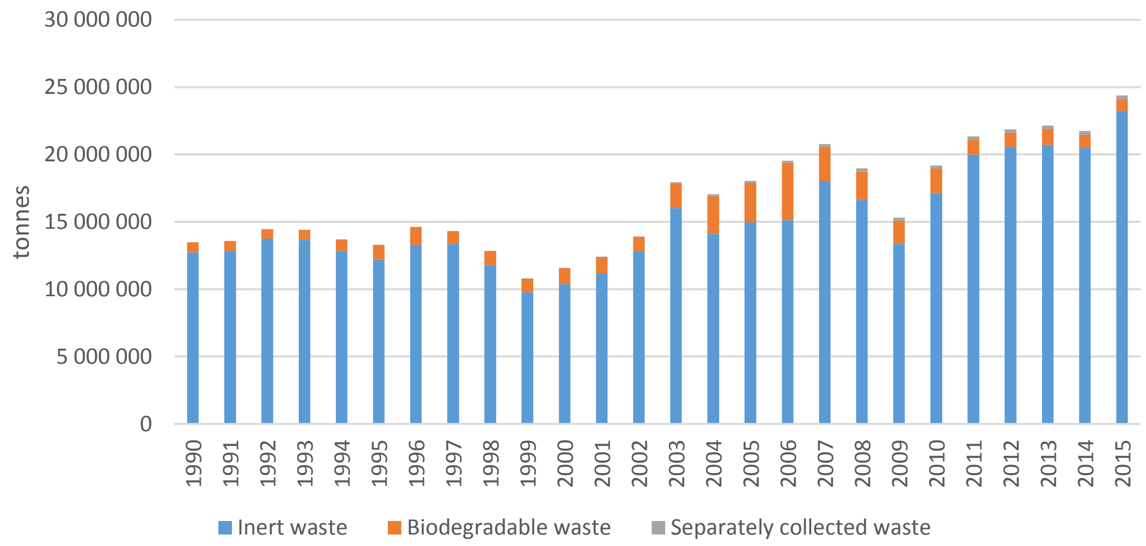

Figure 7.6. Amounts of waste generated in Estonia in 1990–2015, tonnes

In 2015, waste produced by oil shale industry was in decreasing trend constituting 47.0% of the total waste generation. Oil shale industry wastes include wastes from mining and physical-chemical treatment, thermal processes, and other oil shale wastes[280]. In comparison, in 2014 oil shale industry wastes covered 55.7% of the total waste generated. The decrease of the oil shale industry waste is connected with the decrease in the electricity and heat production. Wastes from oil shale industries are not taken into account in the estimation of GHG emissions from SWD. The quantity of municipal waste (MSW) generated in 2015 was about 310 887 tonnes in addition to separately collected fraction, which summed up to 265.3 thousand tonnes. The total amount of MSW generated was about 1.3% of the total waste generation. The total amount of waste disposed onto landfills was 12.22 million tonnes, from which municipal solid waste comprised 25.5 thousand tonnes and industrial waste 12.19 million tonnes (Table 7.5 and Table 7.6). Separately collected MSW and Deposited MSW in Table 7.5 are shown separately as the deposited MSW is calculated based on the mixed MSW sorting studies (Table 7.9). Separately collected MSW is separately derived from JATS.

Table 7.5. Amounts of MSW disposed in SWDS, kt

Year	Food	Garden	Paper	Wood	Textile	Sludge	Inert	Deposited MSW	Separately collected and deposited MSW
1990	147.3	3.5	88.5	11.5	3.1	5.1	95.8	349.8	NO
1991	147.3	3.5	88.5	11.5	3.1	5.4	95.8	349.8	NO
1992	182.1	4.3	109.4	14.3	3.9	2.5	118.5	432.6	NO
1993	156.5	3.7	94.1	12.3	3.3	0.5	101.9	371.8	NO
1994	149.3	3.5	89.7	11.7	3.2	1.3	97.2	354.7	NO
1995	192.5	4.6	115.7	15.1	4.1	0.9	125.3	457.3	NO
1996	237.7	5.6	142.9	18.6	5.1	1.9	154.7	564.7	NO
1997	249.8	5.9	150.1	19.6	5.3	3.1	162.6	593.3	NO
1998	234.6	5.6	141.0	18.4	5.0	2.8	152.7	557.2	NO
1999	239.4	5.7	143.9	18.8	5.1	18.6	155.8	568.6	4.5
2000	231.0	5.5	138.8	18.1	4.9	8.2	150.3	548.7	1.7
2001	168.0	4.0	101.0	13.2	3.6	4.2	109.3	399.1	0.3
2002	175.5	4.2	105.5	13.8	3.8	1.4	114.2	416.8	0.2
2003	155.0	3.7	93.2	12.2	3.3	0.0	100.9	368.2	1.9
2004	154.7	3.7	93.0	12.1	3.3	0.0	100.7	367.5	11.2
2005	152.2	3.6	91.5	11.9	3.3	0.2	99.1	361.6	6.7
2006	82.0	1.9	49.2	6.4	1.8	0.0	53.3	194.7	6.7
2007	98.1	2.3	59.0	7.7	2.1	0.0	63.9	233.1	5.8
2008	104.8	16.9	60.8	3.4	13.5	0.0	138.5	337.9	5.7
2009	87.7	14.1	50.9	2.8	11.3	0.0	116.0	282.9	3.6
2010	72.3	11.7	42.0	2.3	9.3	0.2	95.6	233.2	4.0
2011	60.5	9.8	35.1	2.0	7.8	0.1	80.0	195.2	7.1
2012	30.2	4.1	14.6	2.2	5.5	0.0	51.3	107.9	3.7
2013	12.4	1.7	6.0	0.9	2.3	0.1	21.1	44.4	5.5
2014	8.1	1.1	3.9	0.6	1.5	0.1	13.8	28.9	4.9
2015	7.1	1.0	3.4	0.5	1.3	0.0	12.1	25.5	6.3

[280] Wastes from the treatment of the oil shale and coal, e.g a pitch.

Table 7.6. Amounts of industrial waste disposed in SWDS, kt

Year	Organic	Textile	Wood	Paper	Leather	Rubber	Sludge	Inert*
1990	36.0	0.7	11.5	2.8	0.5	NO	45.9	10 187.0
1991	36.7	0.7	11.4	2.5	0.6	NO	48.3	10 248.8
1992	45.3	1.9	17.9	1.5	1.9	NO	118.0	10 645.2
1993	37.4	0.6	10.8	1.0	0.7	NO	47.8	10 886.4
1994	11.6	0.0	10.0	0.6	0.6	NO	126.1	8 769.1
1995	48.7	0.1	8.0	1.2	0.2	NO	32.2	10 071.9
1996	127.9	0.7	23.3	1.8	0.5	NO	303.9	10 579.9
1997	74.4	0.7	19.0	4.2	0.3	NO	152.8	11 176.0
1998	61.5	0.6	26.9	5.4	0.3	NO	71.9	10 005.1
1999	90.5	0.3	22.7	0.5	0.1	NO	23.4	8 505.4
2000	47.3	0.9	5.3	0.2	0.2	NO	25.5	9 261.2
2001	24.8	0.0	16.1	0.5	0.1	NO	2.1	9 063.4
2002	2.8	0.4	4.7	0.1	0.06	NO	2.3	9 447.2
2003	3.3	0.9	15.6	0.4	NO	NO	3.6	11 556.4
2004	3.8	1.7	13.3	NO	0.01	NO	2.5	11 131.2
2005	4.6	1.2	5.9	NO	NO	NO	1.0	11 058.9
2006	5.2	1.0	2.2	NO	NO	NO	4.0	10 587.7
2007	1.8	0.9	3.2	NO	NO	NO	4.4	11 756.6
2008	1.8	1.0	3.1	NO	NO	NO	0.7	11 335.0
2009	1.5	0.7	1.9	NO	NO	NO	0.7	8 234.7
2010	0.8	0.6	1.5	NO	NO	NO	0.3	11 390.9
2011	0.9	0.5	1.1	NO	NO	NO	1.5	9 054.9
2012	1.2	0.4	0.9	NO	NO	NO	1.2	8 029.7
2013	1.1	0.5	2.0	NO	0.1	NO	0.4	10 643.0
2014	1.4	0.8	0.8	NO	0.07	NO	0.8	13 571.2
2015	1.4	0.6	0.2	NO	NO	NO	0.8	12 183.5

NO – not occurring

* Inert waste includes materials that do not result with CH_4 emission when landfilled-chemicals, inert clinical waste, glass waste, inert waste, metal waste, oil shale waste, plastic waste, pottery and car tyres.

The quantity of DOC[281] generated in 2015 (Figure 7.7), has increased approximately 66.1% compared to the base year of 1990. In comparison with the year 2014, the amount of DOC has decreased about 6.2% and the ratio of DOC landfilled to DOC generated has further decreased from 1.4% to 1.3%.

Waste generation in DOC tonnes during 1990–2001 was in a slight increasing trend due to increasing amount of municipal, organic and industrial wood generation, while share of other waste types were smaller. Notable decrease of generated DOC tonnes in 2002 is caused by sharp decrease of industrial wood waste while the share of other waste types were slightly

[281] DOC-Degradable Organic Carbon.

increasing. Notable increase of the amount of waste generated in DOC tonnes from 2003–2008 is caused by the high but fluctuating industrial wood waste generation. During this period separately collected paper and wood waste were also in increasing trend. On the other hand, the share of municipal waste started to decrease. The downfall of generated waste in 2009 is connected to a sharp decrease of industrial wood waste, which after the increase in 2010 starts to decrease again in 2014. During the period of 1990–2000 high volume of generated waste was disposed to landfills. The decrease of landfilled waste % from 1999–2001 is connected with the decreasing trend of depositing of municipal and organic waste including sludge from industrial and municipal sources. The increase of landfilled % in 2002 is connected with the increase of municipal waste and industrial sludge generation.

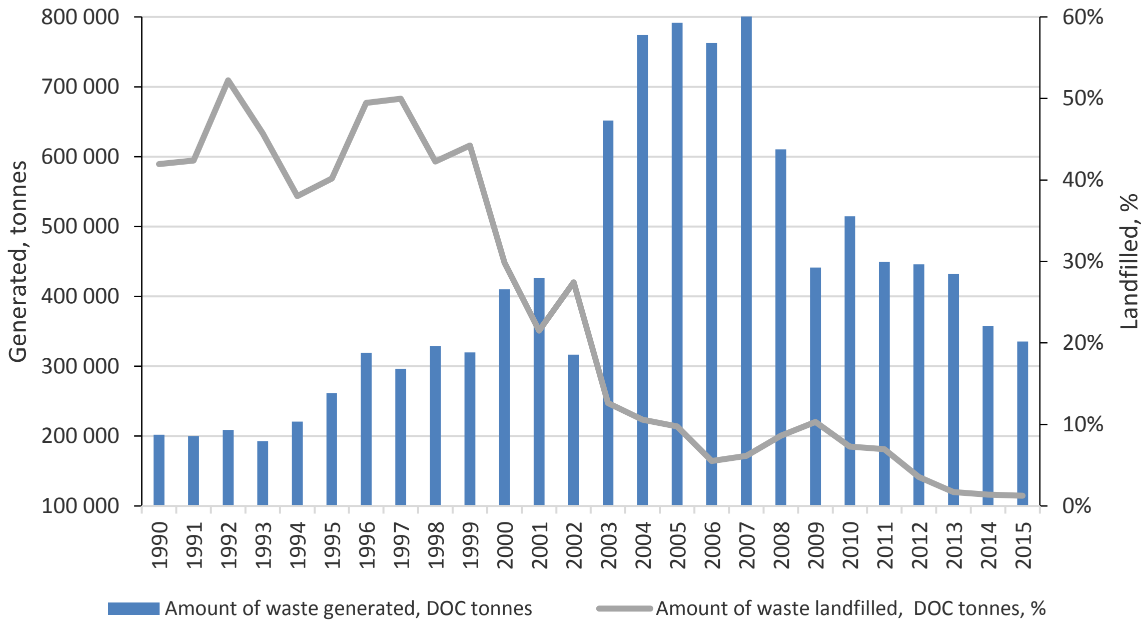

Figure 7.7. Quantity of DOC generated (tonnes) and ratio of DOC landfilled to DOC generated (%) in 1990–2015

Production of biogas

Biogas is a gas fuel obtained via anaerobic fermentation, which is comprised of 50–70% methane (CH_4), 30–40% carbon dioxide (CO_2) and other components such as N_2, O_2, NH_4, H_2S. A biogas station in landfills is provided with pre-preservation storage and mixing containers, biogas reactors, fermenting waste storage area, gas storage units, heating and power station for the use of gas.

The data on the amount of recovered methane in 1994–2007 is based on REN-Estonia – annual questionnaire on renewables and wastes[282]. Starting from 2007, data is obtained from EtEA Air Bureaus information system for ambient air pollution sources OSIS[283], as the landfills with the system of biogas collection report their quantities of recovered biogas directly to the EtEA. The total amount of CH_4 recovered in 2015 was 4.46 kt (Figure 7.8).

[282] REN. 2013. IEA- Eurostat-UNECE. Energy Questionnaire- Renewables and Wastes.
[283] Estonia's information system for ambient air pollution sources OSIS. [www] https://osis.keskkonnainfo.ee/ (28.12.2016).

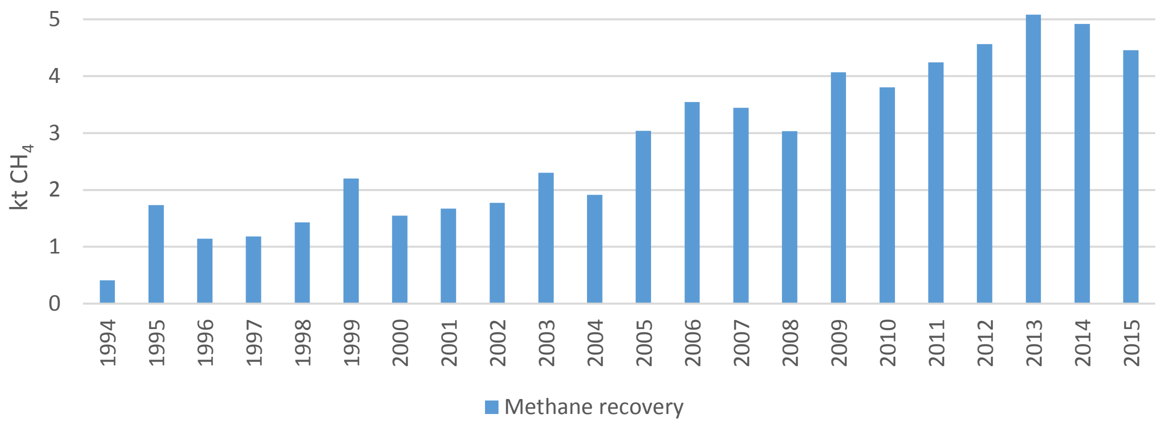

Figure 7.8. CH_4 recovered from landfills 1994–2015, kt

Methane recovery in landfills started in 1994, during 1994–2006 only one landfill in Estonia collected and recovered methane (Pääsküla landfill in Tallinn). The amount of reused CH_4 during this period fluctuates due to changes in the quantity of waste generation and percentage of organic waste in the total amount of waste generated. Jõelähtme landfill started to collect landfill gas in 2007. Decrease of recovered CH_4 in 2008 is caused by the decrease of recovered CH_4 from Pääsküla landfill. Additionally, in 2009 Väätsa landfill and 2010 Paikre landfill started to collect biogas. In 2013 Viljandi and Uikala landfill started burning biogas and in 2014 Aardlapalu landfill started to burn biogas with energy recovery.

The amount of recovered landfill gas, waste recycled and unstable population which fluctuate during the time period affect also the implied emission factor (IEF) of CH_4.

Generally it can be said, that depositing waste in SWDS is in decreasing trend. Remarkable decrease of the amount of disposed municipal solid waste in 2015 is connected with the Iru waste incineration plant, as most of the generated waste is either incinerated or recycled.

Methods

In order to estimate CH_4 emissions from SWD on landfills, the First Order Decay (the FOD) approach, which is IPCC 2006 *Tier 2* method, was employed. FOD spreadsheet model (*IPCC Waste Model*) is based on the Equation 7.2, Equation 7.3, Equation 7.4 and Equation 7.5.

FOD method with default parameters and country-specific activity data were used, due to unavailability of country-specific key parameters.

Equation 7.2[284]

$$DDOCma_T = DDOCmd_T + (DDOCma_{T-1} \times e^{-k})$$

Equation 7.3[285]

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

Where:

[284] IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.9, equation 3.4.

[285] IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.9, equation 3.5.

T = inventory year
$DDOCma_T$ = DDOCm accumulated in the SWDS at the end of year T, kt;
$DDOCma_{T-1}$ = DDOCm accumulated in the SWDS at the end of year T-1, kt;
$DDOCmd_T$ = DDOCm accumulated in the SWDS in year T, kt;
DDOCm $decomp_T$ = DDOCm accumulated in the SWDS in year T, kt.

Equation 7.4[286]

$$CH_4 generated_T = DDOCm\ decomp_T \times F \times 16/12$$

Where:

CH_4 $generated_T$ = Amount of CH_4 generated from decomposable material, kt;
DDOCm $decomp_T$ = DDOCm decomposed in year T, kt;
F = Fraction of CH_4, by volume in generated landfill gas (fraction);
16/12 = Molecular weight ratio CH_4/C (ratio).

Equation 7.5[287]

$$CH_4 Emissions = \left[\sum_x CH_4 generated_{x,T} - R_T\right] \times (1 - OX_T)$$

Where:

CH_4 Emissions = CH_4 emitted in year T, kt;
T = inventory year;
X = waste category or type/material;
R(t) = recovered CH_4 in year T, kt;
OX = oxidation factor in year T (fraction).

Emission factors

Emission factors used in calculations of emissions from SWD sites are default emission factors from IPCC 2006 Guidelines (Table 7.7). No accurate analysis of DOC in different waste types has been carried out in Estonia, therefore default IPCC 2006 Guideline's DOC contents for FOD model are used in emission calculations (Table 7.8).

Table 7.7. Emission factors and parameters used in calculations

Factor/Parameter	Value
MCF — anaerobic[288]	1
MCF — uncategorized SWDS[288]	0.6
DOCf[289]	0.5
F[290]	0.5
OX[291]	0

[286] IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.10, equation 3.6.
[287] IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.37, equation 3A1.18.
[288] IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.14, table 3.1.
[289] IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.13.
[290] IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.15.
[291] IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.15, table 3.2.

Factor/Parameter	Value
Methane generation rate constant[292]	
k1=paper/textile waste	0.06
k2=wood	0.03
k3=organic/garden and park waste	0.1
k4=food waste/sewage sludge	0.185
k5=industrial waste	0.09

Table 7.8. Default DOC content of different waste types (wet basis)[293]

Waste group	DOC content (fraction)
Municipal solid waste	
Food/Grease	0.15
Municipal	see Table 7.11
Garden	0.2
Paper	0.4
Textile	0.24
Wood	0.43
Municipal sludge	0.05
Industrial waste	
Organic	0.15
Textile	0.24
Wood	0.43
Paper	0.4
Leather	0.39
Rubber	0.39
Industrial sludge	0.045

Calculations in the *FOD model* are based on the country-specific data on waste composition of MSW (Table 7.9). There have been three research made in Estonia about waste composition in MSW, the first one in 2000, 2008 and 2013. Time period since 1950 to 1999 is retroactively covered with composition data derived from research made in Estonia in 2000, also time period from 2000–2007 is covered with data from research in 2000. Years 2008–2011 are covered with data from research of 2008.

Calculations made under SWD comprise of managed as well as uncategorized disposal sites. CH_4 emissions in 1990–1993 derive from uncategorized disposal sites, emissions occurring since 2009 derive only from managed disposal sites, meanwhile CH_4 emissions in 1994–2008 are generated both in managed and uncategorized waste disposal sites. Managed disposal site in 1994–2008 is considered as Pääsküla landfill in Tallinn, where landfill gas was recovered. Uncategorized waste management type was chosen, as there is no accurate data available or research made in Estonia about distribution of waste by waste management type (unmanaged shallow or unmanaged deep). CH_4 emissions from both landfill types are reported together in the NIR, as the waste model used for calculations does not allow to report emissions separately.

[292] IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.17, table 3.3.
[293] IPCC 2006 Guidelines, Volume 5, Chapter 2: Waste generation, composition and management data, pages 2.14, 2.16, table 2.4 and 2.5.

Table 7.9. The waste composition of MSW, %

	1950–1999[294]	2000–2007[294]	2008–2011[295]	2012–onward[296]
Organic household waste and non-defined non separated waste	42.1	42.1	36.65	31.8
Paper and cardboard	25.3	25.3	17.53	13.5
Wood	3.3	3.3	0.44	2
Textiles	0.9	0.9	4.43	5.1

The composition of furniture waste is based on an expert judgement and a study made by Stockholm Environment Institute Tallinn Centre[297].

Table 7.10. Furniture waste composition, % in 1990–2015

Furniture waste composition	%
Wood	49.3%
Textile	24.3%
Metal	12.2%
Plastic	14.2%

Table 7.11. DOC content of mixed MSW in Estonia in 1950–2012

	1950–1999	2000–2007	2008–2011	2012–onward
DOC content in MSW	0.20	0.20	0.16	0.14

7.2.3. Uncertainties and time series consistency

The estimation of CH_4 emission from MSW disposal is carried out based on activity data and emission factors.

Uncertainties of default emission factors and activity data used in the estimations are derived accordingly to methodology from IPCC 2006 Guidelines. Values are presented in Table 7.12.

[294] Vaania, (2000). Research on the composition of municipal solid waste including different regions in Estonia (in Estonian).
[295] SEI Tallinn, (2008). Analysis of Estonian municipal waste (including separate packaging waste and biodegradable waste) composition and quantity. Municipal waste sorting study (in Estonian). [www] http://www.envir.ee/sites/default/files/olmejaatmeteuuring2008.pdf (28.12.2016).
[296] SEI Tallinn, (2013). Final report - Study of composition of municipal waste, separately collected paper and packaging and WEEE in 2013 in Estonia (in Estonian). [www] http://www.envir.ee/sites/default/files/sortimisuuring_2013loplik.pdf (28.12.2016).
[297] SEI Tallinn (2014). Improving the recycling system of municipal waste in Tallinn based on the examples of best practices. [www] http://www.tallinn.ee/R4R_study_Tallinn (28.12.2016).

The combined uncertainty rates related to Solid waste disposal sub-category are reported in Chapter 7.1.2.

Table 7.12. Default uncertainty ranges for Solid waste disposal

Input	**Uncertainties**
Activity data[298]	
Total municipal solid waste	± 10%
Total uncertainty of waste composition	± 10%
MSW sent to SWDS	± 10%
Emission factors	
Uncertainty for default half-life($t_{1/2}$)[299]	
Food waste	(0.185) 0.1 – 0.2
Garden	(0.1) 0.06 – 0.1
Paper	(0.06) 0.05 – 0.07
Wood and straw	(0.03) 0.02 – 0.04
Textiles	(0.06) 0.05 – 0.07
Disposable nappies	(0.1) 0.06 – 0.1
Sewage sludge	(0.185) 0.1 – 0.2
Degradable Organic Carbon (DOC)[298]	± 20%
Fraction of DOC decomposed (DOC_f)[298]	± 20%
Methane correction factor 1.0[298]	–10%
Methane recovery[298]	± 30%
Fraction of CH_4 in generated Landfill Gas[298]	± 5%

7.2.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out according to the procedures described in IPCC 2006 Guidelines[300]. In addition, the specific documentation and reporting recommendations relevant to Solid waste disposal described in IPPC 2006 Guidelines, Chapter 3, Section 3.8 have been taken into account when carrying out QC activities.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.2.3.

7.2.5. Source-specific recalculations

CH_4 emission from Solid waste disposal has been recalculated (Table 7.13) based on a research correcting waste classification for the *IPCC Waste Model*. For precise evaluation of uncertain waste types, an excerpt from JATS with company names and specific amounts of generated and deposited waste was made. The research covered both industrial and MSW. The amount of MSW generated and deposited was corrected by subtracting the amount of separately collected waste to avoid double counting and by subtracting furniture waste. There were no changes in the amounts of generated and deposited MSW during 1990-1998 and 2000-2003. MSW generation in 1999 was recalculated due to misapprehension of historical waste report. Also

[298] IPCC 2006 Guidelines, Volume 5, Chapter 3. Solid Waste Disposal, page 3.27, table 3.5.
[299] IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.18, table 3.4.
[300] IPCC 2006 Guidelines, Volume 1, Chapter 6: Quality Assurance / Quality Control and Verification.

information about one additional landfill burning biogas with energy recovery was added to emission calculations. In 2014 Aardpalu landfill combusted 95.66 thousand m^3 and in 2015 667.50 thousand m^3.

Table 7.13. Comparison of the amount of MSW generated and deposited in 1990-2014, tonnes

	2016 submission		2017 submission	
	Generated MSW	**Deposited MSW**	**Generated MSW**	**Deposited MSW**
1999	564 265	571 842	568 694	568 622
2004	470 851	372 329	465 150	367 492
2005	465 438	362 747	459 263	361 609
2006	470 257	367 860	293 580	194 656
2007	395 305	309 662	315 824	233 059
2008	365 630	329 367	350 203	323 655
2009	310 382	285 066	300 353	282 942
2010	289 423	250 336	267 902	233 187
2011	292 716	217 007	257 154	195 188
2012	277 826	118 528	253 045	107 861
2013	294 720	48 014	291 251	43 899
2014	304 835	31 431	299 384	28 913

Furniture waste included to IPCC *Waste Model* calculations (Table 7.14) are based on the composition presented in Table 7.10. In 2017 submission, furniture waste was divided between different waste groups for the first time. In previous submissions, furniture waste was included to total MSW.

Table 7.14. Furniture waste composition, tonnes

	2017 submission							
	Furniture waste generation				**Furniture waste depositing**			
	wood	**textile**	**metal**	**plastic**	**wood**	**textile**	**metal**	**plastic**
2004	640	316	158	184	634	313	157	183
2005	1403	693	346	404	1390	687	343	400
2006	1327	655	327	382	1005	496	248	289
2007	1776	877	438	511	1278	631	315	368
2008	1361	672	336	392	1303	644	321	375
2009	1764	871	435	508	502	248	124	145
2010	1638	809	404	471	762	376	188	219
2011	2154	1064	531	620	2154	1064	531	620
2012	1774	876	438	510	452	223	112	130
2013	1667	823	411	480	1667	823	411	480
2014	2301	1136	568	662	1174	580	290	338
2015	2912	1438	718	838	1703	841	420	490

Comparison of CH_4 and CO_2 eq emission in 2016 submission and in 2017 submission is presented in Table 7.15.

Table 7.15. Recalculation of Solid waste disposal emissions, kt

	2016 submission	2017 submission	2016 submission	2017 submission
	CH_4	CH_4	CO_2 eq	CO_2 eq
1990	8.56	8.55	213.91	213.72
1991	9.15	9.14	228.83	228.61
1992	9.69	9.68	242.13	241.88
1993	10.61	10.59	265.14	264.85
1994	10.62	10.60	265.42	265.11
1995	10.16	10.15	254.09	253.80
1996	11.90	11.88	297.41	297.12
1997	14.26	14.25	356.52	356.20
1998	15.56	15.54	388.96	388.59
1999	15.82	15.80	395.41	394.98
2000	17.53	17.50	438.36	437.60
2001	17.93	17.90	448.24	447.59
2002	17.63	17.60	440.76	440.12
2003	16.84	16.82	421.11	420.49
2004	16.92	16.89	422.94	422.31
2005	15.58	15.54	389.48	388.48
2006	14.84	14.81	371.09	370.33
2007	14.78	13.97	369.62	349.14
2008	14.77	13.71	369.17	342.65
2009	13.19	12.30	329.77	307.38
2010	13.06	12.79	326.59	319.65
2011	12.13	11.03	303.19	275.83
2012	11.23	10.45	280.82	261.29
2013	9.70	8.97	242.53	224.15
2014	8.74	8.05	218.53	201.13

7.2.6. Source-specific planned improvements

Historical data on waste generation per capita and distribution of waste by waste management type will be kept under investigation and updated when data available.

7.3. Biological treatment of solid waste (CRF 5.B)

7.3.1. Source category description

Emissions of CH_4 and N_2O from Biological treatment of solid waste include emissions from composting both municipal and industrial waste and anaerobic digestion in biogas facilities.

The total emission from Biological treatment of solid waste in 2015 comprised of 0.6 kt CH_4 and 0.04 kt N_2O emission (Figure 7.9). The sharp upturns in the quantities of CH_4 emissions since 2003 are related to the large amounts of wood, sludge and organic waste composted in these years. The emissions have been highest in 2009 due to considerable effect from organic waste composting. The decline of composted waste since 2010 was due to the opening of the Iru waste incineration facility. Furthermore, the slightly higher amount of landfilled sludge starting from 2010 is also the cause for decreasing emission from composting. In 2015, the amount of waste composted has slightly increased due to the increased amount of sludge and wood.

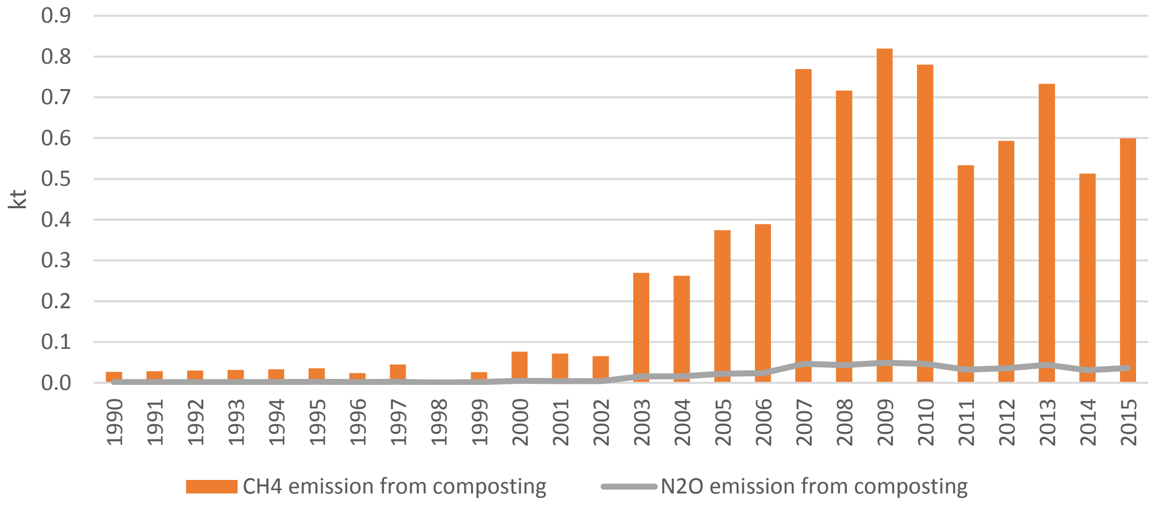

Figure 7.9. CH_4 and N_2O emissions from Biological treatment of solid waste in 1990–2015, kt

The emission from anaerobic digestion with energy recovery has been reported under Energy sector (CRF 1.A.1.A) as an aggregated total biogas production in Estonia. There is currently no anaerobic digestion taking place without energy recovery. Nevertheless, during ERT review, the question of possible leakages emerged. Estonia activated anaerobic digestion at the biogas facilities in 1994 and has estimated unintentional leakages during process disturbance or other unexpected events using IPCC 2006 default value of 5% of generated CH_4. On the basis of 24/CP.19 National Inventory reporting guidance paragraph 37(b)[301] of the UNFCCC Annex I inventory reporting guidelines, the CH_4 leakage calculations resulted with a percentage lower than 0.02 for each year since 1994. Therefore, CH_4 leakages from anaerobic digestion have been reported as NE. Based on the IPCC 2006 Guidelines, N_2O emissions from anaerobic digestion at biogas facilities are assumend to be negligible.

7.3.2. Methodological issues

Activity data

The quantities of waste composted in 2015 are used as activity data. Companies handling wastes are obligated to report on the amount of waste biologically treated to EtEA that is doing the data processing and checking accuracy. In 2015, 149 984 tonnes of wastes were treated biologically (composted). Inert and petroleum product wastes consist of oils and stone, waste from the oil shale industry, and plastic waste are not taken into account in the estimates. As seen from Table 7.16, organic, sludge and wood waste contribute the most in composting in Estonia. Abbreviation NO indicates that the waste type was not composted.

[301] paragraph 37(b)- An emission should only be considered insignificant if the likely level of emissions is below 0.05 per cent of the national total GHG emissions (without LULUCF).

Table 7.16. Amounts of waste used composted in 1990–2015, tonnes[302]

Year	MSW	Organic Waste	Paper	Sludge	Textiles	Wood	Total
1990	NO	3 751	NO	127	144	2 753	6 775
1991	NO	3 948	NO	127	144	2 898	7 117
1992	NO	4 156	NO	127	144	3 050	7 477
1993	NO	4 375	NO	127	144	3 211	7 857
1994	NO	4 605	NO	127	144	3 380	8 256
1995	1	4 847	0.8	127	366	3 558	8 900
1996	NO	5 812	NO	NO	59	133	6 004
1997	NO	9 051	NO	102	72	1 993	11 218
1998	NO	375	NO	78	80	1 494	2 027
1999	NO	2 635	NO	NO	319	3 480	6 434
2000	NO	15 194	NO	120	419	3 277	19 010
2001	NO	5 156	0.04	10 283	NO	2 498	17 937
2002	NO	8 437	59	3 864	54	3 946	16 359
2003	12	23 149	10	35 875	83	8 211	67 339
2004	NO	245	NO	54 017	NO	11 308	65 600
2005	NO	3 857	NO	67 641	NO	22 080	93 578
2006	NO	3 972	607	81 371	NO	11 382	97 332
2007	NO	7 576	628	150 636	NO	33 416	192 256
2008	NO	12 300	808	127 775	NO	38 321	179 204
2009	NO	15 948	50	145 006	NO	43 872	204 876
2010	NO	10 877	1	142 354	NO	41 770	195 002
2011	NO	9 354	27	86 578	NO	37 424	133 383
2012	NO	11 102	47	98 868	NO	38 345	148 362
2013	NO	10 503	121	129 511	NO	43 102	183 237
2014	5 280	10 437	93	86 159	NO	26 398	128 368
2015	NO	7 848	3	111 961	NO	30 172	149 984

NO – not occurring

[302] The data of 1990–1994 were interpolated based on rough assumptions made.

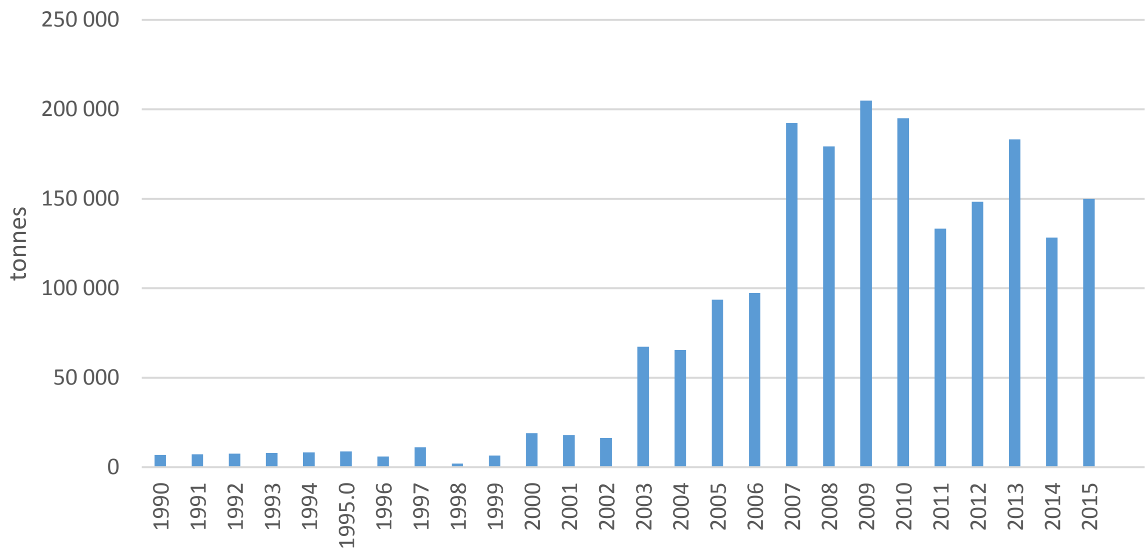

Figure 7.10. Composted organic waste during 1990–2015, tonnes

As seen from the Figure 7.10, the amount of organic waste used in biological treatment has been marginal in the first decade of the period and started to grow rapidly since 2000 and has increased significantly – from 6 775 tonnes in 1990 to 149 984 tonnes in 2015. The decline in biologically treated waste since 2010 resulted from the opening of a waste incineration plant. In addition, the increased amount of sludge landfilled in 2011 and 2012 also decreased the amount of composted waste. In general, the volume of wastes for composting has enlarged significantly in recent years due to adopted Landfill directive 1999/31/EC, where percentage limitation of quantities of organic wastes disposed in landfills is enacted by time periods. The slight increase of the amount of waste composted in 2015 is connected with the growth of waste recycling.

Methods

In order to estimate emissions from Composting IPCC 2006 *Tier 1* approach (Equation 7.6 and Equation 7.7) was used.

Equation 7.6[303]

$$CH_4\ Emissions = \sum_i (M_i \times EF_i) \times 10^{-3} - R$$

Where:

CH_4 emissions =	total CH_4 emissions in inventory year, kt CH_4;
M_i =	mass of organic waste treated by biological treatment type *i*, kt;
EF =	emission factor for treatment *i*, g CH_4/kg waste treated;
R =	total amount of CH_4 recovered in inventory year, kt CH_4;
i =	composting or anaerobic digestion.

[303] IPCC 2006 Guidelines, Volume 5, Chapter 4: Biological treatment of Solid Waste, page 4.5, equation 4.1.

Equation 7.7[304]

$$N_2O\ Emissions = \sum_i (M_i \times EF_i) \times 10^{-3}$$

Where:

N_2O emissions = total N_2O emissions in inventory year, kt N_2O;
M_i = mass of organic waste treated by biological treatment type *i*, kt;
EF = emission factor for treatment i, g N_2O/kg waste treated;
i = composting or anaerobic digestion.

Emission factors

Emission factors used in calculations of emissions from biological treatment of wastes are default emission factors from IPCC 2006 Guidelines (Table 7.17).

Table 7.17. Default emission factors for calculating CH_4 and N_2O emission from Biological treatment of solid waste[305]

Type of biological treatment	CH_4 emission factor (g CH_4/kg waste treated)	N_2O emission factor (g N_2O/kg waste treated)
Composting	4	0.24

7.3.3. Uncertainties and time series consistency

The estimation of GHG emissions from Biological treatment of solid waste (Table 7.18) is carried out taking into account the quantities of waste composted per waste type and emission factors.
The combined uncertainty rates related to Biological treatment of solid waste sub-category have been reported in Chapter 7.1.2. For activity data uncertainty, the uncertainty percentage from the Solid waste disposal is used.

Table 7.18. Default uncertainty ranges for Biological treatment of solid wastes

Input	Value
Activity data[306]	
Waste composition	±10%
Total MSW	±10%
Emission Factor[307]	
CH_4 (Composting)	(4) 0.03…8
N_2O (Composting)	(0.3) 0.06…0.6

[304] IPCC 2006 Guidelines, Volume 5, Chapter 4: Biological treatment of Solid Waste, page 4.5, equation 4.2.
[305] IPCC 2006 Guidelines, Volume 5, Chapter 4: Biological treatment of Solid Waste, page 4.4 and page 4.6 table 4.1.
[306] IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.27, table 3.5.
[307] IPCC 2006 Guidelines, Volume 5, Chapter 4: Biological Treatment of Solid Waste, page 4.6, table 4.1.

7.3.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out according to the procedures described in IPCC 2006 Guidelines[308]. In addition, the specific documentation and reporting recommendations relevant to SWD described in IPCC 2006 Guidelines, Chapter 3, Section 3.8 have been taken into account when carrying out QC activities, as the activities are also applicable for biological treatment of waste.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.2.3.

7.3.5. Source-specific recalculations

Recalculations of CH_4 and N_2O emissions from composting (Table 7.19) are based on a research correcting waste classification for the *IPCC Waste Model*. The waste classification in Solid waste disposal and Biological treatment of solid waste is made on the same basis. For precise evaluation of uncertain waste types, an excerpt from JATS with company names and specific amounts was made.

Table 7.19. Recalculations in composting, kt

	2016 submission		2017 submission	
	CH_4	**N_2O**	**CH_4**	**N_2O**
1990	0.027	0.0016	0.027	0.0016
1991	0.028	0.0017	0.028	0.0017
1992	0.030	0.0018	0.030	0.0018
1993	0.031	0.0019	0.031	0.0019
1994	0.033	0.0020	0.033	0.0020
1995	0.036	0.0021	0.036	0.0021
1996	0.024	0.0014	0.024	0.0014
1997	0.045	0.0027	0.045	0.0027
1998	0.008	0.0005	0.008	0.0005
1999	0.026	0.0015	0.026	0.0015
2000	0.076	0.0046	0.076	0.0046
2001	0.072	0.0043	0.072	0.0043
2002	0.065	0.0039	0.065	0.0039
2003	0.269	0.0162	0.269	0.0162
2004	0.304	0.0183	0.262	0.0157
2005	0.421	0.0253	0.374	0.0225
2006	0.461	0.0277	0.389	0.0234
2007	0.742	0.0445	0.769	0.0461
2008	0.829	0.0497	0.717	0.0430
2009	0.923	0.0554	0.820	0.0492
2010	0.871	0.0522	0.780	0.0468
2011	0.629	0.0377	0.534	0.0320
2012	0.592	0.0355	0.593	0.0356
2013	0.719	0.0432	0.733	0.0440
2014	0.585	0.0351	0.513	0.0308

[308] IPCC 2006 Guidelines, Volume 1, Chapter 6: Quality Assurance / Quality Control and Verification.

7.3.6. Source-specific planned improvements

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

7.4. Incineration and open burning of waste (CRF 5.C)

7.4.1. Source category description

CO_2, CH_4 and N_2O emissions from Incineration and open burning of waste are estimated under CRF 5.C. Emissions from waste incineration with energy recovery are reported under Energy sector and without energy recovery in Waste sector.

CO_2 emissions from combustion of biomass materials (e.g., paper, food waste, wood) are biogenic emissions and are not be included in national total emission estimates, but reported as an informational item under Waste sector. CO_2 emissions from oxidation during incineration of carbon in waste of fossil origin (e.g., plastics, rubber, liquid solvents, waste oils) are considered net emissions and are reported under Waste sector. N_2O and CH_4 emissions include both biogenic and non-biogenic sources of emission.

CO_2 emissions from waste incineration without energy recovery in 1990–2015 are presented in Figure 7.11. CO_2 emitted from non-biogenic sources in 2015 comprised 0.03 kt and from biogenic sources 0.003 kt. The biogenic emission outlier in 1999 and 2000 is connected with high amount of wood waste combustion. The non-biogenic CO_2 emission in 1990-1995 mainly caused by inert, oil and petroleum waste incineration and 2000-2005 non-biogenic CO_2 emission is the result of the high amount of inert waste incineration. After 2006, only minor amounts of waste has been incinerated without energy recovery. In 2008 and 2011 no waste without energy was incinerated and therefore no CO_2 emissions occurred. The specific amount of waste incinerated by category is presented in Table 7.20.

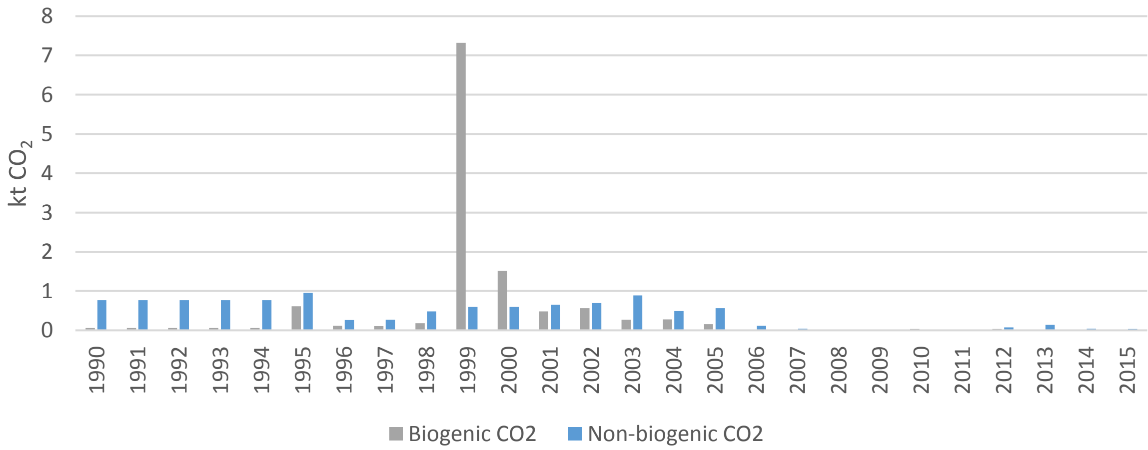

Figure 7.11. CO_2 emissions from Waste incineration without energy recovery in Estonia during 1990–2015, kt

The total CH_4 emission (Figure 7.12) from waste incineration without energy recovery in 2015 was 0.0001 kt, from which 0.00001 kt is biogenic origin and 0.0001 non-biogenic origin. The biogenic emission outlier in 1999 is connected with high amount of wood waste combustion. 2000–2005 non-biogenic CH_4 emission is the result of the high amount of inert waste incineration. After 2006, only minor amounts of waste has been incinerated without energy recovery. In addition there was no waste combusted during 2008 and 2011. The specific amount of waste incinerated by category is presented in Table 7.20.

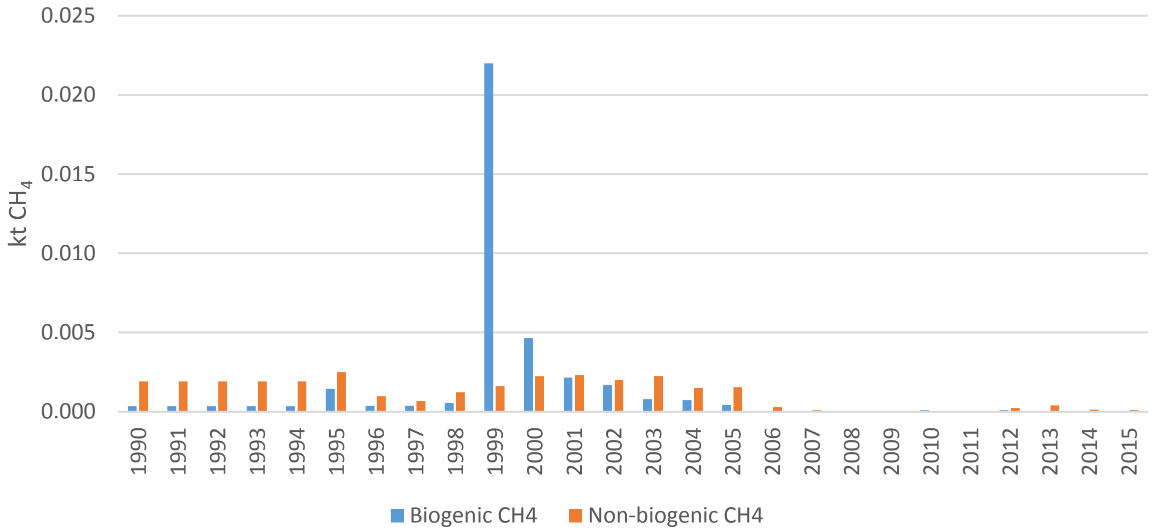

Figure 7.12. CH_4 emissions from Waste incineration without energy recovery in Estonia, in 1990–2015, kt

N_2O emission (Figure 7.13) from Waste incineration in 2015 was 1.53 kg, out of which 1.37 kg is non-biogenic and is 0.15 kg biogenic. Considerable rises in the emissions from non-biogenic wastes have occurred in 2000 and 2001, when clinical, plastic and inert wastes were incinerated. N_2O emissions from the combustion of fossil liquid waste can be considered negligible, therefore it is not included to emission calculations. Since 2001 the proportion of non-biogenic emissions has decreased because wastes are rather incinerated to generate energy. Since 2002 to 2005 emissions from incineration of organic materials have decreased, some emissions occurred from incineration of textile, organic and paper wastes. After 2006, only minor amounts of waste has been incinerated without energy recovery. In addition there was no waste combusted during 2008 and 2011. The specific amount of waste incinerated by category is presented in Table 7.20.

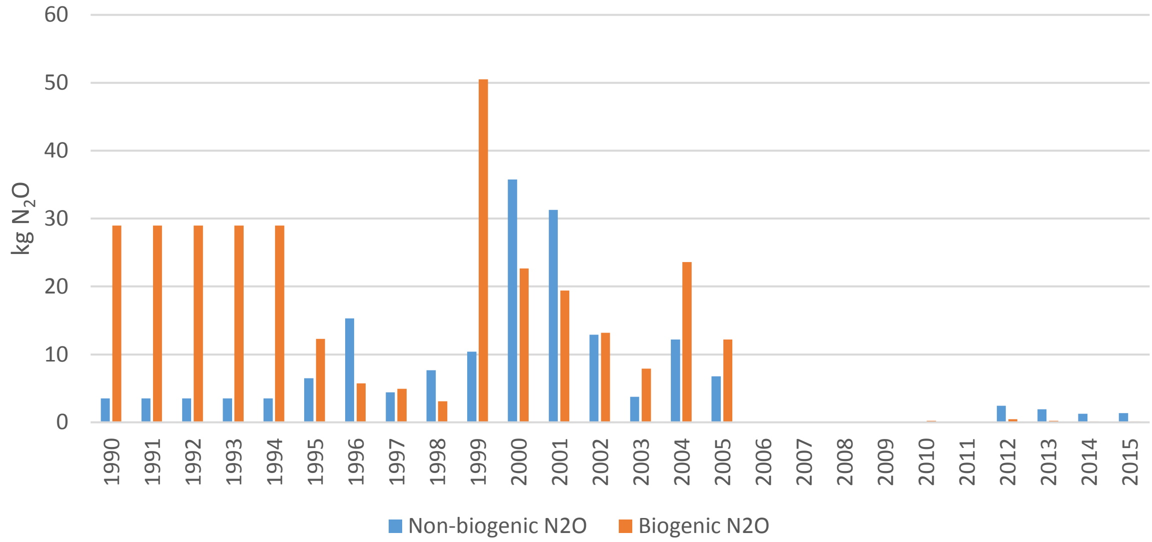

Figure 7.13. N_2O emissions from Waste incineration without energy recovery in Estonia during 1990–2015, kt

CO_2, CH_4 and N_2O emission from Open burning of waste sub-category originates from MSW burning and is presented in Figure 7.14, Figure 7.15 and Figure 7.16.

In Estonia, open burning of waste is not a common practice for eliminating waste, as open burning of MSW is considered as an illegal activity and is forbidden. For being able to include the emission calculation an expert judgement, given by the MoE, was used. The expert judgement of MoE is indicating that in 1990–2004, 2% of MSW was open burned which, starting from 2004, decreased to 1%. The fluctuation of emissions is in correlation with the total amount of waste generated and the composition changes in MSW.

CO_2, CH_4 and N_2O emission from Open burning of waste sub-category is divided to biogenic and non-biogenic emission based on the fraction of fossil and biogenic carbon in the combusted waste material. The biogenic CO_2 emission is not included in national total emission estimates.

In 2015, Open burning of waste resulted with 0.86 kt biogenic CO_2 and 0.96 kt non-biogenic CO_2.

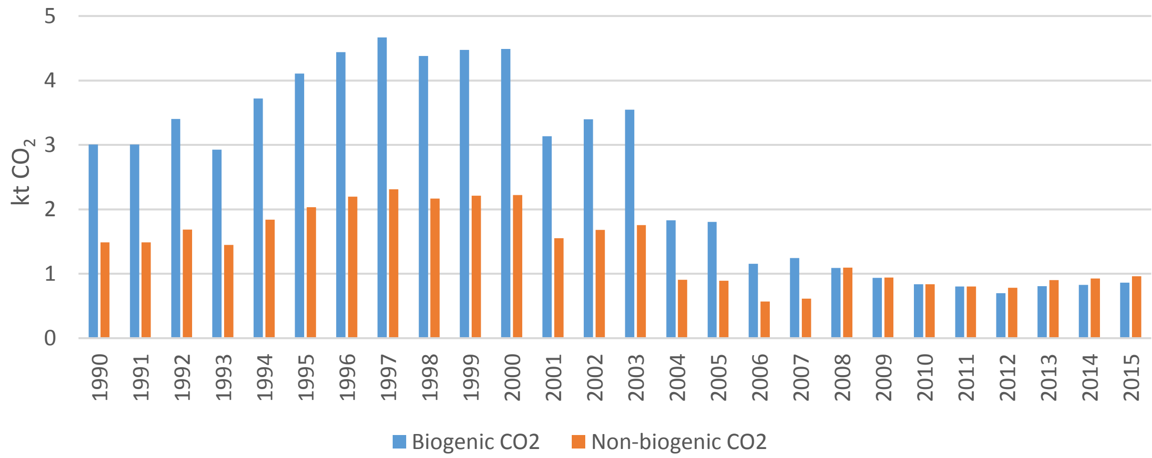

Figure 7.14. CO_2 emissions from Open burning of waste in Estonia in 1990–2015, kt

Total CH_4 emission of 0.018 kt is divided to 0.01 kt biogenic CH_4 and 0.008 kt non-biogenic CH_4.

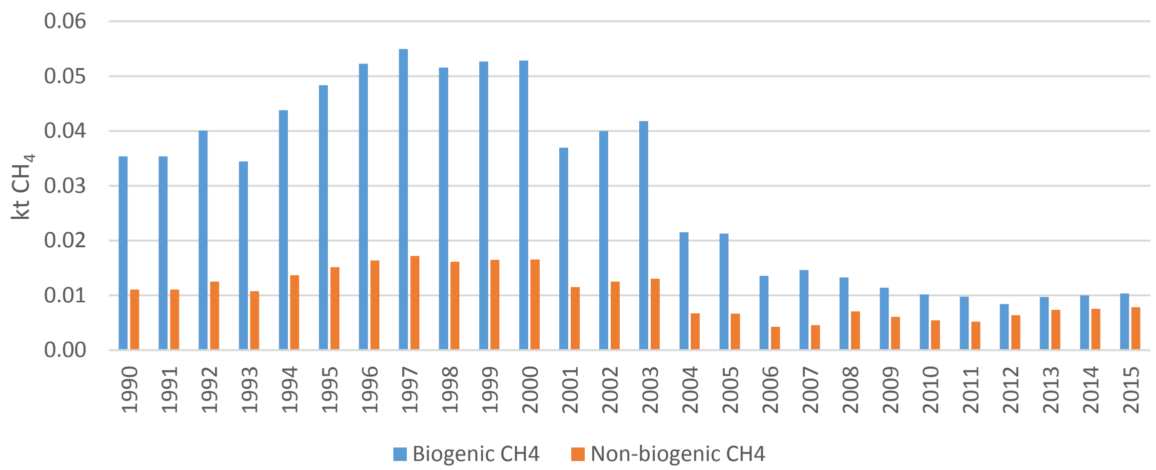

Figure 7.15. CH_4 emissions from Open burning of waste in Estonia in 1990–2015, kt

Total N_2O emission of 0.0003 is divided to 0.00014 kt biogenic N_2O and 0.00017 kt non-biogenic N_2O.

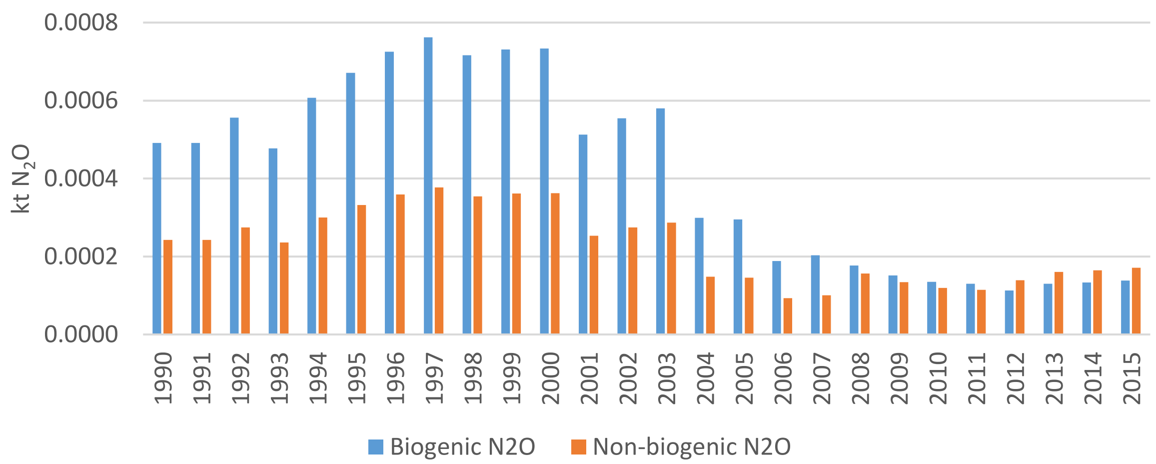

Figure 7.16. N_2O emissions from Open burning of waste in Estonia in 1990–2015, kt

7.4.2. Methodological issues

Activity data

Under Incineration and open burning sub-category, only emissions from waste incineration without energy recovery are reported. The activity data on amounts of waste incinerated is collected and verified by the EtEA. Every company, incinerating waste, is obligated to report to EtEA that is doing the data processing and checking accuracy. For the years 1990–1993, incinerated waste amounts of 1994 was used as there is no available information on the amounts of incinerated waste during that period. Nevertheless, it is assumed that the amount of incinerated waste was similar to 1994.

In 2015, the quantity of waste incinerated without energy recovery was 18 tonnes (Table 7.20). Waste incineration with energy recovery is part of the Energy sector, and therefore has been reported under the Energy sector.

Table 7.20. Amounts of waste incinerated without energy recovery in Estonia in 1990–2015, tonnes[309]

	Inert	Leather Rubber	MSW	Petroleum	Oil	Solvents	Organic	Garden	Paper	Plastic	Sludge	Textile	Wood	Clinical	Total
1990	23	1	4	94	148	1	17	NO	20	6	60	3	NO	5	381
1991	23	1	4	94	148	1	17	NO	20	6	60	3	NO	5	381
1992	23	1	4	94	148	1	17	NO	20	6	60	3	NO	5	381
1993	23	1	4	94	148	1	17	NO	20	6	60	3	NO	5	381
1994	23	1	4	94	148	1	17	NO	20	6	60	3	NO	5	381
1995	34	6	23	248	37	15	15	NO	389	5	2	61	NO	12	846
1996	148	3	14	1	7	0.8	24	NO	35	4	NO	25	NO	6	266
1997	21	4	2	39	30	0.7	55	NO	40	12	NO	2	NO	14	220
1998	42	5	8	0.2	125	0.2	14	NO	7	19	NO	0	90	8	317
1999	88	24	NO	NO	145	NO	0	NO	16	10	NO	9	4 643	5	4 940
2000	362	78	3	NO	3	NO	41	NO	2	5	NO	20	815	12	1 341
2001	336	NO	NO	NO	2	50	12	470	19	0.05	13	47	3	10	961
2002	123	NO	NO	NO	124	50	15	NO	10	NO	NO	85	272	17	696
2003	27	NO	NO	NO	203	84	3	NO	3	NO	0.5	55	122	19	516
2004	85	NO	NO	NO	52	70	1	NO	2	NO	NO	251	NO	22	482
2005	50	NO	NO	NO	106	60	0.3	NO	2	NO	NO	128	10	10	366
2006	NO	NO	NO	NO	NO	40	0.1	NO	NO	NO	NO	NO	NO	0.8	41
2007	NO	NO	NO	NO	NO	14	NO	NO	NO	NO	NO	NO	7	NO	21
2008	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2009	NO	NO	NO	NO	NO	NO	NO	NO	2	NO	NO	NO	NO	NO	2
2010	NO	NO	NO	NO	NO	NO	NO	NO	3	NO	NO	NO	18	NO	21
2011	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

[309] D10 operation of the waste disposal activities – Incineration on land.

	Inert	Leather Rubber	MSW	Petroleum	Oil	Solvents	Organic	Garden	Paper	Plastic	Sludge	Textile	Wood	Clinical	Total
2012	27	NO	NO	NO	10	1	NO	NO	NO	NO	NO	NO	18	NO	56
2013	21	NO	NO	NO	34	4	NO	NO	NO	NO	NO	NO	NO	NO	59
2014	14	NO	NO	NO	NO	6	NO	NO	NO	NO	NO	NO	NO	NO	20
2015	15	NO	NO	NO	0.7	2	NO	NO	NO	NO	NO	NO	NO	NO	18

NO – not occurring

There has been an increase in the amounts of waste incinerated in 1995 and 1999 (Figure 7.17). The remarkable fluctuation of incinerated waste quantities is related to large amounts of waste from paper, wood, inert, petroleum-products and oil combustion in those years. Generally, the trend of waste incineration has decreased through the years since 2000. Reason for the marginal quantities of waste combusted without energy recovery, is that more waste is recycled, composted or incinerated with the purpose to generate energy and the amount of waste for combustion without energy recovery is therefore minimized. EtEA has verified that in 2008 and 2011 no wastes were incinerated without energy recovery.

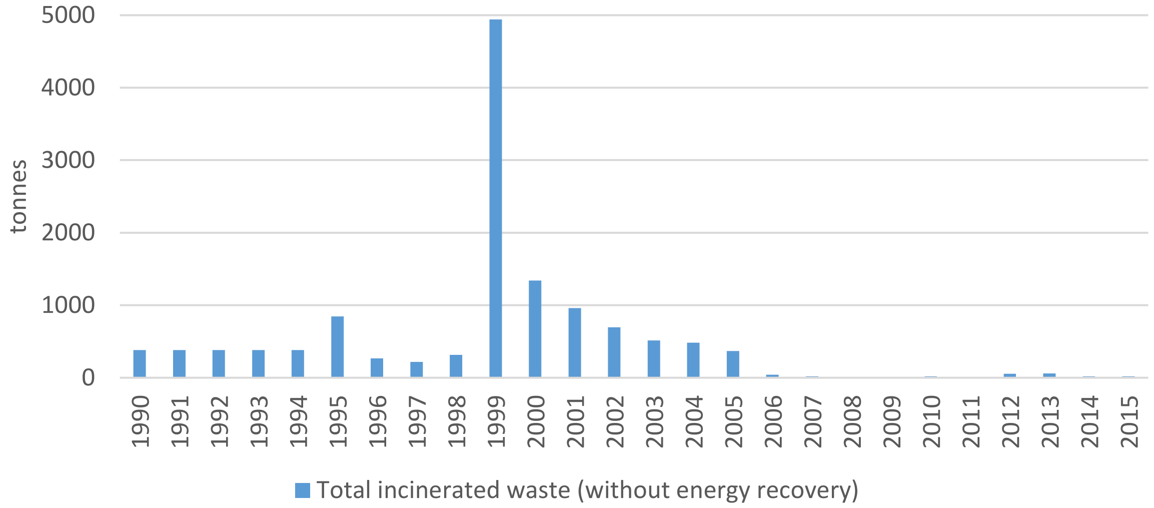

Figure 7.17. Amounts of waste incinerated without energy recovery in Estonia in 1990–2015, tonnes

Time series of open burning of MSW can be seen in the Figure 7.18. The amount of waste open burned and MoE expert judgement, which is indicating that in 1990–2004, 2% of MSW was open burned which, starting from 2004, decreased to 1%. The change of the open burning percentage is connected with the development of organized waste collection system.

By 2012, 95% of the population was connected to the organized waste collection system. MSW from households which are not connected to the official collection system, however, is believed to still reach the official waste collecting system (through public waste containers, packaging containers, waste abandonment in woods etc.). Consequently, it can be assumed, that people are not burning waste to dispose of it, but it could be considered more as a habitual behaviour.

As the activity is forbidden and there are no studies made regarding to the specific composition of MSW burned, then MoE's expert judgement was given for open burning of MSW as a whole (mix of fractions). Without any available studies at the moment it is impossible to define which type of waste is mostly used for open burning nor eliminate any waste fractions. The fluctuations of burned MSW in Figure 7.18 are connected with the fluctuation of MSW generation.

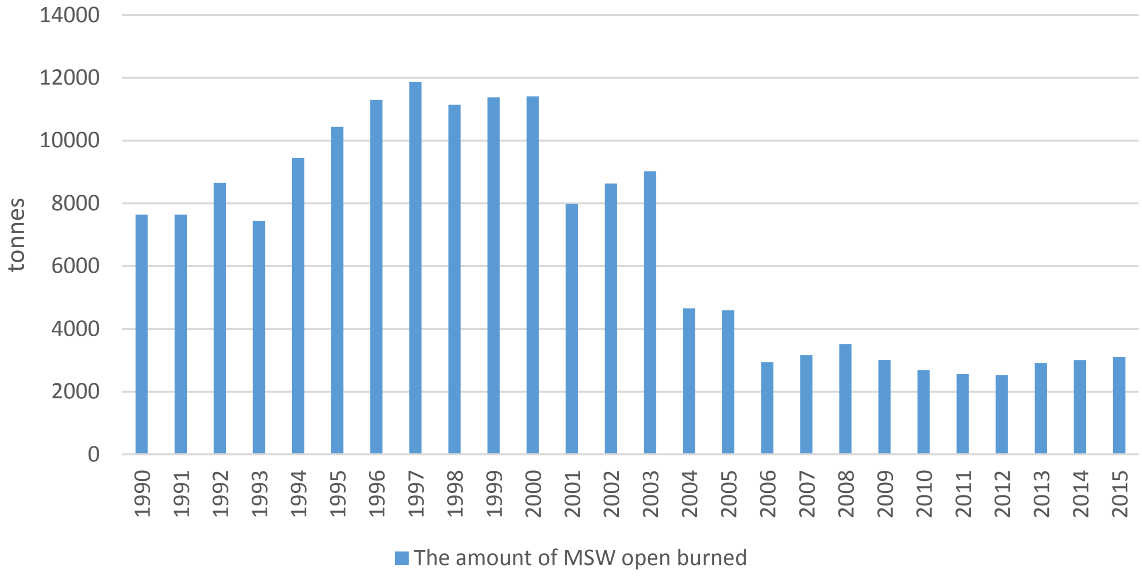

Figure 7.18. Amounts of waste open burned in Estonia in 1990–2015, tonnes

The specific composition of MSW (Table 7.21) which is open burned based on the MSW sorting studies (Table 7.9). Only the fractions of food, paper/cardboard, wood, garden, textiles, plastic and other wastes (flammable materials) are included to calculations (the emission calculations did not include metal and glass wastes).

Table 7.21. The specific composition of open burned MSW, tonnes

Year	Food waste	Paper/ Cardboard	Wood	Garden	Textiles	Plastic	Other	Total
1990	3215	1937	254	NO	72	886	782	7146
1991	3215	1937	254	NO	72	886	782	7146
1992	3639	2193	287	NO	81	1003	886	8089
1993	3128	1884	247	NO	70	862	761	6952
1994	3976	2396	314	NO	89	1096	968	8838
1995	4392	2646	346	NO	98	1211	1069	9763
1996	4751	2862	375	NO	106	1309	1156	10560
1997	4991	3007	394	NO	112	1376	1214	11094
1998	4687	2824	370	NO	105	1292	1141	10419
1999	4784	2882	377	NO	107	1319	1164	10634
2000	4800	2892	379	NO	107	1323	1168	10670
2001	3354	2021	265	NO	75	925	816	7456
2002	3632	2188	286	NO	81	1001	884	8072
2003	3795	2287	299	NO	85	1046	923	8436
2004	1957	1179	154	NO	44	539	476	4349

Year	Food waste	Paper/ Cardboard	Wood	Garden	Textiles	Plastic	Other	Total
2005	1932	1164	152	NO	43	532	470	4294
2006	1235	744	97	NO	28	340	300	2745
2007	1329	800	105	NO	30	366	323	2953
2008	1114	614	15	185	155	652	400	3135
2009	955	527	13	158	133	560	343	2689
2010	852	470	12	141	119	499	306	2398
2011	818	451	11	136	114	479	294	2302
2012	709	342	51	96	129	458	496	2280
2013	816	393	58	111	149	527	571	2624
2014	838	404	60	114	153	542	587	2697
2015	870	420	62	118	159	563	609	2801

NO – not occurring

Methods

CO_2 emission from incineration was calculated with IPCC 2006 *Tier 2a* (Equation 7.8) method and for open burning IPCC 2006 *Tier 1* approach was employed (Equation 7.9).

Equation 7.8[310]

$$CO_2 Emissions = \sum_i (SW_i \times dm_i \times CF_i \times FCF_i \times OF_i) \times 44/12$$

Equation 7.9[311]

$$CO_2 Emissions = MSW \times \sum_j \left(WF_j \times dm_j \times CF_j \times FCF_j \times OF_j\right) \times 44/12$$

Where:

CO_2 emissions = CO_2 emissions in inventory year, kt/year;

SW_i = total amount of solid waste of type *i* (wet weight) incinerated or open burned, kt/year;

WF_j = total amount of solid waste of type *i* (wet weight) incinerated or open burned, kt/year;

$dm_{i,j}$ = dry matter content in waste (wet weight) incinerated or open burned, (fraction);

[310] IPCC 2006 Guidelines, Volume 5, Chapter 5: Incineration and Open Burning of Waste, page 5.7, equation 5.1.

[311] IPCC 2006 Guidelines, Volume 5, Chapter 5: Incineration and Open Burning of Waste, page 5.7, equation 5.2.

$CF_{i,j}$ = fraction of carbon in the dry matter (total carbon content), (fraction);
$FCF_{i,j}$ = fraction of fossil carbon in the total carbon, (fraction);
$OF_{i,j}$ = oxidation factor (fraction);
44/12 = conversion factor from C to CO_2;
i = type of waste incinerated specified as follows:
MSW: municipal solid waste;
ISW: industrial solid waste;
SS: sewage sludge;
HW: hazardous waste;
CW: clinical waste;
j = component of the MSW open burned.

For calculating the CO_2 emissions from open burning of MSW, fractions of solid waste by type *i* presented in Table 7.9 under Solid waste disposal on land was used.

Emission factors

IPCC 2006 Guidelines default oxidation factor (Table 7.22) and emission factors (Table 7.23) have been used for calculating CO_2 emissions from both Waste incineration and Open burning of waste sub-category.

Table 7.22. Default oxidation factors used in Incineration and open burning of waste calculations[312]

	Incineration of waste	Open burning of MSW
Oxidation factor in % of carbon input	100%	58%

Table 7.23. Default dry matter content, total carbon content and fossil carbon content of different waste components used for calculation incineration and open burning of waste emission

Waste component	Dry matter content in % of wet weight	Total carbon content in % of dry matter	Fossil carbon fraction in % of total carbon
MSW[313]			
Food waste	40	38	0
Wood	85	50	0
Paper/cardboard	90	46	1
Textiles	80	50	20
Garden and park waste	40	49	0
Rubber and Leather	84	67	20
Plastics	100	75	100

[312] IPCC 2006 Guidelines, Volume 5, Chapter 5: Incineration and open burning of waste, page 5.18, table 5.2.
[313] IPCC 2006 Guidelines, Volume 5, Chapter 2: Waste generation, composition and management data, page 2.14, table 2.4.

Other, inert waste	90	3	100
Industrial waste[314]			
Textile	80	40	16
Pulp and paper	90	41	1
Clinical waste	65	40	25
Industrial waste[315]	90[314]	50	90
Sewage sludge	10[316]	45	0

For estimating N_2O emissions from Incineration and Open burning of waste IPCC 2006 *Tier 1* approach with Equation 7.10 was employed.

Equation 7.10[317]

$$N_2O\ Emissions = \sum_i (IW_i \times EF_i) \times 10^{-6}$$

Where:

N_2O emissions = N_2O emissions in inventory year, kt/year;
IW_i = amount of incinerated/open burned waste of type *i*, kt/year;
EF_i = N_2O emission factor for waste of type *i*, kg N_2O/kt of waste;
10^{-6} = conversion factor from kilogram to kiloton;
i = category or 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).

Emission factors

IPCC 2006 default EFs are used in calculations of N_2O emissions from Incineration and open burning of waste (Table 7.24).

[314] IPCC 2006 Guidelines, Volume 5, Chapter 2: Waste generation, composition and management data, page 2.15 and 2.16, table 2.5 and 2.6.
[315] IPCC 2006 Guidelines, Volume 5, Chapter 5: Incineration and open burning of waste, page 5.18, table 5.2.
[316] IPCC 2006 Guidelines, Volume 5, Chapter 5: Incineration and open burning of waste, page 5.15.
[317] IPCC 2006 Guidelines, Volume 5, Chapter 5: Incineration and open burning of waste, page 5.14, equation 5.5.

Table 7.24. N_2O emission factors used in calculations of Incineration and open burning of waste[318]

Waste category	Emission factor g N_2O/t waste incinerated	Weight basis
Incineration		
MSW Industrial waste Sludge (except sewage sludge)	50 100 450	Wet basis Wet basis Wet basis
Open burning		
MSW	150 g N_2O/t	Dry matter

For calculating CH_4 emissions from incineration there are not enough EF's in Waste sector guidelines, therefore *Tier 1* approach with the equation (Equation 7.11) from Energy sector was implemented. For open burning, *Tier* 1 method was employed from the Waste sector (Equation 7.12).

Equation 7.11[319]

$$Emissions_{GHG,fuel} = Fuel\ Consumtpion_{fuel} \times Emission\ factor_{GHG,fuel}$$

Where:

$Emissions_{GHG,\ fuel}$ = emissions of a given GHG by type of fuel (kg GHG);
$Fuel\ Consumption_{fuel}$ = amount of fuel combusted (TJ);
$Emission\ Fator_{GHG,\ fuel}$ = default emission factor of a given GHG by type of fuel (kg gas/TJ).

Equation 7.12[320]

$$CH_4 Emissions = \sum_i (IW_i \times EF_i) \times 10^{-6}$$

Where:

CH_4 emissions = CH_4 emissions in inventory year, kt/year;
IW_i = amount of solid waste of type I incinerated/open burned *i*, kt/year;
EF_i = aggregate CH_4 emission factor, kg CH_4/kt of waste;
10^{-6} = conversion factor from kilogram to kiloton;
i = category or type of waste incinerated/open burned specified as follows:
MSW: municipal solid waste;

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318 IPCC 2006 Guidelines, Volume 5, Chapter 5: Incineration and Open Burning of Waste, page 5.22, table 5.6, for incineration; page 5.22 for open burning.
319 IPCC 2006 Guidelines, Volume 2, Chapter 2: Stationary Combustion, page 2.11, equation 2.1.
320 IPCC 2006 Guidelines, Volume 5, Chapter 5: Incineration and Open Burning of Waste, page 5.12, equation 5.4.

ISW: industrial solid waste;
SS: sewage sludge;
HW: hazardous waste;
CW: clinical waste, others (that must be specified).

For calculating CH_4 with the equation from Energy sector, the calorific values from Table 7.25 and emission factors from Table 7.26 have been implemented in calculations.

Table 7.25. Calorific values for calculating CH_4 emission from incineration without energy recovery

Type of waste	Calorific value	MJ/kg=TJ/kt	Source
Inert	21.218	MJ/kg	Kunda Nordic Cement value for other waste/ fossil waste
Leather and rubber			
MSW	10.5	MJ/kg	Iru waste incineration plant
Clinical waste			
Petroleum products	23.991	MJ/kg	Kunda Nordic Cement value for waste oil
Oil			
Solvents			
Organic	11.6	TJ/kt	D -municipal waste (biomass fraction) D- other primary solid biomass
Garden			
Sludge			
Paper	10	TJ/kt	D- municipal waste(non-biomass fraction)
Plastic			
Textile			
Wood	15.6	TJ/kt	D- wood

D – IPCC default factors [321]

Table 7.26. Emission factors for calculating CH_4 emission from incineration without energy recovery and open burning of waste

Waste category	Emission factor
Incineration[322]	
wood; industrial waste; MSW (non-biomass fraction); MSW (biomass fraction); other primary solid biomass; waste oil	300 kg CH_4 /TJ
Open burning[323]	
MSW	6500 g/t MSW wet weight

[321] IPCC 2006 Guidelines, Volume 2, Chapter 1: Introduction, page 1.18, table1.2.
[322]. IPCC 2006 Guidelines, Volume 2, Chapter 2: Stationary Combustion, page 2.21, table 2.4.
[323] IPCC 2006 Guidelines, Volume 5, Chapter 5: Incineration and Open Burning of Waste, page 5.20.

7.4.3. Uncertainties and time series consistency

The estimation of GHG emissions from waste incineration is carried out taking into account the activity data (amount of waste burnt) and emission factors. Uncertainties of default emission factors and activity data used in the estimations are derived accordingly to methodology from IPCC 2006 Guidelines. Values employed in the estimates are presented in Table 7.27.

The combined uncertainty rates related to Waste incineration sub-category are reported in Table 7.3.

Table 7.27. Default uncertainty ranges for Waste incineration

Input	Uncertainties
Activity data[324]	
Amounts of waste incinerated without energy recovery	±5%
Amount of waste open burned	
Dry matter content	±30%
Waste composition[298]	±10%
Amount of waste open burned	±5%
Emission Factors[325]	
CO_2	±40%
CH_4	±50%
N_2O	±100%

7.4.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out according to the procedures described in IPCC 2006 Guidelines[326]. To ensure the accuracy, country specific data has been cross-checked.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.2.3.

7.4.5. Source-specific recalculations

Source specific CO_2, CH_4 and N_2O emission recalculation (Table 7.28, Table 7.29) under Open burning of waste is connected with the recalculations done under Solid waste disposal and are based on a research correcting waste classification for the *IPCC Waste Model.*

The emission calculations of open burning are based on the amount of generated MSW, which in 2016 submission included separately collected waste including furniture. Updated amounts of MSW are presented in Table 7.13. MSW generation in 1999 was recalculated due to misapprehension of historical waste report.

[324] IPCC 2006 Guidelines, Volume 5, Chapter 5: Incineration and Open Burning of Waste, page 5.24.
[325] IPCC 2006 Guidelines, Volume 5, Chapter 5: Incineration and Open Burning of Waste, page5.23.
[326] IPCC 2006 Guidelines, Volume 1, Chapter 6: Quality Assurance / Quality Control and Verification.

Table 7.28. Recalculation of non-biogenic and biogenic CO_2 emission from Open burning of waste, kt

	2016 submission	2017 submission	2016 submission	2017 submission
	non-biogenic CO_2	non- biogenic CO_2	biogenic CO_2	biogenic CO_2
1999	2.1966	2.2138	4.43814	4.4730
2004	0.9165	0.9054	1.85170	1.8293
2005	0.9059	0.8939	1.83041	1.8061
2006	0.9153	0.5714	1.84937	1.1546
2007	0.7694	0.6147	1.55460	1.2420
2008	1.1436	1.0954	1.13961	1.0915
2009	0.9708	0.9395	0.96741	0.9361
2010	0.9053	0.8380	0.90208	0.8350
2011	0.9156	0.8043	0.91235	0.8015
2012	0.8607	0.7840	0.76904	0.7004
2013	0.9131	0.9023	0.81580	0.8062
2014	0.9444	0.9275	0.84380	0.8287

Table 7.29. Recalculation of N_2O and CH_4 emission from Open burning of waste, kt

	2016 submission	2017 submission	2016 submission	2017 submission
	N_2O	N_2O	CH_4	CH_4
1999	0.0010836	0.0010921	0.0686	0.0691
2004	0.0004521	0.0004466	0.0286	0.0283
2005	0.0004469	0.0004410	0.0283	0.0279
2006	0.0004515	0.0002819	0.0286	0.0178
2007	0.0003796	0.0003033	0.0240	0.0192
2008	0.0003479	0.0003332	0.0213	0.0204
2009	0.0002953	0.0002858	0.0181	0.0175
2010	0.0002754	0.0002549	0.0168	0.0156
2011	0.0002785	0.0002447	0.0170	0.0150
2012	0.0002767	0.0002520	0.0163	0.0148
2013	0.0002935	0.0002900	0.0173	0.0171
2014	0.0003036	0.0002981	0.0179	0.0175

7.4.6. Source-specific planned improvements

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

7.5. Wastewater treatment and discharge (CRF 5.D)

7.5.1. Source category description

Total CH_4 emission from Wastewater treatment and discharge in 2015 consists of 1.97 kt from domestic wastewater handling (Figure 7.19) and 0.38 kt from the industrial wastewater handling (Figure 7.20).

The most common wastewater treatment method in developed countries, including Estonia, is centralized aerobic wastewater treatment that consists of primary, secondary, and tertiary treatment. The centralized wastewater treatment (e.g. Paljassaare wastewater plant in Tallinn) for domestic and industrial wastewater is as follows:

Wastewater from households and commercial institutions is collected by drains to the main pumping station, where primary mechanical clearance takes place. After that the wastewater is canalized to the wastewater treatment plant, where physical barriers remove larger solids from water as well as greases, oils and sand. During the secondary treatment coagulants are added and settled organic particulates are removed. Tertiary/biological treatment includes biodegradation by microorganisms in aerobic environment, and activated sludge processes with effluent of phosphorous and nitrogen. Biogas, anaerobic digestion of sludge, is reused to heat up the buildings situated in the plant's territory, and in several wastewater treatment processes. Purified water is led into the sea 3 km away from the coast with a pipeline reaching 26 m below sea level. The similar wastewater treatment is also used in other cities in Estonia. Centralized aerobic treatment plants are not included in calculations of CH_4 emission from wastewater.

The source of domestic CH_4 is divided between anaerobic wastewater systems which include: latrines, septic systems with filtration systems or infiltration systems and anaerobic shallow lagoons. The decrease of domestic CH_4 emission in 1990 and 2007 is the result of the increasing development of centralized aerobic treatment plants. The fluctuation of CH_4 emission from domestic source is also related to the amount of new residential buildings that firstly used anaerobic treatment for their wastewater treatment and later on connected to the centralized wastewater treatment. Since 2000, investments to wastewater treatment systems have led to decreasing trend of CH_4 emissions.

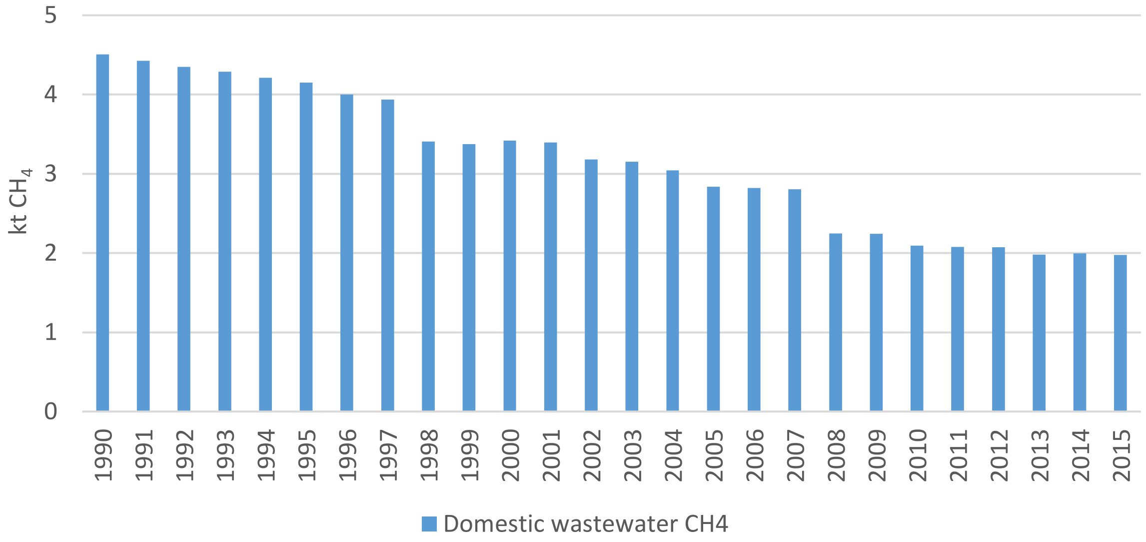

Figure 7.19. CH_4 emissions from Domestic wastewater handling in 1990–2015, kt

The industrial wastewater CH_4 (Figure 7.20) is emitted from a single company in Estonia which is treating its wastewater anaerobically since 2000. CH_4 emission in 2000 and 2001 is calculated with interpolated activity data on the amount of wastewater data from the period of 2002–2005. Interpolation for industrial wastewater quantity for years 2000 and 2001 was needed because cooling water was reported together with the industrial wastewater. Fluctuations from later years are caused by the fluctuation in industry production and the amount of produced wastewater.

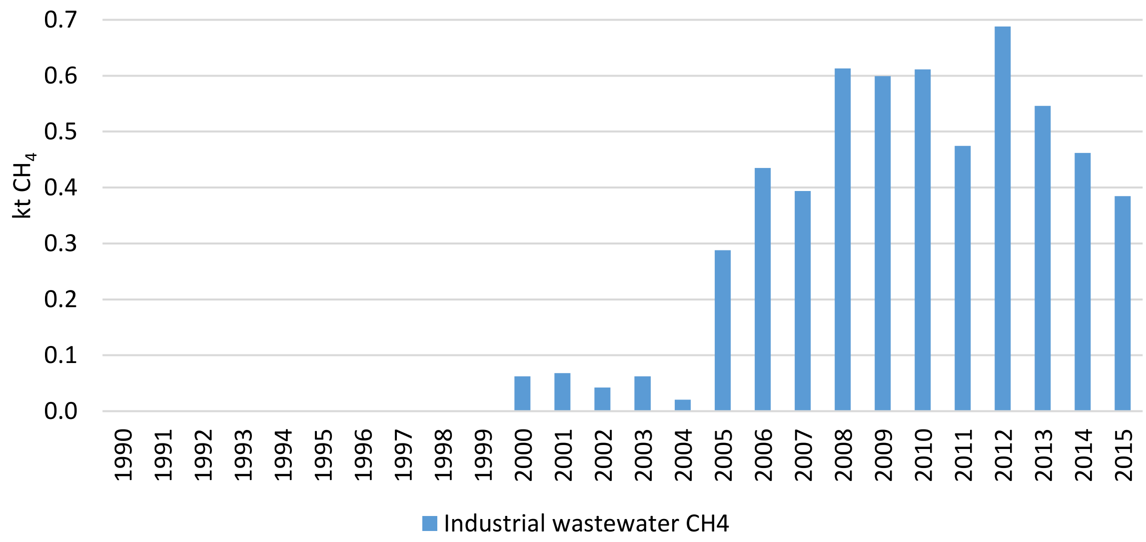

Figure 7.20. CH_4 emissions from Industrial wastewater handling in 1990–2015, kt

N_2O emission from the domestic sources is presented in Figure 7.21. The total amount of N_2O emission from wastewater in 2015 was 0.10 kt. Minor fluctuation in time series is related to changes per capita protein consumption values.

