



REPUBLIC OF ESTONIA
MINISTRY OF CLIMATE

GREENHOUSE GAS EMISSIONS IN ESTONIA 1990-2024 NATIONAL INVENTORY DOCUMENT

SUBMISSION TO THE UNFCCC SECRETARIAT

Common Reporting Tables (CRT) 1990–2024

PREFACE

Estonia's National Inventory Document (NID) to the UNFCCC Secretariat contains following parts:

Description of the greenhouse gas emission inventory according to the UNFCCC reporting guidelines (18/CMA.1) containing description of the organization of the national greenhouse gas inventory, IPCC and other methods applied in calculation of the year 2024 emissions and exemptions to the previous inventories. A summarizing table of the emissions data for the years 1990–2024 is included as well as the description of current emission trends.

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The Climate Department of the Estonian Environmental Research Centre Ms Cris-Tiina Pärn and Ms Kadi Meltz coordinated the process of the inventory preparation. Ms Janika Laht from the Estonian Environment Agency coordinated the preparation of LULUCF sector.

The Ministry of Climate is the single national entity with the overall responsibility for the Estonian greenhouse gas inventory. The Estonian Environmental Research Centre has the responsibility for the preparation and finalization of inventory reports and their submission to the UNFCCC Secretariat and the European Commission on behalf of the Ministry of Climate.

Financial resources for inventory compilation are planned in the National Administrative Agreement and State Budget.

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EXECUTIVE SUMMARY

ES.1. Background information on GHG inventories and climate change (e.g. as it pertains to the national context)

Background information on climate change

According to WMO State of the Global Climate 2024¹ was the warmest year on record with the global average near-surface temperature at 1.55 (± 0.13) °C above the pre-industrial baseline. This means that we have likely just experienced the first calendar year with a global mean temperature of more than 1.5°C above the 1850-1900 average. The past ten years, 2015-2024, were the ten warmest years on record.

Europe is the fastest warming continent, with temperatures rising at around twice the global average rate, in 2024 resulting with extreme weather events with severe impact across Europe². In Estonia, the second period of fast warming started in 1970s. January characterizes the highest increase in temperature. Statistically significant warming is also characteristic of April, July and August. According to the climate normal the average temperature for 1991-2020 is 1.5 degrees higher than the average of 1901-1930.

Extreme climate phenomena occur in Estonia from time to time. In summer, hot weather and unstable air stratification along with thunderstorms may result in squalls, downbursts and whirlwinds (tornadoes/ waterspouts) of destructive force. Another extreme event is hail that can accompany heavy rainfall. The diameter of the largest hailstone on record was eight centimetres (2023). Heat waves are more frequent; they last longer and have an impact on people's health.

In winter, the most hazardous climate phenomena have been powerful snowstorms accompanying cyclones, resulting in the obstruction and even closure of road traffic. Episodes of freezing rain can influence road and air traffic and may cause power outages.

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, in 2002 the Kyoto Protocol and in 2016 the Paris Agreement. 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 Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action (hereafter referred to as the EU Governance Regulation)³. The implementation of the EU Governance Regulation is further specified in the Commission Implementing Regulation (EU) No 2020/1208 and the Commission Delegated Regulation (EU) No 2020/1044.

¹ WMO State of the Global Climate in 2024. [www] <https://wmo.int/publication-series/state-of-global-climate-2024> (06.11.2025)

² Copernicus Climate Change Service (C3S) and World Meteorological Organisation (WMO), 2025. [www] <https://climate.copernicus.eu/esotc/2024> (05.03.2026)

³ Regulation (EU) 2018/1999 of the European Parliament and the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action. (EU Governance Regulation)

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

ES.2. Summary of trends related to national emissions and removals

In 2024, the total emissions of GHGs (with indirect CO₂ and with LULUCF), measured as CO₂ eq., were 12 147.17 kt, and without LULUCF 10 240.62 kt. From 1990 to 2024 emissions with LULUCF decreased by 66.5%. Table ES.1 shows the trend in GHG by gases and total emissions with and without LULUCF during the period 1990–2024. Figure ES. 1 shows greenhouse gas emissions trends in 1990–2024 (with indirect CO₂), with LULUCF and without LULUCF in CO₂ eq.

In 2024, the most important GHG in Estonia was carbon dioxide (CO₂), contributing 79.0% to total national GHG emissions expressed in CO₂ eq. (without LULUCF), followed by methane (CH₄), 10.5%, and nitrous oxide (N₂O), 8.6%. Fluorocarbons (so-called ‘F-gases’) account for about 1.8% of total emissions (see Table ES.2). The Energy sector accounted for 79.5% of total GHG emissions (without LULUCF), followed by Agriculture (15.2%), Waste (2.8%) and Industrial processes and product use (2.5%) (including indirect CO₂).

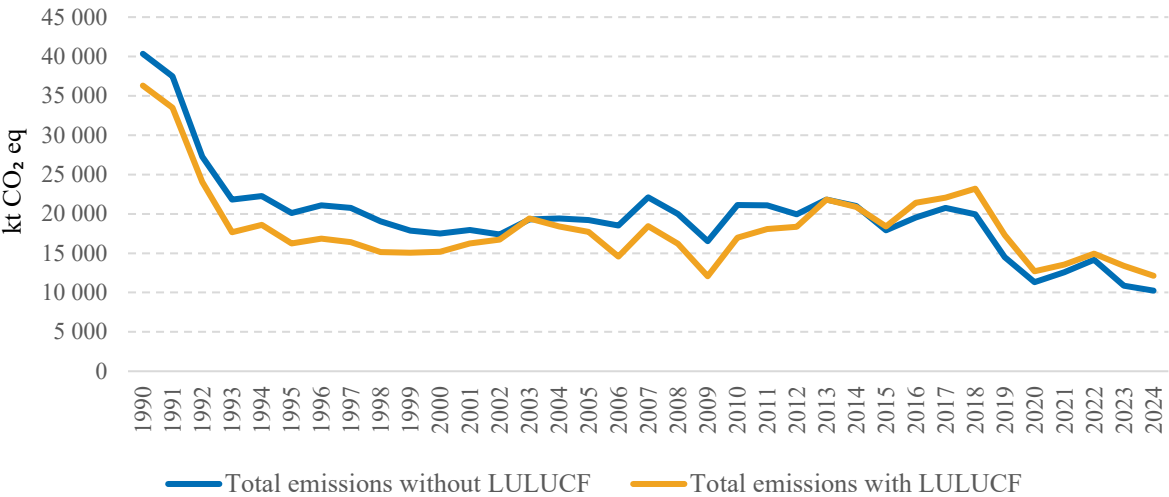


Figure ES. 1. Estonia’s greenhouse gas emissions in 1990–2024 (with indirect CO₂), with LULUCF and without LULUCF, kt CO₂ eq.

Table ES.1. Greenhouse gas emissions in Estonia. Emission trends, kt CO₂ eq.

GREENHOUSE GAS EMISSIONS	1990	2005	2021	2022	2023	2024	Change from base to latest reported year
							(%)
CO ₂ emissions without net CO ₂ from LULUCF	36 906.19	17 089.65	10 391.93	11 971.49	8748.13	8092.59	-78.07
Indirect CO ₂ (from NMVOCs reported under IPPU 2.D.3 Solvent use and road paving with asphalt) *	18.52	21.88	29.31	28.00	24.00	21.85	17.96
CH ₄ emissions without CH ₄ from LULUCF	2189.13	1367.17	1118.65	1102.32	1080.10	1078.49	-50.73
N ₂ O emissions without N ₂ O from LULUCF	1247.08	608.21	864.14	888.97	865.68	880.21	-29.42
HFCs	NO, NA	128.15	190.21	197.10	190.85	185.86	100.00
PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	-
Unspecified mix of HFCs and PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	-
SF ₆	NO,NA	1.11	3.07	3.13	3.21	3.47	100.00
NF ₃	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	-
Total (without LULUCF)	40 342.40	19 194.29	12 568.00	14 163.02	10 887.97	10 240.62	-74.62
Total (with LULUCF)	36 299.12	17 713.60	13 538.96	14 955.37	13 381.39	12 147.17	-66.54
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	2005	2021	2022	2023	2024	Change from base to latest reported year
							(%)
1. Energy	36 181.97	16 628.82	10 405.24	12 000.82	8783.47	8140.35	-77.50
2. Industrial processes and product use	952.36	723.69	294.66	274.94	265.27	257.66	-72.94
3. Agriculture	2765.12	1218.00	1555.92	1579.57	1545.47	1551.74	-43.88
4. Land use, land-use change and forestry ⁽⁵⁾	-4043.28	-1480.68	970.95	792.35	2493.42	1906.55	-147.15
5. Waste	442.96	623.78	312.18	307.68	293.76	290.86	-34.34

* Indirect CO₂ emissions are calculated from NMVOCs reported under IPPU 2.D.3 Solvent use and road paving with asphalt. These emissions are reported under paragraph 4.5.3.2 Solvent use in NID and in CRT sectoral table 2(I). A-Hs2.

** 1990 is a base year

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

GHG EMISSIONS kt CO ₂ eq.		CO ₂ emissions excluding net CO ₂ from LULUCF	CH ₄ emissions excluding CH ₄ from LULUCF	N ₂ O emissions excluding N ₂ O from LULUCF	HFCs	SF ₆	Total (excluding LULUCF)
1990	kt	36 906.19	2189.13	1247.08	NO	NO	40 342.40
	%	91.48%	5.43%	3.09%			100.00%
2005	kt	17 089.65	1367.17	608.21	128.15	1.11	19 194.29
	%	89.04%	7.12%	3.17%	0.67%	0.01%	100.00%
2021	kt	10 391.93	1118.65	864.14	190.21	3.07	12 568.00
	%	82.69%	8.90%	6.88%	1.51%	0.02%	100.00%
2022	kt	11 971.49	1102.32	888.97	197.10	3.13	14 163.02
	%	84.53%	7.78%	6.28%	1.39%	0.02%	100.00%
2023	kt	8748.13	1080.10	865.68	190.85	3.21	10 887.97
	%	80.35%	9.92%	7.95%	1.75%	0.03%	100.00%
2024	kt	8092.59	1078.49	880.21	185.86	3.47	10 240.62
	%	79.02%	10.53%	8.60%	1.81%	0.03%	100.00%

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

The greenhouse gas emissions and removals are divided into the following sectors according to Decision 18/CMA.1 of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement and to the 2006 IPCC Guidelines: Energy, Industrial processes and product use, Agriculture, Land use, land-use change and forestry (LULUCF) and Waste.

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

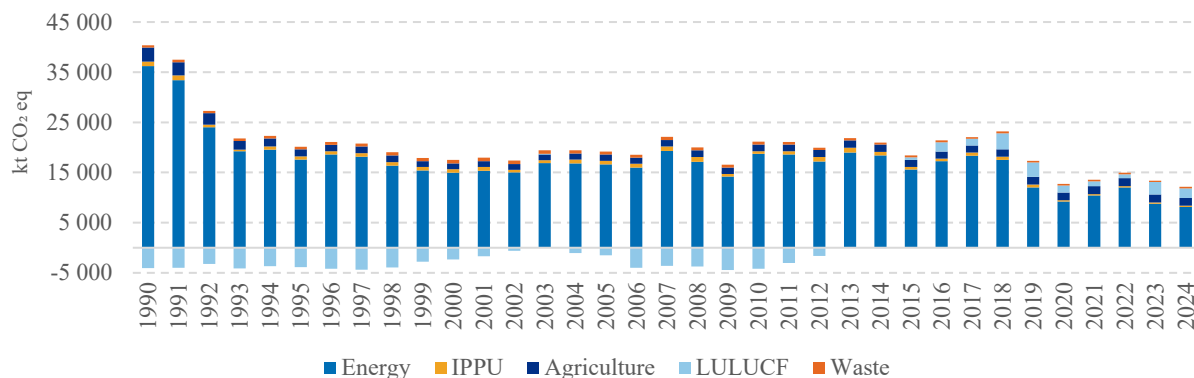


Figure ES.2. Greenhouse gas emissions trends by sector, kt CO₂ eq.

The Energy sector is the most significant source of greenhouse gas emissions in Estonia with 79.49% (8140.35 kt CO₂ eq) share of the total emissions (without LULUCF) in 2024. Since the base year, total GHG emissions from Energy sector in Estonia have decreased by 77.50%. The key driver for the fall in emissions is the transition from a planned economy to a market economy. The GHG emission decrease in 2024 in the Energy industries subsector compared to the previous year was mainly because of certain shale oil plants were undergoing maintenance, which reduced shale oil production, decreased sales volumes and emissions compared to last year. It was also affected by slightly lower global crude oil prices in 2024 compared with 2023, which likely reduced the economic incentive to maintain higher shale-oil production and sales. Lower electricity prices compared to the previous year, combined with EU carbon allowance prices remaining at a similar level to 2023 and reduced profitability of oil shale electricity led to lower electricity generation from oil shale.

Agriculture is the second most significant source of greenhouse gas emissions in Estonia, with emissions of 1551.74 kt CO₂ eq. In 2024 the agriculture sector contributed 15.15% of the total emissions (without LULUCF). Since the base year emissions have decreased by 43.88%, mostly due to the decreasing livestock population and quantities of synthetic fertilizers and manure applied to agricultural fields.

The Waste sector contributed 2.84% (290.86 kt CO₂ eq.) of the total greenhouse gas emissions (without LULUCF) in 2024. The total emissions in CO₂ eq. from the Waste sector decreased by 34.34% compared to the base year.

In 2024 greenhouse gas emissions from Industrial processes and product use contributed 2.52% (257.66 kt CO₂ eq) of the total greenhouse gas emissions (without LULUCF) in Estonia. Emissions have decreased by 72.94% between 1990 and 2024 because of the closing of some relevant industries and reduced output of the remaining industries.

In 2024, the LULUCF sector acted as a CO₂ source, totalling with emissions 1906.55 kt CO₂ eq. Since 1990, net removals have decreased by 147.15%.

ES.4. Other information (e.g. indirect GHGs, precursor gases)

Estonia has chosen to report indirect CO₂ emissions calculated from NMVOC emissions from the CRT subcategory 2.D.3. This subcategory consists of

1. Solvent use (Chapter 4.5.1.);
2. Road paving with asphalt (Chapter 4.5.1.).

ES.5. Key category analysis

The results of the key category analysis are presented in Table 1.2. In this report Tier 1 and Tier 2 method has been used.

ES.6. Improvements introduced

Estonia is consistently working on enhancing the quality of the inventory including finding ways to ensure that the best available activity data is used in emission calculations as well as working on developing country-specific parameters and emission factors subject to available resources. Information on improvements introduced since previous submission can be found under sectoral chapters.

1. NATIONAL CIRCUMSTANCES, INSTITUTIONAL ARRANGEMENTS AND CROSS-CUTTING INFORMATION

1.1. Background information on GHG inventories and climate change (e.g. as it pertains to the national context, to provide information to the general public)

1.1.1. Background information on climate change

According to WMO State of the Global Climate 2024¹ was the warmest year on record with the global average near-surface temperature at 1.55 (± 0.13) °C above the pre-industrial baseline. The past ten years, 2015–2024, were the ten warmest years on record.

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 characterizes 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 recognized.

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 may result in squalls, downbursts and whirlwinds (tornadoes/ waterspouts) of destructive force. Another extreme event is hail that can accompany heavy rainfall. The diameter of the largest hailstone on record was eight centimetres (2023). Heat waves are more frequent; they last longer and have an impact on people's health.

In winter, the most hazardous climate phenomena have been powerful snowstorms accompanying cyclones, resulting in the obstruction and even closure of road traffic. Episodes of freezing rain can influence road and air traffic and may cause power outages.

In 2015, the Estonian Environment Agency drew up an overview of the climatic changes in Estonia, which occurred in the last century, as well as of the projections and assessments of the future climate in Estonia until 2100. The above-mentioned report formed the basis for the assessment of the sectors influenced by the atmospheric condition in drawing up the national development plan for adaptation to the impacts of climate change. Climate projections for Estonia are updated as part of the LIFE-SIP AdaptEST project, which will be implemented in the period 2023-2032. Comprehensive reports on atmospheric climate projections and marine environment climate projections will be published by the beginning of 2027.

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 and in 2016 the Paris Agreement⁴. Estonia has prepared the present National Inventory Document (NID) following the requirements of the UNFCCC and the Paris Agreement.

Single national entity with overall responsibility for the Estonian greenhouse gas inventory is the Estonian Ministry of Climate (MoC) (formerly Ministry of the Environment). Financial resources for inventory compilation are planned in the National Administrative Agreement and in State Budget.

The Institute of Ecology at Tallinn University was responsible for the inventories under contract to the Ministry of the Environment (MoE) 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 2014–2026 inventory were produced in collaboration between the MoC (until 2023 MoE), Estonian Environment Agency (EstEA) and EERC, responsibilities between different institutions are shown in Figure 1.1.

This document presents the national inventory of greenhouse gas emissions and removals from 1990 to 2024. The GHGs covered are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆) and nitrogen trifluoride (NF₃). Estimates on the precursor gases nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO₂) were also included in inventory data.

The document and associated Common Reporting Tables (CRT) (prepared with ETF GHG INVENTORY Reporting Tool) were prepared in accordance with the UNFCCC reporting

⁴ Act on the Ratification of the Paris Agreement. [www] <https://www.riigiteataja.ee/akt/201112016002> (06.11.2025)

guidelines on annual inventories. The methodology used in calculations of emissions is harmonized with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines). According to decision 18/CMA.1 paragraph 38 Estonia's 2026 national inventory report consists of a national inventory document and the common reporting tables.

The structure of this NID follows the UNFCCC reporting guidelines from Decision 18/CMA.1. Chapter 1 introduces 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 2024. Chapters 3–8 give information of GHG emission trends from the base year 1990 to year 2024 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 CO₂ and nitrous oxide emissions. In Chapter 10 improvements and recalculations since the previous submission are summarized.

1.2. A description of national circumstances and institutional arrangements

1.2.1. National entity or national focal point

Single national entity with overall responsibility for the Estonian greenhouse gas inventory is Ministry of Climate (MoC) (until 30.06.2023 Ministry of Environment). In 2018 a change in the national inventory system was made when MoE appointed the Estonian Environmental Research Centre (EERC) to be the institution to have the overall responsibility of maintaining the national system, coordinating the inventory preparation process as a whole, being responsible for the final quality control and quality assurance and submitting the final inventory to the European Commission (EC) and to the UNFCCC Secretariat on behalf of MoC. The inventory will continue to be produced in collaboration between MoC, EERC and EstEA as until now.

The MoC is responsible for:

- maintaining the national inventory system;
- contributing to the renewal of the QA/QC plan;
- planning financial resources for inventory preparation and inventory methodological developments;
- entering into formal agreements with the inventory coordinator (EERC); and
- making the greenhouse gas inventory available to the public.

EERC is responsible for:

- maintaining the national inventory system;
- coordinating the inventory preparation process as a whole;
- compiling the National Inventory Report according to the parts submitted by the inventory compilers;
- coordinating the renewal and implementation of the QA/QC plan and final QA/QC of the inventory;
- sending the final inventory to the MoC and approving the inventory before the official submissions;
- reporting the greenhouse gas inventory to the EC and to the UNFCCC, including the National Inventory Document and Common Reporting Tables on behalf of MoC;
- coordinating cooperation between the inventory compilers, the EC and UNFCCC Secretariat;

- coordinating the UNFCCC inventory reviews and communication with the expert review team, including responses to the review findings.
- 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
- 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 Forest Department of the Estonian Environment Agency is responsible for 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 ETF Reporting Tool and prepare the sectoral parts of the NID. These experts are also responsible for archiving activity data, estimates and all other relevant information according to the archiving system.