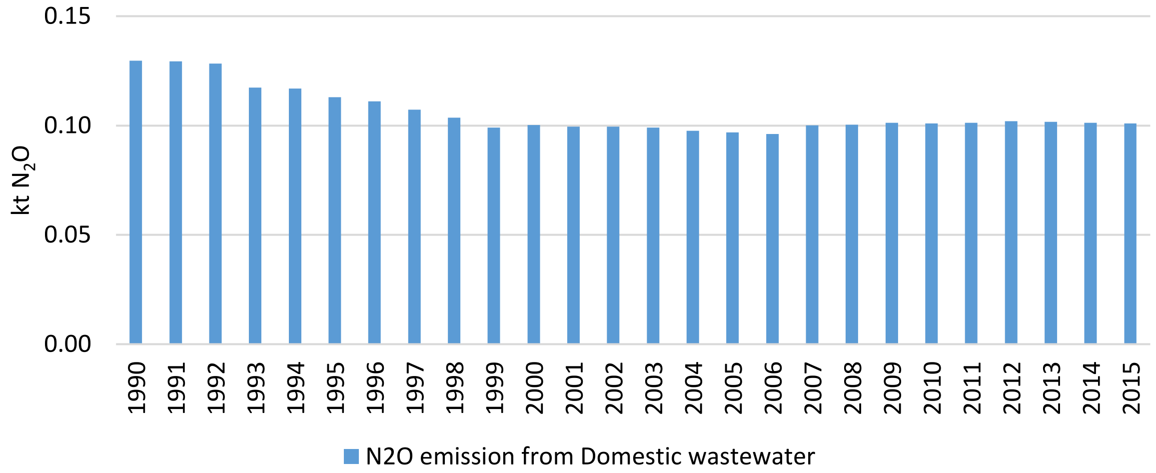

Figure 7.21. N_2O emissions from domestic wastewater handling in 1990–2015, kt

7.5.2. Methodological issues

Activity data

The calculation of CH_4 emission from Domestic wastewater is based on the national inventory of wastewater treatment types in low population settlements[327]. This inventory is covering the time series of the domestic wastewater treatment types in low population settlements with 50 or less persons.

CH_4 emission calculations from domestic sources include anaerobic wastewater treatment systems (Table 7.30):

- latrines (LT);
- septic systems (SEP);
- septic systems (SEP) with filtration systems (FS) or infiltration systems (IF);
- anaerobic shallow lagoons (ASL).

Latrines and wastewater collection tanks are emptied into the centralized aerobic wastewater systems based on need and local government regulations.

Aerobic systems used for wastewater handling but not included to CH_4 calculations are:

- Activated sludge treatment (AST) with fixed film treatment (FFT)
- Biological contactor or trickling filter (BC/TF)

[327] Table is based on the research by Infragate, (2014). Hajaasustuse reovee kohtkäitlussüsteemide inventuuri aruanne. Compared with the 2016 submission, the AST+FFT % has been corrected due to copying error. This correction did not result with changes in emission calculations.

Table 7.30. Wastewater treatment systems in low population settlements, %[327]

Year	AST+ FFT	AST	ASL	BC/TF	LT (1-6 persons)	LT (6-... persons)	SEP	SEP+ FS	SEP+ IF	Total, %
1990	NO	0.7	2.4	0.4	23.4	2.3	59.6	0.1	11.2	100
1991	NO	0.7	2.3	0.4	23.1	2.3	59.5	0.1	11.6	100
1992	NO	0.7	2.3	0.4	22.9	2.2	59.4	0.1	12.0	100
1993	NO	0.7	2.3	0.5	22.6	2.2	59.3	0.1	12.3	100
1994	NO	0.7	2.3	0.5	22.4	2.2	59.2	0.1	12.7	100
1995	NO	0.8	2.2	0.5	22.2	2.2	59.1	0.1	13.0	100
1996	NO	0.8	2.2	0.5	22.0	2.1	59.0	0.1	13.3	100
1997	NO	0.8	2.2	0.5	21.8	2.1	58.9	0.1	13.5	100
1998	NO	0.8	2.2	0.6	21.6	2.1	58.8	0.1	13.8	100
1999	NO	0.8	2.1	0.6	21.5	2.1	58.8	0.1	14.1	100
2000	0.01	0.8	2.1	0.6	21.0	2.1	58.2	0.2	15.0	100
2001	0.02	0.8	2.0	0.6	20.6	2.1	57.8	0.2	15.8	100
2002	0.03	0.8	2.0	0.6	20.2	2.2	57.3	0.3	16.6	100
2003	0.04	0.8	1.9	0.6	19.8	2.2	56.9	0.4	17.3	100
2004	0.05	0.8	1.9	0.7	19.5	2.2	56.5	0.4	18.0	100
2005	0.06	0.8	1.9	0.7	19.2	2.2	56.1	0.5	18.7	100
2006	0.07	0.8	1.8	0.7	18.8	2.2	55.7	0.5	19.3	100
2007	0.07	0.8	1.8	0.7	18.5	2.2	55.4	0.6	19.9	100
2008	0.08	0.8	1.7	0.7	18.3	2.3	55.1	0.6	20.5	100
2009	0.09	0.8	1.7	0.7	18.0	2.3	54.8	0.6	21.0	100
2010	0.08	0.8	1.7	0.7	17.9	2.2	54.1	0.8	21.8	100
2011	0.08	0.7	1.6	0.7	17.8	2.2	53.4	0.9	22.5	100
2012	0.08	0.7	1.6	0.7	17.7	2.2	52.8	1.0	23.2	100
2013	0.08	0.7	1.5	0.7	17.6	2.1	52.2	1.2	23.9	100
2014	0.08	0.7	1.5	0.7	17.6	2.1	52.2	1.2	23.9	100
2015	0.08	0.7	1.5	0.7	17.3	2.1	51.5	1.1	25.0	100

NO - not occurring

Anaerobic wastewater treatment systems in high population settlements (Table 7.31) (from 51 persons), have been interpolated on the national inventory of wastewater treatment types in low population settlements. The rate of wastewater treated aerobically in 1990–1997 is interpolated and based on an expert judgement by MoE. Data from years 1998–2015 has been obtained from EtEA.

Table 7.31. Wastewater treatment systems in high population settlements, %

Year	LT (1-6 persons)	SEP SEP+FS SEP+IF	Centralized, aerobic treatments	Total, %
1990	11.4	25.8	62.8	100
1991	11.5	25.0	63.5	100
1992	11.6	24.2	64.2	100
1993	11.7	23.5	64.8	100
1994	11.7	22.8	65.5	100
1995	11.7	22.2	66.1	100
1996	11.5	21.0	67.5	100
1997	11.5	20.4	68.1	100
1998	7.6	23.4	69.0	100
1999	7.6	23.4	69.0	100
2000	7.4	23.6	69.0	100
2001	7.3	23.7	69.0	100
2002	6.7	22.3	71.0	100
2003	6.5	22.5	71.0	100
2004	6.3	21.7	72.0	100
2005	5.7	20.3	74.0	100
2006	5.7	20.3	74.0	100
2007	5.6	20.4	74.0	100
2008	4.2	15.8	80.0	100
2009	4.2	15.8	80.0	100
2010	3.8	14.6	81.6	100
2011	3.8	14.5	81.7	100
2012	3.7	14.6	81.7	100
2013	3.6	14.2	82.2	100
2014	3.6	14.0	82.4	100
2015	3.5	13.9	82.4	100

Data on population is obtained from the dataset of the SE.

The calculations of CH_4 emissions from Industrial wastewater are based on the plant specific information gathered from a yeast factory, which is the only industrial facility treating its wastewater anaerobically. Other industrial companies are either connected to the sewer systems and their wastewater is treated in centralized aerobic treatment plants (well managed, with MCF 0) or they have their own well managed aerobic treatment systems (MCF 0). Starting from 2014 one additional company started treating its wastewater anaerobically recovered CH_4 for energy.

According to the SE, the energy data from this company has been included to the biogas data used by energy sector, therefore it is included to the Energy sector.

The generated CH4 was flared from 2000–2009 and starting from 2010 CH4 recovered for energy. Degradable Organic Component (DOC) used in the calculations is calculated based on the cleaner efficiency. COD concentration from 2000–2004 is calculated based on the BOD concentration because there is no plant specific COD data on that period. Also, industrial wastewater quantity interpolation for years 2000 and 2001 was needed due to the reporting accuracy on that period, as cooling water was reported together with the industrial wastewater. Starting from 2005, plant specific COD concentrations are included to the calculations.

For calculating N_2O emission the data on population of Estonia was used as activity data and obtained from the dataset of the SE. The annual per capita protein consumption was used from FAO statistical database. The nitrogen in sludge is calculated based on the data obtained from the dataset of the EtEA. As industrial and commercial wastewater in Estonia is co-discharged into the domestic sewer system, than the default $F_{IND-COM}$ fraction of 1.25 is applied the Equation 7.19 for calculation total nitrogen in the effluent.

Methodology

The calculation of CH_4 emission from domestic and industrial wastewater and N_2O from wastewater is based on IPCC 2006 *Tier 1* method due to unavailable country specific parameters.

CH_4 emission calculations from domestic sources were done using Equation 7.13, Equation 7.15 and Equation 7.16. CH_4 emission calculation from industrial sources were done using Equation 7.14, Equation 7.15 and Equation 7.17.

Equation 7.13[328]

$$CH_4 Emissions = \sum \left(TOW_j \times EF_j\right) - S - R$$

Equation 7.14[329]

$$CH_4\ Emissions = \sum_i [(TOW_i - S_i) \times EF_i - R_i]$$

Equation 7.15[330]

$$EF_{j/i} = B_o \times MCF_{j/i}$$

Where:

CH_4 Emissions =	CH_4 emissions in inventory year, kg CH_4/yr;
TOW_i =	total organically degradable material in wastewater from industry *i* in inventory year, kg COD/yr;

[328] Equation proposed by TERT.
[329] IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.20, equation 6.4.
[330] IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.12, equation 6.2

i =	industrial sector;
j =	each treatment/discharge pathway or system;
S_i =	organic component removed as sludge in inventory year, kg COD/yr;
$EF_{j/i}$ =	emission factor for domestic wastewater or industry *I*;
R_i =	amount of CH_4 recovered in inventory year, kg CH_4/yr;
B_o =	methane correction factor, fraction;
$MCF_{j/i}$ =	methane correction factor.

Equation 7.16 is used for calculating TOW in domestic wastewater and Equation 7.17 for TOW in industrial wastewater. The correction factor for additional industrial BOD discharged into sewers is not included to domestic/commercial wastewater TOW calculations. CH_4 emissions are calculated from uncollected wastewater treatment systems, with no additional industrial wastewater.

Equation 7.16[331]

$$TOW = P_j \times BOD_j \times 0.001 \times I \times 365$$

Where:

TOW =	total organics in wastewater in inventory year, kg BOD/yr;
P_j =	country population in inventory year, (person);
BOD_j =	country-specific per capita BOD in inventory year, g/person/day,
j =	each treatment/discharge pathway or system;
0.001 =	conversion from grams BOD to kg BOD;
I =	correction factor for additional industrial BOD discharged into sewers.

Equation 7.17[332]

$$TOW_i = P_i \times W_i \times COD_i$$

Where:

TOW_i =	total organically degradable material in wastewater for industry *i*, kg COD/yr;
i =	industrial sector;
P_i =	total industrial product for industrial sector *i*, t/yr;
W_i =	wastewater generated, m^3/t product;
COD_i =	chemical oxygen demand (industrial degradable organic component in wastewater), kg COD/m^3.

N_2O emission calculations from domestic sources were done using Equation 7.18 and Equation 7.19.

[331] Equation proposed by TERT.
[332] IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.22, equation 6.6.

Equation 7.18[333]

$$N_2O\ Emissions = N_{EFFLUENT} \times EF_{EFFLUENT} \times 44/28$$

Where:

N_2O Emissions =	N_2O emissions in inventory year, kg N_2O/yr;
$N_{EFFLUENT}$ =	nitrogen in the effluent discharged to aquatic environments, kg N/yr:
$EF_{EFFLUENT}$ =	emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N.

The factor 44/28 is the conversion of kg N_2O-N into kg N_2O.

Equation 7.19[334]

$$N_{EFFLUENT} = (P \times PROTEIN \times F_{NPR} \times F_{NON-CON} \times F_{IND-COM}) - F_{SLUDGE}$$

Where:

$N_{EFFLUENT}$ =	total annual amount of nitrogen in the wastewater effluent, kg N/yr;
P =	human population;
Protein =	annual per capita protein consumption, kg/person/yr;
F_{NPR} =	fraction of nitrogen in protein;
$F_{NON-CON}$ =	factor for non-consumed protein added to the wastewater;
$F_{IND-COM}$ =	factor for industrial and commercial co-discharged protein into the sewer system;
N_{SLUDGE} =	nitrogen removed with sludge (default = zero), kg N/yr.

Emission factors

The IPCC 2006 Guidelines default emission factors used in calculations are presented in Table 7.32.

Table 7.32. Emission factors and parameters used in the calculations of Wastewater treatment and discharge

	Value
CH_4 from domestic Wastewater	
Bo (kg CH_4/kg BOD)[335]	0.6
Degradable organic component (g BOD/person/day)[336]	60
MCF anaerobic lagoon[337]	0.2
MCF septic system[337]	0.5
MCF latrines[337]	0.7

333 IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.25, equation 6.7.
334 IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.25, equation 6.8.
335 IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.12, table 6.2.
336 IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.14, table 6.4.
337 IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.13, table 6.3.

	Value
CH_4 from industrial Wastewater	
Bo (kg CH_4/kg COD)[338]	0.25
MCF[339]	0.8
N_2O from wastewater[340]	
F_{NRP} (kg N/year)	0.16
$F_{NON-CON}$	1.4
$F_{IND-COM}$	1.25
$EF_{EFFLUENT}$ (kg N_2O-N/kg-N)	0.005

Default value for the parameter $F_{NON-CON}$ (factor for non-consumed protein added to the wastewater) for developed countries using garbage disposal has been used due to the possibility, that people wash food waste down the drain. it is necessary to consider it. Couple of years ago it was popular that household had a garbage disposal unit shredding food waste and leading it into the wastewater stream. Nowadays this type of technological additions are not so popular, nevertheless the possibility of washing food down the drain is needed to be considered when calculating the N_2O emissions.

7.5.3. Uncertainties and time series consistency

The estimation of CH_4 emissions from Wastewater treatment and discharge is carried out taking into account activity data and emission factors. Default uncertainty ranges for domestic and industrial wastewater are presented in Table 7.33. The data on protein consumption per capita was plotted from FAO databases; the uncertainty of this parameter is not recorded.

Table 7.33. Default uncertainty ranges for Wastewater treatment and discharge

Input	Uncertainties
CH_4 from domestic Wastewater[341]	
Activity data	
Human Population	±5%
BOD/person	±30%
Fraction of people income group	±15%
Degree of utilization of treatment/discharge pathway or system for each income group	±50%
Emission factor	
Latrines, centralised well managed treatment systems, lagoons	±50%; ±10%; ±30%;
Maximum Methane Producing Capacity (B_o)	±30%

338 IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.21.
339 IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.21, table 6.8.
340 IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.27, table 6.11.
341 IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.17, table 6.7.

Input	Uncertainties
CH_4 from industrial Wastewater[342]	
Activity data	
Industrial Production	±5%[1]
Wastewater /unit production	±50%
COD/unit wastewater	
Emission factor	
Maximum Methane Producing Capacity (Bo)	±30%
Methane correction factor[338]	±20%
N_2O from wastewater[343]	
Activity data	
Human Population	±10%
Protein	±10%
FNRP (kg N/year)	(0.16) 0.15 - 0.17
$F_{NON\text{-}CON}$	(1.4) 1.0 - 1.5
$F_{IND\text{-}COM}$	(1.25) 1.0 - 1.5
Emission factor	
$EF_{EFFLUENT}$ (kg N_2O-N/kg-N)	(0.005) 0.0005 - 0.25
EF_{PLANTS}	(3.2) 2-8

[1]Activity data for calculating emissions from industrial wastewater is plant based and therefore and expert judgement has been used.

7.5.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out according to the procedures described in IPCC 2006 Guidelines[344]. In addition, fundamental QA/QC procedures regarding to activity data on wastewater treatment types in domestic wastewater and facility-specific data for industrial wastewater have been carried out.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.2.3.

7.5.5. Source-specific recalculations

No source specific recalculations were carried out.

[342] IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.23, table 6.10.
[343] IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.27, table 6.11.
[344] IPCC 2006 Guidelines, Volume 1, Chapter 6: Quality Assurance / Quality Control and Verification.

7.5.6. Source-specific planned improvements

The activity data for estimating N_2O from advanced centralised wastewater treatment plants is kept under consideration and the emission calculation will be included as soon as activity data is available.

7.6. Biogas burnt in a flare (CRF 5.E)

7.6.1. Source category description

Biogas generated at the Estonia's SWDS are both combusted with energy recovery (reported under Energy sector) and burnt in a flare (part of the Waste sector). There were 3 landfills in 2015 burning biogas in a flare which have also been taken into account under CRF 5.A when calculating emissions from SWDS. Emissions of N_2O and CH_4 from biogas burnt in a flare include emissions from both municipal and industrial sources.

The CH_4 emission from flaring biogas in 2015 was 0.86 kt and N_2O emissions from flaring landfill gas comprised 0.003 kt (Figure 7.22).

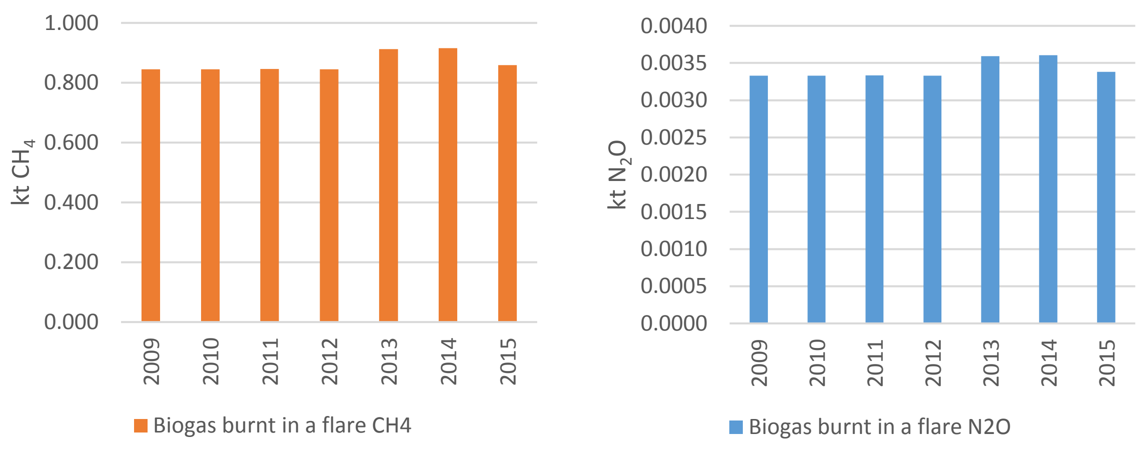

Figure 7.22. CH_4 and N_2O emissions from burning biogas in a flare, kt

7.6.2. Methodological issues

Activity data

When calculating emissions, plant based quantities of biogas burnt is used as activity data, which is derived from OSIS (Table 7.34).

Table 7.34. The amount of landfill gas burnt in a flare, thousand m^3 per landfill[283]

Landfill name	2009	2010	2011	2012	2013	2014	2015
Väätsa	5 500	5 500	5 500	5 500	5 500	5 500	5 500

Landfill name	2009	2010	2011	2012	2013	2014	2015
Paikre	NO	17.13	97.52	19.38	11.72	57.95	29.79
Viljandi	NO	NO	NO	NO	208.671	303.725	154.834
Uikala	NO	NO	NO	NO	1 489.20	1 501.44	NO

Methods

Emission calculations are based on IPCC 2006 Guidelines Tier 2 method of multiplying the amount of flared gas and country-specific emission factors (Equation 7.20).

Equation 7.20[345]

$$Emissions_{GHG} = Fuel\ consumption_{fuel} \times Emission\ factor_{GHG}$$

Where:

$Emission_{GHG}$ = emissions of a given GHG by type of fuel (kg GHG),
$Fuel\ Consumption_{fuel}$ = amount of fuel combusted (TJ);
$Emission\ Factor_{GHG}$= country-specific emission factor (kg/TJ).

Emission factors

Estonia is using country-specific emission factors based on flared biogas measurements. Data will be made available for reviewers if necessary.

7.6.3. Uncertainties and time series consistency

Uncertainty ranges for flaring biogas in landfills are presented in Table 7.35. Activity data uncertainty takes into account the waste composition uncertainty and the amount of deposited MSW. Emission factor uncertainty is based on flared biogas measurements.

Table 7.35. Default uncertainty ranges for Biogas Burnt in a flare

Input	Uncertainties
Activity data[346]	
Total municipal solid waste	± 10%
Total uncertainty of waste composition	± 10%
MSW sent to SWDS	± 10%
Emission factors*	
CH_4	22.96%
N_2O	7.56%

*Uncertainty calculations are based on the flared biogas measurements.

[345] IPCC 2006 Guidelines, Volume 2, Chapter 2: Stationary combustion, page 2.11, equation 2.1.
[346] IPCC 2006 Guidelines, Volume 5, Chapter 3. Solid Waste Disposal, page 3.27, table 3.5.

7.6.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) was carried out according to the procedures described in IPCC 2006 Guidelines[347]. To ensure the accuracy, plant specific data, equations for calculating emission factors and emissions have been cross-checked.

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Section 1.2.3.

7.6.5. Source-specific recalculations

No source specific recalculations were carried out.

7.6.6. Source-specific planned improvements

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

[347] IPCC 2006 Guidelines, Volume 1, Chapter 6: Quality Assurance / Quality Control and Verification.

8. OTHER (CRF 6)

Estonia does not report any emissions under the Other sector.

9. INDIRECT CO_2 AND NITROUS OXIDE EMISSIONS

9.1. Description of sources of indirect emissions in GHG inventory

Estonia has chosen to report indirect CO_2 emissions calculated from NMVOC emissions from the CRF subcategory 2.D.3. This subcategory consists of

3. Solvent use;
4. Road paving with asphalt.

The indirect CO_2 emissions are reported under beforementioned subcategory on CO_2 emission rows.

Information on how the indirect CO_2 emissions were calculated, is provided in chapters 4.4.3.2 Solvent use and 4.4.3.3 Road paving with asphalt.

10. RECALCULATIONS AND IMPROVEMENTS

10.1. Explanations and justifications for recalculations, including in response to the review process

10.1.1. GHG inventory

Explanations and justifications for the recalculations performed for this submission are given in Table 10.1.

Table 10.1. Recalculations made for the 2017 inventory submission by the CRF category and their implications

SECTOR	IPCC CATEGORY	RECALCULATION
Energy	1.A.1.a Public electricity and heat production	For the year 2014 in 1A1a some activity data of other fuels (municipal waste) has been updated. Also, the activity data of oil shale combustion has been updated for the years 2005 – 2015 according to relevant EU ETS enterprises. Estonia is also working on unifying EU ETS oil shale combustion data with the data of Statistics Estonia. Oxidation factors have been updated due to the Regulation of Minister of Environment on “Calculation methods of the amount of CO_2 discharged into ambient air” was updated to be in accordance with the 2006 IPCC Guidelines.
	1.A.1.c Manufacture of solid fuels and other energy industries	The methodology of 1A1c has been enhanced. Namely, the emission factors of shale oil production have been recalculated according to more precise plant specific data.
	1.A.2 Manufacturing industries and construction	Oxidation factors have been updated due to the Regulation of Minister of Environment on “Calculation methods of the amount of CO_2 discharged into ambient air” was updated to be in accordance with the 2006 IPCC Guidelines. In addition the CO_2 emission factors were updated with a more accurate carbon conversion factor specified in the previously mentioned regulation.
	1.A.2.d Pulp, paper and print	For 1A2d, the combustion of biogas has been added to 2014.

SECTOR	IPCC CATEGORY	RECALCULATION
	1.A.3 Transport	In all categories (except 1.A.3.a) oxidation factors were updated according to the updated Regulation of Minister of Environment on “Calculation methods of the amount of CO_2 discharged into ambient air”. In addition the country-specific CO_2 emission factors were updated with a more accurate carbon conversion factor specified in the previously mentioned regulation
	1.A.3.a Domestic aviation	Due to revised 1A3a emission factors, the category 1A3a has been recalculated (see Table 3.34). Revised emission factors are presented in Table 3.33.
	1.A.4 Other sectors	In all categories oxidation factors were updated according to the updated Regulation of Minister of Environment on “Calculation methods of the amount of CO_2 discharged into ambient air”. In addition the country-specific CO_2 emission factors were updated with a more accurate carbon conversion factor specified in the previously mentioned regulation. The differences can be seen in Table 3.42.
	1.A.5 Other	Oxidation factors were updated according to the updated Regulation of Minister of Environment on “Calculation methods of the amount of CO_2 discharged into ambient air”. In addition the country-specific CO_2 emission factors were updated with a more accurate carbon conversion factor specified in the previously mentioned regulation. The differences can be seen in Table 3.42
Industrial processes and product use	2.F.1.e Mobile Air-Conditioning – Wheel tractors and mobile machinery	Activity data and emissions have been recalculated for years 2010–2014, because some of the wheel tractors were not accounted previously in these years.
	2.B.1 Ammonia production	Activity data has been harmonized with statistical data used for energy balance, non-energy use of fuels, and that is the reason why emissions were recalculated.

SECTOR	IPCC CATEGORY	RECALCULATION
Agriculture	3.A Enteric fermentation	The calculations in swine and cattle sub-categories were previously performed on a county level which involved several intermediate calculations which were ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are immediately performed on a country-level using weighed average country-specific activity data which is in line with the IPCC guidelines. The change in calculation approach brought about a reevaluation of used activity data along with some miscalculation errors detected and corrected in working tables, which lead to recalculations under the Enteric fermentation subsector. The recalculations are shown in Table 5.16.
	3.B Manure management	The calculations in swine and cattle Manure management sub-categories were previously performed on a county level that involved several intermediate calculations which were ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are immediately performed on a country-level using weighed average country-specific activity data in line with the IPCC guidelines. The change in calculation approach brought about a reevaluation of used activity data along with some miscalculation errors detected and corrected in working tables, which lead to recalculations in CH_4 emissions under the Manure management subsector. The recalculations are demonstrated in Table 5.25.

SECTOR	IPCC CATEGORY	RECALCULATION
	3.B Manure management	The calculations in swine and cattle Manure management sub-categories were previously performed on a county level that involved several intermediate calculations which were ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are immediately performed on a country-level using weighed average country-specific activity data which is in line with the IPCC guidelines. The change in calculation approach brought about a reevaluation of used activity data along with some miscalculation errors detected and corrected in working tables, which lead to recalculations in N_2O emissions under the Manure management subsector. The recalculations are demonstrated in Table 5.38.
	3.D.1.2.a Animal manure applied to soils and 3.D.1.3 Urne and dung deposited by grazing animals; 3.D.2 Indirect N_2O emissions from managed soils	Direct N_2O emissions from animal manure applied to soils (CRF 3.D.1.2.a) and from urne and dung deposited by grazing animals (CRF 3.D.1.3) were revised do to recalculations under the Manure management subcategory (CRF 3.B) (see Chapter 5.4.7). The results of the recalculations are presented in Table 5.47.
	3.D.1.2.c Other organic fertilizers applied to oils	Activity data of composted biological waste was updated. The results of the recalculations are presented in Table 5.47.
	3.D.1.4 Crop residues	Miscalculation errors were corrected in the working tables during the 2017 submission that resulted in recalculations under the Crop residues subsector. The recalculations are shown in Table 5.47.
	3.D.1.6 Cultivation of organic soils	Cultivation of organic soils (CRF 3.D.1.6) – data on areas of organic soils cultivated were updated in the framework of the NFI (see Chapter 6 LULUCF). The results of the recalculations are shown in Table 5.47
	3.G Liming	CO_2 emissions from liming were submitted separately for calcic limestone ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$) according to the type of lime fertilizer applied on agricultural lands. The results of the recalculations performed are presented on Figure 5.33 in Chapter 5.7.5.

SECTOR	IPCC CATEGORY	RECALCULATION
LULUCF	4.A Forest land	The entire time series of activity data is annually recalculated for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated into overall activity data. Soil emission factors were updated for Land remaining forest land. For 2017 submission NFI data was renewed and methodology was updated. In Table 6.14 changes in applied parameters and in Table 6.15 quantitative overview of recalculations is shown.
	4.B Cropland	The entire time series of activity data is annually recalculated for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated into overall activity data. In Table 6.20 a quantitative overview of recalculations has been shown.
	4.C Grassland	Activity data as well as growing stock and dead wood stock volumes are being updated and if necessary, corrected, each year (see Table 6.24).
	4.D Wetlands	Updated activity data, growing stocks and dead wood volumes from the NFI was used for estimating carbon losses due to land conversion to wetlands and peatlands (see Table 6.29).
	4.E Settlements	Updated activity data, growing stocks and dead wood volumes from the NFI were used for estimating carbon losses due to land conversion to Settlements (see Table **6.32**).
	4.F Other land	Updated activity data, growing stocks and dead wood volumes from the NFI were used for estimating carbon losses due to land conversion to Other Land (see Table 6.35).
	4.G Harvested Wood Products	Activity data is being updated and if necessary, corrected, each year. In Table 6.40 a quantitative overview of recalculations has been shown.

SECTOR	IPCC CATEGORY	RECALCULATION
Waste	5.A Solid waste disposal	CH_4 emission recalculations are based on a research correcting waste classification. The amount of MSW generated and deposited was corrected by subtracting the amount of separately collected waste to avoid double counting and by subtracting furniture waste.
	5.B.1 Composting	CH_4 and N_2O emission recalculations are based on the same research connected with the subsector 5.A correcting waste classification. Recalculations in composting emissions are presented in Table 7.19.
	5.C.2 Open burning of waste	Source specific CO_2, CH_4 and N_2O emission recalculations are based on the same research connected with the subsector 5.A correcting MSW generation.

10.1.2. KP-LULUCF inventory

Areas subject to Afforestation/reforestation, Deforestation and Forest management are annually updated by the NFI, new data is integrated into overall activity data.

10.2. Implications for emission levels

10.2.1. GHG inventory

For the national total CO_2 equivalent emissions (with indirect CO_2 and) without Land-use, land-use change and forestry, the general impact of the improvements and recalculations performed is small and the changes for the whole time-series are between -1.08% (1990) and 0.1% (2014). Therefore, the implications of the recalculations on the level and on the trend, 1990–2014, of this national total are small (Table 10.2).

For the national total CO_2 equivalent emissions (with indirect CO_2 and) with Land-use, land-use change and forestry, the general impact of the recalculations is larger. The differences vary between -34.18% (2001) and 44.05% (1995) (Table 10.2).

Table 10.2. Recalculation performed in 2017 submission for years 1990–2014. Differences in % between this and June 2016 submission for Estonia

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total CO_2 equivalent emissions with LULUCF	17.66	19.30	27.34	39.20	38.60	44.05	41.03	37.33	31.07	8.06	-29.47	-34.18
Energy	1.23	1.20	1.39	1.40	1.44	1.43	1.41	1.45	1.44	1.47	1.54	1.48
Industrial processes and product use	0.42	1.94	0.34	0.25	0.49	0.40	0.44	0.47	0.47	-0.11	0.03	-0.10
Agriculture	-0.49	1.12	1.91	2.75	1.49	1.77	1.82	1.36	0.66	2.37	1.93	1.39
Waste	-0.05	-0.06	-0.06	-0.07	-0.08	-0.07	-0.07	-0.06	-0.07	-0.08	-0.13	-0.11

Total CO_2 equivalent without LULUCF	1.08	1.20	1.39	1.45	1.39	1.39	1.37	1.37	1.31	1.41	1.45	1.36

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total CO_2 equivalent emissions with LULUCF	-33.20	-12.09	5.70	21.09	30.46	31.43	31.82	29.84	24.18	10.28	2.93	-3.24	-5.98
Energy	1.49	1.58	1.45	4.87	4.55	6.79	3.58	3.14	6.30	3.47	3.66	0.69	-0.04
Industrial processes and product use	0.03	0.12	0.05	-0.17	-0.15	-0.17	-0.16	0.00	0.02	0.05	-0.05	0.08	0.14
Agriculture	1.64	1.20	2.53	4.06	3.27	4.52	3.02	3.69	2.29	4.27	4.06	3.11	1.79
Waste	-0.11	-0.11	-0.45	-0.59	-0.90	-3.98	-6.59	-1.02	2.36	-2.28	0.62	1.62	1.03
Total CO_2 equivalent without LULUCF	1.40	1.46	1.40	4.48	4.13	6.13	3.12	2.97	5.83	3.29	3.45	0.82	0.10

10.2.2. KP-LULUCF inventory

Quantitative changes due to recalculations under ARD and FM are shown in Table 10.3, Table 10.4 and Table 10.5.

Table 10.3. AR: Changes in emission estimates due to recalculations, kt C

	2008	2009	2010	2011	2012	2013	2014
2016 submission							
Above-ground biomass	21.4	24.7	27.7	32.0	35.8	40.3	45.5
Below-ground biomass	9.0	10.4	11.7	13.5	15.1	17.0	19.2
Litter	9.37	9.57	9.75	9.89	10.01	10.07	10.09
Dead wood	-0.04	-0.11	-0.04	-0.11	-0.10	-0.16	-0.12
Mineral soils	-17.5	-17.7	-17.9	-17.1	-16.2	-15.2	-14.0
Organic soils	-3.8	-4.1	-4.3	-4.3	-4.2	-4.1	-3.6
Total kt CO_2 eq in 2016	-67.68	-83.80	-98.71	-124.43	-148.13	-175.33	-208.43
2017 submission							
Above-ground biomass	31.97	35.10	36.02	40.20	41.74	44.10	47.39
Below-ground biomass	16.22	16.65	17.06	17.33	17.56	17.73	17.80
Litter	16.22	16.65	17.06	17.33	17.56	17.73	17.80
Dead wood	0.72	0.81	0.85	1.11	1.18	1.23	1.31
Mineral soils	-31.26	-31.81	-32.33	-32.83	-33.27	-33.58	-33.74
Organic soils	-5.91	-6.12	-6.31	-6.41	-6.49	-6.54	-6.57
Total kt CO_2 eq in 2017	-89.13	-104.25	-107.94	-129.03	-136.14	-147.67	-164.40

TOTAL change % 2017/2016	24.1	19.6	8.6	3.6	-8.8	-18.7	-26.8

Table 10.4 D: Changes in emission estimates due to recalculations, kt C

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
2016 submission							
Above-ground biomass	-106.42	-101.16	-79.23	-68.59	-53.43	-36.47	-35.01
Below-ground biomass	-25.05	-23.81	-18.65	-16.15	-12.58	-8.59	-8.24
Litter	-13.93	-15.91	-17.47	-18.87	-19.98	-20.74	-21.48
Dead wood	-3.56	-3.52	-2.85	-2.53	-2.00	-1.37	-1.31
Mineral soils	-6.33	-18.57	-8.40	-9.26	-9.99	-10.60	-11.19
Organic soils	-1.69	-2.01	-2.35	-2.71	-2.97	-3.21	-3.42
Total kt CO2 eq in 2016	575.58	604.91	472.82	433.03	370.15	296.95	295.71
2017 submission							
Above-ground biomass	-93.54	-96.19	-89.81	-58.34	-46.73	-31.60	-15.97
Below-ground biomass	-22.05	-22.68	-21.17	-13.76	-11.02	-7.45	-3.77
Litter	-12.88	-15.03	-17.02	-18.29	-19.33	-20.05	-20.42
Dead wood	-4.52	-4.64	-4.35	-2.83	-2.27	-1.54	-0.78
Mineral soils	-5.93	-7.36	-8.58	-9.39	-10.06	-10.54	-10.84
Organic soils	-2.38	-3.17	-4.02	-4.54	-5.05	-5.45	-5.56
Total kt CO2 eq in 2017	518.11	546.57	531.48	392.85	346.36	280.97	210.24
TOTAL change % 2017/2016	-11.1	-10.7	11.0	-9.4	-6.9	-5.7	-40.7

Table 10.5 FM: Changes in emission estimates due to recalculations, kt C

	2013	**2014**
2016 submission		
Biomass	37.76	-39.28
Litter	NA	NA
Dead wood	26.57	-28.15
Mineral soils	285.6	285.56
Organic soils	-79.45	-79.49
Total kt CO_2 eq. in 2016	-991.74	-508.36
2017submission		
Biomass	373.04	397.81
Litter	NA	NA

Dead wood	38.56	30.79
Mineral soils	255.69	255.72
Organic soils	-98.34	-98.34
Total kt CO_2 eq. in 2017	-2086.10	-2148.62
TOTAL change % 2017/2016	52.5	76.3

10.3. Implications for emission trends, including time series consistency

10.3.1. GHG inventory

It is a high general priority in the considerations leading to recalculations back to 1990 to have and preserve the consistency of the activity data and emissions time-series. As a consequence activity data, emissions factors and methodologies are carefully chosen to represent the emissions for the time-series correctly. Often considerations regarding the consistency of the time-series have led to recalculations for single years when activity data and/or emissions factors have been changed or corrected. Furthermore, when new source are considered, activity data and emissions are as far as possible introduced to the inventories for the whole time-series based on preferably the same methodology.

The implications of the recalculations are further shown in Table 10.6–Table 10.12.

Table 10.6. Recalculations for CO_2 performed in year 2017 for 2014. Difference between this and the June 2016 submission for Estonia

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (CO_2)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
Total National Emissions and Removals	**CO_2**	18 334.45	17 148.47	-1 185.98	-6%	-6%	-6%	Please see explanations below.
1. Energy	**CO_2**	18 419.74	18 413.57	-6.17	0%	0%	0%	See explanations under relevant categories.
A. Fuel combustion activities	CO_2	18 419.71	18 413.54	-6.17	0%	0%	0%	See explanations under relevant categories.
1. Energy industries	CO_2	14 898.11	14 889.90	-8.21	0%	0%	0%	The methodology of shale oil production was enhanced. Oxidation factors have been updated and the carbon conversion factor for CO2 emission factors has been specified. Oil shale acticity data has been updated.
2. Manufacturing industries and construction	CO_2	695.24	698.32	3.08	0%	0%	0%	Oxidation factors have been updated and the carbon conversion factor for CO2 emission factors has been specified.
3. Transport	CO_2	2 236.33	2 234.70	-1.63	0%	0%	0%	The emission factors of 1A3a were revised. Oxidation factors have been updated and the carbon conversion factor for CO2 emission factors has been specified.
4. Other sectors	CO_2	557.41	558.03	0.62	0%	0%	0%	Oxidation factors have been updated and the carbon conversion factor for CO2 emission factors has been specified.
5. Other	CO_2	32.62	32.60	-0.02	0%	0%	0%	Oxidation factors have been updated and the carbon conversion factor for CO2 emission factors has been specified.
B. Fugitive Emissions from Fuels	CO_2	0.03	0.03	-	0%	0%	0%	-
1. Solid fuels								
2. Oil and natural gas	CO_2	0.03	0.03	-	0%	0%	0%	-
C. CO_2 transport and storage								
2. Industrial processes and product use	**CO_2**	484.91	484.91	0.00	0%	0%	0%	-
A. Mineral industry	CO_2	464.46	464.46	-	0%	0%	0%	-
B. Chemical industry	CO_2							
C. Metal industry								

[348] The percentage change due to recalculation with respect to the previous submission.
[349] Total emissions refer to total aggregate GHG emissions expressed in terms of CO_2 equivalent, excluding GHGs from the LULUCF sector.
[350] Total emissions refer to total aggregate GHG emissions expressed in terms of CO_2 equivalent, including GHGs from the LULUCF sector.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (CO_2)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
D. Non-energy products from fuels and solvent use	CO_2	20.45	20.45	0.00	0%	0%	0%	Some activity data were corrected retrospectively.
G. Other product manufacture and use								
H. Other								
3. Agriculture	**CO_2**	13.08	10.76	-2.32	-18%	0%	0%	Please see explanations below.
A. Enteric fermentation								
B. Manure management								
C. Rice cultivation								
D. Agricultural soils								
E. Prescribed burning of savannahs								
F. Field burning of agricultural residues								
G. Liming	CO_2	13.08	8.29	-4.79	-37%	0%	0%	Recalculations were performed to estimate annual CO2 emissions from liming. Type of lime applied to croplands were separated into calcic limestone (CaCO3) and dolomite (CaMg(CO3)2) which by adding these carbonates to soil leads to CO2 emission.
H. Urea application	CO_2	-	2.47	2.47	100%	0%	0%	In previous submissions CO2 emissions were not reported for 2011, 2012 and 2014. In the 2017 submission approximate CO2 emissions have been estimated on the basis of urea-based fertilizers marketing data for 2011-2012 and 2014-2015.
I. Other carbon-containing fertilizer								
J. Other								
4. Land use, land-use change and forestry (net)	**CO_2**	-584.27	-1 761.74	-1 177.48	202%	-6%	-6%	The entire time series of activity data is annually recalculated for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated into overall activity data. NFI data was renewed and methodology was updated.
A. Forest land	CO_2	-1 263.68	-2 183.47	-919.80	73%	-4%	-5%	Soil emission factors were updated for remaining Forest land.
B. Cropland	CO_2	143.41	133.42	-9.99	-7%	0%	0%	Please see comment I37.
C. Grassland	CO_2	-8.06	6.70	14.76	-183%	0%	0%	The grassland organic soil emission factor from Sweden was updated. Soil emission factors were updated.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (CO_2)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
D. Wetlands	CO_2	934.98	905.70	-29.29	-3%	0%	0%	Updated activity data, growing stocks and dead wood volumes from the NFI was used for estimating carbon losses due to land conversion to wetlands and peatlands.
E. Settlements	CO_2	325.14	235.05	-90.09	-28%	0%	0%	Updated activity data, growing stocks and dead wood volumes from the NFI were used for estimating carbon losses due to land conversion to Settlements.
F. Other land	CO_2	22.62	23.41	0.79	3%	0%	0%	Updated activity data, growing stocks and dead wood volumes from the NFI were used for estimating carbon losses due to land conversion to Other Land.
G. Harvested wood products	CO_2	-738.69	-882.55	-143.86	19%	-1%	-1%	Please see comment I37.
H. Other								
5. Waste	**CO_2**	0.98	0.97	-0.02	-2%	0%	0%	Please see explanations below.
A. Solid waste disposal								
B. Biological treatment of solid waste								
C. Incineration and open burning of waste	CO_2	0.98	0.97	-0.02	-2%	0%	0%	Updated activity data.
D. Waste water treatment and discharge								
E. Other								
6. Other (As specified in summary 1.A)								
Memo items:								
International bunkers	**CO_2**	1 104.83	1 101.26	-3.57	0%	0%	0%	Please see explanations below.
Aviation	CO_2	125.13	122.27	-2.85	-2%	0%	0%	There were recalculations in the Aviation bunkering sector due to revising of emissions factors.
Navigation	CO_2	979.70	978.99	-0.71	0%	0%	0%	-
Multilateral operations								
CO_2 emissions from biomass	**CO_2**	3 731.27	3 731.23	-0.04	0%	0%	0%	
CO_2 captured								
Long-term storage of C in waste disposal sites								

Table 10.7. Recalculations for CO_2 performed in year 2017 for 1990. Difference between this and the June 2016 submission for Estonia

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (CO_2)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
Total National Emissions and Removals	**CO_2**	28 533.96	35 332.70	6 798.75	24%	17%	18%	Please see explanations below.
1. Energy	**CO_2**	35 646.74	36 093.57	446.83	1%	1%	1%	See explanations under relevant categories.
A. Fuel combustion activities	CO_2	35 646.65	36 093.48	446.83	1%	1%	1%	See explanations under relevant categories.
1. Energy industries	CO_2	28 824.70	29 256.08	431.38	1%	1%	1%	The methodology of shale oil production was enhanced. Oxidation factors have been updated and the carbon conversion factor for CO2 emission factors has been specified.
2. Manufacturing industries and construction	CO_2	2 479.57	2 497.61	18.04	1%	0%	0%	Oxidation factors have been updated and the carbon conversion factor for CO2 emission factors has been specified.
3. Transport	CO_2	2 417.64	2 415.74	-1.91	0%	0%	0%	The emission factors of 1A3a were revised. Oxidation factors have been updated and the carbon conversion factor for CO2 emission factors has been specified.
4. Other sectors	CO_2	1 881.31	1 880.64	-0.66	0%	0%	0%	Oxidation factors have been updated and the carbon conversion factor for CO2 emission factors has been specified.
5. Other	CO_2	43.44	43.40	-0.03	0%	0%	0%	Oxidation factors have been updated and the carbon conversion factor for CO2 emission factors has been specified.
B. Fugitive Emissions from Fuels	CO_2	0.09	0.09	-	0%	0%	0%	-
1. Solid fuels								
2. Oil and natural gas	CO_2	0.09	0.09	-	0%	0%	0%	-
C. CO_2 transport and storage								
2. Industrial processes and product use	**CO_2**	956.20	960.28	4.09	0%	0%	0%	-
A. Mineral industry	CO_2	614.26	614.26	-	0%	0%	0%	-
B. Chemical industry	CO_2	303.65	307.73	4.09	1%	0%	0%	-
C. Metal industry				-				
D. Non-energy products from fuels and solvent use	CO_2	38.29	38.29	-	0%	0%	0%	-
G. Other product manufacture and use								
H. Other								
3. Agriculture	**CO_2**	56.84	13.11	-43.73	-77%	0%	0%	Please see explanations below.
A. Enteric fermentation								

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (CO_2)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
B. Manure management								
C. Rice cultivation								
D. Agricultural soils								
E. Prescribed burning of savannahs								
F. Field burning of agricultural residues								
G. Liming	CO_2	55.84	12.11	-43.73	-78%	0%	0%	Recalculations were performed to estimate annual CO2 emissions from liming. Type of lime applied to croplands were separated into calcic limestone (CaCO3) and dolomite (CaMg(CO3)2) which by adding these carbonates to soil leads to CO2 emission.
H. Urea application	CO_2	1.00	1.00	-	0%	0%	0%	-
I. Other carbon-containing fertilizer								
J. Other								
4. Land use, land-use change and forestry (net)	**CO_2**	-8 128.07	-1 736.51	6 391.56	-79%	16%	17%	The entire time series of activity data is annually recalculated for all areas of land categories and land-use conversions, since new data about land-use transitions is collected every year and new estimates will be integrated into overall activity data. NFI data was renewed and methodology was updated.
A. Forest land	CO_2	-9 271.91	-2 977.04	6 294.87	-68%	16%	16%	Soil emission factors were updated for Forest land.
B. Cropland	CO_2	89.91	100.92	11.01	12%	0%	0%	Please see comment I37.
C. Grassland	CO_2	-21.38	60.01	81.39	-381%	0%	0%	The grassland organic soil emission factor from Sweden was updated.
D. Wetlands	CO_2	1 074.01	1 079.60	5.59	1%	0%	0%	Updated activity data, growing stocks and dead wood volumes from the NFI was used for estimating carbon losses due to land conversion to wetlands and peatlands.
E. Settlements	CO_2	1.30		-1.30	-100%	0%	0%	Updated activity data, growing stocks and dead wood volumes from the NFI were used for estimating carbon losses due to land conversion to Settlements.
F. Other land								
G. Harvested wood products								

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**Gas (CO_2)**	**Previous submission (CO_2-eq, kt)**	**Latest submission (CO_2-eq, kt)**	**Difference (CO_2-eq, kt)**	**Difference[348] %**	**Impact of recalculation on total emissions excluding LULUCF[349] %**	**Impact of recalculation on total emissions including LULUCF[350] %**	**Explanation for recalculations**
H. Other								
5. Waste	**CO_2**	2.25	2.25	-	0%	0%	0%	-
A. Solid waste disposal								
B. Biological treatment of solid waste								
C. Incineration and open burning of waste	CO_2	2.25	2.25	-	0%	0%	0%	-
D. Waste water treatment and discharge								
E. Other								
6. Other (As specified in summary 1.A)								
Memo items:								
International bunkers	**CO_2**	660.53	659.15	-1.38	0%	0%	0%	Please see explanations below.
Aviation	CO_2	107.73	106.75	-0.98	-1%	0%	0%	There were recalculations in the Aviation bunkering sector due to revising of emissions factors.
Navigation	CO_2	552.80	552.40	-0.40	0%	0%	0%	-
Multilateral operations								
CO_2 emissions from biomass	**CO_2**	962.15	962.15	-	0%	0%	0%	-
CO_2 captured								
Long-term storage of C in waste disposal sites								

Table 10.8. Recalculations for CH_4 performed in year 2016 for 2014. Difference between this and the June 2016 submission for Estonia

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (CH_4)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
Total National Emissions and Removals	**CH_4**	1 040.98	1 045.02	4.04	0%	0%	0%	Please see explanations below.
1. Energy	**CH_4**	162.15	161.96	-0.18	0%	0%	0%	Please see explanations below.
A. Fuel combustion activities	CH_4	144.70	144.52	-0.18	0%	0%	0%	Please see explanations below.
1. Energy industries	CH_4	15.12	14.93	-0.18	-1%	0%	0%	The activity data of 1A1a Oher fuels was revised.
2. Manufacturing industries and construction	CH_4	2.89	2.89	0.00	0%	0%	0%	For 1A2d, the combustion of biogas has been added to 2014.
3. Transport	CH_4	3.95	3.95	-0.00	0%	0%	0%	Due to revised 1A3a emission factors, the category 1A3a has been recalculated. Revised emission factors are presented in NIR, Table 3.33.
4. Other sectors	CH_4	122.71	122.71	-	0%	0%	0%	-
5. Other	CH_4	0.04	0.04	-	0%	0%	0%	-
B. Fugitive Emissions from Fuels	CH_4	17.44	17.44	-	0%	0%	0%	-
1. Solid fuels								
2. Oil and natural gas	CH_4	17.44	17.44	-	0%	0%	0%	-
C. CO_2 transport and storage								
2. Industrial processes and product use								
A. Mineral industry								
B. Chemical industry								
C. Metal industry								
D. Non-energy products from fuels and solvent use								
G. Other product manufacture and use								
H. Other								
3. Agriculture	**CH_4**	645.13	645.66	0.53	0%	0%	0%	Please see explanations below.
A. Enteric fermentation	CH_4	560.65	560.26	-0.39	0%	0%	0%	The calculations in swine and cattle sub-categories were previously performed on a county level which involved several intermediate calculations which were ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are immediately performed on a country-level using weighed average country-specific activity data which is in line with the IPCC guidelines. The change in

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (CH_4)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
								calculation approach brought about a reevaluation of used activity data along with some miscalculation errors detected and corrected in working tables, which lead to recalculations under the Enteric fermentation subsector.
B. Manure management	CH_4	84.48	85.40	0.92	1%	0%	0%	The calculations in swine and cattle Manure management sub-categories were previously performed on a county level that involved several intermediate calculations which were ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are immediately performed on a country-level using weighed average country-specific activity data in line with the IPCC guidelines. The change in calculation approach brought about a reevaluation of used activity data along with some miscalculation errors detected and corrected in working tables, which lead to recalculations in CH4 emissions under the Manure management subsector.
C. Rice cultivation								
D. Agricultural soils								
E. Prescribed burning of savannahs								
F. Field burning of agricultural residues								
G. Liming								
H. Urea application								
I. Other carbon-containing fertilizer								
J. Other								
4. Land use, land-use change and forestry (net)	**CH_4**	0.11	0.10	-0.02	-16%	0%	0%	Please see explanations below.
A. Forest land	CH_4	0.04	0.04	-	0%	0%	0%	-
B. Cropland								
C. Grassland	CH_4	0.00	0.00	-	0%	0%	0%	-
D. Wetlands	CH_4	0.08	0.06	-0.02	-25%	0%	0%	Updated activity data.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (CH_4)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
E. Settlements								
F. Other land								
G. Harvested wood products								
H. Other								
5. Waste	**CH_4**	233.59	237.30	3.71	2%	0%	0%	Please see explanations below.
A. Solid waste disposal	CH_4	218.53	201.13	-17.40	-8%	0%	0%	Updated activity data.
B. Biological treatment of solid waste	CH_4	14.61	12.84	-1.78	-12%	0%	0%	Updated activity data.
C. Incineration and open burning of waste	CH_4	0.45	0.44	-0.01	-2%	0%	0%	Updated activity data.
D. Waste water treatment and discharge	CH_4							
E. Other		-	22.90	22.90				New emission estimates from Biogas burnt in a flare.
6. Other (As specified in summary 1.A)								
Memo items:								
International bunkers	**CH_4**	2.37	2.38	0.01	0%	0%	0%	Please see explanations below.
Aviation	CH_4	0.03	0.04	0.01	43%	0%	0%	There were recalculations in the Aviation bunkering sector due to revising of emissions factors.
Navigation	CH_4	2.34	2.34	-	0%	0%	0%	-

Table 10.9. Recalculations for CH_4 performed in year 2017 for 1990. Difference between this and the June 2016 submission for Estonia

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (CH_4)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
Total National Emissions and Removals	**CH_4**	1 799.84	1 797.25	-2.60	0%	0%	0%	Please see explanations below.
1. Energy	**CH_4**	187.46	187.46	-0.01	0%	0%	0%	Please see explanations below.
A. Fuel combustion activities	CH_4	137.28	137.28	-0.01	0%	0%	0%	Please see explanations below.
1. Energy industries	CH_4	7.60	7.60	-	0%	0%	0%	-
2. Manufacturing industries and construction	CH_4	3.16	3.16	-	0%	0%	0%	-
3. Transport	CH_4	22.98	22.98	-0.01	0%	0%	0%	Due to revised 1A3a emission factors, the category 1A3a has been recalculated. Revised emission factors are presented in NIR, Table 3.33.
4. Other sectors	CH_4	103.49	103.49	-	0%	0%	0%	-
5. Other	CH_4	0.06	0.06	-	0%	0%	0%	-
B. Fugitive Emissions from Fuels	CH_4	50.18	50.18	-	0%	0%	0%	-
1. Solid fuels						0%	0%	
2. Oil and natural gas	CH_4	50.18	50.18	-	0%	0%	0%	-
C. CO_2 transport and storage						0%	0%	
2. Industrial processes and product use						0%	0%	
A. Mineral industry						0%	0%	
B. Chemical industry						0%	0%	
C. Metal industry						0%	0%	
D. Non-energy products from fuels and solvent use							0%	0%
G. Other product manufacture and use						0%	0%	
H. Other						0%	0%	
3. Agriculture	**CH_4**	1 396.23	1 393.84	-2.38	0%	0%	0%	Please see explanations below.
A. Enteric fermentation	CH_4	1 251.14	1 247.12	-4.02	0%	0%	0%	The calculations in swine and cattle sub-categories were previously performed on a county level which involved several intermediate calculations which were ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are immediately performed on a country-level using weighed average country-specific activity data which is in

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (CH_4)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
								line with the IPCC guidelines. The change in calculation approach brought about a reevaluation of used activity data along with some miscalculation errors detected and corrected in working tables, which lead to recalculations under the Enteric fermentation subsector.
B. Manure management	CH_4	145.09	146.72	1.63	1%	0%	0%	The calculations in swine and cattle Manure management sub-categories were previously performed on a county level that involved several intermediate calculations which were ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are immediately performed on a country-level using weighed average country-specific activity data in line with the IPCC guidelines. The change in calculation approach brought about a reevaluation of used activity data along with some miscalculation errors detected and corrected in working tables, which lead to recalculations in CH4 emissions under the Manure management subsector.
C. Rice cultivation						0%	0%	
D. Agricultural soils						0%	0%	
E. Prescribed burning of savannahs						0%	0%	
F. Field burning of agricultural residues						0%	0%	
G. Liming						0%	0%	
H. Urea application						0%	0%	
I. Other carbon-containing fertilizer						0%	0%	
J. Other						0%	0%	
4. Land use, land-use change and forestry (net)	**CH_4**	0.35	0.34	-0.01	-3%	0%	0%	Please see explanations below.
A. Forest land	CH_4	0.28	0.27	-0.01	-4%	0%	0%	Updated activity data.
B. Cropland						0%	0%	
C. Grassland	CH_4	0.00	0.00	0.00	99395%	0%	0%	Updated activity data.
D. Wetlands	CH_4	0.07	0.06	-0.00	-3%	0%	0%	Updated activity data.
E. Settlements						0%	0%	
F. Other land						0%	0%	

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (CH_4)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
G. Harvested wood products						0%	0%	
H. Other						0%	0%	
5. Waste	**CH_4**	215.81	215.61	-0.20	0%	0%	0%	Please see explanations below.
A. Solid waste disposal	CH_4	213.91	213.72	-0.20	0%	0%	0%	Updated activity data.
B. Biological treatment of solid waste	CH_4	0.68	0.68	-	0%	0%	0%	Updated activity data.
C. Incineration and open burning of waste	CH_4	1.22	1.22	-	0%	0%	0%	Updated activity data.
D. Waste water treatment and discharge	CH_4					0%	0%	
E. Other		-	-	-		0%	0%	New emission estimates from Biogas burnt in a flare.
6. Other (As specified in summary 1.A)						0%	0%	
Memo items:						0%	0%	
International bunkers	**CH_4**	1.34	1.35	0.01	1%	0%	0%	Please see explanations below.
Aviation	CH_4	0.02	0.03	0.01	45%	0%	0%	There were recalculations in the Aviation bunkering sector due to revising of emissions factors.
Navigation	CH_4	1.32	1.32	-	0%	0%	0%	-

Table 10.10. Recalculations for N_2O performed in year 2017 for 2014. Difference between this and the June 2016 submission for Estonia

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (N_2O)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
Total National Emissions and Removals	**N_2O**	796.74	821.40	24.66	3%	0%	0%	Please see explanations below.
1. Energy	**N_2O**	115.96	115.69	-0.27	0%	0%	0%	Please see explanations below.
A. Fuel combustion activities	N_2O	115.96	115.69	-0.27	0%	0%	0%	Please see explanations below.
1. Energy industries	N_2O	31.46	31.19	-0.27	-1%	0%	0%	The activity data of 1A1a Other fuels was revised.
2. Manufacturing industries and construction	N_2O	4.80	4.80	0.00	0%	0%	0%	For 1A2d, the combustion of biogas has been added to 2014.
3. Transport	N_2O	25.78	25.78	0.00	0%	0%	0%	Due to revised 1A3a emission factors, the category 1A3a has been recalculated. Revised emission factors are presented in NIR, Table 3.33.
4. Other sectors	N_2O	53.39	53.39	0.00	0%	0%	0%	-
5. Other	N_2O	0.53	0.53	0.00	0%	0%	0%	-
B. Fugitive Emissions from Fuels						0%	0%	
1. Solid fuels						0%	0%	
2. Oil and natural gas						0%	0%	
C. CO_2 transport and storage						0%	0%	
2. Industrial processes and product use	**N_2O**	3.15	3.15	0.00	0%	0%	0%	-
A. Mineral industry						0%	0%	
B. Chemical industry						0%	0%	
C. Metal industry						0%	0%	
D. Non-energy products from fuels and solvent use								
G. Other product manufacture and use	N_2O	3.15	3.15	0.00	0%	0%	0%	-
H. Other						0%	0%	
3. Agriculture	**N_2O**	659.71	685.51	25.80	4%	0%	0%	Please see explanations below.
A. Enteric fermentation						0%	0%	
B. Manure management	N_2O	67.32	64.60	-2.72	-4%	0%	0%	The calculations in swine and cattle Manure management sub-categories were previously performed on a county level that involved several intermediate calculations which were ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (N_2O)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
								immediately performed on a country-level using weighed average country-specific activity data which is in line with the IPCC guidelines. The change in calculation approach brought about a reevaluation of used activity data along with some miscalculation errors detected and corrected in working tables, which lead to recalculations in N2O emissions under the Manure management subsector.
C. Rice cultivation						0%	0%	
D. Agricultural soils	N_2O	592.39	620.91	28.52	5%	0%	0%	N2O emissions from animal manure applied to soils and from urine and dung deposited by grazing animals were revised due to recalculations under the Manure management subcategory and due to corrections in calculations implemented under the crop residues subcategory; data on areas of organic soils cultivated were updated in the framework of the NFI (see chapter LULUCF).
E. Prescribed burning of savannahs						0%	0%	
F. Field burning of agricultural residues						0%	0%	
G. Liming						0%	0%	
H. Urea application						0%	0%	
I. Other carbon-containing fertilizer						0%	0%	
J. Other						0%	0%	
4. Land use, land-use change and forestry (net)	**N_2O**	7.37	6.70	-0.67	-9%	0%	0%	Please see explanations below.
A. Forest land	N_2O	0.00	0.00	0.00	0%	0%	0%	-
B. Cropland	N_2O	5.65	5.40	-0.25	-4%	0%	0%	Updated activity data.
C. Grassland	N_2O	0.00	0.00	0.00	0%	0%	0%	Updated activity data.
D. Wetlands	N_2O	1.70	1.28	-0.42	-25%	0%	0%	Updated activity data.
E. Settlements						0%	0%	
F. Other land						0%	0%	
G. Harvested wood products						0%	0%	
H. Other						0%	0%	
5. Waste	**N_2O**	10.54	10.34	-0.20	-2%	0%	0%	Please see explanations below.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (N_2O)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
A. Solid waste disposal						0%	0%	
B. Biological treatment of solid waste	N_2O	10.45	9.18	-1.27	-12%	0%	0%	Updated activity data.
C. Incineration and open burning of waste	N_2O	0.09	0.09	0.00	-2%	0%	0%	Updated activity data.
D. Waste water treatment and discharge	N_2O				0%	0%	0%	
E. Other		0.00	1.07	1.07	0%	0%	0%	New emission estimates from Biogas burnt in a flare.
6. Other (As specified in summary 1.A)						0%	0%	
Memo items:						0%	0%	
International bunkers	**N_2O**	9.17	9.00	-0.17	-2%	0%	0%	Please see explanations below.
Aviation	N_2O	1.18	1.01	-0.17	-14%	0%	0%	There were recalculations in the Aviation bunkering sector due to revising of emissions factors.
Navigation	N_2O	7.98	7.98	0.00	0%	0%	0%	-

Table 10.11. Recalculations for N_2O performed in year 2017 for 1990. Difference between this and the June 2016 submission for Estonia

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (N_2O)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
Total National Emissions and Removals	**N_2O**	1 349.83	1 386.76	36.93	3%	0%	0%	Please see explanations below.
1. Energy	**N_2O**	116.36	116.36	-	0%	0%	0%	-
A. Fuel combustion activities	N_2O	116.36	116.36	-	0%	0%	0%	-
1. Energy industries	N_2O	17.80	17.80	-	0%	0%	0%	-
2. Manufacturing industries and construction	N_2O	5.85	5.85	-	0%	0%	0%	-
3. Transport	N_2O	38.48	38.48	-	0%	0%	0%	-
4. Other sectors	N_2O	53.49	53.49	-	0%	0%	0%	-
5. Other	N_2O	0.74	0.74	-	0%	0%	0%	-
B. Fugitive Emissions from Fuels						0%	0%	
1. Solid fuels						0%	0%	
2. Oil and natural gas						0%	0%	
C. CO_2 transport and storage						0%	0%	
2. Industrial processes and product use	**N_2O**	5.45	5.45	-	0%	0%	0%	-
A. Mineral industry						0%	0%	
B. Chemical industry						0%	0%	
C. Metal industry						0%	0%	
D. Non-energy products from fuels and solvent use							0%	0%
G. Other product manufacture and use	N_2O	5.45	5.45	-	0%	0%	0%	-
H. Other						0%	0%	
3. Agriculture	**N_2O**	1 225.80	1 262.77	36.97	3%	0%	0%	Please see explanations below.
A. Enteric fermentation						0%	0%	
B. Manure management	N_2O	142.05	134.30	-7.75	-5%	0%	0%	The calculations in swine and cattle Manure management sub-categories were previously performed on a county level that involved several intermediate calculations which were ultimately aggregated to a country level. Starting from the 2017 submission all the calculations are immediately performed on a country-level using weighed average country-specific activity data which is in line with the IPCC guidelines. The change in calculation approach brought about a reevaluation of used activity data along with

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (N_2O)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
								some miscalculation errors detected and corrected in working tables, which lead to recalculations in N2O emissions under the Manure management subsector.
C. Rice cultivation						0%	0%	
D. Agricultural soils	N_2O	1 083.75	1 128.47	44.72	4%	0%	0%	N2O emissions from animal manure applied to soils and from urine and dung deposited by grazing animals were revised due to recalculations under the Manure management subcategory and due to corrections in calculations implemented under the crop residues subcategory; data on areas of organic soils cultivated were updated in the framework of the NFI (see chapter LULUCF).
E. Prescribed burning of savannahs						0%	0%	
F. Field burning of agricultural residues						0%	0%	
G. Liming						0%	0%	
H. Urea application						0%	0%	
I. Other carbon-containing fertilizer						0%	0%	
J. Other						0%	0%	
4. Land use, land-use change and forestry (net)	**N_2O**	1.51	1.47	-0.04	-3%	0%	0%	Please see explanations below.
A. Forest land	N_2O	0.03	0.03	-0.00	-4%	0%	0%	Updated activity data.
B. Cropland						0%	0%	
C. Grassland	N_2O	0.00	0.00	0.00	99395%	0%	0%	Updated activity data.
D. Wetlands	N_2O	1.48	1.43	-0.05	-3%	0%	0%	Updated activity data.
E. Settlements						0%	0%	
F. Other land						0%	0%	
G. Harvested wood products						0%	0%	
H. Other						0%	0%	
5. Waste	**N_2O**	0.71	0.71	-	0%	0%	0%	-
A. Solid waste disposal						0%	0%	
B. Biological treatment of solid waste	N_2O	0.48	0.48	-	0%	0%	0%	-

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (N_2O)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
C. Incineration and open burning of waste	N_2O	0.23	0.23	-	0%	0%	0%	-
D. Waste water treatment and discharge	N_2O					0%	0%	
E. Other						0%	0%	
6. Other (As specified in summary 1.A)						0%	0%	
Memo items:						0%	0%	
International bunkers	**N_2O**	5.53	5.39	-0.13	-2%	0%	0%	Please see explanations below.
Aviation	N_2O	1.02	0.89	-0.13	-13%	0%	0%	There were recalculations in the Aviation bunkering sector due to revising of emissions factors.
Navigation	N_2O	4.51	4.51	-	0%	0%	0%	-

Table 10.12. Recalculations for F-gases performed in year 2017 for 2014. Difference between this and the June 2016 submission for Estonia

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (F-gases)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference[348] %	Impact of recalculation on total emissions excluding LULUCF[349] %	Impact of recalculation on total emissions including LULUCF[350] %	Explanation for recalculations
F-gases: Total actual Emissions	**F-gases**	218.62	219.62	1.00	0%	0%	0%	Please see explanation below.
2.B.9. Flurochemical production								
2.B.10. Other								
2.C.3. Aluminium production								
2.C.4. Magnesium production								
2.C.7. Other								
2.E.1. Integrated circuit or semiconductor								
2.E.2. TFT flat panel display								
2.E.3. Photovoltaics								
2.E.4. Heat transfer fluid								
2.E.5. Other *(as specified in table 2(II))*								
2.F.1. Refrigeration and air conditioning	HFCs	208.13	209.13	1.00	0%	0%	0%	2.F.1.e Mobile Air-Conditioning (Wheel tractors and mobile machinery) - Activity data and emissions have been recalculated for years 2010–2014, because some of the wheel tractors were not accounted previously in these years.
2.F.2. Foam blowing agents	HFCs	2.37	2.37	0.00	0%	0%	0%	-
2.F.3. Fire protection	HFCs	2.70	2.70	0.00	0%	0%	0%	-
2.F.4. Aerosols	HFCs	3.32	3.32	0.00	0%	0%	0%	-
2.F.5. Solvents								
2.F.6. Other applications								
2.G.1. Electrical equipment	SF_6	2.04	2.04	0.00	0%	0%	0%	
2.G.2. SF_6 and PFCs from other product use	SF_6	0.06	0.06	0.00	0%	0%	0%	-
2.G.4. Other								
2.H. Other (please specify)								

10.3.2. KP-LULUCF inventory

See Chapter 10.1.2. KP–LULUCF inventory.

10.4. Planned improvements, including in response to the review response

10.4.1. GHG inventory

Table 10.13 summarises the sectoral improvement needs for the forthcoming inventories recognised by the Estonian experts responsible for the calculations. More detailed information about planned improvements can be found under the sectoral chapters.

Table 10.13. Sector-specific improvement needs of Estonia's national greenhouse gas inventory

SECTOR	IPCC CATEGORY	IMPROVEMENTS
Energy		There are no planned category-specific improvements.
Industrial processes and product use		There are no planned category-specific improvements.
Agriculture	3.A Enteric fermentation	Cattle activity data in different subcategories is currently under revision.
	3.B Manure management	Developing a methodology suitable for Estonian conditions to estimate reduced CH_4 emissions from anaerobically digested slurry.
	3.B Manure management	The animal waste management system data are planned to be renewed and updated by the following submission.
	3.B.2.5 Indirect N_2O emissions	Until 2016 NH_3 and NO_x emissions submitted under the Convention on Long-Range Transboundary Air Pollution in the Estonian Informative Inventory Report 1990–2013, were estimated according to the EMEP/EEA guidebook Tier 1 methodology. Estonia is planning to adopt the Tier 2 methodology also in the GHG inventory during the next submissions for indirect N_2O emissions due to NO_x and NH_3 volatilization and is making an effort to increase co-operation between the two different institutions compiling the separate inventories and harmonize the emission estimates.
LULUCF	4.A Forest land	A number of improvements are required to be carried out in order to assure complete, transparent and accurate emission estimations for Forest land category. The University of Life Sciences have a "Carbon and nitrogen cycling in drained forests" project in cooperation with State Forest Management Centre. This study can potentially

SECTOR	IPCC CATEGORY	IMPROVEMENTS
		provide useful information to estimate emissions for the non-mandatory land use categories and carbon pools: non-CO_2 emissions from drainage of forest soils. The University of Life Sciences also has a project about forest litter "Forest litter, research and modelling" that could help to make the estimation more complete and accurate Estonia was selected to participate in the Specific Contract (SC) 12 taskforce on harmonization of LULUCF inventories: modelling forest soil with Yasso. Please see Chapter 6.2.6 for additional information.
	4.B Cropland	The Agricultural Research Centre of Estonia is conducting fieldwork and estimating carbon stock changes in cultivated mineral and organic soils.
	4.C Grassland	A project titled Applied research of greenhouse gases in the LULUCF sector in the framework of UNFCCC and Kyoto protocol reporting was launched in June 2013, funded by the Environmental Investment Centre. One of the objectives of the project is to determine changes in grassland soil organic carbon stocks. Project activities include conducting fieldwork, resampling previous sample plots and estimating carbon stock changes in natural and semi-natural grassland soils. The aim is to develop country-specific emission factors for grassland soils.
	4.D Wetlands	Updated NFI activity data will be used.
	4.E Settlements	Updated data from the NFI for land-use changes will be used.
	4.F Other land	Updated data derived from the NFI fieldwork for land-use changes will be used.
Waste	5.A Solid waste disposal	Historical data on waste generation per capita and distribution of waste by waste management type will be kept under investigation and updated when data available.
	5.B Biological treatment of solid waste	The activity data is kept under consideration and will be updated necessarily.
	5.C Incineration and open burning of waste	The activity data is kept under consideration and will be updated necessarily.
	5.D Wastewater treatment and discharge	The activity data for estimating N_2O from advanced centralised wastewater treatment plants is kept under consideration and the emission calculation will be included as soon as activity data is available.
	5.E Biogas burnt in a flare	The activity data is kept under consideration and will be updated necessarily.

Table 10.14 summarises Estonia's responses to the 2015/2016 inventory review report (FCCC/ARR/2016/EST).

Table 10.14. Response to the review of the 2015/2016 inventory submissions

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
General - Accuracy	The ERT recommends that Estonia report the actual volume of indirect CO2 emissions, instead of reporting them as "IE" under the relevant sector in CRF table 6, in order to report national total emissions with and without indirect CO2 emissions separately in the NIR and the CRF tables	ARR 2016/G.5	Estonia chose to report indirect CO2 emissions calculated from NMVOC emissions from solvent use and road paving with asphalt under the category other (2.D.3) because previously (until 2015 submission) these emissions were reported under CRF category 3 Solvent and other product use and were part of national total emissions. In addition, in the CRF tables there are specific rows for CO2 emissions for these activities and it is not clear what is expected to report there otherwise. Estonia finds it justified to continue reporting indirect CO2 emissions in the CRF tables in the current way. The issue does not affect emissions.	
General- Kyoto Potocol units	The ERT recommends that Estonia improve the transparency of its reporting of Kyoto Protocol units by making the information on Kyoto Protocol units on its national website consistent with the information available in the European Union registry	ARR 2016/G.6	Information on Kyoto Protocol units on the website of Estonian Ministry of the Environment is now consistent with the information available in the European Union registry and will be kept up to date	
1.B.2 Oil and natural gas and other – oil fuels – CH4	Change the notation key for the distribution of oil products, as this practice does occur in Estonia	ARR 2016/E.6	The notation key will be corrected by the next submission.	
1. Fuel combustion – reference approach –solid, liquid, other fuels – CO2	The ERT noted that in CRF table 1.A(c), the reported differences in energy consumption between the sectoral approach and the reference approach are 67.72 per cent for liquid fuels and 52.67 per cent for other fossil fuels. The overall difference between the sectoral approach and the reference approach is –14.6 per cent. (In all three cases, the estimates under the reference approach are smaller than those under the	ARR 2016/E.7	The differences between fuel types have been further explained in the NIR. In addition, the differences in the emissions have been improved.	Chapter 3.2.1

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	sectoral approach.) In response to a question raised by the ERT during the review, Estonia explained that Statistics Estonia compiles two sets of energy-related data every year: the national energy balance; and the joint questionnaire. The national energy balance is used for calculating the emissions for the sectoral approach, and the reference approach is calculated according to the second dataset (the joint questionnaire). Consequently, the differences between the reference approach and the sectoral approach arise from the different methodologies used in compiling the national energy balance and the joint questionnaire. Furthermore, Estonia is working to find possible courses of action to unify the reference approach with the sectoral approach. Noting the significant presence of shale oil in the energy balance of Estonia, the ERT considers that the main cause of the differences may originate from the transfer of carbon and energy from primary solid fuel (oil shale) to the secondary liquid fuel (shale oil) (as classified by the 2006 IPCC Guidelines) during the oil shale processing The ERT recommends that Estonia further improve the explanation for the significant differences by fuel type (solid and liquid) by indicating the positive and negative differences that result from the transfer of carbon and energy from solid to liquid fuels during the production of shale oil and by-products			
1.A. Fuel combustion – sectoral approach – gas, liquid, solid, other fuels, biomass – CO_2, CH_4 and N_2O	The ERT noted that units are not given for the national energy balance for the most recent inventory year reported in annex 4 to the NIR. There is also no explanation in the annex as to whether the calorific values of the gaseous fuels are reported as NCV or GCV or, if mass and volume units are used, what conditions of the gas are used (i.e. temperature 0, 18 or 20 °C). Furthermore, some of the energy carriers (coke, wood, light fuel oil and diesel, light fuel oil, shale oil gas, biogas, other biomass, municipal waste, other fuels, electricity) are marked with one or two asterisks, but no explanation as to what these asterisks mean is provided in the annex. During the review, Estonia clarified that all the data in the energy balance are presented in TJ and that all fuels are reported as NCV. The Party also provided the missing notes for the energy balance, which include: Coke*: Oil shale coke is exported as coke	ARR2016 /E.8	The energy balance has been improved in the Annex 4. Estonia makes efforts to avoid such mistakes in the future.	Annex 4

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	Wood*: Firewood, wood chips and waste Light fuel oil and diesel**: The imports of light fuel oil and diesel include marine bunkering Light fuel oil**: In the production of converted energy, light fuel oil is the light fraction of shale oil Shale oil gas**: Generator gas and coke oven gases Biogas**: In the years 1999–2010, biogas is included under other fuels Other biomass**: Straw, bone meal, organic waste from animals and black liquor Other fuels**: Until 2010, other fuels include shale oil gas, biogas and black liquor Electricity**: In the production of primary energy, electricity includes hydroelectric and wind energy The ERT recommends that Estonia further improve its QA/QC procedures during the preparation of the NIR and make efforts to avoid missing information and reporting incorrect figures (see also E.10, E.19 and E.20 below), which hinders the ERT's review of the reported information			
1.A. Fuel combustion – sectoral approach – liquid and solid fuels– CO_2, CH_4 and N_2O	Estonia explains, in annex 3 to the NIR, that two different technologies for shale oil production are used in Estonia: oil shale thermal processing with solid heat carrier technology; and oil shale thermal processing with gaseous heat carrier in gas generators technology. The ERT noted that in table A.3.1.2 ("Composition of semi-coke gas from the Narva Solid Heat Carrier") of annex 3, only 88.15 per cent of the components of the gas are reported, and in table A.3.1.5 ("Composition of semi-coke gas from the Kiviõli Solid Heat Carrier processes"), only 94.90 per cent of the gas are reported During the review, in response to questions raised by the ERT about the missing components, Estonia explained that the data for the composition of semi-coke gas are received directly from the shale oil production companies. For emission estimates for 2014 it was not possible for the companies to provide actual data for the components hydrogen sulphide, nitrogen (N2), oxygen (O2) and hydrogen (H2) and so data from a previous year were used instead. Consequently, some totals stayed under 100 per cent The ERT considers the approach applied by the Party to obtain AD is	ARR 2016/E.9	The extrapolation method will be taken to use in the next submission if relevant data is not available.	-

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	not in line with good practice as described in chapter 2 (for data collection) and chapter 5 (for time-series consistency) of volume 1 of the 2006 IPCC Guidelines The ERT recommends that Estonia obtain actual data for all components that are necessary for estimating emissions from shale oil production using solid heat carrier technology. In the case that data for some components are not available, the ERT considers that the appropriate method for time-series consistency is the extrapolation of available data			
1.A. Fuel combustion – sectoral approach – other fuels – CO_2, CH_4 and N_2O	The ERT noted that there is no description of the methodology used, AD and EFs for CH4 and N2O emissions from waste incineration with energy recovery in the energy chapter of the NIR, although the emissions are reported in CRF table 1.A(a) and (b) In response to a question raised by the ERT during the review, Estonia clarified that for waste incineration with energy recovery in 2014, the EF of CH4 was 30 kg/TJ and the EF of N2O was 4 kg/TJ in the heat and power production subcategory (1.A.1.a) of the energy industries category, and that 2 325 TJ of waste was used as fuel. In the non-metallic minerals subcategory (1.A.2.f) of the manufacturing industries category, a total of 2 089 TJ of waste (waste oils, plastics, municipal waste) was incinerated The ERT recommends that Estonia report on the technologies used for waste incineration with energy recovery and on the waste types incinerated, the NCVs and AD	ARR 2016/E.10	The clarity of AD and EFs has been improved. The technologies of waste incineration will be described in the next submissions.	Chapter 3.2.4
1.A. Fuel combustion – sectoral approach – other fuels – CO_2	The ERT noted that, in table 3.8 (“Other fossil based solid waste”) in section 3.2.4 (“Energy industries and manufacturing industries and construction”) of the NIR, Estonia reports the following data for solid fuels - non-biogenic MSW: NCV, 19.0 and CEF, 21.8182 tC/TJ. However, the ERT noted that, in CRF table 1.A(b) for reference approach, the CEF for waste (non-biomass fraction) is reported as 30.75, which is consistent with the IEF for CO2 reported in CRF table 1.A(a).s4 (112 = 30.75 × 3.67) In response to a question raised by the ERT during the review, Estonia clarified that for non-biogenic MSW the CEF value 30.75 is not correct. The Party indicated that the correct value for non-biogenic MSW in the non-metallic minerals subcategory (1.A.2.f) of the	ARR/E.11	The reporting clarity of the relevant waste has been improved.	Chapter 3.2.4

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	manufacturing industries and construction category (1.A.2) is 21.8182 (a plant-specific value) After the review week, the Party confirmed that the CO2 emissions have been estimated correctly. The Party further clarified that the CEF of waste in public electricity and heat production (1.A.1.a) under the category of energy industry is 30.75 and this has been used in the emissions estimates with sectoral approach. The same CEF value is also reported for "non-biomass fraction of waste" in CRF table 1.A(b) for reference approach, because the waste combusted under the category of 1A1a is reported as waste (non-biomass fraction) in reference approach. While, the waste combusted under the non-metallic minerals subcategory (1A2f) (CEF = 21.8182) is reported as other fossil fuels in reference approach along with other waste, such as plastics (CEF = 20.4545) and waste oils (CEF = 20.1818) The ERT recommends that Estonia, in its next submission, report which categories' non-biogenic waste are included under which fuel types in reference approach in a more transparent manner			
1.A. Fuel combustion – sectoral approach – other fuels – all gases	The ERT noted that Estonia reported, in table 3.8 of its NIR (p. 81), CEFs and NVCs of "gas gasoline" and "sod peat", both of which are not specified in the CRF tables and the 2006 IPCC Guidelines. The ERT also notes that there is no explanation what fuels are included under the "Other fuels" in table 3.13 on the NIR (p. 85). Consumption of other fuels is reported since 2013 under the subcategory energy industries and since 2000 under the category manufacturing industries and construction During the review, the Party clarified that gas gasoline is a by-product fuel of shale oil production and that sod peat is a processed form of peat that is compressed into small (40–70 mm) pieces. Other fuels include municipal waste, plastics and waste oils. The consumption of other fuels appears in 2013 under energy industries because in 2013 a waste incineration plant was opened in Estonia. Similarly, in 2000, the combustion of various wastes commenced in Estonia in a cement production plant The ERT recommends that Estonia, in its next NIR, provide descriptions of these fuels and report the reasons for the late appearance of the emissions from those fuels	ARR 2016/E.12	Descriptions of these fuels have been provided in the NIR.	Chapter 3.2.4.2

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
1.A.1 Energy industries – solid fuels – CO2	In response to a recommendation made in the previous review report, Estonia provided a reference that justifies the reasoning that no fugitive losses occur during the process for shale oil production that might not be captured by the current approach. In CRF table 1.A(b), a small amount of carbon is excluded from the reference approach (see also E.3 in table 3). The ERT noted that Estonia developed the required plant carbon balances for the 2014 submission and provided them to the ERT during the 2014 review because they were considered confidential. The ERT recommends that Estonia, in addition to the recommendations made in the previous review reports, prepare a summary with a complete and accurate carbon balance for the totals of oil shale processing and use of products to share with the ERT in a timely manner upon request, in order to avoid the confidentiality problem of quoting carbon balances of individual plants in the NIR	ARR 2016/E.13	The carbon balances will be provided when necessary.	-
1.A.1 Energy industries – solid fuels – CO_2	The ERT noted that Estonia's CO2 IEF for solid fuel in 2014 (73.57 t/TJ) is the lowest among the reporting Parties (whose corresponding IEFs range from 73.57.6 to 169.21 t/TJ). In fact, since 1993 Estonia's CO2 IEF for solid fuel (93.23 t/TJ in 1990 and 71.47 t/TJ in 2012) has been the lowest among the reporting Parties. The Party explained that the category 1.A.1, energy industries, includes both fuel combustion for electricity and heat production and combustion for oil shale production, which emits only a small amount of CO2 compared with the amount of oil shale used in the process The ERT recommends that Estonia, in its next NIR, include reasons for the low CO2 IEF of energy industries	ARR 2016/E.14	The reasons have been provided in the NIR.	Chapter 3.2.4.2
1.A.1.a Public electricity and heat production – solid fuels – CO_2	The ERT noted that the NIR does not report where and how oil shale gas (a generator gas), a by-product of oil shale thermal processing in vertical reactors that is combusted in boilers, is cleaned – whether at the shale oil production plant or at the boilers (by flue gas desulphurization). The NIR also does not indicate where the CO2 emissions from desulphurization are reported for 2012 (they are reported under neither the energy nor the IPPU sector). During the review, the Party explained that the gas is not cleaned before being sent to the boilers for combustion. The cleaning of boiler flue gases takes place at the boilers; they are desulphurized with calcium oxide (quicklime) as the active agent. This process does not emit CO2 or	ARR 2016/E.15	Estonia will consider adding the relevant information to the NIR in the next submissions.	-

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	other GHGs The ERT encourages Estonia to report, in its next NIR, both in the energy and in the IPPU sector, the reasons for the absence of CO2 emissions from desulphurization			
1.A.1.a Public electricity and heat production – solid fuels – CO_2	The ERT noted that the CEF for oil shale combustion under the category energy industries depends on the combustion technology (pulverized combustion or circulated fluidized bed combustion). For the entire time series (1990–2014), Estonia uses country-specific CEFs, 27.85 t C/TJ for older pulverized combustion and 26.94 t C/TJ for circulated fluidized bed combustion boilers (NIR, p. 78), from annex 2 to the regulation “Calculation of the amount of CO2 discharged into the atmosphere”, issued in 2004 by the Ministry of the Environment. The NIR states (p. 89) that these CEFs differ from the plant-specific EFs determined in the verified annual CO2 emission reports under the EU ETS During the review, the Party informed the ERT that Estonia is planning to revise the 2004 regulation on the basis of EU ETS data. The Party considers that the best data from the base year to the introduction of the EU ETS in 2005 are those determined by the 2004 regulation, as ETS data are not available for the 1990–2004 period. The ERT notes that the country-specific EFs used by the Party are lower than the plant-specific EFs that were determined in the verified annual CO2 emission reports under the EU ETS The ERT recommends that Estonia accelerate the revision of the 2004 regulation on CO2 EFs for oil shale combustion and recalculate the emissions from oil shale combustion in the facilities where, and for the period when, the relevant technologies were used, and for the power plants where there have been no changes in combustion technology, apply the most appropriate plant-specific EFs depending on the technologies used in the time series in order to recalculate emission estimates for the entire time series and report how emissions were recalculated	ARR 2016/E.16	Improvements have been made in the calculation of CO2 emissions from the combustion of oil shale. Estonia is working on further improvements for the next submissions.	Chapter 3.2.4.5

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
1.A.3.b Road transportation – liquid fuels – CO_2	In response to a recommendation made in the previous review report, Estonia provided a table listing all the EFs used to calculate the weighted average EF for Estonia, for all years and for all three fuels (see also E.5 in table 3); however, the ERT noted that the NCV of the fuels is not reported in the NIR or in CRF table 1.A(a). In response to a question raised by the ERT during the review, the Party provided the NCVs of diesel (42.3 GJ/kg), LPG (45.5 GJ/kg) and gasoline (33.0 GJ/litre) The ERT recommends that Estonia, in its next NIR, report the information of the NCV of the fuels as it provided to the ERT during the review	ARR 2016/E.17	The information has been provided in the NIR.	Chapter 3.2.5.3
1.A.3.b Road transportation – liquid fuels – CO_2, CH_4 and N_2O	Estonia estimates CO2, CH4 and N2O emissions from road transportation using a tier 2 method provided in the 2006 IPCC Guidelines. The ERT noted that the number of vehicles in Estonia is based on data from Statistics Estonia and is reported in table 3.26 of the NIR, with the divisions: passenger cars; buses; lorries and special vehicles; motorcycles and mopeds; and trailers. The annual road traffic mileage is reported in table 3.27 of the NIR under different divisions: cars; vans; lorries; buses; and motorcycles and mopeds In response to a question raised by the ERT during the review, the Party explained that for COPERT modelling, which was used for the CH4 and N2O emission estimates from road transportation, the vehicles are divided into the following groups: passenger cars; light commercial vehicles; heavy duty trucks; buses; and mopeds and motorcycles. Each group is further divided into subgroups according to engine technology (fuel used, vehicle mass, etc). For COPERT modelling, the number and mileage of vehicles is acquired from the Estonian Road Administration The ERT recommends that Estonia improve the transparency of reporting by explaining how data from different sources (Statistics Estonia and the Estonian Road Administration) are rearranged in a way that ensures consistency across the three data sets (number of vehicles, annual road traffic mileage, and the division used in the COPERT model)	ARR 2016/E.18	The issue will be explained in the next submissions.	-

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
1.A.3.d Domestic navigation – liquid fuels – CO_2	The ERT noted that CO2 emissions from domestic navigation reported for the time series in table 3.20 of the NIR are not consistent with the emissions and explanation in section 3.2.5.5 (on domestic navigation) of the NIR or with the emissions reported in the CRF tables. In response to a question raised by the ERT during the review, the Party explained that an error had occurred in the filling in of table 3.20 The ERT recommends that Estonia correct table 3.20 data	ARR 2016/E.19	The data have been corrected.	Chapter 3.2.5.5
1.A.4.a Commercial/ institutional – gas, liquid, solid, biomass – CO_2, CH_4 and N_2O	The ERT noted that the explanation of the GHG emission trend for the commercial/institutional sector in the NIR is contradictory in that it says the “rapid decrease in emissions in 2006 was caused by structural changes of used fuels – use of wood fuels decreased about 72 per cent when at the same time the use of gaseous fuels increased by 12 per cent compared to 2006” (p. 112). The ERT noted that the reported fuel consumption change (wood fuels decrease and gaseous fuels increase) should result in a significant increase (not a decrease, as reported in the NIR) in CO2 emissions in 2006 In response to a question raised by the ERT during the review, the Party clarified that the fuel-use change was not reported correctly. In addition to the reported change in wood and gas consumption, the use of light fuel oil dropped by 77 per cent and the use of coal dropped by 90 per cent compared with 2005 consumption levels, which resulted in the reported rapid decrease in emissions The ERT recommends that Estonia explain the GHG emission trend and AD in the commercial/institutional sector in a correct and non-contradictory manner	ARR 2016/E.20	The explanations have been corrected.	Chapter 3.2.6.1

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
1.B.2.a Oil – CH4	Previous review reports have made recommendations that Estonia report CH4 emissions for distribution of oil products as “NA”, as this practice does occur in the Party (see also E.6 in table 3 and table 4); however, the ERT noted that the Party still reports “NO” in CRF table 1.B.2 Noting the recommendations made in the previous review reports, the ERT further recommends that Estonia fill in AD in the columns “unit” and “value” of the row “Distribution of oil products”, instead of reporting these values as “NA”, and change the notation keys in the other cells to “NA”	ARR 2016/E.21	The relevant columns have been corrected according to the recommendation.	-
2. IPPU (General)	The ERT recommends that Estonia replace the “NE” notation key for the AD and IEF for category 2.D.3 (solvent use) and instead use NMVOC emissions for AD as basic data for calculating indirect CO2 emissions	ARR2016/ I.3	Estonia reported NMVOC emission quantities for AD in CRF Reporter (category 2.D.3) and IEF was automatically calculated by CRF Reporter	The change was asked to be done only in CRF Reporter.
2.A.4.a Other process uses of carbonates – CO2	The ERT recommends that Estonia improve the transparency of reporting by ensuring consistency of the information provided in the NIR and in the CRF table for this source category, correcting the data presented in table 4.10, and reporting the AD, EFs and emissions from bricks and tiles and lightweight gravel using the appropriate notation keys (i.e. “NO” for lightweight gravel production before 1998 and since 2010)	ARR2016/ I.6	Estonia corrected Table 4.10 in NIR as recommended by ERT	Chapter 4.2.4.1.1
2.A.4.a Other process uses of carbonates – CO2	The ERT recommends that Estonia improve the transparency of the reported trend by including in the NIR the clarification provided to the ERT about replacement of the combustion technology (of limestone in power plants)	ARR2016/ I.7	Estonia clarified in NIR that the reason why one power plant discontinued burning limestone was that they switched to novel integrated desulfurization technology, with calcium oxide as a sorbent.	Chapter 4.2.4.3.1

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
2.B.1 Ammonia production	The ERT recommends that Estonia improve the transparency of reporting by providing more detailed information, in its future NIRs, on the background data sources that inform estimates of natural gas used as fuel in ammonia plants, as well as on the process of cross-checking the data submitted to Statistics Estonia and the data reported as non-energy use in the energy balance, and by correcting the row label in table 4.13 in accordance with the estimation procedure	ARR2016/ I.8	Estonia clarified in NIR chapter 4.3.1.4 which are the background data sources. Estonia provided in table 4.13 results of cross-checking data used for GHG emission calculation with data from Statistics Estonia and corrected title of this table.	Chapters 4.3.1.4 and 4.3.1.2 (activity data), table 4.13.
2.B.1 Ammonia production	The ERT recommends that, in the statement in the QA/QC section of the NIR, Estonia include the outcome of the comparison between operator data on gas feedstock AD and the allocation of non-energy use of fuels in the energy balance from Statistics Estonia, as required by the UNFCCC Annex I inventory reporting guidelines (paragraph 41).	ARR2016/ I.9	Please see the answer to issue I.8 IPPU in table 5 of the ARR2016	Please see the answer to issue I.8 IPPU in table 5 of the ARR2017
2.F.1 Refrigeration and air conditioning - HFCs	ERT recommends that Estonia continue to seek to collect more complete, accurate AD and EF data in order to improve the database and improve the accuracy and completeness of the estimates, and to report on progress in its next submission	ARR/ I.10	Estonia has made sensible efforts to improve accuracy and completeness of industrial refrigeration estimates every year and continues to do so in the future. We cannot guarantee better results because the inventory compilers cannot obligate equipment owners or service companies to give data.	
2.D.3 Other (non-energy products from fuels and solvent use) – CO2	The ERT recommends that Estonia improve the transparency of its reporting by reporting separately indirect CO2 emissions in the NIR and in CRF table 6	ARR2016/ I.11	Estonia is considering reporting indirect CO2 emissions in CRF tabel 6 in 2018 year´s submission. In current submission Estonia reports indirect CO2 emissions separately in NIR Chapter 9 (Indirect CO2 and N2O emissions) which refers to chapters 4.4.3.2, 4.4.3.3 and table 4.17	NIR Chapter 9 (Indirect CO2 and N2O emissions) which refers to chapters 4.4.3.2, 4.4.3.3 and table 4.17
2.F. Product uses as substitutes for ozone depleting substances – PFCs, HFCs, SF6 and NF3	The ERT recommends that Estonia provide an explanation for reporting “NO” for the subcategories solvents and other applications and use the notation keys in accordance with paragraph 37 of the UNFCCC Annex I inventory reporting guidelines	ARR2016/ I.12	Estonia added cell comments to 2.F.5 Solvents into cells for emission of HFC-s. However CRF Reporter did not allow to save comments into 2.F.6, 2.F.6.a and b cells for emission of HFC-s because these are read-only cells. Notation key "NO" is correct for 2.F.6 and 2.F.5 because Estonia has checked the intended uses of HFC-s that had been brought to Estonian market from non-EU countries and EU and reported respectively to EU Eionet BDR database and Estonian F-gases	According to paragraph 37 of the UNFCCC Annex I inventory reporting guidelines notation key "NO" does not need explanation in NIR.