In addition, the GHG inventory team cooperates with the team in charge of the preparation of the atmospheric pollutant emission inventory to the UNECE's Convention on Long-range Transboundary Air Pollution (CLRTAP) by having annual meetings between the two teams to find possibilities to make the information coherent between the two reports. Sectoral experts meet bilaterally from time to time with the aim of reducing differences in the estimates between the two inventories.

Financial resources for inventory compilation are planned in the National Administrative Agreement and in State Budget as MoC has appointed Estonian Environmental Research Centre (EERC) to be the institution to have the overall responsibility of maintaining the national system, coordinating the inventory preparation process as a whole, being responsible for the final quality control and quality assurance and submitting the final inventory to the European Commission (EC) and to the UNFCCC Secretariat on behalf of MoC.

Legal arrangements

In accordance with §143 of the Atmospheric Air Protection Act (RT I, 02.10.2025, 18), activities for the reduction of climate change are organised by the Ministry of Climate 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, the Paris Agreement and the European Union legislation.

In accordance with §6 of the Statutes of the Ministry of the Climate (RT I 29.12.2024, 49), the MoC is responsible for climate change related tasks and according to §22 section 2 point 7, the Climate Department is tasked with organizing, developing and implementing climate change mitigation and adaptation policies. In line with the Statutes of the Climate Department, the department also organizes and coordinates greenhouse gas emission reporting under the UNFCCC, the Kyoto Protocol, the Paris Agreement and relevant European Union legislation. In the beginning of 2018 with an aim to improve/optimize the inventory compiling process in Estonia, MoE (since 2023 MoC) decided to appoint the Estonian Environmental Research Centre to be the overall coordinator of the GHG inventories.

The Estonian Environmental Research Centre (EERC) is a state-owned company established for general interest, all of the shares in which are held by the Republic of Estonia. EERC is subordinate to the Ministry of Climate. Any changes to and the approval of the statutes of the EERC are the responsibility of the Ministry of Climate.

As of 2018 according to §1.8 of the Statutes of the Estonian Environmental Research Centre, EERC as a state-owned company guarantees the organisation and the timely submissions of the GHG inventories to the EC and to the UNFCCC. Statutes of the EERC was amended in the beginning of 2018 according to decision made by the Minister of the Environment as it is the competence of the Minister of the Environment to amend the Statutes of the EERC. Also, EERC management supervision is carried out by the body 100% appointed by the Minister of the Environment (since 2023 Minister of Climate).

EERC compiles the GHG inventory on the basis of contract agreements with the MoC.

The Estonian Environment Agency (EstEA), institution that is responsible for the LULUCF estimates, is a state authority administered by MoC, 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 9 of the Statute of the EstEA, the tasks of the Forest Department include planning, organizing and carrying out statistical forest inventories, monitoring land use, land-use changes and carbon cycle and fulfilling national and international reporting obligations.

The Statistics Estonia collects and coordinates the production of official statistics on the basis of the Official Statistics Act § 9 (RT I, 11.03.2022, 2).

1.2.2. Inventory preparation process

The three core institutions: MoC, EERC and EstEA work together to fulfil 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 EstEA) and inventory coordinator (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;
- planning of methodological developments and possible changes in the future submissions;
- 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.

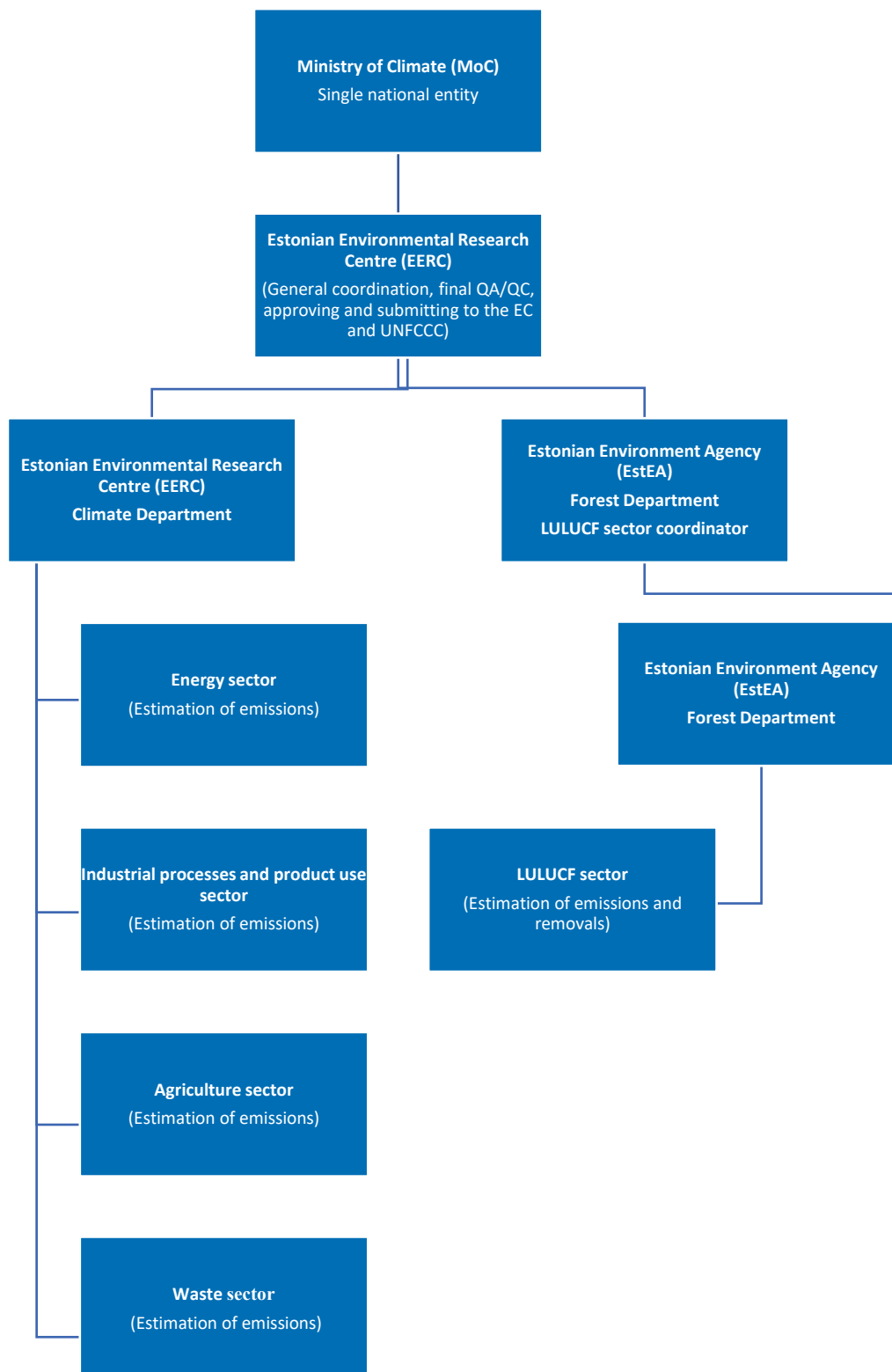


Figure 1.1. National System for GHG inventory in Estonia

Inventory preparation and management

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.

According to regulation (EU) 2018/1999 of the European parliament and of the council article 26 the EU member states shall report every year by 31 July to the European Commission their approximated greenhouse gas inventories for the year X-1. Therefore, data collection for the inventory compilation starts already during the summer prior to the inventory submission. However, it needs to be noted that not all activity data is available already in summer, for example energy balance (activity data for energy sector calculations) is published annually by Statistics Estonia not before the end of September. In addition, the National Forest Inventory, which serves as the main source of activity data for land-use sector areas, is not available by the 31 July and therefore LULUCF emission estimates are not updated by that time. 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 related 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, 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands and in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, as appropriate;
- 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.

1.2.3. Archiving of information

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

The data and information are archived for each submission year. The archiving includes all input data, emission calculations, corresponding letters, all partly filled-in or final CRT, recalculations of previous estimates, submissions to the UNFCCC and EC and NIR-s (since 2024 NID). The archiving system is located in EERC server which undergoes a daily backup, and the backups are securely saved.

The archiving system consists of two parts: data related (1) to the CRT and (2) to the NID. 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 NID. Also, all submissions to the UNFCCC and EC are archived.

Estonia's archiving structure is structured in a way that all relevant materials used in the 2013–2026 inventory submission (e.g., XML and JSON files provided by the inventory compilers to the producers of the CRT tables, also relevant materials from the ftp site) are stored in the archive.

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 CRT tables.

These organizations keep records of their work on hard disks of individual expert's desktop workstations, with copies on backed up network servers.

Starting from autumn 2010 an ftp site has been set up to collect all important documents into one location where everybody can use them. The ftp site is used for sharing documents (xml and json files, draft NID's, QA/QC documents etc.), also previous submissions, review reports, answers to the reviews and guidelines are available. The ftp site is accessible by sectoral experts, inventory compiler and independent 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.

1.2.4. Processes for official consideration and approval of inventory

Following the initial submission to EU in January the initial NID and CRT are sent to different departments of MoC and other relevant institutions for approval. MoC different departments and other relevant institutions carry out QA of the CRT tables and NID and submits the results to the EERC coordinators, after what the EERC and EstEA sectoral experts send their comments to the findings and possible changes according to the QA/QC (performed by the MoC, independent experts and the EU initial checks) to EERC coordinators and then to MoC. Additional QC checks are carried out before the final submission to the EU in March by EERC and the sectoral experts. The inventory is considered finalized for submission after review and approval by the National Inventory Focal Point in the ETF Reporting Tool.

1.3. Brief general description of methodologies (including tiers used) and data sources used

The methodologies used for the Estonia's greenhouse gas inventory are consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) and in some sectors with the 2019 IPCC refinement (IPCC 2019). In LULUCF sector also the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands is used. 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 1.1.

Table 1.1. 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 (EstEA); The Environmental Board; Estonian Transport Administration
A. Fuel combustion	T1, T2, T3	D, CS, PS	Joint Questionnaire dataset made by Statistics Estonia; Statistics Estonia statistical database; data of energy companies, EU ETS and municipal waste fuel data from The Environmental Board, waste fuels data from EstEA
A.1. Energy industries	T1, T2, T3	D, CS, PS	Joint Questionnaire dataset made by Statistics Estonia; Statistics Estonia statistical database; data of energy

IPCC category	Methodology	Emission factor	Activity data
			companies; EU ETS and solid municipal waste data from The Environmental Board
A.2. Manufacturing industries and construction	T1, T2, T3	D, CS, PS	Joint Questionnaire dataset made by Statistics Estonia; Statistics Estonia statistical database; waste fuels (oils, plastics, solid waste) data from EstEA; number of off-road vehicles from Estonian Transport Administration
A.3. Transport	T1, T2, T3	D, CS	Joint Questionnaire dataset made by Statistics Estonia; Statistics Estonia statistical database; aviation activity data as well as road transport fuels activity data, including CH ₄ ja N ₂ O emission estimations from EstEA using COPERT 5 model
A.4. Other sectors	T1, T2	D, CS	Joint Questionnaire dataset made by Statistics Estonia from statistical database; number of off-road vehicles from Estonian Transport Administration
B. Fugitive emissions	T1	D	Joint Questionnaire dataset made by Statistics Estonia
2. Industrial processes and product use	IPCC 2006	IPCC 2006	EU ETS data from The Environmental Board, Statistics Estonia; plant specific data; national and international companies; associations; public institutions; sectoral databases; Eurostat; EstEA
A. Mineral industry	T1, T2, T3	D, PS	Statistics Estonia; plant specific data; EU ETS data from Estonian Environmental Board
C. Metal industry	T3	PS	Statistics Estonia; plant specific data;
D. Non-energy products from fuels and solvent use	T1, T2	D	Statistics Estonia; EstEA; Eurostat
F. Product uses as substitutes for ODS	T2	CS	National and international companies; associations; public institutions; sectoral databases
G. Other product manufacture and use	T2, T3	CS	National and international companies, Statistics Estonia, Eurostat
3. Agriculture	IPCC 2006, 2019 Refinement	IPCC 2006, 2019 Refinement	Statistics Estonia, National Forest Inventory, EstEA, plant specific data, Agriculture and Food Board, Estonian Animal Recording Centre, Agricultural Registers and Information Board, KeMIT (waste data depository)
A. Enteric fermentation	T1, T2	D, CS, OTH	Statistics Estonia, Estonian Animal Recording Centre, EstEA, ARIB
B. Manure management	T1, T2	D, CS	Statistics Estonia, Estonian Animal Recording Centre, EstEA, ARIB, KOTKAS
D. Agricultural soils	T1	D	Statistics Estonia, EstEA; NFI, KeMIT (waste data depository)
G. Liming	T1	D	Statistics Estonia, Agriculture and Food Board

IPCC category	Methodology	Emission factor	Activity data
H. Urea application	T1	D	Statistics Estonia, plant specific data, Agriculture and Food Board, fertilizer producers in Estonia
4. LULUCF	IPCC 2006, IPCC 2014	IPCC 2006, IPCC 2014, IPCC 2019	National Forest Inventory (EstEA); Statistics Estonia; Estonian Rescue Board; Agricultural Registers and Information Board; Centre of Estonian Rural Research and Knowledge; Geological Survey of Estonia; Estonian Land and Spatial Development Board, Estonian Forest and Wood Industries Association; FAO
A. Forest land	T1, T2, T3	D, CS, OTH	National Forest Inventory; Estonian Rescue Board
B. Cropland	T1, T2, T3	D, CS	National Forest Inventory; Statistics Estonia; Agricultural Registers and Information Board; Centre of Estonian Rural Research and Knowledge
C. Grassland	T1, T2, T3	D, CS	National Forest Inventory; Estonian Rescue Board
D. Wetlands	T2, T3	D, CS	National Forest Inventory; Estonian Rescue Service; Statistics Estonia; Geological Survey of Estonia
E. Settlements	T1, T2, T3	D, CS	National Forest Inventory
F. Other land	T1, T2, T3	D, CS	National Forest Inventory
G. Harvested wood products	T2	D, CS	National Forest Inventory; Statistics Estonia; Estonian Forest and Wood Industries Association; FAO
5. Waste	IPCC 2006	IPCC 2006, IPCC 2019	EstEA; KeMIT (waste data depository); KOTKAS; Statistics Estonia; AS Vaania and SEI Tallinn sorting studies, expert opinions; plant specific data; FAOSTAT
A. Solid waste disposal	T2	D	EstEA; KeMIT; Statistics Estonia, AS Vaania and SEI Tallinn sorting studies, , Jäätmeanalüüs OÜ
B. Biological treatment of solid waste	T1	D	EstEA; KeMIT
C. Incineration and open burning of waste	T1, T2a	D	EstEA; KeMIT; KOTKAS; Statistics Estonia; expert opinions, AS Vaania and Tallinn sorting studies, Jäätmeanalüüs OÜ
D. Wastewater treatment and discharge	T1	D	EstEA; KeMIT; KOTKAS, data from companies, Statistics Estonia; FAOSTAT

1.4. Brief description of key categories

Key categories are the categories of emissions/removals, which have a significant influence on the total inventory in terms of the absolute level of emissions (1990 or 2024), the trend of emissions (change between 1990 and 2024) 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 of the key category analysis are presented in Table 1.2.

Table 1.2. Key category analysis 2024

		TIER 1						TIER 2					
		Criteria identification (without LULUCF)			Criteria identification with LULUCF			Criteria identification (without LULUCF)			Criteria identification with LULUCF		
IPCC Source Category	Gas	Level 1990	Level 2024	Trend	Level 1990	Level 2024	Trend	Level 1990	Level 2024	Trend	Level 1990	Level 2024	Trend
1.A.1.a Energy Industries/Public Electricity and Heat Production - Gaseous Fuels	CO ₂	X	X	X	X	X	X	X					
1.A.1.a Energy Industries/Public Electricity and Heat Production - Liquid Fuels	CO ₂	X	X	X	X	X	X	X					
1.A.1.a Energy Industries/Public Electricity and Heat Production - Other Fuels (Waste)	CO ₂		X	X		X	X		X	X		X	
1.A.1.a Energy Industries/Public Electricity and Heat Production - Peat	CO ₂	X		X	X								
1.A.1.a Energy Industries/Public Electricity and Heat Production - Solid Fuels	CO ₂	X	X	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	CO ₂		X	X		X	X		X	X		X	X
1.A.2.c Manufacturing Industries and Construction/Chemicals - Gaseous Fuels	CO ₂	X			X								
1.A.2.c Manufacturing Industries and Construction/Chemicals - Liquid Fuels	CO ₂	X		X	X								
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Gaseous Fuels	CO ₂		X	X									
1.A.2.d Manufacturing Industries and Construction/Pulp, Paper and Print - Liquid Fuels	CO ₂	X		X									
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Gaseous Fuels	CO ₂		X	X		X	X						
1.A.2.e Manufacturing Industries and Construction/Food Processing, Beverages and Tobacco - Liquid Fuels	CO ₂	X	X	X	X		X						
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Gaseous Fuels	CO ₂			X									
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Liquid Fuels	CO ₂	X		X	X								
1.A.2.f Manufacturing Industries and Construction/Non-metallic Minerals - Solid Fuels	CO ₂	X		X	X			X			X		X

		TIER 1						TIER 2					
		Criteria identification (without LULUCF)			Criteria identification with LULUCF			Criteria identification (without LULUCF)			Criteria identification with LULUCF		
1.A.2.g Manufacturing Industries and Construction/Other - Gaseous Fuels	CO ₂	X	X	X	X								
1.A.2.g Manufacturing Industries and Construction/Other - Liquid Fuels	CO ₂	X	X	X	X	X							
1.A.2.g Manufacturing Industries and Construction/Other - Solid Fuels	CO ₂	X		X	X			X					
1.A.3.b Transport/Road Transportation - Liquid Fuels	CO ₂	X	X	X	X	X	X	X	X	X			
1.A.3.b Transport/Road Transportation - Liquid Fuels	N ₂ O		X	X		X	X		X	X			X
1.A.3.c Transport/Railways - Liquid Fuels	CO ₂		X			X	X						
1.A.3.e Transport/Other Transportation - Liquid Fuels	CO ₂		X	X		X	X						
1.A.4.a Other Sectors/Commercial/Institutional - Gaseous Fuels	CO ₂		X	X		X	X						
1.A.4.a Other Sectors/Commercial/Institutional - Liquid Fuels	CO ₂		X	X		X	X						
1.A.4.b Other Sectors/Residential - Gaseous Fuels	CO ₂		X	X		X	X						
1.A.4.b Other Sectors/Residential - Liquid Fuels	CO ₂	X		X	X								
1.A.4.b Other Sectors/Residential - Peat	CO ₂	X		X	X			X			X		
1.A.4.b Other Sectors/Residential - Solid Fuels	CO ₂	X		X	X			X			X		
1.A.4.c.i Other Sectors/Agriculture/Forestry/Fishing/Stationary - Liquid Fuels	CO ₂	X	X	X	X	X	X						
2.F.1.a Commercial Refrigeration	HFC		X	X		X	X						
2.F.1.c Industrial Refrigeration	HFC		X	X									
2.F.1.f Stationary and Room Air-Conditioning	HFC		X	X									
2.A.1 Cement production	CO ₂	X		X	X								
2.B.1 Ammonia production	CO ₂	X		X	X								
3.A.1 Enteric Fermentation - Dairy Cattle	CH ₄	X	X	X	X	X	X	X	X	X	X	X	
3.A.1 Enteric Fermentation - Non-Dairy Cattle	CH ₄	X	X	X	X	X	X	X	X	X	X	X	
3.B.1.1 Manure Management - Dairy Cattle	CH ₄		X	X		X	X						
3.B.1.1 Manure Management - Non-Dairy Cattle	CH ₄		X										
3.B.1.3 Manure Management - Swine	CH ₄		X			X	X						
3.B.2.5 Indirect N ₂ O Emissions from Manure Management	N ₂ O							X	X	X	X		
3.D.1.1 Direct Soil Emissions - Inorganic N Fertilizers	N ₂ O	X	X	X	X	X	X	X	X	X	X	X	X
3.D.1.2a Direct Soil Emissions - Animal Manure Applied to Soils (including manure digestates)	N ₂ O		X	X		X	X	X	X	X	X	X	X
3.D.1.2c Direct Soil Emissions - Compost, and Waste Digestates Applied to Soils	N ₂ O								X	X			X
3.D.1.3 Direct Soil Emissions Urine and Dung Deposited by Grazing Animals	N ₂ O							X	X	X	X		

		TIER 1						TIER 2					
		Criteria identification (without LULUCF)			Criteria identification with LULUCF			Criteria identification (without LULUCF)			Criteria identification with LULUCF		
3.D.1.4 Direct Soil Emissions - Crop Residue	N ₂ O	X	X	X	X	X	X	X	X	X	X	X	X
3.D.1.6 Direct Soil Emissions - Cultivation of Organic Soils	N ₂ O		X	X		X	X	X	X	X	X	X	X
3.D.2.1 Indirect Emissions - Atmospheric Deposition	N ₂ O		X					X	X	X	X	X	X
3.D.2.2 Indirect Emissions - Nitrogen Leaching and Run-off	N ₂ O	X	X	X	X	X	X	X	X	X	X	X	X
4(III) Direct and indirect N ₂ O emissions from N mineralization	CO ₂					X	X					X	
4.A.1 Forest Land remaining Forest Land - dead wood	CO ₂				X	X	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 Land converted to Forest Land - living biomass	CO ₂				X	X	X				X	X	X
4.A.2 Land converted to Forest Land - mineral soils	CO ₂					X	X						
4.A.2 Land converted to Forest Land - organic soils	CO ₂				X	X	X				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 Land converted to Cropland - mineral soils	CO ₂						X					X	X
4.B.2 Land converted to Cropland - organic soils	CO ₂				X	X					X		X
4.E.2 Land converted to Settlements - mineral soils	CO ₂				X	X	X				X	X	X
4.C.1 Grassland remaining Grassland – living biomass	CO ₂				X	X	X				X		
4.C.2 Land converted to Grassland – mineral soils	CO ₂				X	X	X				X	X	X
4.D Forest Land 4(II) Emissions and removals from drainage and rewetting	CH ₄					X	X				X	X	X
4.D Forest Land 4(II) Emissions and removals from drainage and rewetting	N ₂ O					X	X						
4.D.1.1 Peat extraction remaining Peat extraction	CO ₂				X	X	X				X	X	X
4.D.2.3 Land converted to Other Wetlands	CO ₂				X	X	X				X	X	X
4.E.2 Land converted to Settlements - living biomass	CO ₂				X	X	X				X	X	X
4.F.2 Land converted to Other Land	CO ₂				X	X	X				X	X	X
4.G.1 Solid wood	CO ₂				X	X	X				X	X	X
5.A Solid waste disposal	CH ₄	X	X	X	X	X	X	X	X	X	X	X	X
5.D.1 Domestic wastewater	CH ₄		X			X	X	X	X	X	X		
5.D.1 Domestic wastewater	N ₂ O		X						X	X			

1.5. Brief general description of QA/QC plan and implementation

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.

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. Please see the QA/QC plan in Annex IV.

All institutions involved in the inventory process (MoC, EERC and EstEA) are responsible for implementing QC procedures to meet the data quality objectives. EERC as the inventory coordinator 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 EstEA. EERC is also responsible for QC of the data of the emission inventory. EERC as the inventory coordinator is responsible for the overall QA of the national system, including the UNFCCC and EC reviews and any national reviews undertaken.

In the end of 2024 Minister of Climate signed a decree that specifies steps that the EstEA needs to do in developing LULUCF sector methodologies as well as diversifying and improving activity data for the calculations. Also, with this decree a decision was made to establish a Steering Committee whose task is to guide and approve LULUCF sector methodological developments. The Steering Committee was established with a decree signed by the Director or EstEA on the 11th of March 2025. In addition, a LULUCF coordinator position in EstEA was created since 1st of January 2025 to coordinate the work of the Steering Committee. Work of the Steering Committee was included in the QA/QC plan of Estonia for the 2025 submission.

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.

Communication and bilateral meeting are held with Statistics Estonia as needed to discuss activity data coming from the national Statistics.

Please see additional information on QA/QC including QA/QC plan in Annex IV.

1.6. General uncertainty assessment, including data pertaining to the overall uncertainty of inventory totals

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 II.

The uncertainty estimate of the 2026 inventory submission to the UNFCCC Secretariat 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. Uncertainty analyses has been done for the latest inventory year, base year and time series. In many cases uncertainty values have been assigned based on default uncertainty estimates according to IPCC 2006 guidelines or expert judgement, because there is a lack of information. For each source, uncertainties are quantified for emission factors and activity data. For base year, latest inventory uncertainty for activity data and emission factors is used unless additional information is available.

Uncertainties are estimated for direct greenhouse gases, e.g., CO₂, CH₄, N₂O, and F-gases. The uncertainty analysis was done for the sectors: Energy, Industrial processes and product use, Agriculture, LULUCF and Waste sector.

Table 1.3 shows the estimated uncertainties for total greenhouse gas emissions in 1990 and 2024 and the trend (with and without LULUCF). Experts use uncertainty estimations among other input (review recommendations etc.) when prioritizing efforts to improve the accuracy of sectoral inventory estimations. Based on the method used for a certain subcategory emission calculation (Tier 1/Tier 2), on the share of the subcategory emission in total emissions and on the uncertainty percentage it is evaluated if it is possible to level up either the calculation methodology or specify uncertainty percentage.

Table 1.3. Uncertainty in total 2024 inventory submission

	Combined as % of total national emissions in		Introduced into the trend in total national emissions in 2024
	1990	2024	
	Uncertainty [%]		
Without LULUCF	3.57	9.06	1.94
With LULUCF	8.04	16.51	6.13

1.7. General assessment of completeness

1.7.1. Information on completeness (including information on non-reported categories or any methodological or data gaps in the inventory)

Estonia has provided estimates for all significant IPCC source and sink categories according to the detailed CRT classification. Estimates are provided for the following gases: CO₂, N₂O, CH₄, F-gases (HFC, PFC, SF₆ and NF₃), NMVOC, NO_x, CO and SO₂. The geographical coverage of the inventory is complete. Assessment of completeness is presented in Annex V.

1.7.2. Description of insignificant categories

In the LULUCF sector, C stock changes in dead organic matter (DOM) pool under the Cropland remaining cropland subcategory were not estimated and reported as “NE”. Small changes in DOM pool occur due to removal or establishment of orchards, but these emissions or removals are considered insignificant in terms of the overall level and trend in national emissions (as are changes in orchards’ living biomass).

CH₄ and N₂O emissions from biomass burning were not estimated for the Cropland and Settlements categories, as a disproportionate amount of effort would be required to collect the activity data about emissions that would be insignificant in terms of the overall level and trend in national emissions. This argument is based on the fact that according to the latest inventory submission, the average level of emissions from biomass burning reported in the period 1990–2024 is 0.93 kt CO₂ eq. that constitutes 0.01% of the national total GHG emissions (without LULUCF) and that the average GHG emissions from the biomass burning in Cropland and Settlements have a very low likelihood to exceed that, as the biomass density and the area in case of Settlements is considerably lower compared to the Forest land.

Since the 2025 submission, in the waste sector, the emissions from the subcategory Incineration and open burning of waste are no longer reported in a separate chapter due to the emissions from this category being insignificant. In 2024, no incineration of waste without energy recovery occurred and the emissions from open burning were 0.31 kt CO₂ eq, which was only 0.003% of the national total emissions.

1.7.3. Total aggregate emissions considered insignificant

Total aggregate emissions considered insignificant in 2024 are 1.24 kt CO₂ eq., which is 0.01% of total emissions. This comprises of emissions from Waste and LULUCF sectors reported under chapter 1.7.2.

1.8. Metrics

Estonia used in its 2026 GHG inventory calculations the 100-year time-horizon global warming potential (GWP) values from the IPCC Fifth Assessment Report (AR5), for reporting aggregate emissions and removals of GHGs, expressed in CO₂ eq.

Estonia has produced the CRT tables for the 2026 submission with the ETF GHG INVENTORY Reporting Tool and therefore also all the emissions presented in the 2026 NID are calculated using GWPs from AR5.

1.9. Summary of any flexibility applied

Estonia as a developed country Party is not using any flexibility in the implementation of the provisions of Article 13.

2. TRENDS IN GREENHOUSE GAS EMISSIONS AND REMOVALS

2.1. Description of emission and removal trends for aggregated GHG emissions and removals

This chapter provides the trends in GHG emissions and removals by sinks in Estonia for the years 1990–2024.

The GHGs covered are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), nitrogen trifluoride (NF₃), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF₆). Emission estimates for nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), and sulphur dioxide (SO₂).

Total emissions of greenhouse gases in Estonia (without LULUCF) decreased steadily 40 342.40 kt CO₂ eq. in 1990 to 10 240.62 kt CO₂ eq. in 2024 (Figure 2.1). From 1990 to 2024 emissions without LULUCF decreased by 74.62%. This decrease was predominantly caused by the transition from a planned economy to a market economy and the successful implementation of the necessary reforms. Total emissions including LULUCF decreased 66.54% from 36 299.12 kt CO₂ eq. in 1990 to 12 147.17 kt CO₂ eq.

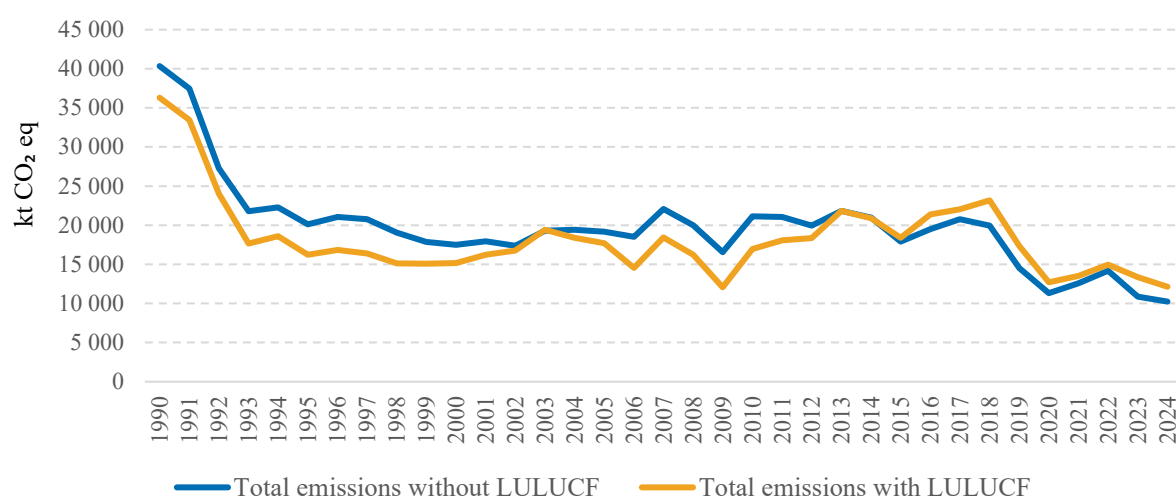


Figure 2.1. Estonia's greenhouse gas emissions in 1990–2024 (with indirect CO₂), with LULUCF and without LULUCF, kt CO₂ eq.

In 2024 the most important GHG in Estonia was carbon dioxide (CO₂), contributing 79.02% to total national GHG emissions (without LULUCF) expressed in CO₂ eq. (including indirect CO₂), followed by methane (CH₄), 10.53%, and nitrous oxide (N₂O), 8.60%. Fluorocarbons (so-called 'F-gases') account for about 1.85% of total emissions (Figure 2.2). Figure 2.2 also includes the GHG gas allocation for total GHG emissions with LULUCF.

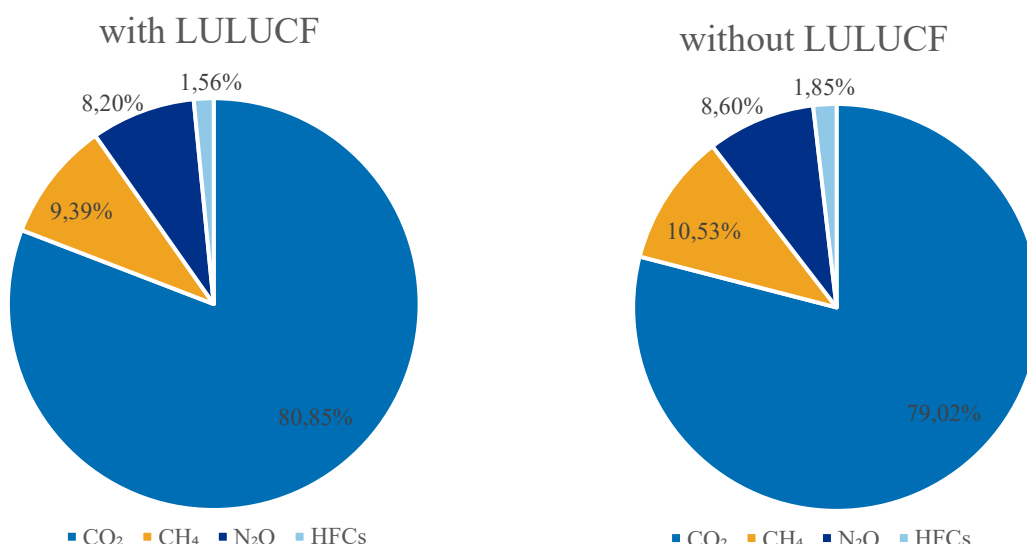


Figure 2.2. GHG emissions by gas in 2024 with and without LULUCF, %

Figure 2.3 shows GHG emission trends by gas in 1990 to 2024. CO₂ emissions (without LULUCF, with indirect CO₂) decreased by 78.07% from 36 906.19 kt in 1990 to 8092.59 kt in 2024, especially CO₂ emissions from Energy sub-sector Public electricity and heat production, which is the major source of CO₂ in Estonia.

Methane is the second most significant contributor to greenhouse gas emissions in Estonia after CO₂. Emissions of CH₄ decreased by 50.73% from 2189.13 kt CO₂ eq. in 1990 to 1078.49 kt CO₂ eq. in 2024, the downturn was especially noticeable in the Agriculture sub-sector Enteric fermentation, which is a leading source of CH₄ in Estonia.

Emissions of N₂O decreased by 29.42% from 1247.08 kt CO₂ eq. in 1990 to 880.21 kt CO₂ eq. in 2024, especially N₂O emissions from Agriculture sub-sector Agricultural soils, which is the main contributor of N₂O emissions in Estonia.

Emissions of the total F-gases (HFCs, PFCs and SF₆) increased from 0 kt CO₂ eq. in 1990 to 189.33 kt CO₂ eq. in 2024, especially HFC emissions from Refrigeration and air conditioning, which is the major source of halocarbons in Estonia. Until 2016 emissions from Refrigeration and air conditioning subsector grew rapidly because of substitution of ozone depleting substances with HFCs. In 2017–2021 emission curbing effects of EU Regulation No 517/2014 on this subsector can be seen. 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. The share of HFC emissions in 2024 was 185.86 kt CO₂ eq. and SF₆ emissions 3.47 kt CO₂ eq.

NF₃ emissions do not occur in Estonia.

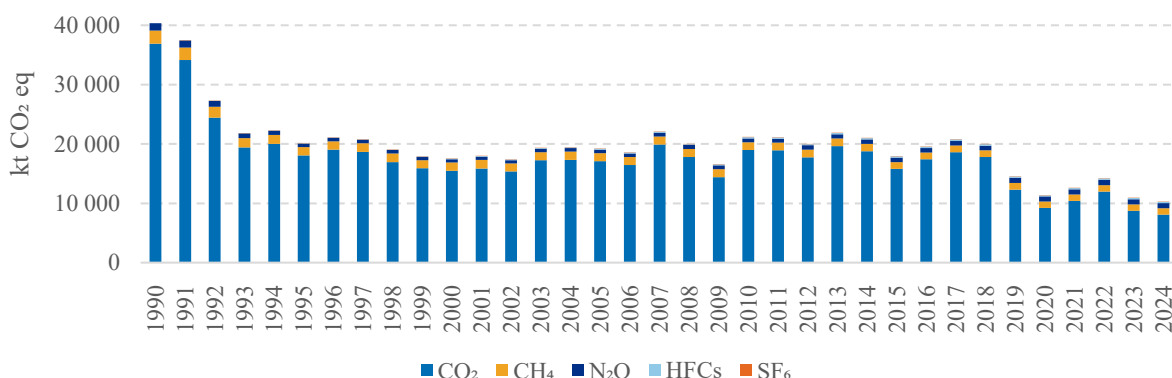


Figure 2.3. Estonia's greenhouse gas emissions by gas 1990–2024 (without LULUCF), kt CO₂ eq.

Air pollutant emissions reported in the CRT are mostly based on the data reported in UNECE/CLRTAP⁵ inventories by the Estonian Environment Agency. In the air pollutant inventory emissions are mainly calculated using actual emissions data reported by the companies and also using the EMEP/EEA Guidebook^{6,7} methodology. In the GHG inventory, the emissions are calculated using some country-specific emission factors and the EMEP/EEA Guidebook Tier 1 methodology; oil shale combustion emissions is the actual data reported by the companies. The emissions are mainly calculated by using actual emissions data reported by the companies as well as by using the EMEP/EEA Guidebook 2023. More detailed information about methodologies used for estimating the indirect GHG emissions are presented in relevant sectoral chapters in the NID. Figure 2.4 shows indirect GHG emission trends in 1990 to 2024.