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
			database. No other use than categories 2.F.1-2.F.4 was found.	
3.D Direct and indirect N2O emissions from agricultural soils – N2O (61, 2014) (53, 2013)	Revise the estimate of FracR (the fraction of total above-ground biomass that is removed from the field as crop product) on the basis of national statistics and studies	ARR 2016/ A.1	Estonia has looked into the matter of estimating FracR, but currently no national studies nor statistics exist in Estonia, hence we are using a default value of FracRemove=0 in assessments of emissions from crop residues,. However Estonia is increasing the efforts to try to provide at least an approximation by the following submissions.	Chapter 5.4.7.1
General (agriculture) – CH4	The ERT noted that country-specific data for uncertainties in the livestock population were not used for the uncertainty analysis for CH_4 emissions from enteric fermentation or for CH_4 and N_2O emissions from manure management. Instead, Estonia obtained uncertainties of AD (livestock population) for a few countries from Rypdal and Winiwarter (2001)[f]: Austria (±10 per cent), Norway (±5–10 per cent), the Netherlands (less than ±5 per cent) and the United States of America (±2 per cent). In the NIR, Estonia indicates that the experiences of Austria were used to calculate uncertainties in emissions from enteric fermentation of livestock. For EFs, the default uncertainty values from the 2006 IPCC Guidelines were used, mainly owing to the lack of an uncertainty analysis for each parameter. Noting that CH4 from enteric fermentation and manure management are key categories, and also noting that Estonia has detailed statistics on livestock, the ERT recommends that Estonia investigate the possibility of using country-specific values for the uncertainty analysis for CH4 emissions from enteric fermentation and for CH4 and N2O emissions from manure management	ARR 2016/ A.2	Estonia has taken notice to investigate the possibility of using country-specific values for the uncertainty analysis for CH4 emission from enteric fermentation and for CH4 and N2O emissions from manure management and is considering to do so in the following submissions.	Chapter 5.2.5 and chapter 5.3.5
3.A Enteric fermentation – CH4	In estimating its young cattle population for reporting on the CH4 emissions, Estonia assumed that about 50 per cent of the total population of calves (0–12 months old) are calves 0–6 months old for the entire time series. In response to a question raised by the ERT during the review, the Party explained that, as resources become	ARR 2016/ A.3	Estonia has taken notice of obtaining separate data of the calf population. Currently cattle activity data is under revision and Estonia will provide more accurate data in the following submissions.	chapter 5.2.2.1

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	available, it plans to improve the reporting of this subcategory The ERT recommends that Estonia improve the accuracy of its reporting by obtaining separate data on the calf population in terms of calves that are 0–6 months old and those that are 7–12 months old in order to apply EFs on milk and on forage respectively			
3.H Urea application – CO2	Estonia reported CO2 emissions from urea application as "NO" for 2011, 2012 and 2014. Emission estimates were compiled on the basis of data from the only urea fertilizer producer in Estonia, and as there was no production of urea fertilizer by this plant in 2011, 2012 and 2014, no application of urea-based fertilizers for those years has been assumed. However, the ERT noted that according to statistics from the International Fertilizer Industry Association that are available in the internet, 7.5 kt urea was used in Estonia in 2014 The ERT recommends that the Party gather supplemental data on the sales and usage of urea in Estonia, and estimate CO2 emissions, if appropriate	ARR 2016/ A.4	Estonia has provided supplemental data as recommended. In 2011-2012 and 2014-2015 CO2 emission estimation of urea have been made based on marketing data provided by the Estonian Agricultural Board	Chapter 5.8.2
4.A.1 Forest land remaining forest land – CO2 (68, 2014) Transparency	Include the information provided to the ERT during the review on the increased frequency of the sampling programme being undertaken in its NFI	ARR 2016/L.1	Resolved. The description of the NFI has been updated in the NIR (p. 319)	
4.A.2 Land converted to forest land – CO2 (69, 2014) Accuracy*	Correct the calculation of removals from land converted to forest land and improve the QC activities	ARR 2016/L.2	Resolved. The recalculation is provided in section 6.2.5 of the NIR. The Party improved its QC activities, as described in section 1.2.3 of the NIR	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
4.D.1 Wetlands remaining wetlands – CO_2	The ERT noted that in CRF table 4.D, most wetlands are categorized as other wetlands remaining other wetlands. In the NIR, Estonia explains that wetlands are divided into unmanaged wetlands and areas of peatland extraction. Emissions from unmanaged wetlands, and from flooded land remaining flooded land, are reported as "NA" in CRF table 4.D. During the review, the Party clarified that other wetlands actually correspond to unmanaged wetlands, which were part of the wetlands remaining wetlands category in CRF table 5.D in previous submissions. The Party indicated its plans to exclude unmanaged wetlands from CRF table 4.D and to reflect them instead in CRF table 4.1 in future submissions The ERT recommends that Estonia implement this planned revision to exclude unmanaged wetlands from other wetlands reported in CRF table 4.D and instead to reflect them as unmanaged wetlands in the land matrix reported in CRF table 4.1	ARR2016/L.3	In CRF Table 4D other wetlands correspond unmanaged wetlands. In previous submissions unmanaged wetlands were part of the wetlands remaining wetlands category in CRF Table 5D and according to this unmanaged wetlands were included in new CRF Table 4D. In next inventory report unmanaged wetlands will be excluded from CRF Table 4D and reflected in Table 4.1.	Chapter 6.5.1
General (KP-LULUCF)(Table 6, 2014) Transparency*	Provide the information submitted to the ERT on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested, taking into account future requirements provided in decision 6/CMP.9	ARR2016/ KL.1	Addressing. Estonia indicated during the review that it will include this information in the next submission	Chapter 11.4.4 Table 11.10
General (KP-LULUCF) (Table 6, 2014) Transparency	Provide the information submitted to the ERT on Estonia's ability to identify areas of land and areas of land-use change, taking into account future requirements provided in decision 6/CMP.9	ARR2016/ KL.2	Addressing. Estonia indicated during the review that it will include information on cadastral and local authority records and the determination of the 1990 land-use baseline in the next submission	Chapter 6.1.3 and Chapter 11.2
Afforestation and reforestation – CO_2 (86, 2014) Transparency*	When revising the estimates of land-use change and the associated uncertainties, following the completion of the current NFI, demonstrate that the methods used are capable of detecting land-use change within acceptable confidence limits	ARR2016/ KL.3	Resolved. Information on the increased frequency of the NFI sampling programme is provided in the NIR (p. 319)	
General (KP-LULUCF) – CO_2	Chapter 11 of the NIR does not provide sufficient information on how the background level of natural disturbances has been estimated. The types of natural disturbance considered in the estimation of the background level are also not provided. The ERT considers the information provided does not meet the requirements of decision	ARR2016/ KL.4	Information is provided according to the requirements.	Chapter 11.5.2.4

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	2/CMP.7, annex, paragraph 33(a) In response to a question raised by the ERT during the review, the Party explained that emissions for natural disturbances are calculated using equation 2.14 of the 2006 IPCC Guidelines (volume 4, p. 2.18), and it provided the calculation sheet developed by the Joint Research Centre of the European Commission, which indicated that wildfires, insect attacks and disease infestations, extreme weather events and other disturbances (e.g. damage by game animals) are included in the background level, covering historical data for the period 2000–2012 The ERT recommends that Estonia include the information on how the background level was calculated and the types of natural disturbances considered as provided to the ERT during the review in future NIR submissions, in order to provide transparent information on the construction of the background level			
General (KP-LULUCF) – CO_2	In accordance with decision 2/CMP.7, annex, paragraph 33, when considering natural disturbances, emissions from and associated with salvage logging must be accounted for, and must not be excluded from the emissions associated with natural disturbances during the commitment period. The ERT noted that the NIR and its reference materials do not transparently explain how historical emissions from natural disturbances exclude emissions from salvage logging, in accordance with good practice specified in the Kyoto Protocol Supplement (section 2.3.9.6). During the review, Estonia indicated that salvage logging is currently included in the background level, and that it intends to improve the accuracy and reliability of this background level The ERT recommends that Estonia correct its estimation of background level for natural disturbances by accounting for emissions from salvage logging, and provide transparent information on how this exclusion was determined	ARR2016/ KL.5	Information is provided according to the requirements and Estonia has taken notice of the recommendation and is considering to include the information in its next submission.	Chapter 11.5.2.5
General (KP-LULUCF) – CO_2	The ERT noted that the post-calibration procedure applied by Estonia automatically incorporates the average rate of past disturbances (for the period 2000–2008) into the projections used in constructing the FMRL. During the review, Estonia indicated that in the future it will include emissions from the background level of natural disturbances in the technical correction	ARR2016/ KL.6	Estonia has taken notice of the recommendation and will use the TC to exclude the effect of past disturbances in the FMRL.	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	The ERT recommends that Estonia use a technical correction to exclude the effect of past disturbances in the FMRL in order to incorporate the background level of natural disturbances without double counting			
Forest management– CO_2	The ERT noted that changes in carbon stock in litter is reported as "NE" owing to lack of data. For the activities of afforestation, reforestation and deforestation, the EF from Sweden (0.3 kt C/ha/year) is used for litter; however, for the activity of forest management, Estonia explains that it chose a tier 1 method, assuming that carbon stocks are in equilibrium. In the NIR (section 10.4.2), Estonia describes an ongoing project about forest litter "Forest litter, research and modelling" that could help to make the estimation more complete and accurate Noting that decision 2/CMP.7, annex, paragraph 26, mandates that litter, as well as above- and below-ground biomass, dead wood and soil organic carbon, shall be accounted for unless the country chooses not to report changes in a pool that has been demonstrated not to be a source, and also noting that Estonia reports CO2 emissions from forest management as a key category, the ERT recommends that the Party obtain necessary data and apply a tier 2 method for estimating carbon stock changes under the litter pool	ARR2016/ KL.7	Estonia is working to obtain necessary data and apply a tier 2 method for estimating carbon stock changes under the litter pool.	Chapter 6.2.6
Forest management– CO_2	The ERT noted large discrepancies between the emissions and removals from forest land remaining forest land under the LULUCF sector and those from forest management under Article 3, paragraph 4, of the Kyoto Protocol. In response to a question raised by the ERT during the review, Estonia explained that the emissions and removals reported for forest management activity under Article 3, paragraph 4, include the areas of forest that have been converted, not in a direct human-induced manner, and thus are not classified as afforestation and reforestation under Article 3, paragraph 3, as well as the effect of the HWP contribution, consistent with figure 2.7.1 of the Kyoto Protocol Supplement. The ERT considers that this creates a lack of transparency and comparability with other Parties The ERT recommends that Estonia add rows to CRF table 4(KP-I).A.1 and table 4(KP-I).B.1 to report subdivisions owing to HWP, grassland converted to forest land, and other land converted to forest land, or	ARR2016/ KL.8	Information is provided in NIR according to the requirements.	Chapter 11.1.4

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	alternatively include a comparative table in the NIR, and provide an explanation to justify the inclusion of areas of forest conversion that are not direct human-induced in its estimates of emissions and removals from forest management			
Harvested wood products– CO_2	Reporting of methodologies and assumptions for HWP in chapter 11 of the NIR is limited and lacks transparency. For example, Estonia did not provide an explanation for how the requirements described in decision 2/CMP.8 are taken into account with a view to improving the transparency of reporting on HWP in the NIR. During the review, the Party explained that HWP emissions and removals for forest management under Article 3, paragraph 4, of the Kyoto Protocol are consistent with the total HWP removals reported in CRF table 4.G under the Convention, which excludes HWP from deforestation, in accordance with the Kyoto Protocol Supplement The ERT recommends that Estonia, in its next NIR, include more information on HWP, in particular an explanation of how it adheres to the guidance provided by the Kyoto Protocol Supplement and decision 2/CMP.8, such as the exclusion of imported HWP, the exclusion of deforestation, the inherent HWP and the relationship of the projection of HWP included in the FMRL with reporting under the Convention	ARR2016/ KL.9	Information is provided in NIR according to the requirements.	Chapter 11.3.1.1, Chapter 11.4.6 and Chapter 11.5.2.5
Forest management – CO2	In the report to facilitate the calculation of the assigned amount for the second commitment period of the Kyoto Protocol of Estonia, Estonia indicates that it is working on the complete and official technical corrections to the FMRL, with the support of the Joint Research Centre of the European Commission. In the NIR, Estonia indicated that it chose not to make technical corrections for the above-mentioned report given that it is not mandatory to make technical corrections annually for the entire commitment period. The Party also indicated that a model recalibration was conducted, but a full rerun of the model would be carried out in the future, which will allow Estonia to implement complete and official technical corrections. The ERT noted that in the report of the technical assessment of the forest management reference level submission of Estonia submitted in 2011 (FCCC/TAR/2011/EST), a recommendation was made to Estonia to make a technical correction to the FMRL when agreement on HWP estimation had been reached, because of the high inter-annual	ARR2016/ KL.10	Estonia has taken notice of the encouragement and will include the information when the TC is conducted.	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	variability of the estimates for forest land in the 2011 GHG inventory, which was the basis for the estimates in document FCCC/TAR/2011/EST, unless causes of such variability were detected and estimates consequently reassessed. The Party was also recommended to not include CO_2 emissions from forest fires reported in CRF table 5(V) in any recalculation of the FMRL based on the 2011 GHG inventory In response to the questions on these matters raised by the ERT during the review, Estonia explained that the emissions and removals of HWP are calculated in accordance with the Kyoto Protocol Supplement, taking into account inherent HWP emissions, HWP from deforestation and HWP for exports, and following the recommendations in document FCCC/TAR/2011/EST Estonia reported its FMRL in the report to facilitate the calculation of the assigned amount both using instantaneous oxidation for HWP (for which a value of –1.742 Mt CO2 eq was reported) and by applying a first-order decay function for HWP (for which –2.741 Mt CO2 eq was reported). In its annual submission, in CRF table 4(KP-I).B.1.1 and CRF table 'accounting', the Party reported the value as –2741.00 Mt CO2 eq The ERT recommends that Estonia follow the recommendation made in document FCCC/TAR/2011/EST when making technical corrections during the second commitment period of the Kyoto Protocol			
CH_4 and N_2O emissions from drained and rewetted organic soils	In CRF table 4(KP-II).2, CH_4 and N_2O emissions from drained and rewetted organic soils are reported as "NA". In the NIR, Estonia explained that improvements are planned to better estimate non-CO_2 emissions from drainage of forest soils. During the review, Estonia indicated that it has AD for drained organic soils, but lacks the comparative data necessary to assess whether the tier 1 method will overestimate or underestimate the emissions Considering that Estonia reports afforestation and reforestation, deforestation and forest management as key categories, the ERT recommends that the Party report CH4 and N2O emissions from organic soils associated with drainage and rewetting under those activities, in accordance with the good practice guidance provided in	ARR2016/ KL.11	Estonia has taken notice of the encouragement and is considering to include the information in its next submission.	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	section 2.12.4 (wetland drainage and rewetting) of the Kyoto Protocol Supplement and in the Wetlands Supplement			
5.A Solid waste disposal on land – CH4 (73, 2014)	Make efforts to use national parameters (especially country-specific DOC and k values for municipal and industrial waste) instead of IPCC default values in order to improve the accuracy of the estimates	ARR 2016/W.1	Calculation of the CH4 emissions from solid waste disposal are made using default IPCC 2006 parameters because no studies with country specific parameters are available.	
5. General (waste)– CO2, CH4 and N2O	The ERT noted that there is no description in the NIR on the waste management practices used in Estonia. During the review, Estonia provided information on these practices and explained that the amount of waste used for emissions estimation is derived from AD on the generated and imported MSW at the beginning of the year for each year of the whole time series. For the years between 2007 and 2014, the Party also provided data on the amount of waste at the end of the year The ERT recommends that Estonia ensure the transparency of its next GHG inventory submission by describing the waste management practices used in the country, as provided during the review week	ARR 2016/W.6	Information provided according to the recommendation.	Chapter 7.2.2
5. General (waste)– CO2, CH4 and N2O	The ERT noted that, in the information provided by Estonia on waste management practices and the AD as explained in W.6 above, the amount of waste at the end of one year does not correspond with the amount of waste at the beginning of the following year. During the review, the Party explained that there are several reasons for this inconsistency, such as incorrect units and data reported by the waste management companies and changes in their profiles. After the review week, the Party further explained that there are the QA/QC procedures in place, and workshops and consulting is also taking place to help companies to submit the annual waste data. The ERT recommends that the Party improve the accuracy of its waste management AD by taking measures with data providers to implement data reporting requirements and by enhansing QA/QC procedures in order to ensure that AD used for the estimation of emissions are the same for the end of one year and the beginning of the following year	ARR 2016/W.7	Information about the amount of waste at the end of one year does not correspond with the amount of waste at the beginning of the following year has been included to NIR.	Chapter 7.2.2
5.A Solid waste disposal on land – CH_4	During the review, the Party explained that the waste generated by the oil shale industry should be corrected to 44 per cent, not 56 per cent, of the total waste generated in the country. Further, the Party explained	ARR 2016/W.8	Estonia will avoid such errors in the future.	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	that about a half of the waste from the oil shale industry (4 543 kt) was recycled, and the other half (5 266 kt) was landfilled. The Party also explained that the inert waste reported in NIR table 7.6 includes waste from the oil shale industry. The ERT recommends that Estonia improve the transparency of its reporting by providing the explanation on the waste data and numerical data that correspond with each other.			
5.B.2 Anaerobic digestion at biogas facilities – CH_4 and N_2O	Estonia reported CH4 and N2O emissions from anaerobic digestion at biogas facilities as "IE" in CRF table 5.B. During the review, the Party explained that the emissions from anaerobic digestion with energy recovery has been reported under Energy sector (CRF 1.A.1.A) and there is currently no anaerobic digestion taking place without energy recovery. However, the ERT notes that, according to the 2006 IPCC Guidelines, CH4 and N2O emissions to be reported under the biological treatment of solid waste (5.B) are the emissions from unintentional leakages at biogas facilities, not emissions from energy recovery. The ERT further noted that no description of the methodology, EF and AD for CH4 and N2O emissions from anaerobic digestion is provided in the NIR. If the Party has no information for CH4 and N2O emissions from from unintentional leakages, it is good practice to use a default value of 5 per cent. The ERT recommends that Estonia estimate and report CH_4 and N_2O emissions from anaerobic digestion at biogas facilities or, if these emissions are considered insignificant by the Party, report them as "NE" and provide a quantitative estimate of the likely level of the emissions in the NIR, in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, in order for the ERT to be able to assess whether the sum of all gases and categories considered insignificant remains below 0.1 per cent of the national total GHG emissions	ARR 2016/W.9	The calculations of unintentional leakages with insignificant emission based on the National Inventory reporting guidance provided in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. Information is provided according to the recommendation.	Chapter 7.3.2
5.D Wastewater treatment and discharge – N_2O	There are two options for default value selection for the parameter FNON-CON (factor for non-consumed protein added to the wastewater) in the 2006 IPCC Guidelines (section 6.3.1.3): for developed countries using garbage disposal, the default value is 1.4. The Party selected the higher value of 1.4 for its FNON-CON without explanation in the NIR	ARR 2016/W.10	Information is provided according to the recommendation	Chapter 7.5.3

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
	The ERT accepts the explanation provided and recommends that Estonia improve the transparency of reporting in its next NIR by including the information provided to the ERT during the review justifying the use of 1.4 for $F_{NON-CON}$			
5.D.1 Domestic wastewater – CH_4	Estonia reported the total CH4 emissions from domestic wastewater handling as 1.99 kt in the NIR and 2.00 kt in the CRF tables. During the review, Estonia confirmed that the correct value is 2.00 kt The ERT recommends that Estonia improve the transparency of its reporting by correcting the error in the NIR	ARR 2016/W.11	Estonia will avoid such errors in the future.	

10.4.2. KP-LULUCF inventory

The University of Life Sciences have a “Carbon and nitrogen cycling in drained forests” project in cooperation with State Forest Management Centre. This study can potentially provide useful information to estimate emissions for the non-mandatory land use categories and carbon pools: non-CO2 emissions from drainage of forest soils. The University of Life Sciences also has a project about forest litter “Forest litter, research and modelling” that could help to make the estimation more complete and accurate. The project started in 2015 and will finish in 2018 resulting with county-specific litter model that is dependent on the main tree species and site type. The model will be used as an input for the calculations needed for greenhouse gas inventory.

Estonia was selected to participate in the Specific Contract (SC) 12 taskforce on harmonization of LULUCF inventories: modelling forest soil with Yasso. The Specific Contract 12 is a framework contract for the provision of forest data and services in support of the European Forest Data Centre. Estonia has some first results on modelling carbon stock change of forest mineral soils with Yasso07, but it will need some further research to provide data for the UNFCCC and Kyōto protocol reporting.

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

11.KP-LULUCF

11.1. General information

Under Article 3, paragraph 3, of the Kyoto Protocol (KP), Estonia reports emissions and removals from Afforestation (A), Reforestation (R) and Deforestation (D), and under Article 3, paragraph 4, emissions and removals from Forest management (FM). Estonia will apply the natural disturbance provision under FM if needed, but not under AR. Estonia will not use the provision of carbon equivalent forest (the emissions/removals from the harvest and conversion of forest plantations to non-forest land described in decision 2/CMP.7, annex, paragraphs 37–39) in the accounting of FM. The estimates of emissions and removals are prepared and reported consistently with the IPCC LULUCF 2006 and 2013 Revised Supplementary Methods and Good Practical Guidance Arising from the Kyoto Protocol, Decisions 15/CMP.1 and 16/CMP.1 of the KP.

An overview of Article 3.3 activities' CO_2 emissions and removals are presented in Table ES.3. In 2015, net emissions from Article 3.3 activities were 6.81kt CO_2 eq. Uptake from Afforestation and reforestation activities including emissions from biomass burning was estimated at -177.80 kt CO_2 eq., whereas Deforestation resulted in a net emission of 184.61 kt CO_2 eq. Areas subject to AR and D were 59 382 and 19 589 ha, respectively by the end of 2015. Annual rates of Afforestation and Deforestation have declined continuously from 1.78 kha to 0.04 kha per year for AR and from 1.81 kha to 0.19 kha per year for D during the period 2008–2015 (Table 11.4).

For Forest management under Article 3.4 activities overview of CO_2 emissions and removals are presented in Table ES.3. In 2015 FM contributed to the total GHG balance with an uptake of -2438.32CO_2 eq. and with HWP it was -3 518.52 kt CO_2 eq. Total area of FM was 2 361.32 kha.

11.1.1. Definition of forest, national forest and any other criteria

Under the Kyoto Protocol, Parties are requested to make national parameter choices for the forest definition within the ranges allowed by Decision 16/CMP.1. Estonia established the definition of forest in the context of the Kyoto Protocol in 2006 with the main parameters of forest definition shown in Table 11.1. Estonia applies the same forest definition for both UNFCCC and KP reporting.

Table 11.1. Parameters for forest definition

Minimum tree crown cover	30%
Minimum land area	0.5 ha
Minimum tree height	2 m

In ARR2013, paragraph 60 ERT noted that various forest definitions were referred in the 2013 NIR. Clarification has been provided as follows.

The definition of forest has been amended several times in the Estonian Forest Act during the last 20 years. Since 2009 it has stipulated forest land as land which meets at least one of the following requirements:

- is entered in the cadastral register as a forest land parcel; or
- has an area of at least 0.1 hectares of land, growing woody plants with a minimum height of 1.3 meters and a tree crown cover of at least 30 percent.

Based on aerial photos data in cadastral register are occasionally updated. To process this for whole country, it takes time; thus, data are not always up to date. An area, which is not in cadastral register, but in the fieldwork, it has been found that second criterion applies, it is considered as forest.

To meet the requirements of UNFCCC and its Kyoto protocol reporting, the NFI is compiling statistical analyses based on both the national and the Kyoto Protocol definition of a forest, regarding the minimum area of a forest. The NFI has been recording information on forests, which remain in the area between 0.1 ha and 0.5 ha due to the fact that criterion of 0.5 ha has been a minimum forest area in one of the earlier redactions of the Forest Act. Thus, there is activity data that is applicable for KP-LULUCF reporting. The same information is used to estimate the forest area according to the FRA (Forest Rights Act) definition.

The criterion of 1.3 m has caused some confusion in earlier greenhouse gas inventory reports; however it should be noted that it is not 'the minimum tree height' in context of the forest land definition. Actually, 1.3 m is the criteria for counting unstocked forest area to stocked forest. The minimum tree height *in situ* by the forest definition of the Forest Act is defined by tree species, the stand's age and site index. Thus, there is no constant criteria for tree height in the national definition. As there are no forest-tree species in Estonia that could not reach the height of 2 m at the age of maturity, the height criterion of the Kyoto Protocol forest definition has been met in the NFI statistics.

All temporarily unstocked forest areas and regeneration areas which have yet to reach a crown density of 30 per cent and tree a height of 1.3 m are also included as forest, as they are areas which are temporarily unstocked as a result of human intervention such as harvesting, or natural causes (fires etc.) but which are expected to revert to forest.

All forest land is considered managed in Estonia – the whole forest land in Estonia is or has been covered with forest management plans. In addition, protected forests are covered with the protection scheme.

By definition natural forest is a forest or other wooded land of naturally regenerated native species; there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed (FRA 2005). According to Estonia's NFI natural forest must also meet the following requirements:

i) forest has natural tree species composition and the age classes for dominant tree species differ from each other by at least 2 age groups; or in the same age stand, the average age for conifers has to be higher than 100 and for deciduous trees at least 80 years;
ii) younger trees can grow in a fail patch in a stand;
iii) the portion of fallen timber and standing dead trees has to be at least 5% of the growing stand; highly decayed dead wood has to make 50% out of all of the fallen timber;

iv) it is not possible to distinguish harvest in any extent that could affect the natural tree species composition (the main stand has to be at least a 100 years (deciduous) or 120 years (conifers) old).

All natural forests in Estonia are protected, thus Estonia does not have emissions arising from the conversion of natural forests to planted forests. For planted forests Estonia uses the FAO definition: forest / wooded land where trees have been established through planting or seeding.

11.1.2. Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

Estonia has decided not to elect any of the activities under Article 3.4 of the Kyoto Protocol. For the second commitment period of 2013–2020, Estonia accounts Forest management as it became mandatory activity under Article 3.4 of the Kyoto Protocol.

Forest management area is determined according to the methodology of the NFI.

11.1.3. Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

Estonia started to make efforts to monitor, estimate and report carbon flows related to Afforestation, Reforestation and Deforestation activities for the first time in 2009, when the NFI started to report land-use changes. Considering Forest management (FM), Estonia started to estimate and report carbon flows in 2015.

In previous submissions, Afforestation and Reforestation areas were obtained from Statistics Estonia. Starting from the 2013 submission, a new approach was implemented. Today, NFI field data about land-use changes are used, assuming that cropland, wetlands and settlement conversion to forest land reported under the Convention is directly human-induced land conversion. These areas are summed in order to get the AR area (Table 11.3). Conversion of the Grassland and Other land into forest land is considered as not directly human induced. Grassland conversion to forest land occurs mainly due to natural succession after land abandonment, therefore these areas are not taken into account for Afforestation reporting. With the new approach, all AR areas are identified and georeferenced – detailed information about growing stock, mineral and organic soil distribution is obtained from the NFI and consistency between UNFCCC and KP-LULUCF reporting is assured.

Data about Deforestation is also acquired from the NFI. All land use changes from Forest land to other land-use categories reported under the Convention are considered Deforestation (Table 11.3).

With the new approach, all activity data (AR, D & FM) is obtained from one source.

11.1.4. Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified.

Article 3.4 activity Forest management area equals with the total Forest land area where the Article 3.3 activity AR area is subtracted. Thus 2015 FM area also equals with the sum of 2015 Convention Forest land remaining forest land, Grassland to forest land and Other land to forest land minus the sum of 1994 Cropland to forest land, Wetland to forest land and Settlements to forest land (2015(FM)= 2015 (FF+GF+OF) – 1994 (CF+WF+SF)). As methodology is slightly different to the Land converted to forest land categories (compared to Forest land remaining or

Forest management EFs) this conversion gives an overestimated FM emissions that are mainly driven by the biomass calculations (Table 11.2)[351].

Table 11.2. Forest management emissions and area comparison

	Area (kha)	**Emissions (kt CO_2 eq.)**
Forest Management	2361.32	-2438.32
2015 (FF+GF+OF) – 1994 (CF+WF+SF)	2361.32	-2507.22
UNFCCC (FF)	2318.24	-2388.66

11.2. Land-related information

Estonia implements *Reporting Method 1* for lands subject to Article 3.3 activities. The area of Estonia is not divided into regions because it is relatively small and homogeneous in terms of ecological conditions. *Approach 2* is used to determine the land areas and land-use changes related to Afforestation/Reforestation and Deforestation. Data for land-use changes is obtained from the National Forest Inventory.

The NFI is a sampling-based inventory system that covers the whole country and all land-use categories (Figure 6.5). During fieldwork, land categories are determined (Figure 6.6), whereby the "LULUCF former land category" is registered if there are signs of any land category change after the base point (31.12.1989). The year of change is first estimated directly in the field, mainly based on the age of trees and characteristics of the surrounding landscape. Older maps and aerial photographs are used afterwards as supporting material to determine the exact year more accurately.

In ARR2013 paragraph 61, the ERT recommended that Estonia include the information on its capacity to detect the exact year of an occurrence of land-use change and its subsequent consistent representation in the time series.

An illustrative example of how land-use changes are verified with maps and relevant materials are presented as follows.

In the cluster in Figure 11.1, Figure 11.2 and Figure 11.3, there are 6 identified land use changes on the NFI sample plots since 1990:

1. *N02* - Grassland to forest land, LUC in 1995
2. *E06* - Cropland to forest land, LUC in 1999
3. *S02* - Cropland to forest land, LUC in 2009
4. *W04* - Cropland to forest land, LUC in 2005
5. *W06* and W08 - Cropland to forest land, LUC in 2008.

[351] ARR2016, Table 5, KL.8

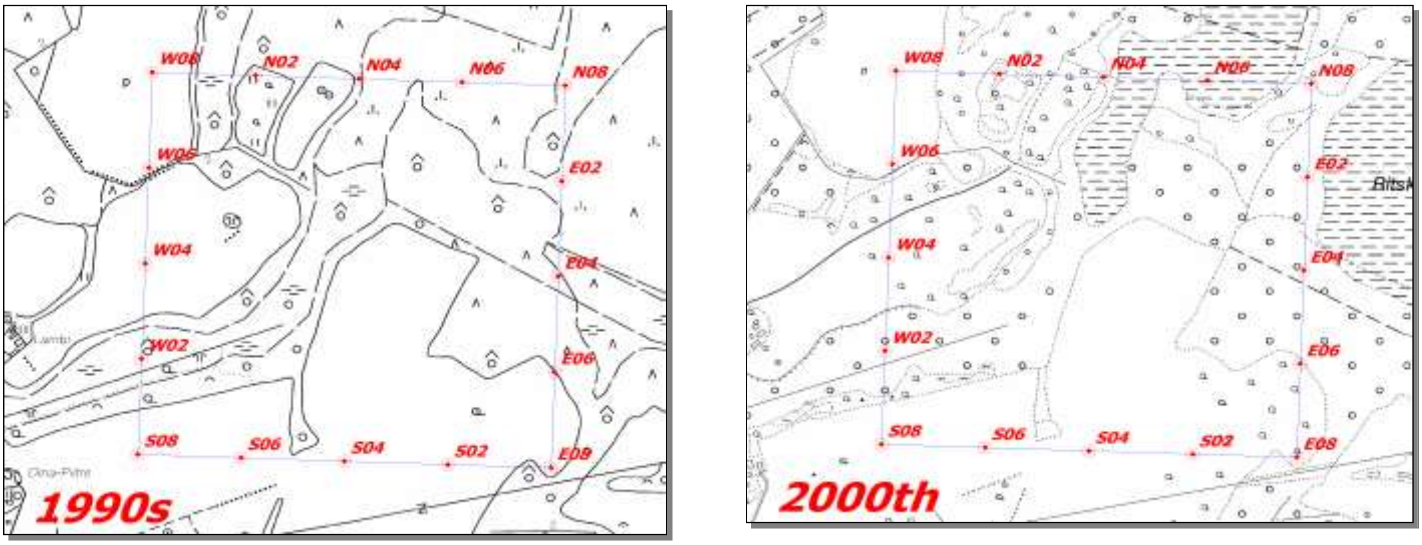

Figure 11.1. Base maps of 1990 and 2000

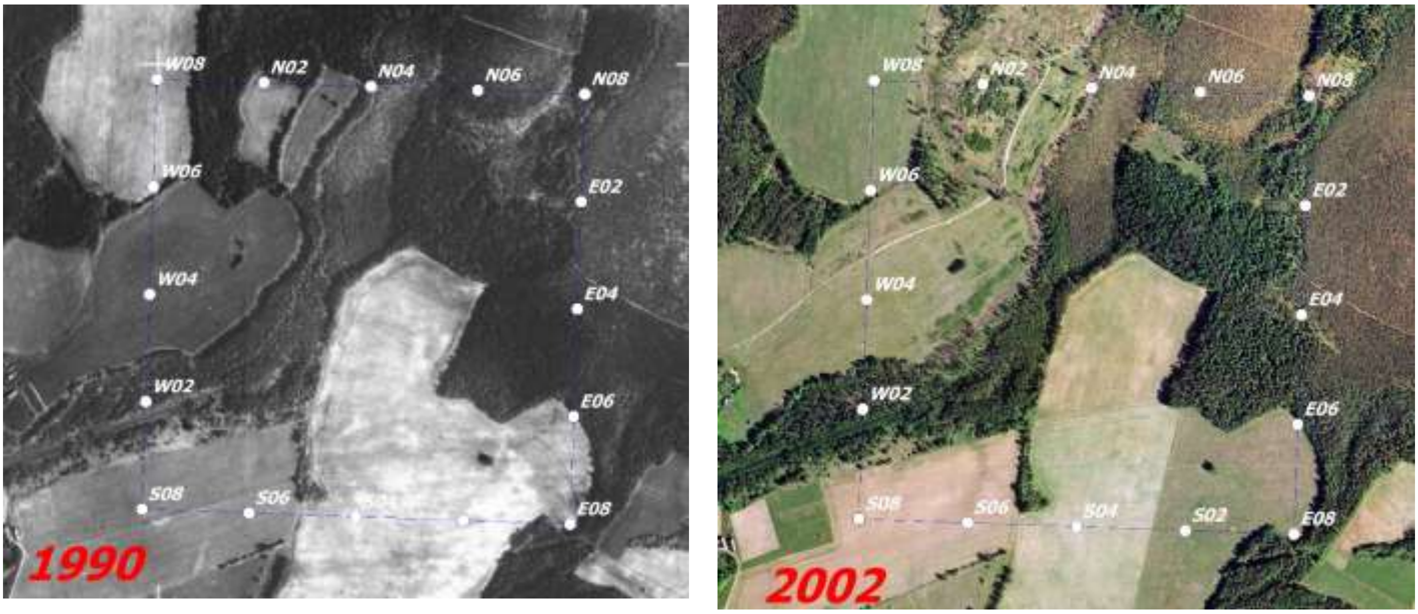

Figure 11.2. Orthophotos of 1990 and 2002

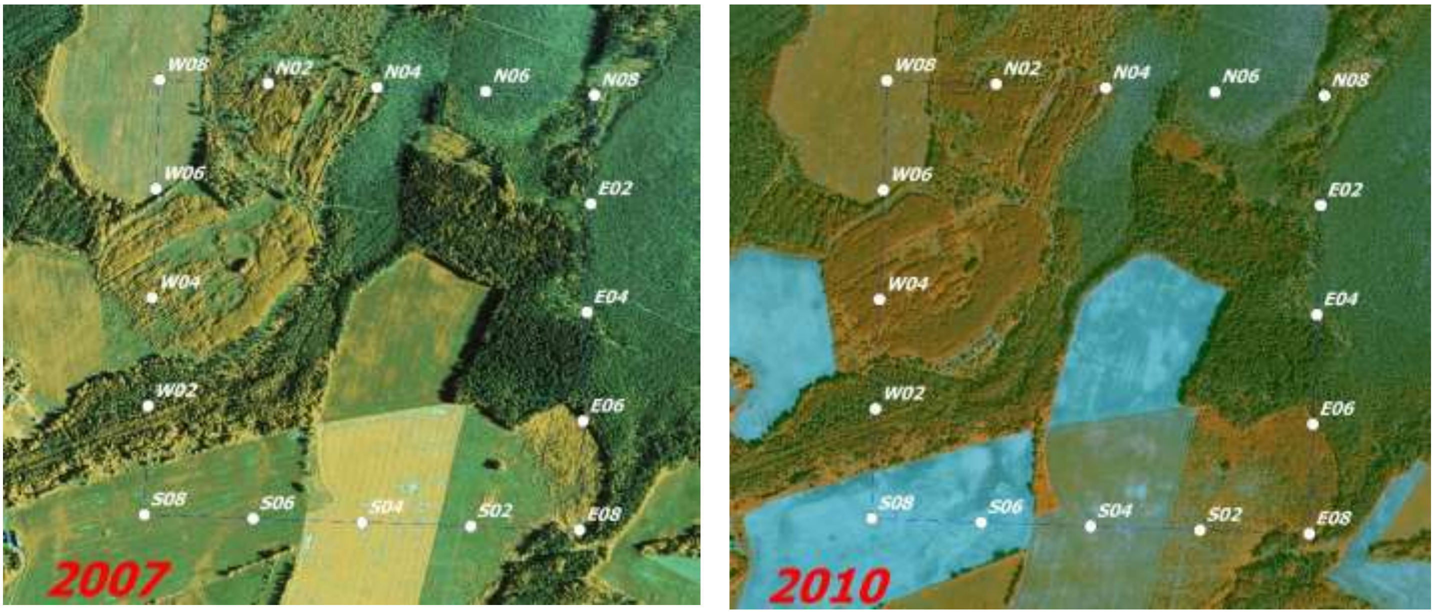

Figure 11.3. Orthophotos of 2007 and 2010

All permanent sample plots, that may also include detected land-use changes, are reinventoried every 5 years (more information in Chapter 6.1.3).

11.2.1. Spatial assessment unit used for determining the area of the units of land under Article 3.3 and under Article 3.4.

The spatial assessment unit to determine the area of units of land under Article 3.3 and Article 3.4 is 0.5 ha, which is the same as the minimum area of forest.

11.2.2. Methodology used to develop the land transition matrix

Approach 2 is employed to estimate areas of land-use change in the LULUCF sector. In order to collect data about land-use transitions, NFI started additional field studies in 2009. Collected data provides information on different land-use classes (there is about 20 years' worth of data), the year of changes and the soil type. During field inventory, "LULUCF former land category" is registered on every sample plot if the land category has changed after base point (31.12.1989). The year of change is being estimated first directly in the field. Older maps and aerial photographs are used afterwards as supporting material to determine the exact year more accurately. Since 1999 there is information available on permanent sample plots. The land use matrix is compiled based on obtained NFI data.

In ARR2013 paragraph 65, the ERT encouraged the inclusion of a summary table consisting of a comparison matrix of the Convention and KP-LULUCF reporting areas for QA/QC purposes. Reported land-use changes under the Convention and respective ARD areas are presented in Table 11.3.

The FM area coincides to the total forest land area from which the Afforestation/Reforestation area has been subtracted.

The area of land-use changes under the Convention and Kyoto LULUCF reporting do not have a full match. Once the time period for UNFCCC reporting of converted lands has elapsed (i.e. 20 years) the land is reported in the land remaining category, whereas under Kyoto reporting, this displacement is not applied.

Table 11.3. Comparison of the Convention and KP-LULUCF cumulative areas

	the Convention		KP-LULUCF	
Land-use change	kha	%	kha	%
			Afforestation/Reforestation	
Cropland → Forest land	33.9	33%	44.2	69%
Grassland → Forest land	42.1	41%		
Wetlands → Forest land	9.1	9%	10.5	18%
Settlements → Forest land	5.7	6%	7.7	13%
Other land → Forest land	11.6	11%		
Total	102.5	100%	59.4	100%
			Deforestation	
Forest land → Cropland	0.2	1%	0.2	1%
Forest land → Grassland	6.0	28%	6.6	32%
Forest land → Wetlands	2.3	17%	3.3	12%
Forest land → Settlements	8.7	44%	9.1	46%
Forest land → Other land	1.8	10%	1.5	9%
Total	18.9	100%	19.6	100%
			Forest management	
Forest land remaining forest land	2 318.2	100%	2 361.3	100%

11.2.3. Maps and/or database to identify the geographical locations, and the system of identification codes for geographical locations

The area of Estonia is not divided into geographical regions. The spatial assessment unit defined in Estonia's national territory, the geographical location of the boundaries of the areas that encompass units of land subject to ARD and FM is that of the entire country.

11.3. Activity-specific information

11.3.1. Methods for carbon stock change and GHG emission and removal estimates

The same methodology, emission factors and data sources are used for reporting LULUCF under the KP as for reporting under UNFCCC.

The activity data subject to Afforestation/Reforestation, Deforestation and Forest management areas are presented in Table 11.4.

Table 11.4. Annual areas subject to Afforestation/Reforestation (AR), Deforestation (D) and Forest management (FM) activities, kha (NFI)

Year	Afforestation/reforestation	Deforestation	Forest management
1990	0.92	0.04	2 317
1991	1.51	0.04	2 319
1992	2.19	0.11	2 321
1993	2.85	0.18	2 324

Year	Afforestation/reforestation	Deforestation	Forest management
1994	3.17	0.27	2 327
1995	3.40	0.38	2 329
1996	3.71	0.45	2 331
1997	3.95	0.49	2 334
1998	4.00	0.60	2 336
1999	3.91	0.55	2 338
2000	3.86	0.55	2 341
2001	3.43	0.59	2 344
2002	2.79	0.62	2 346
2003	2.78	0.74	2 349
2004	2.76	0.93	2 351
2005	2.39	1.05	2 354
2006	2.39	1.68	2 355
2007	2.27	1.82	2 357
2008	1.78	1.81	2 358
2009	1.43	1.85	2 359
2010	1.36	1.72	2 359
2011	0.92	1.12	2 360
2012	0.77	0.89	2 360
2013	0.55	0.60	2 361
2014	0.26	0.30	2 361
2015	0.04	0.19	**2 361**
Total	**59.38**	**19.59**	

11.3.1.1. Description of the methodologies and the underlying assumptions used

Carbon stock changes in living biomass

Estimations on carbon stock changes in living biomass on AR and FM areas are made following the same methodology as under the UNFCCC reporting of Land converted to forest land and Forest land remaining forest land. Activity data and growing stocks are obtained from the NFI.

Living biomass is calculated as follows (Equation 11.1), taking into account tree species distribution on AR areas (by the NFI), average growing stock level by stand age (NFI) and default BCEFs for boreal forests (IPCC 2006, Table 4.5, p 4.50):

Equation 11.1

$$\mathrm{AG}_t = \frac{c}{2}\left(\sum_{i=1}^{3}\alpha_i\beta_{ij(u)}\right)\left(\sum_{k=1990}^{t}s_k(t-k)(t+1-k)\right)$$

where

AG_t =	above-ground biomass, tonnes in year t
c =	average change of growing stock per year in young stands, $m^3\ ha^{-1}$
s_k =	AR area in year k
t, k =	year
α_i =	share of tree species (Table 11.6)

$\beta_{ij(u)}$ = BCEF$_S$ of tree species, tonnes m^{-3} (Table 11.5)

i = index of tree species (Table 11.5, Table 11.6)

$$j(u) = \begin{cases} 1, \textit{if } 0 \le u < 10 \\ 2, \textit{if } 11 \le u \le 16 \\ 3, \quad \textit{if } u > 16 \end{cases}$$

where

$j(u)$ = index of growing stock level by stand age (Table 11.7)

$$u = \sum_{k=1990}^{t} (t-k)$$

Table 11.5. BCEF$_S$ [t biomass/m^3 wood volume]

Species	Growing stock level [m^3/ha]		
	< 20	21–50	51–100
pine	1.20	0.68	0.57
spruce	1.16	0.66	0.58
hardwoods	0.90	0.70	0.62

Weighted average BCEF$_S$	
FL rem FL	0.563

Table 11.6. Distribution of main tree species and applied root-shoot ratio on AR areas

Main tree species	Proportion	Root-shoot ratio[352]
Pine	0.3001	0.39
Spruce	0.2376	0.39
Others (mainly birch)	0.4623	0.46
Weighted average		0.39

Table 11.7. Input BCEF$_S$[353] for above-ground AR biomass calculations

Age of AR yr	Growing stock m^3/ha	BCEF$_S$ weighted average
1...6	< 20	1.06
7...13	21-50	0.68
14...22	51-100	0.59

Equation 6.2 and the same parameters as under Forest land conversion to other land uses are applied to estimate carbon stock changes in above- and below-ground biomass pools and dead wood pools for D areas.

352 IPCC 2006, Vol 4 (AFOLU), Table 4.4, p. 4.49.
353 IPCC 2006, Vol 4 (AFOLU), Table 4.5, p. 4.50.

For Forest management Equation 6.2 and the same parameters as Forest land remaining forest land are applied to estimate carbon stock changes in living biomass pool and dead wood pool.

Carbon stock changes in mineral and organic soils

Emissions from mineral and organic forest soils are calculated as under the Convention applying areas from Table 11.3 (Emission factors - AR: Table 6.11, D: Table 6.22, Table 6.25, Table 6.30, Table 6.35).

Due to insufficient country-specific data regarding stock change in forest mineral and organic soils, the emission factors from Sweden[354] (0.137 Mg C ha^{-1} yr^{-1}) for mineral and (-0.371 Mg C ha^{-1} yr^{-1}) organic soils were implemented for Forest management.

Carbon stock changes in litter and dead wood

Changes in the litter pool were estimated using the same approach as under land converted to Forest land for AR and Forest Land converted to other land uses for D. Applied litter emission factor from Sweden[355] (0.3 Mg C ha^{-1} yr^{-1}) is used for AR and for D: Table 6.11, D: Table 6.22, Table 6.255, Table 6.30, Table 6.35.

For FM Estonia does not have sufficient data regarding litter stocks, thus the *Tier 1* method was implemented, assuming that carbon stocks are in equilibrium, therefore the changes in the litter pool are assumed to be zero. In ARR 2016[356] ERT recommended to obtain necessary data for litter pool. Estonia has an ongoing project to obtain litter stock data and more thorough explanation is added in Chapter 6.2.2.

Emissions related to dead wood after Deforestation were calculated following the same approach as under the Convention reporting (Chapter 6.2.2.3), assuming that all dead wood will be lost after Deforestation.

The amount of dead wood present on AR lands were measured and carbon stocks changes were estimated following the methodology described in Chapter 6.2.2.3. FM dead wood pool was calculated the same way as the dead wood pool for land remaining the same type and the conversion to forest land described also in Chapter 6.2.2.3.

An overview of Afforestation/Reforestation and Deforestation activities emissions and removals by carbon pools during the first and second Kyoto commitment period is presented in Figure 11.4 and Figure 11.5.

[354] The average implied emissioon factor of 1990-2015 in Sweden CRF tables 2016.
[355] Sweden NIR 2016, Annexes, Table A 3:2.11, p. 105.
[356] ARR 2016, KL.7, p.31.

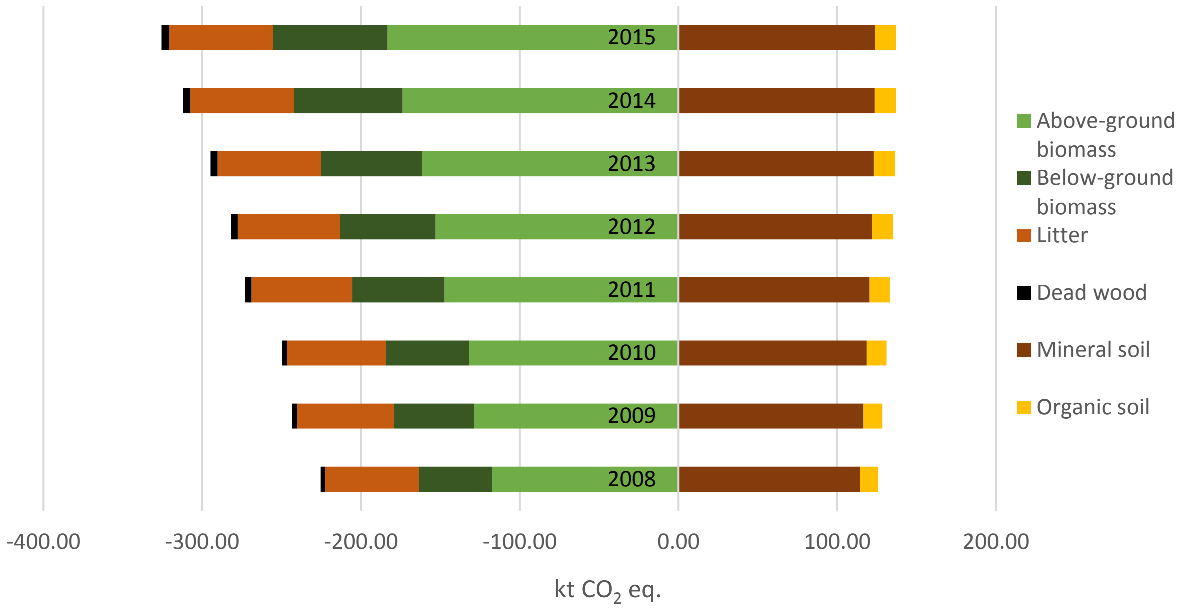

Figure 11.4. Afforestation/Reforestation emissions (+) and removals (-) in 2008–2015, kt CO_2

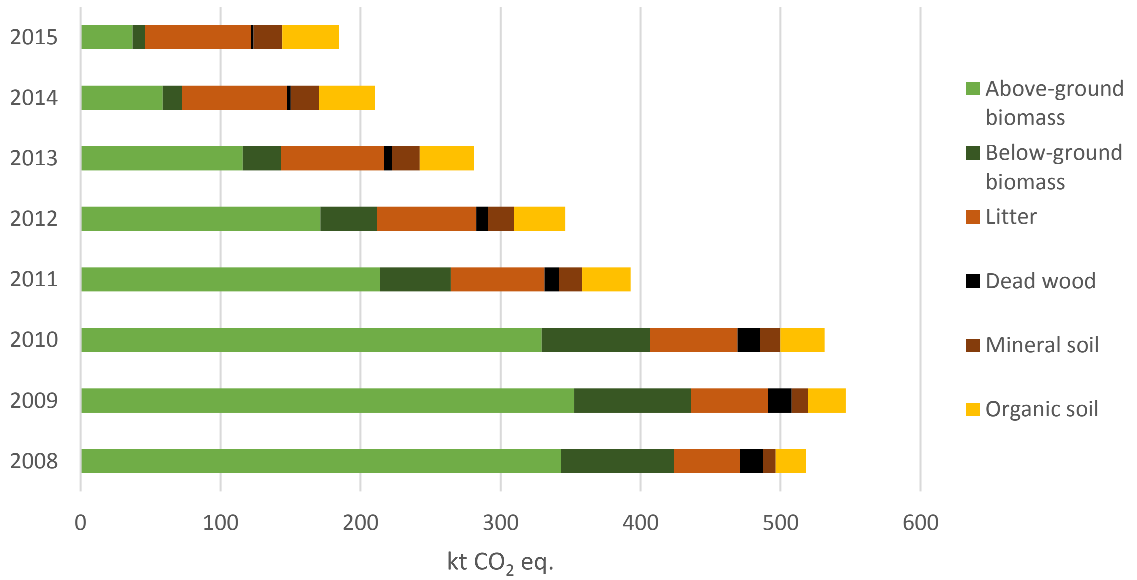

Figure 11.5. Deforestation emissions in 2008–2015, kt CO_2

Harvested wood products

HWP pool was estimated according to the methodology given in the IPCC 2014 Chapter 2.8. Mainly the Tier 2 (first-order decay) function is used, with default half-lives for sawn wood (35 yr.), wood panels (25 yr.) and paper (2 yr.) (IPCC 2014), correspondingly to the method used in Chapter 6.9.

The carbon dioxide emissions from harvested wood products in solid waste disposal sites are not accounted, and the carbon dioxide emissions from wood harvested for energy purposes have been accounted on the basis of instantaneous oxidation under carbon losses from living biomass.

Biomass burning

Non-CO_2 emissions from biomass burning were provided for AR and FM areas. The methodology described under the Convention reported in Chapter 6.8, Equation 6.14 was implemented, and parameters indicated in Table 11.8 were used. Data regarding forest growing stock (biomass burnt) was obtained from the NFI. For AR combustion efficiency, a higher value than the one used under Forest land (CRF 4.A) was chosen based on expert opinion, since compared to mature forests young trees are more affected by forest fires. FM calculation and factors were the same as for the Convention reporting.

Table 11.8. Parameters used for biomass burning estimation on AR areas

	Combustion efficiency [357]	CH_4 emission factor [358]	N_2O emission factor [359]
AR	0.59	6.1	0.06

Instant oxidation is assumed for all biomass under Deforestation, therefore it is reported that burning does not occur under D areas.

Fertilization

Emissions from forest fertilization are not estimated, as they do not occur.

11.3.1.2. Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

No pools have been omitted in the 2017 submission. Missing country-specific data is replaced with emission factors obtained from the Sweden 2016 submission. This approach has been approved by the ERT as an interim measure.

11.3.1.3. Information on whether or not indirect and natural GHG emissions and removals have been factored out

Estonia has not factored out emissions and removals from elevated carbon dioxide concentrations, indirect nitrogen deposition or the dynamic effects of the age structure. The IPCC does not give methods for factoring them out.

11.3.1.4. Changes in data and methods since the previous submission (recalculations)

Areas subject to Afforestation/Reforestation, Deforestation and Forest management are updated annually by NFI, new data is integrated to overall activity data.

In **Error! Reference source not found.** and **Error! Reference source not found.** and 10.5, an overview of the quantitative impact of ARD and FM recalculations has been provided.

Methodological consistency between the reference level and reporting for forest management during the 2nd commitment period, including the area accounted for the treatment of harvested wood products is secured by implementation of the same methodological approaches for the

[357] IPCC 2006, Table 2.3 p. 2.48, Land clearing fire, NFI expert opinion, EEA.
[358] IPCC 2006, Table 2.5 p. 2.47, Biofuel burning.
[359] IPCC 2006, Table 2.5 p. 2.47, Biofuel burning.

whole accounting period and recalculation of the whole time series according to a new methodology.

11.3.1.5. Uncertainty estimates

Tier 1 was implemented to estimate uncertainty rates related to activity data and emission factors employed in the estimates under Article 3.3 activities and Article 3.4 Forest management activity.

Table 11.9. Uncertainties of ARD and FM activities.

IPCC category		Uncertainties %		EF References
		Activity data[360]	Emission factors	
KP.A.1.1	Afforestation and reforestation – living biomass	11.00	46.95	IPCC 2003 & 2006
KP.A.1.1	Afforestation and reforestation – dead wood	11.60	19.84	Köster *et al*. 2015
KP.A.1.1	Afforestation and reforestation – litter	10.94	50.00	Sweden NIR 2015, p. 356
KP.A.1.1	Afforestation and reforestation – mineral soil	12.34	35.00	Sweden NIR 2015, p. 356
KP.A.1.1	Afforestation and reforestation – organic soil	24.34	35.00	Sweden NIR 2015, p. 356
KP.A.1.1	Afforestation and reforestation – biomass burning (CH_4)	22.09	70.00	LULUCF, 2003, p. 3.50
KP.A.1.1	Afforestation and reforestation – biomass burning (N_2O)	22.09	70.00	LULUCF, 2003, p. 3.50
KP.A.2	Deforestation – living biomass	18.43	46.95	IPCC 2003 & 2006
KP.A.2	Deforestation – litter	25.69	50.00	Sweden NIR 2015, p. 356
KP.A.2	Deforestation – dead wood	19.78	19.84	Köster *et al*. 2015
KP.A.2	Deforestation – mineral soil	21.46	35.00	Sweden NIR 2015, p. 356
KP.A.2	Deforestation – organic soil	47.96	35.00	Sweden NIR 2015, p. 356
KP.B.1	Forest management – living biomass	1.16	46.95	IPCC 2003 & 2006
KP.B.1	Forest management – dead wood	3.86	19.84	Köster *et al*. 2015
KP.B.1	Forest management – mineral soil	1.44	25.00	Sweden NIR 2015, p. 356
KP.B.1	Forest management – organic soil	3.50	25.00	Sweden NIR 2015, p. 356
KP.4	Biomass burning (CH_4)	34.50	70.00	LULUCF IPCC 2006, p. 4.7, Table 4.13; p. 2.48, Table 2.6
KP.4	Biomass burning (N_2O)	34.50	70.00	LULUCF IPCC 2006, p. 4.7, Table 4.13; p. 2.48, Table 2.6
KP.4.1 C	Wood panels	28.00	57.00	LULUCF IPCC 2006, p. 12.22, Table 12.6 Lamlom and Savidge, 2003
KP.4.1 C	Sawnwood	28.00	57.00	LULUCF IPCC 2006, p. 12.22, Table 12.6 Lamlom and Savidge, 2003

[360] All activity data uncertainty estimates are obtained from NFI.

IPCC category		Uncertainties %		EF References
		Activity data[360]	Emission factors	
KP.4.1 C	Paper and paperboard	30.00	57.00	LULUCF IPCC 2006, p. 12.22, Table 12.6 Lamlom and Savidge, 2003
KP.4.1 C	Semi-Chemical wood pulp	30.00	57.00	LULUCF IPCC 2006, p. 12.22, Table 12.6 Lamlom and Savidge, 2003

11.3.1.6. Category-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) were carried out for the LULUCF sector according to the IPCC *Tier 1* method. The activities are carried out every year during inventory. The QC checklist is used during inventory.

In accordance with paragraph 65 of ARR2013, a summary table consisting of a comparison matrix of the Convention and KP-LULUCF reporting areas has been added (Table 11.3) for QA/QC purposes in the current NIR.

ERT has recommended several times to verify the area of Deforestation in Estonia[361], since detection of small and scattered events such as A/R or Deforestation (D) may be underestimated due to the density of the NFI sampling grid (5 km × 5 km).

Estonia ordered a verification study from the Forest Management Bureau to determine the Deforestation area. This is an ongoing study, but the first results show that NFI does not underestimate the Deforestation areas.

The harvesting permits show on average 21% lower deforestation area and a 57% lower amount of deforested biomass compared to the NFI. The main reason is that harvesting permits do not represent undertaken activities, but only planned harvest and deforestation. It is also important to note that the definition of deforestation is not identical according to the forest notifications (i.e. harvesting permits) and the IPCC guidelines. In addition to forest land-use changes, clear-cuttings on grasslands, under power lines and road ditches are sometimes regarded as deforestation according to the harvesting permits, which is an indication that the system of forest notifications, including harvesting permits is not unequivocal and transparent. Therefore, when reporting and accounting land use changes from Forest land to other land-use categories and Deforestation, NFI data is implemented. On the other hand, the NFI does not provide exact biomass loss on Deforested areas, but the average growing stock of forest stands is the basis for calculating biomass loss due to Deforestation, which may lead to overestimating of emissions. One-third of Deforested areas are due to clearing of grassland from trees, where biomass is lower than average forest biomass.

11.3.1.7. Information on other methodological issues

A more accurate assessment of AR and D sites is under development in the framework of the NFI. NFI data is applied because it is the only continuous inventory and monitoring system in

[361] ARR2013, paragraph 62 & paragraph79

Estonia that covers all land uses and gives reliable estimates for the land use areas and tree growth.

11.3.1.8. The year of the onset of an activity, if after 2008

Accounting of anthropogenic greenhouse gas emissions by sources and removals by sinks resulting from land use, land-use change and forestry activities under Article 3.3 and 3.4, shall begin with the onset of the activity or the beginning of the commitment period, whichever comes later (*Marrakesh Accords*).

All Article 3.3 activities occurred before 2013, therefore the accounting of these activities began in 2013. Estonia accounts Article 3.4 Forest management activity for the second commitment period of 2013–2020, thus, accounting for FM began in 2013.

11.4. Article 3.3

Estonia reports all emissions by sources and removals by sinks from AR activities under Category A.1.1 Afforestation/Reforestation: units of land not harvested. Forests afforested or reforested since 1990 have not reached the regeneration age by the first commitment period. According to the guidance for good silviculture, the rotation time varies from 30 to 120 years depending on the tree species and site index of a forest.

The areas of Article 3.3 activities are estimated and described in Chapter11.2 – the cumulative sum of areas Afforested/Reforested and Deforested since 1990.

11.4.1. Information that demonstrates that activities under KP.A.1.2 Units of land harvested since the beginning of the commitment period do not occur

In ARR2013, paragraph 78, the ERT identified that Estonia did not report units of land harvested in A/R activities since the beginning of the commitment period. Justifications are as follows:

- Rules of Forest management (under the Forest Act) enacts harvest, reforestation/afforestation and forest protection activities. According to the Rules of Forest management, clear-cutting is not allowed in stands with the dominant tree species (*Pinus sylvestris, Picea abies, Betula, Populus tremula, Alnus glutinosa* and hardwoods), if the stand age is less than 30 … 130 years, depending on the site index class.
- Taking into account reasonable resources for tracking A/R units (NFI) and available data, there is no evidence of harvesting on A/R areas.
- Trees on A/R areas could be (a maximum of) 23 years old, hence it is not profitable (little stem volume) to harvest a forest of this age.

11.4.2. Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2020 and are directly human-induced

The reported AR activities are directly human-induced since they came to life when it was decided not to continue the previous activities but start with the Forest management activities instead. The planting of new forest is the main human-induced reforestation activity directed towards the increase of forest area in Estonia. Afforestation activities have been implemented mainly on agricultural lands and exhausted quarries.

Changes in Deforested areas are detected on NFI sample plots. The land-use category at the end of 1989 was assessed during field measurements, supporting maps and aerial photos were used where necessary.

11.4.3. Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from Deforestation

According to Estonian legislation, the land category change by humans is allowed only with orders from local authorities and/or the Minister of the Environment. This must be preceded by the reassignment of the land (e.g. commercial, residential or transport land), which is reflected both in the Land Cadastre and Land Registry. When a NFI sample plot is located in a clear-cut area, the surveyor assesses whether the cutting has been done for regeneration purpose or for land-use change. Clear signs of a land-use change can be seen in the surrounding and location of the area; also, the data from Land Cadastre and Land Registry is checked.

According to the Forest Act, the forest owner is obliged to implement reforestation techniques to such extent that within five years after logging or forest death a renewed forest is ensured. Re-establishment of a forest usually starts within 2 years after harvesting.

11.4.4. Information on the size and geographical location of forest areas that have lost forest cover but are not yet classified as deforested

Clear-cut forest areas, which have not classified as Deforestation, were classified as temporarily unstocked forest. The last five-year average of clear fellings area for forest regeneration in Estonia is 99.11 thousand hectares. All areas that have lost forest, if there is a reason to expect permanent change of land-use class, are considered as deforested and reported as non-forest land. Area that will remain classified as forest is mainly temporarily unstocked clear-cut area (Table 11.10). Their geographic location is determined by sample plot coordinates.[362]

Table 11.10 Clear-cut forest areas (ha) in Estonia 2000-2015

Year	Area (ha)
2000	10 753
2001	12 186
2002	9 943
2003	9 750
2004	8 278
2005	8 043
2006	5 626
2007	5 073
2008	4 439
2009	6 239
2010	8 054
2011	9 071
2012	10 192
2013	9 987
2014	9 912

[362] ARR2014, Table 6

2015	10 391

Source: National Forest Inventory

11.4.5. Information related to the natural disturbances provision under article 3.3

Estonia does not exclude emissions from natural disturbances under Article 3.3.

11.4.6. Information on Harvested Wood Products under article 3.3

Emissions from HWP under Article 3.3 AR activities do not occur for the same reasons that were explained in Chapter 11.4.1. Harvested wood products resulting from deforestation have been excluded according to the equation 2.8.3[363] and accounted on the bases of *Tier 1* method instantaneous oxidation.

11.5. Article 3.4

11.5.1. Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

All forest land is considered managed in Estonia – the whole forest land in Estonia is or has been covered with forest management plans. In addition, protected forests are covered with the protection scheme.

11.5.2. Information relating to Forest management

Estonia started to account Harvested wood products in the second commitment period and all the instantaneous oxidation have been excluded according to the IPCC guidelines. Harvested wood products for Article 3.4 were calculated according to the IPCC guidelines and the same as described in Chapter 6.9.

Current forest management reference level (FMRL) is based on a projection; the emissions from harvested wood products originating from forests prior to the start of the second commitment period have been included in the accounting.

The emissions and removals resulting from changes in the harvested wood products pool do not include imported harvested wood products, irrespective of their origin. Statistics Estonia data is used to identify share of imported harvested wood products.

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11.5.2.1. Conversion of natural forest to planted forest

In Estonia all natural forests are under protection, thus the conversion of natural forests to planted forests does not occur.

11.5.2.2. Forest management reference level (FMRL)

Estonia was one of the countries for which JRC calculated the FMRL (FCCC/TAR/2011/EST). According to the Decision 2/CMP.7 Estonia's Forest management reference level is -1.742 Mt

[363] 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol, Chapter 2.8.1.2, p. 2.116.

CO_2 eq/year and applying first order decay function for HWP reference level is -2.741 Mt CO_2 eq/year. The estimated annual accumulation of -0.999 MtCO_2 yr^{-1} in HWP pools included in the FMRL is estimated using the approach proposed in FCCC/KP/AWG/2010/CRP.4/Rev.4.

11.5.2.3. Technical corrections of FMRL

In 2017 Estonia chose not to make technical corrections (TC) of FMRL due to the fact it is not mandatory to make TC annually for the entire commitment period. Estonia is aware that TC is needed due to the recalculation of historical data, addition of new pools (mineral soils) and correct inclusion of natural disturbance provision. A small scale model re-calibration was conducted in 2016, but Estonia is now developing a model to implement a complete an official Technical Correction for the next submission.

11.5.2.4. Information related to the natural disturbances provision under article 3.4

Estonia will apply the provisions to exclude emissions from natural disturbances for the accounting for Forest management under Article 3, paragraph 4, of the Kyoto Protocol during the second commitment period (in accordance with decision 2/CMP.7, annex E, paragraph 33, and any relevant supplementary methodological guidance developed by the Intergovernmental Panel on Climate Change and adopted by the CMP and the COP) if needed.

In Estonia, the most important natural disturbances are extreme weather events (storms), wildfires, insect attacks and disease infestations and other (damages made by game animal). Estonia did not consider natural disturbances in the construction of FMRL, but intends to take it into account in the TC. Estonia will not apply the ND provision for the years 2013-2015.

Perished stands

According to Forest Act, a forest in which the canopy density as determined on the basis of live trees is less than 30 per cent due to biotic or abiotic damages is deemed to be perished.

In 1998–2013, the stands, which according to the forest protection expertize were designated to salvage logging due to forest damages, were deemed as perished stands. Area and growing stock of such stands are calculated according to the data of forest protection expertize.

In 1991–1997, the area of perished stand is presented according to the data of Statistics Estonia and in 1990 according the data of Estonian State Forest Protection Service (no data of Statistics Estonia in 1990). In 1990–1997, the growing stock of perished stands is calculated according to the average growing stocks of perished stands by different damaging agents during years 1998–2013.

For calculating annual carbon losses in biomass due to disturbances, the *Tier 2* approach and Method 2 – the stock-difference method[364] was applied. Background level is presented in **Figure 11.6**, it is 167.2 kt CO_2 eq. The margin for the ND is 107.8 kt CO_2 eq., which equals twice the standard deviation of the time series 1990–2009 that defines the background level.

[364] IPCC 2006 Guidelines, Volume 4, Chapter 2: Methodologies Applicable to Multiple Land-Use Categories, page 2.18, equation 2.14.

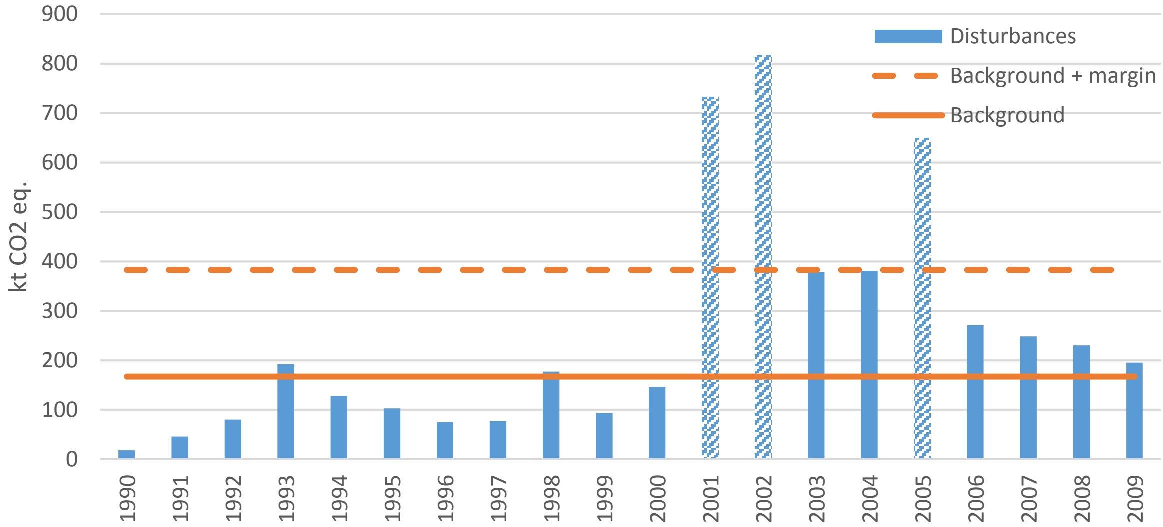

Figure 11.6. Emissions from natural disturbances in 1990-2009 with obtained background level and margin (outliers are marked with diagonal-lined bars), kt CO_2 eq.

Equation 2.14[365] is used to calculate the natural disturbances emissions for annual carbon loss in biomass due to disturbances. Country specific data was used to estimate the fraction of biomass lost in disturbance (fd) in Table 11.11. According to this the proportion of salvage logging was estimated to be 42 %. Wildfires annual emissions are estimated according to the methodology described in Chapter 6.8.

Table 11.11 Fraction of biomass lost in disturbances for national disturbances estimation

	fd
Insect attacks and disease infestation	0.9
Extreme weather events	0.9
Other (damages made by game animal)	0.78

11.5.2.5. Information on Harvested wood products under Article 3.4

Harvested wood products for Article 3.4 were calculated according to the IPCC guidelines and the same as described in Chapter 6.9.

Current forest management reference level (FMRL) is based on a projection; the emissions from harvested wood products originating from forests prior to the start of the second commitment period have been included in the accounting.

11.5.3. Information relating to Cropland management, Grazing land management, Revegetation and wetland drainage and rewetting if elected, for base year

Estonia did not elect any other activities under Article 3.4.

[365] 2006 IPCC Guidlines for National Greenhouse Gas Inventories p. 2.18

11.6. Other information

The Estonian Forestry Development Plan until 2020 was approved by the Parliament on 15 February 2011. The main aim of the Forestry Development Plan is to ensure sustainable Forest management.

At the moment, land reform in Estonia is coming to an end and no special measures regarding Afforestation, Reforestation and Deforestations are foreseen. Therefore, current trends are expected to continue and activities under Article 3.3 are expected to be a source of GHG emissions during the second commitment period.

11.6.1. Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

The basis for the assessment of key categories under Article 3.3 of the KP is the same as for the assessment made for the UNFCCC inventory. Key category analysis for KP-LULUCF was carried out in accordance with the chapter 2.3.6 of the 2013 Revised Supplementary Methods and Good Practice Guida

nce Arising from the Kyoto Protocol.

According to the IPCC GPG for LULUCF, the key categories for the Kyoto Protocol activities can be derived from the identified key categories in the UNFCCC inventory as follows. Whenever a category is identified as a key category in the UNFCCC inventory, the associated activity under the Kyoto Protocol can be considered as a key category in reporting under the Kyoto Protocol. According to this approach, all categories under Articles 3.3 of the Kyoto Protocol (Afforestation and Reforestation, Deforestation) and Forest management under Article 3.4 can be regarded as key categories.

11.7. Information relating to Article 6

No projects in this sector under Article 6 are implemented in Estonia.

12.INFORMATION ON ACCOUNTING OF KYOTO UNITS

12.1. Background information

The contents of the Standard Electronic Format report (hereinafter as SEF) for 2016 can be found as Annex 6 of this document. The SEF tables include information about AAU, ERU, CER, t-CER, l-CER and RMU in Estonian National Registry (hereinafter as NR) standing 31st of December 2016. In addition, the SEF includes information on transfers of the units during the year 2016.

12.2. Summary of information reported in the SEF tables

The total number of units in the NR at the beginning of the year 2016 was 113 261 158 AAUs, 6 437 491 ERUs and 654 680 CERs. In the end of the year the total balance of units was: 113 261 158 AAUs (90 835 022 in retirement, 216 300 in cancellation accounts and 2 340 907 in Article 3.3/3.4 Net-Source Cancellation accounts), 6 437 491 ERUs (4 255 338 in retirement account and in 54 815 in Article 3.3/3.4 Net-Source Cancellation accounts), 494 851 RMUs in Article 3.3/3.4 Net-Source Cancellation accounts and 654 680 CERs (214 157 in retirement account). Estonian NR did not contain any t-CERs or l-CERs nor were there any units on the t-CER and l-CER Replacement accounts.

The total amount of the units in the registry corresponded to 120 848 180.

12.3. Discrepancies and notifications

Information about discrepant transactions is included in SIAR report Annexes 2 and 3. Neither discrepancies nor notifications occurred in 2016. No actions were necessary to be taken as no discrepancies occurred during the reported period.

12.4. Publicly accessible information

Publicly accessible information is available on the webpage of Ministry of the Environment, under information about Kyoto protocol (http://www.envir.ee/et/kyoto-protokoll) as well as on the European Union registry webpage (https://ets-registry.webgate.ec.europa.eu/euregistry/EE/public/reports/publicReports.xhtml).

According to Annex to the Decision 13/CMP.1, II Registry requirements, point E the required public information includes:

- account information;
- JI projects in Estonia;
- information about unit holdings and transactions;
- information about entities authorized to hold units.

Public information required by Commission regulation (EC) No 920/2010 (in addition to the above-mentioned public information) is also available on the webpage of Ministry of the Environment, under information about EU ETS information (http://www.envir.ee/et/euroopa-liidu-kasvuhoonegaaside-heitkogustega-kauplemise-susteem and http://www.envir.ee/et/euroopa-liidu-kasvuhoonegaaside-heitkogustega-kauplemise-perioodid) as well as on the European Union Transaction Log webpage (http://ec.europa.eu/environment/ets/).

It includes:

- information about installations and permit details;
- information about verified emissions, surrenders and compliance status of installations;
- National allocation plan for Estonia and NIMs list.

12.5. Calculation of the commitment period reserve (CPR)

Parties are required by decision 11/CMP.1 under the Kyoto Protocol and paragraph 18 of Decision 1/CMP.8 to establish and maintain a commitment period reserve as part of their responsibility to manage and account for their assigned amount. The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8.

For the purposes of the joint fulfilment, the commitment period reserve applies to the EU, its Member States and Iceland individually.

Both methods to calculate Estonia's commitment period reserve are presented hereinafter:

1. 90% of a Party's assigned amount

90% from 51 056 976= 45 951 278.4 tonnes of CO_2 equivalent.

2. 100% of most recently reviewed inventory multiplied by 8 (Estonia has interpreted the 'most recently reviewed inventory' as the 2016 inventory submission)

21 059 240*8= 168 473 920 tonnes of CO_2 equivalent.

Consequently the commitment period reserve for Estonia is **45 951 279** tonnes of CO_2 equivalent.

12.6. KP-LULUCF accounting

The results of accounting procedure for the activites under Articles 3.3 and 3.4 of the Kyoto Protocol are presented in Table 12.1.

Table 12.1. Accounting quantities for activites under Articles 3.3 and 3.4

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Base Year[2]	NET EMISSIONS/REMOVALS									Accounting parameters	Accounting quantity [4]
		2013	2014	2015	2016	2017	2018	2019	2020	Total[3]		
	(kt CO_2 eq.)											
A. Article 3.3 activities												
A.1. Afforestation/reforestation		-147.67	-164.40	-177.80						-489.86		-489.86
Excluded emissions from natural disturbances[5]		NO	NO	NO						NO		NO
Excluded subsequent removals from land subject to natural disturbances[6]		NA	NA	NA						NA		NA
A.2. Deforestation		280.97	210.24	184.61						675.82		675.82
B. Article 3.4 activities												
B.1. Forest management										-9 474.11		-1 251.11
Net emissions/removals		-2 924.46	-3 031.13	-3 518.52						-9 474.11		
Excluded emissions from natural disturbances[5]		NO	NO	NO						NO		NO
Excluded subsequent removals from land subject to natural disturbances[6]		NO	NO	NO						NO		NO
Any debits from newly established forest (CEF-ne)[7],[8]		NA	NA	NA						NA		NA
Forest management reference level (FMRL)[9]											-2 741.00	
Technical corrections to FMRL[10]											NE	
Forest management cap[11]											11 199.08	-1 251.11
B.2. Cropland management (if elected)	NA	NA	NA	NA						NA		NA
B.3. Grazing land management (if elected)	NA	NA	NA	NA						NA		NA
B.4. Revegetation (if elected)	NA	NA	NA	NA						NA		NA
B.5. Wetland drainage and rewetting (if elected)	NA	NA	NA	NA						NA		NA

13.INFORMATION ON CHANGES IN NATIONAL SYSTEM

The National Forest Inventory (NFI) methodology was reviewed during the year 2016 and some major changes were made. More information concerning the changes made is presented in Chapter 6.1.3 National Forest Inventory.

14. INFORMATION ON CHANGES IN NATIONAL REGISTRY

The following changes to the national registry of Estonia have therefore occurred in 2016.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	The registry administrator was changed from Johanna-Maria Siilak to Piret Väinsalu. National administrator is: Ms. Piret Väinsalu khgregister@envir.ee tel. +372 6262 851
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality. Versions of the CSEUR released after 6.7.3 (the production version at the time of the last Chapter 14 submission) introduced other minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model, including the new tables, is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 6.7.3 of the national registry are listed in Annex B. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). Annex H testing was completed in January 2017 (see Annex H). No other change in the registry's conformance to the technical standards occurred for the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The mandatory use of hard tokens for authentication and signature was introduced for registry administrators.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 6.7.3 of the national registry are listed in Annex B. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission; the report is attached as Annex B. Annex H testing was carried out in January 2017 and the test report is attached as Annex H.

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

15.1. Information on how Estonia is striving, under Article 3, paragraph 14, of the Kyoto Protocol, to implement the commitments mentioned in Article 3, paragraph 1, of the Kyoto Protocol in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention

Estonia is acting together with other Parties in the European Union to fulfil the commitments under the Kyoto Protocol.

European Union has agreed a forward-looking political agenda to achieve its core energy objectives of sustainability, competitiveness and security of supply, by reducing greenhouse gas emissions by 20%, increasing the share of renewables in the energy consumption to 20% and improving energy efficiency by 20%, all of it by 2020.

Two major EU Directives, the Directive on the promotion of the use of renewable energy (Directive 2009/28/EC) and as well as the extension of the EU emission trading scheme to the aviation sector (Directive 2008/101/EC) are more related with potential impacts on third countries.

Estonia has provided information on minimization of adverse impacts in accordance with Article 3, paragraph 14 in its previous national inventory reports under the Kyoto Protocol. The information is provided in accordance with the guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol (Decision 15/CMP.1, Section H.).

15.2. Information on how Estonia gives priority, in implementing the commitments under Article 3, paragraph 14, to specific actions

Estonia reports activities that are related to the actions specified in the subparagraphs (a) to (f) of paragraph 24 of the reporting requirements in the Annex to decision 15/CMP.1.

a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities

Several fiscal measures have been introduced in Estonia to support sustainable energy consumption and reduce GHG emissions. For example excise duties on fuels and pollution charges. Current tax rates are stipulated in the *Alcohol, Tobacco, Fuel and Electricity Excise Duty Act*.

The Government's tax policy is based on objectives aimed at reducing environmental impact by increasing the rates of charges on pollution and resource use. According to the *Environmental Charges Act* (enforced in 2006), pollution charges and charges on the use of natural resources will be gradually increased in subsequent years. The sums derived from environmental charges go to the state budget and are mainly directed to environmental protection projects through the Environmental Investment Centre.

The Environmental Charges Act (enforced in 2006) obliges the owners of combustion equipment to pay pollution charges for several pollutants emitted into the air. The pollution charge in the case of emissions into ambient air must be paid by all enterprises that are required to have an air pollution permit. According to the regulation of the Minister of the Environment the air pollution permit is obligatory for all enterprises which own and operate combustion equipment (utilizing solid, liquid or gas fuel) with a rated capacity equal to or higher than 0.3 MW in one location. As an exception, the CO_2 charge must only be paid by enterprises producing heat.

The Environmental Charges Act provides the option of replacing the pollution charge (incl. the CO_2 charge) with environmental investment by enterprises. The financing replaces the pollution charge if the polluter implements, at its own expense, environmental protection measures that reduce pollutants or waste by 15 percent from their initial value.