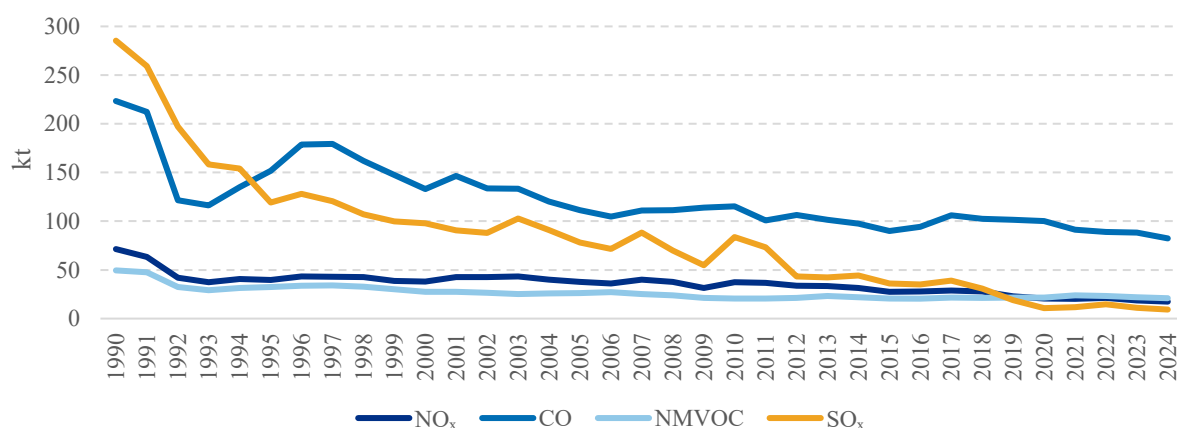


Figure 2.4. Indirect GHG emission trends in 1990 to 2024

2.2. Description of emission and removal trends by sector and by gas

Greenhouse gas emissions by IPCC sectors are presented in Figure 2.5. The largest contribution is the Energy sector, which contributed 79.49% of total greenhouse gas emissions in 2024 (without LULUCF). The second largest sector is Agriculture, which accounted for 15.15% of

⁵ United Nations Economic Commission for Europe/Convention on Long-Range Transboundary Air Pollution

⁶ European Monitoring and Evaluation Programme/European Environment Agency

⁷ EMEP/EEA air pollutant emission inventory guidebook 2023. [www]

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023> (07.03.2025)

the total emissions in 2024 followed by the Waste and the Industrial processes and product use sectors accounting for 2.84% and 2.52% of total emissions in 2024.

Over the period 1990–2024 (Figure 2.4), emissions from the Energy sector decreased by 77.50%, emissions from the Industrial processes and product use sector decreased by 72.94% and emissions from the Agriculture sector decreased by 43.88%. Emissions from the Waste sector decreased by 34.34%. In 2024, the LULUCF sector acted as a CO₂ source, totalling with emissions 1906.55 kt CO₂ eq. Since 1990, net removals have decreased by 147.15%.

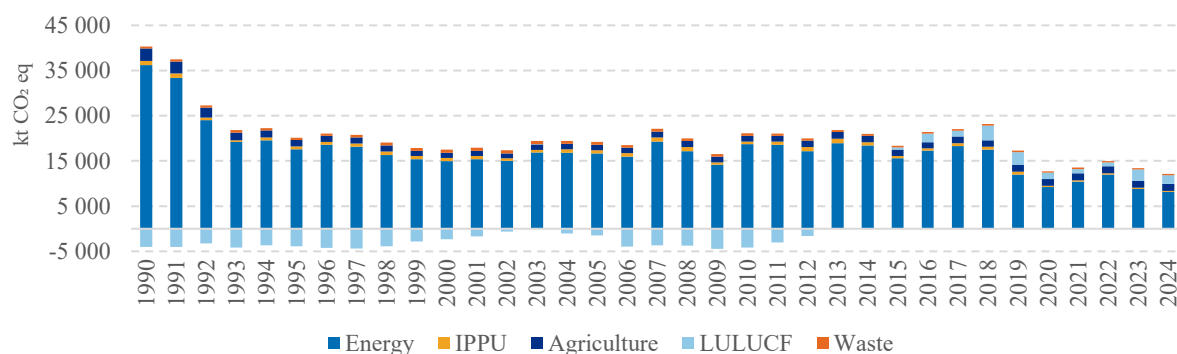


Figure 2.4. Greenhouse gas emission trends, by sectors, kt CO₂ eq.

2.2.1. Trends in Energy (CRT 1)

Emissions from the Energy sector are divided into the following categories: Fuel combustion, which includes Energy industries, Manufacturing industries and construction, Transport, Other sectors; and Fugitive emissions. The share of emissions by sub-category is presented in Figure 2.5.

By the time of the 15th of April 2026 submission, the final verification of Energy sector activity data by Statistics Estonia is not yet available for selected fuels, including liquid fuels (diesel oil, light fuel oil, residual fuel oil) and biomass fuels (solid biomass). As a result, the inventory continues to apply the latest available verified activity data from 2023 for these fuels. These values will be revised and updated in the 2027 submission once the verified information becomes available. In addition, further time-series consistency checks and any resulting revisions, together with the corresponding explanations, will be completed. More detailed information on data availability and planned updates is provided in the respective sectoral and subcategory sections. The Energy sector is the major source of GHG emissions in Estonia contributing 79.49% of total emissions in 2024, totalling 8140.35 kt CO₂ eq. 99.77% of emissions originate from fuel combustion, and only 0.23% from fugitive emissions. Energy-related CO₂ emissions vary mainly concerning the economic trend, the energy supply structure, fuel types used and weather conditions.

The decrease of GHG emissions between 1990 and 1993 is related to major structural changes in the economy as Estonia regained independence from the Soviet Union in 1991. Since then, there has been a drastic decrease in the consumption of fuels and energy in energy industries (closure of factories), agriculture (reorganisation and dissolution of collective farms), transport (the proportion of new environmentally friendly cars has increased, and the number of agricultural machines decreased), households (energy saving), and in the economy. A small increase in emissions in 1994 relates to the growing energy demand in the transport sector. After that, the emissions from the Energy sector were steady (slight decrease until 2002). In 2003 the emissions increased mainly due to the export of oil shale-based electricity. The rise in emissions between 2006-2007 is related to the overall economic upturn and the decrease of emissions

between 2007-2009 to the overall economic downfall. Since 2009 the GHG emissions are strongly related to exported electricity that is mainly produced from oil shale.

The GHG emission decrease in 2024 in the Energy industries subcategory compared to the previous year was mainly because of certain shale oil plants were undergoing maintenance, which reduced shale oil production, decreased sales volumes and emissions compared to last year.⁸ It was also affected by slightly lower global crude oil prices in 2024 compared with 2023, which likely reduced the economic incentive to maintain higher shale-oil production and sales. Lower electricity prices compared to the previous year, combined with EU carbon allowance prices remaining at a similar level to 2023 and reduced profitability of oil shale electricity led to lower electricity generation from oil shale.⁹

This resulted in a further drop in oil shale consumption in the Public electricity and heat production sector and decreased emissions by 16.14% from 3708.52 kt CO₂ eq. in 2023 to 3109.98kt CO₂ eq. in 2024.

Emissions from the Energy sector decreased by 77.50% compared to 1990 (incl. Energy industries – 83.24%; Manufacturing industries and construction –92.46%; Other sectors – 76.78%; and Fugitive emissions –74.45%). Only one subsector had greater emissions in 2024 compared to 1990 – Transport where emissions increased by 5.11%. The overall progression of GHG emissions in the Energy is presented in Figure 2.5.

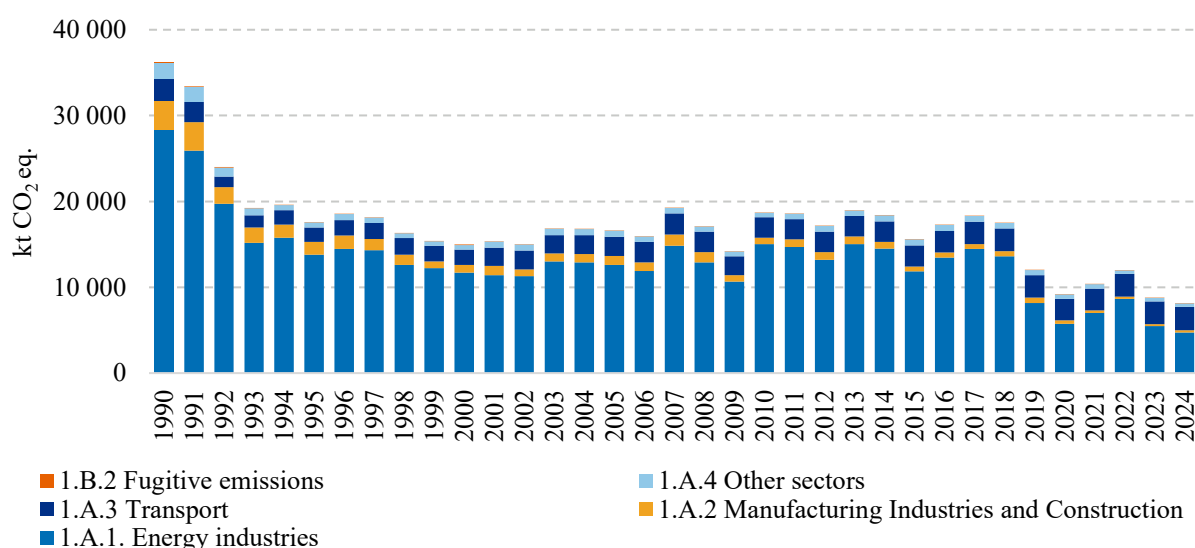


Figure 2.5. Trend in emissions from Energy sector 1990–2024, kt CO₂ eq.

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

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

- Mineral industry (emissions from cement until 2020, lime, glass production and other process uses of carbonates).
- Chemical industry (historically ammonia and carbamide were produced).
- Metal industry (production of secondary lead and rare earth metal compounds).

⁸ Eesti Energia Annual Report 2024. [www] <https://public-docs.enefit.com/ettevottest/investorile/eesti-energia-aastaaruanne-2024-est.pdf> (08.01.2026)

⁹ Eesti Energia ended the year in profit despite uncompetitive oil shale electricity. [www] <https://www.enefit.ee/en/-/uudised/eesti-energia-lopetas-aasta-kasumiga-hoolimata-konkurentsivoimetust-polevkivielektrist/> (08.01.2026)

- Non-energy products from fuels and solvent use (CO₂ 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 and indirect CO₂ emissions calculated from these NMVOC emissions).
- Product uses as substitutes for ODS (HFC emissions from refrigeration and air conditioning, foam blowing, fire protection and aerosols).
- Other product manufacture and use (SF₆ emissions from electrical equipment, SF₆ and PFC emissions from other product use and N₂O emissions from product uses).

In addition, NO_x, CO and SO₂ emissions from Pulp and paper are reported under 2.H Other production. The non-fuel-based CO₂ emissions from pulp and paper industry are estimated to be negligible in Estonia. All N₂O emissions from the pulp and paper and food industry are reported as fuel-based emissions under CRT 1.

In 2024 the Industrial processes and product use sector contributed 2.52% of all GHG emissions in Estonia (without LULUCF), totalling 257.66 kt CO₂ eq. with indirect CO₂ and 235.82 kt CO₂ eq. without indirect CO₂. The most significant emission sources in IPPU sector were HFC emissions from refrigeration and air conditioning at 69.94 % of total emissions from the sector (with indirect CO₂). Compared to 2023, the emissions from Industrial processes and product use (with indirect CO₂) decreased by 2.87 % in 2024.

Industrial CO₂ emissions have fluctuated strongly during years 1990–2024. 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 total emissions of HFCs increased significantly in 1993-2016, especially HFC emissions from refrigeration and air-conditioning equipment, which is the major source of hydrofluorocarbons (HFCs) in Estonia. 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 economic recession. The decline in production was mainly due to insufficient demand on both the domestic and external markets. CO₂ emissions raised in 2012 and 2013, because a power plant temporarily used large amounts of limestone for flue gas desulphurisation. The increase in 2017 emissions was largely caused by an increase of cement production. Decrease in mineral (and cement) industry output was the main driver in overall decrease of industrial CO₂ emissions from 2014 to 2016. Emissions of F-gases have been halted since 2017 because of the effect of restrictions of the previous Regulation (EU) No 517/2017 followed by the new F-gas regulation (EU) 2024/573¹⁰, in force from 11th of March 2024. In 2017-2018 emissions of HFCs have halted and in 2019-2020 significantly decreased because of bans and quota restrictions of EU Regulation No 517/2014 (the strictest ones started from 2020). Decrease in CO₂ emissions in 2023 and 2024 was mainly due to decreased emissions from the decreased usage of HFC-s.

The share of emissions by category and overall progression of GHG emissions in the Industrial processes and product use sector in CO₂ eq. is presented in Figure 2.6.

¹⁰ Regulation (EU) 2024/573 of the European Parliament and of the Council on fluorinated greenhouse gases https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202400573 (22.12.2025)

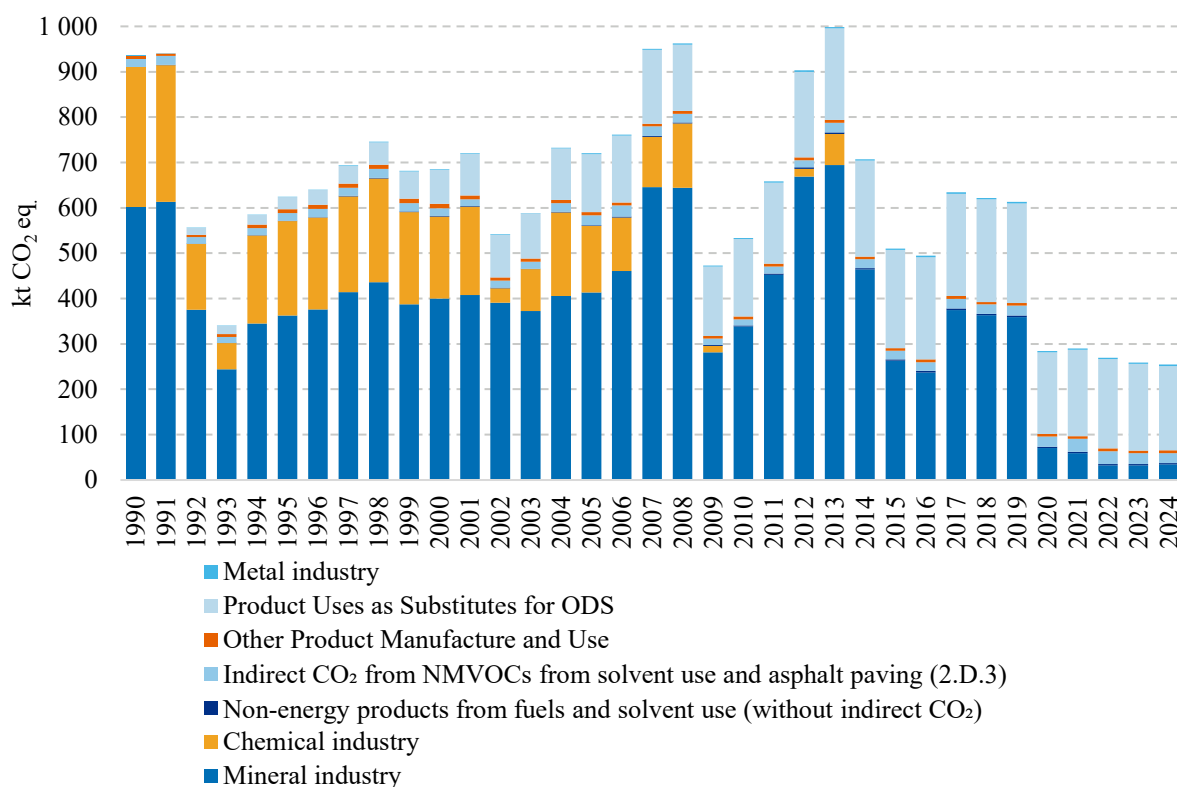


Figure 2.6. Trend in emissions from Industrial processes and product use sector, 1990–2024, kt CO₂ eq.

2.2.3. Trends in Agriculture (CRT 3)

Agricultural GHG emissions in Estonia consist of CH₄ emissions from the Enteric fermentation of domestic livestock, N₂O emissions from Manure management systems, direct and indirect N₂O emissions from Agricultural soils, CO₂ emissions from Liming and Urea application to agricultural soils. Direct N₂O 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, mineralization associated with the loss or gain of soil organic matter, and emissions from urine and dung deposited by grazing animals. Indirect N₂O emissions include emissions due to atmospheric deposition and nitrogen leaching and run-off from manure management. The trend in emissions in CO₂ eq. by category is presented in Figure 2.7.

The total GHG emissions reported in the Agricultural sector for Estonia were 1551.74 kt CO₂ eq. in 2024. The sector contributed about 15.2% to the total CO₂ eq. (without LULUCF) emissions in Estonia. In 2024, the emissions from Enteric fermentation increased by 0.16% compared to the previous year, emissions from Manure management decreased by 2.9%. The decrease of emissions is mostly because of the lower livestock population of cattle, sheep and goats, and increased biogas production from animal manure, the increase of emissions is mostly caused by the increased milk yield per dairy cow and swine population.

As a result of the markets of the former Soviet Union collapsing in the early 1990s, Estonia was left with a large excess supply of agricultural production. 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 the prices on world markets and became insufficient

to cover production costs.¹¹ This led to a rapid decline of agricultural production in Estonia and explains why the GHG emissions from the Agricultural sector have declined by 43.88% in 2024 compared with the base year (1990). In 2002–2008, the most important driving force for Estonian agriculture was the EU accession and the application of supporting the EU's common agricultural policy, the significant effect of which could be noticed even a few years before joining.¹² The positive impact on agricultural production manifested itself years preceding the EU accession and is reflected in the turnover of a downward GHG emissions trend that began in the 1990s.

The agricultural production is in a declining trend in Estonia as the population of cattle, sheep and goats decreased in 2024 compared to the previous year. This is mostly caused by the current difficulties in the agriculture sector starting from 2021 as production costs exceed the profit. This is in turn caused by the energy crisis in EU, leading to higher prices for fertilizers, energy, and feed.¹³ The dairy industry has suffered a decline in production due to economic sanctions imposed by Russia on the EU starting from August 2014, when Russia announced import restrictions for food supply coming from the EU. According to the restrictions, it is prohibited to import beef, pork, poultry, fish, milk and dairy, cheese, sausages, fruits, and nuts etc. from EU countries to Russia.¹⁴ Consequently, the number of dairy cattle in 2024 fell by 13.4% in comparison with 2014. The number of dairy cattle was record low being only 82,800 heads in 2025. The number of swine has fallen by 20.8% in 2024 compared to 2014 in Estonia because of the outbreak of African swine fever in the region in 2015. Regarding the spread of the disease, Baltic countries and Poland are a buffer zone for the whole EU, meaning it was necessary to apply measures to prevent the spreading of the African swine fever to other European countries. Prevention measures included population control, that lead to lower number of swine population in the country.¹⁵ Then, starting from 2017, the number of swine started steadily growing again. This was mainly caused by the improved economic situation in the country. Also, a high demand for pork in both inland and foreign markets as pork being the most popular meat in Estonia helped, to some extent, to recover the number of swine after the low point that started after the African swine fever in 2015. Then, after 2020, the number of swine started decreasing again. This was caused by more outbreaks of African swine fever occurred in 2021.^{16 17 18} What

¹¹ ESTONICA. Encyclopedia about Estonia. Laansalu, A. Crisis in agriculture in the 1990s. [www] https://web.archive.org/web/20070610040459/http://www.estonica.org/eng/lugu.html?menyy_id=914&kateg=40&alam=94&leht=3 (30.10.2025).

¹² Estonian University of Life Sciences. (2011). Rural Development Report. Tartu: AS Ecoprint, lk 86 (in Estonian).

¹³ Estonian Chamber of Agriculture and Commerce. Statistics highlight warning signs in Estonian livestock farming, pork market situation remains gloomy (in Estonian). [www] <https://epkk.ee/statistika-toob-valja-ohusignaaliid-est-loomakasvatustesealihaturu-olukord-endiselt-nukker/> (30.10.2025)

¹⁴ Ministry of Regional Affairs and Agriculture. Russian sanctions on European Union food products (in Estonian). [www] <https://www.agri.ee/maaelu-pollumajandus-toiduturg/pollumajandus-ja-toiduturg/venemaa-sanktsioonid-euroopa-liidu> (29.10.2025).

¹⁵ Ministry of Regional Affairs and Agriculture. Ministers of Agriculture and Heads of Veterinary Boards of the Baltic States discussed urgent measures to prevent the spread of African swine fever. [www] <https://www.agri.ee/en/news/ministers-agriculture-and-heads-veterinary-boards-baltic-states-discussed-urgent-measures> (29.10.2024)

¹⁶ Ministry of Regional Affairs and Agriculture. African swine fever (in Estonian). [www] <https://www.agri.ee/toiduohutus-taime-ja-loomatervis/sigade-aafrika-katk> (30.10.2025); ERR.ee, Swine fever may threaten pig farms in several counties (in Estonian). [www] <https://www.err.ee/1608284100/seakatk-voib-ahvardada-mitme-maakonna-seafarme> (29.10.2025).

¹⁷ Estonian Chamber of Agriculture and Rural Affairs. The peak season for the spread of African swine fever is upon us (in Estonian). [www] <https://epkk.ee/kaes-on-sigade-aafrika-katku-leviku-korgaeg/> (29.10.2025).

¹⁸ Estonian Chamber of Agriculture and Commerce. Statistics highlight warning signs in Estonian livestock farming, pork market situation remains gloomy (in Estonian). [www] <https://epkk.ee/statistika-toob-valja-ohusignaaliid-est-loomakasvatustesealihaturu-olukord-endiselt-nukker/> (29.10.2025).

is more, as pork meat's free market purchase prices have been at least 1/3 lower than the actual production costs, several pork producers have been forced to close down their production.¹³ Furthermore, imported pork is cheaper for the buyer, so people have started to prefer it to domestic pork.¹⁹ However, compared to 2023, swine numbers have risen by 3.1% in 2024.

Emissions from Agricultural soils increased by 2.20% in 2024 compared to 2023. This is caused by the increased crop production because of better weather conditions, and due to increased amounts of compost and biowaste-based digestates applied to fields. Emissions from Liming and Urea application sub-categories decreased by 3.68% and 99.96%, respectively, in 2024 compared to the previous year. This is caused by the decreased usage of lime and urea fertilizers on the fields.

Emissions from Agricultural soils and Enteric fermentation of livestock were the major contributors to the total emissions in the sector – 45.1% and 39.3%, respectively.

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

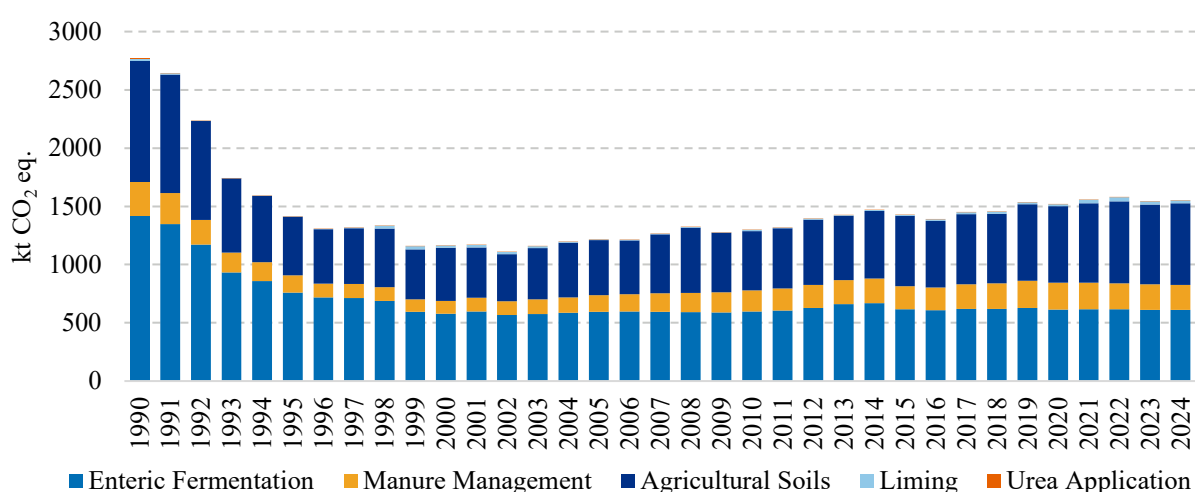


Figure 2.7. Trends in emissions from the Agriculture sector, 1990–2024, kt CO₂ eq.

2.2.4. Trends in Land use, land-use change and forestry (CRT 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, Settlements, Other land and Harvested wood products (HWP). Each category, except HWP, is further divided into 'land remaining' and 'land converted to' subcategories.

Emissions and removals by each land use category during the period 1990–2024 are presented in Figure 2.8. In 2024 net emissions from the LULUCF sector equalled 1906.55 kt CO₂ equivalent, which is 23.5% lower compared to the previous year. In the base year (1990), LULUCF sector acted as a C sink with net emissions of -4043.28 kt CO₂ eq. The LULUCF sector sink is mainly affected by the age structure of forests, management practices in forestry and agriculture, area of drained organic soils, production of horticultural peat, and C sequestration in HWP.

In 2024, Forest land, HWP and Grassland were sequestering CO₂, but this did not compensate for emissions from the other LULUCF categories. Main part of the HWP sink is in the

¹⁹ Estonian Chamber of Agriculture and Commerce. Domestic pig farming needs consumer support – otherwise it will disappear (in Estonian). [www] <https://epkk.ee/kodumaine-seakasvatus-vajab-tarbija-toetust-vastasel-korral-haabub/> (29.10.2025).

sawnwood subcategory, while C sequestration in wood panels has declined significantly. Grasslands sequester carbon mainly in the living biomass and mineral soils following land-use change. The highest net emitter was the Wetlands category, with significant off-site emissions from the horticultural use of peat, followed by the Cropland category, which has high carbon losses in organic soils, but in recent years also in mineral soils.

Forest is the prevailing land-use category in Estonia, and thus the Forest land category has the largest influence on the LULUCF sector's total carbon balance trends. In the first half of the time series, the high proportion of young and middle-aged stands led to a growing net annual increment. At the end of the 1990s, the felling volume also began to grow rapidly, but the impact of the age structure and increasing area of the forest land on the C balance was more significant. Consequently, Forest land sequestered carbon due to the rapid increase in forest growing stock.

Forest C sequestration has declined in recent years due to the high proportion of mature and near-mature forest stands and increasing proportion of forest area belonging to the first development classes (treeless area, area under regeneration and young stands). The fluctuations in annual carbon stock changes in Forest land are mainly caused by the felling rates.

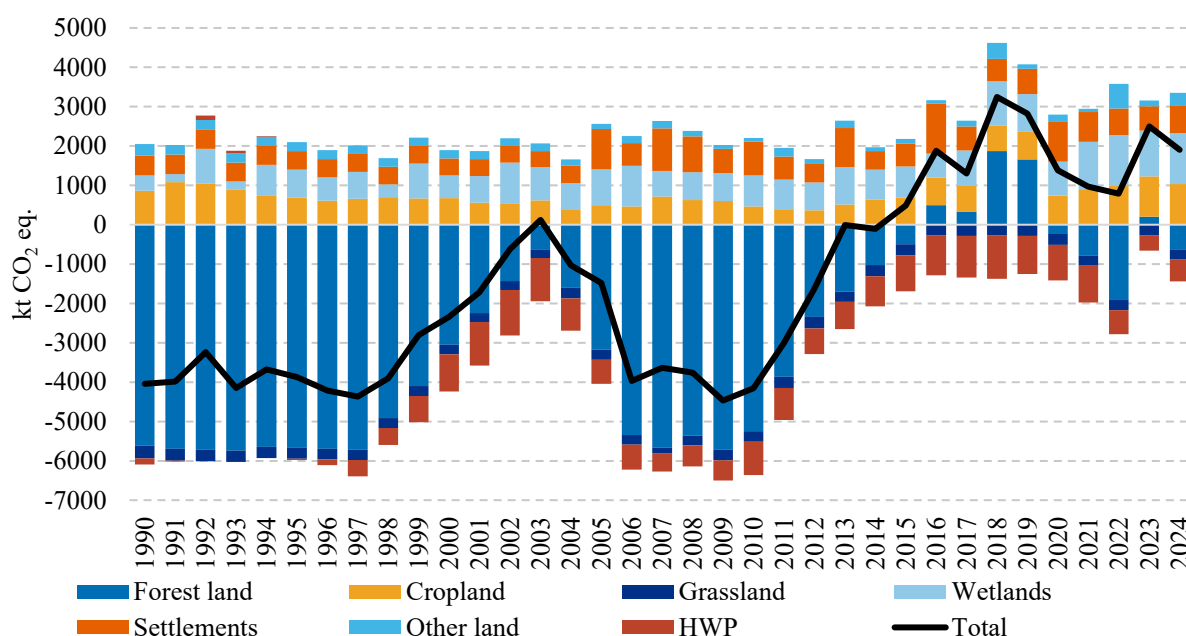


Figure 2.8. Trends in GHG emissions (+) and removals (-) from land use, land-use change and forestry sector 1990–2024, kt CO₂ eq.

2.2.5. Trends in Waste (CRT 5)

Estonia's GHG emissions from Waste sector covers solid waste disposal sites including solid municipal and industrial waste, and CH₄ and N₂O emissions from biological treatment (composting and anaerobic digestion) of solid waste and wastewater treatment and discharge from domestic and industrial sector. Emissions from open burning and incineration without energy recovery are no longer reported since 2025 submission as they are considered insignificant. The share of emissions by each category is presented in Figure 2.9.

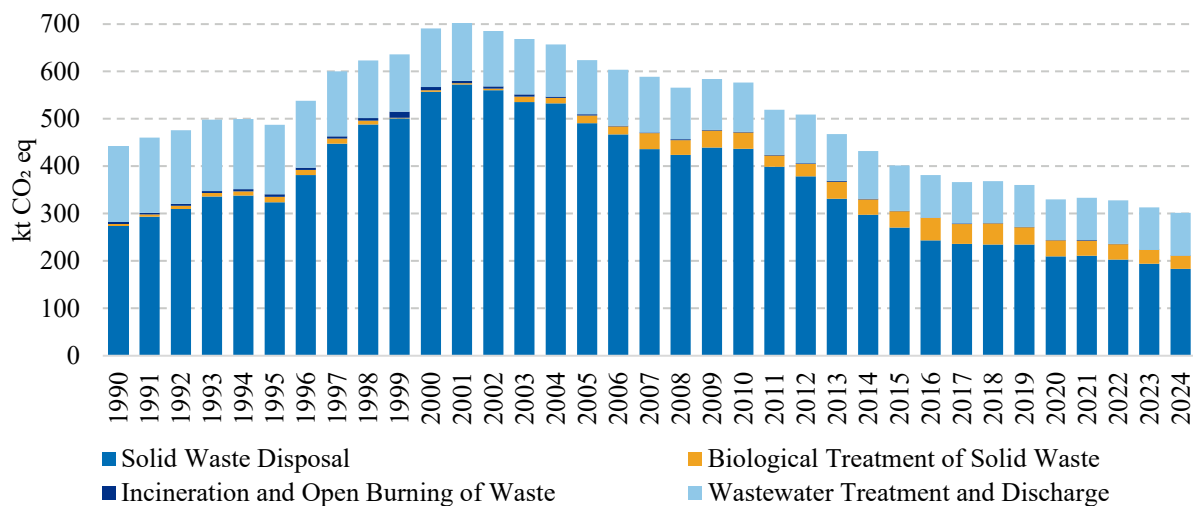


Figure 2.9. Trend in emissions from waste sector by source categories in 1990–2024, kt CO₂ eq.

CO₂ eq. emissions from the Waste sector were 290.86 kt in 2024 and contributed to 2.84% of total GHG emissions in 2024. Total CO₂ eq. emissions from the Waste sector (Table 7.2) in 2024 decreased by 0.99% compared to 2023. Compared to the base year of 1990, the amount of CO₂ eq. emissions in 2024 were 34.3% smaller. Compared to the base year, CO₂ eq. emissions from Solid waste disposal (SWD) have decreased by 36.8% and from Wastewater treatment and discharge by 43.7%. On the other hand, CO₂ eq. emissions from Biological treatment of solid waste have, compared to the base year of 1990, increased by 456.7%. Emissions from waste incineration and open burning are no longer reported since 2025 submission as they are below the reporting threshold.

As seen from Figure 2.9, GHG emissions from the Waste sector are in decreasing trend.

Low CO₂ eq. emissions in 1995 are related to decreasing CH₄ emissions from paper and sludge disposal. The highest CO₂ eq. in 2000–2001 is related to the significant increase in emissions mainly from Solid waste disposal. The 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 the Waste sector after 2004 relates to the increasing amount of CH₄ recovery from landfills. Emissions decrease starting from 2009 is in connection with the financial crisis during 2007–2008. The financial crisis did not affect the Waste sector immediately, because companies had a raw material reserve. The total CO₂ eq. in 2011 decreased significantly compared to previous years, mainly because of the change in the national currency, which raised prices in the country and therefore changed consumption habits and reduced waste generation. Also, opening the Iru waste incineration plant in 2013 had a decreasing effect on the amount of deposited waste trend.

Due to the COVID-19 pandemic, emissions decreased sharply in 2020, as the amount of generated waste decreased. Emissions increased a bit in 2021, but still remained below the 2019 level. The slight increase in 2021 total emissions is mainly driven by 5A (SWD) and 5D (Wastewater treatment) subcategories. In SWD emissions increased, because less landfill gas was collected and therefore methane recovery rate was lower compared to 2020. In addition, emissions in wastewater treatment subcategory increased as the population of low-density settlements increased based on recent census. The lowest CO₂ eq. emissions occurred in 2024, which was mainly connected to the decreasing amount of waste deposited in landfills.

3. ENERGY (CRT SECTOR 1)

3.1. Overview of the sector (e.g. quantitative overview and description, including trends and methodological tiers by category) and background information

The Energy sector is the main source of greenhouse gas emissions in Estonia. In 2024, the Energy sector contributed about 79.49% of total emissions (without LULUCF), totalling 8140.35 kt CO₂ equivalent.

Compared to the base year 1990 (36 181.97 kt CO₂ eq.), the emissions have decreased about 77.50%. Most Energy sector emissions originated from fuel combustion, which accounted for 99.77% (8122.02 kt CO₂ eq.) of Energy sector emissions, while fugitive emissions accounted for 0.23% (18.33 kt CO₂ eq.). Within the Energy sector, the largest share came from 1.A.1 Energy industries, which contributed 46.30% of total national emissions without LULUCF (4741.25 kt CO₂ eq.). This was followed by 1.A.3 Transport with 26.39% (2702.46 kt CO₂ eq.), 1.A.2 Manufacturing industries and construction with 4.08% (417.96 kt CO₂ eq.), 1.A.4 Other sectors with 2.54% (260.35 kt CO₂ eq.), and 1.B Fugitive emissions with 0.18% (18.33 kt CO₂ eq.). A substantial amount of energy-related emissions are caused by an extensive use of fossil fuels in public electricity and heat production, which is included in the 1.A.1 Energy industries sector – Figure 3.1.

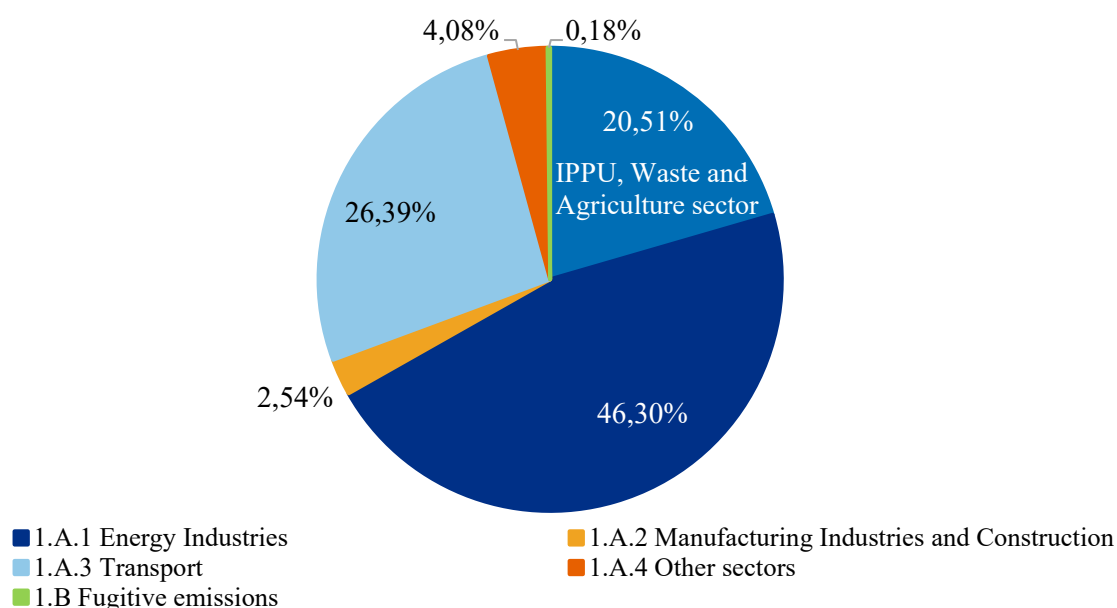


Figure 3.1. Emissions from the Energy sector compared to the total emissions in 2024, %

Inland energy consumption represents the total domestic energy demand and is an energy-balance aggregate that covers energy available for use within the country, while excluding marine bunkering and separately reporting international aviation. In 2024 inland energy consumption was 176.63 PJ, which is about 0.84% less than 2023 – inland consumption includes 43.05% oil shale, 23.78% biomass, 22.37% liquid fossil fuels and 5.31% natural gas. Hydro, wind, and solar power formed 3.82% of inland consumption. Other fuels had smaller shares – fossil wastes 0.67%, liquid and gaseous biofuels 0.95%, peat 0.05%, and coal 0.01% - Figure 3.4. Most notable change compared to fuel consumption composition in 1990 (Figure 3.3) is significant increase in consumption of biomass-based fuels, which has decreased the overall share of liquid fossil fuels, natural gas and oil shale.