Estonia as a Member State of the EU has to comply with the EU requirements (Directive 2003/96/EC) for the taxation of fuels and energy. Estonia has been granted some transitional period for the introduction of relevant taxes. Regarding oil shale, Directive 2004/74/EC stipulates that until 1 January 2013 Estonia is allowed to apply a reduced level of taxation for oil shale, provided that it does not result in taxation falling below 50 per cent of the relevant Community minimum rate as of 1 January 2011. Regarding shale oil (oil produced from oil shale), Estonia was eligible to apply a transitional period until 1 January 2010 to adjust the national level of taxation on shale oil used for district heating purposes to the EU minimum level of taxation. Nevertheless, Estonia had already introduced the tax on shale oil. The tax exemption for natural gas (methane) is permitted by Directive 2003/96/EC, which allows an exemption on natural gas in those Member States where the share of natural gas in energy end-use was less than 15% in 2000. The exemption applies for a maximum of ten years after the directive's entry into force or until the national share of natural gas in energy end-use reaches 25%, whichever comes first. Actually, Estonia imposed excise duty on natural gas on 1 January 2008 already. Directive 2004/74/EC allowed Estonia to apply a transitional period until 1 January 2010 to introduce output taxation on electricity. Despite this exemption, Estonia introduced an excise duty on electricity on 1 January 2008. It should be noted that some excise rates exceed the minimum level provided by Directive 2003/96/EC: for example, for light fuel oil (gas oil) the rate is 5.3 times higher, while for electricity it is 4.5 times higher (non-business use) or 8.9 times higher (business use).

b) Removing subsidies associated with the use of environmentally unsound and unsafe Technologies

No subsidies for environmentally unsound and unsafe technologies have been implemented. Estonia's tax system is presented shortly above (Paragraph 24a) and through this tax system Estonia promotes sustainable production and technologies.

c) Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end

The Government of Estonia is committed to fight against global climate change, focusing especially on the situation in the least developed countries.

Estonia is looking into the possibilities of also involving the private sector in financing climate cooperation with developing countries. For this we are conducting a feasibility study to identify Estonia's cleantech and green growth sectors with the biggest export potential, where the interest of private sector actors to participate in cooperation efforts would consequently also be higher.

Based on the results of the study we will be able to identify climate policy objectives related projects with the highest potential and based on this take the next steps in planning and negotiating the use of the pledged financial support.

d) Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non- Annex I Parties in this effort

Estonia has done research for enhancing technologies that emit less GHGs but at the moment there is no cooperation with developing countries in this field.

e) Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities

Since 2009 Estonia has contributed to the Eastern Europe Energy Efficiency and Environment Partnership Fund. The E5P Fund has supported energy efficiency and environmental sustainability projects mainly in Ukraine, but since 2013 the activities of the Fund have been extended also to Georgia, Moldova and Armenia. Estonia has taken a long-term commitment to support Ukraine with 160 000 EUR, and since 2013 (until 2018) to support Moldova with 200 000 EUR and Georgia with 150 000 EUR.

f) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies

Since 2008 Estonia has contributed annually to the Neighborhood Investment Facility Trust Fund. The total funding 3M EUR for 2008–2016 was earmarked to the Eastern region of European Neighborhood and Partnership Instrument (including Georgia and Republic of Moldova). Trust Fund supports strengthening of infrastructure interconnections between the EU and its neighbors in the areas of transport and energy, addressing common environmental concerns and supports other relevant activities.

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ANNEXES TO THE NATIONAL INVENTORY REPORT

Annex 1. Key categories

This annex contains the detailed information on key categories.
The following tables are provided:

- Tier 1 and Tier 2 level assessment year 1990 without LULUCF;
- Tier 1 and Tier 2 level assessment year 1990 with LULUCF;
- Tier 1 and Tier 2 level assessment year 2014 without LULUCF;
- Tier 1 and Tier 2 level assessment year 2014 with LULUCF;
- Tier 1 and Tier 2 trend assessment without LULUCF; and
- Tier 1 and Tier 2 trend assessment with LULUCF.

The tables follow the format and methodology (Tier 1 and Tier 2) suggested in 2006 IPCC Guidelines.

Tier A.1.1. Tier 1 level assessment year 1990 without LULUCF

IPCC Source Category	Gas	Emissions 1990	Tier 1 level assessment	Cumulative total of column E
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	22109.12	0.547	0.547
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	4896.72	0.121	0.668
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2234.50	0.055	0.724
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO2	1977.19	0.049	0.773
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	755.62	0.019	0.791
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	707.62	0.018	0.809
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CO2	626.49	0.016	0.824
1.A.4.b Other Sectors/Residential - Liquid Fuels	CO2	544.28	0.013	0.838
2.A.1 Cement production	CO2	483.04	0.012	0.850
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	482.27	0.012	0.862
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	CO2	437.45	0.011	0.873
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	CO2	428.20	0.011	0.883
1.A.4.b Other Sectors/Residential - Peat	CO2	339.10	0.008	0.892
1.A.4.b Other Sectors/Residential - Solid Fuels	CO2	337.67	0.008	0.900
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	337.35	0.008	0.908
2.B.1 Ammonia production	CO2	307.73	0.008	0.916
5.A Solid waste disposal	CH4	213.72	0.005	0.921
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	189.26	0.005	0.926
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CO2	188.11	0.005	0.931
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CO2	186.95	0.005	0.935
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N2O	170.32	0.004	0.939
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	CO2	167.24	0.004	0.943
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	162.12	0.004	0.948
1.A.3.c Transport/Railways - Liquid Fuels	CO2	142.55	0.004	0.951

IPCC Source Category	Gas	Emissions 1990	Tier 1 level assessment	Cumulative total of column E
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Liquid Fuels	CO2	139.63	0.003	0.954

Table A.1.2. Tier 1 level assessment year 2015 without LULUCF

IPCC Source Category	Gas	Emissions 2015	Tier 1 level assessment	Cumulative total of column E
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	9862.83	0.547	0.547
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2192.85	0.122	0.668
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CO2	1208.77	0.067	0.735
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO2	583.03	0.032	0.768
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	327.76	0.018	0.786
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	CO2	281.34	0.016	0.801
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	260.21	0.014	0.816
2.A.1 Cement production	CO2	205.61	0.011	0.827
5.A Solid waste disposal	CH4	187.28	0.010	0.838
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	183.73	0.010	0.848
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	167.67	0.009	0.857
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO2	144.78	0.008	0.865
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	139.75	0.008	0.873
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CO2	129.31	0.007	0.880
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CO2	128.71	0.007	0.887
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	123.77	0.007	0.894
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CO2	115.17	0.006	0.900
1.A.4.b Other Sectors/Residential - Gaseous Fuels	CO2	114.80	0.006	0.907
1.A.4.b Other Sectors/Residential - Biomass	CH4	113.50	0.006	0.913
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	90.88	0.005	0.918
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	83.98	0.005	0.923
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	CO2	76.31	0.004	0.927
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N2O	67.81	0.004	0.931
2.F.1.a Commercial Refrigeration	HFC	62.56	0.003	0.934
1.A.3.c Transport/Railways - Liquid Fuels	CO2	59.41	0.003	0.937
5.D.1 Domestic wastewater	CH4	49.35	0.003	0.940
3.D.1.2a Direct Soil Emissions - Animal Manure Applied to Soils	N2O	46.96	0.003	0.943
1.A.4.b Other Sectors/Residential - Liquid Fuels	CO2	45.41	0.003	0.945
2.F.1.c Industrial Refrigeration	HFC	43.31	0.002	0.948
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	CO2	39.63	0.002	0.950
2.A.2 Lime production	CO2	38.70	0.002	0.952
3.D.2.1 Indirect Emissions - Atmospheric Deposition	N2O	36.07	0.002	0.954

Table A.1.3. Tier 1 trend assessment without LULUCF

IPCC Source Category	Gas	Emissions 1990	Emissions 2015	Tier 1 trend assess ment	% Contributio n to Trend	Cumulative total of column F
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	4896.72	260.21	0.239	0.250	0.250
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2234.50	2192.85	0.148	0.155	0.406
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CO2	86.10	1208.77	0.145	0.152	0.558
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO2	1977.19	583.03	0.037	0.039	0.597
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CO2	626.49	0.00	0.035	0.036	0.633
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	755.62	123.77	0.027	0.028	0.661
1.A.4.b Other Sectors/Residential - Liquid Fuels	CO2	544.28	45.41	0.025	0.026	0.687
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	CO2	437.45	2.31	0.024	0.025	0.712
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO2	0.00	144.78	0.018	0.019	0.730
1.A.4.b Other Sectors/Residential - Peat	CO2	339.10	10.66	0.017	0.018	0.749
1.A.4.b Other Sectors/Residential - Solid Fuels	CO2	337.67	11.20	0.017	0.018	0.767
2.B.1 Ammonia production	CO2	307.73	0.00	0.017	0.018	0.785
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CO2	0.00	115.17	0.014	0.015	0.800
1.A.4.b Other Sectors/Residential - Biomass	CH4	40.08	113.50	0.012	0.012	0.812
5.A Solid waste disposal	CH4	213.72	187.28	0.011	0.012	0.824
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	CO2	428.20	281.34	0.011	0.012	0.836
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	CO2	167.24	6.68	0.008	0.009	0.845
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	CO2	20.43	76.31	0.008	0.009	0.853
1.A.4.b Other Sectors/Residential - Gaseous Fuels	CO2	116.78	114.80	0.008	0.008	0.861
2.F.1.a Commercial Refrigeration	HFC	0.00	62.56	0.008	0.008	0.870
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Liquid Fuels	CO2	139.63	2.40	0.007	0.008	0.877
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	189.26	139.75	0.007	0.007	0.885
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CO2	188.11	129.31	0.006	0.006	0.890
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CO2	186.95	128.71	0.006	0.006	0.896
2.F.1.c Industrial Refrigeration	HFC	0.00	43.31	0.005	0.006	0.902
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	92.58	83.98	0.005	0.006	0.908

IPCC Source Category	Gas	Emissions 1990	Emissions 2015	Tier 1 trend assess ment	% Contributio n to Trend	Cumulative total of column F
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	482.27	183.73	0.004	0.004	0.912
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	CO2	21.79	39.63	0.004	0.004	0.916
2.F.1.d Mobile Air-Conditioning - Passenger cars	HFC	0.00	28.70	0.004	0.004	0.919
2.F.1.d Refrigerated Vehicles	HFC	0.00	24.86	0.003	0.003	0.922
2.F.1.e Stationary and Room Air-Conditioning	HFC	0.00	23.51	0.003	0.003	0.926
5.E Other (Biogas Burnt in a flare)	CH4	0.00	21.46	0.003	0.003	0.928
1.A.2.c Manufacturing Industries and Construction/Chemicals - Liquid Fuels	CO2	12.67	26.88	0.003	0.003	0.931
2.A.2 Lime production	CO2	129.69	38.70	0.002	0.002	0.934
1.A.1.a Energy Industries/Public Electricity and Heat Production - Biomass	N2O	2.75	20.07	0.002	0.002	0.936
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	162.12	90.88	0.002	0.002	0.938
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	337.35	167.67	0.002	0.002	0.941
3.B.1.1 Manure Management - Dairy Cattle	CH4	28.07	29.39	0.002	0.002	0.943
1.A.2.g Manufacturing Industries and Construction/Other - Solid Fuels	CO2	37.81	0.09	0.002	0.002	0.945
1.A.4.b Other Sectors/Residential - Biomass	N2O	6.37	18.04	0.002	0.002	0.947
5.B.1 Composting	CH4	0.68	15.00	0.002	0.002	0.949
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	N2O	41.84	32.75	0.002	0.002	0.951
5.D.1 Domestic wastewater	N2O	38.63	30.10	0.002	0.002	0.952
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Gaseous Fuels	CO2	0.00	12.81	0.002	0.002	0.954

Table A.1.4. Tier 1 level assessment year 1990 with LULUCF

IPCC Source Category	Gas	Emissions 1990	Emissions 1990 (ABS)	Tier 1 level assessm ent	Cumulati ve total of column E
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	22109.12	22109.12	0.480	0.480
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	4896.72	4896.72	0.106	0.587
4.A.1. Forest Land remaining Forest Land - living biomass	CO2	-2253.34	2253.34	0.049	0.636
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2234.50	2234.50	0.049	0.684
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO2	1977.19	1977.19	0.043	0.727
4.D.1 Wetlands remaining Wetlands\Peatland - organic soils managed for peat extraction CO2	CO2	1070.69	1070.69	0.023	0.750
4.A.1. Forest Land remaining Forest Land - mineral soils	CO2	-914.61	914.61	0.020	0.770
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	755.62	755.62	0.016	0.787
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	707.62	707.62	0.015	0.802
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CO2	626.49	626.49	0.014	0.815

IPCC Source Category	Gas	Emissions 1990	Emissions 1990 (ABS)	Tier 1 level assessment	Cumulative total of column E
1.A.4.b Other Sectors/Residential - Liquid Fuels	CO2	544.28	544.28	0.012	0.827
2.A.1 Cement production	CO2	483.04	483.04	0.010	0.838
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	482.27	482.27	0.010	0.848
4.B.1 Cropland remaining Cropland - organic soils	CO2	453.05	453.05	0.010	0.858
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	CO2	437.45	437.45	0.010	0.868
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	CO2	428.20	428.20	0.009	0.877
4.A.1. Forest Land remaining Forest Land - organic soils	CO2	353.21	353.21	0.008	0.885
4.B.1 Cropland remaining Cropland - mineral soils	CO2	-350.92	350.92	0.008	0.892
1.A.4.b Other Sectors/Residential - Peat	CO2	339.10	339.10	0.007	0.900
1.A.4.b Other Sectors/Residential - Solid Fuels	CO2	337.67	337.67	0.007	0.907
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	337.35	337.35	0.007	0.914
2.B.1 Ammonia production	CO2	307.73	307.73	0.007	0.921
5.A Solid waste disposal	CH4	213.72	213.72	0.005	0.926
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	189.26	189.26	0.004	0.930
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CO2	188.11	188.11	0.004	0.934
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CO2	186.95	186.95	0.004	0.938
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N2O	170.32	170.32	0.004	0.942
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	CO2	167.24	167.24	0.004	0.945
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	162.12	162.12	0.004	0.949
4.A.1. Forest Land remaining Forest Land - dead wood	CO2	-152.70	152.70	0.003	0.952

Table A.1.5. Tier 1 level assessment year 2015 with LULUCF

IPCC Source Category	Gas	Emissions 2015	Emissions 2015 (ABS)	Tier 1 level assessment	Cumulative total of column E
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	9862.83	9862.83	0.397	0.397
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2192.85	2192.85	0.088	0.486
4.A.1. Forest Land remaining Forest Land - living biomass	CO2	-1713.10	1713.10	0.069	0.555
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CO2	1208.77	1208.77	0.049	0.603
Wood panels and sawnwood	CO2	-1062.63	1062.63	0.043	0.646
4.A.1. Forest Land remaining Forest Land - mineral soils	CO2	-916.15	916.15	0.037	0.683
4.D.1 Wetlands remaining Wetlands\Peatland - organic soils managed for peat extraction CO2	CO2	779.45	779.45	0.031	0.714

IPCC Source Category	Gas	Emissions 2015	Emissions 2015 (ABS)	Tier 1 level assessment	Cumulative total of column E
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO2	583.03	583.03	0.023	0.738
4.B.1 Cropland remaining Cropland - organic soils	CO2	385.39	385.39	0.016	0.753
4.A.1. Forest Land remaining Forest Land - organic soils	CO2	354.68	354.68	0.014	0.768
4.B.1 Cropland remaining Cropland - mineral soils	CO2	-342.37	342.37	0.014	0.781
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	327.76	327.76	0.013	0.795
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	CO2	281.34	281.34	0.011	0.806
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	260.21	260.21	0.010	0.816
2.A.1 Cement production	CO2	205.61	205.61	0.008	0.825
5.A Solid waste disposal	CH4	187.28	187.28	0.008	0.832
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	183.73	183.73	0.007	0.840
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	167.67	167.67	0.007	0.846
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO2	144.78	144.78	0.006	0.852
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	139.75	139.75	0.006	0.858
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CO2	129.31	129.31	0.005	0.863
4.C.2 Land converted to Grassland – mineral soils	CO2	-128.71	128.71	0.005	0.868
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CO2	128.71	128.71	0.005	0.873
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	123.77	123.77	0.005	0.878
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CO2	115.17	115.17	0.005	0.883
1.A.4.b Other Sectors/Residential - Gaseous Fuels	CO2	114.80	114.80	0.005	0.888
4.A.1. Forest Land remaining Forest Land - dead wood	CO2	-114.09	114.09	0.005	0.892
1.A.4.b Other Sectors/Residential - Biomass	CH4	113.50	113.50	0.005	0.897
4.A.2.1. Cropland converted to Forest Land - mineral soil	CO2	106.75	106.75	0.004	0.901
4.A.2.2. Grassland converted to Forest Land - living biomass	CO2	-99.15	99.15	0.004	0.905
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	90.88	90.88	0.004	0.909
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	83.98	83.98	0.003	0.912
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	CO2	76.31	76.31	0.003	0.915

IPCC Source Category	Gas	Emissions 2015	Emissions 2015 (ABS)	Tier 1 level assessment	Cumulative total of column E
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N2O	67.81	67.81	0.003	0.918
4.C.2.1 Forest Land converted to Grassland - living biomass	CO2	66.42	66.42	0.003	0.921
2.F.1.a Commercial Refrigeration	HFC	62.56	62.56	0.003	0.923
1.A.3.c Transport/Railways - Liquid Fuels	CO2	59.41	59.41	0.002	0.926
4.C.2 Land converted to Grassland – organic soils	CO2	52.48	52.48	0.002	0.928
4.C.1 Grassland remaining Grassland – organic soils	CO2	51.65	51.65	0.002	0.930
4.B.2.2 Grassland converted to Cropland - mineral soils	CO2	50.16	50.16	0.002	0.932
5.D.1 Domestic wastewater	CH4	49.35	49.35	0.002	0.934
4.A.2.2. Grassland converted to Forest Land - dead wood	CO2	-47.07	47.07	0.002	0.936
3.D.1.2a Direct Soil Emissions - Animal Manure Applied to Soils	N2O	46.96	46.96	0.002	0.938
4.E.2.2 Cropland converted to Settlements - soils	CO2	45.77	45.77	0.002	0.939
1.A.4.b Other Sectors/Residential - Liquid Fuels	CO2	45.41	45.41	0.002	0.941
2.F.1.c Industrial Refrigeration	HFC	43.31	43.31	0.002	0.943
4.E.2.1 Forest Land converted to Settlements – living biomass	CO2	42.33	42.33	0.002	0.945
4.E.2.3 Grassland converted to Settlements - soils	CO2	42.28	42.28	0.002	0.946
4.E.2.1 Forest Land converted to Settlements (min+org soils)	CO2	41.47	41.47	0.002	0.948
4.E.2.1 Forest Land converted to Settlements – deadwood	CO2	39.87	39.87	0.002	0.950
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	CO2	39.63	39.63	0.002	0.951
2.A.2 Lime production	CO2	38.70	38.70	0.002	0.953
4.A.2.1. Cropland converted to Forest Land - dead wood	CO2	-38.01	38.01	0.002	0.954

Table A.1.6. Tier 1 trend assessment with LULUCF

IPCC Source Category	Gas	Emissions 1990	Emissions 2015	Emissions 2015 (ABS)	Tier 1 trend assessment	% Contribution to Trend	Cumulative total of column F
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	4896.72	260.21	260.21	0.271	0.134	0.134
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2234.50	2192.85	2192.85	0.202	0.100	0.235
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CO2	86.10	1208.77	1208.77	0.185	0.091	0.326
Wood panels and sawnwood	CO2	0.00	-1062.63	1062.63	0.167	0.083	0.409
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	22109.12	9862.83	9862.83	0.141	0.070	0.479

IPCC Source Category	Gas	Emissions 1990	Emissions 2015	Emissions 2015 (ABS)	Tier 1 trend assess ment	% Contrib ution to Trend	Cumul ative total of column F
4.A.1. Forest Land remaining Forest Land - living biomass	CO2	-2253.34	-1713.10	1713.10	0.126	0.062	0.541
4.A.1. Forest Land remaining Forest Land - mineral soils	CO2	-914.61	-916.15	916.15	0.086	0.042	0.583
4.D.1 Wetlands remaining Wetlands\Peatland - organic soils managed for peat extraction CO2	CO2	1070.69	779.45	779.45	0.054	0.027	0.610
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CO2	626.49	0.00	0.00	0.040	0.020	0.630
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO2	1977.19	583.03	583.03	0.034	0.017	0.647
4.A.1. Forest Land remaining Forest Land - organic soils	CO2	353.21	354.68	354.68	0.033	0.016	0.663
4.B.1 Cropland remaining Cropland - organic soils	CO2	453.05	385.39	385.39	0.032	0.016	0.679
4.B.1 Cropland remaining Cropland - mineral soils	CO2	-350.92	-342.37	342.37	0.031	0.016	0.695
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	755.62	123.77	123.77	0.029	0.014	0.709
1.A.4.b Other Sectors/Residential - Liquid Fuels	CO2	544.28	45.41	45.41	0.028	0.014	0.723
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	CO2	437.45	2.31	2.31	0.028	0.014	0.736
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO2	0.00	144.78	144.78	0.023	0.011	0.747
4.C.2 Land converted to Grassland – mineral soils	CO2	-0.42	-128.71	128.71	0.020	0.010	0.757
1.A.4.b Other Sectors/Residential - Peat	CO2	339.10	10.66	10.66	0.020	0.010	0.767
1.A.4.b Other Sectors/Residential - Solid Fuels	CO2	337.67	11.20	11.20	0.020	0.010	0.777
2.B.1 Ammonia production	CO2	307.73	0.00	0.00	0.020	0.010	0.787
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CO2	0.00	115.17	115.17	0.018	0.009	0.796
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	CO2	428.20	281.34	281.34	0.017	0.008	0.804
4.A.2.1. Cropland converted to Forest Land - mineral soil	CO2	2.89	106.75	106.75	0.017	0.008	0.812
5.A Solid waste disposal	CH4	213.72	187.28	187.28	0.016	0.008	0.820
1.A.4.b Other Sectors/Residential - Biomass	CH4	40.08	113.50	113.50	0.015	0.008	0.828
4.A.2.2. Grassland converted to Forest Land - living biomass	CO2	-10.29	-99.15	99.15	0.015	0.007	0.835
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	CO2	20.43	76.31	76.31	0.011	0.005	0.841
1.A.4.b Other Sectors/Residential - Gaseous Fuels	CO2	116.78	114.80	114.80	0.011	0.005	0.846
4.C.2.1 Forest Land converted to Grassland - living biomass	CO2	0.00	66.42	66.42	0.010	0.005	0.851
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	189.26	139.75	139.75	0.010	0.005	0.856
2.F.1.a Commercial Refrigeration	HFC	0.00	62.56	62.56	0.010	0.005	0.861

IPCC Source Category	Gas	Emissions 1990	Emissions 2015	Emissions 2015 (ABS)	Tier 1 trend assess ment	% Contrib ution to Trend	Cumul ative total of column F
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	CO2	167.24	6.68	6.68	0.010	0.005	0.865
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Liquid Fuels	CO2	139.63	2.40	2.40	0.009	0.004	0.870
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CO2	188.11	129.31	129.31	0.008	0.004	0.874
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CO2	186.95	128.71	128.71	0.008	0.004	0.878
4.A.1. Forest Land remaining Forest Land - dead wood	CO2	-152.70	-114.09	114.09	0.008	0.004	0.882
4.C.2 Land converted to Grassland – organic soils	CO2	1.63	52.48	52.48	0.008	0.004	0.886
4.B.2.2 Grassland converted to Cropland - mineral soils	CO2	0.00	50.16	50.16	0.008	0.004	0.890
4.A.2.2. Grassland converted to Forest Land - dead wood	CO2	-1.01	-47.07	47.07	0.007	0.004	0.894
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	92.58	83.98	83.98	0.007	0.004	0.897
4.E.2.2 Cropland converted to Settlements - soils	CO2	0.00	45.77	45.77	0.007	0.004	0.901
2.F.1.c Industrial Refrigeration	HFC	0.00	43.31	43.31	0.007	0.003	0.904
4.E.2.1 Forest Land converted to Settlements – living biomass	CO2	0.00	42.33	42.33	0.007	0.003	0.907
4.E.2.3 Grassland converted to Settlements - soils	CO2	0.00	42.28	42.28	0.007	0.003	0.911
4.E.2.1 Forest Land converted to Settlements (min+org soils)	CO2	0.00	41.47	41.47	0.007	0.003	0.914
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	707.62	327.76	327.76	0.006	0.003	0.917
4.E.2.1 Forest Land converted to Settlements – deadwood	CO2	0.00	39.87	39.87	0.006	0.003	0.920
4.A.2.1. Cropland converted to Forest Land - dead wood	CO2	-0.52	-38.01	38.01	0.006	0.003	0.923
Semi-Chemical wood pulp	CO2	0.00	-33.56	33.56	0.005	0.003	0.926
4.A.2.2. Grassland converted to Forest Land - mineral soils	CO2	0.58	32.31	32.31	0.005	0.002	0.928
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	337.35	167.67	167.67	0.005	0.002	0.931
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	CO2	21.79	39.63	39.63	0.005	0.002	0.933
2.F.1.e Mobile Air-Conditioning - Passenger cars	HFC	0.00	28.70	28.70	0.005	0.002	0.935
4.C.1 Grassland remaining Grassland – organic soils	CO2	58.79	51.65	51.65	0.004	0.002	0.937
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	162.12	90.88	90.88	0.004	0.002	0.939
2.F.1.d Refrigerated Vehicles	HFC	0.00	24.86	24.86	0.004	0.002	0.941
2.F.1.f Stationary and Room Air-Conditioning	HFC	0.00	23.51	23.51	0.004	0.002	0.943
4.B.2.2 Grassland converted to Cropland - organic soils	CO2	0.00	22.88	22.88	0.004	0.002	0.945
1.A.2.c Manufacturing Industries and Construction/Chemicals - Liquid Fuels	CO2	12.67	26.88	26.88	0.003	0.002	0.947
5.E Other (Biogas Burnt in a flare)	CH4	0.00	21.46	21.46	0.003	0.002	0.948
4.C.2 Land converted to Grassland – living biomass (excl. FL)	CO2	0.00	-20.16	20.16	0.003	0.002	0.950

IPCC Source Category	Gas	Emissions 1990	Emissions 2015	Emissions 2015 (ABS)	Tier 1 trend assess ment	% Contrib ution to Trend	Cumul ative total of column F
1.A.1.a Energy Industries/Public Electricity and Heat Production - Biomass	N2O	2.75	20.07	20.07	0.003	0.001	0.951
3.B.1.1 Manure Management - Dairy Cattle	CH4	28.07	29.39	29.39	0.003	0.001	0.953
4.C.2.1 Forest Land converted to Grassland - dead wood	CO2	0.00	16.47	16.47	0.003	0.001	0.954

Table A.1.7. Tier 2 level assessment year 1990 without LULUCF

IPCC Source Category	Gas	Emissions 1990	Lxt	Uxt	Tier 2 level assessme nt	Normalised Tier 2 level assessment	Cumulat ive total of column H
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	22109.12	0.547	4.1%	0.022	0.150	0.150
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	337.35	0.008	200.2%	0.017	0.112	0.262
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	162.12	0.004	287.3%	0.012	0.077	0.340
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	189.26	0.005	202.2%	0.009	0.064	0.403
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N2O	170.32	0.004	212.4%	0.009	0.060	0.463
3.D.2.1 Indirect Emissions - Atmospheric Deposition	N2O	72.52	0.002	435.2%	0.008	0.052	0.516
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	755.62	0.019	39.0%	0.007	0.049	0.565
3.B.2.5 Indirect N2O Emissions from Manure Management	N2O	64.60	0.002	403.4%	0.006	0.043	0.608
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CO2	626.49	0.016	39.0%	0.006	0.041	0.649
3.D.1.2a Direct Soil Emissions - Animal Manure Applied to Soils	N2O	103.57	0.003	212.4%	0.005	0.037	0.686
5.A Solid waste disposal	CH4	213.72	0.005	88.9%	0.005	0.032	0.717
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	92.58	0.002	201.1%	0.005	0.031	0.748
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	707.62	0.018	22.4%	0.004	0.026	0.775

IPCC Source Category	Gas	Emissions 1990	Lxt	Uxt	Tier 2 level assessment	Normalised Tier 2 level assessment	Cumulative total of column H
1.A.4.b Other Sectors/Residential - Peat	CO2	339.10	0.008	39.0%	0.003	0.022	0.797
1.A.4.b Other Sectors/Residential - Solid Fuels	CO2	337.67	0.008	39.0%	0.003	0.022	0.818
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	4896.72	0.121	2.5%	0.003	0.020	0.839
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	482.27	0.012	22.4%	0.003	0.018	0.857
5.D.1 Domestic wastewater	CH4	112.70	0.003	89.7%	0.003	0.017	0.873
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO2	1977.19	0.049	3.9%	0.002	0.013	0.886
1.A.4.b Other Sectors/Residential - Biomass	CH4	40.08	0.001	150.3%	0.001	0.010	0.896

Table A.1.8. Tier 2 level assessment year 2015 without LULUCF

IPCC Source Category	Gas	Emissions 2015	Lxt	Uxt	Tier 2 level assessment	Normalised Tier 2 level assessment	Cumulative total of column H
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CO2	1208.77	0.067	39.04%	0.026	0.130	0.130
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	9862.83	0.547	4.07%	0.022	0.111	0.240
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	167.67	0.009	200.25%	0.019	0.092	0.333
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	139.75	0.008	202.24%	0.016	0.078	0.411
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	90.88	0.005	287.28%	0.014	0.072	0.482
1.A.4.b Other Sectors/Residential - Biomass	CH4	113.50	0.006	150.33%	0.009	0.047	0.529
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	83.98	0.005	201.14%	0.009	0.046	0.576
5.A Solid waste disposal	CH4	187.28	0.010	88.86%	0.009	0.046	0.622
3.D.2.1 Indirect Emissions - Atmospheric Deposition	N2O	36.07	0.002	435.20%	0.009	0.043	0.665
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N2O	67.81	0.004	212.37%	0.008	0.040	0.705
3.B.2.5 Indirect N2O Emissions from Manure Management	N2O	27.68	0.002	403.36%	0.006	0.031	0.735

IPCC Source Category	Gas	Emissions 2015	Lxt	Uxt	Tier 2 level assess ment	Norm alised Tier 2 level assess ment	Cumu lative total of colum n H
3.D.1.2a Direct Soil Emissions - Animal Manure Applied to Soils	N2O	46.96	0.003	212.37%	0.006	0.027	0.763
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO2	144.78	0.008	60.21%	0.005	0.024	0.787
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	327.76	0.018	22.36%	0.004	0.020	0.807
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CO2	115.17	0.006	60.21%	0.004	0.019	0.826
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2192.85	0.122	2.48%	0.003	0.015	0.841
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	123.77	0.007	39.04%	0.003	0.013	0.854
5.D.1 Domestic wastewater	CH4	49.35	0.003	89.72%	0.002	0.012	0.866
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	183.73	0.010	22.36%	0.002	0.011	0.878
5.D.1 Domestic wastewater	N2O	30.10	0.002	108.82%	0.002	0.009	0.887
1.A.4.b Other Sectors/Residential - Biomass	N2O	18.04	0.001	150.33%	0.002	0.007	0.894
3.D.1.2c Direct Soil Emissions - Compost Applied to Soils	N2O	12.84	0.001	201.00%	0.001	0.007	0.901

Table A.1.9. T2 trend assesment without LULUCF

IPCC Source Category	Gas	Emissi ons 1990	Emissi ons 2015	Txt	Uxt	Tier 2 trend assess ment	Norma lised Tier 2 trend assess ment	Cumula tive total of column I
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CO2	86.10	1208.77	0.145	39%	0.057	0.245	0.245
1.A.4.b Other Sectors/Residential - Biomass	CH4	40.08	113.50	0.012	150%	0.018	0.077	0.322
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	189.26	139.75	0.007	202%	0.014	0.060	0.382
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CO2	626.49	0.00	0.035	39%	0.014	0.059	0.440
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO2	0.00	144.78	0.018	60%	0.011	0.047	0.487
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	92.58	83.98	0.005	201%	0.011	0.046	0.533
1.A.2.f Manufacturing Industries and	CO2	755.62	123.77	0.027	39%	0.010	0.045	0.578

Construction/Non-metallic Minerals - Solid Fuels								
5.A Solid waste disposal	CH4	213.72	187.28	0.011	89%	0.010	0.044	0.621
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CO2	0.00	115.17	0.014	60%	0.009	0.037	0.659
1.A.4.b Other Sectors/Residential - Peat	CO2	339.10	10.66	0.017	39%	0.007	0.029	0.688
1.A.4.b Other Sectors/Residential - Solid Fuels	CO2	337.67	11.20	0.017	39%	0.007	0.029	0.717
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	162.12	90.88	0.002	287%	0.007	0.028	0.746
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	4896.72	260.21	0.239	2%	0.006	0.026	0.771
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	337.35	167.67	0.002	200%	0.004	0.018	0.790
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2234.50	2192.85	0.148	2%	0.004	0.016	0.805
3.D.1.2c Direct Soil Emissions - Compost Applied to Soils	N2O	0.58	12.84	0.002	201%	0.003	0.014	0.819
1.A.4.b Other Sectors/Residential - Biomass	N2O	6.37	18.04	0.002	150%	0.003	0.012	0.831
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N2O	170.32	67.81	0.001	212%	0.002	0.009	0.841
3.D.2.1 Indirect Emissions - Atmospheric Deposition	N2O	72.52	36.07	0.000	435%	0.002	0.009	0.849
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	CO2	21.79	39.63	0.004	50%	0.002	0.008	0.857
2.F.1.a Commercial Refrigeration	HFC	0.00	62.56	0.008	22%	0.002	0.007	0.865
5.D.1 Domestic wastewater	N2O	38.63	30.10	0.002	109%	0.002	0.007	0.872
2.F.1.c Industrial Refrigeration	HFC	0.00	43.31	0.005	30%	0.002	0.007	0.879
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO2	1977.19	583.03	0.037	4%	0.001	0.006	0.885
1.A.1.a Energy Industries/Public Electricity and Heat Production - Biomass	N2O	2.75	20.07	0.002	60%	0.001	0.006	0.892
5.B.1 Composting	CH4	0.68	15.00	0.002	76%	0.001	0.006	0.897
1.A.4.c.ii Other Sectors/Agriculture/Forestry/ Fishing/Off-road vehicles and other machinery - Liquid Fuels	N2O	41.84	32.75	0.002	75%	0.001	0.006	0.903

Table A.1.10. Tier 2 level assessment year 1990 with LULUCF

IPCC Source Category	Gas	Emissions 1990	Absolute value	Lxt	Uxt	Tier 2 level assessment	Normalised Tier 2 level assessment	Cumulative total of column I
4.A.1. Forest Land remaining Forest Land - living biomass	CO2	-2253.34	2253.34	0.049	47.0%	0.023	0.117	0.117
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	22109.12	22109.12	0.480	4.1%	0.020	0.100	0.217
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	337.35	337.35	0.007	200.2%	0.015	0.075	0.292
4.D.1 Wetlands remaining Wetlands\Peatland - organic soils managed for peat extraction CO2	CO2	1070.69	1070.69	0.023	55.0%	0.013	0.065	0.357
4.A.1. Forest Land remaining Forest Land - mineral soils	CO2	-914.61	914.61	0.020	60.0%	0.012	0.061	0.418
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	162.12	162.12	0.004	287.3%	0.010	0.052	0.470
4.B.1 Cropland remaining Cropland - organic soils	CO2	453.05	453.05	0.010	91.8%	0.009	0.046	0.516
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	189.26	189.26	0.004	202.2%	0.008	0.042	0.558
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N2O	170.32	170.32	0.004	212.4%	0.008	0.040	0.599
3.D.2.1 Indirect Emissions - Atmospheric Deposition	N2O	72.52	72.52	0.002	435.2%	0.007	0.035	0.634
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	755.62	755.62	0.016	39.0%	0.006	0.033	0.666
3.B.2.5 Indirect N2O Emissions from Manure Management	N2O	64.60	64.60	0.001	403.4%	0.006	0.029	0.695
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CO2	626.49	626.49	0.014	39.0%	0.005	0.027	0.722
3.D.1.2a Direct Soil Emissions - Animal Manure Applied to Soils	N2O	103.57	103.57	0.002	212.4%	0.005	0.024	0.747

IPCC Source Category	Gas	Emissions 1990	Absolute value	Lxt	Uxt	Tier 2 level assessment	Normalised Tier 2 level assessment	Cumulative total of column I
5.A Solid waste disposal	CH4	213.72	213.72	0.005	88.9%	0.004	0.021	0.768
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	92.58	92.58	0.002	201.1%	0.004	0.021	0.788
4.B.1 Cropland remaining Cropland - mineral soils	CO2	-350.92	350.92	0.008	50.1%	0.004	0.019	0.808
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	707.62	707.62	0.015	22.4%	0.003	0.018	0.825
4.A.1. Forest Land remaining Forest Land - organic soils	CO2	353.21	353.21	0.008	40.2%	0.003	0.016	0.841
1.A.4.b Other Sectors/Residential - Peat	CO2	339.10	339.10	0.007	39.0%	0.003	0.015	0.856
1.A.4.b Other Sectors/Residential - Solid Fuels	CO2	337.67	337.67	0.007	39.0%	0.003	0.015	0.870
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	4896.72	4896.72	0.106	2.5%	0.003	0.013	0.884
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	482.27	482.27	0.010	22.4%	0.002	0.012	0.896

Table A.1.11. Tier 2 level assessment year 2015 with LULUCF

IPCC Source Category	Gas	Emissions 2015	Absolute value	Lxt	Uxt	Tier 2 level assessment	Normalised Tier 2 level assessment	Cumulative total of column I
Wood panels and sawnwood	CO2	-1062.63	1062.63	0.043	101.7%	0.044	0.139	0.139
4.A.1. Forest Land remaining Forest Land - living biomass	CO2	-1713.10	1713.10	0.069	47.0%	0.032	0.103	0.242
4.A.1. Forest Land remaining Forest Land - mineral soils	CO2	-916.15	916.15	0.037	60.0%	0.022	0.071	0.313
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CO2	1208.77	1208.77	0.049	39.0%	0.019	0.061	0.373
4.D.1 Wetlands remaining Wetlands\Peatland - organic soils	CO2	779.45	779.45	0.031	55.0%	0.017	0.055	0.428

IPCC Source Category	Gas	Emissions 2015	Absolute value	Lxt	Uxt	Tier 2 level assess ment	Normalised Tier 2 level assessment	Cumulative total of column I
managed for peat extraction CO2								
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	9862.83	9862.83	0.397	4.1%	0.016	0.052	0.480
4.B.1 Cropland remaining Cropland - organic soils	CO2	385.39	385.39	0.016	91.8%	0.014	0.045	0.526
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	167.67	167.67	0.007	200.2%	0.014	0.043	0.569
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	139.75	139.75	0.006	202.2%	0.011	0.036	0.605
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	90.88	90.88	0.004	287.3%	0.011	0.034	0.638
4.B.1 Cropland remaining Cropland - mineral soils	CO2	-342.37	342.37	0.014	50.1%	0.007	0.022	0.660
1.A.4.b Other Sectors/Residential - Biomass	CH4	113.50	113.50	0.005	150.3%	0.007	0.022	0.682
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	83.98	83.98	0.003	201.1%	0.007	0.022	0.704
5.A Solid waste disposal	CH4	187.28	187.28	0.008	88.9%	0.007	0.021	0.725
3.D.2.1 Indirect Emissions - Atmospheric Deposition	N2O	36.07	36.07	0.001	435.2%	0.006	0.020	0.746
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N2O	67.81	67.81	0.003	212.4%	0.006	0.018	0.764
4.A.1. Forest Land remaining Forest Land - organic soils	CO2	354.68	354.68	0.014	40.2%	0.006	0.018	0.782
3.B.2.5 Indirect N2O Emissions from Manure Management	N2O	27.68	27.68	0.001	403.4%	0.004	0.014	0.797
3.D.1.2a Direct Soil Emissions - Animal Manure Applied to Soils	N2O	46.96	46.96	0.002	212.4%	0.004	0.013	0.810
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO2	144.78	144.78	0.006	60.2%	0.004	0.011	0.821

IPCC Source Category	Gas	Emissions 2015	Absolute value	Lxt	Uxt	Tier 2 level assess ment	Normalised Tier 2 level assessment	Cumulat ive total of column I
4.C.2 Land converted to Grassland – mineral soils	CO2	-128.71	128.71	0.005	61.3%	0.003	0.010	0.831
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	327.76	327.76	0.013	22.4%	0.003	0.009	0.840
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CO2	115.17	115.17	0.005	60.2%	0.003	0.009	0.849
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2192.85	2192.85	0.088	2.5%	0.002	0.007	0.856
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	123.77	123.77	0.005	39.0%	0.002	0.006	0.862
4.A.2.2. Grassland converted to Forest Land - living biomass	CO2	-99.15	99.15	0.004	48.5%	0.002	0.006	0.869
5.D.1 Domestic wastewater	CH4	49.35	49.35	0.002	89.7%	0.002	0.006	0.874
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	183.73	183.73	0.007	22.4%	0.002	0.005	0.880
4.A.2.1. Cropland converted to Forest Land - mineral soil	CO2	106.75	106.75	0.004	37.4%	0.002	0.005	0.885
4.C.2.1 Forest Land converted to Grassland - living biomass	CO2	66.42	66.42	0.003	60.0%	0.002	0.005	0.890
5.D.1 Domestic wastewater	N2O	30.10	30.10	0.001	108.8%	0.001	0.004	0.894
4.C.2 Land converted to Grassland – organic soils	CO2	52.48	52.48	0.002	59.7%	0.001	0.004	0.898
4.B.2.2 Grassland converted to Cropland - organic soils	CO2	22.88	22.88	0.001	122.4%	0.001	0.004	0.902

Table A.1.12. Tier 2 trend assessment with LULUCF

IPCC Source Category	Gas	Emissions 1990	Emissions 2015	Absolute value (2015)	Txt	Uxt	Tier 2 trend assessment	Normalised Tier 2 trend assesment	Cumulative total of column I
Wood panels and sawnwood	CO2	0.00	-1062.63	1062.63	0.167	101.7%	0.170	0.221	0.221
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CO2	86.10	1208.77	1208.77	0.185	39.0%	0.072	0.094	0.314
4.A.1. Forest Land remaining Forest Land - living biomass	CO2	-2253.34	-1713.10	1713.10	0.126	47.0%	0.059	0.077	0.391
4.A.1. Forest Land remaining Forest Land - mineral soils	CO2	-914.61	-916.15	916.15	0.086	60.0%	0.051	0.067	0.458
4.D.1 Wetlands remaining Wetlands\Peatland - organic soils managed for peat extraction CO2	CO2	1070.69	779.45	779.45	0.054	55.0%	0.030	0.039	0.497
4.B.1 Cropland remaining Cropland - organic soils	CO2	453.05	385.39	385.39	0.032	91.8%	0.029	0.038	0.534
1.A.4.b Other Sectors/Residential - Biomass	CH4	40.08	113.50	113.50	0.015	150.3%	0.023	0.030	0.564
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	189.26	139.75	139.75	0.010	202.2%	0.020	0.026	0.590
4.B.1 Cropland remaining Cropland - mineral soils	CO2	-350.92	-342.37	342.37	0.031	50.1%	0.016	0.020	0.611
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CO2	626.49	0.00	0.00	0.040	39.0%	0.016	0.020	0.631
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	92.58	83.98	83.98	0.007	201.1%	0.015	0.019	0.650
5.A Solid waste disposal	CH4	213.72	187.28	187.28	0.016	88.9%	0.014	0.018	0.668
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO2	0.00	144.78	144.78	0.023	60.2%	0.014	0.018	0.686

IPCC Source Category	Gas	Emissions 1990	Emissions 2015	Absolute value (2015)	Txt	Uxt	Tier 2 trend assessment	Normalised Tier 2 trend assessment	Cumulative total of column I
4.A.1. Forest Land remaining Forest Land - organic soils	CO2	353.21	354.68	354.68	0.033	40.2%	0.013	0.017	0.704
4.C.2 Land converted to Grassland – mineral soils	CO2	-0.42	-128.71	128.71	0.020	61.3%	0.012	0.016	0.720
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	162.12	90.88	90.88	0.004	287.3%	0.011	0.015	0.734
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	755.62	123.77	123.77	0.029	39.0%	0.011	0.015	0.749
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CO2	0.00	115.17	115.17	0.018	60.2%	0.011	0.014	0.763
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	337.35	167.67	167.67	0.005	200.2%	0.010	0.013	0.776
1.A.4.b Other Sectors/Residential - Peat	CO2	339.10	10.66	10.66	0.020	39.0%	0.008	0.010	0.786
1.A.4.b Other Sectors/Residential - Solid Fuels	CO2	337.67	11.20	11.20	0.020	39.0%	0.008	0.010	0.796
4.A.2.2. Grassland converted to Forest Land - living biomass	CO2	-10.29	-99.15	99.15	0.015	48.5%	0.007	0.009	0.805
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	4896.72	260.21	260.21	0.271	2.5%	0.007	0.009	0.814
4.C.2.1 Forest Land converted to Grassland - living biomass	CO2	0.00	66.42	66.42	0.010	60.0%	0.006	0.008	0.822
4.A.2.1. Cropland converted to Forest Land - mineral soil	CO2	2.89	106.75	106.75	0.017	37.4%	0.006	0.008	0.830

IPCC Source Category	Gas	Emissions 1990	Emissions 2015	Absolute value (2015)	Txt	Uxt	Tier 2 trend assessment	Normalised Tier 2 trend assessment	Cumulative total of column I
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	22109.12	9862.83	9862.83	0.141	4.1%	0.006	0.007	0.838
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2234.50	2192.85	2192.85	0.202	2.5%	0.005	0.007	0.844
4.C.2 Land converted to Grassland – organic soils	CO2	1.63	52.48	52.48	0.008	59.7%	0.005	0.006	0.851
3.D.2.1 Indirect Emissions - Atmospheric Deposition	N2O	72.52	36.07	36.07	0.001	435.2%	0.005	0.006	0.856
4.B.2.2 Grassland converted to Cropland - organic soils	CO2	0.00	22.88	22.88	0.004	122.4%	0.004	0.006	0.862
3.D.1.2c Direct Soil Emissions - Compost Applied to Soils	N2O	0.58	12.84	12.84	0.002	201.0%	0.004	0.005	0.867
Semi-Chemical wood pulp	CO2	0.00	-33.56	33.56	0.005	72.0%	0.004	0.005	0.872
4.E.2.1 Forest Land converted to Settlements – living biomass	CO2	0.00	42.33	42.33	0.007	55.4%	0.004	0.005	0.877
1.A.4.b Other Sectors/Residential - Biomass	N2O	6.37	18.04	18.04	0.002	150.3%	0.004	0.005	0.882
4.E.2.2 Cropland converted to Settlements - soils	CO2	0.00	45.77	45.77	0.007	46.3%	0.003	0.004	0.886
4.E.2.3 Grassland converted to Settlements - soils	CO2	0.00	42.28	42.28	0.007	48.4%	0.003	0.004	0.890
4.B.2.2 Grassland converted to Cropland - mineral soils	CO2	0.00	50.16	50.16	0.008	39.7%	0.003	0.004	0.894
4.A.2.2. Grassland converted to Forest Land - mineral soils	CO2	0.58	32.31	32.31	0.005	61.2%	0.003	0.004	0.898
4.E.2.1 Forest Land converted to	CO2	0.00	41.47	41.47	0.007	38.6%	0.003	0.003	0.902

IPCC Source Category	Gas	Emissions 1990	Emissions 2015	Absolute value (2015)	Txt	Uxt	Tier 2 trend assessment	Normalised Tier 2 trend assessment	Cumulative total of column I
Settlements (min+org soils)									

Annex 2. Assessment of uncertainty

Table A.2.1. Tier 1 uncertainty analysis without LULUCF

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	EF / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	UN in trend in national emissions introduced by EF / estimation parameter UN	UN in trend in national emissions introduced by AD UN	UN introduced into the trend in total national emissions
		Gg CO2 equivalent	Gg CO2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G\bullet D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	4896.72	260.21	1.70%	1.80%	2.48%	0.0000	4.76%	0.64%	0.09%	0.02%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	22109.12	9862.83	3.30%	2.39%	4.07%	0.0005	0.02%	24.41%	0.00%	1.14%	0.01%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO2	1977.19	583.03	1.40%	3.60%	3.86%	0.0000	0.74%	1.44%	0.03%	0.03%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CO2	186.95	128.71	3.30%	2.39%	4.07%	0.0000	0.11%	0.32%	0.00%	0.01%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO2	0.00	144.78	5.00%	60.00%	60.21%	0.0000	0.36%	0.36%	0.22%	0.03%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CH4	4.73	0.26	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CH4	0.19	0.23	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CH4	0.90	0.26	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CH4	0.04	0.03	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CH4	0.00	1.80	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	EF / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	UN in trend in national emissions introduced by EF / estimation parameter UN	UN in trend in national emissions introduced by AD UN	UN introduced into the trend in total national emissions
1.A.1.a Energy Industries/Public Electricity and Heat Production - Biomass	CH4	1.65	12.22	5.00%	50.00%	50.25%	0.0000	0.03%	0.03%	0.01%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	N2O	11.27	0.61	5.00%	60.00%	60.21%	0.0000	0.01%	0.00%	0.01%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	N2O	1.83	7.36	5.00%	60.00%	60.21%	0.0000	0.02%	0.02%	0.01%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	N2O	1.07	0.31	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	N2O	0.79	0.55	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	N2O	0.00	2.86	5.00%	60.00%	60.21%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Biomass	N2O	2.75	20.07	5.00%	60.00%	60.21%	0.0000	0.05%	0.05%	0.03%	0.00%	0.00%
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CO2	86.10	1208.77	3.30%	38.90%	39.04%	0.0007	2.90%	2.99%	1.13%	0.14%	0.01%
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CH4	0.08	1.07	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	N2O	0.10	1.28	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Liquid Fuels	CO2	0.00	0.00	1.70%	1.80%	2.48%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Solid Fuels	CO2	3.04	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Gaseous Fuels	CO2	0.00	0.00	1.40%	3.60%	3.86%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Liquid Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Solid Fuels	CH4	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Gaseous Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	EF / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	UN in trend in national emissions introduced by EF / estimation parameter UN	UN in trend in national emissions introduced by AD UN	UN introduced into the trend in total national emissions
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Biomass	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Liquid Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Solid Fuels	N2O	0.01	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Gaseous Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Biomass	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Liquid Fuels	CO2	0.00	0.20	1.70%	1.80%	2.48%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Solid Fuels	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Gaseous Fuels	CO2	0.00	0.00	1.40%	3.60%	3.86%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Liquid Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Solid Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Gaseous Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Biomass	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Liquid Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Solid Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	EF / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	UN in trend in national emissions introduced by EF / estimation parameter UN	UN in trend in national emissions introduced by AD UN	UN introduced into the trend in total national emissions
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Gaseous Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Biomass	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Liquid Fuels	CO2	12.67	26.88	1.70%	1.80%	2.48%	0.0000	0.05%	0.07%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CO2	626.49	0.00	3.30%	38.90%	39.04%	0.0000	0.69%	0.00%	0.27%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	CO2	167.24	6.68	1.40%	3.60%	3.86%	0.0000	0.17%	0.02%	0.01%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Liquid Fuels	CH4	0.01	0.02	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CH4	0.10	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	CH4	0.08	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Biomass	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Liquid Fuels	N2O	0.03	0.06	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	N2O	0.13	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	N2O	0.09	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Biomass	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	EF / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	UN in trend in national emissions introduced by EF / estimation parameter UN	UN in trend in national emissions introduced by AD UN	UN introduced into the trend in total national emissions
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Liquid Fuels	CO2	0.00	1.11	1.70%	1.80%	2.48%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Solid Fuels	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Gaseous Fuels	CO2	0.00	12.81	1.40%	3.60%	3.86%	0.0000	0.03%	0.03%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Liquid Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Solid Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Gaseous Fuels	CH4	0.00	0.01	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Biomass	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Liquid Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Solid Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Gaseous Fuels	N2O	0.00	0.01	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Biomass	N2O	0.00	0.01	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	CO2	437.45	2.31	1.70%	1.80%	2.48%	0.0000	0.48%	0.01%	0.01%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	EF / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	UN in trend in national emissions introduced by EF / estimation parameter UN	UN in trend in national emissions introduced by AD UN	UN introduced into the trend in total national emissions
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Solid Fuels	CO2	4.59	0.00	3.30%	38.90%	39.04%	0.0000	0.01%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Gaseous Fuels	CO2	14.85	7.68	1.40%	3.60%	3.86%	0.0000	0.00%	0.02%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	CH4	0.45	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Solid Fuels	CH4	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Gaseous Fuels	CH4	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Biomass	CH4	0.12	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	N2O	1.07	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Solid Fuels	N2O	0.02	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Gaseous Fuels	N2O	0.01	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	EF / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	UN in trend in national emissions introduced by EF / estimation parameter UN	UN in trend in national emissions introduced by AD UN	UN introduced into the trend in total national emissions
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Biomass	N2O	0.19	0.01	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Liquid Fuels	CO2	139.63	2.40	1.70%	1.80%	2.48%	0.0000	0.15%	0.01%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	755.62	123.77	3.30%	38.90%	39.04%	0.0000	0.53%	0.31%	0.21%	0.01%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Gaseous Fuels	CO2	46.33	28.77	1.40%	3.60%	3.86%	0.0000	0.02%	0.07%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Peat	CO2	10.00	0.00	3.30%	38.90%	39.04%	0.0000	0.01%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CO2	0.00	115.17	5.00%	60.00%	60.21%	0.0000	0.29%	0.29%	0.17%	0.02%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Liquid Fuels	CH4	0.14	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CH4	1.87	0.32	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Gaseous Fuels	CH4	0.02	0.01	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CH4	0.00	1.09	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Biomass	CH4	0.01	0.18	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Liquid Fuels	N2O	0.32	0.01	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	EF / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	UN in trend in national emissions introduced by EF / estimation parameter UN	UN in trend in national emissions introduced by AD UN	UN introduced into the trend in total national emissions
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	N2O	3.16	0.54	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Gaseous Fuels	N2O	0.03	0.02	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Peat	N2O	0.04	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	N2O	0.00	1.73	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Biomass	N2O	0.02	0.29	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CO2	188.11	129.31	1.70%	1.80%	2.48%	0.0000	0.11%	0.32%	0.00%	0.01%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Solid Fuels	CO2	37.81	0.09	3.30%	38.90%	39.04%	0.0000	0.04%	0.00%	0.02%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Gaseous Fuels	CO2	53.78	32.52	1.40%	3.60%	3.86%	0.0000	0.02%	0.08%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Peat	CO2	0.00	0.10	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CH4	0.16	0.12	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Solid Fuels	CH4	0.10	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Gaseous Fuels	CH4	0.02	0.01	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Biomass	CH4	0.06	1.18	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	N2O	0.44	0.31	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Solid Fuels	N2O	0.17	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Gaseous Fuels	N2O	0.03	0.02	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	EF / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	UN in trend in national emissions introduced by EF / estimation parameter UN	UN in trend in national emissions introduced by AD UN	UN introduced into the trend in total national emissions
1.A.2.g Manufacturing Industries and Construction/Other - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Biomass	N2O	0.09	1.87	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.a Transport/Domestic Aviation - Liquid Fuels	CO2	5.52	1.24	1.70%	1.80%	2.48%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.a Transport/Domestic Aviation - Liquid Fuels	CH4	0.00	0.00	5.00%	40.00%	40.31%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.a Transport/Domestic Aviation - Liquid Fuels	N2O	0.06	0.01	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2234.50	2192.85	1.70%	1.80%	2.48%	0.0000	2.96%	5.43%	0.05%	0.13%	0.00%
1.A.3.b Transport/Road Transportation - Liquid Fuels	CH4	22.71	3.66	5.00%	40.00%	40.31%	0.0000	0.02%	0.01%	0.01%	0.00%	0.00%
1.A.3.b Transport/Road Transportation - Biomass	CH4	0.00	0.008	5.00%	100.00%	100.12%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.b Transport/Road Transportation - Liquid Fuels	N2O	21.56	19.55	5.00%	50.00%	50.25%	0.0000	0.02%	0.05%	0.01%	0.00%	0.00%
1.A.3.b Transport/Road Transportation - Biomass	N2O	0.00	0.02	5.00%	150.00%	150.08%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Liquid Fuels	CO2	142.55	59.41	1.70%	1.80%	2.48%	0.0000	0.01%	0.15%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Solid Fuels	CO2	11.38	0.00	3.30%	38.90%	39.04%	0.0000	0.01%	0.00%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Liquid Fuels	CH4	0.20	0.08	5.00%	40.00%	40.31%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Solid Fuels	CH4	0.01	0.00	5.00%	40.00%	40.31%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Liquid Fuels	N2O	16.63	6.94	4.00%	50.00%	50.16%	0.0000	0.00%	0.02%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Solid Fuels	N2O	0.05	0.00	5.00%	40.00%	40.31%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	CO2	21.79	39.63	5.00%	50.00%	50.25%	0.0000	0.07%	0.10%	0.04%	0.01%	0.00%
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	CH4	0.05	0.10	5.00%	40.00%	40.31%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	N2O	0.18	0.32	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

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1.A.4.a Other Sectors/Commercial/Institutional - Liquid Fuels	CO2	18.97	14.74	1.70%	1.80%	2.48%	0.0000	0.02%	0.04%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Solid Fuels	CO2	4.59	0.00	3.30%	38.90%	39.04%	0.0000	0.01%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	CO2	20.43	76.31	1.40%	3.60%	3.86%	0.0000	0.17%	0.19%	0.01%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Peat	CO2	3.55	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Liquid Fuels	CH4	0.06	0.05	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Solid Fuels	CH4	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	CH4	0.05	0.17	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Peat	CH4	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Biomass	CH4	2.97	1.60	10.00%	150.00%	150.33%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Liquid Fuels	N2O	0.04	0.03	5.00%	75.00%	75.17%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Solid Fuels	N2O	0.02	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	N2O	0.01	0.04	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Peat	N2O	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Biomass	N2O	0.47	0.25	10.00%	150.00%	150.33%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Liquid Fuels	CO2	544.28	45.41	1.70%	1.80%	2.48%	0.0000	0.49%	0.11%	0.01%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Solid Fuels	CO2	337.67	11.20	3.30%	38.90%	39.04%	0.0000	0.35%	0.03%	0.13%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Gaseous Fuels	CO2	116.78	114.80	1.40%	3.60%	3.86%	0.0000	0.16%	0.28%	0.01%	0.01%	0.00%
1.A.4.b Other Sectors/Residential - Peat	CO2	339.10	10.66	3.30%	38.90%	39.04%	0.0000	0.35%	0.03%	0.14%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Liquid Fuels	CH4	1.82	0.55	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

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1.A.4.b Other Sectors/Residential - Solid Fuels	CH4	26.48	0.89	5.00%	50.00%	50.25%	0.0000	0.03%	0.00%	0.01%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Gaseous Fuels	CH4	0.26	0.26	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Peat	CH4	26.24	0.83	5.00%	50.00%	50.25%	0.0000	0.03%	0.00%	0.01%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Biomass	CH4	40.08	113.50	10.00%	150.00%	150.33%	0.0001	0.24%	0.28%	0.35%	0.04%	0.00%
1.A.4.b Other Sectors/Residential - Liquid Fuels	N2O	1.19	0.69	5.00%	75.00%	75.17%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Solid Fuels	N2O	1.58	0.05	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Gaseous Fuels	N2O	0.06	0.06	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Peat	N2O	1.46	0.05	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Biomass	N2O	6.37	18.04	10.00%	150.00%	150.33%	0.0000	0.04%	0.04%	0.06%	0.01%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Liquid Fuels	CO2	47.41	31.42	1.70%	1.80%	2.48%	0.0000	0.03%	0.08%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Solid Fuels	CO2	15.97	0.00	3.30%	38.90%	39.04%	0.0000	0.02%	0.00%	0.01%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Gaseous Fuels	CO2	3.70	5.14	1.40%	3.60%	3.86%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Liquid Fuels	CH4	0.16	0.10	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Solid Fuels	CH4	1.25	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Gaseous Fuels	CH4	0.01	0.01	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

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1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Biomass	CH4	1.49	0.84	10.00%	150.00%	150.33%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Liquid Fuels	N2O	0.11	0.06	5.00%	75.00%	75.17%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Solid Fuels	N2O	0.07	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Gaseous Fuels	N2O	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Peat	N2O	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Biomass	N2O	0.24	0.13	10.00%	150.00%	150.33%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	CO2	428.20	281.34	1.70%	1.80%	2.48%	0.0000	0.22%	0.70%	0.00%	0.02%	0.00%
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	CH4	2.60	0.42	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	N2O	41.84	32.75	5.00%	75.00%	75.17%	0.0000	0.03%	0.08%	0.03%	0.01%	0.00%
1.A.5.b Other/Mobile - Liquid Fuels	CO2	43.40	26.78	1.70%	1.80%	2.48%	0.0000	0.02%	0.07%	0.00%	0.00%	0.00%
1.A.5.b Other/Mobile - Liquid Fuels	CH4	0.06	0.04	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.5.b Other/Mobile - Liquid Fuels	N2O	0.74	0.44	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.B.2.b.iv - Gaseous Fuels	CO2	0.00	0.00	10.00%	25.00%	26.93%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

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1.B.2.b.iv - Gaseous Fuels	CH4	2.84	0.88	10.00%	25.00%	26.93%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.B.2.b.v - Gaseous Fuels	CO2	0.09	0.03	10.00%	25.00%	26.93%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.B.2.b.v - Gaseous Fuels	CH4	47.34	14.63	10.00%	25.00%	26.93%	0.0000	0.02%	0.04%	0.00%	0.01%	0.00%
2.A.1 Cement production	CO2	483.04	205.61	0.02%	0.50%	0.50%	0.0000	0.02%	0.51%	0.00%	0.00%	0.00%
2.A.2 Lime production	CO2	129.69	38.70	0.72%	2.00%	2.12%	0.0000	0.05%	0.10%	0.00%	0.00%	0.00%
2.A.3 Glass production	CO2	1.23	10.01	1.10%	1.00%	1.49%	0.0000	0.02%	0.02%	0.00%	0.00%	0.00%
2.A.4.a Ceramics	CO2	0.00	0.95	1.00%	1.70%	1.97%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.A.4.b Soda ash use	CO2	0.31	0.19	3.00%	5.00%	5.83%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.A.4.d Other - Limestone use for flue gas desulpurisation	CO2	0.00	7.19	0.10%	2.00%	2.00%	0.0000	0.02%	0.02%	0.00%	0.00%	0.00%
2.B.1 Ammonia production	CO2	307.73	0.000	1.00%	3.60%	3.74%	0.0000	0.34%	0.00%	0.01%	0.00%	0.00%
2.D.1 Lubricant use	CO2	16.11	2.42	5.00%	50.90%	51.14%	0.0000	0.01%	0.01%	0.01%	0.00%	0.00%
2.D.2 Paraffin wax use	CO2	1.29	2.24	20.00%	100.05%	102.02%	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
2.D.3 Other - Urea based catalysts for motor vehicles	CO2	0.00	0.85	30.00%	0.70%	30.01%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.D.3 Other - Solvent use	indirect CO2	20.85	15.85	25.00%	10.00%	26.93%	0.0000	0.02%	0.04%	0.00%	0.01%	0.00%
2.D.3 Other - Road paving with asphalt	indirect CO2	0.05	0.04	10.00%	100.50%	101.00%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.1.a Commercial Refrigeration	HFC	0.00	62.56	20.00%	10.00%	22.36%	0.0000	0.15%	0.15%	0.02%	0.04%	0.00%
2.F.1.b Domestic Refrigeration	HFC	0.00	0.88	20.00%	10.00%	22.36%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.1.c Industrial Refrigeration	HFC	0.00	43.31	26.00%	15.00%	30.02%	0.0000	0.11%	0.11%	0.02%	0.04%	0.00%
2.F.1.d Refrigerated Vehicles	HFC	0.00	24.86	8.50%	5.00%	9.86%	0.0000	0.06%	0.06%	0.00%	0.01%	0.00%
2.F.1.d Reefer Containers	HFC	0.00	1.27	8.40%	5.00%	9.78%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.1.e Heat Pumps	HFC	0.00	7.36	9.00%	5.00%	10.30%	0.0000	0.02%	0.02%	0.00%	0.00%	0.00%

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2.F.1.e Stationary and Room Air-Conditioning	HFC	0.00	23.51	15.00%	18.00%	23.43%	0.0000	0.06%	0.06%	0.01%	0.01%	0.00%
2.F.1.d Mobile Air-Conditioning - Passenger cars	HFC	0.00	28.70	8.50%	5.00%	9.86%	0.0000	0.07%	0.07%	0.00%	0.01%	0.00%
2.F.1.d Mobile Air-Conditioning - Trucks	HFC	0.00	6.53	8.50%	5.00%	9.86%	0.0000	0.02%	0.02%	0.00%	0.00%	0.00%
2.F.1.d Mobile Air-Conditioning - Buses	HFC	0.00	3.41	8.70%	5.00%	10.03%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.F.1.d Mobile Air-Conditioning - Ships	HFC	0.00	7.13	3.00%	4.00%	5.00%	0.0000	0.02%	0.02%	0.00%	0.00%	0.00%
2.F.1.d Mobile Air-Conditioning - Railcars	HFC	0.00	0.12	3.00%	5.00%	5.83%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.1.d Mobile Air-Conditioning - Wheel tractors and mobile machinery	HFC	0.00	5.01	14.50%	10.00%	17.61%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.F.2.a Foam blowing agents; PU Insulation Panels	HFC	0.00	0.11	10.00%	10.00%	14.14%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.2.a Spray and Injection PU Foam	HFC	0.00	0.00	10.00%	10.00%	14.14%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.2.a XPS Insulation Foam	HFC	0.00	0.08	20.00%	10.00%	22.36%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.2.b One Component PU Foam	HFC	0.00	2.09	15.00%	0.00%	15.00%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.F.3 Fire protection	HFC	0.00	2.63	10.00%	10.00%	14.14%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.F.4 Aerosols; Metered dose inhalers	HFC	0.00	3.28	10.00%	0.00%	10.00%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.G.1 Electrical equipment	SF6	0.00	2.19	3.00%	10.00%	10.44%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.G.2 Particle accelerators	SF6	0.00	0.06	21.00%	21.00%	29.70%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.G.3 N2O from product use	N2O	5.45	3.79	5.00%	2.00%	5.39%	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	707.62	327.76	10.00%	20.00%	22.36%	0.0000	0.03%	0.81%	0.01%	0.11%	0.00%
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	482.27	183.73	10.00%	20.00%	22.36%	0.0000	0.08%	0.45%	0.02%	0.06%	0.00%
3.A.2 Enteric Fermentation - Sheep	CH4	31.70	17.63	10.00%	40.00%	41.23%	0.0000	0.01%	0.04%	0.00%	0.01%	0.00%
3.A.3 Enteric Fermentation - Swine	CH4	20.82	7.62	10.00%	20.00%	22.36%	0.0000	0.00%	0.02%	0.00%	0.00%	0.00%
3.A.4 Enteric Fermentation - Goats	CH4	0.26	0.64	10.00%	40.00%	41.23%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.A.4 Enteric Fermentation - Horses	CH4	3.87	2.84	10.00%	40.00%	41.23%	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%

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3.A.4 Enteric Fermentation - Fur animals	CH4	0.58	0.29	10.00%	40.00%	41.23%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.1.1 Manure Management - Dairy Cattle	CH4	28.07	29.39	50.99%	20.00%	54.77%	0.0000	0.04%	0.07%	0.01%	0.05%	0.00%
3.B.1.1 Manure Management -Non-Dairy Cattle	CH4	15.72	12.05	50.99%	20.00%	54.77%	0.0000	0.01%	0.03%	0.00%	0.02%	0.00%
3.B.1.2 Manure Management - Sheep	CH4	0.75	0.42	50.99%	30.00%	59.16%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.1.3 Manure Management - Swine	CH4	93.93	32.09	50.99%	20.00%	54.77%	0.0000	0.02%	0.08%	0.00%	0.06%	0.00%
3.B.1.4 Manure Management - Goats	CH4	0.01	0.02	50.99%	30.00%	59.16%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.1.4 Manure Management - Horses	CH4	0.34	0.25	50.99%	30.00%	59.16%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.1.4Manure Management - Poultry	CH4	3.81	1.70	50.99%	30.00%	59.16%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.1.4 Manure Management - Fur animals	CH4	3.92	1.98	50.99%	30.00%	59.16%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.1.4 Manure Management - Rabbits	CH4	0.17	0.10	50.99%	30.00%	59.16%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.1 Manure Management - Dairy Cattle	N2O	31.27	15.31	50.99%	111.80%	122.88%	0.0000	0.00%	0.04%	0.00%	0.03%	0.00%
3.B.2.1 Manure Management -Non-Dairy Cattle	N2O	20.19	9.53	50.99%	111.80%	122.88%	0.0000	0.00%	0.02%	0.00%	0.02%	0.00%
3.B.2.2 Manure Management - Sheep	N2O	4.02	2.23	50.99%	111.80%	122.88%	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
3.B.2.3 Manure Management - Swine	N2O	2.25	1.32	50.99%	111.80%	122.88%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.4 Manure Management - Goats	N2O	0.05	0.11	50.99%	111.80%	122.88%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.4 Manure Management - Horses	N2O	0.71	0.52	50.99%	111.80%	122.88%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.4 Manure Management - Poultry	N2O	5.62	2.60	50.99%	111.80%	122.88%	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
3.B.2.4 Manure Management - Fur animals	N2O	3.98	1.51	50.99%	111.80%	122.88%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.4 Manure Management - Rabbits	N2O	1.63	0.94	50.99%	111.80%	122.88%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.5 Indirect N2O Emissions from Manure Management	N2O	64.60	27.68	50.99%	400.12%	403.36%	0.0000	0.00%	0.07%	0.01%	0.05%	0.00%
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	337.35	167.67	10.00%	200.00%	200.25%	0.0003	0.04%	0.42%	0.08%	0.06%	0.00%
3.D.1.2a Direct Soil Emissions - Animal Manure Applied to Soils	N2O	103.57	46.96	50.99%	206.16%	212.37%	0.0000	0.00%	0.12%	0.00%	0.08%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	EF / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	UN in trend in national emissions introduced by EF / estimation parameter UN	UN in trend in national emissions introduced by AD UN	UN introduced into the trend in total national emissions
3.D.1.2b Direct Soil Emissions - Sewage Sludge Applied to Soils	N2O	0.17	0.14	20.00%	200.00%	201.00%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.D.1.2c Direct Soil Emissions - Compost Applied to Soils	N2O	0.58	12.84	20.00%	200.00%	201.00%	0.0000	0.03%	0.03%	0.06%	0.01%	0.00%
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N2O	170.32	67.81	50.99%	206.16%	212.37%	0.0001	0.02%	0.17%	0.04%	0.12%	0.00%
3.D.1.5 Direct Soil Emissions - Mineralization/Immobilization Associated with Loss/Gain of Soil Organic Matter	N2O	0.00	0.00	33.24%	30.00%	44.77%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	189.26	139.75	30.00%	200.00%	202.24%	0.0002	0.14%	0.35%	0.27%	0.15%	0.00%
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	92.58	83.98	21.41%	200.00%	201.14%	0.0001	0.11%	0.21%	0.21%	0.06%	0.00%
3.D.2.1 Indirect Emissions - Atmospheric Deposition	N2O	72.52	36.07	14.84%	434.95%	435.20%	0.0001	0.01%	0.09%	0.04%	0.02%	0.00%
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	162.12	90.88	17.60%	286.74%	287.28%	0.0002	0.05%	0.22%	0.13%	0.06%	0.00%
3.G Liming	CO2	12.11	8.29	29.15%	50.00%	57.88%	0.0000	0.01%	0.02%	0.00%	0.01%	0.00%
3.H Urea Application	CO2	1.00	2.95	2.00%	50.00%	50.04%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
5.A Solid waste disposal	CH4	213.72	187.28	17%	87%	89%	0.0001	0.23%	0.46%	0.20%	0.11%	0.00%
5.B.1 Composting	CH4	0.68	15.00	14%	75%	76%	0.0000	0.04%	0.04%	0.03%	0.01%	0.00%
5.B.1 Composting	N2O	0.48	10.73	14%	65%	67%	0.0000	0.03%	0.03%	0.02%	0.01%	0.00%
5.C.1 Waste incineration	CH4	0.06	0.00	5%	50%	50%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.C.1 Waste incineration	N2O	0.01	0.00	5%	100%	100%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.C.1 Waste incineration	CO2	0.76	0.03	5%	40%	40%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.C.2 Open Burning of Waste	CH4	1.16	0.46	32%	50%	59%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.C.2 Open Burning of Waste	N2O	0.22	0.09	32%	100%	105%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.C.2 Open Burning of Waste	CO2	1.49	0.96	32%	40%	51%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.D.1 Domestic wastewater	CH4	112.70	49.35	60%	66%	90%	0.0000	0.00%	0.12%	0.00%	0.10%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	EF / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	UN in trend in national emissions introduced by EF / estimation parameter UN	UN in trend in national emissions introduced by AD UN	UN introduced into the trend in total national emissions
5.D.1 Domestic wastewater	N2O	38.63	30.10	25%	106%	109%	0.0000	0.03%	0.07%	0.03%	0.03%	0.00%
5.D.2 Industrial wastewater	CH4	0.00	9.62	50%	36%	62%	0.0000	0.02%	0.02%	0.01%	0.02%	0.00%
5.E Other (Biogas Burnt in a flare)	CH4	0.00	21.46	17%	23%	29%	0.0000	0.05%	0.05%	0.01%	0.01%	0.00%
5.E Other (Biogas Burnt in a flare)	N2O	0.00	1.01	17%	8%	19%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
Total		**40402.7411**	**18040.48448**				**0.0026**					**0.033%**
Total Uncertainties						**Uncertainty in total inventory %:**	**5.05%**				**Trend uncertainty %:**	**1.81%**

Table A.2.2. Tier 1 uncertainty analysis with LULUCF

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		Gg CO2 equivalent	Gg CO2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO2	4896.72	260.21	1.70%	1.80%	2.48%	0.0000	4.45%	0.67%	0.08%	0.02%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO2	22109.12	9862.83	3.30%	2.39%	4.07%	0.0007	2.34%	25.51%	0.06%	1.19%	0.01%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO2	1977.19	583.03	1.40%	3.60%	3.86%	0.0000	0.56%	1.51%	0.02%	0.03%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CO2	186.95	128.71	3.30%	2.39%	4.07%	0.0000	0.14%	0.33%	0.00%	0.02%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO2	0.00	144.78	5.00%	60.00%	60.21%	0.0000	0.37%	0.37%	0.22%	0.03%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CH4	4.73	0.26	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CH4	0.19	0.23	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CH4	0.90	0.26	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CH4	0.04	0.03	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CH4	0.00	1.80	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Biomass	CH4	1.65	12.22	5.00%	50.00%	50.25%	0.0000	0.03%	0.03%	0.01%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	N2O	11.27	0.61	5.00%	60.00%	60.21%	0.0000	0.01%	0.00%	0.01%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	N2O	1.83	7.36	5.00%	60.00%	60.21%	0.0000	0.02%	0.02%	0.01%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	N2O	1.07	0.31	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	N2O	0.79	0.55	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	N2O	0.00	2.86	5.00%	60.00%	60.21%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
1.A.1.a Energy Industries/Public Electricity and Heat Production - Biomass	N2O	2.75	20.07	5.00%	60.00%	60.21%	0.0000	0.05%	0.05%	0.03%	0.00%	0.00%
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CO2	86.10	1208.77	3.30%	38.90%	39.04%	0.0009	3.04%	3.13%	1.18%	0.15%	0.01%
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	CH4	0.08	1.07	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.1.c Energy Industries/Manufacture of Solid Fuels and Other Energy Industries - Solid Fuels	N2O	0.10	1.28	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Liquid Fuels	CO2	0.00	0.00	1.70%	1.80%	2.48%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Solid Fuels	CO2	3.04	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Gaseous Fuels	CO2	0.00	0.00	1.40%	3.60%	3.86%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Liquid Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Solid Fuels	CH4	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Gaseous Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Biomass	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Liquid Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Solid Fuels	N2O	0.01	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Gaseous Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.a Manufacturing Industries and Construction/Iron and Steel - Biomass	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Liquid Fuels	CO2	0.00	0.20	1.70%	1.80%	2.48%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Solid Fuels	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Gaseous Fuels	CO2	0.00	0.00	1.40%	3.60%	3.86%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Liquid Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Solid Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Gaseous Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Biomass	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Liquid Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Solid Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Gaseous Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.b Manufacturing Industries and Construction/Non-Ferrous Metals - Biomass	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.2.c Manufacturing Industries and Construction/Chemicals - Liquid Fuels	CO2	12.67	26.88	1.70%	1.80%	2.48%	0.0000	0.06%	0.07%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CO2	626.49	0.00	3.30%	38.90%	39.04%	0.0000	0.66%	0.00%	0.26%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	CO2	167.24	6.68	1.40%	3.60%	3.86%	0.0000	0.16%	0.02%	0.01%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Liquid Fuels	CH4	0.01	0.02	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	CH4	0.10	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	CH4	0.08	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Biomass	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Liquid Fuels	N2O	0.03	0.06	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Solid Fuels	N2O	0.13	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	N2O	0.09	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.c Manufacturing Industries and Construction/Chemicals - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.2.c Manufacturing Industries and Construction/Chemicals - Biomass	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Liquid Fuels	CO2	0.00	1.11	1.70%	1.80%	2.48%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Solid Fuels	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Gaseous Fuels	CO2	0.00	12.81	1.40%	3.60%	3.86%	0.0000	0.03%	0.03%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Liquid Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Solid Fuels	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Gaseous Fuels	CH4	0.00	0.01	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Biomass	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Liquid Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Solid Fuels	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Gaseous Fuels	N2O	0.00	0.01	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Biomass	N2O	0.00	0.01	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	CO2	437.45	2.31	1.70%	1.80%	2.48%	0.0000	0.45%	0.01%	0.01%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Solid Fuels	CO2	4.59	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Gaseous Fuels	CO2	14.85	7.68	1.40%	3.60%	3.86%	0.0000	0.00%	0.02%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	CH4	0.45	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Solid Fuels	CH4	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Gaseous Fuels	CH4	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Biomass	CH4	0.12	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	N2O	1.07	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Solid Fuels	N2O	0.02	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Gaseous Fuels	N2O	0.01	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Biomass	N2O	0.19	0.01	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Liquid Fuels	CO2	139.63	2.40	1.70%	1.80%	2.48%	0.0000	0.14%	0.01%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO2	755.62	123.77	3.30%	38.90%	39.04%	0.0000	0.47%	0.32%	0.18%	0.01%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Gaseous Fuels	CO2	46.33	28.77	1.40%	3.60%	3.86%	0.0000	0.03%	0.07%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Peat	CO2	10.00	0.00	3.30%	38.90%	39.04%	0.0000	0.01%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CO2	0.00	115.17	5.00%	60.00%	60.21%	0.0000	0.30%	0.30%	0.18%	0.02%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Liquid Fuels	CH4	0.14	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CH4	1.87	0.32	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Gaseous Fuels	CH4	0.02	0.01	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	CH4	0.00	1.09	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Biomass	CH4	0.01	0.18	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Liquid Fuels	N2O	0.32	0.01	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	N2O	3.16	0.54	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Gaseous Fuels	N2O	0.03	0.02	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Peat	N2O	0.04	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Other Fuels	N2O	0.00	1.73	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Biomass	N2O	0.02	0.29	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CO2	188.11	129.31	1.70%	1.80%	2.48%	0.0000	0.14%	0.33%	0.00%	0.01%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Solid Fuels	CO2	37.81	0.09	3.30%	38.90%	39.04%	0.0000	0.04%	0.00%	0.02%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Gaseous Fuels	CO2	53.78	32.52	1.40%	3.60%	3.86%	0.0000	0.03%	0.08%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Peat	CO2	0.00	0.10	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CH4	0.16	0.12	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Solid Fuels	CH4	0.10	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Gaseous Fuels	CH4	0.02	0.01	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Biomass	CH4	0.06	1.18	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	N2O	0.44	0.31	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Solid Fuels	N2O	0.17	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Gaseous Fuels	N2O	0.03	0.02	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.2.g Manufacturing Industries and Construction/Other - Peat	N2O	0.00	0.00	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.2.g Manufacturing Industries and Construction/Other - Biomass	N2O	0.09	1.87	5.00%	60.00%	60.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.a Transport/Domestic Aviation - Liquid Fuels	CO2	5.52	1.24	1.70%	1.80%	2.48%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.a Transport/Domestic Aviation - Liquid Fuels	CH4	0.00	0.00	5.00%	40.00%	40.31%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.a Transport/Domestic Aviation - Liquid Fuels	N2O	0.06	0.01	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO2	2234.50	2192.85	1.70%	1.80%	2.48%	0.0000	3.33%	5.67%	0.06%	0.14%	0.00%
1.A.3.b Transport/Road Transportation - Liquid Fuels	CH4	22.71	3.66	5.00%	40.00%	40.31%	0.0000	0.01%	0.01%	0.01%	0.00%	0.00%
1.A.3.b Transport/Road Transportation - Biomass	CH4	0.00	0.008	5.00%	100.00%	100.12%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.b Transport/Road Transportation - Liquid Fuels	N2O	21.56	19.55	5.00%	50.00%	50.25%	0.0000	0.03%	0.05%	0.01%	0.00%	0.00%
1.A.3.b Transport/Road Transportation - Biomass	N2O	0.00	0.02	5.00%	150.00%	150.08%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Liquid Fuels	CO2	142.55	59.41	1.70%	1.80%	2.48%	0.0000	0.00%	0.15%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Solid Fuels	CO2	11.38	0.00	3.30%	38.90%	39.04%	0.0000	0.01%	0.00%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Liquid Fuels	CH4	0.20	0.08	5.00%	40.00%	40.31%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Solid Fuels	CH4	0.01	0.00	5.00%	40.00%	40.31%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Liquid Fuels	N2O	16.63	6.94	4.00%	50.00%	50.16%	0.0000	0.00%	0.02%	0.00%	0.00%	0.00%
1.A.3.c Transport/Railways - Solid Fuels	N2O	0.05	0.00	5.00%	40.00%	40.31%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	CO2	21.79	39.63	5.00%	50.00%	50.25%	0.0000	0.08%	0.10%	0.04%	0.01%	0.00%
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	CH4	0.05	0.10	5.00%	40.00%	40.31%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.3.d Transport/Domestic Navigation - Liquid Fuels	N2O	0.18	0.32	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Liquid Fuels	CO2	18.97	14.74	1.70%	1.80%	2.48%	0.0000	0.02%	0.04%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Solid Fuels	CO2	4.59	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	CO2	20.43	76.31	1.40%	3.60%	3.86%	0.0000	0.18%	0.20%	0.01%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Peat	CO2	3.55	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Liquid Fuels	CH4	0.06	0.05	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Solid Fuels	CH4	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	CH4	0.05	0.17	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Peat	CH4	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Biomass	CH4	2.97	1.60	10.00%	150.00%	150.33%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Liquid Fuels	N2O	0.04	0.03	5.00%	75.00%	75.17%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Solid Fuels	N2O	0.02	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	N2O	0.01	0.04	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Peat	N2O	0.01	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.a Other Sectors/Commercial/Institutional - Biomass	N2O	0.47	0.25	10.00%	150.00%	150.33%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Liquid Fuels	CO2	544.28	45.41	1.70%	1.80%	2.48%	0.0000	0.45%	0.12%	0.01%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1.A.4.b Other Sectors/Residential - Solid Fuels	CO2	337.67	11.20	3.30%	38.90%	39.04%	0.0000	0.32%	0.03%	0.13%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Gaseous Fuels	CO2	116.78	114.80	1.40%	3.60%	3.86%	0.0000	0.17%	0.30%	0.01%	0.01%	0.00%
1.A.4.b Other Sectors/Residential - Peat	CO2	339.10	10.66	3.30%	38.90%	39.04%	0.0000	0.33%	0.03%	0.13%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Liquid Fuels	CH4	1.82	0.55	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Solid Fuels	CH4	26.48	0.89	5.00%	50.00%	50.25%	0.0000	0.03%	0.00%	0.01%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Gaseous Fuels	CH4	0.26	0.26	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Peat	CH4	26.24	0.83	5.00%	50.00%	50.25%	0.0000	0.03%	0.00%	0.01%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Biomass	CH4	40.08	113.50	10.00%	150.00%	150.33%	0.0001	0.25%	0.29%	0.38%	0.04%	0.00%
1.A.4.b Other Sectors/Residential - Liquid Fuels	N2O	1.19	0.69	5.00%	75.00%	75.17%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Solid Fuels	N2O	1.58	0.05	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Gaseous Fuels	N2O	0.06	0.06	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Peat	N2O	1.46	0.05	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.b Other Sectors/Residential - Biomass	N2O	6.37	18.04	10.00%	150.00%	150.33%	0.0000	0.04%	0.05%	0.06%	0.01%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Liquid Fuels	CO2	47.41	31.42	1.70%	1.80%	2.48%	0.0000	0.03%	0.08%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Solid Fuels	CO2	15.97	0.00	3.30%	38.90%	39.04%	0.0000	0.02%	0.00%	0.01%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Gaseous Fuels	CO2	3.70	5.14	1.40%	3.60%	3.86%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%

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1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Peat	CO2	0.00	0.00	3.30%	38.90%	39.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Liquid Fuels	CH4	0.16	0.10	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Solid Fuels	CH4	1.25	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Gaseous Fuels	CH4	0.01	0.01	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Peat	CH4	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Biomass	CH4	1.49	0.84	10.00%	150.00%	150.33%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Liquid Fuels	N2O	0.11	0.06	5.00%	75.00%	75.17%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Solid Fuels	N2O	0.07	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Gaseous Fuels	N2O	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Peat	N2O	0.00	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Biomass	N2O	0.24	0.13	10.00%	150.00%	150.33%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

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1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	CO2	428.20	281.34	1.70%	1.80%	2.48%	0.0000	0.28%	0.73%	0.01%	0.02%	0.00%
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	CH4	2.60	0.42	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4.c.ii Other Sectors/Agriculture/Forestry/Fishing/Off-road vehicles and other machinery - Liquid Fuels	N2O	41.84	32.75	5.00%	75.00%	75.17%	0.0000	0.04%	0.08%	0.03%	0.01%	0.00%
1.A.5.b Other/Mobile - Liquid Fuels	CO2	43.40	26.78	1.70%	1.80%	2.48%	0.0000	0.02%	0.07%	0.00%	0.00%	0.00%
1.A.5.b Other/Mobile - Liquid Fuels	CH4	0.06	0.04	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.5.b Other/Mobile - Liquid Fuels	N2O	0.74	0.44	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.B.2.b.iv - Gaseous Fuels	CO2	0.00	0.00	10.00%	25.00%	26.93%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.B.2.b.iv - Gaseous Fuels	CH4	2.84	0.88	10.00%	25.00%	26.93%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.B.2.b.v - Gaseous Fuels	CO2	0.09	0.03	10.00%	25.00%	26.93%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
1.B.2.b.v - Gaseous Fuels	CH4	47.34	14.63	10.00%	25.00%	26.93%	0.0000	0.01%	0.04%	0.00%	0.01%	0.00%
2.A.1 Cement production	CO2	483.04	205.61	0.02%	0.50%	0.50%	0.0000	0.03%	0.53%	0.00%	0.00%	0.00%
2.A.2 Lime production	CO2	129.69	38.70	0.72%	2.00%	2.12%	0.0000	0.04%	0.10%	0.00%	0.00%	0.00%
2.A.3 Glass production	CO2	1.23	10.01	1.10%	1.00%	1.49%	0.0000	0.02%	0.03%	0.00%	0.00%	0.00%
2.A.4.a Ceramics	CO2	0.00	0.95	1.00%	1.70%	1.97%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.A.4.b Soda ash use	CO2	0.31	0.19	3.00%	5.00%	5.83%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.A.4.d Other - Limestone use for flue gas desulpurisation	CO2	0.00	7.19	0.1%	2%	2.00%	0.0000	0.02%	0.02%	0.00%	0.00%	0.00%
2.B.1 Ammonia production	CO2	307.73	0.000	1.00%	3.60%	3.74%	0.0000	0.32%	0.00%	0.01%	0.00%	0.00%
2.D.1 Lubricant use	CO2	16.11	2.42	5.00%	50.90%	51.14%	0.0000	0.01%	0.01%	0.01%	0.00%	0.00%

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2.D.2 Paraffin wax use	CO2	1.29	2.24	20.00%	100.05%	102.02%	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
2.D.3 Other - Solvent use	indirect CO2	0.00	0.85	30.00%	0.70%	30.01%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.D.3 Other - Road paving with asphalt	indirect CO2	20.85	15.85	25.00%	10.00%	26.93%	0.0000	0.02%	0.04%	0.00%	0.01%	0.00%
2.D.3 Other - Other- Urea based catalytic converters for motor vehicles	CO2	0.05	0.04	10.00%	100.50%	101.00%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.1.a Commercial Refrigeration	HFC	0.00	62.56	20.00%	10.00%	22.36%	0.0000	0.16%	0.16%	0.02%	0.05%	0.00%
2.F.1.b Domestic Refrigeration	HFC	0.00	0.88	20.00%	10.00%	22.36%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.1.c Industrial Refrigeration	HFC	0.00	43.31	26.00%	15.00%	30.02%	0.0000	0.11%	0.11%	0.02%	0.04%	0.00%
2.F.1.d Refrigerated Vehicles	HFC	0.00	24.86	8.50%	5.00%	9.86%	0.0000	0.06%	0.06%	0.00%	0.01%	0.00%
2.F.1.d Reefer Containers	HFC	0.00	1.27	8.40%	5.00%	9.78%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.1.f Heat Pumps	HFC	0.00	7.36	9.00%	5.00%	10.30%	0.0000	0.02%	0.02%	0.00%	0.00%	0.00%
2.F.1.f Stationary and Room Air-Conditioning	HFC	0.00	23.51	15.00%	18.00%	23.43%	0.0000	0.06%	0.06%	0.01%	0.01%	0.00%
2.F.1.e Mobile Air-Conditioning - Passenger cars	HFC	0.00	28.70	8.50%	5.00%	9.86%	0.0000	0.07%	0.07%	0.00%	0.01%	0.00%
2.F.1.e Mobile Air-Conditioning - Trucks	HFC	0.00	6.53	8.50%	5.00%	9.86%	0.0000	0.02%	0.02%	0.00%	0.00%	0.00%
2.F.1.e Mobile Air-Conditioning - Buses	HFC	0.00	3.41	8.70%	5.00%	10.03%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.F.1.e Mobile Air-Conditioning - Ships	HFC	0.00	7.13	3.00%	4.00%	5.00%	0.0000	0.02%	0.02%	0.00%	0.00%	0.00%
2.F.1.e Mobile Air-Conditioning - Railcars	HFC	0.00	0.12	3.00%	5.00%	5.83%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.1.e Mobile Air-Conditioning - Wheel tractors and mobile machinery	HFC	0.00	5.01	14.50%	10.00%	17.61%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.F.2.a Foam blowing agents; PU Insulation Panels	HFC	0.00	0.11	10.00%	10.00%	14.14%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.2.a Spray and Injection PU Foam	HFC	0.00	0.00	10.00%	10.00%	14.14%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

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2.F.2.a XPS Insulation Foam	HFC	0.00	0.08	20.00%	10.00%	22.36%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.F.2.b One Component PU Foam	HFC	0.00	2.09	15.00%	0.00%	15.00%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.F.3 Fire protection	HFC	0.00	2.63	10.00%	10.00%	14.14%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.F.4 Aerosols; Metered dose inhalers	HFC	0.00	3.28	10.00%	0.00%	10.00%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.G.1 Electrical equipment	SF6	0.00	2.19	3.00%	10.00%	10.44%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
2.G.2 Particle accelerators	SF6	0.00	0.06	21.00%	21.00%	29.70%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
2.G.3 N2O from product use	N2O	5.45	3.79	5.00%	2.00%	5.39%	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
3.A.1 Enteric Fermentation - Dairy Cattle	CH4	707.62	327.76	10.00%	20.00%	22.36%	0.0000	0.11%	0.85%	0.02%	0.12%	0.00%
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH4	482.27	183.73	10.00%	20.00%	22.36%	0.0000	0.03%	0.48%	0.01%	0.07%	0.00%
3.A.2 Enteric Fermentation - Sheep	CH4	31.70	17.63	10.00%	40.00%	41.23%	0.0000	0.01%	0.05%	0.00%	0.01%	0.00%
3.A.3 Enteric Fermentation - Swine	CH4	20.82	7.62	10.00%	20.00%	22.36%	0.0000	0.00%	0.02%	0.00%	0.00%	0.00%
3.A.4 Enteric Fermentation - Goats	CH4	0.26	0.64	10.00%	40.00%	41.23%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.A.4 Enteric Fermentation - Horses	CH4	3.87	2.84	10.00%	40.00%	41.23%	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
3.A.4 Enteric Fermentation - Fur animals	CH4	0.58	0.29	10.00%	40.00%	41.23%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.1.1 Manure Management - Dairy Cattle	CH4	28.07	29.39	50.99%	20.00%	54.77%	0.0000	0.05%	0.08%	0.01%	0.05%	0.00%
3.B.1.1 Manure Management -Non-Dairy Cattle	CH4	15.72	12.05	50.99%	20.00%	54.77%	0.0000	0.01%	0.03%	0.00%	0.02%	0.00%
3.B.1.2 Manure Management - Sheep	CH4	0.75	0.42	50.99%	30.00%	59.16%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.1.3 Manure Management - Swine	CH4	93.93	32.09	50.99%	20.00%	54.77%	0.0000	0.02%	0.08%	0.00%	0.06%	0.00%
3.B.1.4 Manure Management - Goats	CH4	0.01	0.02	50.99%	30.00%	59.16%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.1.4 Manure Management - Horses	CH4	0.34	0.25	50.99%	30.00%	59.16%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.1.4Manure Management - Poultry	CH4	3.81	1.70	50.99%	30.00%	59.16%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

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3.B.1.4 Manure Management - Fur animals	CH4	3.92	1.98	50.99%	30.00%	59.16%	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
3.B.1.4 Manure Management - Rabbits	CH4	0.17	0.10	50.99%	30.00%	59.16%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.1 Manure Management - Dairy Cattle	N2O	31.27	15.31	50.99%	111.80%	122.88%	0.0000	0.01%	0.04%	0.01%	0.03%	0.00%
3.B.2.1 Manure Management -Non-Dairy Cattle	N2O	20.19	9.53	50.99%	111.80%	122.88%	0.0000	0.00%	0.02%	0.00%	0.02%	0.00%
3.B.2.2 Manure Management - Sheep	N2O	4.02	2.23	50.99%	111.80%	122.88%	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
3.B.2.3 Manure Management - Swine	N2O	2.25	1.32	50.99%	111.80%	122.88%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.4 Manure Management - Goats	N2O	0.05	0.11	50.99%	111.80%	122.88%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.4 Manure Management - Horses	N2O	0.71	0.52	50.99%	111.80%	122.88%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.4 Manure Management - Poultry	N2O	5.62	2.60	50.99%	111.80%	122.88%	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
3.B.2.4 Manure Management - Fur animals	N2O	3.98	1.51	50.99%	111.80%	122.88%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.4 Manure Management - Rabbits	N2O	1.63	0.94	50.99%	111.80%	122.88%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.B.2.5 Indirect N2O Emissions from Manure Management	N2O	64.60	27.68	50.99%	400.12%	403.36%	0.0001	0.00%	0.07%	0.02%	0.05%	0.00%
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N2O	337.35	167.67	10.00%	200.00%	200.25%	0.0005	0.08%	0.43%	0.16%	0.06%	0.00%
3.D.1.2a Direct Soil Emissions - Animal Manure Applied to Soils	N2O	103.57	46.96	50.99%	206.16%	212.37%	0.0000	0.01%	0.12%	0.03%	0.09%	0.00%
3.D.1.2b Direct Soil Emissions - Sewage Sludge Applied to Soils	N2O	0.17	0.14	20.00%	200.00%	201.00%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
3.D.1.2c Direct Soil Emissions - Compost Applied to Soils	N2O	0.58	12.84	20.00%	200.00%	201.00%	0.0000	0.03%	0.03%	0.07%	0.01%	0.00%
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N2O	170.32	67.81	50.99%	206.16%	212.37%	0.0001	0.00%	0.18%	0.01%	0.13%	0.00%
3.D.1.5 Direct Soil Emissions - Mineralization/Immobilization Associated with Loss/Gain of Soil Organic Matter	N2O	0.00	0.00	33.24%	30.00%	44.77%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
3.D.1.4 Direct Soil Emissions - Crop Residue	N2O	189.26	139.75	30.00%	200.00%	202.24%	0.0003	0.16%	0.36%	0.33%	0.15%	0.00%
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N2O	92.58	83.98	21.41%	200.00%	201.14%	0.0001	0.12%	0.22%	0.24%	0.07%	0.00%
3.D.2.1 Indirect Emissions - Atmospheric Deposition	N2O	72.52	36.07	14.84%	434.95%	435.20%	0.0001	0.02%	0.09%	0.08%	0.02%	0.00%
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N2O	162.12	90.88	17.60%	286.74%	287.28%	0.0003	0.07%	0.24%	0.19%	0.06%	0.00%
3.G Liming	CO2	12.11	8.29	29.15%	50.00%	57.88%	0.0000	0.01%	0.02%	0.00%	0.01%	0.00%
3.H Urea Application	CO2	1.00	2.95	2.00%	50.00%	50.04%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
4.A.1. Forest Land remaining Forest Land - living biomass	CO2	-2253.34	-1713.10	1.16%	46.95%	46.96%	0.0026	2.07%	4.43%	0.97%	0.07%	0.01%
4.A.1. Forest Land remaining Forest Land - mineral soils	CO2	-914.61	-916.15	1.44%	60.00%	60.02%	0.0012	1.41%	2.37%	0.85%	0.05%	0.01%
4.A.1. Forest Land remaining Forest Land - organic soils	CO2	353.21	354.68	3.50%	40.00%	40.15%	0.0001	0.55%	0.92%	0.22%	0.05%	0.00%
4.A.1. Forest Land remaining Forest Land - dead wood	CO2	-152.70	-114.09	3.86%	19.84%	20.22%	0.0000	0.14%	0.30%	0.03%	0.02%	0.00%
4.A.2.1. Cropland converted to Forest Land - living biomass	CO2	0.00	-5.54	13.35%	46.95%	48.81%	0.0000	0.01%	0.01%	0.01%	0.00%	0.00%
4.A.2.1. Cropland converted to Forest Land - mineral soil	CO2	2.89	106.75	13.30%	35.00%	37.44%	0.0000	0.27%	0.28%	0.10%	0.05%	0.00%
4.A.2.1. Cropland converted to Forest Land - dead wood	CO2	-0.52	-38.01	13.84%	19.84%	24.20%	0.0000	0.10%	0.10%	0.02%	0.02%	0.00%
4.A.2.2. Grassland converted to Forest Land - living biomass	CO2	-10.29	-99.15	12.04%	46.95%	48.47%	0.0000	0.25%	0.26%	0.12%	0.04%	0.00%
4.A.2.2. Grassland converted to Forest Land - mineral soils	CO2	0.58	32.31	12.03%	60.00%	61.19%	0.0000	0.08%	0.08%	0.05%	0.01%	0.00%
4.A.2.2. Grassland converted to Forest Land - organic soils	CO2	0.04	3.23	45.46%	40.00%	60.55%	0.0000	0.01%	0.01%	0.00%	0.01%	0.00%
4.A.2.2. Grassland converted to Forest Land - dead wood	CO2	-1.01	-47.07	12.59%	19.84%	23.50%	0.0000	0.12%	0.12%	0.02%	0.02%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
4.A.2.3 Wetlands converted to Forest Land - living biomass	CO2	0.00	-11.94	32.79%	46.95%	57.27%	0.0000	0.03%	0.03%	0.01%	0.01%	0.00%
4.A.2.3. Wetlands converted to Forest Land - organic soils	CO2	0.10	10.06	32.77%	40.00%	51.71%	0.0000	0.03%	0.03%	0.01%	0.01%	0.00%
4.A.2.3. Wetlands converted to Forest Land - dead wood	CO2	-0.10	-10.44	32.99%	19.84%	38.50%	0.0000	0.03%	0.03%	0.01%	0.01%	0.00%
4.A.2.4. Settlements converted to Forest Land - living biomass	CO2	0.00	1.21	31.16%	46.95%	56.35%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.A.2.4. Settlements converted to Forest Land - mineral soils	CO2	-0.18	-2.52	34.17%	60.00%	69.05%	0.0000	0.01%	0.01%	0.00%	0.00%	0.00%
4.A.2.4. Settlements converted to Forest Land - organic soils	CO2	0.04	1.47	67.96%	40.00%	78.85%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.A.2.4. Settlements converted to Forest Land - dead wood	CO2	-0.39	-6.37	31.37%	19.84%	37.12%	0.0000	0.02%	0.02%	0.00%	0.01%	0.00%
4.A.2.5. Other Land converted to Forest Land - living biomass	CO2	0.00	-1.22	22.01%	46.95%	51.85%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.A.2.5. Other Land converted to Forest Land - mineral soil	CO2	-0.26	-6.43	21.98%	60.00%	63.90%	0.0000	0.02%	0.02%	0.01%	0.01%	0.00%
4.A.2.5. Other Land converted to Forest Land - dead wood	CO2	-0.50	-13.04	22.32%	19.84%	29.86%	0.0000	0.03%	0.03%	0.01%	0.01%	0.00%
4.B.1 Cropland remaining Cropland - living biomass	CO2	-1.21	0.19	39.27%	46.95%	61.21%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.B.1 Cropland remaining Cropland - mineral soils	CO2	-350.92	-342.37	2.31%	50.00%	50.05%	0.0001	0.52%	0.89%	0.26%	0.03%	0.00%
4.B.1 Cropland remaining Cropland - organic soils	CO2	453.05	385.39	18.13%	90.00%	91.81%	0.0005	0.52%	1.00%	0.47%	0.26%	0.00%
4.B.2.1 Forest Land converted to Cropland - mineral soils	CO2	0.00	0.78	277.29%	30.00%	278.91%	0.0000	0.00%	0.00%	0.00%	0.01%	0.00%
4.B.2.2 Grassland converted to Cropland - living biomass	CO2	0.00	0.03	29.15%	46.95%	55.26%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.B.2.2 Grassland converted to Cropland - mineral soils	CO2	0.00	50.16	25.95%	30.00%	39.66%	0.0000	0.13%	0.13%	0.04%	0.05%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
4.B.2.2 Grassland converted to Cropland - organic soils	CO2	0.00	22.88	82.90%	90.00%	122.36%	0.0000	0.06%	0.06%	0.05%	0.07%	0.00%
4.B.2.2 Grassland converted to Cropland - (5III) mineral soils (N2O)	N2O	0.00	5.42	25.95%	50.00%	56.33%	0.0000	0.01%	0.01%	0.01%	0.01%	0.00%
4(IV) Indirect N2O Emissions from Managed Soils	N2O	0.00	0.02	25.95%	12.50%	28.80%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.B.2.2 Grassland converted to Cropland - dead wood	CO2	0.00	0.02	59.31%	19.84%	62.55%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.B.2.3 Wetlands converted to Cropland - organic soils	CO2	0.00	2.71	277.29%	90.00%	291.53%	0.0000	0.01%	0.01%	0.01%	0.03%	0.00%
4.C.1 Grassland remaining Grassland – living biomass	CO2	0.00	-0.41	13.71%	46.95%	48.91%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.C.1 Grassland remaining Grassland – organic soils	CO2	58.79	51.65	12.78%	40.00%	41.99%	0.0000	0.07%	0.13%	0.03%	0.02%	0.00%
4.C.2.1 Forest Land converted to Grassland - living biomass	CO2	0.00	66.42	37.29%	46.95%	59.96%	0.0000	0.17%	0.17%	0.08%	0.09%	0.00%
4.C.2 Land converted to Grassland – living biomass (excl. FL)	CO2	0.00	-20.16	18.85%	46.95%	50.59%	0.0000	0.05%	0.05%	0.02%	0.01%	0.00%
4.C.2 Land converted to Grassland – mineral soils	CO2	-0.42	-128.71	12.59%	60.00%	61.31%	0.0000	0.33%	0.33%	0.20%	0.06%	0.00%
4.C.2 Land converted to Grassland – organic soils	CO2	1.63	52.48	44.34%	40.00%	59.72%	0.0000	0.13%	0.14%	0.05%	0.09%	0.00%
4.C.2.1 Forest Land converted to Grassland - dead wood	CO2	0.00	16.47	63.71%	19.84%	66.73%	0.0000	0.04%	0.04%	0.01%	0.04%	0.00%
4.C.2 Land converted to Grassland – dead wood (excl. FL)	CO2	0.00	-0.17	54.99%	19.84%	58.46%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.D.1 Wetlands remaining Wetlands\Peatland - organic soils managed for peat extraction CO2	CO2	1070.69	779.45	22.84%	50.00%	54.97%	0.0007	0.89%	2.02%	0.45%	0.65%	0.01%
4.D.2.1 Forest Land converted to Wetlands - organic soils managed for peat extraction	CO2	0.00	11.11	72.03%	50.00%	87.69%	0.0000	0.03%	0.03%	0.01%	0.03%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
4.D.2.1 Wetland converted to Wetlands - organic soils managed for peat extraction	CO2	0.00	1.40	174.54%	50.00%	181.56%	0.0000	0.00%	0.00%	0.00%	0.01%	0.00%
4.D.2.5 Land converted to Wetlands - deadwood	CO2	0.46	0.16	56.67%	19.84%	60.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.D.2. Land converted to Wetlands - living biomass	CO2	8.45	2.61	114.38%	46.95%	123.64%	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
4.D.1.1.1 Wetlands 4(II) - drained organic soils	N2O	1.43	1.28	64.49%	50.00%	81.60%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.D.1.1.1 Wetlands 4(II) - drained organic soils	CH4	0.06	0.06	64.49%	50.00%	81.60%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.E.2.1 Forest Land converted to Settlements (min+org soils)	CO2	0.00	41.47	29.40%	25.00%	38.59%	0.0000	0.11%	0.11%	0.03%	0.04%	0.00%
4.E.2.1 Forest Land converted to Settlements – living biomass	CO2	0.00	42.33	29.42%	46.95%	55.41%	0.0000	0.11%	0.11%	0.05%	0.05%	0.00%
4.E.2.1 Forest Land converted to Settlements – deadwood	CO2	0.00	39.87	29.65%	19.84%	35.68%	0.0000	0.10%	0.10%	0.02%	0.04%	0.00%
4.E.2.2 Cropland converted to Settlements - soils	CO2	0.00	45.77	39.01%	25.00%	46.34%	0.0000	0.12%	0.12%	0.03%	0.07%	0.00%
4.E.2.3 Grassland converted to Settlements - soils	CO2	0.00	42.28	41.43%	25.00%	48.39%	0.0000	0.11%	0.11%	0.03%	0.06%	0.00%
4.E.2.3 Grassland converted to Settlements – living biomass	CO2	0.00	-0.42	43.64%	46.95%	64.10%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.E.2.3 Grassland converted to Settlements – deadwood	CO2	0.00	-0.01	67.62%	19.84%	70.47%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
4.E.2.5 Other Land Converted to Settlements - soils	CO2	0.00	2.80	114.38%	25.00%	117.08%	0.0000	0.01%	0.01%	0.00%	0.01%	0.00%
4.F.2 Forest land converted to Other land – soils	CO2	0.00	8.51	67.96%	25.00%	72.41%	0.0000	0.02%	0.02%	0.01%	0.02%	0.00%
4.F.2.1 Forest Land converted to Other Land – deadwood	CO2	0.00	7.85	68.07%	19.84%	70.90%	0.0000	0.02%	0.02%	0.00%	0.02%	0.00%
4.F.2.2 Cropland converted to Other land - soils	CO2	0.00	3.35	174.54%	25.00%	176.32%	0.0000	0.01%	0.01%	0.00%	0.02%	0.00%
4.F.2.3 Grassland converted to Other land - soils	CO2	0.00	2.27	277.29%	25.00%	278.41%	0.0000	0.01%	0.01%	0.00%	0.02%	0.00%

IPCC category/Group	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
4.F.2.4 Wetlands converted to Other land - soils	CO2	0.00	1.44	277.29%	25.00%	278.41%	0.0000	0.00%	0.00%	0.00%	0.01%	0.00%
Biomass burning (CH4)	CH4	0.27	0.00	34.50%	70.00%	78.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
Biomass burning (N2O)	N2O	0.03	0.00	34.50%	70.00%	78.04%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
Wood panels and sawnwood	CO2	0.00	-1062.63	62.77%	80.00%	101.69%	0.0048	2.75%	2.75%	2.20%	2.44%	0.11%
Paper and paperboard	CO2	0.00	15.98	45.00%	57.00%	72.62%	0.0000	0.04%	0.04%	0.02%	0.03%	0.00%
Semi-Chemical wood pulp	CO2	0.00	-33.56	44.00%	57.00%	72.01%	0.0000	0.09%	0.09%	0.05%	0.05%	0.00%
5.A Solid waste disposal	CH4	213.72	187.28	17.32%	87.16%	88.86%	0.0001	0.26%	0.48%	0.23%	0.12%	0.00%
5.B.1 Biological treatment of waste	CH4	0.68	15.00	14.14%	74.63%	75.95%	0.0000	0.04%	0.04%	0.03%	0.01%	0.00%
5.B.1 Biological treatment of waste	N2O	0.48	10.73	14.14%	65.00%	66.52%	0.0000	0.03%	0.03%	0.02%	0.01%	0.00%
5.C.1 Waste incineration	CH4	0.06	0.00	5.00%	50.00%	50.25%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.C.1 Waste incineration	N2O	0.01	0.00	5.00%	100.00%	100.12%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.C.1 Waste incineration	CO2	0.76	0.03	5.00%	40.00%	40.31%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.C.2 Open Burning of Waste	CH4	1.16	0.46	32.02%	50.00%	59.37%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.C.2 Open Burning of Waste	N2O	0.22	0.09	32.02%	100.00%	105.00%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.C.2 Open Burning of Waste	CO2	1.49	0.96	32.02%	40.00%	51.23%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
5.D.1 Domestic wastewater	CH4	112.70	49.35	60.42%	66.33%	89.72%	0.0000	0.01%	0.13%	0.01%	0.11%	0.00%
5.D.1 Domestic wastewater	N2O	38.63	30.10	24.97%	105.91%	108.82%	0.0000	0.04%	0.08%	0.04%	0.03%	0.00%
5.D.2 Industrial wastewater	CH4	0.00	9.62	50.25%	36.06%	61.85%	0.0000	0.02%	0.02%	0.01%	0.02%	0.00%
5.E Other (Biogas Burnt in a flare)	CH4	0.00	21.46	17%	23%	29%	0.0000	0.06%	0.06%	0.01%	0.01%	0.00%
5.E Other (Biogas Burnt in a flare)	N2O	0.00	1.01	17%	8%	19%	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%

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Total		38668.03	15658.79				0.0136					0.17%
Total Uncertainties						Uncertainty in total inventory %:	11.65%				Trend uncertainty %:	4.16%

Annex 3. Detailed methodological description for individual source or sink categories

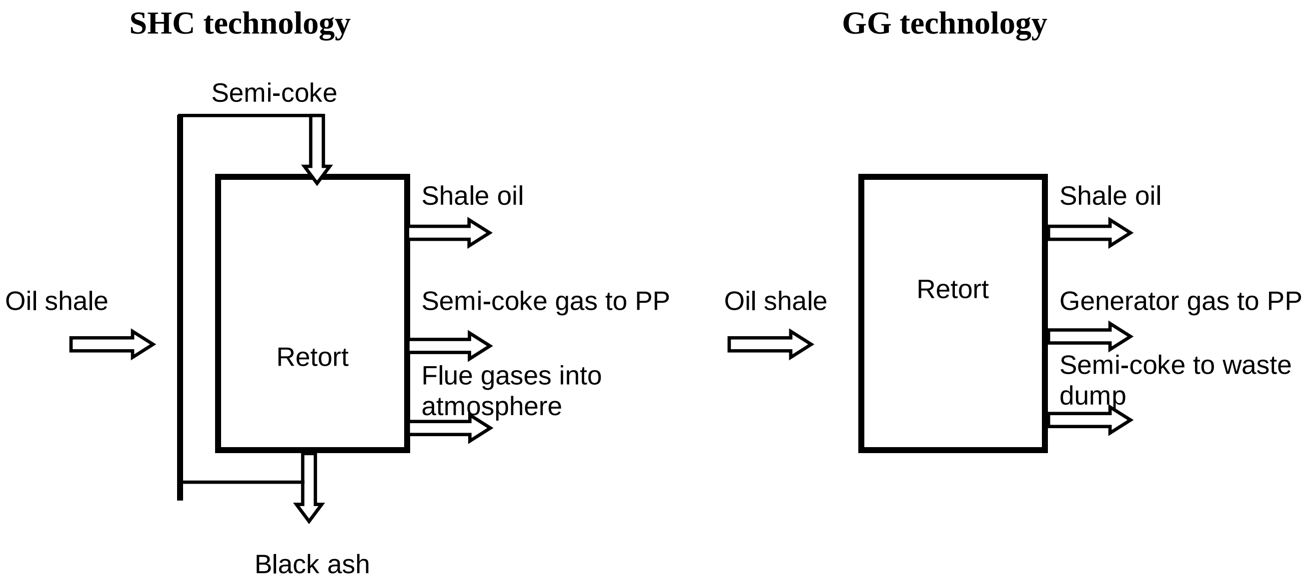
A.3.1. Energy

A.3.1.1. Description of shale oil production technologies and detailed methodology for estimation of carbon emission factors of oil shale gases

There are two different technologies for shale oil production in Estonia: oil shale thermal processing with solid heat carrier (SHC technology) and oil shale thermal processing with gaseous heat carrier in gas generators (GG technology). In 2014 three oil production companies and 7 oil plants were in operation:

1. AS Eesti Energia Narva Oil Plant – two SHC technology plants;
2. Viru Chemistry Group AS (VKG) Oil Plant – three SHC technology plants (since 2010, 2014 and 2015) and a GG technology plant;
3. Kiviõli Oil Plant – SHC technology plant (since 2010) and GG technology plant.

The following simplified schemes describe the output products and waste by different oil shale thermal processing technologies.



During oil shale thermal processing in retort shale oil (a liquid fuel) and semi-coke or generator gas will by formed (depending of technology used). Oil shale gases are usually delivered to power plants nearby for combustion and no GHG or other emissions will be emitted at oil plant. The waste product of the oil shale processing is semi-coke. Using GG technology formed semi-coke will be delivered to waste dump and the small amount of carbon in semi-coke will be stored. Using SHC technology formed semi-coke will be delivered for combustion in aerofountain chamber. The combustion product – flue gases have been used for oil shale draining and after that delivered into atmosphere. To find the amount of CO_2 emitted with flue gases into atmosphere a carbon balance method has been developed.

The idea of carbon balance method is very simple: from the carbon amount delivered with oil shale into retorting process will be take off carbon amount of shale oil, semi coke gas and black ash. The rest of the carbon is the amount which will be emitted into atmosphere.

For generator gas technology the carbon balance method was used to estimate the amount of carbon delivered with semi-coke to waste dump.

Table A.3.1.1. Composition of semi-coke gas from the Narva Solid Heat Carrier-140 processes

Compostition of semi-coke gas	Content in volume, %	Carbon mole ratio	Density (kg/Nm^3)	Density rate (kg/Nm^3)	Rate of C in gas volume, %	Rate of C in gas weight, %	Heat value of gas Q^r_{scg} (MJ/Nm3)	Rate of Q^r_{scg} (MJ/Nm3)
1	2	3	4	5=2x4/100	6=2x3	7=6x4/sum(5)	8	9=2x8/100
CO_2	8.700	0.273	1.964	0.171	2.373	3.482		0.000
H_2S	2.970		1.520	0.045	0.000	0.000	23.384	0.695
N_2	3.270		1.257	0.041	0.000	0.000		0.000
O_2	0.240		1.428	0.003	0.000	0.000		0.000
CO	10.600	0.429	1.250	0.133	4.543	4.243	12.636	1.339
H_2	15.370		0.090	0.014	0.000	0.000	10.798	1.660
CH_4	14.100	0.750	0.720	0.102	10.575	5.689	35.820	5.051
C_2H_6	8.800	0.800	1.340	0.118	7.040	7.049	63.751	5.610
C_2H_4	10.800	0.857	1.250	0.135	9.257	8.646	59.066	6.379
C_3H_8	3.400	0.818	1.970	0.067	2.782	4.095	91.256	3.103
C_3H_6	8.300	0.857	1.880	0.156	7.114	9.994	86.005	7.138
C_4H_{10}	1.800	0.828	2.590	0.047	1.490	2.883	118.651	2.136
C_4H_8+C_4H_6	3.100	0.857	2.500	0.078	2.657	4.964	113.514	3.519
C_5H_{12}	2.100	0.833	3.220	0.068	1.750	4.211	146.087	3.068
C_5H_{10}	5.200	0.857	3.120	0.162	4.457	10.391	140.780	7.321
Total	**98.750**			**1.338**		**65.646**		**47.018**

The carbon emission factor from semi-coke gas combustion can be calculated by the following formula:

$$q_{c\ scg} = 10\ (12/16 \text{ x } CH_4 + 24/30 \text{ x } C_2H_6 + 24/28 \text{ x } C_2H_4 + 36/44 \text{ x } C_3H_8 + 36/42 \text{ x } C_3H_6 + 48/58 \text{ x } C_4H_{10} + 48/56 \text{ x } C_4H_8 + 60/72 \text{ x } C_5H_{12} + 60/70 \text{ x } C_5H_{10} + 72/82 \text{ x } C_6H_{10} + 12/44 \text{ x } CO_2 + 12/28 \text{ x } CO)/Q^{r'}_{scg}, \text{ tC/TJ,} \quad (1)$$

where

$q_{c\ scg}$ – carbon emission factor of semi-coke gas, tC/TJ,

C_Σ – total carbon content in semi-coke gas, % and

$Q^{r'}_{scg}$ – lower heating value of semi-coke gas, MJ/kg.

Q^r_{scg} – lower heating value of semi-coke gas: = **45.018 MJ/Nm³**,

ρ_{scg} – density of semi-coke gas 1.338 kg/Nm^3 and

$Q^{r'}_{scg} = Q^r_{sg}/\ \rho_{sg}$ = 47.018/1.338 = 35.132 **MJ/kg.**

The carbon emission factor of Narva semi-coke gas:

$q_{c\ scg} = 10 \text{ x } C_\Sigma / Q^{r'}_{scg}$ = 10 x 65.646/35.132 = **18.686 tC/TJ**

Table A.3.1.2. Composition of semi-coke gas from the Narva Solid Heat Carrier-280 processes

Compostition of semi-coke gas	Content in volume, %	Carbon mole ratio	Density (kg/Nm^3)	Density rate (kg/Nm^3)	Rate of C in gas volume, %	Rate of C in gas weight, %	Heat value of gas Q^r_{scg} (MJ/Nm3)	Rate of Q^r_{scg} (MJ/Nm3)
1	**2**	**3**	**4**	**5=2x4/100**	**6=2x3**	**7=6x4/sum(5)**	**8**	**9=2x8/100**
CO_2	9.6	0.273	1.964	0.189	2.618	3.927		0.000
H_2S	2.970		1.520	0.045	0.000	0.000	23.384	0.695
N_2	3.270		1.257	0.041	0.000	0.000		0.000
O_2	0.240		1.428	0.003	0.000	0.000		0.000
CO	9.300	0.429	1.250	0.116	3.986	3.805	12.636	1.175
H_2	15.370		0.090	0.014	0.000	0.000	10.798	1.660
CH_4	12.300	0.750	0.720	0.089	9.225	5.073	35.820	4.406
C_2H_6	7.600	0.800	1.340	0.102	6.080	6.223	63.751	4.845
C_2H_4	9.000	0.857	1.250	0.113	7.714	7.365	59.066	5.316
C_3H_8	2.800	0.818	1.970	0.055	2.291	3.447	91.256	2.555
C_3H_6	7.400	0.857	1.880	0.139	6.343	9.108	86.005	6.364
C_4H_{10}	1.500	0.828	2.590	0.039	1.241	2.456	118.651	1.780
$C_4H_8+C_4H_6$	2.800	0.857	2.500	0.070	2.400	4.583	113.514	3.178
C_5H_{12}	1.700	0.833	3.220	0.055	1.417	3.484	146.087	2.483
C_5H_{10}	7.700	0.857	3.120	0.240	6.600	15.727	140.780	10.840
Total	**93.550**			**1.309**		**65.197**		**45.297**

The carbon emission factor from semi-coke gas combustion can be calculated by the following formula:

$$q_{c\ scg} = 10\ (12/16 \times CH_4 + 24/30 \times C_2H_6 + 24/28 \times C_2H_4 + 36/44 \times C_3H_8 + 36/42 \times C_3H_6 + 48/58 \times C_4H_{10} + 48/56 \times C_4H_8 + 60/72 \times C_5H_{12} + 60/70 \times C_5H_{10} + 72/82 \times C_6H_{10} + 12/44 \times CO_2 + 12/28 \times CO)/Q^{r'}_{scg},\ tC/TJ, \qquad (1)$$

where

$q_{c\ scg}$ – carbon emission factor of semi-coke gas, tC/TJ,

C_Σ – total carbon content in semi-coke gas, % and

$Q^{r'}_{scg}$ – lower heating value of semi-coke gas, MJ/kg.

Q^r_{scg} – lower heating value of semi-coke gas: = **45.297 MJ/Nm³**,

ρ_{scg} – density of semi-coke gas 1.309 kg/Nm^3 and

$Q^{r'}_{scg} = Q^r_{sg}/\ \rho_{sg}$ = 45.297/1.309 = 34.596 **MJ/kg.**

The carbon emission factor of Narva semi-coke gas:

$q_{c\ scg} = 10 \times C_\Sigma / Q^{r'}_{scg}$ = 10 x 65.197/34.596 = **18.845 tC/TJ**

Table A.3.1.3. Composition of semi-coke gas from the VKG Solid Heat Carrier (Petroter I) processes

Compostition of semi-coke gas	Content in volume, %	Carbon mole ratio	Density (kg/Nm^3)	Density rate (kg/Nm^3)	Rate of C in gas volume, %	Rate of C in gas weight, %	Heat value of gas Q^r_{scg} (MJ/Nm3)	Rate of Q^r_{scg} (MJ/Nm3)
1	**2**	**3**	**4**	**5=2x4/100**	**6=2x3**	**7=6x4/sum(5)**	**8**	**9=2x8/100**
CO_2	10.410	0.273	1.964	0.204	2.839	4.062		0.000
H_2S	2.530		1.52	0.038	0.000	0.000	23.384	0.592
N_2	5.740		1.257	0.072	0.000	0.000		0.000
O_2	0.160		1.428	0.002	0.000	0.000		0.000
CO	9.650	0.429	1.25	0.121	4.136	3.766	12.636	1.219
H_2	12.710		0.09	0.011	0.000	0.000	10.798	1.372
CH_4	15.440	0.750	0.72	0.111	11.580	6.074	35.82	5.531
C_2H_6	8.510	0.800	1.34	0.114	6.808	6.646	63.751	5.425
C_2H_4	11.460	0.857	1.25	0.143	9.823	8.945	59.066	6.769
C_3H_8	2.880	0.818	1.97	0.057	2.356	3.382	91.256	2.628
C_3H_6	8.560	0.857	1.88	0.161	7.337	10.049	86.005	7.362
C_4H_{10}	0.990	0.828	2.59	0.026	0.819	1.546	118.651	1.175
C_4H_8+C_4H_6	5.330	0.857	2.5	0.133	4.569	8.320	113.514	6.050
C_5H_{12}	2.812	0.833	3.22	0.091	2.343	5.497	146.087	4.108
C_5H_{10}	2.812	0.857	3.12	0.088	2.410	5.478	140.78	3.959
C_6H_{10}		0.878	3.21	0.000	0.000	0.000	141.571	0.000
Total	**99.994**			**1.373**		**63.765**		**46.190**

Using the formula 1,

where

$q_{c\ scg}$ – carbon emission factor of semi-coke gas, tC/TJ,

C_Σ – total carbon content in semi-coke gas, % and

$Q^{r'}_{scg}$ – lower heating value of semi-coke gas, MJ/kg.

Q^r_{scg} – lower heating value of semi-coke gas: = **46.190 MJ/Nm³**,

ρ_{scg} – density of semi-coke gas 1.373 kg/Nm^3 and

$Q^{r'}_{scg} = Q^r_{sg}/\rho_{sg}$ = 46.190/1.373 = **33.649 MJ/kg.**

The carbon emission factor of VKG semi-coke gas:

$q_{c\ scg} = 10 \times C_\Sigma / Q^{r'}_{scg}$ = 10 x 63.765/33.649 = **18.950 tC/TJ**

Table A.3.1.4. Composition of semi-coke gas from the VKG Solid Heat Carrier (Petroter II) processes

Compostition of semi-coke gas	Content in volume, %	Carbon mole ratio	Density (kg/Nm^3)	Density rate (kg/Nm^3)	Rate of C in gas volume, %	Rate of C in gas weight, %	Heat value of gas Q^r_{scg} (MJ/Nm3)	Rate of Q^r_{scg} (MJ/Nm3)
1	**2**	**3**	**4**	**5=2x4/100**	**6=2x3**	**7=6x4/sum(5)**	**8**	**9=2x8/100**
CO_2	13.260	0.273	1.964	0.260	3.616	5.063		0.000
H_2S	2.790		1.52	0.042	0.000	0.000	23.384	0.652
N_2	5.630		1.257	0.071	0.000	0.000		0.000
O_2	0.180		1.428	0.003	0.000	0.000		0.000
CO	9.190	0.429	1.25	0.115	3.939	3.509	12.636	1.161
H_2	11.540		0.09	0.010	0.000	0.000	10.798	1.246
CH_4	15.030	0.750	0.72	0.108	11.273	5.786	35.82	5.384
C_2H_6	8.520	0.800	1.34	0.114	6.816	6.511	63.751	5.432
C_2H_4	11.090	0.857	1.25	0.139	9.506	8.470	59.066	6.550
C_3H_8	2.910	0.818	1.97	0.057	2.381	3.344	91.256	2.656
C_3H_6	8.270	0.857	1.88	0.155	7.089	9.500	86.005	7.113
C_4H_{10}	1.020	0.828	2.59	0.026	0.844	1.559	118.651	1.210
C_4H_8+C_4H_6	5.070	0.857	2.5	0.127	4.346	7.745	113.514	5.755
C_5H_{12}	2.751	0.833	3.22	0.089	2.293	5.262	146.087	4.019
C_5H_{10}	2.751	0.857	3.12	0.086	2.358	5.244	140.78	3.873
C_6H_{10}		0.878	3.21	0.000	0.000	0.000	141.571	0.000
Total	**100.002**			**1.403**		**61.992**		**45.051**

Using the formula 1,

where

$q_{c\ scg}$ – carbon emission factor of semi-coke gas, tC/TJ,

C_Σ – total carbon content in semi-coke gas, % and

$Q^{r'}_{scg}$ – lower heating value of semi-coke gas, MJ/kg.

Q^r_{scg} – lower heating value of semi-coke gas: = **45.051 MJ/Nm³**,

ρ_{scg} – density of semi-coke gas 1.403 kg/Nm^3 and

$Q^{r'}_{scg} = Q^r_{sg/}\ \rho_{sg}$ = 45.051/1.403 = **32.114 MJ/kg.**

The carbon emission factor of VKG semi-coke gas:

$q_{c\ scg} = 10 \times C_\Sigma / Q^{r'}_{scg}$ = 10 x 61.992/32.114 = **19.304 tC/TJ**

Table A.3.1.5. Composition of semi-coke gas from the VKG Solid Heat Carrier (Petroter II and Petroter III) processes

Compostition of semi-coke gas	Content in volume, %	Carbon mole ratio	Density (kg/Nm^3)	Density rate (kg/Nm^3)	Rate of C in gas volume, %	Rate of C in gas weight, %	Heat value of gas Q^r_{scg} (MJ/Nm3)	Rate of Q^r_{scg} (MJ/Nm3)
1	**2**	**3**	**4**	**5=2x4/100**	**6=2x3**	**7=6x4/sum(5)**	**8**	**9=2x8/100**
CO_2	13.380	0.273	1.964	0.263	3.649	5.065		0.000
H_2S	3.660		1.52	0.056	0.000	0.000	23.384	0.856
N_2	2.030		1.257	0.026	0.000	0.000		0.000
O_2	0.100		1.428	0.001	0.000	0.000		0.000
CO	9.210	0.429	1.25	0.115	3.947	3.487	12.636	1.164
H_2	11.910		0.09	0.011	0.000	0.000	10.798	1.286
CH_4	15.710	0.750	0.72	0.113	11.783	5.995	35.82	5.627
C_2H_6	8.720	0.800	1.34	0.117	6.976	6.606	63.751	5.559
C_2H_4	10.960	0.857	1.25	0.137	9.394	8.299	59.066	6.474
C_3H_8	3.080	0.818	1.97	0.061	2.520	3.508	91.256	2.811
C_3H_6	8.830	0.857	1.88	0.166	7.569	10.056	86.005	7.594
C_4H_{10}	1.080	0.828	2.59	0.028	0.894	1.636	118.651	1.281
C_4H_8+C_4H_6	5.480	0.857	2.5	0.137	4.697	8.299	113.514	6.221
C_5H_{12}	2.921	0.833	3.22	0.094	2.434	5.539	146.087	4.267
C_5H_{10}	2.921	0.857	3.12	0.091	2.504	5.521	140.78	4.112
C_6H_{10}		0.878	3.21	0.000	0.000	0.000	141.571	0.000
Total	**99.992**			**1.415**		**64.011**		**47.252**

Using the formula 1,

where

$q_{c\ scg}$ – carbon emission factor of semi-coke gas, tC/TJ,

C_Σ – total carbon content in semi-coke gas, % and

$Q^{r'}_{scg}$ – lower heating value of semi-coke gas, MJ/kg.

Q^r_{scg} – lower heating value of semi-coke gas: = **47.252 MJ/Nm^3**,

ρ_{scg} – density of semi-coke gas 1.415 kg/Nm^3 and

$Q^{r'}_{scg} = Q^r_{sg/}\ \rho_{sg}$ = 47.252/1.415 = **33.394 MJ/kg.**

The carbon emission factor of VKG semi-coke gas:

$q_{c\ scg} = 10 \times C_{\Sigma\ /}\ Q^{r'}_{scg}$ = 10 x 64.011/33.394 = **19.169 tC/TJ**

Table A.3.1.6. Composition of semi-coke gas from the Kiviõli Solid Heat Carrier processes

Compostition of semi-coke gas	Content in volume, %	Carbon mole ratio	Density (kg/Nm^3)	Density rate (kg/Nm^3)	Rate of C in gas volume, %	Rate of C in gas weight, %	Heat value of gas Q^r_{scg} (MJ/Nm3)	Rate of Q^r_{scg} (MJ/Nm3)
1	**2**	**3**	**4**	**5=2x4/100**	**6=2x3**	**7=6x4/sum(5)**	**8**	**9=2x8/100**
CO_2	2.800	0.273	1.964	0.055	0.764	1.229		0.000
H_2S	0.300		1.520	0.005	0.000	0.000	23.384	0.070
N_2	17.370		1.257	0.218	0.000	0.000		0.000
O_2	3.020		1.428	0.043	0.000	0.000		0.000
CO	8.330	0.429	1.250	0.104	3.570	3.658	12.636	1.053
H_2	14.020		0.090	0.013	0.000	0.000	10.798	1.514
CH_4	16.240	0.750	0.720	0.117	12.180	7.189	35.820	5.817
C_2H_6	8.810	0.800	1.340	0.118	7.048	7.742	63.751	5.616
C_2H_4	11.580	0.857	1.250	0.145	9.926	10.171	59.066	6.840
C_3H_8	2.690	0.818	1.970	0.053	2.201	3.554	91.256	2.455
C_3H_6	7.240	0.857	1.880	0.136	6.206	9.564	86.005	6.227
C_4H_{10}	0.910	1.714	2.590	0.024	1.560	3.312	118.651	1.080
C_4H_8+C_4H_6	4.510	0.857	2.500	0.113	3.866	7.922	113.514	5.119
C_5H_{12}	2.390	0.833	3.220	0.077	1.992	5.257	146.087	3.491
C_5H_{10}	0.000	0.857	3.120	0.000	0.000	0.000	140.780	0.000
C_6H_{10}	0.000	0.878	3.210	0.000	0.000	0.000	141.571	0.000
Total	**100.210**			**1.220**		**59.599**		**39.282**

Using the formula 1,

where

$q_{c\ scg}$ – carbon emission factor of semi-coke gas, tC/TJ,

C_Σ – total carbon content in semi-coke gas, % and

$Q^{r'}_{scg}$ – lower heating value of semi-coke gas, MJ/kg.

Q^r_{scg} – lower heating value of semi-coke gas: = **39.282 MJ/Nm³**,

ρ_{scg} – density of semi-coke gas 1.220 kg/Nm^3 and

$Q^{r'}_{scg} = Q^r_{sg} / \rho_{sg}$ = 39.282/1.220 = 32.202 **MJ/kg.**

The carbon emission factor of Kiviõli semi-coke gas:

$$q_{c\ scg} = 10 \times C_\Sigma / Q^{r'}_{scg} = 10 \times 59.599/32.202 = \mathbf{18.508\ tC/TJ}$$

Table A.3.1.7. Composition of the VKG generator gas

Compostition of semi-coke gas	Content in volume, %	Carbon mole ratio	Density (kg/Nm^3)	Density rate (kg/Nm^3)	Rate of C in gas volume, %	Rate of C in gas weight, %	Heat value of gas Q^r_{scg} (MJ/Nm3)	Rate of Q^r_{scg} (MJ/Nm3)
1	**2**	**3**	**4**	**5=2x4/100**	**6=2x3**	**7=6x4/sum(5)**	**8**	**9=2x8/100**
CO_2	16.030	0.273	1.964	0.315	4.372	6.625		0.000
H_2S	0.520		1.52	0.008	0.000	0.000	23.384	0.122
N_2	66.070		1.257	0.830	0.000	0.000		0.000
O_2	1.220		1.428	0.017	0.000	0.000		0.000
CO	6.130	0.429	1.25	0.077	2.627	2.534	12.636	0.775
H_2	6.840		0.09	0.006	0.000	0.000	10.798	0.739
CH_4	1.560	0.750	0.72	0.011	1.170	0.650	35.82	0.559
C_2H_6	0.300	0.800	1.34	0.004	0.240	0.248	63.751	0.191
C_2H_4	0.520	0.857	1.25	0.007	0.446	0.430	59.066	0.307
C_3H_8	0.100	0.818	1.97	0.002	0.082	0.124	91.256	0.091
C_3H_6	0.230	0.857	1.88	0.004	0.197	0.286	86.005	0.198
C_4H_{10}	0.050	0.828	2.59	0.001	0.041	0.083	118.651	0.059
$C_4H_8+C_4H_6$	0.130	0.857	2.5	0.003	0.111	0.215	113.514	0.148
C_5H_{12}	0.159	0.833	3.22	0.005	0.133	0.329	146.087	0.232
C_5H_{10}	0.159	0.857	3.12	0.005	0.136	0.328	140.78	0.224
C_6H_{10}		0.878	3.21	0.000	0.000	0.000	141.571	0.000
Total	**100.018**			**1.296**		**11.851**		**3.644**

Using the formula 1,

where

$q_{c\ gg}$ – carbon emission factor of generator gas, tC/TJ,

C_Σ – total carbon content in generator gas, % and

$Q^{r'}_{gg}$ – lower heating value of generator gas, MJ/kg.

Q^r_{gg} – lower heating value of generator gas: = **3.644 MJ/Nm³**,

ρ_{gg} – density of generator gas 1.296 kg/Nm^3 and

$Q^{r'}_{gg} = Q^r_{sg}/\rho_{sg}$ = 3.644/1.296 = **2.812 MJ/kg.**

The carbon emission factor of VKG generator gas:

$q_{c\ gg} = 10 \times C_\Sigma / Q^{r'}_{scg}$ = 10 x 11.851/2.812 = **42.153 tC/TJ**

Table A.3.1.8. Composition of the Kiviõli generator gas

Compostition of semi-coke gas	Content in volume, %	Carbon mole ratio	Density (kg/Nm^3)	Density rate (kg/Nm^3)	Rate of C in gas volume, %	Rate of C in gas weight, %	Heat value of gas Q^r_{scg} (MJ/Nm3)	Rate of Q^r_{scg} (MJ/Nm3)
1	**2**	**3**	**4**	**5=2x4/100**	**6=2x3**	**7=6x4/sum(5)**	**8**	**9=2x8/100**
CO_2	17.490	0.273	1.964	0.344	4.770	7.100		0.000
H_2S	0.490		1.520	0.007	0.000	0.000	23.384	0.115
N_2	67.210		1.257	0.845	0.000	0.000		0.000
O_2	1.730		1.428	0.025	0.000	0.000		0.000
CO	4.040	0.429	1.250	0.051	1.731	1.640	12.636	0.510
H_2	5.740		0.090	0.005	0.000	0.000	10.798	0.620
CH_4	1.590	0.750	0.720	0.011	1.193	0.651	35.820	0.570
C_2H_6	0.300	0.800	1.340	0.004	0.240	0.244	63.751	0.191
C_2H_4	0.630	0.857	1.250	0.008	0.540	0.512	59.066	0.372
C_3H_8	0.100	0.818	1.970	0.002	0.082	0.122	91.256	0.091
C_3H_6	0.200	0.857	1.880	0.004	0.171	0.244	86.005	0.172
C_4H_{10}	0.050	1.714	2.590	0.001	0.086	0.168	118.651	0.059
C_4H_8+C_4H_6	0.130	0.857	2.500	0.003	0.111	0.211	113.514	0.148
C_5H_{12}	0.300	0.833	3.220	0.010	0.250	0.610	146.087	0.438
C_5H_{10}	0.000	0.857	3.120	0.000	0.000	0.000	140.780	0.000
C_6H_{10}	0.000	0.878	3.210	0.000	0.000	0.000	141.571	0.000
Total	**100.000**			**1.319**		**11.503**		**3.286**

Using the formula 1,

where

$q_{c\ gg}$ – carbon emission factor of generator gas, tC/TJ,

C_Σ – total carbon content in generator gas, % and

$Q^{r'}_{gg}$ – lower heating value of generator gas, MJ/kg.

Q^r_{gg} – lower heating value of generator gas: = **3.286 MJ/Nm^3**,

ρ_{gg} – density of generator gas 1.319 kg/Nm^3 and

$Q^{r'}_{gg} = Q^r_{sg/}\ \rho_{sg}$ = 3.286/1.319 = **2.491 MJ/kg.**

The carbon emission factor of Kiviõli generator gas:

$$q_{c\ gg} = 10 \times C_{\Sigma} / Q^{r'}_{gg} = 10 \times 11.503/2.491 = \mathbf{56.183\ tC/TJ}$$

Carbon Balances

Activity data used in calculations in carbon balances are collected from private companies and are therefore considered confidential. Activity data on oil shale, shale oil and oil shale gases production by oil companies and calculations of carbon balances are not part of the national inventory report and are allocated into archive. The data can be made available during the review process for the review team.

Table A.2.7 Carbon stored with semi-coke

Narva 140	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Amount of black ash to landfill	TJ	84	46	71	115	128	116	124	138	115	111	156	168	182	209	220	240	226	221	298	353	397	380	431	438	455	413
Carbon stored with black ash	Gg	2.6	1.4	2.2	3.5	3.9	3.5	3.8	4.2	3.5	3.4	4.7	5.1	5.5	6.4	6.7	7.3	6.9	6.7	9.1	10.8	12.1	11.6	13.1	13.4	13.9	12.6
Enefit 280	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Amount of black ash to landfill	TJ																									93.74	261.30
Carbon stored with black ash	Gg																									2.86	7.97

VKG GG Technology	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Semi-coke to landfill	TJ	3769	3356	2953	3778	2077	3670	3272	3521	2958	1816	2294	3543	2556	2631	2833	3275	2966	2761	2663	2524	3032	3330	3466	3624	3653	2848
Carbon stored with semi-coke	Gg	114.9	102.3	90.0	115.2	63.3	111.9	99.8	107.4	90.2	55.4	69.9	108.0	77.9	80.2	86.4	99.9	90.4	84.2	81.2	76.9	92.4	101.5	105.7	110.5	111.4	86.8
VKG SHC																											
Semi-coke to landfill	TJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59	153	167	180	182	211
Carbon stored with black ash	Gg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.8	4.7	5.1	5.5	5.5	6.4

VKG Petroter II

Semi-coke to landfill																										67.8	232.4
Carbon stored with black ash																										2.1	7.1

VKG Petroter III

Semi-coke to landfill																											74.9
Carbon stored with black ash																											2.3

Kiviõli GG Technology	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Semi-coke to landfill	TJ	1616	1465	1358	1460	1220	1304	1373	1477	1087	105	1251	1225	1333	1301	964	635	457	405	195	285	323	195	287	240	335	767
Carbon stored with semi-coke	Gg	49.3	44.7	41.4	44.5	37.2	39.7	41.8	45.0	33.1	3.2	38.1	37.3	40.6	39.7	29.4	19.3	13.9	12.4	5.9	8.7	9.9	5.9	8.8	7.3	10.2	23.4
Kiviõli SHC																											
Semi-coke to landfill	TJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.01	11.17	7.53	4.12	7.80	9.67
Carbon stored with black ash	Gg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.3	0.2	0.1	0.2	0.3

Total carbon stored with semi-coke

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Oil Shale Total	TJ	5469	4867	4381	5352	3426	5090	4769	5136	4160	2032	3701	4936	4071	4141	4017	4150	3649	3388	3156	3162	3818	4069	4359	4487	4794	4817
Carbon stored with semi-coke and black ash	kt	166.7	148.4	133.6	163.2	104.5	155.2	145.4	156.6	126.8	61.9	112.8	150.5	124.1	126.3	122.5	126.5	111.2	103.3	96.2	96.4	116.4	124.1	132.9	136.8	146.2	146.9

Table A.3.1.9. Fuel combustion by fuel types, PJ

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Solid Fuels	**233.1**	**211.4**	**170.3**	**130.1**	**135.9**	**124.0**	**127.6**	**125.7**	**112.3**	**106.0**	**106.8**	**104.8**	**101.4**	**119.8**	**120.2**	**114.2**	**107.4**	**133.4**	**123.4**	**104.8**	**140.9**	**149.9**	**137.6**	**161.1**	**162.3**	**139.5**
Oil Shale	215.4	195.4	158.5	121.3	128.0	115.2	118.5	117.0	106.8	101.5	100.5	97.1	95.0	113.6	113.4	107.4	99.6	123.7	113.1	95.4	130.9	139.5	126.6	150.4	151.4	130.8
Coal	9.3	9.0	5.7	2.9	2.2	2.5	2.8	2.4	1.8	1.9	2.3	3.0	1.6	1.2	1.6	1.5	1.9	3.5	3.5	2.3	1.6	1.9	1.7	1.7	2.1	0.8
Oil shale semi-coke gas	0.7	0.4	0.6	1.1	0.9	0.9	1.0	1.0	0.9	0.8	1.0	1.3	1.3	1.3	1.5	1.6	1.6	1.5	2.0	2.4	3.2	3.8	4.1	3.7	3.7	3.6
Oil shale generator gas	6.4	5.5	4.5	3.8	3.8	4.4	4.3	4.3	2.2	1.2	2.2	2.4	2.6	2.7	2.8	2.8	3.2	3.5	3.6	3.4	3.5	3.2	3.3	3.4	3.4	2.4
Gas gasoline	1.0	0.8	0.9	1.0	1.0	1.0	1.0	1.0	0.6	0.5	0.8	0.9	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.3	1.6	1.6	1.9	1.7	1.7	2.0
Coke	0.4	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Liquid Fuels	**121.8**	**111.0**	**61.6**	**59.8**	**58.3**	**46.8**	**49.9**	**48.5**	**48.3**	**43.7**	**36.1**	**42.2**	**43.3**	**42.2**	**42.3**	**42.7**	**42.7**	**44.8**	**41.9**	**38.9**	**41.2**	**41.6**	**42.3**	**40.5**	**41.0**	**42.7**
Heavy fuel oil	67.8	61.7	26.9	28.7	23.4	14.4	15.7	13.1	13.5	11.0	3.7	3.3	2.4	1.2	0.7	0.5	0.2	0.3	0.2	0.2	0.2	0.1	0.0	0.0	0.0	0.0
Light fuel oil	5.1	3.7	1.6	0.9	0.7	1.0	1.7	2.0	2.2	2.7	3.2	4.9	4.7	4.7	4.3	4.0	2.6	2.9	2.8	2.1	2.1	0.4	0.3	0.4	0.2	0.5
Motor gasoline	22.8	20.3	9.8	10.1	12.5	10.7	12.1	13.1	12.7	12.0	12.2	14.4	13.4	12.9	12.4	12.5	13.5	14.2	14.0	12.9	12.0	11.3	10.9	10.2	10.4	10.3
Diesel oil	24.4	23.8	14.4	13.3	14.3	13.0	14.2	14.1	15.1	12.6	12.4	14.2	17.7	18.2	19.5	20.6	22.2	24.0	21.5	20.6	23.4	24.1	25.4	25.2	27.0	27.7
LPG	1.6	1.5	0.5	0.3	0.5	0.3	0.3	0.4	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.4	0.3	0.4	0.4	0.5	0.6
Aviation Gasoline	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shale oil (heavy fraction)	0.0	0.0	8.4	6.6	6.9	7.3	5.9	5.8	4.4	5.0	4.2	5.0	4.8	4.8	5.1	4.7	3.9	3.0	3.0	2.7	3.2	2.5	2.6	2.0	1.7	2.0
Shale oil (light fraction)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.5	2.4	1.2	1.5
Gaseous fuels	**43.5**	**44.2**	**26.4**	**13.4**	**16.5**	**19.4**	**21.9**	**21.2**	**19.9**	**19.5**	**23.6**	**25.3**	**23.8**	**25.1**	**27.9**	**28.6**	**29.0**	**29.0**	**27.4**	**21.4**	**23.5**	**21.2**	**21.6**	**20.0**	**17.7**	**15.7**
Natural Gas	43.5	44.2	26.4	13.4	16.5	19.4	21.9	21.2	19.9	19.5	23.6	25.3	23.8	25.1	27.9	28.6	29.0	29.0	27.4	21.4	23.5	21.2	21.6	20.0	17.7	15.7

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Peat	**5.4**	**4.5**	**3.8**	**3.2**	**2.8**	**4.0**	**4.3**	**3.3**	**2.4**	**2.0**	**1.8**	**2.0**	**2.3**	**2.3**	**2.0**	**1.8**	**2.0**	**2.4**	**2.1**	**2.1**	**2.3**	**2.1**	**2.0**	**1.7**	**1.4**	**1.3**
Milled Peat	1.8	1.1	1.2	1.1	1.2	1.8	1.3	1.3	1.0	0.8	0.7	1.2	1.2	1.2	1.0	1.0	1.2	1.6	1.3	1.3	1.7	1.6	1.5	1.2	1.0	1.0
Sod Peat	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.9	0.9	0.7	0.7	0.6	0.8	0.8	0.8	0.6	0.6	0.6	0.6	0.6	0.5	0.2	0.3	0.3	0.2	0.2
Peat Briquette	3.6	3.3	2.6	2.0	1.6	2.2	2.0	1.1	0.6	0.5	0.5	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Other Fuels	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.3**	**0.4**	**0.8**	**0.6**	**0.6**	**0.8**	**0.9**	**0.5**	**0.6**	**1.1**	**1.5**	**3.8**	**4.2**	**3.9**
Waste oils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.7	0.6	0.6	0.7	0.6	0.2	0.2	0.2	0.2	0.2	0.1	0.2
Plastics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Municipal Solid Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.4	0.2	0.4	0.9	1.3	3.7	4.0	3.7
Biomass	**8.6**	**8.5**	**8.1**	**7.7**	**12.5**	**20.3**	**24.3**	**24.8**	**21.1**	**21.3**	**21.4**	**22.6**	**22.9**	**24.1**	**25.0**	**24.5**	**22.1**	**24.9**	**26.9**	**29.4**	**35.0**	**33.7**	**34.3**	**33.8**	**33.9**	**35.4**
Solid biomass	8.6	8.5	8.1	7.7	12.5	20.3	24.2	24.7	21.0	21.2	21.4	22.5	22.8	24.0	24.9	24.4	21.9	24.7	26.6	29.2	34.5	33.4	34.0	33.4	33.4	34.8
Liquid biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.3	0.2	0.2	0.1	0.2	0.1
Gaseous biomass	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.3	0.3	0.5

Table A.3.1.10. CO_2 emissions from fuel combustion, Mt

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Solid Fuels	23.570	21.445	17.161	12.929	13.508	12.403	12.711	12.480	11.041	10.361	10.406	10.169	9.827	11.614	11.555	10.864	10.207	12.858	11.668	9.663	12.988	13.613	12.162	14.439	14.202	10.749
Oil Shale	21.316	19.429	15.658	11.796	12.455	11.205	11.498	11.307	10.349	9.857	9.654	9.273	9.030	10.831	10.722	10.025	9.245	11.696	10.428	8.556	11.844	12.475	11.030	13.329	13.062	9.913
Coal	0.889	0.861	0.544	0.280	0.209	0.240	0.268	0.230	0.175	0.186	0.219	0.283	0.154	0.114	0.149	0.144	0.181	0.337	0.341	0.224	0.155	0.180	0.166	0.160	0.198	0.075
Oil shale semi-coke gas	0.048	0.026	0.042	0.072	0.062	0.062	0.068	0.072	0.063	0.054	0.071	0.086	0.086	0.090	0.101	0.109	0.111	0.105	0.137	0.164	0.219	0.259	0.283	0.251	0.253	0.245
Oil shale generator gas	1.206	1.037	0.845	0.703	0.708	0.825	0.800	0.796	0.408	0.229	0.403	0.453	0.490	0.509	0.512	0.517	0.595	0.641	0.678	0.626	0.656	0.583	0.549	0.560	0.564	0.372
Gas gasoline	0.068	0.057	0.061	0.070	0.069	0.068	0.073	0.073	0.043	0.032	0.054	0.060	0.065	0.068	0.069	0.068	0.075	0.079	0.083	0.091	0.113	0.117	0.134	0.124	0.125	0.143
Coke	0.043	0.034	0.009	0.008	0.005	0.003	0.004	0.002	0.003	0.003	0.005	0.013	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.016	0.000	0.000
Liquid Fuels	9.168	8.351	4.642	4.514	4.376	3.497	3.726	3.609	3.599	3.251	2.647	3.088	3.186	3.103	3.111	3.109	3.094	3.239	3.036	2.828	3.013	3.039	3.085	2.957	2.996	3.115
Heavy fuel oil	5.263	4.788	2.088	2.228	1.819	1.120	1.223	1.016	1.051	0.854	0.290	0.259	0.185	0.094	0.052	0.039	0.017	0.020	0.015	0.015	0.017	0.005	0.003	0.003	0.001	0.002
Light fuel oil	0.374	0.274	0.118	0.064	0.054	0.071	0.125	0.145	0.165	0.199	0.237	0.362	0.350	0.348	0.321	0.297	0.189	0.213	0.208	0.159	0.153	0.030	0.023	0.027	0.015	0.040
Motor gasoline	1.633	1.448	0.704	0.722	0.893	0.767	0.862	0.940	0.912	0.863	0.859	1.023	0.966	0.940	0.900	0.881	0.944	0.993	0.988	0.918	0.867	0.823	0.785	0.737	0.758	0.746
Diesel oil	1.789	1.740	1.054	0.971	1.048	0.952	1.041	1.035	1.109	0.928	0.912	1.038	1.296	1.335	1.427	1.508	1.622	1.758	1.570	1.507	1.709	1.758	1.859	1.841	1.973	2.022
LPG	0.103	0.095	0.035	0.022	0.031	0.021	0.022	0.023	0.025	0.021	0.021	0.024	0.017	0.019	0.019	0.020	0.018	0.022	0.023	0.018	0.023	0.021	0.026	0.024	0.029	0.039
Aviation Gasoline	0.006	0.006	0.002	0.004	0.003	0.003	0.003	0.003	0.002	0.003	0.002	0.002	0.002	0.002	0.003	0.002	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.001	0.001	0.001
Shale oil (heavy fraction)	0.000	0.000	0.641	0.503	0.528	0.563	0.449	0.446	0.335	0.384	0.325	0.380	0.370	0.366	0.390	0.362	0.302	0.231	0.230	0.209	0.242	0.195	0.200	0.151	0.129	0.151
Shale oil (light fraction)	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	0.000	0.000	0.000	0.000	0.204	0.186	0.172	0.089	0.113
Natural Gas	2.390	2.432	1.452	0.737	0.909	1.068	1.205	1.167	1.092	1.069	1.297	1.393	1.309	1.380	1.536	1.570	1.594	1.594	1.508	1.177	1.295	1.168	1.190	1.098	0.975	0.864

Peat	0.538	0.443	0.382	0.316	0.283	0.400	0.433	0.334	0.247	0.200	0.188	0.211	0.235	0.234	0.205	0.188	0.206	0.252	0.220	0.215	0.244	0.215	0.211	0.174	0.146	0.140
Milled Peat	0.192	0.120	0.129	0.119	0.130	0.191	0.140	0.143	0.105	0.081	0.073	0.123	0.129	0.125	0.102	0.107	0.130	0.169	0.134	0.141	0.175	0.174	0.158	0.127	0.106	0.104
Sod Peat	0.000	0.000	0.000	0.000	0.000	0.000	0.102	0.087	0.089	0.070	0.070	0.062	0.077	0.077	0.080	0.060	0.058	0.062	0.060	0.058	0.051	0.022	0.033	0.028	0.021	0.022
Peat Briquette	0.346	0.322	0.253	0.197	0.153	0.209	0.191	0.104	0.053	0.050	0.046	0.026	0.029	0.032	0.023	0.021	0.019	0.020	0.027	0.015	0.017	0.019	0.020	0.019	0.019	0.013
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.010	0.026	0.030	0.058	0.045	0.045	0.057	0.072	0.040	0.044	0.089	0.115	0.258	0.297	0.260
Waste oils	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.009	0.025	0.025	0.054	0.044	0.042	0.048	0.044	0.018	0.012	0.014	0.011	0.011	0.011	0.014
Plastics	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	0.000	0.000	0.003	0.001	0.000	0.000	0.000	0.001	0.000
Municipal Solid Waste	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.004	0.004	0.001	0.002	0.009	0.028	0.019	0.031	0.074	0.104	0.247	0.285	0.246

Table A.3.1.11. CH_4 emissions from fuel combustion, kt CO_2 eq

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Solid Fuels	30.11	31.76	11.44	5.86	2.25	5.81	9.24	9.42	7.40	8.24	6.90	6.32	6.87	4.55	7.54	6.84	5.71	4.33	3.62	2.83	2.81	3.77	3.41	3.21	3.22	2.51
Oil Shale	1.58	1.47	1.18	0.90	1.12	0.91	0.87	0.68	1.02	0.68	0.73	0.65	0.60	0.54	0.64	0.80	0.66	1.22	0.95	0.69	0.75	1.08	1.09	0.90	1.08	1.24
Coal	28.25	30.06	10.11	4.82	1.00	4.76	8.23	8.60	6.30	7.50	6.08	5.55	6.16	3.91	6.79	5.92	4.93	2.98	2.53	1.99	1.89	2.52	2.14	2.09	1.94	1.05
Oil Shale Gas	0.18	0.15	0.13	0.12	0.12	0.13	0.13	0.13	0.08	0.05	0.08	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.14	0.14	0.17	0.17	0.19	0.18	0.20	0.23
Coke	0.10	0.08	0.02	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
Liquid Fuels	33.15	30.03	15.51	15.38	16.45	14.78	15.19	16.79	13.35	14.87	13.31	15.52	13.98	12.63	11.58	11.15	10.71	10.35	9.19	7.83	7.30	6.70	6.20	5.61	5.37	5.39
Heavy fuel oil	5.83	5.19	2.09	2.36	1.82	1.08	1.18	0.98	1.03	0.83	0.28	0.26	0.18	0.09	0.05	0.04	0.02	0.02	0.01	0.01	0.02	0.01	0.00	0.01	0.00	0.00
Light fuel oil	0.86	0.63	0.29	0.13	0.09	0.10	0.22	0.23	0.28	0.35	0.44	0.86	0.80	0.70	0.62	0.56	0.37	0.39	0.40	0.26	0.24	0.07	0.06	0.06	0.04	0.07
Motor gasoline	23.16	21.09	10.61	10.52	11.97	10.92	11.19	13.00	9.31	11.30	10.30	11.83	10.04	8.93	7.90	7.56	7.47	7.20	6.25	5.48	4.84	4.33	3.93	3.55	3.42	3.37
Diesel oil	3.14	2.95	1.80	1.83	2.00	2.09	2.12	2.11	2.37	1.99	1.93	2.17	2.58	2.51	2.61	2.63	2.53	2.49	2.27	1.84	1.93	1.77	1.71	1.56	1.62	1.56
LPG	0.16	0.17	0.06	0.04	0.04	0.03	0.04	0.04	0.04	0.03	0.04	0.04	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.05
Aviation Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shale oil (heavy fraction)	0.00	0.00	0.64	0.52	0.53	0.56	0.44	0.44	0.33	0.38	0.32	0.37	0.36	0.36	0.38	0.35	0.30	0.23	0.23	0.21	0.24	0.20	0.20	0.16	0.13	0.17
Shale oil (light fraction)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.26	0.25	0.12	0.17
Natural Gas	1.34	1.42	0.91	0.60	0.70	0.69	0.70	0.69	0.68	0.66	0.77	0.81	0.82	0.85	0.92	0.96	0.98	1.05	1.04	0.88	0.96	0.83	0.83	0.81	0.76	0.75
Peat	26.30	24.18	19.34	14.23	9.95	14.19	14.47	8.13	4.33	3.97	3.45	2.06	2.21	1.95	1.49	1.56	1.14	1.37	1.90	0.92	1.19	1.38	1.31	1.30	1.28	0.86
Milled Peat	0.05	0.03	0.03	0.54	0.30	0.14	0.42	0.48	0.44	0.09	0.02	0.03	0.09	0.03	0.03	0.05	0.06	0.04	0.03	0.03	0.04	0.04	0.04	0.03	0.03	0.02

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Sod Peat	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.24	0.16	0.17	0.11	0.10	0.09	0.09	0.13	0.04	0.03	0.03	0.01	0.04	0.02	0.03	0.01	0.01	0.01	0.01
Peat Briquette	26.25	24.15	19.30	13.69	9.66	14.05	13.87	7.41	3.72	3.72	3.33	1.92	2.03	1.83	1.33	1.46	1.06	1.30	1.85	0.85	1.13	1.31	1.26	1.26	1.25	0.83
Biomass	46.38	44.14	42.31	42.24	65.16	117.68	137.05	143.07	112.84	110.01	110.84	110.16	109.70	116.30	117.71	103.30	99.61	125.97	129.50	138.42	145.45	128.35	134.72	132.29	130.77	129.53
Solid Biomass	46.38	44.14	42.31	42.24	65.16	117.68	137.05	143.07	112.84	110.01	110.83	110.16	109.70	116.30	117.71	103.30	99.60	125.96	129.49	138.42	145.43	128.33	134.70	132.27	130.74	129.51
Liquid Biomass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01
Gaseous Biomass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Other Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	0.26	0.30	0.58	0.46	0.45	0.57	0.71	0.39	0.42	0.84	1.09	2.86	3.13	2.89
Waste oils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.09	0.25	0.25	0.55	0.45	0.43	0.49	0.44	0.19	0.12	0.14	0.12	0.11	0.11	0.14
Plastics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.01	0.00
Municipal Solid Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.04	0.01	0.02	0.09	0.26	0.18	0.29	0.70	0.97	2.74	3.01	2.75

Table A.3.1.12. N_2O emissions from fuel combustion, kt CO_2 eq

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Solid Fuels	7.147	6.767	4.690	2.559	2.716	2.713	2.782	2.307	2.543	1.925	2.209	2.505	1.768	1.464	4.628	8.175	8.642	10.104	10.114	7.840	8.132	8.844	7.451	9.597	9.157	9.236
Oil Shale	2.599	2.427	1.957	1.071	1.577	1.423	1.356	1.066	1.619	0.982	1.069	1.016	0.920	0.802	3.798	7.367	7.649	8.377	8.386	6.617	7.204	7.797	6.451	8.574	7.978	8.611
Coal	4.153	4.022	2.542	1.308	0.978	1.119	1.253	1.076	0.818	0.869	1.024	1.323	0.718	0.531	0.697	0.672	0.845	1.574	1.557	1.048	0.722	0.840	0.777	0.745	0.940	0.356
Oil Shale Gas	0.211	0.175	0.152	0.144	0.140	0.158	0.157	0.158	0.092	0.061	0.096	0.110	0.116	0.121	0.126	0.130	0.144	0.149	0.168	0.172	0.201	0.206	0.222	0.212	0.240	0.269
Coke	0.184	0.144	0.039	0.036	0.020	0.013	0.015	0.007	0.014	0.013	0.021	0.056	0.014	0.009	0.006	0.005	0.005	0.004	0.003	0.003	0.005	0.000	0.000	0.067	0.000	0.000
Liquid Fuels	95.479	91.354	59.419	57.996	52.292	52.068	59.375	55.864	54.204	49.835	52.142	67.366	77.662	58.663	57.610	56.497	52.942	52.032	46.559	50.610	57.996	53.774	54.629	53.181	61.453	61.782

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Heavy fuel oil	12.129	11.030	4.802	5.125	4.183	2.577	2.811	2.334	2.417	1.964	0.667	0.597	0.425	0.216	0.119	0.091	0.040	0.046	0.036	0.034	0.039	0.013	0.007	0.007	0.002	0.005
Light fuel oil	0.904	0.660	0.286	0.154	0.131	0.173	0.301	0.350	0.398	0.480	0.573	0.873	0.845	0.840	0.776	0.716	0.457	0.515	0.502	0.383	0.369	0.073	0.057	0.065	0.036	0.097
Motor gasoline	15.199	14.307	6.344	8.257	14.756	17.517	22.537	21.080	15.466	18.399	22.990	40.273	38.604	17.150	16.850	16.330	11.084	10.720	9.976	8.796	7.847	7.104	6.308	5.335	4.840	4.703
Diesel oil	67.144	65.258	46.457	43.239	31.949	30.445	32.636	31.013	35.104	28.059	27.117	24.700	36.890	39.569	38.913	38.487	40.631	40.186	35.474	40.881	49.147	45.602	47.297	46.980	56.032	56.320
LPG	0.047	0.044	0.016	0.010	0.014	0.010	0.010	0.010	0.011	0.010	0.010	0.011	0.008	0.009	0.009	0.009	0.008	0.010	0.011	0.008	0.011	0.010	0.012	0.011	0.014	0.018
Aviation Gasoline	0.056	0.056	0.019	0.037	0.025	0.035	0.032	0.035	0.026	0.027	0.025	0.025	0.026	0.025	0.034	0.019	0.015	0.015	0.024	0.018	0.018	0.022	0.028	0.010	0.010	0.010
Shale oil (heavy fraction)	0.000	0.000	1.496	1.174	1.234	1.313	1.048	1.042	0.782	0.896	0.760	0.888	0.863	0.854	0.909	0.845	0.706	0.539	0.536	0.489	0.565	0.454	0.467	0.351	0.302	0.353
Shale oil (light fraction)	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	0.000	0.000	0.000	0.000	0.497	0.452	0.420	0.217	0.275
Natural Gas	1.295	1.317	0.787	0.399	0.493	0.577	0.653	0.633	0.592	0.580	0.703	0.755	0.709	0.748	0.832	0.851	0.864	0.864	0.818	0.638	0.702	0.633	0.645	0.595	0.529	0.468
Peat	2.300	1.896	1.632	1.353	1.211	1.714	1.861	1.431	1.058	0.860	0.810	0.904	1.006	1.004	0.881	0.803	0.881	1.076	0.942	0.916	1.039	0.911	0.900	0.740	0.622	0.594
Milled Peat	0.810	0.507	0.543	0.499	0.545	0.806	0.589	0.600	0.440	0.340	0.306	0.521	0.543	0.529	0.431	0.450	0.547	0.714	0.564	0.596	0.740	0.732	0.665	0.536	0.448	0.438
Sod Peat	0.000	0.000	0.000	0.000	0.000	0.000	0.445	0.381	0.387	0.305	0.306	0.269	0.336	0.338	0.351	0.264	0.252	0.274	0.263	0.255	0.223	0.095	0.146	0.121	0.092	0.098
Peat Briquette	1.491	1.389	1.089	0.854	0.666	0.907	0.827	0.450	0.231	0.215	0.198	0.114	0.127	0.137	0.099	0.090	0.082	0.089	0.115	0.065	0.076	0.084	0.089	0.084	0.082	0.058
Biomass	10.130	10.097	9.670	9.213	14.921	24.154	28.875	29.469	25.091	25.228	25.455	26.790	27.153	28.591	29.554	28.975	25.892	29.314	31.527	34.693	40.718	37.119	335.119	633.119	931.119	1229.119
Solid Biomass	10.130	9.940	9.503	9.056	14.764	23.996	28.278	29.203	24.892	24.837	25.022	26.358	26.523	27.905	29.006	28.211	25.186	28.600	30.885	34.137	40.347	39.170	39.892	38.957	38.953	40.692
Liquid Biomass	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	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Gaseous Biomass	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	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.160	0.415	0.470	0.928	0.727	0.717	0.913	1.128	0.623	0.673	1.336	1.733	4.545	4.971	4.591
Waste oils	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.149	0.396	0.405	0.868	0.711	0.684	0.777	0.706	0.297	0.197	0.228	0.185	0.181	0.177	0.220
Plastics	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	0.000	0.005	0.041	0.018	0.000	0.000	0.005	0.013	0.001
Municipal Solid Waste	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.019	0.066	0.060	0.016	0.032	0.135	0.417	0.285	0.457	1.108	1.548	4.360	4.781	4.370

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March 14, 2011 nr

Subject: Possible methane emission from
Estonian oil shale mining

In reply to your question whether methane exists in Estonian oil shale mining and in which kinds of Estonian studies this topic is treated, our answer is the following:

Estonian underground mines are continually ventilated and quality of air inside the mines is controlled. Oil shale is a mixture of clay and kerogen matter, and does not emit methane. During the 90-year long period of mining in Estonia there have never been any problems related to methane. Methane is non-existent in Estonian oil shale.

Risk of fire is related only to the kerogen matter in the oil shale, which can ignite. While oil shale is being crushed, fine dust is produced and it may explode.

So as methane does not exist in Estonian mines, it has not been an issue for scientific studies and there are no related publications dealing with Estonia.

Sincerely

Prof. Ingo Valgma
Director

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A.3.1.2. Feedstocks and non-energy use of fuels

In this annex, additional information regarding CRF category 1.AD Feedstocks and non-energy use is presented. Under this category carbon stored in products is reported.

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

1.AD.2 Lubricants

1.AD.3 Bitumen

1.AD 5 Natural Gas

1.AD 10 Other/Oil Shale

Activity data on lubricants and bitumen consumption is received from IEA statistics; the national statistics does not publish this data. Data on natural gas use for non-energy use are taken from national energy balance sheet. Activity data on oil shale reported in the CRF 1.AD.10 is calculated. This is oil shale semi coke – the by-product of shale oil production and contains a small amount of organic matter (carbon). Oil shale semi-coke is stored in the oil shale waste dumps (carbon stored).

In the Table A.3.1.13 carbon stored in products is presented.