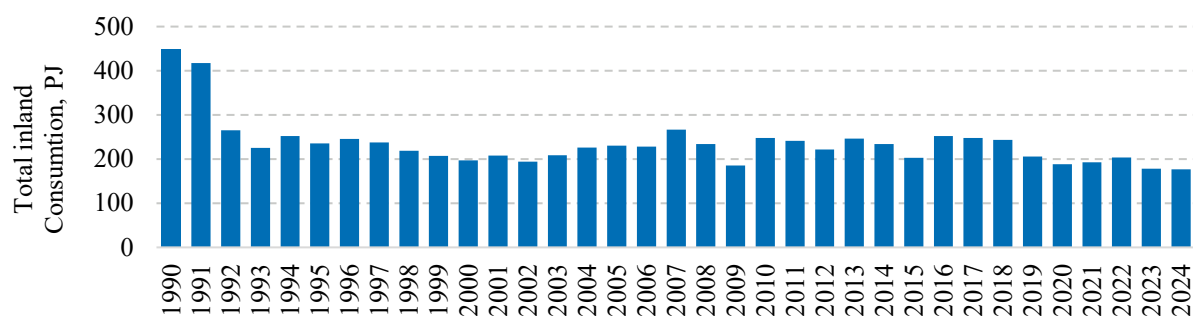


Figure 3.2. Development of inland energy consumption in Estonia in 1990–2024, PJ (Source: Statistics Estonia)

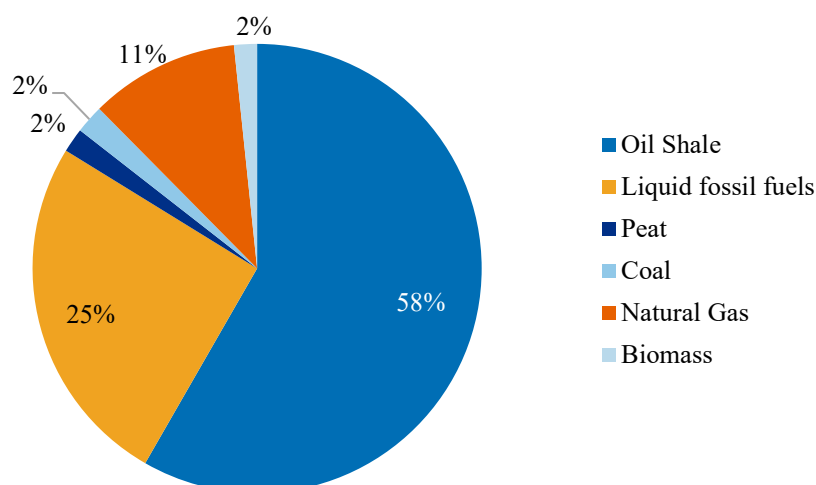


Figure 3.3. Structure of inland energy consumption in Estonia in 1990, %

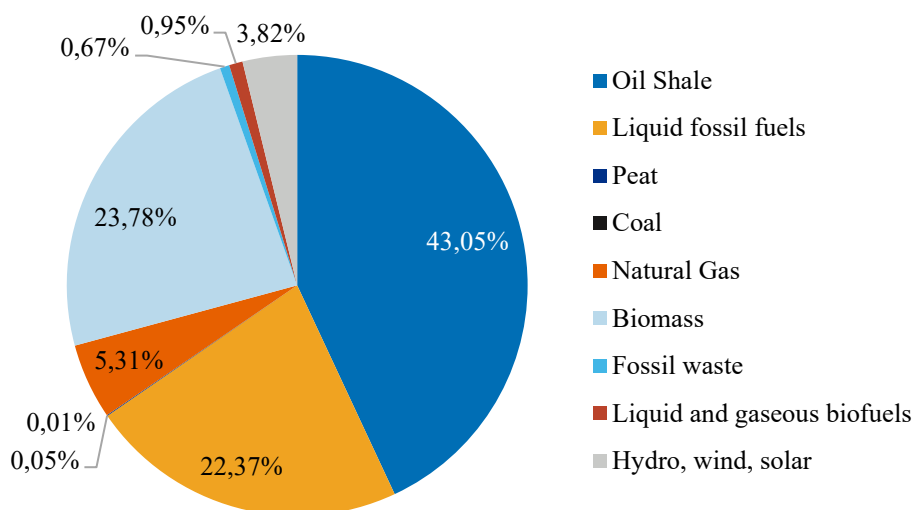


Figure 3.4. Structure of inland energy consumption in Estonia in 2024, %

Estonia's nominal GDP has steadily grown since 2009, except in 2020 when GDP fell by 2.2% at constant prices, because of restrictions from COVID-19 pandemic, but was twice lower than EU average. In 2021 nominal GDP increased 12.9% compared to 2020 as the economy began to recover from the COVID-19 crisis. This recovery continued in 2022, with nominal GDP increasing 15.4%, compared to the previous year. Nominal GDP growth slowed in 2023 and

was only 5.7% higher compared to 2022. Nominal GDP growth slowed even more in 2024 and was only 3.9% higher compared to 2023 and real GDP was 0.1% lower than 2023.

Domestic fuels have a high share in Estonia’s energy resources and the primary energy balance, and it is mainly based on oil shale and biomass. Most of the oil shale is consumed in power plants and as a raw material for shale oil production. Biomass and natural gas are used in boiler houses and biomass in the public electricity and power production and residential sector (Figure 3.5).

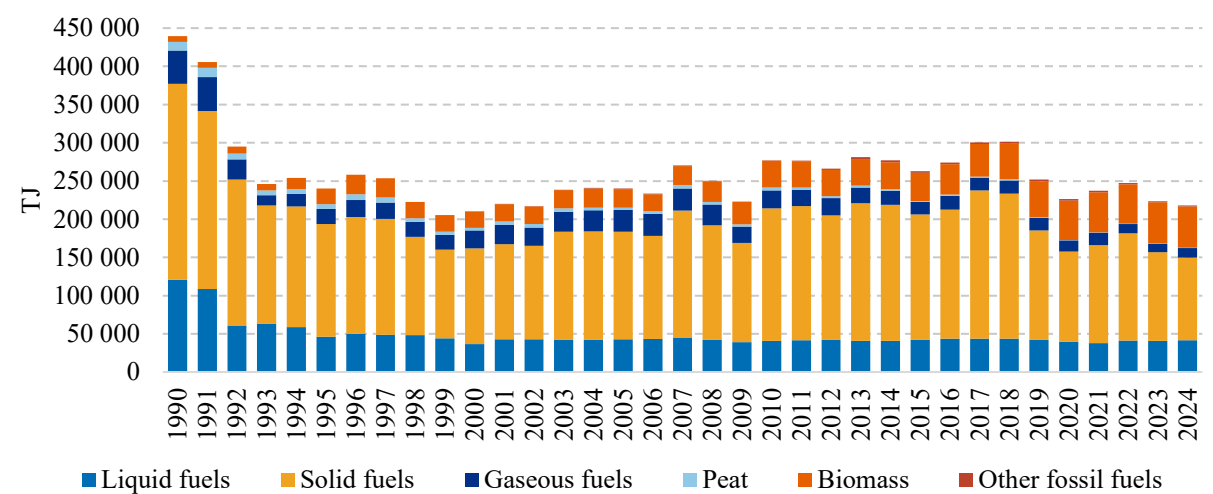


Figure 3.5. Fuel consumption in Energy sector in 1990–2024, TJ

The GHG emission and fuel consumption decreased compared to the previous year primarily in the Energy industries, as fuel prices and electricity prices were lower compared to 2023 and EU ETS allowance prices stayed on a similar level, which reduced some competitiveness of electricity generation from oil shale in the electricity market. This resulted in a drop in oil shale consumption in the Public electricity and power production sector and decreased emissions by 16.51 % from 3708.52 kt CO₂ eq. in 2023 to 3109.98 kt CO₂ eq. in 2024. Emissions from the Energy sector by subcategories in 1990–2024 are presented in Figure 3.6.

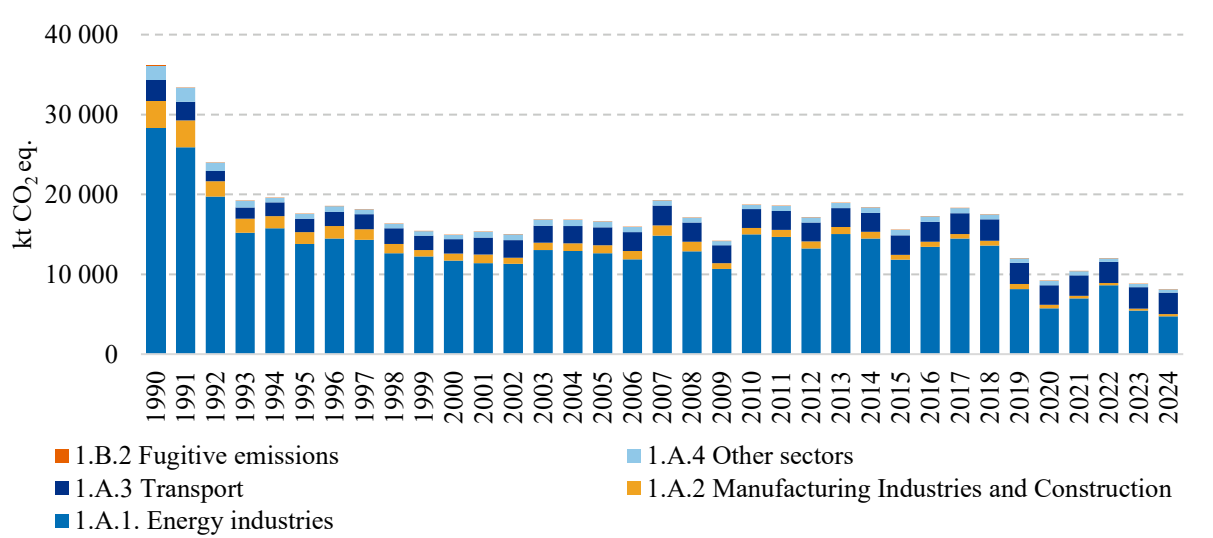


Figure 3.6. Emissions from the Energy sector by subcategory in 1990–2024, kt CO₂ eq.

The greenhouse gases emitted in the Energy sector are carbon dioxide (CO₂), small amounts of methane (CH₄), and nitrous oxide (N₂O). Energy-related CO₂ emissions vary according to the energy supply structure, electricity market dynamics and weather conditions. Electricity prices

and also the price of EU ETS allowances have a significant effect on Estonian emissions, as they determine the amount of electricity produced from oil shale. As suggested in the IPCC 2006 Guidelines, the emissions in the Energy sector are divided into Emissions from fuel combustion (CRT 1.A) and Fugitive emissions (CRT 1.B). Emissions from the Energy sector in 1990–2024 by greenhouse gas are presented in Table 3.1.

Table 3.1. Emissions from the Energy sector in 1990, 2005, and 2021–2024 by greenhouse gas, kt CO₂ eq.

Category	1990	2005	2021	2022	2023	2024
1 Energy Total, CO ₂ eq.	36 181.97	16 628.82	10 405.24	12 000.82	8783.47	8140.35
1.A Fuel Combustion Total, kt CO ₂ eq.	36 110.24	16 582.33	10 381.97	11 983.61	8768.10	8122.02
1.A Fuel Combustion, kt CO ₂	35 943.21	16 491.10	10 263.60	11 863.43	8649.90	8000.56
1.A Fuel Combustion, CH ₄ , kt CO ₂ eq	106.43	40.67	40.44	39.59	38.60	38.48
1.A Fuel Combustion, N ₂ O, kt CO ₂ eq	60.59	50.56	77.93	80.58	79.60	82.98
1.B Fugitive Emissions, kt CO ₂ eq.	71.73	46.49	23.27	17.21	15.37	18.33

3.2. Fuel combustion (CRT 1.A)

3.2.1. Comparison of the sectoral approach with the reference approach

Reference approach (RA) is carried out using import–export, production, and stock change data from the Joint Questionnaire dataset reported to Eurostat by Statistics Estonia (www.stat.ee).

In the 2026 inventory submission, the difference in CO₂ emissions in 2024 between RA and Sectoral approach (SA) was 46.61%. A lot of secondary fuels that are used in final consumption are made from oil shale: shale oil, semi-coke, and oil shale gas. This brings about differences in solid fuel consumption between RA and SA. These two datasets are comparable because in SA and RA the same amount of oil shale must be theoretically consumed. But, the amount of emitted CO₂ is different, as SA considers 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 (some of the carbon is transferred into shale oil). In RA calculations entire carbon in oil shale is combusted. To conclude, the emissions in RA from solid fuels are greater than in SA.

Shale oil is reported under Liquid fuels Shale Oil in RA in CRT tables and under Other hydrocarbons in the energy balance. The production of secondary fuels (which shale oil is) is not accounted for in the energy balance and in RA and Estonia exports most of its produced shale oil. This causes a negative apparent consumption of shale oil in the energy balance. This is the reason there is a negative value reported in the stock change in RA as there is no consumption reported and the calculated consumption in CRT has to be zero.

Waste consumption and emissions allocation reported in CRT Sectoral approach and Reference approach:

- Sectoral approach
 - 1.A.1.a municipal waste fossil part in Other fossil fuels
 - 1.A.1.a municipal waste biogenic part in Biomass
 - 1.A.2.f fossil waste in Other fossil fuels
- Reference approach
 - 1.A.1.a municipal waste fossil part in Waste (non-biomass fraction)

- 1.A.1.a municipal waste biogenic part in Other non-fossil fuels
- 1.A.2.f fossil waste in Other fossil fuels

More detailed comparison of the sectoral approach with the reference approach is presented in the Annex III: Detailed description of the reference approach (including inputs to the reference approach such as the national energy balance) and the results of the comparison of national estimates of emissions with those obtained using the reference approach (related to a nonmandatory provision as per para. 36 of the MPGs).

3.2.2. International bunker fuels

In the 15th of April 2026 submission, updated activity data for international bunkers are only partially available. For international aviation, new 2024 activity data are applied. For international navigation, however, the inventory continues to apply the latest available verified activity data (2023) for liquid fuels, as the verification of the updated information by Statistics Estonia has not yet been finalised. The data will be revised in the 2027 submission once verified information becomes available, together with any necessary time-series consistency updates and explanations.

International bunkers cover international aviation and navigation according to the IPCC 2006 Guidelines. Emissions from international bunkers for aviation and navigation are not included in the national total but instead reported separately as a memo item in CRT 1.D.

In 2024 GHG emissions from international bunkering were 914.36 kt CO₂ eq., including international navigation 744.43 kt CO₂ eq. and international aviation 169.93 kt of CO₂ eq.

GHG emissions from navigation increased from 2005 through 2008. After 2008 a decline lasted until 2012. Due to the methodology change in activity data by Statistics Estonia, the emissions increased about two times in 2012 compared to 2011. The sharp difference in GHG emissions in 2011/2012 in International navigation remains and Statistics Estonia who provides fuel consumption data is working on data consistency issue. In 2017 LNG was introduced in this sector for the first time. In 2019 emissions from navigation fell 40.7% next to 2018 due to substituting diesel oil with LNG and a decrease in passenger traffic. In 2020 emissions from navigation increased 60.6% compared to 2019 due to an increase in fuel stocks. In 2024 emissions from international navigation increased by 2.18% compared to 2023 driven by higher LNG use.

The emissions trend in international aviation has been quite stable, slight increases in 2007 and 2008 were caused by lower bunker fuel prices in Estonia. In 2020 emissions from International aviation decreased 65.7% compared to 2019 because of a severely reduced international air traffic due to COVID-19 pandemic. In 2021 the emissions increased about 79.2% as passenger demand recovered due to reduced movement restrictions from COVID-19 pandemic.. In 2024 emissions increased by 16.36% compared to 2023, reflecting higher jet kerosene consumption. This is consistent with increased aviation activity, with 3.49 million passengers passing through Tallinn Airport in 2024, an 18% increase, and 42 403 flight operations performed, an 11% increase from 2023²⁰.

Figure 3.7 presents the trend of GHG emissions from International aviation and navigation.

²⁰ Tallinn Airport Annual Report 2024. [www] <https://airport.ee/wp-content/uploads/2025/04/Tallinna-Lennujaam-ilus-pdf-eng.pdf> (05.03.2026)

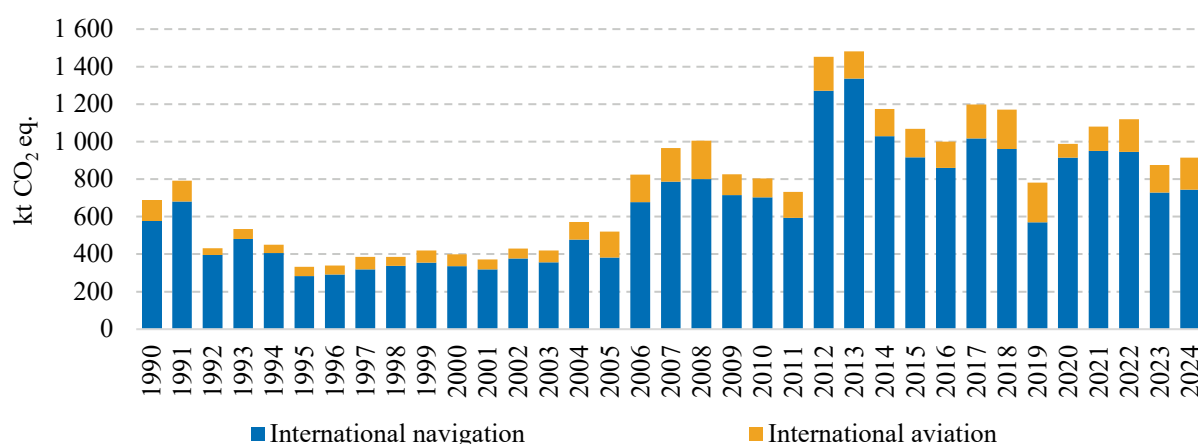


Figure 3.7. Emissions from International bunkers in 1990–2024, kt CO₂ eq.

Activity data in International navigation is taken from Joint Questionnaire made by Statistics Estonia. Statistics Estonia obtains this data from the international trade database according to the relevant merchandise code.

Activity data for the calculations in International aviation (landing and take-off cycles, fuel consumption) is obtained from the Estonian Environment Agency.

Emissions are calculated using the IPCC 2006 methodology. In international aviation the CO₂, CH₄, and N₂O emissions are calculated using IPCC 2006 default emission factors and in international navigation CO₂ emissions are calculated using country-specific emission factors for residual fuel oil, light fuel oil, and natural gas (LNG) and for CH₄ and N₂O the IPCC 2006 default emission factors are used.

3.2.3. Feedstocks and non-energy use of fuels

The following fuels are reported under CRT 1.A.D Feedstocks, reductants and other non-energy use: lubricants, bitumen, natural gas, and oil shale.

Activity data on lubricants, bitumen, and natural gas consumption for non-energy use is received from Joint Questionnaire made by Statistics Estonia and is annually sent to Eurostat and IEA. Oil shale activity data is calculated using plant-specific data. The reported amount is oil shale semi-coke which is 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).

Natural gas was used for non-energy purposes in ammonia production in Nitrofert AS and is reported in the CRT 2.B.1. In 2010 and 2011 the factory was temporarily closed due to low ammonia prices in the world market. The ammonia production factory has remained closed since 2013.

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

Additional information regarding CRT category 1.A(d) Feedstocks and non-energy use is presented in Annex 5 (A.V.1.3).

3.2.4. Energy industries (1.A.1)

3.2.4.1. Category description

In the 15th of April 2026 submission, updated activity data for Energy industries (1.A.1) are only partially available. The inventory continues to apply the latest available verified activity data (2023) for selected fuels, including liquid fuels (diesel oil, light fuel oil, residual fuel oil) and biomass fuels (solid biomass). The data will be revised in the 2027 submission once verified information becomes available, together with any necessary time-series consistency updates and explanations.

Energy industries (CRT 1.A.1) includes GHG emissions from fuel combustion in 1.A.1.a Public electricity and heat production and in 1.A.1.c Manufacture of solid fuels and other energy industries which includes GHG emissions from shale oil production from point sources.