Table A.3.1.13. Carbon stored in products

Lubricants	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fuel consumption, TJ	1085	1045	683	522	683	442	482	362	402	281	322	281	241	281	241	161	161	281	201	161	161	161	121	121	121	121
Fraction of C stored	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
CEF, tC/TJ	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
C stored, kt	4.3	4.2	2.7	2.1	2.7	1.8	1.9	1.4	1.6	1.1	1.3	1.1	1.0	1.1	1.0	0.6	0.6	1.1	0.8	0.6	0.6	0.6	0.5	0.5	0.5	0.5
CO2 not emitted, kt	15.9	15.3	10.0	7.7	10.0	6.5	7.1	5.3	5.9	4.1	4.7	4.1	3.5	4.1	3.5	2.4	2.4	4.1	2.9	2.4	2.4	2.4	1.8	1.8	1.8	1.8
Bitumen	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Fuel consumption, TJ	2170	1849	965	1246	1366	844	1125	1045	1286	1286	1366	1125	2733	2050	2653	3657	4220	4099	3697	3416	3054	2693	2411	3296	3657	2853
Fraction of C stored	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CEF, tC/TJ	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
C stored, kt	47.7	40.7	21.2	27.4	30.1	18.6	24.8	23.0	28.3	28.3	30.1	24.8	60.1	45.1	58.4	80.5	92.8	90.2	81.3	75.2	67.2	59.2	53.1	72.5	80.5	62.8
CO2 not emitted, kt	175.1	149.1	77.8	100.5	110.2	68.1	90.8	84.3	103.7	103.7	110.2	90.8	220.5	165.3	214.0	295.0	340.4	330.7	298.3	275.6	246.4	217.2	194.5	265.8	295.0	230.2
Natural Gas	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Fuel consumption, TJ	7 657	7 361	3 665	1 440	4 736	4 978	4 930	4 859	4 899	4 674	4 166	4 459	1 152	2 413	4 533	4 915	4 919	4 715	4 872	538	0	0	448	2 808	0	0
Fraction of C stored	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CEF, tC/TJ	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07	15.07
C stored, kt	115.4	110.9	55.2	21.7	71.4	75.0	74.3	73.2	73.8	70.4	62.8	67.2	17.4	36.4	68.3	74.1	74.1	71.1	73.4	8.1	0.0	0.0	6.8	42.3	0.0	0.0
CO2 not emitted, kt	423.1	406.7	202.5	79.6	261.7	275.1	272.4	268.5	270.7	258.3	230.2	246.4	63.7	133.3	250.5	271.6	271.8	260.5	269.2	29.7	0.0	0.0	24.8	155.2	0.0	0.0
Oil Shale	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**

Fuel consumption, TJ	5469	4867	4381	5352	3426	5090	4769	5136	4160	2032	3701	4936	4071	4141	4017	4150	3649	3388	3156	3162	3818	4069	4359	4487	4794	4817
Fraction of C stored	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CEF, tC/TJ	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
C stored, kt	166.8	148.4	133.6	163.2	104.5	155.3	145.5	156.7	126.9	62.0	112.9	150.5	124.2	126.3	122.5	126.6	111.3	103.3	96.3	96.4	116.4	124.1	132.9	136.8	146.2	146.9
CO2 not emitted, kt	611.7	544.3	490.0	598.5	383.1	569.3	533.3	574.4	465.2	227.2	413.9	552.0	455.2	463.1	449.2	464.1	408.0	378.9	353.0	353.6	426.9	455.0	487.5	501.7	536.1	538.7

Table A.3.1.14. Emission factors for LTO-cycle (kg/LTO)

	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Turbofans (Jets)*							
Airbus A310	4 853	0.5	0.2	23.2	25.8	5	1.5
Airbus A320	2 527	0.2	0.1	10.8	17.6	1.7	0.8
Bae 111	2 147	2.1	0.1	4.9	37.7	19.3	0.7
Bae 146	1 794	0.1	0.1	4.2	9.7	0.9	0.6
B727	4 450	0.7	0.1	12.6	26.4	6.5	1.4
B737-100	2 897	0.1	0.1	8	4.8	0.5	0.9
B737-400	2 600	0.1	0.1	8.3	11.8	0.6	0.8
B747-100-300	10 754	3.7	0.3	55.9	78.2	33.6	3.4
B747-400	10 717	0.2	0.3	56.6	19.5	1.6	3.4
B757	3 947	0.1	0.1	19.7	12.5	1.1	1.3
B767-300	5 094	0.1	0.2	26	6.1	0.8	1.6
B777	8 073	2.3	0.3	53.6	61.4	20.5	2.6
Fokker 100	2 345	0.1	0.1	5.8	13.7	1.3	0.7
Fokker 28	2 098	3.3	0.1	5.2	32.7	29.6	0.7
2XB737-100	5 794	0.2	0.2	16	9.6	1	1.8
McDonnell Douglas DC-9	2 760	0.1	0.1	7.3	5.4	0.7	0.9
McDonnell Douglas DC-10	7 501	2.3	0.2	41.7	61.6	20.5	2.4
McDonnell Douglas	3 160	0.2	0.1	12.3	6.5	1.4	1
C525	1 070	0.33	0.03	0.74	34.07	3.01	0.34
EC RJ_100ER	1 060	0.06	0.03	2.27	6.7	0.56	0.33
ERJ-145	990	0.06	0.03	2.69	6.18	0.5	0.31
GLF4	2 160	0.14	0.1	5.63	8.88	1.23	0.68
GLF5	1 890	0.03	0.1	5.58	8.42	0.28	0.6
RJ85	1 910	0.13	0.1	4.34	11.21	1.21	0.6
Turboprop**							
turboprop, <1000sph/engine	230	0.06	0.01	0.3	2.97	0.58	0.07
turboprop, 1000-2000 sph/engine	640	0	0.02	1.51	2.24	0	0.2
turboprop, >2000sph/engine	620	0.03	0.02	1.82	2.33	0.26	0.2
Piston engine***							
microlight aircraft	4.41	0.00	0.00	0.03	0.94	0.04	0.00
4 seat single engine (<180hp)	12.29	0.01	0.00	0.01	3.93	0.06	0.00
singe engine high performance (180-360hp)	23.63	0.02	0.00	0.02	7.33	0.16	0.00
twin engine high performance (2x235hp)	68.04	0.02	0.00	0.05	19.33	0.22	0.01
Helicopters****							
A109	103.32	0.10	0.00	0.13	1.31	0.89	0.02
A139	189.95	0.08	0.01	0.38	0.97	0.68	0.03
ALO3	67.47	0.03	0.00	0.11	0.40	0.28	0.01
AS32	243.81	0.05	0.01	0.65	0.68	0.49	0.04
AS35	86.63	0.02	0.00	0.18	0.32	0.22	0.01
AS50	79.38	0.03	0.00	0.15	0.35	0.24	0.01
AS55	109.62	0.09	0.00	0.15	1.20	0.82	0.02
H269	20.79	0.01	0.00	0.01	6.59	0.09	0.00
B412	242.55	0.05	0.01	0.64	0.69	0.49	0.04
B06	57.33	0.04	0.00	0.08	0.50	0.35	0.01
EC35	129.47	0.08	0.00	0.21	1.03	0.71	0.02
EN48	58.59	0.04	0.00	0.08	0.48	0.34	0.01
MI8	220.50	0.06	0.01	0.53	0.78	0.55	0.04
R22	19.53	0.01	0.00	0.01	6.21	0.09	0.00
R44	27.72	0.01	0.00	0.02	8.79	0.11	0.00
S76	151.83	0.07	0.00	0.29	0.85	0.59	0.02

***Turbofans (Jet engine)** – The original data source for the Large Commercial Aircraft group LTO emissions factors is the EMEP/EEA guidebook (EMEP/EEA air pollutant emission inventory guidebook — 2009, www.eea.europa.eu/emep-eea-guidebook), the ICAO Engine Exhaust Emissions Data Bank (http://www.dera.gov.uk) and IPCC Guidelines (2006 IPCC Guidelines for National Greenhouse Gas Inventories).*

*****Turboprops (Turbojet engine, driving a propeller)** - This group is represented by three typical aircraft size based on engine shaft horsepower (2006 IPCC Guidelines for National Greenhouse Gas Inventories).*

******Piston engine aircraft** – This group is represented by four typical aircraft size based on engine horsepower by “Aircraft Piston Engine Emissions Summary Report” (Federal Office of Civil Aviation FOCA) in Estonia's report.*

*******Helicopters** – Emission factor of helicopters used are taken from “Guidance on the Determination of Helicopter Emissions” (Federal Office of Civil Aviation FOCA).*

A.3.2. Agriculture

A.3.2_I. LIVESTOCK POPULATION IN ESTONIA IN 1990–2015

Table A.3.2_I.1. Cattle population size in 1990–1998 in Estonia, 1000 heads

Year	Cattle, total	Dairy Cattle	Non-dairy cattle			
			Mature males	Mature females	Bovine animals (aged between 1 and 2 years)	Calves (less than 1 year old)
1990	757.8	280.7	4.2	47.0	172.1	251.9
1991	706.2	264.3	4.1	46.7	171.1	220.0
1992	614.6	253.4	3.4	38.1	139.4	178.8
1993	463.2	226.7	2.2	25.0	91.7	116.9
1994	419.5	211.4	1.9	21.3	77.9	105.8
1995	370.4	185.4	1.6	18.4	67.3	97.0
1996	343	171.6	1.5	17.2	63.0	89.1
1997	325.6	167.7	1.4	16.2	59.3	80.4
1998	307.5	158.6	1.3	14.9	54.7	77.1

Table A3.2_I.2. Swine population size in 1990–1998 in Estonia, 1000 heads

Year	Swine, total	…of which					
		Piglets, live weight less than 20 kg	Young pigs, live weight 20–50 kg	Pigs, live weight 50–80 kg	Pigs, live weight 80–110 kg	Pigs, live weight more than 110 kg	Breeding pigs, live weight more than 50 kg
1990	859.9	279.6	237.5	185.0	103.2	7.6	47.1
1991	798.6	260.1	221.3	172.3	96.1	7.0	41.5
1992	541.1	176.6	150.0	116.8	65.2	4.8	27.7
1993	424.3	137.2	116.6	90.8	50.6	3.7	25.3
1994	459.8	149.0	126.6	157.6	55.0	4.0	26.6
1995	448.8	146.3	124.3	96.8	54.0	4.0	23.4
1996	298.4	96.6	82.1	63.9	35.6	2.6	17.6
1997	306.3	98.0	83.3	64.9	36.2	2.6	21.3
1998	326.4	104.5	88.8	69.1	38.6	2.8	22.6

Table A.3.2_I.3. Total dairy-cattle population size in 1994–1998 by counties of Estonia, 1000 heads (Agriculture 1994)

County	1994	1995	1996	1997	1998
Total	211.4	185.4	171.6	167.7	158.6
Harju	17.6	13.7	10.6	10.7	9.9
Hiiu	2.3	2.1	1.8	1.7	1.6
Ida-Viru	6.9	5.9	5.4	5	4.6
Jõgeva	17.7	15.7	15.5	14.9	13.9
Järva	22.1	20.6	20.7	20.7	20.9
Lääne	8.8	8	7.3	7.1	6.9
Lääne-Viru	20.8	18.5	17.1	16.5	16.5
Põlva	11.9	11.1	10.7	10.3	9.6
Pärnu	22.1	19.9	18.7	18.4	16.8
Rapla	14.6	12	12	12.6	11.4
Saare	13.9	11.1	10.6	10.2	9.8
Tartu	13.8	13	11.1	10.6	10.1
Valga	8.5	7.9	7.4	6.7	6.2
Viljandi	19.7	16	13.8	13.4	12.4
Võru	10.7	9.9	8.9	8.9	8

Table A.3.2_I.4. Number of cattle in 1999 by counties of Estonia, 1000 heads (Agriculture 1999)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
COUNTRY TOTAL															
1999	**267.3**	**138.4**	**0.5**	**1.6**	**14.0**	**0.5**	**13.5**	**8.3**	**40.2**	**1.8**	**38.4**	**64.3**	**10.8**	**42.9**	**10.6**
Harju	18.7	10.4	…	0.1	0.9	…	…	0.7	2.5	…	…	4.1	…	…	…
Hiiu	2.6	1.2	…	0.0	0.2	…	…	0.1	0.4	…	…	0.7	…	…	…
Ida-Viru	7.7	4.0	…	0.0	0.3	…	…	0.3	1.2	…	…	1.9	…	…	…
Jõgeva	23.6	12.0	…	0.3	1.0	…	…	0.5	3.8	…	…	6.0	…	…	…
Järva	38.4	19.9	…	0.1	2.1	…	…	0.7	6.2	…	…	9.4	…	…	…
Lääne	11.3	5.3	…	0.1	0.7	…	…	0.8	1.5	…	…	2.8	…	…	…
Lääne-Viru	30.5	14.5	…	0.1	2.0	…	…	1.3	4.7	…	…	7.8	…	…	…
Põlva	13.7	7.2	…	0.1	0.8	…	…	0.3	2.2	…	…	3.1	…	…	…
Pärnu	26.9	14.7	…	0.2	1.6	…	…	0.5	3.9	…	…	6.0	…	…	…
Rapla	18.6	10.2	…	0.1	0.7	…	…	0.5	2.8	…	…	4.2	…	…	…
Saare	15.8	8.1	…	0.1	0.8	…	…	0.5	2.3	…	…	4.0	…	…	…
Tartu	16.6	8.5	…	0.1	0.7	…	…	0.6	2.6	…	…	4.0	…	…	…
Valga	9.9	4.8	…	0.1	0.5	…	…	0.4	1.6	…	…	2.5	…	…	…
Viljandi	21.3	11.0	…	0.1	1.1	…	…	0.8	3.0	…	…	5.3	…	…	…
Võru	11.7	6.6	…	0.1	0.6	…	…	0.3	1.5	…	…	2.5	…	…	…
ENTERPRISES															
1999	**167.1**	**82.1**	**0.4**	**0.7**	**11.7**	**0.3**	**11.4**	**4.3**	**28.1**	**1.0**	**27.1**	**39.8**	**7.7**	**27.8**	**4.3**
Harju	13.0	6.3	0.0	0.1	0.8	0.0	0.8	0.6	2.1	0.2	1.9	3.1	0.8	1.7	0.6
Hiiu	0.8	0.3	0.0	0.0	0.1	0.0	0.1	0.0	0.2	-	0.2	0.2	0.0	0.1	0.1
Ida-Viru	3.4	1.6	0.0	0.0	0.2	0.0	0.2	0.1	0.7	0.1	0.6	0.8	0.2	0.5	0.1
Jõgeva	18.1	8.9	0.0	0.3	0.9	0.2	0.7	0.2	3.2	0.2	3.0	4.6	1.0	3.1	0.5
Järva	30.4	15.4	0.0	0.0	1.9	0.0	1.9	0.4	5.2	0.1	5.1	7.5	1.2	5.7	0.6
Lääne	5.8	2.1	0.1	0.1	0.6	0.0	0.6	0.6	0.8	0.0	0.8	1.5	0.6	0.8	0.1
Lääne-Viru	22.9	10.7	0.1	0.0	1.8	0.1	1.7	1.0	3.7	0.0	3.7	5.6	0.9	3.7	1.0
Põlva	8.2	4.2	0.0	0.0	0.7	0.0	0.7	0.1	1.5	0.0	1.5	1.7	0.1	1.4	0.2
Pärnu	17.7	9.2	0.0	0.2	1.4	0.0	1.4	0.1	2.8	0.1	2.7	4.0	0.8	3.0	0.2
Rapla	9.6	4.9	0.0	0.0	0.5	0.0	0.5	0.2	1.8	0.0	1.8	2.2	0.3	1.7	0.2
Saare	7.6	3.8	0.0	0.0	0.6	0.0	0.6	0.1	1.3	0.1	1.2	1.8	0.3	1.4	0.1
Tartu	10.1	4.8	0.1	0.0	0.6	0.0	0.6	0.4	1.8	0.1	1.7	2.4	0.6	1.5	0.3
Valga	4.3	2.2	0.0	0.0	0.4	0.0	0.4	0.1	0.7	0.0	0.7	0.9	0.2	0.6	0.1
Viljandi	10.2	4.8	0.0	0.0	0.8	0.0	0.8	0.4	1.6	0.1	1.5	2.6	0.6	1.8	0.2
Võru	5.0	2.9	0.1	0.0	0.4	0.0	0.4	0.0	0.7	0.0	0.7	0.9	0.1	0.8	0.0

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
PRIVATE FARMS															
1999	**55.9**	**30.0**	**0.1**	**0.5**	**1.3**	**0.1**	**1.2**	**2.4**	**7.2**	**0.5**	**6.7**	**14.4**	**1.8**	**8.9**	**3.7**
Harju	3.5	2.5	…	0.0	0.0	…	…	0.1	0.3	…	…	0.6	…	…	…
Hiiu	1.1	0.5	…	0.0	0.1	…	…	0.1	0.1	…	…	0.3	…	…	…
Ida-Viru	2.1	0.9	…	0.0	0.1	…	…	0.1	0.3	…	…	0.7	…	…	…
Jõgeva	2.9	1.6	…	0.0	0.1	…	…	0.2	0.3	…	…	0.7	…	…	…
Järva	6.1	3.5	…	0.1	0.1	…	…	0.2	0.8	…	…	1.4	…	…	…
Lääne	1.7	1.1	…	0.0	0.0	…	…	0.0	0.2	…	…	0.4	…	…	…
Lääne-Viru	4.9	2.1	…	0.1	0.1	…	…	0.3	0.8	…	…	1.5	…	…	…
Põlva	3.6	1.8	…	0.1	0.1	…	…	0.1	0.5	…	…	1.0	…	…	…
Pärnu	4.1	2.2	…	0.0	0.0	…	…	0.2	0.6	…	…	1.1	…	…	…
Rapla	4.9	2.7	…	0.1	0.1	…	…	0.2	0.5	…	…	1.2	…	…	…
Saare	3.5	1.7	…	0.0	0.1	…	…	0.2	0.5	…	…	1.0	…	…	…
Tartu	3.4	1.9	…	0.0	0.1	…	…	0.1	0.4	…	…	0.9	…	…	…
Valga	3.6	1.5	…	0.1	0.1	…	…	0.2	0.5	…	…	1.2	…	…	…
Viljandi	7.1	4.2	…	0.0	0.2	…	…	0.2	0.9	…	…	1.6	…	…	…
Võru	3.4	1.8	…	0.0	0.1	…	…	0.2	0.5	…	…	0.8	…	…	…
HOUSEHOLD PLOTS															
1999	**44.3**	**26.3**	**0.0**	**0.4**	**1.0**	**0.1**	**0.9**	**1.6**	**4.9**	**0.3**	**4.6**	**10.1**	**1.3**	**6.2**	**2.6**
Harju	2.2	1.6	…	0.0	0.1	…	…	0.0	0.1	…	…	0.4	…	…	…
Hiiu	0.7	0.4	…	0.0	0.0	…	…	0.0	0.1	…	…	0.2	…	…	…
Ida-Viru	2.2	1.5	…	0.0	0.0	…	…	0.1	0.2	…	…	0.4	…	…	…
Jõgeva	2.6	1.5	…	0.0	0.0	…	…	0.1	0.3	…	…	0.7	…	…	…
Järva	1.9	1.0	…	0.0	0.1	…	…	0.1	0.2	…	…	0.5	…	…	…
Lääne	3.8	2.1	…	0.0	0.1	…	…	0.2	0.5	…	…	0.9	…	…	…
Lääne-Viru	2.7	1.7	…	0.0	0.1	…	…	0.0	0.2	…	…	0.7	…	…	…
Põlva	1.9	1.2	…	0.0	0.0	…	…	0.1	0.2	…	…	0.4	…	…	…
Pärnu	5.1	3.3	…	0.0	0.2	…	…	0.2	0.5	…	…	0.9	…	…	…
Rapla	4.1	2.6	…	0.0	0.1	…	…	0.1	0.5	…	…	0.8	…	…	…
Saare	4.7	2.6	…	0.1	0.1	…	…	0.2	0.5	…	…	1.2	…	…	…
Tartu	3.1	1.8	…	0.1	0.0	…	…	0.1	0.4	…	…	0.7	…	…	…
Valga	2.0	1.1	…	0.0	0.0	…	…	0.1	0.4	…	…	0.4	…	…	…
Viljandi	4.0	2.0	…	0.1	0.1	…	…	0.2	0.5	…	…	1.1	…	…	…
Võru	3.3	1.9	…	0.1	0.1	…	…	0.1	0.3	…	…	0.8	…	…	…

Table A.3.2_I.5. Swine population size in 1999 by counties of Estonia, 1000 heads (Agriculture 1999)

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total				
					50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
COUNTRY TOTAL													
1999	**285.7**	**75.2**	**77.9**	**98.8**	**66.0**	**29.0**	**3.8**	**1.6**	**32.2**	**18.5**	**6.1**	**13.7**	**6.2**
Harju	18.3	3.7	5.8	6.4	…	…	…	…	2.3	…	…	…	…
Hiiu	0.4	0.1	0.1	0.2	…	…	…	…	0.0	…	…	…	…
Ida-Viru	7.4	2.1	2.5	2.1	…	…	…	…	0.6	…	…	…	…
Jõgeva	20.5	4.7	6.6	6.7	…	…	…	…	2.3	…	…	…	…
Järva	29.2	6.8	7.1	11.8	…	…	…	…	3.3	…	…	…	…
Lääne	9.2	1.6	2.4	4.2	…	…	…	…	1.0	…	…	…	…
Lääne-Viru	32.9	7.1	8.1	14.3	…	…	…	…	3.2	…	…	…	…
Põlva	11.2	2.6	2.9	4.6	…	…	…	…	1.0	…	…	…	…
Pärnu	8.9	2.3	3.0	2.6	…	…	…	…	0.9	…	…	…	…
Rapla	27.4	8.1	8.2	7.7	…	…	…	…	3.3	…	…	…	…
Saare	14.1	4.6	3.8	3.9	…	…	…	…	1.7	…	…	…	…
Tartu	19.9	4.1	5.6	8.2	…	…	…	…	1.9	…	…	…	…
Valga	12.8	2.6	3.4	5.4	…	…	…	…	1.3	…	…	…	…
Viljandi	68.3	23.9	16.9	18.5	…	…	…	…	8.8	…	…	…	…
Võru	5.2	0.9	1.5	2.2	…	…	…	…	0.6	…	…	…	…
ENTERPRISES													
1999	**238.3**	**67.1**	**64.8**	**77.0**	**50.5**	**24.0**	**2.5**	**1.1**	**28.3**	**15.5**	**5.3**	**12.8**	**5.9**
Harju	16.7	3.4	5.3	5.7	3.7	2.0	-	0.1	2.2	1.2	0.4	1.0	0.6
Hiiu	-	-	-	-	-	-	-	-	-	-	-	-	-
Ida-Viru	6.4	2.0	2.2	1.6	1.3	0.3	-	0.1	0.5	0.4	0.2	0.1	0.1
Jõgeva	18.2	4.3	6.0	5.6	3.4	2.1	0.1	0.2	2.1	1.2	0.3	0.9	0.6
Järva	25.1	6.1	6.0	9.9	7.6	2.3	-	0.1	3.0	1.6	0.4	1.4	0.9
Lääne	7.9	1.4	2.0	3.6	1.6	1.0	1.0	0.0	0.9	0.7	0.3	0.2	0.1
Lääne-Viru	26.3	6.0	6.3	11.3	7.0	4.1	0.2	0.1	2.6	1.8	0.5	0.8	0.5
Põlva	6.6	1.8	1.6	2.5	2.4	0.0	0.1	0.1	0.6	0.4	0.0	0.2	0.1
Pärnu	4.9	1.6	1.9	0.8	0.7	0.1	-	0.0	0.6	0.4	0.0	0.2	0.1
Rapla	22.1	7.2	6.7	5.2	2.1	3.1	0.0	0.1	2.9	1.8	0.6	1.1	0.3
Saare	13.2	4.4	3.6	3.5	2.6	0.9	0.0	0.1	1.6	0.5	0.3	1.1	0.3
Tartu	16.7	3.6	4.7	6.7	4.6	2.0	0.1	0.1	1.6	1.0	0.2	0.6	0.2
Valga	10.3	2.2	2.7	4.3	3.9	0.4	0.0	0.0	1.1	1.0	0.3	0.1	0.1
Viljandi	62.2	22.8	15.3	15.7	9.2	5.5	1.0	0.1	8.3	3.3	1.8	5.0	1.9
Võru	1.7	0.3	0.5	0.6	0.4	0.2	-	0.0	0.3	0.2	0.0	0.1	0.1

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total	covered sows	of which covered for the first time	other sows	of which gilts not yet covered
					50–80 kg	80–110 kg	more than 110 kg						
PRIVATE FARMS													
1999	**29.4**	**5.0**	**8.1**	**13.6**	**9.7**	**3.1**	**0.8**	**0.3**	**2.4**	**1.8**	**0.5**	**0.6**	**0.2**
Harju	0.9	0.2	0.3	0.4	…	…	…	…	0.0	…	…	…	…
Hiiu	0.3	0.1	0.1	0.1	…	…	…	…	0.0	…	…	…	…
Ida-Viru	0.4	0.0	0.1	0.2	…	…	…	…	0.1	…	…	…	…
Jõgeva	1.4	0.2	0.4	0.7	…	…	…	…	0.1	…	…	…	…
Järva	3.2	0.5	0.9	1.5	…	…	…	…	0.2	…	…	…	…
Lääne	0.4	0.1	0.1	0.2	…	…	…	…	0.0	…	…	…	…
Lääne-Viru	5.3	0.9	1.4	2.4	…	…	…	…	0.5	…	…	…	…
Põlva	3.5	0.6	1.0	1.6	…	…	…	…	0.3	…	…	…	…
Pärnu	1.5	0.3	0.4	0.7	…	…	…	…	0.1	…	…	…	…
Rapla	3.6	0.6	1.0	1.7	…	…	…	…	0.3	…	…	…	…
Saare	0.5	0.1	0.1	0.2	…	…	…	…	0.1	…	…	…	…
Tartu	1.5	0.2	0.4	0.8	…	…	…	…	0.1	…	…	…	…
Valga	1.4	0.2	0.4	0.6	…	…	…	…	0.2	…	…	…	…
Viljandi	3.8	0.7	1.0	1.7	…	…	…	…	0.3	…	…	…	…
Võru	1.7	0.3	0.5	0.8	…	…	…	…	0.1	…	…	…	…
HOUSEHOLD PLOTS													
1999	**18.0**	**3.1**	**5.0**	**8.2**	**5.8**	**1.9**	**0.5**	**0.2**	**1.5**	**1.2**	**0.3**	**0.3**	**0.1**
Harju	0.7	0.1	0.2	0.3	…	…	…	…	0.1	…	…	…	…
Hiiu	0.1	0.0	0.0	0.1	…	…	…	…	0.0	…	…	…	…
Ida-Viru	0.6	0.1	0.2	0.3	…	…	…	…	0.0	…	…	…	…
Jõgeva	0.9	0.2	0.2	0.4	…	…	…	…	0.1	…	…	…	…
Järva	0.9	0.2	0.2	0.4	…	…	…	…	0.1	…	…	…	…
Lääne	0.9	0.1	0.3	0.4	…	…	…	…	0.1	…	…	…	…
Lääne-Viru	1.3	0.2	0.4	0.6	…	…	…	…	0.1	…	…	…	…
Põlva	1.1	0.2	0.3	0.5	…	…	…	…	0.1	…	…	…	…
Pärnu	2.5	0.4	0.7	1.1	…	…	…	…	0.2	…	…	…	…
Rapla	1.7	0.3	0.5	0.8	…	…	…	…	0.1	…	…	…	…
Saare	0.4	0.1	0.1	0.2	…	…	…	…	0.0	…	…	…	…
Tartu	1.7	0.3	0.5	0.7	…	…	…	…	0.2	…	…	…	…
Valga	1.1	0.2	0.3	0.5	…	…	…	…	0.0	…	…	…	…
Viljandi	2.3	0.4	0.6	1.1	…	…	…	…	0.2	…	…	…	…
Võru	1.8	0.3	0.5	0.8	…	…	…	…	0.2	…	…	…	…

Table A.3.2_I.6. Number of cattle in 2000 by counties of Estonia, 1000 heads (Agriculture 2000)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
COUNTRY TOTAL															
2000	**252.8**	**131.0**	**0.7**	**1.2**	**14.0**	**0.2**	**13.8**	**9.2**	**35.6**	**1.1**	**34.5**	**61.1**	**10.5**	**39.5**	**11.1**
Harju	17.4	9.6	…	0.0	1.0	…	…	0.6	2.4	…	…	3.7	…	…	…
Hiiu	2.9	1.4	…	0.0	0.1	…	…	0.3	0.4	…	…	0.7	…	…	…
Ida-Viru	6.7	3.4	…	0.0	0.5	…	…	0.3	1.1	…	…	1.4	…	…	…
Jõgeva	23.5	11.9	…	0.1	1.2	…	…	0.8	3.4	…	…	6.1	…	…	…
Järva	37.6	19.8	…	0.1	2.6	…	…	0.8	5.6	…	…	8.7	…	…	…
Lääne	10.2	4.4	…	0.2	0.7	…	…	1.1	1.4	…	…	2.1	…	…	…
Lääne-Viru	28.2	12.9	…	0.1	1.6	…	…	1.6	4.5	…	…	7.4	…	…	…
Põlva	14.0	7.8	…	0.1	0.7	…	…	0.3	1.6	…	…	3.5	…	…	…
Pärnu	25.0	13.7	…	0.3	1.5	…	…	0.3	3.3	…	…	5.9	…	…	…
Rapla	16.3	9.0	…	0.1	0.8	…	…	0.5	2.2	…	…	3.6	…	…	…
Saare	15.9	8.3	…	0.1	0.7	…	…	0.6	2.3	…	…	3.9	…	…	…
Tartu	14.9	7.7	…	0.0	0.6	…	…	0.4	2.1	…	…	4.1	…	…	…
Valga	9.5	4.5	…	0.0	0.7	…	…	0.5	1.3	…	…	2.5	…	…	…
Viljandi	19.5	10.3	…	0.1	0.8	…	…	0.7	2.6	…	…	5.0	…	…	…
Võru	11.2	6.3	…	0.0	0.5	…	…	0.4	1.4	…	…	2.5	…	…	…
ENTERPRISES															
2000	**154.6**	**75.4**	**0.2**	**0.7**	**11.6**	**0.1**	**11.5**	**4.2**	**24.9**	**0.7**	**24.2**	**37.6**	**6.4**	**27.1**	**4.1**
Harju	11.9	5.6	0.0	0.0	0.8	0.0	0.8	0.5	2.0	0.2	1.8	3.0	0.5	1.8	0.7
Hiiu	1.0	0.4	0.0	0.0	0.1	-	0.1	0.1	0.2	-	0.2	0.2	0.0	0.2	0.0
Ida-Viru	3.0	1.4	0.0	0.0	0.3	0.0	0.3	0.1	0.5	0.0	0.5	0.7	0.1	0.5	0.1
Jõgeva	18.2	8.7	0.0	0.1	1.0	0.0	1.0	0.6	2.9	0.2	2.7	4.9	1.0	3.3	0.6
Järva	29.7	15.2	-	0.1	2.4	0.0	2.4	0.4	4.5	0.1	4.4	7.1	0.7	5.7	0.7
Lääne	4.2	1.6	0.0	0.1	0.5	-	0.5	0.4	0.8	0.0	0.8	0.8	0.3	0.5	0.0
Lääne-Viru	21.2	9.7	0.0	0.1	1.5	0.1	1.4	1.0	3.5	0.1	3.4	5.4	1.1	3.4	0.9
Põlva	7.7	3.9	0.0	0.0	0.6	-	0.6	0.1	1.2	-	1.2	1.9	0.3	1.5	0.1
Pärnu	15.5	7.9	0.0	0.1	1.5	-	1.5	0.1	2.3	0.0	2.3	3.6	0.5	2.8	0.3
Rapla	8.8	4.4	0.1	0.1	0.6	0.0	0.6	0.1	1.6	0.1	1.5	1.9	0.2	1.6	0.1
Saare	7.6	3.8	0.0	0.1	0.6	0.0	0.6	0.1	1.3	-	1.3	1.7	0.2	1.4	0.1
Tartu	9.0	4.3	-	0.0	0.5	0.0	0.5	0.2	1.5	-	1.5	2.5	0.7	1.6	0.2
Valga	4.1	2.1	0.0	0.0	0.4	0.0	0.4	0.2	0.6	-	0.6	0.8	0.2	0.6	0.0
Viljandi	8.2	4.0	0.0	0.0	0.5	0.0	0.5	0.3	1.2	0.0	1.2	2.2	0.5	1.5	0.2
Võru	4.5	2.4	0.1	0.0	0.3	-	0.3	0.0	0.8	-	0.8	0.9	0.1	0.7	0.1

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
PRIVATE FARMS															
2000	**54.7**	**29.8**	**0.2**	**0.3**	**1.4**	**0.0**	**1.4**	**2.9**	**6.3**	**0.2**	**6.1**	**13.8**	**2.5**	**7.2**	**4.1**
Maakonnad								0.1	0.2	…	…	0.4	…	…	…
Counties															
Harju	3.3	2.4	…	0.0	0.1	…	…	0.2	0.1	…	…	0.3	…	…	…
Hiiu	1.2	0.6	…	0.0	-	…	…	0.1	0.4	…	…	0.4	…	…	…
Ida-Viru	1.8	0.8	…	0.0	0.1	…	…	0.1	0.3	…	…	0.6	…	…	…
Jõgeva	2.8	1.7	…	0.0	0.1	…	…	0.3	0.8	…	…	1.3	…	…	…
Järva	6.1	3.5	…	0.0	0.2	…	…	0.2	0.1	…	…	0.5	…	…	…
Lääne	1.9	1.0	…	0.0	0.0	…	…	0.5	0.7	…	…	1.4	…	…	…
Lääne-Viru	4.5	1.8	…	0.0	0.1	…	…	0.1	0.3	…	…	1.1	…	…	…
Põlva	4.1	2.4	…	0.1	0.1	…	…	0.1	0.5	…	…	1.2	…	…	…
Pärnu	4.2	2.3	…	0.1	0.0	…	…	0.2	0.4	…	…	1.0	…	…	…
Rapla	4.0	2.3	…	0.0	0.1	…	…	0.2	0.5	…	…	1.1	…	…	…
Saare	3.6	1.8	…	0.0	0.0	…	…	0.1	0.3	…	…	0.9	…	…	…
Tartu	3.1	1.7	…	-	0.1	…	…	0.2	0.5	…	…	1.1	…	…	…
Valga	3.4	1.4	…	0.0	0.2	…	…	0.3	0.8	…	…	1.6	…	…	…
Viljandi	7.3	4.3	…	0.1	0.2	…	…	0.2	0.4	…	…	0.9	…	…	…
Võru	3.4	1.8	…	0.0	0.1	…	…								
HOUSEHOLD PLOTS															
2000	**43.5**	**25.8**	**0.3**	**0.2**	**1.0**	**0.1**	**0.9**	**2.1**	**4.4**	**0.2**	**4.2**	**9.7**	**1.6**	**5.2**	**2.9**
Harju	2.2	1.6	…	0.0	0.1	…	…	0.0	0.2	…	…	0.3	…	…	…
Hiiu	0.7	0.4	…	0.0	-	…	…	0.0	0.1	…	…	0.2	…	…	…
Ida-Viru	1.9	1.2	…	0.0	0.1	…	…	0.1	0.2	…	…	0.3	…	…	…
Jõgeva	2.5	1.5	…	0.0	0.1	…	…	0.1	0.2	…	…	0.6	…	…	…
Järva	1.8	1.1	…	0.0	0.0	…	…	0.1	0.3	…	…	0.3	…	…	…
Lääne	4.1	1.8	…	0.1	0.2	…	…	0.5	0.5	…	…	0.8	…	…	…
Lääne-Viru	2.5	1.4	…	0.0	0.0	…	…	0.1	0.3	…	…	0.6	…	…	…
Põlva	2.2	1.5	…	0.0	0.0	…	…	0.1	0.1	…	…	0.5	…	…	…
Pärnu	5.3	3.5	…	0.1	0.0	…	…	0.1	0.5	…	…	1.1	…	…	…
Rapla	3.5	2.3	…	0.0	0.1	…	…	0.2	0.2	…	…	0.7	…	…	…
Saare	4.7	2.7	…	0.0	0.1	…	…	0.3	0.5	…	…	1.1	…	…	…
Tartu	2.8	1.7	…	-	0.0	…	…	0.1	0.3	…	…	0.7	…	…	…
Valga	2.0	1.0	…	0.0	0.1	…	…	0.1	0.2	…	…	0.6	…	…	…
Viljandi	4.0	2.0	…	0.0	0.1	…	…	0.1	0.6	…	…	1.2	…	…	…
Võru	3.3	2.1	…	0.0	0.1	…	…	0.2	0.2	…	…	0.7	…	…	…

Table A.3.2_I.7. Swine population size in 2000 by counties of Estonia, 1000 heads (Agriculture 2000)

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total	covered sows	of which covered for the first time	other sows	of which gilts not yet covered
					50–80 kg	80–110 kg	more than 110 kg						
COUNTRY TOTAL													
2000	**300.2**	**81.2**	**79.5**	**99.0**	**63.8**	**32.0**	**3.2**	**1.9**	**38.6**	**26.1**	**6.7**	**12.5**	**8.0**
Harju	19.8	4.8	5.9	6.5	…	…	…	…	2.5	…	…	…	…
Hiiu	0.7	-	0.2	0.5	…	…	…	…	0.0	…	…	…	…
Ida-Viru	5.3	1.3	1.9	1.4	…	…	…	…	0.6	…	…	…	…
Jõgeva	25.1	6.4	7.9	7.7	…	…	…	…	3.0	…	…	…	…
Järva	32.2	8.6	7.0	12.0	…	…	…	…	4.3	…	…	…	…
Lääne	9.0	1.6	2.4	4.0	…	…	…	…	0.9	…	…	…	…
Lääne-Viru	40.0	8.3	10.6	17.8	…	…	…	…	3.1	…	…	…	…
Põlva	8.9	2.6	1.7	3.7	…	…	…	…	0.8	…	…	…	…
Pärnu	10.8	1.6	4.0	3.3	…	…	…	…	1.7	…	…	…	…
Rapla	24.2	8.0	4.8	6.9	…	…	…	…	4.2	…	…	…	…
Saare	16.1	4.6	4.1	5.3	…	…	…	…	2.0	…	…	…	…
Tartu	25.1	6.2	6.0	10.4	…	…	…	…	2.3	…	…	…	…
Valga	6.3	1.6	1.5	2.4	…	…	…	…	0.8	…	…	…	…
Viljandi	71.3	24.3	20.8	14.7	…	…	…	…	11.4	…	…	…	…
Võru	5.4	1.3	0.7	2.4	…	…	…	…	1.0	…	…	…	…
ENTERPRISES													
2000	**242.9**	**73.6**	**65.1**	**70.5**	**45.4**	**23.6**	**1.5**	**1.0**	**32.7**	**22.1**	**5.6**	**10.6**	**7.0**
Harju	17.7	4.3	5.1	5.9	3.7	2.2	0.0	0.1	2.3	1.3	0.4	1.0	0.3
Hiiu	-	-	-	-	-	-	-	-	-	-	-	-	-
Ida-Viru	3.4	1.2	1.0	0.7	0.5	0.2	-	0.1	0.4	0.3	0.1	0.1	0.0
Jõgeva	22.6	5.6	7.2	7.1	4.9	2.2	0.0	0.1	2.6	1.7	0.5	0.9	0.7
Järva	27.5	8.4	6.1	9.4	6.6	2.7	0.1	0.1	3.5	2.1	0.6	1.4	0.6
Lääne	7.7	1.3	1.9	3.6	1.5	1.2	0.9	0.1	0.8	0.8	0.2	0.0	0.1
Lääne-Viru	30.3	7.4	9.2	10.8	8.5	2.2	0.1	0.1	2.8	1.9	0.3	0.9	0.5
Põlva	4.9	2.0	1.1	1.2	1.0	0.2	0.0	0.0	0.6	0.5	0.1	0.1	0.1
Pärnu	4.1	1.2	0.9	1.4	0.9	0.5	-	0.0	0.6	0.4	0.0	0.2	0.1
Rapla	18.7	7.8	4.0	3.4	1.9	1.5	0.0	0.1	3.4	2.0	0.6	1.4	1.0
Saare	14.3	4.4	4.0	4.1	3.0	1.1	-	0.1	1.7	1.3	0.6	0.4	0.1
Tartu	20.2	5.0	5.0	8.0	5.0	2.9	0.1	0.1	2.1	1.6	0.5	0.5	0.2
Valga	4.0	1.0	0.9	1.6	0.9	0.7	0.0	0.0	0.5	0.4	0.1	0.1	0.1
Viljandi	65.7	23.5	18.6	12.5	6.4	5.8	0.3	0.1	11.0	7.7	1.5	3.3	3.0
Võru	1.8	0.5	0.1	0.8	0.6	0.2	0.0	0.0	0.4	0.1	0.1	0.3	0.2

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total	covered sows	of which covered for the first time	other sows	of which gilts not yet covered
					50–80 kg	80–110 kg	more than 110 kg						
PRIVATE FARMS													
2000	**35.0**	**4.5**	**8.1**	**18.5**	**12.0**	**5.7**	**0.8**	**0.5**	**3.4**	**2.4**	**0.8**	**1.0**	**0.6**
Harju	1.2	0.3	0.4	0.3	…	…	…	…	0.2	…	…	…	…
Hiiu	0.5	-	0.1	0.4	…	…	…	…	0.0	…	…	…	…
Ida-Viru	0.8	0.1	0.4	0.3	…	…	…	…	0.0	…	…	…	…
Jõgeva	1.5	0.5	0.4	0.4	…	…	…	…	0.2	…	…	…	…
Järva	3.7	0.2	0.7	2.1	…	…	…	…	0.6	…	…	…	…
Lääne	0.4	0.1	0.2	0.1	…	…	…	…	0.0	…	…	…	…
Lääne-Viru	7.7	0.7	1.1	5.6	…	…	…	…	0.2	…	…	…	…
Põlva	3.0	0.4	0.5	1.9	…	…	…	…	0.1	…	…	…	…
Pärnu	2.5	0.1	1.2	0.7	…	…	…	…	0.4	…	…	…	…
Rapla	3.7	0.2	0.5	2.3	…	…	…	…	0.6	…	…	…	…
Saare	1.0	0.1	0.1	0.6	…	…	…	…	0.2	…	…	…	…
Tartu	2.4	0.6	0.5	1.1	…	…	…	…	0.2	…	…	…	…
Valga	1.3	0.3	0.3	0.5	…	…	…	…	0.2	…	…	…	…
Viljandi	3.5	0.5	1.4	1.4	…	…	…	…	0.2	…	…	…	…
Võru	1.8	0.4	0.3	0.8	…	…	…	…	0.3	…	…	…	…
HOUSEHOLD PLOTS													
2000	**22.3**	**3.1**	**6.3**	**10.0**	**6.4**	**2.7**	**0.9**	**0.4**	**2.5**	**1.6**	**0.3**	**0.9**	**0.4**
Harju	0.9	0.2	0.4	0.3	…	…	…	…	0.0	…	…	…	…
Hiiu	0.2	-	0.1	0.1	…	…	…	…	0.0	…	…	…	…
Ida-Viru	1.1	0.0	0.5	0.4	…	…	…	…	0.2	…	…	…	…
Jõgeva	1.0	0.3	0.3	0.2	…	…	…	…	0.2	…	…	…	…
Järva	1.0	0.0	0.2	0.5	…	…	…	…	0.2	…	…	…	…
Lääne	0.9	0.2	0.3	0.3	…	…	…	…	0.1	…	…	…	…
Lääne-Viru	2.0	0.2	0.3	1.4	…	…	…	…	0.1	…	…	…	…
Põlva	1.0	0.2	0.1	0.6	…	…	…	…	0.1	…	…	…	…
Pärnu	4.2	0.3	1.9	1.2	…	…	…	…	0.7	…	…	…	…
Rapla	1.8	0.0	0.3	1.2	…	…	…	…	0.2	…	…	…	…
Saare	0.8	0.1	0.0	0.6	…	…	…	…	0.1	…	…	…	…
Tartu	2.5	0.6	0.5	1.3	…	…	…	…	0.0	…	…	…	…
Valga	1.0	0.3	0.3	0.3	…	…	…	…	0.1	…	…	…	…
Viljandi	2.1	0.3	0.8	0.8	…	…	…	…	0.2	…	…	…	…
Võru	1.8	0.4	0.3	0.8	…	…	…	…	0.3	…	…	…	…

Table A.3.2_I.8. Number of cattle in 2001 by counties of Estonia, 1000 heads (Agriculture 2001)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2001 TOTAL	**260.5**	**128.6**	**0.8**	**1.2**	**11.2**	**0.4**	**10.8**	**11.1**	**37.7**	**3.6**	**34.1**	**69.9**	**16.8**	**38.9**	**14.2**
Harju	18.1	8.9	0.1	0.0	0.7	0.0	0.7	0.9	2.5	0.2	2.3	5.0	1.0	2.7	1.3
Hiiu	3.0	1.2	0.1	0.0	0.1	0.0	0.1	0.3	0.4	0.1	0.3	0.9	0.2	0.4	0.3
Ida-Viru	6.7	3.7	0.0	0.0	0.3	0.0	0.3	0.3	0.7	0.0	0.7	1.7	0.4	0.9	0.4
Jõgeva	28.2	12.5	0.0	0.0	1.1	0.1	1.0	1.5	4.3	0.3	4.0	8.8	1.7	4.4	2.7
Järva	37.1	18.7	0.0	0.1	2.0	0.1	1.9	0.7	6.1	0.3	5.8	9.5	1.9	6.5	1.1
Lääne	10.9	4.6	0.1	0.2	0.8	0.1	0.7	0.8	1.3	0.2	1.1	3.1	1.1	1.4	0.6
Lääne-Viru	30.8	12.9	0.1	0.3	1.5	0.0	1.5	2.0	4.8	0.3	4.5	9.2	2.5	4.6	2.1
Põlva	15.1	7.2	0.1	0.1	0.7	0.0	0.7	0.6	2.2	0.4	1.8	4.2	1.0	2.5	0.7
Pärnu	25.4	13.5	0.0	0.1	1.0	0.0	1.0	0.7	4.0	0.5	3.5	6.1	0.9	4.0	1.2
Rapla	16.6	9.0	0.1	0.1	0.7	0.0	0.7	0.5	2.1	0.2	1.9	4.1	1.1	2.3	0.7
Saare	14.2	7.0	0.1	0.0	0.8	0.1	0.7	0.7	2.1	0.3	1.8	3.5	0.9	2.0	0.6
Tartu	14.6	8.3	0.0	0.1	0.4	0.0	0.4	0.4	1.9	0.1	1.8	3.5	1.2	1.9	0.4
Valga	9.1	4.8	0.0	0.0	0.2	0.0	0.2	0.4	1.3	0.2	1.1	2.4	0.7	1.2	0.5
Viljandi	20.1	10.5	0.1	0.1	0.7	0.0	0.7	0.9	2.6	0.3	2.3	5.2	1.5	2.7	1.0
Võru	10.6	5.8	0.0	0.1	0.2	0.0	0.2	0.4	1.4	0.2	1.2	2.7	0.7	1.4	0.6
Agricultural holdings	257.8	127.1	0.8	1.2	11.1	0.4	10.7	11.0	37.4	3.6	33.8	69.2	16.6	38.5	14.1
natural persons	97.1	51.9	0.6	0.6	1.9	0.3	1.6	6.4	10.7	2.9	7.8	25.0	7.1	10.1	7.8
legal persons	160.7	75.2	0.2	0.6	9.2	0.1	9.1	4.6	26.7	0.7	26.0	44.2	9.5	28.4	6.3
Harju	17.8	8.7	0.1	0.0	0.7	0.0	0.7	0.8	2.5	0.2	2.3	5.0	1.0	2.7	1.3
Hiiu	3.0	1.2	0.1	0.0	0.1	0.0	0.1	0.3	0.4	0.1	0.3	0.9	0.2	0.4	0.3
Ida-Viru	6.3	3.5	0.0	0.0	0.3	0.0	0.3	0.2	0.7	0.0	0.7	1.6	0.4	0.8	0.4
Jõgeva	28.0	12.5	0.0	0.0	1.1	0.1	1.0	1.5	4.2	0.3	3.9	8.7	1.7	4.4	2.6
Järva	37.0	18.6	0.0	0.1	2.0	0.1	1.9	0.7	6.1	0.3	5.8	9.5	1.9	6.5	1.1
Lääne	10.8	4.5	0.1	0.2	0.8	0.1	0.7	0.8	1.3	0.2	1.1	3.1	1.1	1.4	0.6
Lääne-Viru	30.5	12.8	0.1	0.3	1.4	0.0	1.4	2.0	4.8	0.3	4.5	9.1	2.5	4.5	2.1
Põlva	15.0	7.2	0.1	0.1	0.7	0.0	0.7	0.6	2.2	0.4	1.8	4.1	1.0	2.4	0.7
Pärnu	25.2	13.4	0.0	0.1	1.0	0.0	1.0	0.7	4.0	0.5	3.5	6.0	0.9	3.9	1.2
Rapla	16.5	8.9	0.1	0.1	0.7	0.0	0.7	0.6	2.0	0.2	1.8	4.1	1.1	2.3	0.7
Saare	14.0	6.9	0.1	0.0	0.8	0.1	0.7	0.7	2.0	0.3	1.7	3.5	0.9	2.0	0.6
Tartu	14.3	8.1	0.0	0.1	0.4	0.0	0.4	0.4	1.9	0.1	1.8	3.4	1.1	1.9	0.4
Valga	8.9	4.7	0.0	0.0	0.2	0.0	0.2	0.4	1.3	0.2	1.1	2.3	0.6	1.2	0.5

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
Viljandi	20.0	10.4	0.1	0.1	0.7	0.0	0.7	0.9	2.6	0.3	2.3	5.2	1.5	2.7	1.0
Võru	10.5	5.7	0.0	0.1	0.2	0.0	0.2	0.4	1.4	0.2	1.2	2.7	0.7	1.4	0.6
Agricultural households	2.7	1.5	0.0	0.0	0.1	0.0	0.1	0.1	0.3	0.0	0.3	0.7	0.2	0.4	0.1

Table A.3.2_I.9. Swine population size in 2001 by counties of Estonia, 1000 heads (Agriculture 2001)

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total	covered sows	of which covered for the first time	other sows	of which gilts not yet covered
					50–80 kg	80–110 kg	more than 110 kg						
COUNTRY TOTAL													
2001	**345.0**	**100.3**	**103.6**	**99.5**	**57.0**	**40.8**	**1.7**	**1.5**	**40.1**	**26.1**	**7.4**	**14.0**	**7.4**
Harju	20.0	4.3	8.2	5.2	3.3	1.9	0.0	0.1	2.2	1.4	0.3	0.8	0.4
Hiiu	4.1	0.2	2.0	1.9	0.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ida-Viru	5.8	1.5	2.5	1.2	0.8	0.4	0.0	0.1	0.5	0.4	0.1	0.1	0.0
Jõgeva	29.2	6.4	10.4	8.8	6.6	2.1	0.1	0.1	3.5	2.3	0.5	1.2	0.7
Järva	34.0	8.6	9.5	11.4	7.3	4.0	0.1	0.1	4.4	2.6	1.2	1.8	0.8
Lääne	11.5	2.2	3.1	4.9	3.1	1.8	0.0	0.1	1.2	0.7	0.3	0.5	0.2
Lääne-Viru	47.2	11.1	13.8	17.8	9.6	7.8	0.4	0.1	4.4	3.1	0.7	1.3	0.6
Põlva	10.5	3.1	3.0	3.2	2.4	0.6	0.2	0.1	1.1	0.8	0.2	0.3	0.1
Pärnu	9.2	1.9	3.4	2.9	1.9	0.8	0.2	0.1	0.9	0.6	0.1	0.3	0.2
Rapla	29.6	6.8	9.2	9.6	4.9	4.7	0.0	0.1	3.9	2.5	0.7	1.4	0.8
Saare	17.2	5.3	5.2	4.6	2.8	1.7	0.1	0.1	2.0	1.1	0.2	0.9	0.6
Tartu	26.7	6.2	7.8	9.7	6.1	3.4	0.2	0.2	2.8	1.9	0.6	0.9	0.4
Valga	7.2	1.7	2.5	2.2	1.5	0.6	0.1	0.1	0.7	0.5	0.1	0.2	0.1
Viljandi	86.0	39.7	20.2	14.1	5.4	8.5	0.2	0.1	11.9	7.9	2.3	4.0	2.4
Võru	6.8	1.3	2.8	2.0	1.2	0.7	0.1	0.1	0.6	0.3	0.1	0.3	0.1
Agricultural holdings	342.8	99.8	102.8	98.8	56.5	40.6	1.7	1.5	39.9	26.0	7.4	13.9	7.4
natural persons	53.5	12.3	19.8	16.9	10.9	5.1	0.9	0.5	4.0	2.6	0.8	1.4	0.5
legal persons	289.3	87.5	83.0	81.9	45.6	35.5	0.8	1.0	35.9	23.4	6.6	12.5	6.9
Harju	19.9	4.3	8.2	5.1	3.3	1.8	0.0	0.1	2.2	1.4	0.3	0.8	0.4
Hiiu	4.1	0.2	2.0	1.9	0.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ida-Viru	5.7	1.4	2.5	1.2	0.8	0.4	0.0	0.1	0.5	0.4	0.1	0.1	0.0
Jõgeva	29.1	6.4	10.4	8.8	6.6	2.1	0.1	0.1	3.4	2.3	0.5	1.1	0.7

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total	covered sows	of which covered for the first time	other sows	of which gilts not yet covered
					50–80 kg	80–110 kg	more than 110 kg						
Järva	33.7	8.5	9.4	11.3	7.2	4.0	0.1	0.1	4.4	2.6	1.2	1.8	0.8
Lääne	11.5	2.2	3.1	4.9	3.1	1.8	0.0	0.1	1.2	0.7	0.3	0.5	0.2
Lääne-Viru	47.0	11.1	13.7	17.7	9.5	7.8	0.4	0.1	4.4	3.1	0.7	1.3	0.6
Põlva	10.4	3.0	3.0	3.2	2.4	0.6	0.2	0.1	1.1	0.8	0.2	0.3	0.1
Pärnu	8.9	1.8	3.3	2.8	1.8	0.8	0.2	0.1	0.9	0.6	0.1	0.3	0.2
Rapla	29.5	6.8	9.2	9.5	4.8	4.7	0.0	0.1	3.9	2.5	0.7	1.4	0.8
Saare	17.1	5.3	5.1	4.6	2.8	1.7	0.1	0.1	2.0	1.1	0.2	0.9	0.6
Tartu	26.5	6.2	7.7	9.6	6.0	3.4	0.2	0.2	2.8	1.9	0.6	0.9	0.4
Valga	7.1	1.7	2.4	2.2	1.5	0.6	0.1	0.1	0.7	0.5	0.1	0.2	0.1
Viljandi	85.7	39.6	20.1	14.1	5.4	8.5	0.2	0.1	11.8	7.8	2.3	4.0	2.4
Võru	6.6	1.3	2.7	1.9	1.2	0.6	0.1	0.1	0.6	0.3	0.1	0.3	0.1
Agricultural households	2.2	0.5	0.8	0.7	0.5	0.2	0.0	0.0	0.2	0.1	0.0	0.1	0.0

Table A.3.2_I.10. Number of cattle in 2002 by counties of Estonia, 1000 heads (Agriculture 2002)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
COUNTRY TOTAL															
2002	**253.9**	**115.6**	**1.6**	**1.1**	**10.5**	**0.2**	**10.3**	**11.5**	**43.6**	**2.2**	**41.4**	**70.0**	**6.0**	**40.7**	**23.3**
Harju	19.2	8.2	0.3	0.0	1.2	0.0	1.2	1.5	3.0	0.2	2.8	5.0	0.5	2.6	1.9
Hiiu	3.0	1.1	0.0	0.1	0.1	0.0	0.1	0.2	0.8	0.0	0.8	0.7	0.1	0.3	0.3
Ida-Viru	6.8	2.8	0.0	0.0	0.3	0.0	0.3	0.5	1.2	0.1	1.1	2.0	0.3	1.0	0.7
Jõgeva	25.4	10.7	0.0	0.0	1.1	0.0	1.1	1.2	4.0	0.0	4.0	8.4	0.4	4.4	3.6
Järva	36.9	18.3	0.2	0.1	1.5	0.0	1.5	0.8	7.6	0.1	7.5	8.4	0.6	6.5	1.3
Lääne	9.7	4.0	0.0	0.0	0.5	0.0	0.5	0.7	1.4	0.1	1.3	3.1	0.2	1.4	1.5
Lääne-Viru	28.6	12.5	0.1	0.3	1.0	0.1	0.9	1.6	5.4	0.2	5.2	7.7	0.7	4.2	2.8
Põlva	13.8	6.4	0.1	0.2	0.8	0.0	0.8	0.4	2.0	0.0	2.0	3.9	0.3	2.9	0.7
Pärnu	24.6	12.4	0.0	0.1	0.8	0.0	0.8	0.9	4.2	0.3	3.9	6.2	0.6	3.5	2.1
Rapla	18.8	8.1	0.1	0.1	0.7	0.0	0.7	0.9	3.4	0.5	2.9	5.5	0.3	2.4	2.8
Saare	12.5	6.0	0.1	0.0	0.7	0.1	0.6	0.3	1.7	0.1	1.6	3.7	0.4	2.3	1.0
Tartu	17.5	8.5	0.0	0.2	0.2	0.0	0.2	0.5	3.1	0.2	2.9	5.0	0.6	2.8	1.6
Valga	8.3	3.6	0.0	0.0	0.3	0.0	0.3	0.4	1.7	0.0	1.7	2.3	0.4	1.4	0.5
Viljandi	18.6	8.1	0.1	0.0	1.1	0.0	1.1	1.2	2.6	0.3	2.3	5.5	0.4	3.3	1.8
Võru	10.2	4.9	0.6	0.0	0.2	0.0	0.2	0.4	1.5	0.1	1.4	2.6	0.2	1.7	0.7

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
Agricultural holdings	251.5	114.5	1.6	1.1	10.4	0.2	10.2	11.3	43.3	2.1	41.2	69.3	5.8	40.4	23.1
natural persons	87.1	39.1	0.7	0.4	3.6	0.1	3.5	4.1	14.9	0.8	14.1	24.3	2.1	14.0	8.2
legal persons	164.4	75.4	0.9	0.7	6.8	0.1	6.7	7.2	28.4	1.3	27.1	45.0	3.7	26.4	14.9
Harju	18.9	8.1	0.3	0.0	1.2	0.0	1.2	1.4	3.0	0.2	2.8	4.9	0.5	2.6	1.8
Hiiu	3.0	1.1	0.0	0.1	0.1	0.0	0.1	0.2	0.8	0.0	0.8	0.7	0.1	0.3	0.3
Ida-Viru	6.5	2.7	0.0	0.0	0.2	0.0	0.2	0.5	1.1	0.1	1.0	2.0	0.3	1.0	0.7
Jõgeva	25.3	10.7	0.0	0.0	1.1	0.0	1.1	1.2	4.0	0.0	4.0	8.3	0.4	4.4	3.5
Järva	36.7	18.2	0.2	0.1	1.5	0.0	1.5	0.8	7.5	0.1	7.4	8.4	0.6	6.5	1.3
Lääne	9.6	3.9	0.0	0.0	0.5	0.0	0.5	0.7	1.4	0.1	1.3	3.1	0.2	1.4	1.5
Lääne-Viru	28.5	12.4	0.1	0.3	1.0	0.1	0.9	1.6	5.4	0.2	5.2	7.7	0.7	4.2	2.8
Põlva	13.7	6.4	0.1	0.2	0.8	0.0	0.8	0.4	2.0	0.0	2.0	3.8	0.3	2.8	0.7
Pärnu	24.4	12.3	0.0	0.1	0.8	0.0	0.8	0.9	4.1	0.2	3.9	6.2	0.6	3.5	2.1
Rapla	18.6	8.0	0.1	0.1	0.7	0.0	0.7	0.9	3.4	0.5	2.9	5.4	0.3	2.3	2.8
Saare	12.4	6.0	0.1	0.0	0.7	0.1	0.6	0.2	1.7	0.1	1.6	3.7	0.4	2.3	1.0
Tartu	17.2	8.3	0.0	0.2	0.2	0.0	0.2	0.5	3.1	0.2	2.9	4.9	0.6	2.7	1.6
Valga	8.2	3.6	0.0	0.0	0.3	0.0	0.3	0.4	1.7	0.0	1.7	2.2	0.3	1.4	0.5
Viljandi	18.4	8.0	0.1	0.0	1.1	0.0	1.1	1.2	2.6	0.3	2.3	5.4	0.3	3.3	1.8
Võru	10.1	4.8	0.6	0.0	0.2	0.0	0.2	0.4	1.5	0.1	1.4	2.6	0.2	1.7	0.7
Agricultural households	2.4	1.1	0.0	0.0	0.1	0.0	0.1	0.2	0.3	0.1	0.2	0.7	0.2	0.3	0.2

Table A.3.2_I.11. Swine population size in 2002 by counties of Estonia, 1000 heads (Agriculture 2002)

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total	covered sows	of which covered for the first time	other sows	of which gilts not yet covered
					50–80 kg	80–110 kg	more than 110 kg						
COUNTRY TOTAL 2002	**340.8**	**104.1**	**82.8**	**114.1**	**64.7**	**45.8**	**3.6**	**2.1**	**37.7**	**27.4**	**5.5**	**10.3**	**4.8**
Harju	21.2	4.6	6.3	7.4	4.0	3.1	0.3	0.1	2.8	1.7	0.4	1.1	0.5
Hiiu	5.8	0.1	1.5	4.1	1.9	1.7	0.5	0.0	0.1	0.1	0.0	0.0	0.0
Ida-Viru	4.4	1.1	1.6	1.4	1.0	0.4	0.0	0.0	0.3	0.2	0.0	0.1	0.0
Jõgeva	26.2	6.5	7.8	8.7	6.9	1.8	0.0	0.1	3.1	2.1	0.4	1.0	0.6
Järva	28.2	7.7	7.5	9.9	5.9	3.3	0.7	0.1	3.0	2.1	0.6	0.9	0.4
Lääne	9.6	2.1	2.1	4.3	3.6	0.5	0.2	0.1	1.0	0.7	0.2	0.3	0.1
Lääne-Viru	51.2	13.2	11.5	20.0	10.0	9.8	0.2	0.9	5.6	3.1	0.5	2.5	0.4

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total	covered	of which	other	of which
					50–80 kg	80–110 kg	more than 110 kg			sows	covered for the first time	sows	gilts not yet covered
Põlva	10.6	3.2	4.0	2.4	1.9	0.3	0.2	0.1	0.9	0.7	0.3	0.2	0.0
Pärnu	7.5	1.7	2.1	3.0	1.6	1.1	0.3	0.0	0.7	0.4	0.1	0.3	0.1
Rapla	28.4	7.4	9.4	8.4	4.7	3.7	0.0	0.1	3.1	2.3	0.6	0.8	0.4
Saare	19.8	4.1	7.5	6.1	3.6	2.5	0.0	0.1	2.0	1.3	0.3	0.7	0.4
Tartu	23.3	4.5	6.6	9.5	5.4	4.0	0.1	0.2	2.5	2.1	0.3	0.4	0.2
Valga	4.8	1.6	0.8	1.7	1.1	0.5	0.1	0.1	0.6	0.5	0.2	0.1	0.1
Viljandi	90.9	43.2	12.7	24.0	10.7	12.3	1.0	0.1	10.9	9.3	1.5	1.6	1.4
Võru	8.9	3.1	1.4	3.2	2.4	0.8	0.0	0.1	1.1	0.8	0.1	0.3	0.2
Agricultural holdings	338.2	103.5	81.8	113.3	64.2	45.5	3.6	2.1	37.5	27.3	5.5	10.2	4.8
natural persons	40.8	11.7	10.6	13.7	8.2	5.0	0.5	0.3	4.5	3.2	0.7	1.3	0.5
legal persons	297.4	91.8	71.2	99.6	56.0	40.5	3.1	1.8	33.0	24.1	4.8	8.9	4.3
Harju	21.0	4.5	6.3	7.3	4.0	3.0	0.3	0.1	2.8	1.7	0.4	1.1	0.5
Hiiu	5.7	0.1	1.5	4.0	1.9	1.6	0.5	0.0	0.1	0.1	0.0	0.0	0.0
Ida-Viru	4.3	1.1	1.5	1.4	1.0	0.4	0.0	0.0	0.3	0.2	0.0	0.1	0.0
Jõgeva	26.0	6.5	7.7	8.6	6.8	1.8	0.0	0.1	3.1	2.1	0.4	1.0	0.6
Järva	28.0	7.7	7.4	9.8	5.8	3.3	0.7	0.1	3.0	2.1	0.6	0.9	0.4
Lääne	9.5	2.1	2.1	4.3	3.6	0.5	0.2	0.1	0.9	0.7	0.2	0.2	0.1
Lääne-Viru	50.9	13.1	11.4	19.9	9.9	9.8	0.2	0.9	5.6	3.1	0.5	2.5	0.4
Põlva	10.5	3.2	3.9	2.4	1.9	0.3	0.2	0.1	0.9	0.7	0.3	0.2	0.0
Pärnu	7.3	1.6	2.1	2.9	1.5	1.1	0.3	0.0	0.7	0.4	0.1	0.3	0.1
Rapla	28.2	7.4	9.3	8.4	4.7	3.7	0.0	0.1	3.0	2.2	0.6	0.8	0.4
Saare	19.7	4.1	7.4	6.1	3.6	2.5	0.0	0.1	2.0	1.3	0.3	0.7	0.4
Tartu	23.0	4.4	6.5	9.4	5.4	3.9	0.1	0.2	2.5	2.1	0.3	0.4	0.2
Valga	4.8	1.6	0.8	1.7	1.1	0.5	0.1	0.1	0.6	0.5	0.2	0.1	0.1
Viljandi	90.6	43.1	12.6	23.9	10.6	12.3	1.0	0.1	10.9	9.3	1.5	1.6	1.4
Võru	8.7	3.0	1.3	3.2	2.4	0.8	0.0	0.1	1.1	0.8	0.1	0.3	0.2
Agricultural households	2.6	0.6	1.0	0.8	0.5	0.3	0.0	0.0	0.2	0.1	0.0	0.1	0.0

Table A.3.2_I.12. Number of cattle in 2003 by counties of Estonia, 1000 heads (Agriculture 2003)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	for breeding
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
COUNTRY TOTAL 2003	**257.2**	**116.8**	**2.0**	**0.8**	**12.5**	**0.4**	**12.1**	**12.6**	**40.2**	**1.7**	**38.5**	**72.3**	**7.3**	**42.7**	**22.3**
Harju	19.3	8.6	0.3	0.0	0.8	0.0	0.8	1.0	3.2	0.2	3.0	5.4	0.4	3.3	1.7
Hiiu	2.8	0.9	0.1	0.1	0.3	0.0	0.3	0.2	0.4	0.1	0.3	0.8	0.0	0.5	0.3
Ida-Viru	6.6	2.6	0.0	0.0	0.3	0.0	0.3	0.5	0.9	0.1	0.8	2.3	0.5	0.9	0.9
Jõgeva	26.0	11.3	0.1	0.0	1.1	0.0	1.1	1.1	4.2	0.0	4.2	8.2	1.2	4.2	2.8
Järva	35.1	17.9	0.1	0.0	1.4	0.0	1.4	0.9	5.8	0.0	5.8	9.0	1.1	6.4	1.5
Lääne	11.5	3.5	0.1	0.2	1.5	0.0	1.5	1.3	1.6	0.2	1.4	3.3	0.8	1.5	1.0
Lääne-Viru	28.9	12.6	0.0	0.2	1.2	0.1	1.1	2.0	4.5	0.1	4.4	8.4	0.2	4.9	3.3
Põlva	13.5	6.6	0.5	0.0	0.5	0.0	0.5	0.4	2.2	0.0	2.2	3.3	0.3	2.5	0.5
Pärnu	24.9	12.7	0.1	0.0	1.6	0.2	1.4	1.0	3.8	0.1	3.7	5.7	0.5	4.0	1.2
Rapla	19.0	7.9	0.3	0.2	0.5	0.0	0.5	1.0	2.6	0.0	2.6	6.5	0.2	3.4	2.9
Saare	14.7	7.1	0.0	0.0	1.0	0.1	0.9	0.9	2.0	0.4	1.6	3.7	0.4	2.5	0.8
Tartu	14.9	7.1	0.0	0.0	0.6	0.0	0.6	0.5	2.6	0.0	2.6	4.1	0.2	2.5	1.4
Valga	11.8	5.0	0.1	0.0	0.4	0.0	0.4	0.4	2.0	0.0	2.0	3.9	1.3	1.2	1.4
Viljandi	19.6	9.2	0.0	0.1	0.9	0.0	0.9	1.1	3.0	0.3	2.7	5.3	0.2	3.3	1.8
Võru	8.6	3.8	0.3	0.0	0.4	0.0	0.4	0.3	1.4	0.2	1.2	2.4	0.0	1.6	0.8
Agricultural holdings	253.7	115.2	2.0	0.8	12.3	0.3	12.0	12.3	39.8	1.6	38.2	71.3	7.0	42.3	22.0
natural persons	89.9	39.5	0.9	0.4	4.8	0.1	4.7	4.7	14.0	0.8	13.2	25.6	2.7	14.8	8.1
legal persons	163.8	75.7	1.1	0.4	7.5	0.2	7.3	7.6	25.8	0.8	25.0	45.7	4.3	27.5	13.9
Harju	19.0	8.5	0.3	0.0	0.8	0.0	0.8	1.0	3.1	0.2	2.9	5.3	0.4	3.2	1.7
Hiiu	2.7	0.9	0.1	0.1	0.3	0.0	0.3	0.2	0.3	0.1	0.2	0.8	0.0	0.5	0.3
Ida-Viru	6.3	2.5	0.0	0.0	0.3	0.0	0.3	0.4	0.9	0.1	0.8	2.2	0.5	0.8	0.9
Jõgeva	25.8	11.1	0.1	0.0	1.1	0.0	1.1	1.1	4.2	0.0	4.2	8.2	1.2	4.2	2.8
Järva	34.7	17.7	0.1	0.0	1.4	0.0	1.4	0.8	5.8	0.0	5.8	8.9	1.1	6.3	1.5
Lääne	11.4	3.4	0.1	0.2	1.5	0.0	1.5	1.3	1.6	0.2	1.4	3.3	0.8	1.5	1.0
Lääne-Viru	28.6	12.5	0.0	0.2	1.1	0.1	1.0	2.0	4.5	0.1	4.4	8.3	0.2	4.9	3.2
Põlva	13.3	6.5	0.5	0.0	0.5	0.0	0.5	0.4	2.1	0.0	2.1	3.3	0.3	2.5	0.5
Pärnu	24.7	12.6	0.1	0.0	1.6	0.2	1.4	1.0	3.8	0.1	3.7	5.6	0.4	4.0	1.2
Rapla	18.8	7.8	0.3	0.2	0.5	0.0	0.5	1.0	2.6	0.0	2.6	6.4	0.2	3.4	2.8
Saare	14.5	7.1	0.0	0.0	0.9	0.0	0.9	0.9	2.0	0.4	1.6	3.6	0.4	2.5	0.7
Tartu	14.6	7.0	0.0	0.0	0.6	0.0	0.6	0.4	2.6	0.0	2.6	4.0	0.2	2.4	1.4
Valga	11.6	4.9	0.1	0.0	0.4	0.0	0.4	0.4	2.0	0.0	2.0	3.8	1.2	1.2	1.4
Viljandi	19.2	9.0	0.0	0.1	0.9	0.0	0.9	1.1	2.9	0.2	2.7	5.2	0.1	3.3	1.8
Võru	8.5	3.7	0.3	0.0	0.4	0.0	0.4	0.3	1.4	0.2	1.2	2.4	0.0	1.6	0.8

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
Agricultural households	3.5	1.6	0.0	0.0	0.2	0.1	0.1	0.3	0.4	0.1	0.3	1.0	0.3	0.4	0.3

Table A.3.2_I.13. Swine population size in 2003 by counties of Estonia, 1000 heads (Agriculture 2003)

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total				
					50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
COUNTRY TOTAL **2003**	**344.6**	**104.1**	**91.9**	**110.7**	**64.3**	**44.6**	**1.8**	**1.3**	**36.6**	**26.3**	**5.4**	**10.3**	**3.1**
Harju	21.6	3.1	6.8	9.2	5.4	3.8	0.0	0.1	2.4	1.0	0.3	1.4	0.6
Hiiu	6.1	0.2	2.1	3.8	2.1	1.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Ida-Viru	4.1	0.8	1.5	1.5	1.1	0.4	0.0	0.0	0.3	0.2	0.0	0.1	0.0
Jõgeva	33.0	7.7	9.1	11.9	9.2	2.6	0.1	0.2	4.1	3.1	0.6	1.0	0.6
Järva	23.0	4.7	7.1	9.1	4.7	3.8	0.6	0.1	2.0	1.2	0.2	0.8	0.2
Lääne	8.5	1.7	1.7	4.1	3.3	0.8	0.0	0.0	1.0	0.7	0.1	0.3	0.0
Lääne-Viru	50.5	13.7	13.3	18.0	11.5	6.2	0.3	0.2	5.3	3.3	0.9	2.0	0.5
Põlva	8.6	2.1	3.4	2.2	0.8	1.3	0.1	0.0	0.9	0.7	0.2	0.2	0.0
Pärnu	8.3	1.4	2.4	3.8	2.3	1.5	0.0	0.1	0.6	0.4	0.1	0.2	0.1
Rapla	22.5	5.0	7.4	7.1	3.6	3.5	0.0	0.1	2.9	2.0	0.5	0.9	0.1
Saare	23.1	6.8	6.7	7.3	4.3	3.0	0.0	0.1	2.2	1.6	0.3	0.6	0.3
Tartu	22.4	6.7	6.3	7.8	3.2	4.6	0.0	0.1	1.5	1.2	0.3	0.3	0.1
Valga	4.9	1.5	1.0	1.8	1.4	0.4	0.0	0.1	0.5	0.4	0.1	0.1	0.1
Viljandi	99.2	45.9	21.0	20.2	9.9	10.2	0.1	0.1	12.0	10.0	1.7	2.0	0.5
Võru	8.8	2.8	2.1	2.9	1.5	0.9	0.5	0.1	0.9	0.5	0.1	0.4	0.0
Agricultural holdings	340.9	103.3	90.5	109.5	63.6	44.2	1.7	1.2	36.4	26.2	5.3	10.2	3.1
natural persons	34.3	9.3	9.8	11.6	6.4	4.9	0.3	0.1	3.5	2.4	0.5	1.1	0.3
legal persons	306.6	94.0	80.7	97.9	57.2	39.3	1.4	1.1	32.9	23.8	4.8	9.1	2.8
Harju	21.4	3.1	6.7	9.1	5.4	3.7	0.0	0.2	2.3	1.0	0.3	1.3	0.6
Hiiu	6.0	0.1	2.1	3.8	2.1	1.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Ida-Viru	4.0	0.8	1.4	1.5	1.1	0.4	0.0	0.0	0.3	0.2	0.0	0.1	0.0
Jõgeva	32.7	7.7	9.0	11.7	9.1	2.5	0.1	0.2	4.1	3.1	0.6	1.0	0.6

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total				
					50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
Järva	22.8	4.7	6.9	9.1	4.6	3.9	0.6	0.1	2.0	1.2	0.2	0.8	0.2
Lääne	8.3	1.6	1.6	4.1	3.3	0.8	0.0	0.0	1.0	0.7	0.1	0.3	0.0
Lääne-Viru	50.0	13.6	13.1	17.8	11.4	6.2	0.2	0.2	5.3	3.3	0.9	2.0	0.5
Põlva	8.4	2.1	3.3	2.1	0.7	1.3	0.1	0.0	0.9	0.7	0.2	0.2	0.0
Pärnu	8.0	1.3	2.4	3.6	2.2	1.4	0.0	0.1	0.6	0.4	0.0	0.2	0.1
Rapla	22.3	4.9	7.4	7.0	3.5	3.5	0.0	0.1	2.9	2.0	0.5	0.9	0.1
Saare	22.8	6.7	6.5	7.3	4.3	3.0	0.0	0.1	2.2	1.6	0.3	0.6	0.3
Tartu	22.1	6.7	6.2	7.7	3.2	4.5	0.0	0.1	1.4	1.1	0.3	0.3	0.1
Valga	4.8	1.5	1.0	1.8	1.4	0.4	0.0	0.0	0.5	0.4	0.1	0.1	0.1
Viljandi	98.6	45.7	20.8	20.0	9.8	10.1	0.1	0.1	12.0	10.0	1.7	2.0	0.5
Võru	8.7	2.8	2.1	2.9	1.5	0.9	0.5	0.0	0.9	0.5	0.1	0.4	0.0
Agricultural households	3.7	0.8	1.4	1.2	0.7	0.4	0.1	0.1	0.2	0.1	0.1	0.1	0.0

Table A.3.2_I.14. Number of cattle in 2004 by counties of Estonia, 1000 heads (Agriculture 2004)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		Total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2004	**249.8**	**116.5**	**2.7**	**1.3**	**12.0**	**0.1**	**11.9**	**10.2**	**40.8**	**1.1**	**39.7**	**66.3**	**3.5**	**40.1**	**22.7**
Agricultural holdings	249.4	116.1	2.7	1.3	12.0	0.1	11.9	10.2	40.8	1.1	39.7	66.3	3.5	40.1	22.7
natural persons	88.3	40.1	1.1	0.5	4.6	0.0	4.6	3.9	14.4	0.4	14.0	23.7	1.3	14.2	8.2
legal persons	161.1	76.0	1.6	0.8	7.4	0.1	7.3	6.3	26.4	0.7	25.7	42.6	2.2	25.9	14.5
Harju	14.5	6.2	0.2	0.1	0.8	0.1	0.7	0.8	2.5	0.2	2.3	3.9	0.4	2.1	1.4
Hiiu	2.5	1.0	0.1	0.0	0.1	0.0	0.1	0.2	0.3	0.0	0.3	0.8	0.0	0.4	0.4
Ida-Viru	7.4	3.6	0.0	0.0	0.3	0.0	0.3	0.3	1.5	0.0	1.5	1.7	0.1	1.0	0.6
Jõgeva	26.3	11.5	0.2	0.0	1.0	0.0	1.0	1.4	4.0	0.1	3.9	8.2	0.3	4.5	3.4
Järva	36.6	18.7	0.1	0.1	1.6	0.0	1.6	0.5	6.7	0.3	6.4	8.9	0.6	6.7	1.6
Lääne	8.5	3.5	0.1	0.1	0.5	0.0	0.5	0.7	1.3	0.0	1.3	2.3	0.1	1.3	0.9
Lääne-Viru	28.6	12.1	0.6	0.2	1.3	0.0	1.3	1.5	5.0	0.1	4.9	7.9	0.2	4.4	3.3
Põlva	14.7	7.2	0.1	0.0	0.7	0.0	0.7	0.5	1.9	0.0	1.9	4.3	0.2	2.9	1.2
Pärnu	25.7	13.2	0.3	0.1	1.3	0.0	1.3	0.6	4.4	0.2	4.2	5.8	0.4	3.9	1.5
Rapla	17.1	7.8	0.1	0.2	0.6	0.0	0.6	0.7	3.0	0.1	2.9	4.7	0.2	2.4	2.1
Saare	14.3	6.2	0.2	0.1	0.7	0.0	0.7	1.1	1.9	0.0	1.9	4.1	0.6	2.1	1.4
Tartu	15.0	7.1	0.1	0.0	0.3	0.0	0.3	0.6	2.5	0.0	2.5	4.4	0.1	2.7	1.6
Valga	9.5	4.6	0.2	0.3	0.9	0.0	0.9	0.1	1.1	0.0	1.1	2.3	0.1	1.6	0.6
Viljandi	19.1	8.7	0.1	0.1	1.4	0.0	1.4	0.8	3.5	0.0	3.5	4.5	0.2	2.7	1.6
Võru	9.6	4.7	0.3	0.0	0.5	0.0	0.5	0.4	1.2	0.1	1.1	2.5	0.0	1.4	1.1
Agricultural households	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A.3.2_I.15. Swine population size in 2004 by counties of Estonia, 1000 heads (Agriculture 2004)

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total				
					50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2004	**340.1**	**113.7**	**83.9**	**106.6**	**65.5**	**37.8**	**3.3**	**1.2**	**34.7**	**22.6**	**5.0**	**12.1**	**4.2**
Agricultural holdings	339.2	113.5	83.6	106.3	65.3	37.7	3.3	1.2	34.6	22.5	5.0	12.1	4.2
natural persons	31.4	9.6	7.6	10.9	6.6	4.1	0.2	0.2	3.1	2.2	0.5	0.9	0.3
legal persons	307.8	103.9	76.0	95.4	58.7	33.6	3.1	1.0	31.5	20.3	4.5	11.2	3.9
Harju	26.3	4.9	9.2	9.4	4.5	4.9	0.0	0.1	2.7	1.5	0.4	1.2	0.4
Hiiu	x	x	x	x	x	x	x	x	x	x	x	x	x
Ida-Viru	5.5	0.9	1.3	2.9	1.8	1.1	0.0	0.0	0.4	0.3	0.0	0.1	0.0
Jõgeva	27.4	5.8	8.8	9.8	8.0	1.8	0.0	0.2	2.8	2.1	0.4	0.7	0.4
Järva	17.6	4.3	4.9	6.6	3.6	2.8	0.2	0.1	1.7	1.0	0.2	0.7	0.2
Lääne	9.2	1.9	2.2	4.2	3.0	1.2	0.0	0.0	0.9	0.7	0.3	0.2	0.2
Lääne-Viru	44.1	13.3	12.0	14.1	10.0	4.0	0.1	0.1	4.6	3.5	0.9	1.1	0.3
Põlva	9.9	3.9	2.2	2.7	0.8	1.9	0.0	0.1	1.0	0.9	0.2	0.1	0.0
Pärnu	6.9	1.6	1.0	3.6	3.0	0.6	0.0	0.1	0.6	0.4	0.1	0.2	0.1
Rapla	20.8	5.8	5.5	6.5	4.1	2.3	0.1	0.1	2.9	2.4	0.4	0.5	0.1
Saare	20.2	7.3	5.9	4.6	2.7	1.8	0.1	0.1	2.3	1.7	0.3	0.6	0.4
Tartu	24.5	6.3	7.5	9.1	7.4	1.7	0.0	0.1	1.5	1.2	0.3	0.3	0.1
Valga	5.3	1.2	1.4	2.0	1.3	0.5	0.2	0.1	0.6	0.4	0.1	0.2	0.1
Viljandi	x	x	x	x	x	x	x	x	x	x	x	x	x
Võru	11.4	2.1	2.5	5.9	3.5	2.4	0.0	0.0	0.9	0.5	0.1	0.4	0.2
Agricultural households	0.9	0.2	0.3	0.3	0.2	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0

Table A.3.2_I.16. Number of cattle in 2005 by counties of Estonia, 1000 heads (Agriculture 2005)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows			heifers			bulls	heifers			total		for breeding	
		dairy cows	other	bulls	total	for slaughter	for breeding		total	for slaughter	for breeding		for slaughter	heifers	bulls
2005	**249.5**	**112.8**	**4.8**	**0.8**	**12**	**0.4**	**11.6**	**11.2**	**40.7**	**1.1**	**39.6**	**67.2**	**3.8**	**40.6**	**22.8**
Agricultural holdings	247.2	111.8	4.8	0.8	11.9	0.4	11.5	11	40.4	1.1	39.3	66.5	3.6	40.3	22.6
natural persons	83.6	35	2.2	0.3	4.3	0.2	4.1	4	13.9	0.5	13.4	23.9	1.4	14.3	8.2
legal persons	163.6	76.8	2.6	0.5	7.6	0.2	7.4	7	26.5	0.6	25.9	42.6	2.2	26	14.4
Harju	14	6.2	0.3	0.1	1.1	0.1	1	0.5	2.2	0.1	2.1	3.6	0.3	2.1	1.2
Hiiu	2.8	0.9	0.3	0	0.1	0	0.1	0.2	0.4	0	0.4	0.9	0	0.5	0.4
Ida-Viru	6.7	3.1	0.1	0	0.3	0.1	0.2	0.4	1	0.1	0.9	1.8	0	0.9	0.9
Jõgeva	25.9	11.3	0.1	0	1	0	1	1.7	4.1	0	4.1	7.7	0.5	4.3	2.9
Järva	36.2	18.1	0.3	0.1	1.4	0	1.4	0.7	6.7	0.1	6.6	8.9	0.3	6.4	2.2
Lääne	9	3	1	0.1	0.5	0	0.5	0.6	1.1	0.2	0.9	2.7	0	1.4	1.3
Lääne-Viru	29.8	12.3	0.5	0.1	1.2	0	1.2	2.2	5.4	0.1	5.3	8.1	0.2	4.8	3.1
Põlva	14	6.8	0.1	0	0.8	0	0.8	0.3	2.1	0	2.1	3.9	0.4	2.7	0.8
Pärnu	24.3	12.4	0.3	0.1	1.4	0	1.4	0.5	4	0.1	3.9	5.6	0.3	3.8	1.5
Rapla	18.1	7.8	0.4	0.2	0.8	0	0.8	1.2	2.8	0	2.8	4.9	0.1	2.5	2.3
Saare	14.9	6.5	0.4	0	0.9	0.1	0.8	0.7	2.3	0.1	2.2	4.1	0.5	2.5	1.1
Tartu	14.8	6.5	0.2	0	0.7	0	0.7	0.6	2.6	0	2.6	4.2	0.2	2.3	1.7
Valga	8.8	3.9	0.3	0	0.4	0	0.4	0.3	1.2	0	1.2	2.7	0.1	1.5	1.1
Viljandi	18.3	8.6	0.3	0.1	0.9	0	0.9	0.7	3	0.1	2.9	4.7	0.2	3	1.5
Võru	9.6	4.4	0.2	0	0.4	0.1	0.3	0.4	1.5	0.2	1.3	2.7	0.5	1.6	0.6
Agricultural households	2.3	1	0	0	0.1	0	0.1	0.2	0.3	0	0.3	0.7	0.2	0.3	0.2

Table A.3.2_I.17. Swine population size in 2005 by counties of Estonia, 1000 heads (Agriculture 2005)

	Total	of which						breeding pigs, live weight more than 50 kg					
				fattening pigs				boars	sows				
					of which, live weight				total				
	Total	piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	total	50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2005	**346.5**	**113.3**	**87.2**	**110.4**	**77.2**	**31.7**	**1.5**	**1.3**	**34.3**	**26.3**	**5.3**	**8**	**4.3**
Agricultural holdings	343.8	112.7	86.2	109.4	76.6	31.4	1.4	1.3	34.2	26.2	5.3	8	4.3
natural persons	34.7	11.1	9	11.4	8.1	3.1	0.2	0.2	3	2.3	0.5	0.7	0.3
legal persons	309.1	101.6	77.2	98	68.5	28.3	1.2	1.1	31.2	23.9	4.8	7.3	4
Harju	22.7	4.2	6.4	9.8	6	3.8	0	0.2	2.1	1.5	0.3	0.6	0.3
Hiiu	x	x	x	x	x	x	x	x	x	x	x	x	x
Ida-Viru	3.5	0.7	1	1.5	0.9	0.6	0	0	0.3	0.2	0	0.1	0
Jõgeva	28.1	7.4	7	10.7	9.1	1.6	0	0.2	2.8	2.1	0.4	0.7	0.6
Järva	16.1	4.8	3.8	5.6	3.1	2.2	0.3	0.1	1.8	1.2	0.2	0.6	0.3
Lääne	9.3	1.8	2.5	4.2	2.9	1	0.3	0.1	0.7	0.5	0.1	0.2	0
Lääne-Viru	x	x	x	x	x	x	x	x	x	x	x	x	x
Põlva	17.5	10.9	3.6	2.7	1.7	1	0	0	0.3	0.2	0	0.1	0
Pärnu	6.7	1.1	2.3	2.8	1.9	0.9	0	0	0.5	0.4	0.1	0.1	0.1
Rapla	20.8	5.4	6.2	6.6	5.2	1.4	0	0.1	2.5	1.9	0.6	0.6	0.1
Saare	23	7.7	6.6	6.2	3.5	2.6	0.1	0.1	2.4	1.7	0.4	0.7	0.3
Tartu	24	4.5	9.7	8	6.1	1.9	0	0.1	1.7	1.4	0.2	0.3	0.1
Valga	6.6	1.1	0.8	4.3	3.4	0.8	0.1	0	0.4	0.3	0	0.1	0
Viljandi	101	49.2	18.2	20.4	12.7	7.5	0.2	0.2	13	10.5	1.8	2.5	1.9
Võru	13.2	2.5	3.9	5.9	4.1	1.5	0.3	0.1	0.8	0.6	0.1	0.2	0.1
Agricultural households	2.7	0.6	1	1	0.6	0.3	0.1	0	0.1	0.1	0	0	0

Table A.3.2_I.18. Number of cattle in 2006 by counties of Estonia, 1000 heads (SE, 2011)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2006	**244.8**	**108.4**	**6**	**1.7**	**11.1**	**0.4**	**10.7**	**8.7**	**42.9**	**1.5**	**41.4**	**66**	**3.1**	**62.9**	**42.4**
Harju	14.7	7	0.3	0	0.8	0	0.8	0.5	2.7	0.4	2.3	5.1	0.2	4.2	2.9
Hiiu	2.9	0.8	0.5	0	0.1	0	0.1	0.2	0.4	0.1	0.3	0.9	0	0.9	0.5
Ida-Viru	6	2.7	0.3	0.1	0.2	0	0.2	0.2	0.9	0	0.9	1.6	0	1.6	1
Jõgeva	23.4	10.6	0.2	0.2	0.9	0	0.9	1	4.1	0	4.1	6.4	0.1	6.3	4.3
Järva	32.3	16.2	0	0.1	1.3	0	1.3	0.4	6.5	0.1	6.4	7.8	0.3	7.5	5.7
Lääne	9.7	2.8	1	0.1	0.4	0.1	0.3	0.7	1.5	0.2	1.3	3.2	0.1	3.1	1.6
Lääne-Viru	31	12.9	1	0.2	1.4	0	1.4	1.5	5.6	0.1	5.5	8.4	0.4	8	5.3
Põlva	14	6.7	0.1	0	1.2	0	1.2	0.3	2.2	0	2.2	3.5	0.2	3.3	2.5
Pärnu	24.5	12.6	0.2	0.2	1.3	0.1	1.2	0.3	4	0	4	5.9	0.4	5.5	4.2
Rapla	19.2	8.4	0.5	0.3	0.8	0.1	0.7	0.7	3.4	0.4	3	5.1	0.3	4.8	3
Saare	15.3	6.5	0.6	0.2	0.7	0.1	0.6	0.9	2.6	0.1	2.5	3.8	0.3	3.5	2.4
Tartu	14.4	6.5	0.2	0	0.5	0	0.5	0.5	2.4	0	2.4	4.3	0.3	4	2.5
Valga	9.2	3.4	0.5	0.1	0.4	0	0.4	0.4	1.6	0	1.6	2.8	0.1	2.7	1.7
Viljandi	16.2	7.4	0.4	0.1	0.9	0	0.9	0.5	2.8	0	2.8	4.1	0.1	4	2.8
Võru	9.7	3.9	0.2	0.1	0.2	0	0.2	0.4	1.8	0	1.8	3.1	0.1	3	1.7

Table A.3.2_I.19. Swine population size in 2006 by counties of Estonia, 1000 heads (SE, 2011)

	Total	of which						breeding pigs, live weight more than 50 kg					
				fattening pigs				boars	sows				
					of which, live weight				total				
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	total	50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2006	**345.8**	**118.8**	**76.9**	**111.7**	**72.8**	**36.5**	**2.4**	**1**	**37.4**	**26.3**	**5.3**	**11.1**	**4.5**
Harju	18.9	2.6	7.1	7.1	4.1	3	0	0	2.1	1.1	0.3	1	0.7
Hiiu	4.5	.	.	.	.	.	.	.	.	.	.	.	.
Ida-Viru	4.5	.	.	.	.	.	.	.	.	.	.	.	.
Jõgeva	29.2	8.5	6.9	9.5	6.7	2.6	0.2	0.2	4.1	2.7	0.6	1.4	0.4
Järva	11.6	2.5	3.6	4.2	2.4	1.7	0.1	0.1	1.2	0.8	0.1	0.4	0.2
Lääne	8.1	2.9	1.5	2.8	1.9	0.9	0	0	0.9	0.6	0.1	0.3	0.1
Lääne-Viru	53.9	13.4	13.4	21.1	14.8	6.1	0.2	0.2	5.8	4.1	1.2	1.7	0.4
Põlva	26.7	13	2.3	11.1	10.8	0.2	0.1	0	0.3	0.3	0	0	0
Pärnu	5.3	0.9	1.2	2.6	1.7	0.9	0	0	0.6	0.4	0.1	0.2	0
Rapla	19.4	4.9	5.3	6.1	3.9	2.2	0	0.1	3	1.9	0.4	1.1	0.5
Saare	25.1	8.6	7.2	6.6	3.4	3.1	0.1	0.1	2.6	2	0.5	0.6	0.3
Tartu	23.4	4.7	7.7	9.2	6.3	1.9	1	0.1	1.7	1.4	0.3	0.3	0.1
Valga	6.3	2.3	1	2.4	1.6	0.6	0.2	0	0.6	0.5	0.1	0.1	0
Viljandi	96.5	47.3	14.9	21.3	10.7	10.2	0.4	0.1	12.9	9.2	1.5	3.7	1.7
Võru	12.4	2.2	3.2	6.2	3.6	2.6	0	0.1	0.7	0.6	0.1	0.1	0.1

Table A.3.2_I.20. Number of cattle in 2007 by counties of Estonia, 1000 heads (SE, 2011)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2007	**240.5**	103.0	8.5	**1.8**	**11.6**	0.7	10.9	8.4	42.7	1.4	41.3	**64.5**	3	42.3	19.2
Harju	12.9	5.8	0.5	0	0.5	0	0.5	0.6	2.4	0.1	2.3	3.8	0	2.2	0.9
Hiiu	3.5	0.8	0.7	0.1	0.1	0	0.1	0.3	0.4	0.1	0.3	1.1	0	0.5	0.6
Ida-Viru	5.9	2.3	0.2	0.1	0.3	0	0.3	0.2	1.1	0.2	0.9	1.7	0	1.1	0.6
Jõgeva	22.1	9.9	0.1	0.1	1.2	0.1	1.1	0.5	4.1	0.2	3.9	6.2	0.2	3.8	2.2
Järva	30.8	15.4	0.3	0.1	1.4	0	1.4	0.3	5.4	0	5.4	7.9	0.3	6.2	1.4
Lääne	10.7	2.7	1.5	0.1	0.5	0.2	0.3	0.9	1.8	0.1	1.7	3.2	0.3	1.7	1.2
Lääne-Viru	29.4	12.8	0.8	0.1	1	0.1	0.9	1	6	0.1	5.9	7.7	0.1	5.2	2.4
Põlva	14.1	6.6	0.1	0.1	1.1	0.1	1	0.4	2.3	0	2.3	3.5	0.2	2.4	0.9
Pärnu	23.9	10.9	0.7	0.1	0.9	0	0.9	0.6	4.7	0.1	4.6	6	0.4	4.4	1.2
Rapla	18.1	7.2	0.9	0.6	0.6	0.2	0.4	0.7	3.1	0.2	2.9	5	0.4	3.2	1.4
Saare	15.4	6.1	0.9	0.1	0.7	0	0.7	0.7	2.6	0.1	2.5	4.3	0.2	2.6	1.5
Tartu	15.4	6.4	0.3	0	0.7	0	0.7	0.6	2.9	0	2.9	4.5	0.3	2.6	1.6
Valga	9.3	3.5	0.7	0	1.1	0	1.1	0.4	1.2	0	1.2	2.4	0.2	1.3	0.9
Viljandi	16.9	7.6	0.5	0.1	1.2	0	1.2	0.5	2.5	0	2.5	4.5	0.2	3.1	1.2
Võru	9.8	4.0	0.3	0.2	0.3	0	0.3	0.5	1.8	0.1	1.7	2.7	0	1.7	1

Table A.3.2_I.21. Swine population size in 2007 by counties of Estonia, 1000 heads (SE, 2011)

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total				
					50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2007	**379**	**123.3**	**81.8**	**137.4**	**78.5**	**56.3**	**2.6**	**0.8**	**35.7**	**25.1**	**5.1**	**10.6**	**3.5**
Harju	20.4	2.2	8	8.8	6	2.7	0.1	0	1.4	1	0.2	0.4	0.1
Hiiu	*4.5*	*27.45*	*7.9*	*15.9*	*5.95*	*9.9*	*0.05*	*0.05*	*6.5*	*4.4*	*0.85*	*2.1*	*0.7*
Ida-Viru	3.3	1.5	0.6	0.8	0.5	0.3	0	0	0.4	0.3	0.1	0.1	0
Jõgeva	34.6	8.4	9.4	12.6	6.1	6	0.5	0.1	4.1	3.6	0.9	0.5	0.4
Järva	12.2	2.5	4.4	4.2	2.8	1.3	0.1	0	1.1	0.9	0.1	0.2	0.2
Lääne	8.4	2.9	2.8	1.8	1.8	0	0	0	0.9	0.8	0.2	0.1	0.1
Lääne-Viru	55.4	13.6	9.2	27.1	13.7	13.1	0.3	0.1	5.4	3.5	0.6	1.9	0.5
Põlva	30.8	15.5	2	12.9	11.4	0.7	0.8	0	0.4	0.2	0.1	0.2	0.1
Pärnu	6.4	1.1	1.1	3.6	2.7	0.9	0	0	0.6	0.4	0.1	0.2	0.1
Rapla	18.9	4.1	5.6	6.6	4.2	2.4	0	0.1	2.5	1.6	0.3	0.9	0.1
Saare	27	8.9	8.3	7.4	5	2.3	0.1	0.1	2.3	1.6	0.5	0.7	0.3
Tartu	28.8	4.8	9.7	11.9	7.5	4.4	0	0.1	2.3	1.6	0.2	0.7	0.2
Valga	4.9	1.2	1	2.2	1.5	0.5	0.2	0.1	0.4	0.2	0	0.2	0
Viljandi	*111.1*	*27.45*	*7.9*	*15.9*	*5.95*	*9.9*	*0.05*	*0.05*	*6.5*	*4.4*	*0.85*	*2.1*	*0.7*
Võru	12.3	1.7	3.9	5.7	3.4	1.9	0.4	0.1	0.9	0.6	0.1	0.3	0

Table A.3.2_I.22. Number of cattle in 2008 by counties of Estonia, 1000 heads (SE, 2011)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2008	237.9	100.4	8.2	2.2	14.5	1	13.5	7.5	39.5	1.4	38.1	65.6	3.2	41.8	20.6
Harju	12.4	5.0	0.6	0.2	1.0	0.1	0.9	0.4	1.8	0.1	1.7	3.3	0.1	2	1.2
Hiiu	3.7	0.7	0.6	0.1	0.2	0.1	0.1	0.3	0.5	0.1	0.4	1.2	0	0.7	0.5
Ida-Viru	6.4	2.2	0.3	0	0.5	0	0.5	0.3	1	0.2	0.8	2.0	0.1	1.2	0.7
Jõgeva	22.6	10.7	0.3	0.1	1.0	0.1	0.9	0.4	3.8	0.2	3.6	6.2	0.2	4	2
Järva	31.0	15.1	0.2	0.2	1.5	0	1.5	0.4	5.7	0.1	5.6	7.8	0.3	6	1.5
Lääne	10.3	3.1	1.2	0.2	0.7	0.3	0.4	0.6	1.5	0	1.5	2.9	0.2	1.6	1.1
Lääne-Viru	29.6	12.5	0.6	0.1	1.7	0.1	1.6	0.9	5.2	0.1	5.1	8.5	0.2	5.5	2.8
Põlva	14.2	6.2	0.2	0.1	0.7	0	0.7	0.4	2.5	0	2.5	4.0	0.2	2.7	1.1
Pärnu	23.5	10.5	0.7	0.3	1.7	0	1.7	0.5	4.1	0.1	4	5.6	0.3	4	1.3
Rapla	16.4	5.9	0.9	0.3	1.1	0.3	0.8	0.7	2.7	0.2	2.5	4.7	0.3	2.8	1.6
Saare	16.0	6.3	1	0.1	1.2	0	1.2	0.6	2.5	0.1	2.4	4.2	0.2	2.6	1.4
Tartu	15.0	6.6	0.2	0.2	0.9	0	0.9	0.4	2.4	0	2.4	4.2	0.4	2.4	1.4
Valga	10.9	4.1	0.4	0	0.7	0	0.7	0.5	1.7	0	1.7	3.4	0.3	1.7	1.4
Viljandi	16.6	7.8	0.4	0.3	0.9	0	0.9	0.5	2.4	0	2.4	4.2	0.2	2.7	1.3
Võru	10.0	4.1	0.6	0	0.6	0	0.6	0.4	1.4	0.1	1.3	2.7	0	1.6	1.1

Table A.3.2_I.23. Swine population size in 2008 by counties of Estonia, 1000 heads (SE, 2011)

	Total	of which						breeding pigs, live weight more than 50 kg					
				fattening pigs				boars	sows				
					of which, live weight				total				
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	total	50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2008	364.9	117.1	96.2	116.9	70.1	44.2	2.6	0.6	34.1	22.5	5	11.6	4
Harju	19.2	3.5	6.8	7.7	4.5	3.2	0	0	1.2	0.9	0.3	0.3	0.1
Hiiu	58.4	23.7	16.4	11.7	6.9	4.8	0.0	0.1	6.6	3.3	0.9	3.3	1.0
Ida-Viru	2.2	0.9	0.6	0.4	0.2	0.2	0	0	0.3	0.2	0.1	0.1	0
Jõgeva	40.5	9.2	12	14.3	6	8	0.3	0.1	4.9	4	0.7	0.9	0.8
Järva	11.4	3.3	2.8	4.3	4	0.3	0	0	1	0.8	0.3	0.2	0.1
Lääne	8.9	3.6	0.2	4	4	0	0	0	1.1	0.7	0.2	0.4	0.3
Lääne-Viru	52.3	12.8	11.8	22.8	12.2	9.2	1.4	0.1	4.8	3.7	0.4	1.1	0.4
Põlva	28.2	14.5	4.8	8.6	5.1	3.5	0	0	0.3	0.2	0	0.1	0
Pärnu	6.6	1.7	0.8	3.5	1.3	2.2	0	0	0.6	0.4	0.3	0.2	0.1
Rapla	12.6	2	4.1	4.6	3.6	1	0	0.1	1.8	1.1	0.2	0.7	0
Saare	27.8	8.7	9.4	7.4	4.5	2.3	0.6	0.1	2.2	1.7	0.3	0.5	0.1
Tartu	26.5	7.6	6.2	10.6	8.8	1.7	0.1	0.1	2	1.6	0.4	0.4	0.2
Valga	2.8	0.6	0.9	1.1	0.9	0.2	0	0	0.2	0.2	0	0	0
Viljandi	58.4	23.7	16.4	11.7	6.9	4.8	0.0	0.1	6.6	3.3	0.9	3.3	1.0
Võru	9.1	1.4	3	4.2	1.2	2.8	0.2	0	0.5	0.4	0.1	0.1	0

Table A.3.2_I.24. Number of cattle in 2009 by counties of Estonia, 1000 heads (SE, 2011)

	Total	of which														
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)				
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other	bulls	total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2009	234.7	96.7	10.3	2.0	14.3	1	13.3	8.3	39.6	1.4	38.2	63.5	3.2	40.4	19.9
Harju	11.5	4.6	0.7	0.2	0.8	0	0.8	0.4	1.8	0.1	1.7	3.0	0.1	1.8	1.1
Hiiu	4.2	0.5	0.9	0.1	0.3	0.1	0.2	0.4	0.6	0.1	0.5	1.4	0	0.8	0.6
Ida-Viru	5.8	2.2	0.3	0	0.4	0	0.4	0.3	0.9	0.2	0.7	1.7	0.1	1	0.6
Jõgeva	21.8	10.5	0.4	0	0.9	0.1	0.8	0.6	4	0.2	3.8	6.6	0.2	3.8	1.9
Järva	29.8	14.1	0.3	0.1	1.8	0	1.8	0.6	5.9	0.1	5.6	7.5	0.3	5.8	1.4
Lääne	10.1	3.0	1.3	0.3	0.8	0.3	0.5	0.5	1.4	0.1	1.4	2.8	0.2	1.5	1.1
Lääne-Viru	28.1	12.0	0.8	0.2	1.4	0.1	1.3	1	5.1	0.1	5	7.6	0.2	4.9	2.5
Põlva	13.2	5.7	0.3	0.1	0.6	0	0.6	0.4	2.4	0	2.4	3.7	0.2	2.5	1
Pärnu	23.5	10.8	0.9	0.1	1.7	0	1.7	0.5	4.2	0.1	4.2	5.8	0.3	4.1	1.4
Rapla	16.2	5.8	1	0.2	1.1	0.3	0.8	1	2.7	0.2	2.5	4.5	0.3	2.6	1.6
Saare	16.5	6.1	1.4	0.1	1.1	0	1.1	0.7	2.6	0.1	2.5	4.5	0.2	2.8	1.5
Tartu	13.5	5.9	0.2	0.2	0.7	0.1	0.6	0.3	2.3	0	2.3	3.9	0.3	2.3	1.3
Valga	10.6	3.6	0.6	0.1	0.8	0	0.8	0.6	1.6	0	1.6	3.3	0.3	1.7	1.3
Viljandi	17.0	7.6	0.6	0.2	1.2	0	1.2	0.5	2.5	0	2.5	4.4	0.2	2.9	1.3
Võru	10.6	4.3	0.6	0.1	0.7	0	0.7	0.5	1.6	0.1	1.5	2.8	0.1	1.6	1.1

Table A.3.2_I.25. Swine population size in 2009 by counties of Estonia, 1000 heads (SE, 2011)

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total				
					50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2009	365.1	120.7	94.6	115.2	68.4	36.7	10.1	0.5	34.1	24.1	4.7	10	3.5
Harju	19.7	2.3	7.3	8.7	5.4	3.3	0	0	1.4	1.2	0.3	0.2	0.1
Hiiu	2.6	0.6	1.0	0.8	0.5	0.3	0.0	0.0	0.2	0.1	0.0	0.1	0.0
Ida-Viru	2.9	0.9	0.8	0.9	0.4	0.4	0.1	0	0.3	0.3	0.1	0	0
Jõgeva	56.3	9.3	18.2	23	18.8	4	0.2	0.1	5.7	3.9	0.7	1.8	1.1
Järva	9.3	2.1	2.9	3.2	2.6	0.6	0	0	1.1	1	0	0.1	0
Lääne	1.4	0.3	0.2	0.7	0.6	0.1	0	0	0.2	0.1	0	0.1	0
Lääne-Viru	51.5	14.9	15	16.7	9.2	7.4	0.1	0.1	4.8	3.7	0.6	1.1	0.2
Põlva	6.7	1.1	1.2	3.8	2.1	1.5	0.2	0	0.6	0.4	0.1	0.2	0.1
Pärnu	7.5	1.9	1.4	3.7	1.4	2.3	0	0	0.5	0.4	0.1	0.1	0
Rapla	10.5	1.4	3.6	3.7	2.1	1.6	0	0.1	1.7	1	0.2	0.7	0.1
Saare	27.9	9.3	9	7.3	4.6	2.4	0.3	0.1	2.2	1.7	0.3	0.5	0.1
Tartu	32.7	8.6	11.2	10.6	8.3	2.1	0.2	0	2.3	1.8	0.4	0.5	0.2
Valga	2.6	0.7	0.6	1.1	0.8	0.3	0	0	0.2	0.2	0	0	0
Viljandi	122.8	63.9	17.2	29.2	10.8	9.4	9.0	0.1	12.4	7.9	1.8	4.5	1.6
Võru	10.7	3.4	5	1.8	0.8	1	0	0	0.5	0.4	0.1	0.1	0

Table A.3.2_I.26. Number of cattle in 2010 by counties of Estonia, 1000 heads (SE, 2011)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2010	236.3	96.5	12.1	2.3	15.0	1	14	8.1	39.6	1.4	38.2	3.1	59.6	41.7	17.9
Harju	12.6	4.6	0.9	0.2	1.1	0.1	1	0.5	2	0.1	1.9	0.1	3.2	2.2	1
Hiiu	4.3	0.6	0.9	0.1	0.4	0.1	0.3	0.4	0.6	0.1	0.5	0	1.3	0.7	0.6
Ida-Viru	6.0	1.9	0.4	0.1	0.4	0	0.4	0.3	1	0.2	0.8	0.1	1.8	1.2	0.6
Jõgeva	21.0	9.7	0.4	0.1	1.0	0.1	0.9	0.5	3.8	0.2	3.6	0.2	5.3	4	1.3
Järva	30.1	13.7	0.5	0.1	1.8	0	1.8	0.6	5.8	0.1	5.7	0.3	7.3	5.9	1.4
Lääne	10.6	3.2	1.4	0.3	1.0	0.4	0.6	0.4	1.5	0	1.5	0.2	2.6	1.6	1
Lääne-Viru	28.1	12.0	1	0.2	1.8	0.1	1.7	0.9	4.9	0.1	4.8	0.2	7.1	5.1	2
Põlva	13.5	6.3	0.3	0.1	0.6	0	0.6	0.4	2.2	0	2.2	0.2	3.4	2.4	1
Pärnu	23.4	11.2	1.1	0.2	1.7	0	1.7	0.6	3.9	0.1	3.8	0.3	5.4	4	1.4
Rapla	16.3	5.7	1.3	0.2	0.9	0.2	0.7	0.7	2.9	0.2	2.7	0.3	4.3	2.8	1.5
Saare	15.6	5.5	1.5	0.1	1.1	0	1.1	0.7	2.5	0.1	2.4	0.2	4	2.7	1.3
Tartu	15.0	7.1	0.2	0.2	0.8	0	0.8	0.3	2.5	0	2.5	0.3	3.6	2.6	1
Valga	10.5	4.1	0.6	0.1	0.6	0	0.6	0.5	1.5	0	1.5	0.3	2.8	1.6	1.2
Viljandi	17.9	7.7	0.8	0.2	1.1	0	1.1	0.7	2.8	0	2.8	0.2	4.4	3.1	1.3
Võru	9.1	3.2	0.8	0.1	0.6	0	0.6	0.4	1.4	0.1	1.3	0	2.6	1.5	1.1

Table A.3.2_I.27. Swine population size in 2010 by counties of Estonia, 1000 heads (SE, 2011)

		of which						breeding pigs, live weight more than 50 kg					
				fattening pigs				boars	sows				
					of which, live weight				total				
	Total	piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	total	50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2010	371.7	116.1	100.2	119.7	73.7	44.5	1.5	0.6	35.1	27	4.9	8.1	4
Harju	20	3	5.8	9.9	6.3	3.6	0	0	1.3	1	0.2	0.3	0.1
Hiiu	2.6	0.6	1.0	0.8	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ida-Viru	2.5	0.3	0.8	0.9	0.4	0.4	0.1	0	0.5	0.3	0.1	0.2	0.2
Jõgeva	55.2	10.8	20.4	18.2	16.1	2	0.1	0	5.8	4	0.8	1.8	0.9
Järva	8.9	2.2	2.6	3.1	2	1.1	0	0	1	0.9	0.1	0.1	0
Lääne	1.4	0.3	0.2	0.7	0.6	0.1	0	0.1	1	0.6	0.15	0.4	0.25
Lääne-Viru	58.7	15.4	14.9	23.4	12.5	10.8	0.1	0.1	4.9	3.3	0.5	1.6	0.3
Põlva	8.6	2.7	1.2	4.2	2.8	1.4	0	0.0	0.5	0.4	0	0.1	0
Pärnu	5.2	2.5	0.6	1.5	1	0.5	0	0.1	0.5	0.4	0	0.1	0
Rapla	10.6	2	3.6	3.3	3.3	0	0	0.1	1	0.6	0.15	0.4	0.25
Saare	28.2	8.5	10.3	7	2.3	3.8	0.9	0.1	2.3	1.9	0.3	0.4	0.1
Tartu	36.1	6.9	14.1	12.2	8.4	3.7	0.1	0.1	2.8	2	0.5	0.8	0.2
Valga	2.8	0.7	0.8	1	0.9	0.1	0	0	0.3	0.3	0.1	0	0
Viljandi	122.3	58.2	20.0	31.3	15.3	15.8	0.2	0.1	12.7	10.9	1.9	1.8	1.7
Võru	8.6	2	3.9	2.2	1.3	0.9	0	0	0.5	0.4	0.1	0.1	0

Table A.3.2_I.28. Number of cattle in 2011 by counties of Estonia, 1000 heads (SE, 2012)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2011	238.3	96.2	14.5	2.4	15.3	1.2	14.1	6.5	40.8	1.4	39.4	62.6	3.2	42.1	17.3
No distribution by county (agricultural household plots)	2.3	1	0	0	0.1	0	0.1	0.2	0.3	0.1	0.2	0.7	0.2	0.3	0.2
Harju	12.2	5	0.7	0.2	1	0	1	0.5	1.9	0.1	1.8	2.9	0.1	1.9	0.9
Hiiu	4.3	0.5	1.1	0.1	0.3	0.1	0.2	0.3	0.6	0.1	0.5	1.4	0	0.8	0.6
Ida-Viru	5.6	1.8	0.5	0	0.4	0	0.4	0.2	1.1	0.2	0.9	1.6	0.1	1	0.5
Jõgeva	21.4	9.9	0.5	0.1	1.1	0.1	1	0.2	3.9	0.2	3.7	5.7	0.2	4.1	1.4
Järva	29.6	13.8	0.6	0.1	1.5	0	1.5	0.4	5.6	0	5.6	7.6	0.3	5.7	1.6
Lääne	11.8	3.1	1.9	0.3	1.1	0.4	0.7	0.5	1.8	0.1	1.7	3.1	0.2	1.8	1.1
Lääne-Viru	27.6	11.9	1.3	0.2	1.8	0.1	1.7	0.6	4.7	0.1	4.6	7.1	0.2	5.1	1.8
Põlva	14.1	6.3	0.4	0.1	0.8	0.1	0.7	0.3	2.6	0	2.6	3.6	0.2	2.5	0.9
Pärnu	23.2	9.9	1.4	0.2	1.6	0	1.6	0.5	3.9	0.1	3.8	5.7	0.3	4	1.4
Rapla	17.4	5.7	1.5	0.3	1.4	0.4	1	0.7	3.1	0.2	2.9	4.7	0.3	3	1.4
Saare	16.5	5.6	1.9	0.2	1.4	0	1.4	0.6	2.6	0.1	2.5	4.2	0.2	2.8	1.2
Tartu	16.7	7.5	0.2	0.2	0.8	0	0.8	0.2	3.2	0	3.2	4.6	0.4	3.1	1.1
Valga	10.2	3.8	0.7	0.1	0.5	0	0.5	0.5	1.6	0	1.6	3	0.3	1.6	1.1
Viljandi	17.1	7.5	0.9	0.2	1.1	0	1.1	0.5	2.6	0	2.6	4.3	0.2	2.9	1.2
Võru	8.3	2.9	0.9	0.1	0.4	0	0.4	0.3	1.3	0.1	1.2	2.4	0	1.5	0.9

Table A.3.2_I.29. Swine population size in 2011 by counties of Estonia, 1000 heads (SE, 2012)

		of which						breeding pigs, live weight more than 50 kg					
				fattening pigs				boars	sows				
					of which, live weight				total				
	Total	piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	total	50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2011	365.7	113.9	98.4	117.2	72.6	42.2	2.4	0.6	35.6	27.5	5.8	8	4.3
No distribution by county (agricultural household plots)	2.6	0.6	1	0.8	0.5	0.3	0	0	0.2	0.1	0	0.1	0
Harju	23.7	3.8	6.9	10.1	6.2	3.5	0.4	0.1	2.8	2.2	1.1	0.6	0.3
Hiiu	0	0	0	0	0	0	0	0	0	0	0	0	0
Ida-Viru	3.8	0.3	1.1	2.1	1	1	0.1	0	0.3	0.3	0.1	0	0
Jõgeva	51.4	10.7	19.4	15.2	13.5	1.6	0.1	0.1	6	3.8	1	2.2	1.2
Järva	6.1	2	1.1	2.6	2.3	0.2	0.1	0	0.4	0.4	0	0	0
Lääne	7.5	1.5	2.5	2.6	1.9	0.7	0.0	0	1.1	.	.	.	.
Lääne-Viru	57.9	15.6	15.6	21.6	12.6	8.6	0.4	0.1	5	3.7	0.5	1.3	0.4
Põlva	7.5	2.1	0.9	4.1	1.8	1.7	0.6	0	0.4	0.3	0.1	0.1	0
Pärnu	8.1	1.8	1.8	3.6	1.9	1.7	0	0	0.9	0.7	0.1	0.2	0.1
Rapla	7.5	1.5	2.5	2.6	1.9	0.7	0.0	0	1.1	.	.	.	.
Saare	26.8	6.9	10.3	7.3	2	4.8	0.5	0	2.3	1.8	0.3	0.5	0.1
Tartu	37.3	8	13.6	13.1	10	3	0.1	0.1	2.5	2	0.5	0.5	0.3
Valga	1.6	0.2	0.4	0.9	0.7	0.2	0	0	0.1	0	0	0	0
Viljandi	119.2	58.2	20.4	28.2	14.1	14.1	0	0.1	12.3	10.7	1.7	1.6	1.5
Võru	7.2	1.4	2	3.3	2.7	0.5	0.1	0	0.5	0.4	0.1	0.1	0

Table A.3.2_I.30. Number of cattle in 2012 by counties of Estonia, 1000 heads (SE, 2013)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2012	246	96.8	15.4	2.6	16.2	1.2	15	6.7	42.8	1.4	41.4	65.5	3.1	44.3	18.1
No distribution by county (agricultural household plots)	1.3	0.5	0.1	0.1	0.1	0	0.1	0	0.2	0	0.2	0.3	0	0.2	0.1
Harju	13.5	5.1	0.9	0.2	1.3	0.1	1.2	0.5	2.2	0.1	2.1	3.3	0.1	2.1	1.1
Hiiu	4.5	0.6	1.2	0.1	0.3	0.1	0.2	0.3	0.6	0.1	0.5	1.4	0	0.8	0.6
Ida-Viru	5.8	2.2	0.5	0.1	0.3	0	0.3	0.2	1	0.2	0.8	1.5	0	1	0.5
Jõgeva	23.3	10	0.6	0.1	1.2	0.1	1.1	0.2	4.5	0.2	4.3	6.7	0.3	4.1	1.7
Järva	29	13.6	0.5	0	1.5	0	1.5	0.4	5.6	0.1	5.5	7.4	0.3	5.7	1.5
Lääne	12.1	3.1	2	0.3	1.1	0.4	0.7	0.5	1.9	0.1	1.8	3.2	0.2	1.8	1.1
Lääne-Viru	27.9	11.5	1.3	0.2	1.9	0.1	1.8	0.7	4.9	0.1	4.8	7.4	0.2	5.1	1.9
Põlva	14.8	6.4	0.4	0.1	0.8	0.1	0.7	0.4	2.8	0	2.8	3.9	0.2	2.5	0.9
Pärnu	24.9	9.5	1.6	0.2	1.9	0	1.9	0.6	4.5	0.1	4.4	6.6	0.4	4	1.6
Rapla	17.7	6.4	1.5	0.3	1.3	0.3	1	0.7	2.9	0.2	2.7	4.6	0.3	3	1.4
Saare	17.8	5.9	2	0.2	1.6	0	1.6	0.7	2.9	0.1	2.8	4.5	0.2	2.8	1.3
Tartu	16.2	7.4	0.2	0.2	0.7	0	0.7	0.2	3	0	3	4.5	0.4	3.1	1.1
Valga	10.9	3.7	0.8	0.1	0.6	0	0.6	0.5	1.8	0	1.8	3.4	0.3	1.6	1.2
Viljandi	17.6	7.7	0.9	0.3	1.1	0	1.1	0.5	2.7	0	2.7	4.4	0.2	2.9	1.2
Võru	8.7	3.2	0.9	0.1	0.5	0	0.5	0.3	1.3	0.1	1.2	2.4	0	1.5	0.9

Table A.3.2_I.31. Swine population size in 2012 by counties of Estonia, 1000 heads (SE, 2013)

		of which							breeding pigs, live weight more than 50 kg					
				fattening pigs				boars	sows				
					of which, live weight				total				
	Total	piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	total	50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2012	375.1	125.6	94.4	120.2	68.5	48.4	3.3	0.6	34.3	26.3	4.8	8	4.3
No distribution by county (agricultural household plots)	11.4	2.1	3.9	3.7	3.3	0.4	0	0	1.7	1.1	0.2	0.6	0
Harju	23.4	3.8	5.6	12.5	8.9	3.1	0.5	0	1.5	1.1	0.1	0.4	0.2
Hiiu	0	0	0	0	0	0.9	0	0	0	0	0	0	0
Ida-Viru	3.5	0.4	0.9	1.9	0.8	3.7	0.2	0	0.3	0.3	0	0	0
Jõgeva	53.8	10.3	20.1	17.4	13.4	0.1	0.3	0.1	5.9	3.8	1.1	2.1	1.2
Järva	3.6	1.7	0.2	1.3	1.2	.	0	0	0.4	0.4	0	0	0
Lääne	.	.	.	.	.	10.4	.	.	.	.	.	.	.
Lääne-Viru	65.1	17.2	20.6	21.7	11	1.4	0.3	0.1	5.5	4.1	0.9	1.4	0.4
Põlva	8.1	2.4	2	3.1	1.1	1.6	0.6	0	0.6	0.4	0	0.2	0
Pärnu	7.2	2.1	1.1	3.4	1.7	.	0.1	0.1	0.5	0.4	0.1	0.1	0
Rapla	.	.	.	.	.	4.9	.	.	.	.	.	.	.
Saare	28.9	9.2	10.3	7.1	1.4	4.4	0.8	0.1	2.2	1.8	0.3	0.4	0.1
Tartu	38.4	14.6	9.8	11.4	6.9	0.1	0.1	0.1	2.5	1.9	0.3	0.6	0.3
Valga	1.1	0.2	0.3	0.6	0.4	16.7	0.1	0	0	0	0	0	0
Viljandi	125.3	60	18.5	34	17	0.6	0.3	0.1	12.7	10.6	1.7	2.1	2.1
Võru	4.7	1.4	0.9	1.9	1.3	0	0	0	0.5	0.4	0.1	0.1	0

Table A.3.2_I.32. Number of cattle in 2013 by counties of Estonia, 1000 heads (SE, 2015)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2013	261.4	137.1	117.7	97.9	19.8	3.00	16.4	1.3	15.1	53.6	9.8	43.8	1.5	42.3	70.7
No distribution by county (agricultural household plots)	1.3	0.8	0.7	0.6	0.1	0	0.1	0	0.1	0.2	0	0.2	0	0.2	0.3
Harju	14.1	7.2	5.7	4.6	1.1	0.3	1.2	0.1	1.1	3	0.5	2.5	0.1	2.4	3.9
Hiiu	5.6	2.7	2	0.5	1.5	0.2	0.5	0.1	0.4	1.3	0.5	0.8	0.1	0.7	1.6
Ida-Viru	6.2	3.2	2.7	2.1	0.6	0.1	0.4	0	0.4	1.3	0.3	1	0.2	0.8	1.7
Jõgeva	25.1	12.5	11.3	10.5	0.8	0.1	1.1	0.1	1	5.5	0.8	4.7	0.2	4.5	7.1
Järva	30.3	16.9	15.3	14.6	0.7	0.2	1.4	0	1.4	5.8	0.6	5.2	0	5.2	7.6
Lääne	13.7	7.3	5.8	3.2	2.6	0.3	1.2	0.5	0.7	2.8	0.8	2	0.1	1.9	3.6
Lääne-Viru	28.7	15.4	13.5	11.9	1.6	0.2	1.7	0.1	1.6	5.8	0.9	4.9	0.1	4.8	7.5
Põlva	15.4	7.9	7	6.4	0.6	0.1	0.8	0.1	0.7	3.3	0.6	2.7	0	2.7	4.2
Pärnu	26.2	14	11.8	9.9	1.9	0.2	2	0	2	5.4	0.9	4.5	0.1	4.4	6.8
Rapla	18.1	9.6	8	6.2	1.8	0.4	1.2	0.3	0.9	3.6	0.8	2.8	0.2	2.6	4.9
Saare	18.6	9.7	7.9	5.2	2.7	0.2	1.6	0	1.6	3.9	0.9	3	0.1	2.9	5
Tartu	16.2	8.4	7.5	7	0.5	0.1	0.8	0	0.8	3.1	0.4	2.7	0	2.7	4.7
Valga	12.1	5.6	4.8	3.7	1.1	0.1	0.7	0	0.7	2.7	0.7	2	0.1	1.9	3.8
Viljandi	19.8	10.6	8.9	7.7	1.2	0.4	1.3	0	1.3	3.9	0.6	3.3	0.1	3.2	5.3
Võru	10	5.3	4.8	3.8	1	0.1	0.4	0	0.4	2	0.5	1.5	0.1	1.4	2.7

Tabel A.3.2_I.33. Swine population size in 2013 by counties of Estonia, 1000 heads (SE, 2015)

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total				
					50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2013	358.7	118.6	86.7	119.6	67.5	44.2	7.9	33.8	0.5	33.3	26.1	4.8	7.2
No distribution by county (agricultural household plots)	0.6	0.2	0.1	0.3	0.1	0.1	0.1	0	0	0	0	0	0
Harju	358.1	118.4	86.6	119.3	67.4	44.1	7.8	33.8	0.5	33.3	26.1	4.8	7.2
Hiiu	24.1	6.3	4	12.2	8.7	3.1	0.4	1.6	0.1	1.5	1.3	0.3	0.2
Ida-Viru	0	0	0	0	0	0	0	0	0	0	0	0	0
Jõgeva	4.1	0.7	1	1.8	0.6	0.7	0.5	0.6	0	0.6	0.2	0.1	0.4
Järva	55.6	9.3	23	17.3	12.9	4.1	0.3	6	0.1	5.9	3.9	0.9	2
Lääne	0.6	0.1	0	0.4	0.1	0.3	0	0.1	0	0.1	0.1	0	0
Lääne-Viru	..	..	..	..	..	..	..	..	..	..	..	..	..
Põlva	59.7	15.8	18.9	20.5	13.6	6.8	0.1	4.5	0.1	4.4	3.7	0.6	0.7
Pärnu	7	1.9	0.6	4	1.3	2.4	0.3	0.5	0	0.5	0.4	0.1	0.1
Rapla	7.6	1	2.3	3.8	2.1	1.7	0	0.5	0	0.5	0.4	0.1	0.1
Saare	..	..	..	..	..	..	..	..	..	..	..	..	..
Tartu	28.1	11.4	7.6	6.8	1.6	4.3	0.9	2.3	0	2.3	1.8	0.3	0.5
Valga	28.4	8.6	7.7	9.7	4	5.3	0.4	2.4	0.1	2.3	1.9	0.2	0.4
Viljandi	1.2	0.2	0.1	0.8	0.5	0.3	0	0.1	0	0.1	0.1	0	0
Võru	123.2	58.8	16.3	35.1	15.9	14.4	4.8	13	0.1	12.9	10.8	2	2.1

Table A.3.2_I.34. Number of cattle in 2014 by counties of Estonia, 1000 heads (SE, 2015)

	Total	of which													
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other		total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2014	264.7	95.6	22.8	3.5	15.7	1.3	14.4	9.3	44.8	1.9	42.9	73.0	4.2	48.3	20.5
No distribution by county (agricultural household plots)	1.3	0.6	0.1	0.0	0.1	0.0	0.1	0.0	0.2	0.0	0.2	0.3	0.0	0.2	0.1
Harju	14.6	4.7	1.4	0.4	1.3	0.1	1.2	0.7	2.4	0.2	2.2	3.7	0.1	2.5	1.1
Hiiu	5.2	0.6	1.5	0.2	0.5	0.1	0.4	0.3	0.7	0.1	0.6	1.4	0.0	0.8	0.6
Ida-Viru	6.1	1.9	0.8	0.1	0.3	0.0	0.3	0.3	0.9	0.2	0.7	1.8	0.1	1.1	0.6
Jõgeva	24.0	10.3	0.9	0.2	0.9	0.1	0.8	0.4	4.4	0.3	4.1	6.9	0.3	4.8	1.8
Järva	30.9	13.5	0.9	0.2	1.2	0.0	1.2	0.6	5.9	0.1	5.8	8.6	0.4	6.1	2.1
Lääne	13.4	2.9	2.7	0.3	1.2	0.5	0.7	0.7	1.9	0.0	1.9	3.7	0.4	2.0	1.3
Lääne-Viru	29.8	11.4	2.0	0.2	1.8	0.1	1.7	1.0	5.1	0.1	5.0	8.3	0.3	5.8	2.2
Põlva	14.6	6.4	0.6	0.1	0.5	0.0	0.5	0.5	2.7	0.1	2.6	3.8	0.2	2.7	0.9
Pärnu	27.4	10.5	2.3	0.3	1.9	0.0	1.9	0.8	4.5	0.1	4.4	7.1	0.5	4.9	1.7
Rapla	19.4	6.3	2.0	0.4	1.5	0.4	1.1	0.8	3.1	0.2	2.9	5.3	0.5	3.3	1.5
Saare	19.5	5.3	3.1	0.3	1.7	0.0	1.7	0.9	3.0	0.2	2.8	5.2	0.3	3.3	1.6
Tartu	15.5	6.2	0.6	0.2	0.6	0.0	0.6	0.4	2.8	0.0	2.8	4.7	0.4	2.8	1.5
Valga	12.8	4.1	1.2	0.1	0.7	0.0	0.7	0.7	2.1	0.2	1.9	3.9	0.3	2.4	1.2
Viljandi	19.9	7.4	1.5	0.4	1.1	0.0	1.1	0.8	3.3	0.0	3.3	5.4	0.3	3.6	1.5
Harju	14.6	4.7	1.4	0.4	1.3	0.1	1.2	0.7	2.4	0.2	2.2	3.7	0.1	2.5	1.1

Table A.3.2_I.35. Swine population size in 2014 by counties of Estonia, 1000 heads (SE, 2015)

	Total	of which						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total				
					50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2014	357.9	111.6	89.9	121.8	71.1	42.4	8.3	1.0	33.6	26.0	4.1	7.6	3.8
No distribution by county (agricultural household plots)	0.5	0.2	0.1	0.2	0.1	0.1	0	0	0	0	0	0	0
Harju	357.4	111.4	89.8	121.6	71	42.3	8.3	1	33.6	26	4.1	7.6	3.8
Hiiu	25.8	4.7	7	12.3	9	3.3	0	0	1.8	1.5	0.3	0.3	0.2
Ida-Viru	0	0	0	0	0	0	0	0	0	0	0	0	0
Jõgeva	.	.	.	.	.	.	.	.	.	.	.	.	.
Järva	52.5	8.3	21	17.7	13.2	4.3	0.2	0.1	5.4	3.6	0.7	1.8	1.2
Lääne	0.8	0.2	0.1	0.4	0.4	0	0	0	0.1	0	0	0.1	0
Lääne-Viru	.	.	.	.	.	.	.	.	.	.	.	.	.
Põlva	55.2	13	13.3	24.4	18.5	5.9	0	0.1	4.4	3.7	0.3	0.7	0.2
Pärnu	9	2.8	1.9	3.9	1.8	1.6	0.5	0	0.4	0.3	0	0.1	0
Rapla	7.5	2.7	1.2	3.2	1.2	2	0	0.1	0.3	0.2	0	0.1	0
Saare	.	.	.	.	.	.	.	.	.	.	.	.	.
Tartu	27.9	10.4	8.9	6.5	1.8	3.3	1.4	0	2.1	1.6	0.4	0.5	0.2
Valga	27.7	7.5	5.7	11.3	4.5	6.3	0.5	0.6	2.6	2.2	0.2	0.4	0.1
Viljandi	3.4	1.2	0.9	0.9	0.8	0.1	0	0	0.4	0.2	0	0.2	0
Võru	.	.	.	.	.	.	.	.	.	.	.	.	.

Table A.3.2_I.36. Number of cattle in 2015 by counties of Estonia, 1000 heads (SE, 2016)

	Total	of which												
		cows, bulls and heifers (2 years and over)						bovine animals (aged between 1 and 2 years)				calves (less than 1 year old)			
		cows		bulls	heifers			bulls	heifers			total	for slaughter	for breeding	
		dairy cows	other	bulls	total	for slaughter	for breeding		total	for slaughter	for breeding			heifers	bulls
2015	256.2	90.6	25.1	3.3	14.3	1.2	13.1	7.7	52.6	44.9	1.5	70.3	3.3	47.9	19.1
No distribution by county (agricultural household plots)	1.3	0.6	0.1	0	0	0	0	0.1	0.3	0.2	0	0.3	0	0.2	0.1
Harju	254.9	90	25	3.3	14.3	1.2	13.1	7.6	52.3	44.7	1.5	70	3.3	47.7	19
Hiiu	14.4	4.4	1.6	0.5	1.3	0	1.3	0.5	3	2.5	0.1	3.6	0.1	2.4	1.1
Ida-Viru	5.3	0.6	1.6	0.2	0.5	0.1	0.4	0.3	0.9	0.6	0.1	1.5	0	0.9	0.6
Jõgeva	5.7	1.7	0.9	0.1	0.2	0	0.2	0.2	1.1	0.9	0.2	1.7	0.1	1	0.6
Järva	19.4	8.3	0.9	0.1	0.5	0	0.5	0.4	4.3	3.9	0.2	5.3	0.3	4	1
Lääne	31.1	13.7	1	0.1	1.1	0	1.1	0.4	6.1	5.7	0.1	9.1	0.3	6.1	2.7
Lääne-Viru	12.9	2.5	2.9	0.3	1.2	0.5	0.7	0.7	2.7	2	0.1	3.3	0.2	2.1	1
Põlva	28.4	10.8	2.2	0.2	1.5	0.1	1.4	0.6	5.9	5.3	0.1	7.8	0.1	5.8	1.9
Pärnu	15.1	6.2	0.7	0.1	0.7	0.1	0.6	0.4	3.2	2.8	0	4.2	0.2	3.1	0.9
Rapla	26.4	10.1	2.6	0.3	1.5	0	1.5	0.7	5.2	4.5	0.1	6.7	0.3	4.9	1.5
Saare	19.2	6.1	2.2	0.4	1.4	0.4	1	0.7	3.8	3.1	0.2	5.3	0.4	3.3	1.6
Tartu	19.9	5.3	3.5	0.3	1.6	0	1.6	0.8	4	3.2	0.1	5.2	0.3	3.4	1.5
Valga	14	5.6	0.6	0.1	0.7	0	0.7	0.4	3	2.6	0	4	0.3	2.6	1.1
Viljandi	12.7	4.1	1.4	0.1	0.6	0	0.6	0.6	2.8	2.2	0	3.7	0.3	2.2	1.2
Harju	20.7	7.7	1.6	0.4	1.1	0	1.1	0.6	4.2	3.6	0.1	5.7	0.3	4	1.4

Table A.3.2_I.37. Swine population size in 2015 by counties of Estonia, 1000 heads (SE, 2016)

	Total	of						breeding pigs, live weight more than 50 kg					
		piglets, live weight less than 20 kg	young pigs, live weight 20–50 kg	fattening pigs				boars	sows				
				total	of which, live weight				total				
					50–80 kg	80–110 kg	more than 110 kg			covered sows	of which covered for the first time	other sows	of which gilts not yet covered
2015	304.5	96.7	76.2	106.5	62.2	38	6.3	10.5	25.1	19.1	3.4	5.5	3.1

Table A.3.2_I.38. Sheep and goats population quarterly data 2004–2015, 1000 heads (SE, 2016)

Sheep and goats quarterly data				
Year	March 31st	June 30th	September 30th	December 31st
2004	55.5	57.4	54.6	41.7
2005	60.1	63.0	58.8	52.4
2006	75.4	77.3	70.1	66.0
2007	88.2	90.8	87.0	76.4
2008	100.5	100.0	95.0	81.8
2009	101.0	100.4	101.5	80.4
2010	108.8	108.5	103.0	82.7
2011	101.7	105.3	99.9	88.2
2012	99.3	105.3	99.5	81.4
2013	82.6	88.6	92.9	86.8
2014	83.0	91.5	97.6	89.8
2015	85.8	97.1	99.3	90.9

Table A.3.2_I.39. Number of poultry in Estonia 1990–2015, 1000 heads (SE, 2016)

Year	Eggs, mln pcs	Eggs production per layer per year	Layers	Broilers + dead and perished (average yearly population)	Other poultry	Other hens and roosters	Yearly average population calculated
1990	547.1	246.0	2 224.0	1 951.8	161.9	1259.5	5 597.2
1991	559.1	254.0	1 788.9	1 653.7	161.9	1067.2	4 671.7
1992	456.0	228.0	1 816.1	1 020.6	97.7	658.6	3 593.1
1993	345.8	222.0	1 207.8	963.3	45.3	621.6	2 838.0
1994	359.4	246.0	912.5	904.7	41.0	603.1	2 461.3
1995	326.7	260.0	828.3	862.2	22.1	561.0	2 273.6
1996	300.8	285.0	843.4	528.2	19.4	448.0	1 838.9
1997	295.7	280.0	719.2	517.5	16.6	501.4	1 754.6
1998	305.2	298.0	780.9	779.1	13.9	507.9	2 081.7
1999	275.4	302.0	791.7	645.4	11.1	349.3	1 797.5
2000	254.7	306.0	723.5	616.7	18.9	313.5	1 672.6
2001	277.9	295.0	995.6	724.9	42.2	359.0	2 121.7
2002	252.8	303.0	834.3	924.6	31.8	404.6	2 195.3
2003	234.3	290.0	807.9	1 103.6	20.1	450.1	2 381.8

Year	Eggs, mln pcs	Eggs production per layer per year	Layers	Broilers + dead and perished (average yearly population)	Other poultry	Other hens and roosters	Yearly average population calculated
2004	230.9	275.0	839.6	1 142.2	21.4	495.7	2 498.9
2005	209.0	288.0	725.7	1 033.8	24.5	279.8	2 063.8
2006	183.0	287.0	637.6	980.9	29.6	369.0	2 017.1
2007	157.6	245.0	643.3	956.0	34.1	125.9	1 759.2
2008	146.5	290.0	550.1	1 031.0	33.5	395.6	2 010.2
2009	173.3	281.0	644.8	1 083.2	43.9	314.4	2 086.3
2010	181.9	283.0	578.2	1 212.2	48.8	377.2	2 216.4
2011	183.8	288.0	568.9	1 298.3	59.6	513.7	2 440.6
2012	179.5	279.0	693.9	1 267.9	74.0	456.5	2 492.3
2013	189.9	288.0	716.6	1 361.5	91.4	191.5	2 361.0
2014	199.4	291.0	752.8	1398.0	54.3	450.8	2 655.9
2015	204.4	281.0	825.0	1376.9	59.0	416.6	2677.5

Table A.3.3_I.40. Average number of rabbits in Estonia (calculated) 1990–2015 (SE, 2016)

Year	Breeding females	Breeding males	Young (yearly average population)	Yearly average population (calculated)
1990	8 298.5	922.1	76 732.4	85 952.9
1991	8 780.8	975.6	81 192.7	90 949.2
1992	9 276.5	1 030.7	85 775.7	96 082.9
1993	9 307.4	1 034.2	86 061.2	96 402.7
1994	7 847.2	871.9	72 560.2	81 279.3
1995	7 241.4	804.6	66 958.1	75 004.1
1996	5 452.7	605.9	50 418.6	56 477.2
1997	4 587.2	509.7	42 415.7	47 512.6
1998	4 818.0	535.3	44 549.8	49 903.1
1999	3 981.3	442.4	36 813.6	41 237.3
2000	5 798.9	644.3	53 619.8	60 063.0
2001	10 069.0	1 118.8	93 103.8	104 291.5
2002	8 580.5	953.4	79 340.2	88 874.1
2003	7 092.0	788.0	65 576.7	73 456.7

Year	Breeding females	Breeding males	Young (yearly average population)	Yearly average population (calculated)
2004	5 067.0	563.0	46 852.4	52 482.4
2005	8 061.0	895.7	74 536.6	83 493.3
2006	7 038.5	782.1	65 082.0	72 902.6
2007	6 016.0	668.4	55 627.4	62 311.8
2008	5 137.0	570.8	47 499.7	53 207.4
2009	4 258.0	473.1	39 371.9	44 103.0
2010	3 379.0	375.4	31 244.2	34 998.6
2011	3 243.5	360.4	29 991.3	33 595.2
2012	3 108.0	345.3	28 738.4	32 191.7
2013	4 778.0	530.9	44 180.1	49 489.0
2014	4 778.0	530.9	44 180.1	49 489.0
2015	4 778.0	530.9	44 180.1	49 489.0

Table A.3.3_I.41. Average number of fur animals in Estonia 1990–2015 (SE, 2016)

Year	Foxes and racoon dogs			Minks, chinchillas and other fur animals		
	For breeding (calculated)	Killed for fur	Average population	For breeding (calculated)	Killed for fur	Yearly average population calculated
1990			85.2			145.6
1991			85.2			145.6
1992			85.4			117.4
1993			85.7			89.1
1994	26.0	59.9	86.0	18.4	42.5	60.9
1995	28.0	65.3	93.3	8.8	29.7	38.5
1996	25.5	15.3	40.8	3.7	10.5	14.3
1997	23.2	52.5	75.7	4.7	9.3	14.0
1998	22.5	49.9	72.4	6.5	13.4	19.9
1999	12.8	50.3	63.1	2.7	7.9	10.6
2000	10.8	32.9	43.6	2.1	4.7	6.8
2001	14.9	29.6	44.5	5.7	11.8	17.5
2002	14.2	32.4	46.6	11.1	21.2	32.3
2003	14.2	28.7	42.8	17.4	37.7	55.2
2004	14.5	28.5	42.9	18.7	39.7	58.4

Year	Foxes and racoon dogs			Minks, chinchillas and other fur animals		
	For breeding (calculated)	Killed for fur	Average population	For breeding (calculated)	Killed for fur	Yearly average population calculated
2005	12.0	26.8	38.8	26.0	61.2	87.2
2006	10.2	22.5	32.7	21.4	49.6	71.0
2007	11.9	26.8	38.7	23.8	56.3	80.1
2008	3.6	9.1	12.7	21.3	57.2	78.6
2009	4.0	9.0	13.0	26.7	63.8	90.6
2010	3.9	8.7	12.6	26.3	61.3	87.7
2011	4.3	9.7	14.0	28.9	68.7	97.6
2012	4.2	9.7	13.9	28.0	68.5	96.6
2013	4.3	9.8	14.1	29.0	69.4	98.4
2014	4.4	9.6	14.0	29.5	67.8	97.2
2015	4.2	10.4	14.6	28.3	73.6	101.9

A.3.2_II. MILK YIELD PER COW, FAT CONTENT OF MILK AND PERCENTAGE OF COW THAT GAVE BIRTH IN ESTONIA IN 1990–2015

Table A.3.2_II.1. Average milk yield per cow in 1991–1993, kg/cow (Agriculture 1994)

Year	Average yield per cow, kg
1991	3 968
1992	3 530
1993	3 322

Table A.3.2_II.2. Average milk yield per cow in 1994–2015, kg/cow/year (Agriculture 1994–2005; SE, 2016)

County	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Average yield per cow, kg	3 455	3 588	3 809	4 484	4 456	4 049	4 652	5 313	5 138	5 231	5 596	5 886	6 285
Harju county	3 016	3 027	3 301	3 775	4 137	3 831	3 951	4 843	4 588	4 816	5 141	5 756	5 937
Hiiu county	2 566	2 498	2 669	3 079	3 132	3 964	4 540	5 603	4 589	4 663	4 510	4 987	4 720
Ida-Viru county	2 374	2 143	2 449	2 960	3 320	3 397	4 057	4 425	4 767	4 593	4 706	5 492	5 612
Jõgeva county	3 399	3 596	3 769	3 870	4 731	4 218	4 960	5 392	5 461	5 362	5 744	6 188	6 715
Järva county	4 066	4 224	4 458	5 020	5 399	4 751	5 375	6 216	6 057	6 058	6 243	6 330	6 900
Lääne county	2 520	2 513	2 742	3 017	3 297	3 494	3 513	4 039	4 111	4 223	4 558	4 731	5 343
Lääne-Viru county	3 548	3 418	3 950	4 394	4 721	4 061	4 685	5 420	5 291	5 391	5 954	6 205	6 542
Põlva county	3 134	3 616	4 111	4 684	4 874	4 517	5 040	6 310	5 868	6 213	6 180	6 506	7 123
Pärnu county	3 220	3 256	3 380	3 666	4 210	3 736	4 451	5 005	4 920	4 986	5 373	5 806	6 326
Rapla county	3 088	3 301	3 763	4 077	4 673	4 301	4 767	5 232	5 047	5 066	5 809	6 105	6 101
Saare county	2 732	2 573	2 894	3 330	3 657	3 817	4 071	5 162	4 341	4 496	5 034	5 113	5 464
Tartu county	3 337	3 417	3 785	4 089	4 457	3 767	4 898	5 099	5 028	5 556	6 070	6 423	6 812
Valga county	2 553	2 776	2 961	3 135	3 384	3 076	3 496	4 089	4 503	3 866	4 878	5 259	5 598
Viljandi county	3 143	2 865	3 140	3 544	3 829	3 406	4 167	4 921	4 918	4 663	4 894	5 098	5 436
Võru county	3 126	3 188	3 431	3 747	3 972	3 581	3 880	4 982	4 893	4 996	5 070	5 481	5 810

Table A.3.2_II.3. Average milk yield per cow in 1994–2015, kg/cow/year (continued)

County	2007	2008	2009	2010	2011	2012	2013	2014	2015
Average yield per cow, kg	6 484	6 781	6 838	7 021	7 168	7 526	7 990	8 233	8442
Harju county	6 019	6 396	6 359	6 402	6 600	6 769	7 377	7 351	7725
Hiiu county	4 687	4 646	5 052	4 520	4 667	5 266	4 650	5 468	4998
Ida-Viru county	5 438	6 053	6 039	6 334	6 298	6 554	7 250	7 237	7204
Jõgeva county	6 812	7 119	7 058	7 230	7 465	7 657	7 807	8 176	8496
Järva county	7 045	7 164	7 048	7 254	7 473	7 816	8 338	8 728	8895
Lääne county	5 512	6 295	6 281	6 368	6 388	6 802	7 552	7 674	7944
Lääne-Viru county	6 823	7 096	7 139	7 390	7 524	7 783	8 186	8 317	8306
Põlva county	7 339	7 562	7 581	7 671	7 737	7 980	8 306	9 543	8983
Pärnu county	6 407	6 651	6 733	6 948	7 294	7 690	8 054	8 128	8694
Rapla county	6 325	6 796	7 078	7 355	7 267	7 784	8 108	7 974	9005
Saare county	5 619	5 844	6 008	6 243	6 179	6 633	7 371	7 588	7476
Tartu county	7 103	7 880	8 019	7 997	8 237	8 544	9 520	9 463	9230
Valga county	5 870	5 851	5 926	6 127	6 470	7 125	7 581	7 894	8149
Viljandi county	5 932	6 205	6 530	6 784	6 711	7 220	7 485	7 818	8344
Võru county	6 281	6 319	6 493	6 461	6 345	6 948	7 290	7 667	7586

Table A.3.2_II.4. Average fat content of milk in Estonia in 1990–1997, % (EARC, 2012)[366]

Year	Fat content, %
1990	4.18
1991	4.14
1992	4.07
1993	4.10
1994	4.12
1995	4.20
1996	4.34
1997	4.32

Table A.3.2_II.5. Fat content of milk in 1998–2015 by county of Estonia, % (EARC, 2016)[367]

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Harju	4.25	4.23	4.31	4.38	4.32	4.34	4.29	4.27	4.21	4.18	4.14	4.17	4.11	4.07	4.03	3.96	4.0	3.93
Hiiu	4.46	4.40	4.25	4.29	4.38	4.38	4.26	4.19	4.24	4.28	4.34	4.44	4.41	4.37	4.22	4.27	4.2	4.2
Ida-Viru	4.32	4.33	4.31	4.29	4.21	4.25	4.23	4.09	4.06	4.08	4.08	4.09	4.07	4.11	4.09	4.09	4.0	3.9
Jõgeva	4.37	4.32	4.36	4.39	4.46	4.46	4.30	4.28	4.24	4.20	4.18	4.17	4.14	4.14	4.06	4.05	4.1	4.0
Järva	4.18	4.19	4.25	4.25	4.23	4.29	4.27	4.17	4.14	4.11	4.08	4.09	4.07	4.03	4.03	3.99	4.0	3.9
Lääne	4.36	4.24	4.34	4.36	4.28	4.27	4.28	4.25	4.28	4.28	4.24	4.29	4.2	4.13	4.03	4.03	4.0	4.0
Lääne-Viru	4.18	4.14	4.19	4.21	4.19	4.20	4.16	4.11	4.07	4.03	4.02	4.01	4.01	4.05	4.02	3.95	3.9	3.8
Põlva	4.29	4.24	4.28	4.38	4.33	4.30	4.30	4.23	4.14	4.11	4.09	4.08	4.14	4.12	4.13	4.01	4.0	3.7
Pärnu	4.23	4.20	4.36	4.41	4.32	4.35	4.33	4.27	4.20	4.19	4.16	4.17	4.12	4.08	3.99	4.01	4.0	3.9
Rapla	4.23	4.16	4.21	4.27	4.19	4.20	4.21	4.11	4.05	4.06	4.00	4.12	4.18	4.21	4.09	4.01	4.0	4.0
Saare	4.46	4.40	4.38	4.36	4.40	4.40	4.38	4.27	4.26	4.23	4.17	4.22	4.15	4.13	3.98	3.96	4.1	4.1
Tartu	4.3	4.26	4.25	4.28	4.32	4.28	4.28	4.22	4.19	4.13	4.08	4.09	4.02	4.03	3.91	3.91	3.9	3.8
Valga	4.25	4.18	4.27	4.30	4.25	4.26	4.29	4.21	4.19	4.22	4.25	4.29	4.17	4.14	4.16	4.08	4.1	4.1
Viljandi	4.28	4.19	4.32	4.31	4.31	4.39	4.31	4.26	4.27	4.26	4.21	4.22	4.12	4.10	4.08	4.05	4.1	4.0
Võru	4.22	4.25	4.35	4.33	4.34	4.32	4.25	4.26	4.28	4.29	4.21	4.29	4.24	4.22	4.16	4.05	4.0	4.0

[366] Results of animal recording in Estonia in 1997–2011. Annual Reports. Available at: www.jkkeskus.ee/page.php?page=0147.

[367] Results of animal recording in Estonia in 1997–2015. Annual Reports. Available at: www.jkkeskus.ee/page.php?page=0147.

Table A.3.2_II.6. Percentage of cow that gave birth in 1990–2015, %

Year	%
1990	80.0
1991	80.0
1992	80.0
1993	80.0
1994	80.0
1995	80.0
1996	95.8
1997	94.9
1998	97.1
1999	81.3
2000	76.9
2001	76.3
2002	82.8
2003	81.3
2004	81.7
2005	84.0
2006	92.2
2007	88.4
2008	89.2
2009	93.3
2010	94.0
2011	88.8
2012	90.2
2013	94.8
2014	95.2
2015	95.7

A.3.2_III. WEIGHT OF DAIRY CATTLE BY CATTLE BREED IN ESTONIA IN 1990–2015

Table A.3.2_III.1. Average weight of dairy cattle by breed in Estonia in 1990–2015

Year	Population by dairy-cattle breed				Average weight of cows, kg
	Estonian Red	Estonian Holstein	Estonian Native	Total number in Registry	
Typical weight, kg[368]	540	550	460		
1990	121 125	125 235	566	246 926	544.9
1991	107 873	121 077	549	229 499	545.1
1992	94 610	116 722	577	211 909	545.3
1993	74 543	106 033	563	181 139	545.6
1994	59 691	91 676	564	151 931	545.7
1995	49 285	79 767	555	129 607	545.8
1996	43 537	74 968	570	119 075	545.9
1997	40 118	74 186	535	114 839	546.1
1998	38 705	77 717	504	116 926	546.3
1999	33 820	75 589	472	109 881	546.5
2000	29 875	71 799	443	102 117	546.7
2001	27 981	73 173	481	101 635	546.8
2002	26 726	74 733	507	101 966	546.9
2003	26 314	74 981	490	101 785	547.0
2004	26 571	73 781	538	100 890	546.9
2005	26 607	73 261	537	100 405	546.9
2006	25 348	72 894	544	98 786	546.9
2007	23 842	70 816	514	95 172	547.0
2008	22 357	69 599	517	92 473	547.1
2009	20 578	68 058	475	89 111	547.2
2010	19 724	67 904	461	88 089	547.3
2011	18 917	69 216	493	88 626	547.4
2012	18 294	70 511	479	89 284	547.5
2013	18 175	71 716	441	90 332	547.6
2014	18 356	72 810	459	91 625	547.6
2015	17 247	69 772	484	87 503	547.5

[368] References sources: Estonian Red and Estonian Holstein – (Ling et al., 2012); Estonian Native – (Kalamees, K., 2008).

Table A.3.2_III.2. Data on weight and weight gain of non-dairy cattle used in the estimates

Cattle category	Weight, kg	Weight gain, kg/day
Manure non-dairy cattle[369]:		
…Mature females	500	
…Mature males	600	
Bovine animals (aged between 1 and 2 years)[370]	300	0.70
Calves (6-12 months)[371]	205	0.55
Calves (0-6 months) [372]	41	0.90

Table A.3.2_III.3. Data on weight of main swine categories used in the estimates

Swine category	Weight, kg
Piglets, live weight less than 20 kg	10
Young pigs, live weight 20–<50 kg	35
Fattening pigs	
…live weight 50–<80 kg	65
…live weight 80–<110 kg	95
…live weight 110 kg or more	110
Breeding pigs, live weight 50 kg or more	75

[369] Dairy Cattle – Table A-1; Non-dairy cattle – Table A-2 of the 1996 Revised IPCC guidelines, pp. 4.42-4.43 (for Eastern European countries). The data correspond to Estonian data on weight of mature cattle.
[370] Bovine animals – (Juhend, 2008).
[371] Calves (6-12 months) – the start weight was calculated based on the final weight of calves (0-6 months) and their weight gain. The weigh gain of calves (6-12 months) was estimated taking into account the start weigh of mature cattle. Production cycle at 183 days per year was applied.
[372] Calves (0-6 months): the start weigh and weight gain were obtain from (Lehtsalu et al., 2010). Production cycle at 182 days per year was applied.

A.3.2_IV. MANURE MANAGEMENT SYSTEMS

Manure management systems: cattle and swine livestock categories

Country-specific module on manure management system (MMS) was started to be developed in the 2012 submission and was finalized by the 2013 submission.

Data on cattle and swine livestock population, housing technology and data on location of MMS were used as a basis for development of the MMS module. The data on livestock population and MMS location were collected by SE in the framework of Agricultural Survey of 2001 and 2010. The both databases contain data on village level. Actually, village was a basis for merging of two datasets. Since, it was adjusted that type of MMS built and located in a certain village is a main type of storage for manure generated by livestock kept in this village. In addition, information presented in the environmental permits, which were applied by farms under the IPPC directive (Saastuse komplekse..., 2011), was consulted to determine type of MMS built for storage animal waste and housing technology applied in a certain agricultural holdings. Data due to a project launched by Ministry of the Environment (ELLE, 2010) to monitor conditions of MMSs located on nitrate vulnerable zones were consulted as well.

The country-specific MMS module for 1990 has been developed based on statistical data on livestock population and structure by country of Estonia and expert opinions regarding housing technology applied for cattle and swine.

The interpolation was applied between 1990 and 2001, and between 2001 and 2010 to develop country-specific module on MMS for cattle and swine for the entire inventory period.

1990: to develop the module on MMS, data on size and number of cattle and swine breeding holdings were used from the annual statistical report (Eesti…, 1991).

In general, a major number of holdings, which kept cattle and swine, were large in the beginning of ninetieth: about 90% of the total number of farms were with more than 1000 heads of cattle and swine (Table A.3.3_IV.1). High number of animals per swine farm, in greater degree, stipulated housing technology occurred in holdings – mostly partially or completely slatted floors, with liquid/slurry MMS, was applied (Table A.3.3_IV.4). With exception of a low number of swine, which kept in private farms, where mainly solid storage MMS was applied in Estonia.

Table A.3.2_IV.1. Structure of cattle and swine breeding farms by size and herd in 1989 (Eesti…, 1991)

Number of livestock	Collective farms/holdings		State farms/holdings	
	Cattle	Swine	Cattle	Swine
< 600	1.6	4.1	3.3	7.8
600–999	4.7	9.2	4.0	3.5
1000–3000	77.0	35.7	74.6	53.5
> 3000	16.7	51.1	18.1	35.1

In 1990, mainly (only) tie stall housing system occurred in dairy-cattle and non-dairy cattle (including young animals) holdings. The housing technology assumes generation and storage of solid manure. It means that in the beginning of the nineties, mainly solid storage MMS was applied in cattle breeding holdings. The housing technology applied in dairy cattle as well non-dairy cattle breeding holdings has started to be changed in the beginning of 2000-ties – in 2002, the first farm with loose-housing technology was built up in Jõgeva county. The technology of young cattle housing has started to change also in that time, the changes from tie stall technology to loose-technology with slatted floor and deep litter, namely from solid storage MMS to liquid/slurry MMS or Deep Litter MMS (in accordance, with the definitions established in the IPCC) have started to be launched.

It was assumed that the housing technology of calves has not changed since 1990 until nowadays. Hence, in the nineties, calves (0-6 months) were kept in groups or individual boxes with solid storage MMS.

2001: more than 30,500 holdings with different size of livestock herds and about 1,700 holdings with different types of MMS were analyzed. The large difference in numbers of holdings keeping livestock and those, which have MMS, is explained by size of livestock herds. In Estonia, holdings with less than 10 livestock units are not under obligatory to build MMS for animal waste storage (Veeseadus, 2011), usually these holdings storage animal waste in cattle-shed or pigsty, in manure-heap, truck etc. i.e., there is typical for these farms to store animal waste in 'solid storage MMS' (according to the classification established under the IPCC[373]).

In general, a share of holdings that kept less than 10 cattle heads was 86% of the total number of agricultural holdings in 2001, the holdings kept about 18% of the total population of cattle of Estonia. A share of small holdings keeping less than 10 heads[374] of dairy cows was 93% of the total agricultural holdings with dairy cattle, these holdings kept about 24% of the total population of 2001 (Tables A.3.3.IV.2 – A.3.3.IV.4). The total number of large holdings was more than 1% (246 holdings in total) from the total number of cattle breeding farms, which kept about 60% of the total cattle population in Estonia. The main research focus was paid on these large holdings.

As it was mentioned, the cattle housing technology occurred in holdings has started to be changed in the beginning of 2000-ties – from tie stall housing to loose-housing technology and from solid storage MMS to liquid/slurry MMS. Hence, this information was also kept in mind, in the process of analyzing of two datasets on cattle population and MMS location.

Table A.3.2_IV.2. Cattle breeding by size of herd in 2001–2010 (SE, 2012)

		total	1–9	10–49	50–99	100–299	>=300
Number of holdings	2001	20 281	17 443	2 239	229	184	186
	2010	4 620	2 779	1 121	469	223	191
Number of cows	2001	280 884	50 316	42 472	15 472	33 128	139 496
	2010	241 025	8 981	25 811	21 316	37 198	147 719

Table A.3.2_IV.3. Dairy cattle breeding by size of herd in 2001–2010 (SE, 2012)

		total	1–9	10–49	50–99	100–299	>=300
Number of holdings	2001	17 527	16 254	920	104	173	76
	2003	12 398	11 220	834	97	166	81
	2005	9 210	8 082	771	112	159	86
	2007	6 120	5 067	686	132	144	91
	2010	3 520	2 598	580	124	129	89

[373] IPCC 1997. Agriculture. Reference Manual. Table 4-8, pp. 4.25.
[374] 1 dairy cow = 1 livestock unit (Põllumajandusministri määrus nr 130, 12.12.2009).

		total	1–9	10–49	50–99	100–299	>=300
Number of dairy cows	2001	127 969	31 042	16 834	7 352	30 761	41 980
	2003	119 805	20 646	16 309	6 766	30 587	45 497
	2005	115 229	14 876	15 222	7 280	28 602	49 249
	2007	107 884	9 686	13 394	8 650	26 089	50 065
	2010	96 263	5 297	10 827	7 267	22 321	50 551

A share of holdings kept less than 50 pigs (about 10 livestock unit) was 98% of the total number of holdings keeping pigs. The population of pigs in these swine holdings made up 13% of the total pig population in Estonia in 2001. The swine population in large holdings (more than 1000 pigs) was more than 73% of the total swine population, the contribution of large farms to the total number of the swine holdings was less than 1% from the total number. In fact, these holdings were analyzed in detail.

Swine housing technology, and MMS applied in farms, in greater degree, depends on swine herd size – namely, liquid/slurry MMS mainly in large holdings, solid storage MMS – in holdings with low number of pigs. It is important to note that structure of swine population by size of herd has changed remarkably from the nineties (Table A.3.3_IV.1 and Table A.3.3_IV.4), hence the changes occurred also in MMS applied from swine manure storage.

Table A.3.2_IV.4. Swine breeding by size of herd (SE, 2012)

		total	1–9	10–49[375]	50–199	200–1000	1000–1999	>=2000
Number of holdings	2001	11 791	10 822	730	103	74	31	31
	2003	7 675	6 901	551	88	68	30	37
	2005	4 708	4 188	350	49	58	20	43
	2007	2 889	2 540	211	34	39	25	40
	2010	1 549	1 294	149	27	23	11	45
Number of swine	2001	328 920	26 782	13 763	9 791	39 812	45 984	192 788
	2003	356 898	17 170	11 255	8 479	34 854	42 098	243 042
	2005	355 242	10 760	7 072	5 011	28 951	27 062	276 386
	2007	369 734	6 825	3 878	2 910	21 582	37 361	297 178
	2010	388 502	3 504	2 865	2 529	9 443	15 610	354 551

2010: more than 5,800 holdings with different size of livestock herds and about 2,800 holdings with MMSs were analyzed in the framework of development of country-specific module on MMS in 2010. The combination of two datasets was made based on village level. Especial attention was paid on large holdings, which contributed a major share to the total cattle and swine population of Estonia: on cattle breeding holdings with more than 100 cattle heads (more than 70% of the total cattle population) and on swine breeding holdings with more than 200 swine heads (more than 95% of the total swine population).

During the last ten years (since 2001 to 2010), Estonian agriculture has changed markedly. The total number of holdings decreased, the main decline was in the number of holdings, which

[375] Data of the table were used from web-based dataset of SE. Therefore, an average conversion factor (at 0.2 swine heads = 1 livestock unit (Põllumajandusministri määrus nr 130, 12.12.2009)) to number of livestock unit was used for pigs. However, more detailed data (based on pig categories) were used in the analysis, these data are confidential.

keep 1–9 heads of swine or cattle. However, number of swine and cattle population and the number of large holdings has increased during the last ten years (Tables A.3.3_IV.2.–A.3.3_IV.4).

As it was mentioned several times, the changes in cattle housing technology has started to be implemented in the beginning of 2000-ties and since then, the technology has been applied very intensively during the last ten years. If, in 2002 was only one farm (in Jõgeva county) with loose-housing technology occurred, then by 2011 – about 150 holdings with cattle have been implemented loose-housing technology. Hence, share of liquid/slurry MMS for dairy cattle has markedly increased since 2002 by 2010. The changes in the housing technology were occurred also in bovine and young cattle keeping – from tie stall to loose-housing with slatted floor or with deep litter.

For mature non-dairy cattle, it was assumed that the technology of cattle housing has not changed sine the nineties, and until nowadays tie stall technology is applied for mature non-dairy cattle, which stipulates solid storage MMS. The housing technology has not changed for calves (0-6 months) as well, which are(were) kept in group or individual boxes with solid storage MMS.

In the context of swine MMS development, also additional information regarding organic livestock farming was taken into account. The organic farming has started to be developed in the mid of 2000ties in Estonia. The farming stipulates pasture of swine livestock. Data of Agricultural Board were used to evaluate share of manure left on pasture by pigs.

In addition, in 2006, the first pig-slurry based biogas production was launched, which uses swine slurry and operates until nowadays. The plant is located in Saare county. Swine liquid/slurry generated and used in the facility was defined as liquid/slurry in the inventory report. However, the emissions from biogas treated manure were calculated separately from the emissions occurred in swine liquid/slurry storage, the experience of Danish colleagues were used in the estimations (Danish NIR, 2011).

To specify grazing period of cattle and quantity of manure generated on pasture, the average pasture-period was used from (Taustauuring, 2009). The ratios of agricultural holdings, which graze cattle, were taken from the same study. The results of the study illustrated that a share of dairy and non-dairy cattle population, which is depastured, depends on size of herd. For example, agricultural holdings, which keep less than 20 dairy cattle, all depasture cattle; however, only 89% from the total cattle holding, with herd population at 200–400 heads of dairy cattle, depasture cattle livestock. Swine holdings do not have practice to graze swine livestock in Estonia.

Table A.3.2_IV.5. Ratio of agricultural holding, which depasture cattle livestock, by size of cattle herds (Taustauuring, 2009)

Cattle herd size	Agricultural holding, which keep…		
	Dairy cows	Mature cattle	Young cattle
less than 20 cattle	100	100	97
20…99 cattle	89	79	89
101…199 cattle	96	92	96
200…399 cattle	89	56	89
more than 400 cattle	95	86	94

Table A.3.2_IV.6. Number of grazing days by category of livestock

Livestock category	Number of grazing days	Reference
Cattle	160	Taustauuring, 2009, p. 35
Sheep	180	Taustauuring, 2009, p. 32
Goats	180	Taustauuring, 2009, p. 32
Horses	150	Taustauuring, 2009, p. 33

To sum up, the module on MMS was developed for each county of Estonia based on data of 1990, 2003 and 2010. The data was interpolated between 1990th and 2000, and between 2000 and 2010. The results of the investigations performed are presented below, in Tables A.3.3_IV.7 – A.3.3_IV.16:

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Table A.3.2_IV.7. Share of Liquid/Slurry MMS in 1990–2015 by county, %

	Harju	Hiiu	Ida-Viru	Jõgeva	Järva	Lääne	Lääne-Viru	Põlva	Pärnu	Rapla	Saare	Tartu	Valga	Viljandi	Võru
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2003	5.6	0.0	0.0	8.0	16.3	0.0	9.5	18.6	8.1	4.9	2.0	7.3	7.3	5.2	0.0
2004	6.9	0.0	2.5	9.3	17.2	1.9	12.2	20.5	11.9	8.3	3.9	12.5	9.6	7.8	1.7
2005	8.2	0.0	5.0	10.6	18.1	3.8	15.0	22.4	15.7	11.8	5.9	17.7	11.9	10.3	3.4
2006	9.5	0.0	7.6	12.0	19.0	5.7	17.7	24.3	19.6	15.2	7.8	22.8	14.2	12.9	5.2
2007	10.7	0.0	10.1	13.3	19.9	7.6	20.5	26.3	23.4	18.7	9.7	28.0	16.5	15.4	6.9
2008	12.0	0.0	12.6	14.7	20.9	9.5	23.2	28.2	27.3	22.1	11.6	33.2	18.8	18.0	8.6
2009	13.3	0.0	15.1	16.0	21.8	11.4	26.0	30.1	31.1	25.6	13.6	38.4	21.2	20.5	10.3
2010	14.6	0.0	17.7	17.4	22.7	13.3	28.7	32.0	34.9	29.0	15.5	43.5	23.5	23.1	12.1
2011	14.6	0.0	17.7	17.4	22.7	13.3	28.7	32.0	34.9	29.0	15.5	43.5	23.5	23.1	12.1
2012	14.6	0.0	17.7	17.4	22.7	13.3	28.7	32.0	34.9	29.0	15.5	43.5	23.5	23.1	12.1
2013	14.6	0.0	17.7	17.4	22.7	13.3	28.7	32.0	34.9	29.0	15.5	43.5	23.5	23.1	12.1
2014	14.6	0.0	17.7	17.4	22.7	13.3	28.7	32.0	34.9	29.0	15.5	43.5	23.5	23.1	12.1
2015	14.6	0.0	17.7	17.4	22.7	13.3	28.7	32.0	34.9	29.0	15.5	43.5	23.5	23.1	12.1

Table A.3.2_IV.8. Share of Solid Storage MMS in 1990–2015 by county, %

	Harju	Hiiu	Ida-Viru	Jõgeva	Järva	Lääne	Lääne-Viru	Põlva	Pärnu	Rapla	Saare	Tartu	Valga	Viljandi	Võru
1990	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1991	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1992	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1993	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1994	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1995	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1996	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1997	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1998	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1999	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
2000	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
2001	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
2002	56.2	56.2	56.2	54.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
2003	52.0	56.2	56.2	50.0	44.5	56.8	50.0	45.7	51.0	53.4	54.2	48.8	49.6	53.2	57.0
2004	51.1	56.2	54.1	48.8	43.4	55.7	47.7	43.2	48.0	50.2	52.7	44.0	47.3	51.0	55.3
2005	50.3	56.2	52.0	47.7	42.3	54.5	45.4	40.7	45.0	46.9	51.1	39.2	45.0	48.7	53.7
2006	49.4	56.2	50.0	46.5	41.1	53.3	43.1	38.1	42.0	43.7	49.6	34.5	42.7	46.5	52.0
2007	48.5	56.2	47.9	45.4	40.0	52.1	40.7	35.6	39.0	40.5	48.1	29.7	40.4	44.2	50.4
2008	47.6	56.2	45.8	44.2	38.8	50.9	38.4	33.1	36.0	37.2	46.6	24.9	38.1	42.0	48.7
2009	46.7	56.2	43.7	43.1	37.7	49.7	36.1	30.5	33.1	34.0	45.1	20.1	35.8	39.7	47.1
2010	45.9	56.2	41.7	42.0	36.6	48.6	33.8	28.0	30.1	30.8	43.6	15.3	33.5	37.5	45.4
2011	45.9	56.2	41.7	42.0	36.6	48.6	33.8	28.0	30.1	30.8	43.6	15.3	33.5	37.5	45.4
2012	45.9	56.2	41.7	42.0	36.6	48.6	33.8	28.0	30.1	30.8	43.6	15.3	33.5	37.5	45.4
2013	45.9	56.2	41.7	42.0	36.6	48.6	33.8	28.0	30.1	30.8	43.6	15.3	33.5	37.5	45.4
2014	45.9	56.2	41.7	42.0	36.6	48.6	33.8	28.0	30.1	30.8	43.6	15.3	33.5	37.5	45.4
2015	45.9	56.2	41.7	42.0	36.6	48.6	33.8	28.0	30.1	30.8	43.6	15.3	33.5	37.5	45.4

Table A.3.2_IV.9. Share of Pasture, Range and Paddock in 1990–2015 by county, %

	Harju	Hiiu	Ida-Viru	Jõgeva	Järva	Lääne	Lääne-Viru	Põlva	Pärnu	Rapla	Saare	Tartu	Valga	Viljandi	Võru
1990	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1991	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1992	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1993	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1994	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1995	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1996	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1997	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1998	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1999	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
2000	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
2001	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
2002	43.8	43.8	43.8	41.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
2003	42.6	43.8	43.8	42.1	39.2	43.2	40.5	35.7	41.0	41.7	43.8	43.8	43.1	41.5	43.0
2004	42.1	43.8	43.4	41.9	39.4	42.4	40.1	36.3	40.1	41.5	43.4	43.5	43.1	41.2	43.0
2005	41.7	43.8	42.9	41.7	39.6	41.7	39.7	36.9	39.3	41.3	43.0	43.1	43.1	40.9	42.9
2006	41.3	43.8	42.5	41.5	39.9	41.0	39.2	37.5	38.4	41.0	42.6	42.7	43.1	40.6	42.8
2007	40.9	43.8	42.0	41.3	40.1	40.3	38.8	38.1	37.6	40.8	42.2	42.3	43.1	40.3	42.7
2008	40.4	43.8	41.6	41.1	40.3	39.5	38.4	38.8	36.7	40.6	41.8	41.9	43.1	40.0	42.7
2009	40.0	43.8	41.1	40.9	40.5	38.8	37.9	39.4	35.8	40.4	41.3	41.6	43.1	39.7	42.6
2010	39.6	43.8	40.7	40.7	40.7	38.1	37.5	40.0	35.0	40.2	40.9	41.2	43.1	39.4	42.5
2011	39.6	43.8	40.7	40.7	40.7	38.1	37.5	40.0	35.0	40.2	40.9	41.2	43.1	39.4	42.5
2012	39.6	43.8	40.7	40.7	40.7	38.1	37.5	40.0	35.0	40.2	40.9	41.2	43.1	39.4	42.5
2013	39.6	43.8	40.7	40.7	40.7	38.1	37.5	40.0	35.0	40.2	40.9	41.2	43.1	39.4	42.5
2014	39.6	43.8	40.7	40.7	40.7	38.1	37.5	40.0	35.0	40.2	40.9	41.2	43.1	39.4	42.5
2015	39.6	43.8	40.7	40.7	40.7	38.1	37.5	40.0	35.0	40.2	40.9	41.2	43.1	39.4	42.5

Country-specific manure management systems of Bovine cattle (young cattle in the CRF reporter)

Table A.3.2_IV.10. Share of Solid Storage MMS in 1990–2015 by county, %

	Harju	Hiiu	Ida-Viru	Jõgeva	Järva	Lääne	Lääne-Viru	Põlva	Pärnu	Rapla	Saare	Tartu	Valga	Viljandi	Võru
1990	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1991	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1992	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1993	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1994	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1995	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1996	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1997	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1998	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
1999	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
2000	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
2001	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
2002	56.2	56.2	56.2	52.3	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
2003	52.8	56.2	56.2	46.6	46.6	56.3	50.7	47.7	50.8	54.4	54.0	49.1	47.9	53.8	56.2
2004	52.2	56.2	56.2	45.1	45.3	55.5	49.9	44.6	49.3	52.2	53.9	45.0	47.0	53.6	56.4
2005	51.7	56.2	56.3	43.5	43.9	54.7	49.1	41.6	47.7	49.9	53.8	40.9	46.0	53.4	56.6
2006	51.2	56.2	56.4	42.0	42.5	54.0	48.3	38.6	46.2	47.7	53.7	36.8	45.0	53.2	56.8
2007	50.7	56.2	56.5	40.5	41.2	53.2	47.5	35.6	44.7	45.4	53.6	32.7	44.1	52.9	57.1
2008	50.2	56.2	56.6	38.9	39.8	52.4	46.7	32.6	43.2	43.2	53.5	28.6	43.1	52.7	57.3
2009	49.7	56.2	56.6	37.4	38.4	51.6	45.9	29.6	41.6	40.9	53.4	24.5	42.2	52.5	57.5
2010	49.2	56.2	56.7	35.9	37.1	50.8	45.1	26.6	40.1	38.6	53.2	20.4	41.2	52.3	57.7
2011	49.2	56.2	56.7	35.9	37.1	50.8	45.1	26.6	40.1	38.6	53.2	20.4	41.2	52.3	57.7
2012	49.2	56.2	56.7	35.9	37.1	50.8	45.1	26.6	40.1	38.6	53.2	20.4	41.2	52.3	57.7
2013	49.2	56.2	56.7	35.9	37.1	50.8	45.1	26.6	40.1	38.6	53.2	20.4	41.2	52.3	57.7
2014	49.2	56.2	56.7	35.9	37.1	50.8	45.1	26.6	40.1	38.6	53.2	20.4	41.2	52.3	57.7
2015	49.2	56.2	56.7	35.9	37.1	50.8	45.1	26.6	40.1	38.6	53.2	20.4	41.2	52.3	57.7

Table A.3.2_IV.11. Share of Liquid/Slurry MMS in 1990–2015 by county, %

	Harju	Hiiu	Ida-Viru	Jõgeva	Järva	Lääne	Lääne-Viru	Põlva	Pärnu	Rapla	Saare	Tartu	Valga	Viljandi	Võru
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2003	0.7	0.0	0.0	1.9	1.9	0.0	1.7	1.7	1.1	0.3	0.4	1.4	1.6	0.5	0.0
2004	1.8	0.0	0.3	2.3	3.0	0.0	1.7	3.3	2.7	0.3	0.6	3.1	1.4	0.5	0.0
2005	2.8	0.0	0.6	2.7	4.1	0.0	1.7	4.9	4.4	0.2	0.8	4.7	1.2	0.4	0.0
2006	3.9	0.0	1.0	3.1	5.2	0.0	1.6	6.6	6.0	0.2	1.0	6.4	0.9	0.4	0.0
2007	4.9	0.0	1.3	3.5	6.4	0.0	1.6	8.2	7.7	0.1	1.2	8.0	0.7	0.4	0.0
2008	6.0	0.0	1.6	3.9	7.5	0.0	1.6	9.8	9.3	0.1	1.4	9.7	0.5	0.4	0.0
2009	7.1	0.0	1.9	4.3	8.6	0.0	1.5	11.4	11.0	0.0	1.6	11.4	0.2	0.4	0.0
2010	8.1	0.0	2.2	4.7	9.7	0.0	1.5	13.1	12.6	0.0	1.8	13.0	0.0	0.4	0.0
2011	8.1	0.0	2.2	4.7	9.7	0.0	1.5	13.1	12.6	0.0	1.8	13.0	0.0	0.4	0.0
2012	8.1	0.0	2.2	4.7	9.7	0.0	1.5	13.1	12.6	0.0	1.8	13.0	0.0	0.4	0.0
2013	8.1	0.0	2.2	4.7	9.7	0.0	1.5	13.1	12.6	0.0	1.8	13.0	0.0	0.4	0.0
2014	8.1	0.0	2.2	4.7	9.7	0.0	1.5	13.1	12.6	0.0	1.8	13.0	0.0	0.4	0.0
2015	8.1	0.0	2.2	4.7	9.7	0.0	1.5	13.1	12.6	0.0	1.8	13.0	0.0	0.4	0.0

Table A.3.2_IV.12. Share of Deep litter MMS in 1990–2015 by county, %

	Harju	Hiiu	Ida-Viru	Jõgeva	Järva	Lääne	Lääne-Viru	Põlva	Pärnu	Rapla	Saare	Tartu	Valga	Viljandi	Võru
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2003	2.8	0.0	0.0	7.7	7.6	0.0	6.9	6.8	4.3	1.4	1.7	5.7	6.6	1.9	0.0
2004	3.7	0.0	0.7	9.3	8.5	1.7	8.4	8.8	5.5	4.3	2.6	9.1	8.0	3.2	0.1
2005	4.7	0.0	1.5	10.9	9.4	3.5	10.0	10.9	6.7	7.2	3.4	12.5	9.4	4.5	0.2
2006	5.7	0.0	2.2	12.5	10.3	5.2	11.5	12.9	7.9	10.1	4.2	16.0	10.7	5.9	0.4
2007	6.7	0.0	3.0	14.1	11.2	7.0	13.0	14.9	9.2	13.0	5.0	19.4	12.1	7.2	0.5
2008	7.6	0.0	3.7	15.7	12.1	8.7	14.6	16.9	10.4	15.8	5.8	22.9	13.5	8.5	0.6
2009	8.6	0.0	4.4	17.3	13.0	10.5	16.1	19.0	11.6	18.7	6.6	26.3	14.9	9.8	0.7
2010	9.6	0.0	5.2	18.9	13.9	12.2	17.6	21.0	12.8	21.6	7.5	29.8	16.3	11.1	0.9
2011	9.6	0.0	5.2	18.9	13.9	12.2	17.6	21.0	12.8	21.6	7.5	29.8	16.3	11.1	0.9
2012	9.6	0.0	5.2	18.9	13.9	12.2	17.6	21.0	12.8	21.6	7.5	29.8	16.3	11.1	0.9
2013	9.6	0.0	5.2	18.9	13.9	12.2	17.6	21.0	12.8	21.6	7.5	29.8	16.3	11.1	0.9
2014	9.6	0.0	5.2	18.9	13.9	12.2	17.6	21.0	12.8	21.6	7.5	29.8	16.3	11.1	0.9
2015	9.6	0.0	5.2	18.9	13.9	12.2	17.6	21.0	12.8	21.6	7.5	29.8	16.3	11.1	0.9

Table A.3.2_IV.13. Share of Pasture, Range and Paddock in 1990–2015 by county, %

	Harju	Hiiu	Ida-Viru	Jõgeva	Järva	Lääne	Lääne-Viru	Põlva	Pärnu	Rapla	Saare	Tartu	Valga	Viljandi	Võru
1990	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1991	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1992	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1993	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1994	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1995	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1996	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1997	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1998	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
1999	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
2000	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
2001	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
2002	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
2003	43.9	43.8	43.8	43.8	43.8	43.7	40.7	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8
2004	42.3	43.8	42.7	43.4	43.2	42.7	40.0	43.2	42.5	43.2	42.9	42.8	43.6	42.7	43.5
2005	40.8	43.8	41.6	42.9	42.5	41.8	39.3	42.6	41.2	42.7	42.0	41.8	43.5	41.7	43.1
2006	39.3	43.8	40.4	42.4	41.9	40.8	38.6	41.9	39.8	42.1	41.1	40.8	43.3	40.6	42.8
2007	37.7	43.8	39.3	41.9	41.3	39.9	37.9	41.3	38.5	41.5	40.2	39.8	43.1	39.5	42.4
2008	36.2	43.8	38.2	41.4	40.6	38.9	37.2	40.7	37.1	40.9	39.3	38.8	42.9	38.4	42.1
2009	34.6	43.8	37.0	41.0	40.0	37.9	36.5	40.0	35.8	40.3	38.4	37.8	42.7	37.3	41.8
2010	33.1	43.8	35.9	40.5	39.3	37.0	35.8	39.4	34.5	39.7	37.5	36.8	42.5	36.2	41.4
2011	33.1	43.8	35.9	40.5	39.3	37.0	35.8	39.4	34.5	39.7	37.5	36.8	42.5	36.2	41.4
2012	33.1	43.8	35.9	40.5	39.3	37.0	35.8	39.4	34.5	39.7	37.5	36.8	42.5	36.2	41.4
2013	33.1	43.8	35.9	40.5	39.3	37.0	35.8	39.4	34.5	39.7	37.5	36.8	42.5	36.2	41.4
2014	33.1	43.8	35.9	40.5	39.3	37.0	35.8	39.4	34.5	39.7	37.5	36.8	42.5	36.2	41.4
2015	9.6	0.0	5.2	18.9	13.9	12.2	17.6	21.0	12.8	21.6	7.5	29.8	16.3	11.1	0.9

Country-specific manure management systems of Swine livestock

Table A.3.2_IV.14. Share of Solid Storage MMS in 1990–2015 by county, %

	Harju	Hiiu	Ida-Viru	Jõgeva	Järva	Lääne	Lääne-Viru	Põlva	Pärnu	Rapla	Saare	Tartu	Valga	Viljandi	Võru
1990	12.4	11.6	11.4	11.0	10.8	13.3	13.7	12.0	10.6	15.2	14.0	11.2	14.3	11.9	18.7
1991	13.5	14.1	16.1	12.9	11.4	15.6	15.5	19.5	12.2	17.0	14.4	13.5	21.2	12.5	25.6
1992	14.6	16.6	20.8	14.7	11.9	18.0	17.3	26.9	13.7	18.7	14.9	15.8	28.0	13.1	32.4
1993	15.7	19.1	25.5	16.5	12.5	20.3	19.0	34.3	15.3	20.4	15.4	18.2	34.8	13.7	39.3
1994	16.7	21.6	30.1	18.3	13.0	22.7	20.8	41.7	16.8	22.2	15.9	20.5	41.6	14.3	46.1
1995	17.0	32.8	30.4	19.6	15.1	22.6	19.7	41.3	22.7	21.0	16.1	22.7	45.2	13.4	48.2
1996	17.3	44.0	30.6	20.9	17.2	22.6	18.5	40.9	28.7	19.8	16.4	25.0	48.8	12.5	50.3
1997	17.7	55.2	30.9	22.2	19.3	22.6	17.3	40.5	34.6	18.6	16.7	27.2	52.3	11.7	52.4
1998	18.0	66.4	31.1	23.5	21.4	22.6	16.2	40.0	40.5	17.4	16.9	29.4	55.9	10.8	54.5
1999	18.3	77.6	31.4	24.8	23.5	22.6	15.0	39.6	46.4	16.2	17.2	31.7	59.5	10.0	56.6
2000	18.6	88.8	31.6	26.1	25.6	22.6	13.8	39.2	52.3	15.1	17.5	33.9	63.1	9.1	58.6
2001	18.9	100.0	31.9	27.6	27.3	22.6	12.7	58.3	38.8	13.9	13.1	36.1	66.6	8.3	60.7
2002	17.0	100.0	32.8	31.6	26.0	31.2	14.9	58.8	36.8	12.7	9.7	36.4	67.7	7.6	65.0
2003	15.1	100.0	33.8	35.6	24.6	39.8	17.2	59.3	34.8	11.4	6.4	36.6	68.7	6.9	69.4
2004	13.1	100.0	34.7	39.6	23.2	48.4	19.5	59.8	32.8	10.2	5.8	36.8	69.7	6.2	73.7
2005	11.2	100.0	35.7	43.6	21.9	57.0	21.7	60.4	30.8	9.0	5.2	37.0	70.7	5.5	78.0
2006	9.3	100.0	36.7	47.6	20.5	65.6	24.0	60.9	28.7	7.8	4.5	37.3	71.7	4.7	82.4
2007	7.3	100.0	37.6	51.6	19.1	74.2	26.3	61.4	26.7	6.6	3.9	37.5	72.7	4.0	86.7
2008	5.4	100.0	38.6	55.6	17.7	82.8	28.5	61.9	24.7	5.4	3.3	37.7	73.7	3.3	91.0
2009	3.4	99.9	39.5	59.5	16.3	91.3	30.7	62.4	22.6	4.1	2.6	37.8	74.6	2.5	95.3
2010	1.3	99.7	40.2	63.3	14.7	99.7	32.8	62.7	20.4	2.7	1.4	37.9	75.4	1.6	99.4
2011	1.3	99.7	40.2	63.3	14.7	99.7	32.8	62.7	20.4	2.7	1.4	37.9	75.4	1.6	99.4
2012	1.3	99.7	40.2	63.3	14.7	99.7	32.8	62.7	20.4	2.7	1.4	37.9	75.4	1.6	99.4
2013	1.3	99.7	40.2	63.3	14.7	99.7	32.8	62.7	20.4	2.7	1.4	37.9	75.4	1.6	99.4
2014	1.3	99.7	40.2	63.3	14.7	99.7	32.8	62.7	20.4	2.7	1.4	37.9	75.4	1.6	99.4
2015	1.3	99.7	40.2	63.3	14.7	99.7	32.8	62.7	20.4	2.7	1.4	37.9	75.4	1.6	99.4

Table A.3.2_IV.15. Share of Liquid/Slurry MMS in 1990–2015 by county, %

	Harju	Hiiu	Ida-Viru	Jõgeva	Järva	Lääne	Lääne-Viru	Põlva	Pärnu	Rapla	Saare	Tartu	Valga	Viljandi	Võru
1990	87.6	88.4	88.6	89.0	89.2	86.7	86.3	88.0	89.4	84.8	86.0	88.8	85.7	88.1	81.3
1991	86.5	85.9	83.9	87.1	88.6	84.4	84.5	80.5	87.8	83.0	85.6	86.5	78.8	87.5	74.4
1992	85.4	83.4	79.2	85.3	88.1	82.0	82.7	73.1	86.3	81.3	85.1	84.2	72.0	86.9	67.6
1993	84.3	80.9	74.5	83.5	87.5	79.7	81.0	65.7	84.7	79.6	84.6	81.8	65.2	86.3	60.7
1994	83.3	78.4	69.9	81.7	87.0	77.3	79.2	58.3	83.2	77.8	84.1	79.5	58.4	85.7	53.9
1995	83.0	67.2	69.6	80.4	84.9	77.4	80.3	58.7	77.3	79.0	83.9	77.3	54.8	86.6	51.8
1996	82.7	56.0	69.4	79.1	82.8	77.4	81.5	59.1	71.3	80.2	83.6	75.0	51.2	87.5	49.7
1997	82.3	44.8	69.1	77.8	80.7	77.4	82.7	59.5	65.4	81.4	83.3	72.8	47.7	88.3	47.6
1998	82.0	33.6	68.9	76.5	78.6	77.4	83.8	60.0	59.5	82.6	83.1	70.6	44.1	89.2	45.5
1999	81.7	22.4	68.6	75.2	76.5	77.4	85.0	60.4	53.6	83.8	82.8	68.3	40.5	90.0	43.4
2000	81.4	11.2	68.4	73.9	74.4	77.4	86.2	60.8	47.7	84.9	82.5	66.1	36.9	90.9	41.4
2001	81.1	0.0	68.1	72.4	72.7	77.4	87.3	41.7	61.2	86.1	86.9	63.9	33.4	91.7	39.3
2002	83.0	0.0	67.2	68.4	74.0	68.8	85.1	41.2	63.2	87.3	90.3	63.6	32.3	92.4	35.0
2003	84.9	0.0	66.2	64.4	75.4	60.2	82.8	40.7	65.2	88.6	93.6	63.4	31.3	93.1	30.6
2004	86.9	0.0	65.3	60.4	76.8	51.6	80.5	40.2	67.2	89.8	94.2	63.2	30.3	93.8	26.3
2005	88.8	0.0	64.3	56.4	78.1	43.0	78.3	39.6	69.2	91.0	94.8	63.0	29.3	94.5	22.0
2006	90.7	0.0	63.3	52.4	79.5	34.4	76.0	39.1	71.3	92.2	95.5	62.7	28.3	95.3	17.6
2007	92.6	0.0	62.4	48.4	80.9	25.8	73.7	38.6	73.3	93.4	96.1	62.5	27.3	96.0	13.3
2008	94.6	0.0	61.4	44.4	82.2	17.2	71.5	38.1	75.3	94.6	96.7	62.3	26.3	96.7	9.0
2009	96.5	0.0	60.4	40.4	83.6	8.6	69.2	37.5	77.3	95.8	97.3	62.1	25.3	97.4	4.6
2010	98.4	0.0	59.5	36.4	85.0	0.0	66.9	37.0	79.3	97.0	98.3	61.8	24.3	98.1	0.3
2011	98.4	0.0	59.5	36.4	85.0	0.0	66.9	37.0	79.3	97.0	98.3	61.8	24.3	98.1	0.3
2012	98.4	0.0	59.5	36.4	85.0	0.0	66.9	37.0	79.3	97.0	98.3	61.8	24.3	98.1	0.3
2013	98.4	0.0	59.5	36.4	85.0	0.0	66.9	37.0	79.3	97.0	98.3	61.8	24.3	98.1	0.3
2014	98.4	0.0	59.5	36.4	85.0	0.0	66.9	37.0	79.3	97.0	98.3	61.8	24.3	98.1	0.3
2015	98.4	0.0	59.5	36.4	85.0	0.0	66.9	37.0	79.3	97.0	98.3	61.8	24.3	98.1	0.3

Table A.3.2_IV.16. Share of Pasture, Range and Paddock in 1990–2015 by county, %

	Harju	Hiiu	Ida-Viru	Jõgeva	Järva	Lääne	Lääne-Viru	Põlva	Pärnu	Rapla	Saare	Tartu	Valga	Viljandi	Võru
1990															
1991															
1992															
1993															
1994															
1995															
1996															
1997															
1998															
1999															
2000															
2001															
2002															
2003															
2004															
2005															
2006															
2007	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
2008	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
2009	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
2010	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
2011	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
2012	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
2013	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
2014	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
2015	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30

Manure management systems: poultry

The module on MMS for poultry manure storage was developed based on data on poultry population kept by legal and in private agricultural holdings (Table A.3.3._IV.17).