In 2024 Energy industries (1.A.1) contributed 58.24% of Energy sector emissions, totalling 4741.25 kt CO₂ eq. and 46.30% of total GHG emissions. Compared to the base year 1990, the emissions were 83.24% lower (1990 emissions were 28 284.61 kt CO₂ eq.). The decrease of 13.35% in 2024 in the Energy industries compared to the previous year was mainly because of certain shale oil plants were undergoing maintenance, which reduced shale oil production, decreased sales volumes and emissions compared to previous year. It was also affected by slightly lower global crude oil prices in 2024 compared with 2023, which likely reduced the economic incentive to maintain higher shale-oil production and sales.⁸ Lower electricity prices compared to the previous year, combined with EU carbon allowance prices remaining at a similar level to 2023 and reduced profitability of oil shale electricity led to lower electricity generation from oil shale.⁹

The emissions from Energy industries by relevant subcategories and gases in 1990–2024 are presented in Table 3.2 and Figure 3.8.

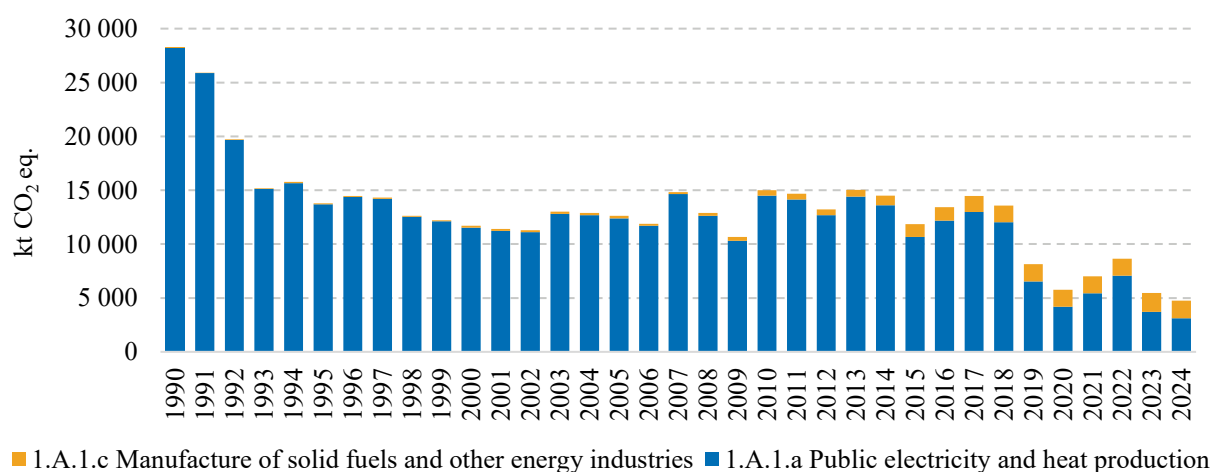


Figure 3.8. Trend of GHG emissions from Energy industries by relevant sub-categories in 1990–2024, kt CO₂ eq.

Table 3.2. GHG emissions from Energy industries by relevant subcategories in 1990, 2005, and 2021–2024, kt CO₂ eq.

	1990	2005	2021	2022	2023	2024
1.A.1 Energy Industries Total, CO₂ eq.	28 284.61	12 611.61	6997.67	8635.49	5471.89	4741.25
1.A.1.a Public Electricity and Heat Production Total, CO ₂ eq.	28 206.06	12 383.43	5449.05	7071.52	3708.52	3109.98
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries Total, CO ₂ eq.	78.56	228.19	1548.63	1563.97	1763.37	1631.27

In general the trend of GHG emissions in Energy industries follows the trend of fuel consumption. The decrease of GHG emissions in 1.A.1.a Public electricity and power production sub-sector in 2024 compared to 1990 was -88.97%. This considerable decrease was caused by the structural changes in the economy after 1991 when Estonia regained independence. There has been a drastic decrease in the consumption of solid, liquid, and gaseous fossil fuels to produce heat and power and increase in the use of solid biofuels. At the same time, the GHG emissions from 1.A.1.c Manufacture of solid fuels and other energy industries (shale oil production) have increased over 20 times compared to 1990 due to extended production and export of shale oil.

Estonia imported natural gas, liquid fuels, coal, and solid biofuels in 2024. Natural gas imports increased about 8.19% compared to 2023, due to increased demand. Motor gasoline and diesel imports increased about 11.48% compared to the previous year. Coal imports decreased about 84.25% compared to 2023, but the overall quantities of coal were marginal – only 0.8 kt.

1.A.1.a Public electricity and heat production

The decrease of GHG emissions in 1.A.1.a Public electricity and power production sub-sector in 2024 compared to 1990 was -88.97%. This considerable decrease was caused by the structural changes in the economy after 1991 when Estonia regained independence. There has been a drastic decrease in the consumption of solid, liquid, and gaseous fossil fuels to produce heat and power and increase in the use of solid biofuels.

In 2024 the gross electricity production was 6368 GWh – about 11 % higher compared to 2023 (5745 GWh). The electricity export decreased from 4355.4 GWh in 2023 to 2562 GWh in 2024 (about 41.2%). The electricity import increased from 7 659.7 GWh in 2023 to 5477 GWh in 2024 (28.5%).

Renewable energy is generated from wind, biomass, solar and small hydroelectric plants in Estonia. The growth of wind parks, solar power, and biomass has significantly contributed to the increasing share of renewable energy in total energy production. In addition to the cheapening and availability of technology, the impulse for more active deployment of solar power plants in Estonia is provided by the support scheme for renewable electricity production.

In 2024 the total heat production was 22 942 TJ and in 2023 it was 21 737 TJ. It increased around 5.54% compared to 2023 due to increased heating demand. Roughly 40.04% of heat was produced in heating plants and power plants produced about 59.96% of heat.

In 2013 a waste incinerator plant was opened in Estonia. These emissions are accounted for in Other fossil fuels in Energy industries sector. In 2024 Iru waste incineration plant emitted 124.72 kt CO₂ eq.

1.A.1.b Petroleum refining

There are no petroleum refining activities taking place in Estonia.

1.A.1.c Manufacture of solid fuels and other energy industries

The GHG emissions from 1.A.1.c Manufacture of solid fuels and other energy industries (includes shale oil production) have increased over 20 times compared to 1990 due to extended export of shale oil. 1205.29 kt of shale oil was produced in 2024, which was 1,78% less compared to 2023 production. The GHG emissions decreased by 7.49% in 2024 from 1763.37 kt CO₂ eq in 2023 to 1631.27 kt CO₂ eq in 2024.

3.2.4.2. Methodological issues

Choice of methods

Emissions from Fuel combustion in 1.A.1 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 is applied. For domestic fuels – oil shale, shale oil, oil shale semi-coke, oil shale semi-coke gas, generator gas, and peat – *Tier 2* and *Tier 3* approaches are used.

1.A.1.a Public electricity and heat production

Oil Shale

Oil shale is a primary indigenous fuel in Estonia, which is mainly used to produce electricity and shale oil. Estonian oil shale is characterised with a high ash (45–47%), a moderate moisture (11–13%), and sulphur content (1.5–1.7%), a low net calorific value (about 8.3–8.7 MJ/kg), and a high 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, carbonate²¹.

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 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 best quality oil shale layers have mostly been exhausted²¹.

CO₂ is formed not only as a burning product of organic carbon during the combustion of pulverised oil shale but also as a decomposition product of the ash carbonate part. Therefore, the total quantity of carbon dioxide increases by up to 25% in flue gases of oil shale²¹.

Two different combustion technologies, the older pulverised combustion of oil shale (PC) and the newer circulated fluidised bed combustion (CFBC) technology are currently used in the Estonian power plants.

The first CFBC power unit (215 MW_{el}) started at the Estonian Power Plant at the end of 2003. The conducted tests showed that the transition from pulverised combustion boilers to circulating fluidised bed boilers comes with several changes: the CFBC boiler CO₂ discharge rose from 82–84% to 75% (the carbonate decomposition rate was sometimes even less), the SO₂ atmospheric discharges stopped almost completely ($k_s=0.999$), the boiler efficiency increased from 81–82% to ~90–95%, thus the fuel consumption also decreased, and power production efficiency at nominal load range dropped from 35–36% to 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 CO₂ binding at ash fields are presented in Equation 3.1.

²¹ Ots, A. (2004). Oil shale combustion technology. Tallinn: Tallinna Raamatutrükikoda, page 833.

$$CEF_{oil\ shale} = \frac{10 \times [C_t^r + k \times (CO_2)_M^r \times 0.273]}{Q_i^r} \left[\frac{tC}{TJ} \right]$$

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 CO₂ discharged into ambient air’²² 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.

CO₂ emissions from pulverised combustion and circulating fluidised bed combustion boilers are therefore calculated separately. These values have been used for most years. When available, more accurate plant-specific emission factors are used. The ranges of the emission factors are presented in Table 3.6.

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. Semi-coke gas is the by-product of oil shale thermal processing in solid heat carrier installation (SHC), generator gas is produced in the oil shale processing in vertical reactors (gas generators), and gas gasoline is a by-product fuel in oil shale production. In Table 3.3 semi-coke gas and generator gas production data for different shale oil plants is presented.

Table 3.3. Semi-coke gas and generator gas production by shale oil plants, PJ

Year	Solid Heat Carrier			Total	Gaseous Heat Carrier		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
2005	1.60	NO	NO	1.60	2.46	0.86	3.32	4.92
2020	5.86	5.24	NO	11.10	1.67	0.94	2.61	13.71
2021	5.49	4.76	NO	10.25	1.57	1.01	2.58	12.83
2022	4.74	4.13	0.41	9.28	1.53	0.70	2.23	11.51
2023	4.93	4.87	0.36	10.16	1.56	0.66	2.22	12.38
2024	4.82	4.91	0.42	10.15	1.48	0.57	2.05	12.20

NO – no production occurred

Description of oil shale production technologies and detailed methodology for estimation of carbon emission factors for oil shale gases is presented in Annex V (A.V.1.1). GHG emissions from the combustion of different oil shale gases are calculated separately and included into CRT 1.A.1.a Public electricity and heat production under Solid fuels.

²² Riigi Teataja. Methods for calculating carbon dioxide emissions released into the ambient air. [www] <https://www.riigiteataja.ee/akt/129122016063?leiaKehitiv> (19.12.2024).

Waste incineration

Enefit Green AS (Enefit Green Ltd. Iru incineration plant) uses waste in their daily activity.

Kunda Nordic Cement used waste oils, plastic waste, and other fossil-based solid waste as an alternative fuel source to produce cement, clinker, and splinters until 2020 when Kunda Nordic Cement closed down the clinker production.

Iru incineration plant uses municipal waste to produce heat and electricity since 2013. The plant uses MARTIN moving grate technology, consisting of moving grates at an angle of 26 degrees. Each part of the grate has a drive with automatically adjustable speed. The grates are made out of wear and temperature-resistant material (CrFe). The pace and speed selection of mobile grates ensure the most efficient and safe combustion process possible. A unique “reverse” reburn system ensures fuel mixing and good carbon extraction. The volatile part is lit above the grate. This operation also ensures the continuous coverage of the firing grates with a protective layer of waste or ash, preventing the grate from burning naked, giving them a longer life-span. This technology does not require cooling water for waste with high calorific values.

For the 2024 submission Estonia updated the methodology to calculate emissions from Iru waste plant. The new methodology also allowed to introduce separate carbon emission factors for imported municipal waste in the calculations. The fossil and biogenic waste fractions as well as fossil and biogenic carbon emission factors for the municipal waste have been updated for the whole timeseries. The updated fractions and emission factors are taken from the three studies conducted at the Iru waste plant in 2015²³, 2019²⁴ and 2024²⁴ so the carbon emission factors and waste fractions are plant specific. For the years 2013-2018 the biogenic fraction of waste is 45% and fossil 55%, from 2019 the biogenic fraction is 32% and fossil 68%, and from 2023 biogenic fraction is 37% and fossil fraction is 63% for the local waste. Biogenic fraction of waste is 41% and fossil 59% for the imported waste throughout the timeseries.

1.A.1.b Petroleum refining

There are no petroleum refining activities taking place in Estonia.

1.A.1.c Manufacture of solid fuels and other energy industries

Shale Oil

In Estonia shale oil production (reported under other energy industries) takes place in three companies: **Kiviõli Keemiatööstuse OÜ** (Kiviõli Oil Shale Processing and Chemicals Plant Ltd.) in Kiviõli, **Viru Keemia Grupp AS (VKG)** (Viru Chemistry Group Ltd.) in Kohtla-Järve, and **Enefit Power AS** (Enefit Power Ltd.) in Auvere.

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

The technology of processing oil shale in vertical retorts with a **gaseous heat carrier (GHC)** is a universal technology and is suitable for retorting high-calorific oil shale. The vertical retort

²³ Determining the composition and properties of Estonian mixed municipal waste incinerated in the Iru electric power plant waste energy block. The study is available upon request.

²⁴ Determining the physical composition and characteristics of the waste incinerated in the Iru electric power plant and the CO₂ emission coefficient produced during combustion. The study is available upon request.

is a metal vessel lined on the inside with refractory bricks. The oil shale charging device, 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 the influence of gases, the oil shale is warmed and dried up, and after achieving a necessary temperature for retorting, the organic part of the 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 exit 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 occurs without any contact with the ambient atmosphere; therefore no pollutants are emitted²⁵. As GHC plants have no direct emissions from the shale oil production process, the CEF is effectively 0. This causes the IEF of Energy industries to be very low.

In **solid heat carrier installation (SHC)** hot oil shale dust as a heat carrier is used. Pre-dried fine-grained oil shale with hot oil shale dust (800 °C) is delivered to a horizontal rotating reactor where the retorting process occurs in just a few minutes. The mixture of heat carrier with oil and water vapours moves into the dust separation chamber. Oil vapours and gas move to the condensation chamber where the condensed oil is separated and semi-coke gas is sent to the power plant. The mixture of semi-coke and dust will be 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 the raw oil shale in the dryer and then they are entirely emitted into the atmosphere. Some of the dust is delivered back to the reactor²¹ and the rest to the ash hill.

In 2024 81.36 PJ of oil shale was consumed for shale oil production in total and processing of 59.97 PJ of oil shale caused direct CO₂ emissions at the solid heat carrier-type plants (see Table 3.4). This occurs because of a difference in technologies as no CO₂ is emitted directly from gas generator-type plants (all gases produced in the process are burned in the electric plants), however, CO₂ is emitted in solid heat carrier-type plants.

Table 3.4. Oil shale consumption and for shale oil production by different technologies, PJ

Year	Solid Heat Carrier			Total	Gaseous Heat Carrier		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
2005	8.87	NO	NO	8.87	17.78	4.21	22.00	30.86
2020	29.36	28.30	1.74	59.40	16.13	4.99	21.13	80.53
2021	28.90	27.09	1.88	57.86	15.62	4.82	20.45	78.31
2022	29.15	24.23	2.00	55.38	15.73	5.60	21.33	76.70
2023	31.85	28.53	1.99	62.37	15.72	5.15	20.87	83.25
2024	29.03	28.70	2.24	59.97	16.02	5.37	21.39	81.36

NO – no consumption occurred

Activity data

Activity data for GHG emission calculations are collected from several sources. The final fuel consumption data by sectors, including sub-sectors, is received from Joint Questionnaire (JQ) dataset made by Statistics Estonia. This data is also presented in the SE database²⁶ and added to Annex 3 (A.3.2). Some detailed data (i.e. pulverised and fluidised bed combustion of oil shale

²⁵ Soone, J., Doilov, S. (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.

²⁶ Statistics Estonia. [www] <https://andmed.stat.ee/et> (10.01.2025).

consumption; shale oil, and semi-coke gas production) is obtained from the energy company Enefit Power AS. Information on oil shale, shale oil, semi-coke, and generator gas consumption in Kiviõli and VKG oil plants is obtained directly from the oil plant operators.

Municipal solid waste incineration data in 1.A.1.a is plant specific and taken from The Environmental Board database KOTKAS.

Fuel consumption in Energy industries (CRT 1.A.1) in 1990–2024 is presented in Figure 3.9 and Table 3.5.

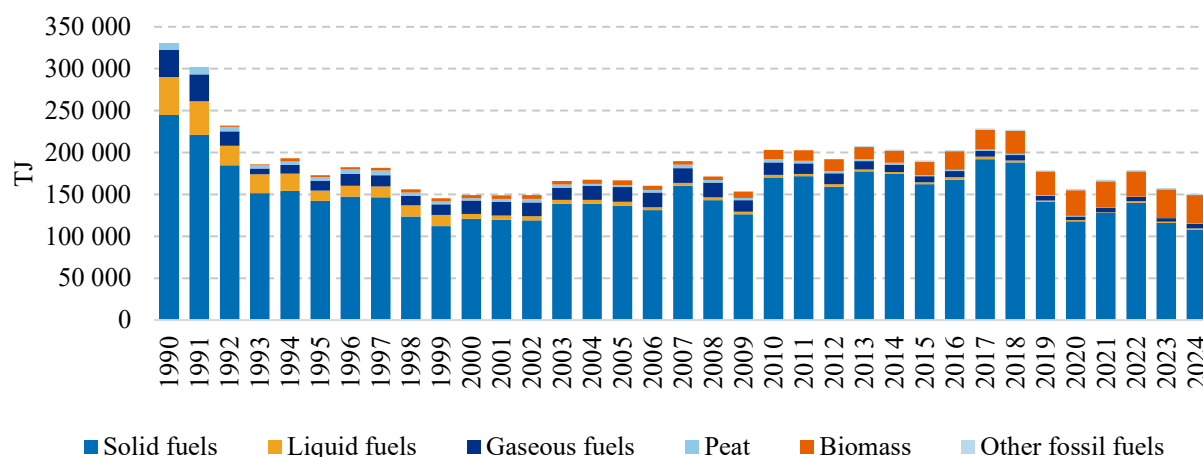


Figure 3.9. Trend of fuel consumption in Energy industries, TJ

Table 3.5. Fuel consumption in Energy industries in 1990, 2005, and 2021–2024, TJ

Category/activity data	1990	2005	2021	2022	2023	2024
1.A.1 Energy Industries Total, TJ.	330 776	166 794	167 411	178 951	157 608	150 567
Liquid fuels	45 263	4342	817	1672	1387	1487
Solid fuels	244 766	136 734	127 767	140 203	115 960	108 016
Gaseous fuels	32 792	17 551	5734	5080	4282	5427
Peat	7956	2525	199	246	149	77
Biomass	NO	5642	31 249	30 296	34 339	34 153
Other fossil fuels	NO	NO	1646	1455	1491	1409

Emission factors

Carbon emission factors, oxidation factors, and net calorific values used in the emission calculations in 1.A.1 are presented below in Table 3.6.

Almost all natural gas consumed in Estonia originated from Russia until 2023, when sanctions against Russian natural gas were enforced. Natural gas consumed in 2024 originated from different countries and a similar methodology to liquid fuels was implemented to determine the CO₂ CEF of natural gas. The methodology is to calculate weighted average CEF of natural gas consumed in Estonia using natural gas import quantities by country and CO₂ CEF-s of natural gas reported by these countries (from the latest submitted CRT fail). The reason why the average CO₂ CEF is so low is because the US CEF for natural gas is very low (13.68 tC/TJ or 50.16 tCO₂/TJ) and as US was the first largest source of natural gas in 2024 this resulted in the lower average result.