According to the information presented in the environmental permits, which were submitted by large poultry holdings to the Environmental Board, the holdings use 'solid storage MMS' for all amount of waste generated by poultry. Manure, generated by poultry kept by private holdings (farms), is stored in 'solid storage MMS'. However, in addition, in private holdings, in the summer time during solar time, poultry are kept outside of hen-house, which could be classified as 'pasture' MMS (Table A.3.3._IV.18).

Table A.3.2_IV.17. Poultry population in agricultural holdings by form in Estonia in 1990–2010, 1000 heads (SE, 2012)

year	Total population	…incl. in private holdings
1990	6 537	1 170
2001	2 214	479
2003	2 276	328
2005	2 132	296
2007	1 719	147
2010	1 941	139

Table A.3.2_IV.18. Country-specific MMS of poultry in 1990–2010, %

year	Solid storage	Pasture
1990	96.7	3.3
1991	96.6	3.4
1992	96.6	3.4
1993	96.5	3.5
1994	96.5	3.5
1995	96.4	3.6
1996	96.4	3.6
1997	96.3	3.7
1998	96.3	3.7
1999	96.2	3.8
2000	96.2	3.8
2001	96.1	3.9
2002	96.7	3.3
2003	97.2	2.8
2004	97.3	2.7
2005	97.3	2.7
2006	97.8	2.2
2007	98.3	1.7
2008	98.4	1.6
2009	98.4	1.6
2010	98.5	1.5

A.3.2_V. NITROGEN EXCRETION RATES

Table A.3.2_V.1. Nitrogen content of feed, % (Kaasik et al., 2002)

Cattle category	Nitrogen content of feed, %
Dairy cattle	2.4
Mature females	1.6
Mature males	2.3
Bovine animals (aged between 1 and 2 years)	2.3
Calves (0-6 months)	2.3

Table A.3.2_V.2. Content of N in body weight and embryo (Standard Values…, 1997)

	Nitrogen, g/kg
	Dairy cattle
Weight gain	25.6
Embryo	29.6
	Young cattle
Weight gain	29.6

Table A.3.2_V.3. Average protein content of milk in Estonia in 1990–1997, % of mass (EARC, 2012)[376]

Year	Fat content, %
1990	3.22
1991	3.25
1992	3.14
1993	3.11
1994	3.15
1995	3.17
1996	3.20
1997	3.15

[376] Results of animal recording in Estonia in 1997–2012. Annual Reports. Available at: www.jkkeskus.ee/page.php?page=0147.

Table A.3.2_V.4. Protein content of milk in 1998–2015 in Estonia, % in mass (EARC, 2016)

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
The average of Estonia	3.18	3.15	3.28	3.31	3.27	3.30	3.31	3.34	3.35	3.36	3.36	3.37	3.36	3.39	3.39	3.38	3.37	3.33
Harju	3.13	3.11	3.25	3.30	3.20	3.22	3.25	3.28	3.28	3.29	3.30	3.32	3.32	3.34	3.37	3.35	3.33	3.30
Hiiu	3.21	3.21	3.31	3.30	3.27	3.30	3.29	3.26	3.26	3.26	3.33	3.32	3.30	3.34	3.34	3.31	3.32	3.28
Ida-Viru	3.16	3.14	3.29	3.31	3.25	3.25	3.30	3.35	3.39	3.38	3.37	3.38	3.38	3.40	3.38	3.40	3.38	3.34
Jõgeva	3.26	3.22	3.36	3.40	3.36	3.39	3.39	3.41	3.41	3.40	3.40	3.41	3.42	3.43	3.44	3.41	3.41	3.36
Järva	3.17	3.15	3.26	3.30	3.27	3.31	3.31	3.35	3.34	3.36	3.38	3.37	3.37	3.40	3.39	3.36	3.36	3.32
Lääne	3.15	3.10	3.22	3.26	3.20	3.20	3.24	3.24	3.28	3.28	3.30	3.31	3.31	3.31	3.34	3.31	3.33	3.30
Lääne-Viru	3.13	3.11	3.22	3.27	3.24	3.25	3.28	3.32	3.36	3.36	3.36	3.34	3.36	3.39	3.38	3.38	3.35	3.30
Põlva	3.20	3.19	3.32	3.28	3.32	3.33	3.34	3.34	3.35	3.34	3.34	3.36	3.32	3.39	3.4	3.36	3.33	3.29
Pärnu	3.14	3.12	3.26	3.28	3.22	3.26	3.29	3.33	3.33	3.33	3.34	3.34	3.33	3.38	3.36	3.35	3.34	3.32
Rapla	3.16	3.12	3.26	3.27	3.25	3.26	3.30	3.30	3.29	3.31	3.32	3.33	3.34	3.36	3.36	3.35	3.37	3.34
Saare	3.27	3.24	3.34	3.39	3.36	3.36	3.38	3.38	3.39	3.38	3.40	3.41	3.39	3.39	3.39	3.40	3.41	3.39
Tartu	3.18	3.16	3.31	3.34	3.32	3.36	3.37	3.38	3.39	3.39	3.37	3.38	3.39	3.42	3.41	3.39	3.37	3.35
Valga	3.14	3.11	3.25	3.29	3.24	3.29	3.32	3.37	3.40	3.41	3.42	3.43	3.44	3.43	3.44	3.43	3.40	3.36
Viljandi	3.22	3.17	3.31	3.33	3.29	3.31	3.31	3.34	3.38	3.38	3.38	3.38	3.36	3.39	3.41	3.40	3.39	3.37
Võru	3.14	3.12	3.24	3.26	3.23	3.26	3.23	3.29	3.32	3.32	3.34	3.36	3.35	3.42	3.42	3.38	3.36	3.33

A.3.2_VI. SYNTHETIC FERTILIZERS APPLIED ON AGRICULTURAL SOILS IN ESTONIAN IN 1990–2015

Table A.3.2_VI.1. Amounts of synthetic fertilizers applied on agricultural soils, tonnes (SE, 2016)

Year	Use of mineral fertilizers (nitrogen) for..						Total
	cereals	industrial crops	potatoes	forage crops	open-field vegetables	orchards and greenhouses	
1990	28 882	108	1 739	40 990	218	102	72 039
1991	30 510	105	1 680	37 091	283	155	69 824
1992	26 257	217	3 028	26 882	607	1 369	58 360
1993	13 168	146	1 457	14 667	323	188	29 949
1994	10 870	216	1 262	13 167	234	319	26 068
1995	9 830	542	300	7 667	333	233	18 905
1996	9 605	443	561	5 775	28	148	16 560
1997	13 053	400	545	6 213	73	187	20 471
1998	15 198	858	565	8 008	172	131	24 932
1999	12 255	1 397	481	5 551	80	131	19 895
2000	14 589	1 655	577	5 373	85	117	22 396
2001	12 023	1 703	507	5 178	107	85	19 603
2002	10 056	1 629	190	4 502	68	255	16 700
2003	14 332	4 146	261	4 260	123	133	23 255
2004	15 262	4 257	488	4 424	223	179	24 833
2005	11 108	2 045	357	6 288	122	163	20 083
2006	13 078	3 320	473	5 304	157	278	22 610
2007	14 069	3 928	455	6 217	147	166	24 982
2008	22 049	7 639	228	5 316	160	63	35 455
2009	16 517	7 516	302	2 702	238	53	27 328
2010	16 200	7 169	454	4 449	257	97	28 626
2011	17 321	7 741	313	4 214	158	56	29 803
2012	19 362	8 314	321	4 721	184	76	32 978
2013	20 790	8 753	263	3 539	240	74	33 659
2014	22 407	8 316	275	4 527	163	118	35 806

A.3.2_VII. PRODUCTION OF CROPS IN ESTONIA IN 1990–2015

Table A.3.2_VII.1. Production of field crops in 1990–2015, 1000 tonnes (SE, 2016)

Year	Cereals	Legumes	Rape seed	Vegetables and greens	Potatoes	Forage roots
1990	957.3	0.2	1.1	105	618.1	534.8
1991	939.2	0.2	1.1	120.5	592.1	493.8
1992	598.1	0.4	2.3	78.4	669.1	176.8
1993	810.7	0.7	1.7	70	538.6	198.5
1994	510.4	1.1	2.2	78	563	216.3
1995	513.5	6.3	7	56.8	537.4	240.8
1996	629.2	13.8	10	54.7	500.2	180.8
1997	650.5	17	9.6	52.3	437.5	146.8
1998	576.2	8.3	17.9	50.2	316.7	96.7
1999	401.6	3.1	29.8	44.7	403.7	58.4
2000	696.6	6.6	38.6	53.3	471.7	49.5
2001	558.4	6.5	41.3	54	343.1	36.1
2002	524.7	5	63.9	39.3	210.9	7.3
2003	505.7	5	69.2	57.5	244.4	7.2
2004	608.1	3.3	68.6	53.6	166.5	6.7
2005	760.1	5.7	83.1	62.7	209.8	3.1
2006	619.3	5.5	84.6	61.3	152.6	2
2007	879.5	9.5	133.3	71.6	191.8	3.4
2008	864.2	3.3	111.1	64.5	125.2	0.4
2009	873.5	7.6	136	70.6	139.1	0.7
2010	678.4	12.6	131	73.9	163.4	0.3
2011	771.6	15.5	144.2	88.1	164.7	0.5
2012	991.2	12.9	157.8	66.1	138.9	0.2
2013	975.5	31.4	174.0	78.9	127.7	0.2
2014	1 221	39.5	166.2	66.4	117.3	0.3
2015	1 535	86.2	196.3	85.9	117.2	0.5

Table A.3.2_VII.2. Sown area of field crops in 1990–2015, 1000 ha (SE, 2016)

Year	Cereals	Legumes	Industrial crops	Open-field vegetables	Potatoes	Fodder roots
1990	397	0.1	3.2	5.2	45.5	11.1
1991	418.1	0.1	3	5.7	52.2	12.3
1992	423.1	0.4	4.7	5.1	46.3	11.8
1993	375.1	0.4	2.1	4.6	42.6	11.4
1994	319.5	0.7	3.6	4.4	39.9	12
1995	304.3	3.7	7.3	4.6	36.9	10.8
1996	288.8	5.8	9.5	4.2	35.3	8.8
1997	326.6	8.7	9	3.9	35.2	6.9
1998	354.1	6.4	17.8	4.2	32.6	4.7
1999	321	2.9	24.6	3.9	31.1	3.5
2000	329.3	3.9	29.1	3.8	30.9	2.5
2001	274.1	3.7	28.3	3.3	22.1	1.4
2002	259.2	2.4	33.2	3	16	0.4
2003	263.2	4.4	46.7	3.4	17	0.3
2004	261	4.3	50.6	3.5	16.1	0.2

Year	Cereals	Legumes	Industrial crops	Open-field vegetables	Potatoes	Fodder roots
2005	282.1	4.4	47.1	3	14	0.2
2006	280.3	4.6	62.9	2.8	11.5	0.1
2007	292.3	5.7	74.7	2.8	11.1	0.2
2008	309.3	4.8	78.5	2.4	8.7	0.1
2009	316.4	4.9	83.4	2.8	9.1	0.1
2010	275.3	7.3	99.3	2.8	9.4	0.1
2011	297.0	8.5	90.0	3.0	9.2	0.1
2012	290.5	11.0	87.9	2.9	7.6	0
2013	311.1	13.6	87.2	2.8	6.6	0
2014	332.9	19.1	81.0	2.9	6.4	0
2015	350.4	31.3	72.6	3.1	5.8	0

Table A.3.2_VII.3. Average yields of field crops by field crop in 1990–2015, kg/ha (SE, 2016)

Year	Cereals	Legumes	Rape seed	Potatoes	Fodder roots
1990	2 411	1 370	1 780	13 600	48 020
1991	2 247	1 310	991	11 340	40 050
1992	1 414	920	799	14 450	14 950
1993	2 161	1 550	1 324	12 640	17 350
1994	1 597	1 619	819	14 096	18 069
1995	1 687	1 711	1 165	14 559	22 429
1996	2 179	2 398	1 170	14 176	20 651
1997	1 992	1 945	1 216	12 415	21 333
1998	1 627	1 303	1 024	9 729	20 297
1999	1 251	1 044	1 232	12 970	16 489
2000	2 115	1 706	1 339	15 281	19 596
2001	2 037	1 780	1 499	15 503	25 838
2002	2 024	2 115	1 944	13 160	18 087
2003	1 922	1 131	1 494	14 393	21 809
2004	2 330	757	1 362	10 342	30 825
2005	2 694	1 282	1 781	15 028	19 686
2006	2 210	1 198	1 354	13 261	24 650
2007	3 009	1 668	1 812	17 195	18 934
2008	2 794	691	1 431	14 315	12 882
2009	2 761	1 547	1 657	15 275	19 917
2010	2 464	1 713	1 334	17 456	5 460
2011	2 598	1 811	1 620	17 836	13 939
2012	3 412	1 179	1 811	18 217	17 000
2013	3 136	2 315	2 021	19 245	13 294
2014	3 669	2 070	2 078	18 472	23 000.
2015	4 382	2 756	2 771	20 138	15 903

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Table A.3.2_VII.4. Production, sown area and yields of clover and alfalfa in 1990–2014 in Estonia (SE, 2015)

Year	Production, 1000 tonnes		Sown area, 1000 ha		Average yields, t/ha	
	Clover (at least >80%)	Alfalfa (at least >80%)	Clover (at least >80%)	Alfalfa (at least >80%)	Clover (at least >80%)	Alfalfa (at least >80%)
1990	3 034.2[(377)]	253.5	224.1[(378)]	19.6	13.54[(379)]	12.94
1991	3 034.2	253.5	224.1	19.6	13.54	12.94
1992	2 920.5	227.7	215.7	17.6	13.54	12.94
1993	2 710.7	210.8	200.2	16.3	13.54	12.94
1994	1 829.2	139.7	135.1	10.8	13.54	12.94
1995	1 589.6	122.9	117.4	9.5	13.54	12.94
1996	1 437.9	157.8	106.2	12.2	13.54	12.94
1997	1 015.5	157.8	75.0	12.2	13.54	12.94
1998	1 600.4	165.6	118.2	12.8	13.54	12.94
1999	980.3	159.1	72.4	12.3	13.54	12.94
2000	736.6	188.9	54.4	14.6	13.54	12.94
2001	649.9	106.1	48.0	8.2	13.54	12.94
2002	617.4	124.2	45.6	9.6	13.54	12.94
2003	379.1	111.2	28.0	8.6	13.54	12.94
2004	482.0	143.9	34.5	11.0	13.97	13.08
2005	633.5	176.6	37.7	12.0	16.80	14.72
2006	381.4	139.8	36.2	12.9	10.54	10.84
2007	638.8	165.8	50.8	12.6	12.57	13.16
2008	697.8	181.0	46.8	13.1	14.91	13.82
2009	583.0	142.1	42.5	10.7	13.72	13.28
2010	607.1	128.2	49.5	11.0	12.26	11.65
2011	527.4	85.5	40.5	6.1	13.01	14.02
2012	402.6	111.3	26.1	6.3	15.44	17.74
2013	332.5	49.3	23.8	3.9	13.95	12.60
2014	293.4	77.9	22.1	5.1	13.27	14.92

[377] The production quantities for 1990–2003 were calculated based on the sown areas and the average yields.
[378] The data of 1991.
[379] The yields of 1990–2003 were extrapolated based on the yield values of 2004–2010.

A.3.2_VIII AMOUNTS OF LIME FERTILIZERS USED IN ESTONIA

Table A.3.2_VIII.1. Amounts of lime fertilizers applied to soils, tonnes

Year	Annual amount of calcic limestone ($CaCO_3$) (t/yr)	Annual amount of clinker dust (t/yr)	Annual amount of chalk and powder limestone (t/yr)	Annual amount of dolomite ($CaMg(CO_3)_2$) (t/yr)
1990	27529.4	68000	0	0
1991	25388.7	62700	0	0
1992	5910.7	14600	0	0
1993	5404.7	13350	0	0
1994	4898.6	12100	0	0
1995	8167.2	13388.2	2747.1	0
1996	8291.8	10286.8	4127.3	0
1997	13087.6	13277.9	7712.1	0
1998	56709.2	47241.1	37583.9	0
1999	58719.4	50172.7	38407.3	0
2000	44123.5	39051.0	28314.0	0
2001	47334.7	44131.8	29468.2	0
2002	42797.6	43446.4	25208.6	0
2003	38300.4	45869.7	19730.3	0
2004	28143.4	54554.9	6057.2	107.9
2005	30314.5	42541.0	13092.1	206.9
2006	27631.9	40990.8	11037.0	172.2
2007	24989.3	36415.6	10246.6	1897.8
2008	21645.7	38979.2	5865.2	75.7
2009	2690.0	5623.0	413.5	32.4
2010	21087.9	31487.3	8340.4	183.3
2011	8830.3	11696.5	4095.1	92.8
2012	15673.1	0	15673.1	182.0
2013	13780.7	0	13780.7	88.5
2014	17597.8	1341.0	17054.9	1156.2
2015	16311.3	2876	15147	2342.0

A.3.2_IX. AMOUNTS OF UREA FERTILIZERS USED IN ESTONIA

Table A.3.2_IX.1. Amounts of urea fertilizers applied to soils, tonnes

Year	Annual amount of used urea fertilizers (t/yr)
1990	1360.2
1991	1265.4
1992	663.9
1993	269.0
1994	895.0
1995	873.0
1996	807.4
1997	653.9
1998	489.7
1999	631.7
2000	592.9
2001	612.1
2002	378.5
2003	527.5
2004	884.1
2005	1919.7
2006	1041.1
2007	2117.5
2008	251.7
2009	304.0
2010	11,7
2011	1545.1
2012	3754.5
2013	498.9
2014	3362.0
2015	4019.9

A.3.2_X. AVERAGE MONTHLY TEMPERATURE AND PRECIPITATION IN ESTONIA IN 1992–2015

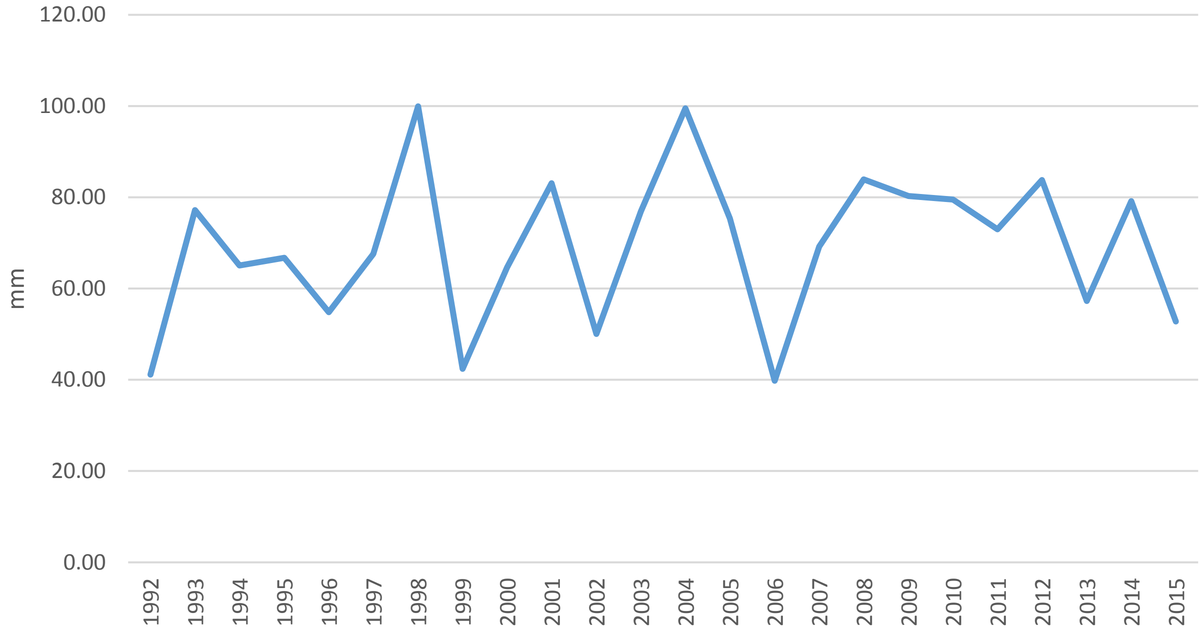

Figure A.3.2_X.1. Total precipitation from May to September in Estonia in 1992–2015, mm (SE, 2015; EtEA, 2016)

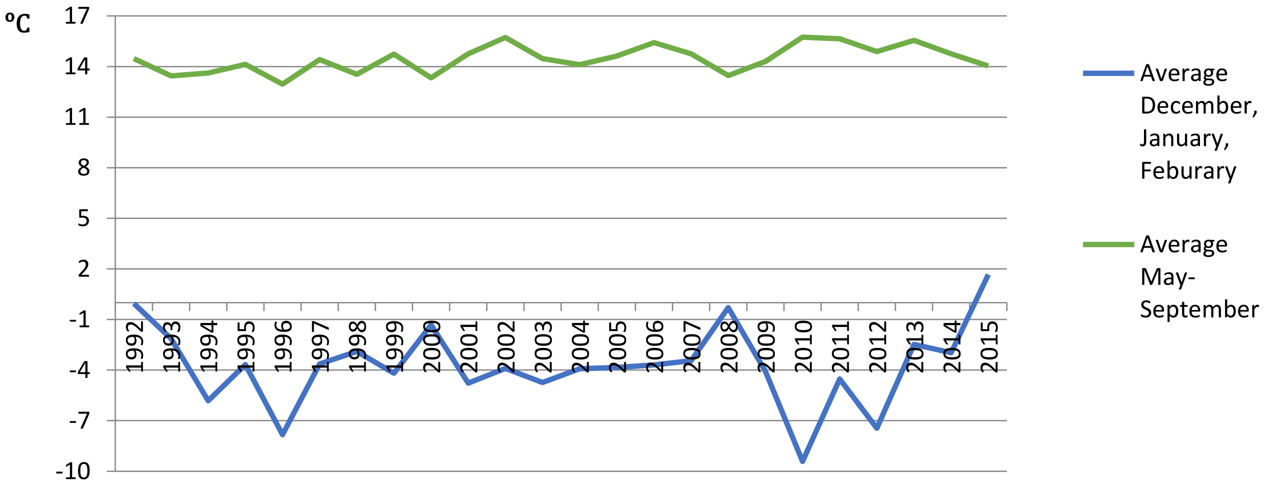

Figure A.3.2_X.2. Average yearly temperatures in Estonia in 1992–2015, ^{0}C (SE, 2015; EtEA, 2016)

Annex 4. The national energy balance for the most recent inventory year, TJ

	Coal	Coke*	Oil shale	Milled peat	Sod peat	Peat briquette	Wood*	Firewood	Wood chips and waste	Wood chips	Wood waste
In stocks at the beginning of the year	1 204	5	36 864	495	1 449	1	792	247	545	480	65
Production of primary energy	0	0	176 544	771	486	0	33 595	12 679	20 916	13 248	7 668
Imports	201	1	0	0	0	0	196	27	169	0	169
Resources of primary energy	1 405	6	213 408	1 266	1 935	1	34 583	12 953	21 630	13 728	7 902
Exports	0	213	0	0	436	0	1 234	1 230	4	0	4
Marine bunkering	0	0	0	0	0	0	0	0	0	0	0
In stocks at the end of the year	608	14	52 317	149	1 278	1	922	141	781	711	70
Supply of primary energy	797	-221	161 091	1 117	221	0	32 427	11 582	20 845	13 017	7 828
Consumption for conversion to other forms of energy	70	0	152 612	1 118	211	27	15 806	234	15 572	12 652	2 920
..consumption for electricity generation	5	0	92 722	268	0	0	3 552	0	3 552	3 552	0
..consumption for heat generation	65	0	3 261	712	211	27	12 249	229	12 020	9 100	2 920
..consumption for conversion to other forms of fuels	0	0	56 629	138	0	0	5	5	0	0	0
Production of converted energy	0	220	0	0	0	138	0	0	0	0	0
Own use by energy sector	0	0	415	0	8	0	102	2	100	97	3
Losses	0	0	0	0	0	0	4	0	4	0	4
Consumption for non-energy purposes	0	0	7 412	0	0	0	0	0	0	0	0
Final consumption calculated	727	0	652	-1	2	111	16 515	11 346	5 169	268	4 901
Final consumption observed	727	0	653	0	0	111	16 539	11 347	5 192	290	4 902
..final consumption in industry	608	0	653	0	0	1	1 559	20	1 539	271	1 268
....final consumption in iron and steel industry	0	0	0	0	0	0	0	0	0	0	0
....final consumption in chemical industry	0	0	0	0	0	0	1	1	0	0	0
....final consumption in production of non-ferrous metals	0	0	0	0	0	0	0	0	0	0	0

	Coal	Coke*	Oil shale	Milled peat	Sod peat	Peat briquette	Wood*	Firewood	Wood chips and waste	Wood chips	Wood waste
....final consumption in production of other non-metallic mineral products	607	0	653	0	0	0	4	1	3	0	3
....final consumption in production of transport equipment	0	0	0	0	0	1	18	3	15	15	0
....final consumption in machinery	0	0	0	0	0	0	10	5	5	5	0
....final consumption in mining and quarrying	0	0	0	0	0	0	0	0	0	0	0
....final consumption in food processing, beverages and tobacco	0	0	0	0	0	0	5	2	3	2	1
....final consumption in pulp, paper and printing industry	0	0	0	0	0	0	2	2	0	0	0
....final consumption in production of wood and wood products	0	0	0	0	0	0	1 515	3	1 512	248	1 264
....final consumption in construction	0	0	0	0	0	0	0	0	0	0	0
....final consumption in textile, leather and clothing industry	1	0	0	0	0	0	1	1	0	0	0
....final consumption in other industries	0	0	0	0	0	0	3	2	1	1	0
..final consumption in agriculture and fishing	0	0	0	0	0	0	94	82	12	11	1
..final consumption in transport	0	0	0	0	0	0	0	0	0	0	0
....final consumption in railway transport	0	0	0	0	0	0	0	0	0	0	0
....final consumption in land transport	0	0	0	0	0	0	0	0	0	0	0
......final consumption in urban and suburban passenger land transport	..	..	..	..	..	..	..	..	..	..	..
....final consumption in waterway transport	0	0	0	0	0	0	0	0	0	0	0
....final consumption in air transport	0	0	0	0	0	0	0	0	0	0	0
..final consumption in commercial and public services	0	0	0	0	0	0	137	109	28	8	20
..final consumption in households	119	0	0	0	0	110	14 749	..	..	..	..
Statistical difference	0	0	-1	-1	2	0	-24	-1	-23	-22	-1

	Briquette and pellets	Briquette	Pellets	Natural gas	Liquefied gas	Heavy fuel oil	Shale oil (heavy fraction)	Shale oil (light fraction)	Light fuel oil and diesel**	Light fuel oil**	Diesel oil
In stocks at the beginning of the year	1 620	10	1 610	0	95	366	1 780	94	4 674	81	4 593
Production of primary energy	15 644	199	15 445	0	0	0	0	0	0	0	0
Imports	342	49	293	15 832	1 200	14 092	0	0	32 317	4 399	27 918
Resources of primary energy	17 606	258	17 348	15 832	1 295	14 458	1 780	94	36 991	4 480	32 511
Exports	14 972	27	14 945	0	611	5 672	30 159	0	563	284	279
Marine bunkering	0	0	0	0	0	8 230	0	0	3 892	3 892	0
In stocks at the end of the year	1 898	5	1 894	0	70	527	1 680	115	4 295	47	4 248
Supply of primary energy	736	226	509	15 832	614	29	-30 059	-21	28 241	257	27 984
Consumption for conversion to other forms of energy	235	35	201	10 350	50	13	1 617	657	243	44	199
..consumption for electricity generation	0	0	0	329	0	0	640	0	6	2	4
..consumption for heat generation	235	35	201	10 021	50	13	977	657	237	42	195
..consumption for conversion to other forms of fuels	0	0	0	0	0	0	0	0	0	0	0
Production of converted energy	0	0	0	0	0	0	32 042	1 552	0	0	0
Own use by energy sector	0	0	0	209	0	0	217	42	612	0	612
Losses	0	0	0	2	0	0	2	0	1	0	1
Consumption for non-energy purposes	0	0	0	0	0	0	0	0	0	0	0
Final consumption calculated	501	191	308	5 271	564	16	147	832	27 385	213	27 172
Final consumption observed	499	194	306	5 270	563	15	138	840	27 378	207	27 171
..final consumption in industry	21	12	10	1 602	177	4	19	466	1 542	0	1 542
....final consumption in iron and steel industry	0	0	0	0	0	0	0	0	0	0	0
....final consumption in chemical industry	0	0	0	121	73	0	0	0	301	0	301
....final consumption in production of non-ferrous metals	0	0	0	0	2	0	0	0	1	0	1
....final consumption in production of other non-metallic mineral products	0	0	0	521	1	0	0	3	29	0	29

	Briquette and pellets	Briquette	Pellets	Natural gas	Liquefied gas	Heavy fuel oil	Shale oil (heavy fraction)	Shale oil (light fraction)	Light fuel oil and diesel**	Light fuel oil**	Diesel oil
....final consumption in production of transport equipment	1	0	1	45	5	0	0	1	17	0	17
....final consumption in machinery	12	9	3	134	40	0	0	8	11	0	11
....final consumption in mining and quarrying	0	0	0	180	3	0	0	0	222	0	222
....final consumption in food processing, beverages and tobacco	1	1	0	139	12	0	1	12	8	0	8
....final consumption in pulp, paper and printing industry	0	0	0	232	7	0	0	0	9	0	9
....final consumption in production of wood and wood products	1	0	1	15	6	0	0	44	125	0	125
....final consumption in construction	2	0	2	193	4	3	18	352	815	0	815
....final consumption in textile, leather and clothing industry	0	0	0	16	1	1	0	1	0	0	0
....final consumption in other industries	4	2	3	6	23	0	0	45	4	0	4
..final consumption in agriculture and fishing	18	0	18	93	103	3	94	235	3 842	0	3 842
..final consumption in transport	0	0	0	114	8	0	0	0	18 273	17	18 256
....final consumption in railway transport	0	0	0	0	0	0	0	0	814	0	814
....final consumption in land transport	0	0	0	114	8	0	0	0	16 916	0	16 916
......final consumption in urban and suburban passenger land transport	..	..	..	..	..	..	..	..	..	..	..
....final consumption in waterway transport	0	0	0	0	0	0	0	0	543	17	526
....final consumption in air transport	0	0	0	0	0	0	0	0	0	0	0
..final consumption in commercial and public services	76	1	75	1 382	30	8	25	139	443	0	443
..final consumption in households	384	181	203	2 079	245	0	0	0	3 278	190	3 088
Statistical difference	2	-3	2	1	1	1	9	-8	7	6	1

	Motor gasoline	Aviation gasoline	Shale oil gas**	Biogas**	Other biomass**	Municipal waste	Other fuels**	Total fuels	Electricity**	Heat
In stocks at the beginning of the year	2 115	116	0	0	6	36	0	51 712	0	0
Production of primary energy	0	0	0	482	1 393	2 819	0	231 734	2 671	0
Imports	17 712	3 154	0	0	0	0	0	85 047	19 627	0
Resources of primary energy	19 827	3 270	0	482	1 399	2 855	0	368 493	22 298	0
Exports	6 248	2 122	0	0	0	0	0	62 230	22 957	0
Marine bunkering	0	0	0	0	0	0	0	12 122	0	0
In stocks at the end of the year	3 212	110	0	0	5	39	0	67 240	0	0
Supply of primary energy	10 367	1 038	0	482	1 394	2 816	0	226 901	-659	0
Consumption for conversion to other forms of energy	0	0	5 800	386	1 380	2 372	0	192 947	39	0
..consumption for electricity generation	0	0	2 552	128	84	1 106	0	101 392	0	0
..consumption for heat generation	0	0	3 248	258	1 296	1 266	0	34 783	39	0
..consumption for conversion to other forms of fuels	0	0	0	0	0	0	0	56 772	0	0
Production of converted energy	0	0	5 929	0	0	0	0	39 881	34 831	30 988
Own use by energy sector	1	0	128	6	4	0	0	1 744	6 962	2 083
Losses	1	0	0	0	0	0	0	10	2 509	2 948
Consumption for non-energy purposes	0	0	0	0	0	0	0	7 412	0	0
Final consumption calculated	10 365	1 038	1	90	10	444	0	64 670	24 662	25 957
Final consumption observed	10 369	1 039	0	90	0	444	0	64 675	24 661	25 960
..final consumption in industry	26	0	0	90	0	444	0	7 212	7 406	7 095
....final consumption in iron and steel industry	0	0	0	0	0	0	0	0	3	2
....final consumption in chemical industry	0	0	0	0	0	0	0	496	481	454
....final consumption in production of non-ferrous metals	0	0	0	0	0	0	0	3	15	47
....final consumption in production of other non-metallic mineral products	0	0	0	0	0	444	0	2 262	571	161

	Motor gasoline	Aviation gasoline	Shale oil gas**	Biogas**	Other biomass**	Municipal waste	Other fuels**	Total fuels	Electricity**	Heat
....final consumption in production of transport equipment	1	0	0	0	0	0	0	89	235	118
....final consumption in machinery	3	0	0	0	0	0	0	218	901	431
....final consumption in mining and quarrying	1	0	0	0	0	0	0	406	64	3
....final consumption in food processing, beverages and tobacco	0	0	0	0	0	0	0	178	1 154	1 169
....final consumption in pulp, paper and printing industry	0	0	0	90	0	0	0	340	1 328	1 463
....final consumption in production of wood and wood products	3	0	0	0	0	0	0	1 709	1 346	2 599
....final consumption in construction	18	0	0	0	0	0	0	1 405	292	120
....final consumption in textile, leather and clothing industry	0	0	0	0	0	0	0	21	351	167
....final consumption in other industries	0	0	0	0	0	0	0	85	665	361
..final consumption in agriculture and fishing	13	0	0	0	0	0	0	4 495	739	362
..final consumption in transport	2 516	1 039	0	0	0	0	0	21 950	169	87
....final consumption in railway transport	0	0	0	0	0	0	0	814	23	17
....final consumption in land transport	2 507	0	0	0	0	0	0	19 545	139	69
......final consumption in urban and suburban passenger land transport	..	..	..	..	..	..	..	..	61.2	..
....final consumption in waterway transport	9	0	0	0	0	0	0	552	7	0
....final consumption in air transport	0	1 039	0	0	0	0	0	1 039	0	1
..final consumption in commercial and public services	26	0	0	0	0	0	0	2 266	10 126	6 547
..final consumption in households	7 788	0	0	0	0	0	0	28 752	6 221	11 869
Statistical difference	-4	-1	1	0	10	0	0	-5	1	-3

Due to rounding, the values of the aggregate data may differ from the sum. Since 2012 data of imports and exports include re/exports.
Coke*: Oil-shale coke is exported as coke.
Wood*: Firewood, wood chips and waste.
Light fuel oil and diesel**: The imports of light fuel oil and diesel include marine bunkering.
Light fuel oil**: In the production of converted energy, light fuel oil is light fraction of shale oil.
Shale oil gas**: Generator gas, coke oven gases.
Biogas**: In years 1999-2010 biogas is included under other fuels.
Other biomass**: Other biomass includes straw, bone meal, organic waste of animals, black liquor.
Electricity**: In the production of primary energy, electricity includes hydro-electric and wind-energy.

Annex 5. Any additional information

A.5.1 Assessment of completeness

Completeness of the Estonia's inventory submissions is evaluated here by sectors in tables below. The completeness has been estimated by gases (CO_2, N_2O CH_4, F-gases and also NOx, CO, NMVOC and SO_2) and emission sources according to the detailed CRF Reporter classification.

Abbreviations used in tables:

X - Included in to the inventory
NO - Not occurring in Estonia
NA - Not available
NE - Not estimated
IE - Included elsewhere.

*** Notes,**

if category reporting includes some national specific emission source, which is not required in IPCC guidelines and other relevant issues.

Energy, Fuel combustion (CRF 1.A)

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2	Notes*
1. A. Fuel combustion activities								
1.A.A. Sectoral Approach								
1.AA.1.A. Energy industries								
1.AA.1.A. Public Electricity and Heat Production	X	X	X	X	X	X	X	
1.AA.1.B. Petroleum Refining	NO	NO	NO	NO	NO	NO	NO	
1.AA.1.C. Manufacture of Solid Fuels and Other Energy Industries	X	X	X	X	X	X	X	
1.AA.2. Manufacturing Industries and Construction								
1.AA.2.A. Iron and Steel*	X	X	X	X	X	X	X	There was no production of iron and steel products in 1991, 1992, 1993 and 2013–2015.
1.AA.2.B. Non-Ferrous Metals*	X	X	X	X	X	X	X	There was no production of non-ferrous metals products in 1990-1999 and 2001.
1.AA.2.C. Chemicals	X	X	X	X	X	X	X	
1.AA.2.D. Pulp, Paper and Print*	X	X	X	X	X	X	X	There was no production of pulp and paper in 1990, 1991 and 1996 and SO_2 in 1997 was NA.

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2	Notes*
1.AA.2.E. Food Processing, Beverages and Tobacco	X	X	X	X	X	X	X	
1.AA.2.F. Non-metallic Minerals	X	X	X	X	X	X	X	
1.AA.2.G Other manufacturing industries and construction	X	X	X	X	X	X	X	
1.AA.3. Transport								
1.AA.3.A. Civil Aviation	X	X	X	X	X	X	X	
1.AA.3.B. Road Transportation	X	X	X	X	X	X	X	
1.AA.3.C. Railways	X	X	X	X	X	X	X	
1.AA.3.D. Navigation	X	X	X	X	X	X	X	
1.AA.3.E. Other Transportation - other fuels from the Civil Aviation sub-sector	NO	NO	NO	NO	NO	NO	NO	
1.AA.4. Other Sectors								
1.AA.4.A. Commercial/ Institutional	X	X	X	X	X	X	X	
1.AA.4.B. Residential	X	X	X	X	X	X	X	
1.AA.4.C. Agriculture/Forestry/ Fisheries	X	X	X	X	X	X	X	
1.AA.5. Other *(please specify)*								
1.AA.5. A. Stationary	NO	NO	NO	NO	NO	NO	NO	
1.AA.5. B. Mobile	X	X	X	X	X	X	X	Motor fuels used in public sector and in military.

Energy, Fugitive emissions (CRF 1.B)

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2	Notes*
1.B Fugitive emissions from fuels								
1.B.1. Solid fuels								
1.B.1.A. Coal Mining	NO	NO	NO	NO	NO	NO	NO	
1.B.1.B. Solid Fuel Transformation	NO	NO	NO	NO	NO	NO	NO	
1.B.1.C. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	
1.B.2. Oil and Natural Gas								
1.B.2.A. Oil	NO	NO	NO	NO	NO	NO	NO	
1.B.2.B.4 Natural Gas/Transmission and storage	X	X	NO	NO	NO	NO	NO	
1.B.2.B.5 Natural Gas/Distribution	X	X	NO	NO	NO	NO	NO	
1.B.2.C. Venting and Flaring	NO	NO	NO	NO	NO	NO	NO	
1.B.2.D. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	

Industrial processes and product use (CRF 2)

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2	Notes*
2. Industrial processes and Product Use								
2.A. Mineral Industry								
2.A.1. Cement Production	X	NO	NO	NO	NO	NO	X	
2.A.2. Lime Production	X	NO	NO	NO	NO	NO	NO	
2.A.3. Glass Production	X	NO	NO	NO	NO	NO	NO	
2.A.4.a Ceramics	X	NO	NO	NO	NO	NO	NO	
2.A.4.b. Other uses of Soda Ash	X	NO	NO	NO	NO	NO	X	
2.A.4.c Non-metallurgical Magnesium Production	NO	NO	NO	NO	NO	NO	NO	
2.A.4.d Other – Limestone use for flue gas desulphurisation	X	NO	NO	NO	NO	NO	NO	
2.B. Chemical Industry								
2.B.1. Ammonia Production	X	NO	NO	X	X	X	NO	Historical activity and emissions are reported from 1990 to 2013.
2.B.2. Nitric Acid Production	NO	NO	NO	NO	NO	NO	NO	
2.B.3. Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO	
2.B.4. Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	NO	NO	NO	NO	NO	NO	
2.B.5. Carbide Production	NO	NO	NO	NO	NO	NO	NO	
2.B.6. Titanium Dioxide Production	NO	NO	NO	NO	NO	NO	NO	
2.B.7. Soda Ash Production	NO	NO	NO	NO	NO	NO	NO	
2.B.8. Petrochemical and Carbon Black Production	NO	NO	NO	NO	NO	NO	NO	
2.B.10 Other	NO	NO	NO	NO	NO	NO	NO	
	HFC	**PFC**	**SF_6**	**NF_3**	**Unspecified mix of HFC and PFC**			
2.B.9. Fluorochemical Production	NO	NO	NO	NO	NO			
2.D. Non-energy Products from fuels and Solvent use								
Greenhouse gas source and sink categories	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**	**SO_2**	**Notes***
2.D.1. Lubricant Use	X	NO	NO	NO	NO	NO	NO	
2.D.2. Paraffin Wax use	X	NO	NO	NO	NO	NO	NO	
2.D.3. Other – Solvent Use	X	NO	NO	NO	X	X	NO	Indirect CO_2 emissions from NMVOC emissions are reported.
2.D.3. Other – Road paving with asphalt	X	NO	NO	NO	NO	X	NO	Indirect CO_2 emissions from NMVOC emissions are reported.
2.D.3 Other; Other – Urea based catalysts for motor vehicles	X	NO	NO	NO	NO	NO	NO	

2.C. Metal Production												
Greenhouse gas source and sink categories	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**	**SO_2**	**HFCs**	**PFCs**	**SF_6**	**NF_3**	**Unspecified mix of HFC and PFC**
2.C.1. Iron and Steel Production	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA	NA
2.C.2.Ferroalloys Production	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA	NA
2.C.3. Aluminium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.4. Magnesium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.5. Lead Production	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA	NA
2.C.6 Zinc Production	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA	NA
2.C.7 Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories	**HFCs**	**PFCs**	**Unspecified mix of HFCs and PFCs**	**SF_6**	**NF_3**	**Notes***
2.E. Electronics Industry						
2.E.1. Integrated Circuit or Semiconductor	NO	NO	NO	NO	NO	
2.E.2. TFT Flat Panel Display	NO	NO	NO	NO	NO	
2.E.3. Photovoltaics	NO	NO	NO	NO	NO	
2.E.4. Heat Transfer Fluid	NO	NO	NO	NO	NO	
2.E.5. Other	NO	NO	NO	NO	NO	
2.F. Product Uses and Substitutes for ODS						
2.F.1. Refrigeration and Air Conditioning	X	NO	NO	NO	NO	
2.F.2. Foam Blowing Agents	X	NO	NO	NO	NO	
2.F.3. Fire Protection	X	NO	NO	NO	NO	
2.F.4. Aerosols	X	NO	NO	NO	NO	
2.F.5. Solvents	NO	NO	NO	NO	NO	It was checked from relevant databases that HFCs have been sold in Estonia only for use in categories 2.F.1-2.F.4.
2.F.6. Other applications using ODS Substitutes	NO	NO	NO	NO	NO	It was checked from relevant databases that HFCs have been sold in Estonia only for use in categories 2.F.1-2.F.4.

Greenhouse gas source and sink categories	HFCs	PFCs	SF_6	N_2O	Notes*
2.G. Other Product Manufacture and Use					
2.G.1 Electrical Equipment	NO	NO	X	NO	
2.G.2. Other - Particle accelerators	NO	NO	X	NO	
2.G.2. Other – Sport Shoes	NO	NO	NO	NO	PFC emissions from sport shoes with gas cushion occurred in Estonia from 2006 to 2008 and SF_6 emissions from 1995 to 2006.
2.G.2. Other – Car tyres	NO	NO	NO	NO	SF_6 emissions from car tyres occured in 1993–2003.
2.G.3.a N_2O from Medical Applications	NO	NO	NO	X	
2.G.3.b Other – Propellant for pressure and aerosol products	NO	NO	NO	X	

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2	Notes*
2.H. Other Production								
2.H.1. Pulp and Paper	NO	NO	NO	X	X	X	X	
2.H.2. Food and beverages	NO	NO	NO	NO	NO	X	NO	

Agriculture (CRF 4)

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2	Notes*
3.A. Enteric Fermentation	NO	X	NO	NO	NO	NO	NO	CO_2 emissions from livestock are not estimated because annual net CO_2 emissions are assumed to be zero – the CO_2 photosynthesized by plants is returned to the atmosphere as respired CO_2.
3.B. Manure Management	NO	X	X	NO	NO	X	NO	
3.C. Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	
3.D. Agricultural soils				X				
3.D.1. Direct Soil Emissions								
3.D.1.1. Synthetic Fertilizers	NO	NO	X	NO	NO	NO	NO	
3.D.1.2. Organic N Fertilizers	NO	NO	X	NO	NO	NO	NO	
3.D.1.3. Urine and Dung Deposited by Grazing Animals	NO	NO	X	NO	NO	NO	NO	
3.D.1.4. Crop Residues	NO	NO	X	NO	NO	NO	NO	
3.D.1.5. Mineralization/Immobilization Associated with Loss/Gain of Soil Organic Matter	NO	NO	NO	NO	NO	NO	NO	No management changes in cropland remaining cropland have occurred in Estonia during 1990–2015, hence no

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2	Notes*
								emissions have been reported under this section.
3.D.1.6. Cultivation of Organic Soils	NO	NO	X	NO	NO	NO	NO	
3.D.2. Indirect Emissions	NO							
3.D.2.1. Atmospheric Deposition	NO	NO	X	NO	NO	NO	NO	
3.D.2.2. Nitrogen Leaching and Run-off	NO	NO	X	NO	NO	NO	NO	
3.E. Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	There are no savannas in Estonia.
3.F. Field Burning of Agricultural Residues	NO	NO	NO	NO	NO	NO	NO	Burning of agricultural residues is not a common practice in Estonia.
3.G. Liming	X	NO	NO	NO	NO	NO	NO	
3.H. Urea Application	X	NO	NO	NO	NO	NO	NO	

Waste (CRF 5)

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	Notes*
5.A. Solid waste disposal on land								
5.A.1. Managed waste disposal on land								Based on the 2006 IPCC Guidelines, CO_2 emissions from Solid Waste Disposal is not included in national total emission estimates, because the carbon is of biogenic origin and net emissions are accounted for under AFOLU Sector. N_2O emissions from Solid Waste Disposal on Land are not significant and there is no methodology provided to calculate the emissions.
5.A.1.a. Aerobic	NE	X	NE	NE	NE	NE	NE	
5.A.1.b. Semi- aerobic	NO	NO	NO	NO	NO	NO	NO	
5.A.2. Unmanaged waste disposal sites	NO	NO	NO	NO	NO	NO	NO	
5.A.3. Uncategorized waste disposal on land	NE	X	NE	NE	NE	NE	NE	
5.B. Biological treatment of solid waste								
5.B.1. Composting	NO	X	X	NE	NE	NE	NE	

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	Notes*
5.B.2. Anaerobic digestion at biogas facility	NE	NE	NE	NE	NE	NE	NE	The emission from anaerobic digestion with energy recovery has been reported under Energy sector (CRF 1.A.1.A) as an aggregated total biogas production in Estonia. There is currently no anaerobic digestion taking place without energy recovery. Estonia has estimated unintentional leakages during process disturbance or other unexpected events which resulted with insignificant emission based on the National Inventory reporting guidance provided in the National Inventory reporting guidance, paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.
5.C. Incineration and open burning of waste								
5.C.1. Waste incineration								
5.C.1.1. Biogenic	NE	X	X	NE	NE	NE	NE	Based on the 2006 IPCC Guidelines, CO_2 emissions from Incineration of biogenic material is not included in national total emission estimates.
5.C.1.2. Non-biogenic	X	X	X	NE	NE	NE	NE	
5.C.2. Open Burning of Waste				X	X	X	X	
5.C.2.1. Biogenic	NE	X	X	NE	NE	NE	NE	Based on the 2006 IPCC Guidelines, CO_2 emissions from Open Burning of biogenic material is not included in national total emission estimates. NO_x, CO and NMVOC from Open Burning of waste from both biogenic and non-biogenic sources is reported as a sum under 5.C.2 Open burning of Waste
5.C.2.2. Non-biogenic	X	X	X	NE	NE	NE	NE	
5.D. Wastewater Treatment and Discharge								

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	Notes*
5.D.1. Domestic wastewater	NO	X	X	NE	NE	NE	NE	
5.D.2. Industrial wastewater	NO	X	NO	NE	NE	NE	NE	
6.E. Other (Biogas burnt in a flare)	NE	X	X	NE	NE	NE	NE	CO_2 emissions from Biogas burnt in a flare are biogenic origin and therefore not estimated
6.F. Memo items	NO	NO	NO	NO	NO	NO	NO	

LULUCF (CRF 4)

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	Notes*
4.A. Forest Land							
Carbon stock change	X	NO	NA	NE	NE	NE	
4(I) Direct N_2O emissions from N Inputs to Managed Soils	NA	NA	NO	NE	NE	NE	Estonia does not have sufficient data regarding direct N2O emissions from N Mineralization/ Immobilization.
4(III) Direct N2O Emissions from N Mineralization/Immobilization	NA	NA	NE	NE	NE	NE	
4(IV) Indirect N2O Emissions from Managed Soils	NA	NA	NA	NE	NE	NE	
4(V) Biomass burning	IE, NO	X	X	NE	NE	NE	CO_2 emission estimates are included in FL remaining FL living biomass emission estimates due to *Stock Change method* used.
4.A.1. Forest Land remaining Forest Land							
Carbon stock change	X	NO	NA	NE	NE	NE	
4(I) Direct N_2O emissions from N fertilization	NA	NA	NO	NE	NE	NE	According to Estonian Forest Act, application of mineral fertilizers is prohibited in forests.
4(V) Biomass burning	IE, NO	X	X	NE	NE	NE	CO_2 emission estimates are included in FL remaining FL living biomass emission estimates due to *Stock Change method* used.
4.A.2. Land converted to Forest Land							
4.A.2.1. Cropland converted to Forest Land	X	NO	NA	NE	NE	NE	
4.A.2.2. Grassland converted to Forest Land	X	NO	NA	NE	NE	NE	
4.A.2.3. Wetlands converted to Forest Land	X	NO	NA	NE	NE	NE	
4.A.2.4. Settlements converted to Forest Land	X	NO	NA	NE	NE	NE	
4.A.2.5. Other Land converted to Forest Land	X	NO	NA	NE	NE	NE	
4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils	NA	NA	NA	NA	NE	NE	According to 2006 IPCC it is not mandatory to report CH_4 and N_2O

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	Notes*
							emissions here, but improvements are planned to better estimate non-CO2 emissions from drainage of forest soils.
4.B. Cropland							
Carbon stock change	X	NO	NA	NE	NE	NE	
4(III) Direct N2O Emissions from N Mineralization/Immobilization	NA	NA	NO	NE	NE	NE	Estonia does not have sufficient data regarding direct N2O emissions from N Mineralization/ Immobilization.
4(V) Biomass burning	NO	NO	NO	NE	NE	NE	
4.B.1. Cropland remaining Cropland							
Carbon Stock Change	X	NO	NA	NE	NE	NE	
4(V) Biomass Burning	NO	NO	NO	NE	NE	NE	
4.B.2. Land converted to Cropland							
4.B.2.1. Forest Land Converted to Cropland	X	NO	NA	NE	NE	NE	
4.B.2.2. Grassland converted to Cropland	X	NO	NA	NE	NE	NE	
4.B.2.3. Wetlands converted to Cropland	X	NO	NA	NE	NE	NE	
4.B.2.4. Settlements converted to Cropland	NO	NO	NA	NE	NE	NE	
4.B.2.5. Other land converted to Cropland	NO	NO	NA	NE	NE	NE	
4(III) Direct N2O Emissions from N Mineralization/Immobilization	NA	NA	X	NE	NE	NE	
4(V) Biomass Burning	NO	NO	NO	NE	NE	NE	
4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils	NA	NA	NA	NE	NE	NE	According to 2006 IPCC it is not mandatory to report this category.
4.C. Grassland							
Carbon Stock Change	X	NO	NA	NE	NE	NE	
4(V) Biomass Burning	IE, NO	X	X	NE	NE	NE	CO_2 emission estimates are included in GL remaining GL living biomass emission estimates due to *Stock Change method* used.
4.C.1. Grassland remaining Grassland							
Carbon stock change	X	NO	NA	NE	NE	NE	
4 (V) Biomass Burning	IE, NO	X	X	NE	NE	NE	
4.C.2. Land converted to Grassland							
4.C.2.1. Forest Land Converted to Grassland	X	NO	NA	NE	NE	NE	
4.C.2.2. Cropland converted to Grassland	X	NO	NA	NE	NE	NE	
4.C.2.3. Wetlands converted to Grassland	X	NO	NA	NE	NE	NE	
4.C.2.4. Settlements converted to Grassland	X	NO	NA	NE	NE	NE	
4.C.2.5. Other land converted to Grassland	X	NO	NA	NE	NE	NE	
4(V) Biomass Burning	IE, NO	IE, NO	IE, NO	NE	NE	NE	
4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils	NA	NA	NA	NE	NE	NE	According to 2006 IPCC it is not mandatory to report this category.

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	Notes*
4.D. Wetlands							
Carbon Stock Change	X	NO	NA	NE	NE	NE	
4(V) Biomass Burning	IE, NO	IE, NO	IE, NO	NE	NE	NE	Reported under category 4.C.1 Grassland remaining Grassland 4(V) Biomass Burning due to combined statistical data.
5.D.1. Wetlands remaining Wetlands							
Carbon Stock Change/ Peat extraction	X	X	X	NE	NE	NE	
4(V) Biomass Burning	IE, NO	IE, NO	IE, NO	NE	NE	NE	Reported under category 4.C.1 Grassland remaining Grassland 4(V) Biomass Burning due to combined statistical data.
4.D.2. Land converted to Wetlands							
4.D.2.1. Forest Land Converted to Wetlands	X	NO	NA	NE	NE	NE	
4.D.2.2. Cropland converted to Wetlands	NO	NO	NA	NE	NE	NE	
4.D.2.3. Grassland converted to Wetlands	NA	NA	NA	NE	NE	NE	This is a non human-induced land-use change, thus no emissions are reported, area is reported.
4.D.2.4. Settlements converted to Wetlands	NO	NO	NA	NE	NE	NE	
4.D.2.5. Other land converted to Wetlands	NO	NO	NA	NE	NE	NE	
4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils	NA	X	X	NE	NE	NE	According to 2006 IPCC it is not mandatory to report this category.
4.E. Settlements							
4.E.1. Settlements remaining Settlements	NE	NE	NE	NE	NE	NE	
4.E.2. Land converted to Settlements	X	NO	NA	NE	NE	NE	
4.E.2.1. Forest Land Converted to Settlements	X	NO	NA	NE	NE	NE	
4.E.2.2. Cropland converted to Settlements	X	NO	NA	NE	NE	NE	
4.E.2.3. Grassland converted to Settlements	X	NO	NA	NE	NE	NE	
4.E.2.4. Wetlands converted to Settlements	NO	NO	NA	NE	NE	NE	
4.E.2.5. Other land converted to Settlements	X	NO	NA	NE	NE	NE	
4.F. Other Land							
4.F.2.1. Forest Land converted to Other Land	X	NO	NA	NE	NE	NE	
4.F.2.2. Cropland converted to Other Land	X	NO	NA	NE	NE	NE	
4.F.2.3. Grassland converted to Other Land	X	NO	NA	NE	NE	NE	
4.F.2.4. Wetlands converted to Other Land	X	NO	NA	NE	NE	NE	
4.F.2.5. Settlements converted to Other Land	NO	NO	NA	NE	NE	NE	
4.G. Harvested Wood Products							
HWP from domestic harvest	X						
4.H. Other (please specify)							
	NA	NA	NA	NA	NA	NA	

Annex 6. Standard Independent Assessment Report

NATIONAL REGISTRY OF ESTONIA

STANDARD INDEPENDENT ASSESSMENT REPORT

To the UNFCCC secretariat

2016

Tallinn 2017

PREFACE

Standard Independent Assessment Report of National Registry (hereinafter as NR) of Estonia under the United Nations Framework Convention on Climate Change (hereinafter as UNFCCC) contains the following parts:

Part I. Description Kyoto Protocol Units

Part II. Changes to National Registry

Part III Appendixes

Johanna-Maria Siilak (Registry System Administrator (hereinafter as RSA) of National Registry of Estonia from Climate and Radiation Department of the Ministry of the Environment (hereinafter as MoE)) has compiled the Standard Independent Assessment Report 2016 (hereinafter as SIAR) and other information included in this report.

In this document, 2016 refers to the year for which the data is submitted, and not to the year of submission (publication).

ABBREVIATIONS

UNFCCC – United Nations Framework on Climate Change Convention

EE – Estonia

CDM – Clean Development Mechanism

MoE– Ministry of the Environment

NR – National Registry

CPR – Commitment Period Reserve

RSA – Registry System Administrator

SEF – Standard Electronic Format

ITL – International Transaction Log

CITL – Community Transaction Log

KP – Kyoto Protocol

CR – Community Registry

ERT – Expert Review Team

IAR – Independent Assessment Report

SIAR – Standard Independent Assessment Report

EU ETS – European Union Emission Trading Scheme

NIR – National Inventory Report

CITL – Community Independent Transaction Log

EULT – European Union Transaction Log

ERU – Emission Reduction Unit

CER – Certified Emission Reduction Unit

lCER – Long-term Certified Emission Reduction Unit

tCER – Temporary Certified Emission Reduction Unit

RMU – Removal Unit

1. PART I. KYOTO PROTOCOL UNITS

1.2 Information on Accounting of the Kyoto Protocol Units (Chapter 12 of NIR)

The following reports are described in this document and correspond to the requirements of decisions 14/CMP.1 and 15/CMP.1. Information required under Decision 15/CMP.1 paragraph 11 is displayed as required by UNFCCC ITL Administrators' "Standard Independent Assessment Report. Reporting Requirements and Guidance for Registries v4.7" in "RREG1_EE_2016.xls". The Standard Electronic Format (hereinafter as SEF) report for 2016 has been submitted to the UNFCCC Secretariat electronically and the contents of the report can also be found as Appendix 1 of this document. The SEF tables include information about AAU, ERU, CER, t-CER, l-CER and RMU in Estonian National Registry (hereinafter as NR) standing 31st of December 2016. Also the SEF includes information on transfers of the units during the year 2016.

The total number of units in the NR at the beginning of the year 2016 was 113 261 158

AAUs, 6 437 491 ERUs and 654 680 CERs. In the end of the year the total balance of units was: 113 261 158 AAUs (90 835 022 in retirement, 216 300 in cancellation accounts and 2 340 907 in Article 3.3/3.4 Net-Source Cancellation accounts), 6 437 491 ERUs (4 255 338 in retirement account and in 54 815 in Article 3.3/3.4 Net-Source Cancellation accounts), 494 851 RMUs in Article 3.3/3.4 Net-Source Cancellation accounts and 654 680 CERs (214 157 in retirement account). Estonian NR did not contain any t-CERs or l-CERs nor were there any units on the t-CER and l-CER Replacement accounts.

The total amount of the units in the registry corresponded to 120 848 180.

SEF report will be also included in Estonian Standard Independent Assessment Report (hereinafter as SIAR) 2016 report as Appendix 1 (as SIAR Report R-1).

Annual Submission Item	Reporting Guidance
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	The Standard Electronic Format report for 2016 has been submitted to the UNFCCC Secretariat electronically. SEF, containing the information required in paragraph 11 of the annex to decision 15/CMP.1, is included in the "Greenhouse Gas emissions in Estonia 1990–2015. National Inventory Report under the UNFCCC and the Kyoto Protocol. Common Reporting Formats (CRF) 1990-2015. Tallinn 2017" (hereinafter as NIR) in Chapter 12.2 "Summary of information reported in the SEF tables" and the report is a part of NIR as Annex 6. This SEF report is referenced as report R-1 in this document. See Appendix 1 for more details related to the SEF report.
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	Information of discrepant transactions is included in the NIR in Chapter 12.3 "Discrepancies and notifications" and the report is a part of NIR as Annex 6. The report of discrepant transactions is referenced as report R-2 in this document. See Appendix 2 for more details related to the discrepant transactions. No discrepancies and no notifications occurred in 2016.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	Information on CDM notifications is included in the NIR in Chapter 12.3 "Discrepancies and notifications" and report is a part of NIR as Annex 6.

Annual Submission Item	Reporting Guidance
	The report of CDM notifications is referenced as report R-3 in this document. See Appendix 3 for more details related to the discrepant transactions. No CDM notifications occurred in 2016.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	Information on non-replacements is included in the NIR as Chapter 12.3 "Discrepancies and notifications" and report is a part of NIR as Annex 6. The report on non-replacements is referenced as report R-4 in this document. See Appendix 3 for more details related to the non-replacements. No non-replacements occurred in 2016.
15/CMP.1 annex I.E paragraph 16: List of invalid units	Information of invalid units is included in the NIR as Chapter 12.3 "Discrepancies and notifications" and report is a part of NIR as Annex 6. The report of invalid units is referenced as report R-5 of this document. See Appendix 3 for more details related to the list of invalid units. No invalid units exist as at 31.12.2016.
15/CMP.1 annex I.E paragraph 17	No actions were taken or changes made to address discrepancies for the period under review. No change occurred during the reported period.

Annual Submission Item	Reporting Guidance
Actions and changes to address discrepancies	
15/CMP.1 annex I.E Publicly accessible information	Following information is publicly accessible via user interface of the MoE http://www.envir.ee/et/kyoto-protokoll. Information regarding the NR is publicly available to users via MoE web page http://www.envir.ee/et/euroopa-liidu-kasvuhoonegaaside-heitkogustega-kauplemise-susteem and http://www.envir.ee/et/euroopa-liidu-kasvuhoonegaaside-heitkogustega-kauplemise-perioodid. Due to the updates on the publicly available information web page in year 2011, information referred in Decision 13/CMP.1; II Registry requirements; E. Publicly accessible information in paragraphs 45-48 are as following: 3. account information (information on paragraph 45 of annex to the decision 13/CMP.1); 4. JI projects in Estonia (information on paragraph 46 of annex to the decision 13/CMP.1); 5. information about unit holdings and transactions (information on paragraph 47 of annex to the decision 13/CMP.1); 6. information about Entities Authorized to hold units (information on paragraph 48 of annex to the decision 13/CMP.1). This information is currently available at: 1) **Paragraph 45 of annex to the decision 13/CMP.1** (account information). This information is available to users via user interface of the MoE http://www.envir.ee/et/kyoto-protokoll and via EUTL

Annual Submission Item	Reporting Guidance
	http://ec.europa.eu/environment/ets/ (selecting from left hand menu "ETS" – "Accounts" – "select Estonia" – "Search"); 2) **Paragraph 46 of annex to the decision 13/CMP.1** (information of JI projects in Estonia). This information is available to users via user interface of the web page of the Ministry of the Environment http://www.envir.ee/et/kyoto-protokoll (selecting the headline "Ühisrakendusprojektide ülevaade / JI projects overview"); 3) Paragraph 47 of annex to the decision 13/CMP.1 (information about unit holdings and transactions). Following information is publicly accessible via user interface of the EUTL http://ec.europa.eu/environment/ets/ (selecting from left hand menu "Transactions" - "Selecting Estonia and other relevant parameters displayed in the search field" – "Search"). In accordance with the annex XVI of the EC regulation (No 2216/2004 of 21 Dec. 2004) "the information for each completed transaction relevant for the registries system for year X shall be displayed from 15 January onwards of year X+5". 4) Paragraph 48 of annex to the decision 13/CMP.1 (information about Entities Authorised to hold units under its responsibility). The Decision 280/2004/EC of the European Parliament and of the Council requires EU Member States to provide information on the legal entities authorized to participate in the mechanism under Articles 6, 12 and 17 of the Kyoto Protocol in the NIR. According to the Estonian national legislation (Atmospheric Air Protection Act §143) the Ministry of the Environment as competent authority is authorized to trade with AAUs, RMUs, ERUs and CERs. Installations falling under the scope of the Directive 2003/87/EC are authorised to use ERUs and CERs for compliance according to the percentage set out in National Allocation Plan for 2008-2012. This information is available to users via user interface of the web page of the Ministry of the Environment:

Annual Submission Item	Reporting Guidance
	http://www.envir.ee/et/euroopa-liidu-kasvuhoonegaaside-heitkogustega-kauplemise-perioodid selecting "Euroopa Liidu kasvuhoonegaaside heitkogustega kauplemise periood 2008-2012". Public information required by Commission regulation (EC) No 920/2010 (in addition to the above-mentioned public information): 1) Installation and permit details - information about installations and permit details is available to users via user interface of MoE http://www.envir.ee/et/euroopa-liidu-kasvuhoonegaaside-heitkogustega-kauplemise-susteem under "ELi HKSi kuuluvate käitiste unikaalsed koodid" and via EUTL http://ec.europa.eu/environment/ets/welcome.do?languageCode=en selecting from left hand menu "ETS" – "Operator Holding Accounts" - "Search" – "selecting Estonia"; 2) Information about verified emissions, surrenders and compliance status of installations - information about verified emissions, surrenders and compliance status of installations is available to users via user interface of the MoE web page at http://www.envir.ee/et/euroopa-liidu-kasvuhoonegaaside-heitkogustega-kauplemise-perioodid and from the interface of the EUTL http://ec.europa.eu/environment/ets/ selecting from left hand menu "ETS" – "Allocation/Compliance" - "Search" - selecting Estonia; 3) National allocation plan for Estonia (NAP) - information on national allocation plan for Estonia (NAP) is available via user interface of the MoE web page at http://test.envir.ee/et/euroopa-liidu-kasvuhoonegaaside-heitkogustega-kauplemise-perioodid and via EUTL web page http://ec.europa.eu/environment/ets/ selecting from left hand menu "NAP-info" - "Search" - selecting Estonia.
15/CMP.1 annex I.E paragraph 18	Parties are required by decision 11/CMP.1 under the Kyoto Protocol and paragraph 18 of Decision 1/CMP.8 to establish and maintain a

Annual Submission Item	Reporting Guidance
CPR Calculation	commitment period reserve as part of their responsibility to manage and account for their assigned amount. The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8. For the purposes of the joint fulfilment, the commitment period reserve applies to the EU, its Member States and Iceland individually. Both methods to calculate Estonia's commitment period reserve are presented hereinafter: 3. 90% of a Party's assigned amount 90% from 51 056 976= 45 951 278.4 tonnes of CO_2 equivalent. 4. 100% of most recently reviewed inventory multiplied by 8 (Estonia has interpreted the 'most recently reviewed inventory' as the 2016 inventory submission) 21 059 240*8= 168 473 920 tonnes of CO_2 equivalent. Consequently the commitment period reserve for Estonia is **45 951 279** tonnes of CO_2 equivalent.

2. PART II. CHANGES IN THE NATIONAL REGISTRY

2.1 Information on Changes in National Registry (Chapter 14 of NIR)

Directive 2009/29/EC adopted in 2009, provides for the centralization of the EU ETS operations into a single European Union registry operated by the European Commission as well as for the inclusion of the aviation sector. At the same time, and with a view to increasing efficiency in the operations of their respective national registries, the EU Member States who are also Parties to the Kyoto Protocol (25) plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and decision 24/CP.8.

With a view to complying with the new requirements of Commission Regulation 920/2010 and Commission Regulation 1193/2011, in addition to implementing the platform shared by the consolidating Parties, the registry of EU has undergone a major re-development. The consolidated platform which implements the national registries in a consolidated manner (including the registry of EU) is called Consolidated System of EU registries (CSEUR) and was developed together with the new EU registry on the basis the following modalities:

(1) Each Party retains its organization designated as its registry administrator to maintain the national registry of that Party and remains responsible for all the obligations of Parties that are to be fulfilled through registries;

(2) Each Kyoto unit issued by the Parties in such a consolidated system is issued by one of the constituent Parties and continues to carry the Party of origin identifier in its unique serial number;

(3) Each Party retains its own set of national accounts as required by paragraph 21 of the Annex to Decision 15/CMP.1. Each account within a national registry keeps a unique account number comprising the identifier of the Party and a unique number within the Party where the account is maintained;

(4) Kyoto transactions continue to be forwarded to and checked by the UNFCCC Independent Transaction Log (ITL), which remains responsible for verifying the accuracy and validity of those transactions;

(5) The transaction log and registries continue to reconcile their data with each other in order to ensure data consistency and facilitate the automated checks of the ITL;

(6) The requirements of paragraphs 44 to 48 of the Annex to Decision 13/CMP.1 concerning making non-confidential information accessible to the public would be fulfilled by each Party individually;

(7) All registries reside on a consolidated IT platform sharing the same infrastructure technologies. The chosen architecture implements modalities to ensure that the consolidated national registries are uniquely identifiable, protected and distinguishable from each other, notably:

(a) With regards to the data exchange, each national registry connects to the ITL directly and establishes a distinct and secure communication link through a consolidated communication channel (VPN tunnel);

(b) The ITL remains responsible for authenticating the national registries and takes the full and final record of all transactions involving Kyoto units and other administrative processes such that those actions cannot be disputed or repudiated;

(c) With regards to the data storage, the consolidated platform continues to guarantee that data is kept confidential and protected against unauthorized manipulation;

(d) The data storage architecture also ensures that the data pertaining to a national registry are distinguishable and uniquely identifiable from the data pertaining to other consolidated national registries;

(e) In addition, each consolidated national registry keeps a distinct user access entry point (URL) and a distinct set of authorisation and configuration rules.

Following the successful implementation of the CSEUR platform, the 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20

June 2012. During the go-live process, all relevant transaction and holdings data were migrated to the CSEUR platform and the individual connections to and from the ITL were re-established for each Party.

The following changes to the national registry of Estonia have occurred in 2016:

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	The registry administrator was changed from Johanna-Maria Siilak to Piret Väinsalu. National administrator is: Ms. Piret Väinsalu khgregister@envir.ee tel. +372 6262 851
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality. Versions of the CSEUR released after 6.7.3 (the production version at the time of the last Chapter 14 submission) introduced other minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model, including the new tables, is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 6.7.3 of the national registry are listed in Annex B. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). Annex H testing was completed in January 2017 and the test report is attached. No other change in the registry's conformance to the technical standards occurred for the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The mandatory use of hard tokens for authentication and signature was introduced for registry administrators.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 6.7.3 of the national registry are listed in Annex B. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission; the report is attached as Annex B. Annex H testing was carried out in January 2017 and the test report is attached.

3. PART III. APPENDIXES

Appendix 1 – Report R-1: SEF_2016

Party	Estonia
Submission Year	2017
Reported Year	2016
Commitment Period	1

Table 1. Total quantities of Kyoto Protocol units by account type at beginning of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	19 868 929	2 127 093	NO	424 474	NO	NO
Entity holding accounts	NO	245	NO	16 049	NO	NO
Article 3.3/3.4 net source cancellation accounts	2 340 907	54 815	494 851	NO		
Non-compliance cancellation account	NO	NO	NO	NO		
Other cancellation accounts	216 300	NO	NO	NO	NO	NO
Retirement account	90 835 022	4 255 338	NO	214 157	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	113 261 158	6 437 491	494 851	654 680	NO	NO

Party	Estonia
Submission Year	2017
Reported Year	2016
Commitment Period	1

Table 2a. Annual internal transactions

	Additions						Subtractions					
Transaction type	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Art6 issuance and conversion												
Party verified projects		NO					NO		NO			
Independently verified projects		NO					NO		NO			
Art3.3 and 3.4 issuance or cancellation												
3.3 Afforestation reforestation			NO				NO	NO	NO	NO		
3.3 Deforestation			NO				NO	NO	NO	NO		
3.4 Forest management			NO				NO	NO	NO	NO		
3.4 Cropland management			NO				NO	NO	NO	NO		
3.4 Grazing land management			NO				NO	NO	NO	NO		
3.4 Revegetation			NO				NO	NO	NO	NO		
Art 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired lCERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Other cancellation							NO	NO	NO	NO	NO	NO
Subtotal		NO	NO				NO	NO	NO	NO	NO	NO

Transaction type	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Retirement	NO	NO	NO	NO	NO	NO

Party	Estonia
Submission Year	2017
Reported Year	2016
Commitment Period	1

Table 2b. Annual external transactions

	Additions						Subtractions					
Transfers and acquisitions	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Subtotal	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Additional Information

	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Independently verified ERU								NO				

Table 2c. Total annual transactions

	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Total (Sum of table 2(a) and 2(b))	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Party	Estonia
Submission Year	2017
Reported Year	2016
Commitment Period	1

Table 3. Expiry, cancellation and replacement

	Expiry, cancellation and requirement to replace		Replacement					
Transaction or event type	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Temporary CERs (tCERs)								
Expired in retirement and replacement accounts	NO							
Replacement of expired tCERs			NO	NO	NO	NO	NO	
Expired in holding accounts	NO							
Cancellation of tCERs expired in holding accounts	NO							
Long-term CERs (lCERs)								
Expired in retirement and replacement accounts		NO						
Replacement of expired lCERs			NO	NO	NO	NO		
Expired in holding accounts		NO						
Cancellation of lCERs expired in holding accounts		NO						
Subject to replacement for reversal of storage		NO						
Replacement for reversal of storage			NO	NO	NO	NO		NO
Subject to replacement for non-submission of certification report		NO						
Replacement for non-submission of certification report			NO	NO	NO	NO		NO
Total			NO	NO	NO	NO	NO	NO

Party	Estonia
Submission Year	2017
Reported Year	2016
Commitment Period	1

Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	19 868 929	2 127 093	NO	424 474	NO	NO
Entity holding accounts	NO	245	NO	16 049	NO	NO
Article 3.3/3.4 net source cancellation accounts	2 340 907	54 815	494 851	NO		
Non-compliance cancellation account	NO	NO	NO	NO		
Other cancellation accounts	216 300	NO	NO	NO	NO	NO
Retirement account	90 835 022	4 255 338	NO	214 157	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	113 261 158	6 437 491	494 851	654 680	NO	NO

Party	Estonia
Submission Year	2017
Reported Year	2016
Commitment Period	1

Table 5a. Summary information on additions and subtractions

	Additions						Subtractions					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Starting Values												
Issuance pursuant to Article 3.7 and 3.8	196 062 637											
Non-compliance cancellation							NO	NO	NO	NO		
Carry-over	NO	NO		NO								
Subtotal	196 062 637	NO		NO			NO	NO	NO	NO		
Annual Transactions												
Year 0 (2007)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 1 (2008)	1 238 538	NO	NO	NO	NO	NO	90 538	NO	NO	NO	NO	NO
Year 2 (2009)	309 318	44 934	NO	957	NO	NO	1 056 151	NO	NO	NO	NO	NO
Year 3 (2010)	22 964 195	337 510	NO	NO	NO	NO	42 322 448	184 371	NO	NO	NO	NO
Year 4 (2011)	5 443 848	334 550	NO	NO	NO	NO	38 482 265	519 175	NO	NO	NO	NO
Year 5 (2012)	735 465	4 240 658	NO	28 594	NO	NO	13 930 921	495 627	NO	NO	NO	NO
Year 6 (2013)	NO	9 227 950	NO	424 474	NO	NO	13 518 351	10 663 487	NO	12 996	NO	NO
Year 7 (2014)	3 437	NO	NO	1 120	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	4 114 549	494 851	212 531	NO	NO	6 652 813	54 815	494 851	NO	NO	NO
Subtotal	30 694 801	18 300 151	494 851	667 676	NO	NO	116 053 487	11 917 475	494 851	12 996	NO	NO
Total	226 757 438	18 300 151	494 851	667 676	NO	NO	116 053 487	11 917 475	494 851	12 996	NO	NO

Table 5b. Summary information on replacement

	Expiry, cancellation and requirement to replace		Replacement					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Previous CPs			NO	NO	NO	NO	NO	NO
Year 1 (2008)		NO	NO	NO	NO	NO	NO	NO
Year 2 (2009)		NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)		NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)		NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO	NO	NO

Table 5c. Summary information on retirement

Year	Retirement					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Year 1 (2008)	NO	NO	NO	NO	NO	NO
Year 2 (2009)	13 552 575	NO	NO	NO	NO	NO
Year 3 (2010)	10 115 135	NO	NO	NO	NO	NO
Year 4 (2011)	14 345 407	NO	NO	NO	NO	NO
Year 5 (2012)	15 072 383	141 034	NO	16 555	NO	NO
Year 6 (2013)	15 072 383	141 034	NO	16 555	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO
Year 8 (2015)	37 749 522	4 114 304	NO	197 602	NO	NO
Total	105 907 405	4 396 372	NO	230 712	NO	NO

Party	Estonia
Submission Year	2017
Reported Year	2016
Commitment Period	1

Table 6a. Memo item: corrective transactions relating to additions and subtractions

Additions						Subtractions					
AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Table 6b. Memo item: corrective transactions relating to replacement

Expiry, cancellation and requirement to replace		Replacement					
tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Table 6c. Memo item: corrective transactions relating to retirement

Retirement					
AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Appendix 2 – Report R-2: List of Discrepant Transactions

No discrepant transactions to list for the reporting period.

Appendix 3 – Report R-3, Report R-4 and Report R-5

List of CDM Notifications - No CDM notifications where received during the reporting period.

List of Non-replacements - No non-replacements occurred during the reporting period.

List of Invalid Units - No invalid units to list for the reporting period.

Appendix 4 – Further Detailed Information about Reporting Changes to National Registry

A complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. This description includes:

- **Readiness questionnaire**
- **Application logging**
- **Change management procedure**
- **Disaster recovery**
- **Manual Intervention**
- **Operational Plan**
- **Roles and responsibilities**
- **Security Plan**
- **Time Validation Plan**
- **Version change Management**

The documents above are provided as an appendix to this document.