Table 3.6. Carbon emission factors, oxidation factors, and net calorific values in 2024

Fuels	NCV average	Unit	CEF, tC/TJ	Oxidation factor	Source of emission factor
Liquid fuels					
LPG	45.5	GJ/t	17.33	1	CS (Estonia)
Motor gasoline	44	GJ/t	19.16	1	CS (Estonia)
Light fuel oil	42.3	GJ/t	19.99	1	CS (Estonia)
Diesel oil	42.3	GJ/t	19.99	1	CS (Estonia)
Residual fuel oil (heavy fuel oil)	39.25	GJ/t	21.15	1	CS (Estonia)
Solid fuels					
Coal	24.94	GJ/t	25.90	1	CS (Estonia)
Coke oven coke	28.5	GJ/t	29.02	1	CS (Estonia)
Oil shale	8.11	GJ/t	26.42 – 27.25	1	PS (Estonia)
Milled&sod peat ²⁷	10.33	GJ/t	28.9	1	D, IPCC 2006
Peat briquette	16	GJ/t	26.45	1	FI (Finland)
Oil shale semi-coke gas (SHC technology, Narva Enefit 140 plant)	34.8	GJ/10 00 m ³	19.77	1	PS (Estonia)
Oil shale semi-coke gas (SHC technology, Narva Enefit 280 plant)	42.91	GJ/10 00 m ³	19.02	1	PS (Estonia)
Oil shale semi-coke gas (VKG Petroter I plant)	40.13	GJ/10 00 m ³	19.33	1	PS (Estonia)
Oil shale semi-coke gas (VKG Petroter II plant)	40.13	GJ/10 00 m ³	19.33	1	PS (Estonia)
Oil shale semi-coke gas (VKG Petroter III plant)	40.13	GJ/10 00 m ³	19.33	1	PS (Estonia)
Oil shale semi-coke gas (Kiviõli plant)	49.39	GJ/10 00 m ³	17.60	1	PS (Estonia)
Oil shale generator gas (Kiviõli plant)	2.22	GJ/10 00 m ³	54.01	1	PS (Estonia)
Oil shale generator gas (VKG plant)	2.58	GJ/10 00 m ³	50.01	1	PS (Estonia)
Gas gasoline	44	GJ/t	19.16	1	CS (Estonia)
Municipal solid waste (MSW, fossil part) (CRT 1.A.1.a)	9.89	GJ/t	24.13	1	PS, Iru incineration plant
Natural gas	35.76	GJ/10 00 m ³	14.59	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
Municipal solid waste (MSW, biogenic part) (CRT 1.A.1.a)	9.89	GJ/t	42.36	1	PS, Iru incineration plant
Biogas (landfill gas and biogas from wastewater treatment)	17.4	GJ/10 00 m ³	14.89	1	D, IPCC 2006

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

CH₄ and N₂O emission factors for 1.A.1 Energy industries for different fuels are presented in Table 3.7. In 2021 Estonia developed country-specific CH₄ and N₂O emission factors for 1-50 MW combustion plants for natural gas, biogas, light fuel oil, residual fuel oil, peat, biomass, and municipal solid waste. The emission factors are used in the Energy Industry sector 1.A.1.a, Manufacturing industries and construction subsectors, 1.A.4.a, and 1.A.4.c. CH₄ and N₂O

²⁷A processed form of peat that is compressed into mall (40–70 mm) pieces.

emission factors for less than 1 MW and larger than 50 MW combustion plants are IPCC 2006 default values.

Table 3.7. CH₄ and N₂O emission factors by fuel, kg/TJ

Fuels	Energy industries		Manufacturing industries and construction		Source
	CH ₄	N ₂ O	CH ₄	N ₂ O	
Liquid fuels					
LPG (liquefied petrol gas)	1	0.1	1	0.1	D, IPCC 2006
Motor gasoline	3	0.6	3	0.6	D, IPCC 2006
Light fuel oil	3/0.003*	0.6/0.17*	3/0.003*	0.6/0.17*	D, IPCC 2006/CS ²⁸
Diesel oil	3	0.6	3	0.6	D, IPCC 2006
Residual fuel oil (heavy fuel oil)	3/0.003*	0.6/0.17*	3/0.003*	0.6/0.17*	D, IPCC 2006/CS ²⁸
Waste oil	30	0.6	30	0.6	D, IPCC 2006
Solid fuels					
Oil shale _{PC} ¹⁵	0*	0*	10	1.5	CS (A.Ots); D, IPCC 2006
Oil shale _{FBC}	0*	0.82*	10	1.5	CS/ D, IPCC 2006
Milled&sod peat	1/1.7*	1.5/2.5*	2/1.7*	1.5/2.5*	D, IPCC 2006/CS ²⁸
Peat briquette	1/1.7*	1.5/2.5*	2/1.7*	1.5/2.5*	D, IPCC 2006/CS ²⁸
Oil shale gases (semi-coke gas and generator gas)	1	0.1	1	0.1	D, IPCC 2006 (natural gas)
Municipal solid waste	0.004*	0.17*	—	—	CS ²⁸
Gaseous fuels					
Natural gas	1/0.003*	0.1/0.12*	1/0.003*	0.1/0.12*	D, IPCC 2006/ CS ²⁸
Biomass fuels					
Solid biomass (solid, includes e.g. firewood, bark, chips, sawdust, and other industrial wood residues, pellets, and briquettes)	30/0.29*	4/0.21*	30/0.29*	4/0.21*	D, IPCC 2006/CS ²⁸
Biogas (landfill gas and biogas from wastewater treatment)	1/0.0025*	0.1/0.12*	—	—	D, IPCC 2006/CS ²⁸

D – IPCC default value; CS – country-specific; * – country-specific

The NO_x, CO, and NMVOC emissions are calculated by Estonian Environmental Agency. Emission factors come from different sources. If possible, a country-specific and plant-specific emission factor is used, if not, the emission factors from EMEP/EEA Guidebook 2023 are used²⁹. The oil shale direct combustion data is plant-specific. The NO_x, CO, and NMVOC emissions are calculated by using Equation 3.2.

Equation 3.2.

$$EF_{pollutant} = AR_{activity} \times EF_{pollutant}$$

Where:

$E_{pollutant}$ = the emission of the specific pollutant;

²⁸Country-specific emission factors for 1-50 MW are based on “Control measurements and updating of data for specific emissions of GHGs and air pollutants from households and large and medium-sized combustion plants in the energy sector” The report is available upon request.

²⁹EMEP/EEA air pollutant emission inventory guidebook – 2023.

[www] <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion> (05.03.2024).

AR_{activity} = the activity rate;
 $EF_{\text{pollutant}}$ = the emission factor for this pollutant.

3.2.4.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Energy industries subcategory, please see Annex A.II.1 Energy, 1.A.1 Energy industries chapter.

3.2.4.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Chapter 1.5. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Energy industries according to the IPCC *Tier 1* method.

There are several QC procedures. The most resource-demanding is checking the fuel consumption data in Joint Questionnaires received from Statistics Estonia:

Fuel consumption data in natural units (tons or thousand cubic meters) and energy units (TJ) is available in Joint Questionnaires from Statistics Estonia (www.stat.ee). Year average net calorific values are received from Statistics Estonia. 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 presented in the statistical database. Sometimes there are some small differences due to the rounding the values. The second step is to check all activity data on previous years because Statistics Estonia sometimes corrects old data. The third step is to verify national energy balance data with IEA data. IEA uses constant NCV-s but national energy data uses TJ that are calculated using year-specific NCV-s. Some differences also occur in produced heat. IEA reports only fuels used for sold heat produced by district heating power plants and auto-producers in the Energy conversion sector, but fuels used for heat production by auto-producers (used for their own consumption) are reported under the final consumption.

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

In the 2026 inventory submission Energy sector CO₂ emissions were compared against the emissions of European Union Emission Trading Scheme (EU ETS) enterprises (for the year 2024). The consistency of EU ETS data and the inventory submission has improved since the 2016 submission. Firstly, the methodology of calculating the emissions of shale oil production has improved. Inventory compilers receive additional information from shale oil producers which make inventory emissions data more precise and reliable. Estonia has unified the oil shale combustion data presented in the EU ETS and in the energy balance of Statistics Estonia and continues to do so.

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

3.2.4.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

There were no category-specific recalculations.

3.2.4.6. Category-specific planned improvements, if applicable including tracking of those identified in the review process

Verification measurements of specific CH₄ and N₂O emission factors (e.g. for solid biomass) for large combustion plants (over 50 MW) in the energy sector are currently ongoing (started in 2025).

In cooperation with the inventory compiler, Statistics Estonia will review the Energy industries (1.A.1) fuel quantities reported in the energy balance and the underlying compilation methodology, with the aim of improving year-to-year consistency and transparency of the data. If necessary, Statistics Estonia will introduce methodological adjustments and provide revised fuel time series, which will be implemented in the GHG inventory together with appropriate documentation and explanations in 2027 submission.

3.2.5. Manufacturing industries and construction (1.A.2)

3.2.5.1. Category description

Manufacturing industries and construction (CRT 1.A.2) include emissions from industrial sectors (power plants, boilers, and industrial plants with boilers, and/or other combustion). In 2024 the Manufacturing industries and construction contributed about 3.20% of Energy sector emissions, totalling 260.35 kt CO₂ eq., and about 2.54% of total GHG emissions.

The structural changes in the economy after regaining independence in 1991 caused the relevant decrease from 1992. Compared to 1990 the emissions have decreased by 92.46% in 2024. Emissions increased in the Manufacturing industries and construction sector by 14.15% compared to 2023, mainly because of increased fossil fuel consumption, with natural gas as the main contributor.

In the 15th of April 2026 submission, updated activity data for manufacturing industries and construction are only partially available. The inventory continues to apply the latest available verified activity data (2023) for selected fuels, including some liquid fuels (diesel oil, light fuel oil, residual fuel oil) and biomass fuels (solid biomass). The data will be revised in the 2027 submission once verified information becomes available, together with any necessary time-series consistency updates and explanations. A more detailed overview of planned improvements is provided in section 3.2.5.6.

According to the structure of CRT tables Manufacturing industries and construction sub-sectors are presented in the following CRT 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; 2.f Non-metallic minerals, and 2.g Other. Table 3.8 and Figure 3.10 represent the emissions from Manufacturing industries and construction by relevant subcategories.

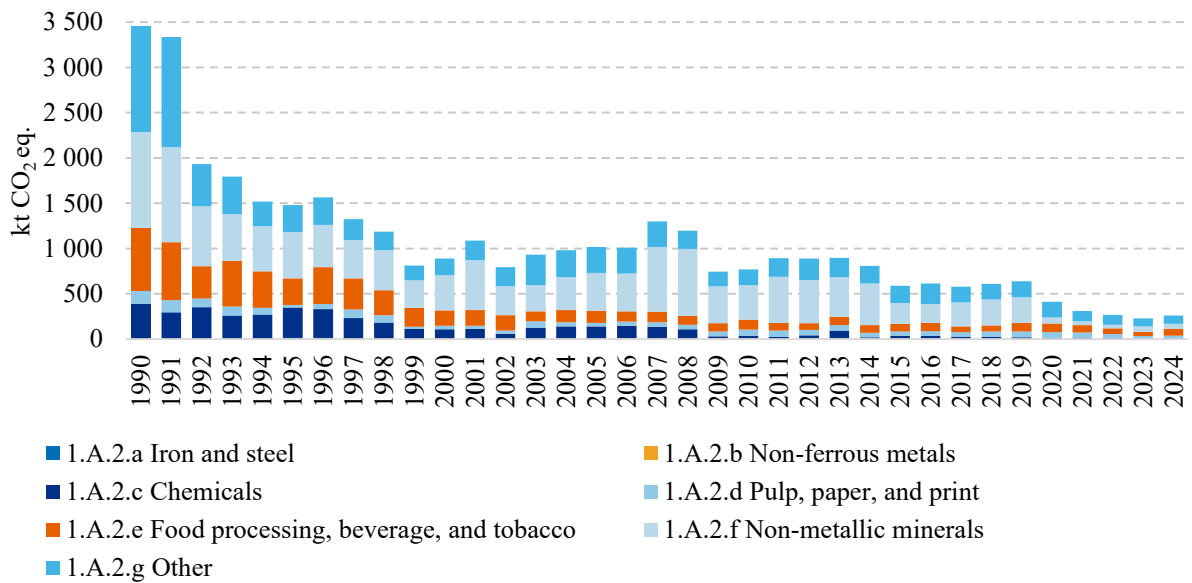


Figure 3.10. Trend of GHG emissions from Manufacturing industries and construction by relevant sub-categories in 1990–2024, kt CO₂ eq.

Table 3.8. GHG emissions from Manufacturing industries and construction by relevant subcategories 1990, 2005, and 2021–2024, kt CO₂ eq.

Category	1990	2005	2021	2022	2023	2024
1.A.2 Manufacturing Industries and Construction Total, CO₂ eq.	3454.24	1017.78	309.33	266.70	228.07	260.35
1.A.2.a Iron and Steel, CO ₂ eq.	NO	1.24	0.73	0.69	0.47	0.50
1.A.2.b Non-Ferrous metals, CO ₂ eq.	NO	1.00	0.50	NO	0.76	0.74
1.A.2.c Chemicals, CO ₂ eq.	389.90	139.32	14.66	12.93	6.82	8.07
1.A.2.d Pulp, Paper and Print, CO ₂ eq.	145.35	38.60	56.49	42.26	25.40	29.29
1.A.2.e Food Processing, Beverages and Tobacco, CO ₂ eq.	697.01	132.62	82.48	61.92	46.48	73.01
1.A.2.f Non-Metallic Minerals, CO ₂ eq.	1 057.16	418.62	42.02	40.73	61.96	55.66
1.A.2.g Other, CO ₂ eq.	1 164.83	286.38	112.45	108.17	86.17	93.09

1.A.2.a Iron and steel

The 1.A.2.a Iron and steel CRT sub-category has a very small share in Estonia. This category consists largely of factories using fuel for manufacturing goods from imported iron and steel. Estonia imported the raw material (iron and steel) from Russia and after regaining independence in 1991 all iron- and steel-using factories were closed. In 1994 those factories started working again. As the production of goods depends on the raw material supply and final production export possibilities, the production decrease in 1997–1999 was directly caused by the economic crisis in Russia during the same period. Production stabilized from 2000 to 2006 and the decrease in emissions from 2007 to 2009 relates to the last economic depression. Since 2007 the annual emissions have been below 1 kt CO₂ eq. In 2024 emissions amounted to 0.50 kt CO₂ eq. Reported fuel consumption reflects small-scale fuel use within the sector and does not indicate a structural change.

The trend of GHG emissions in 1.A.2.a Iron and steel in 1990–2024 is presented in Figure 3.11.

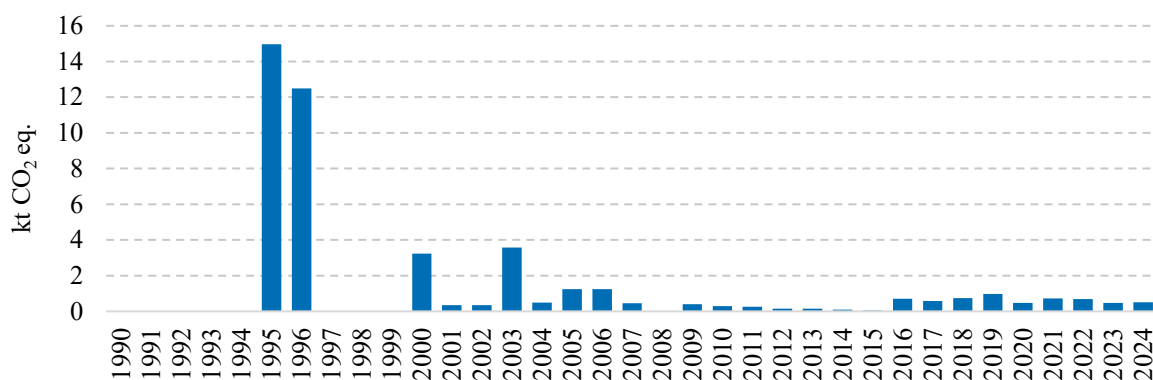


Figure 3.11. Trend of GHG emissions from Iron and steel in 1990–2024, kt CO₂ eq.

1.A.2.b Non-ferrous metals

The 1.A.2.b Non-ferrous metals sub-sector is small-scale in Estonia consisting only of 2–3 enterprises. The growth of GHG emissions in 2006 compared to previous years is connected to fuel consumption increase and is probably caused by large order(s) by some of these enterprises. In 2022 the emissions from Non-ferrous metals were 0 kt CO₂ eq. since no fuel consumption for 2022 was reported for this sector by Statistics Estonia. In 2024 the emissions were 0.74 kt CO₂ eq.

Figure 3.12 presents the trend of GHG emissions in 1.A.2.b Non-ferrous metals in 1990–2024.

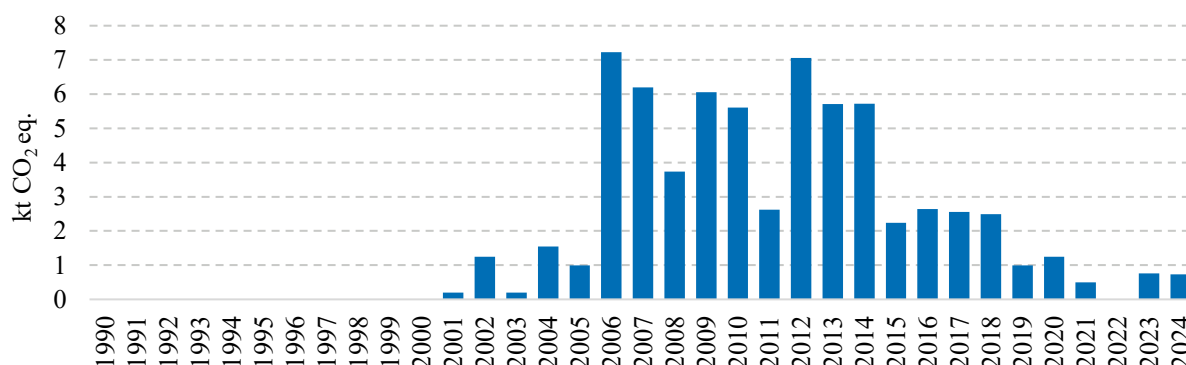


Figure 3.12. Trend of GHG emissions from Non-ferrous metals in 1990–2024, kt CO₂ eq.

1.A.2.c Chemicals

In 1.A.2.c Chemicals sub-category emissions from several chemical factories are reported. The biggest fuel consumer (mainly natural gas) was historically the ammonia and urea producer Nitrofert AS. In 2024, this sub-sector contributed 3.10% of the Manufacturing industries and construction sector GHG emissions and amounted to 8.07 kt CO₂ eq., increasing by 18.33% compared to the previous year mainly due to higher natural gas consumption, while LPG usage remained very low.

The first decrease in the trend of GHG emissions in 1993 was caused by privatisation of chemical enterprises after regaining independence in 1991, and by a transition from eastern to western markets. The second decrease in 1999 was resulting from the extensive restructuring of Estonia's biggest chemical enterprise Kiviter AS. The main product of Kiviter AS is shale oil (a liquid fuel made from oil shale), but since 1999 the shale oil production is reported under the Energy sector. Only the by-products of oil shale industry, like formalin, toluene, etc are still reported under chemical industry. In 2002 and 2009 the production of Nitrofert AS was very

small, in 2010 and 2011 the factory was temporarily closed due to low ammonia prices in the world market. In 2013 the factory was reopened. Since the GHG emission trend follows the fuel consumption trend, and the fluctuations are determined by the ammonia export possibilities of Nitrofert AS. From 2014 the production facilities of Nitrofert AS is closed, so the overall emissions are noticeably lower.

Figure 3.13 presents the trend of GHG emissions from 1.A.2.c Chemicals in 1990–2024.

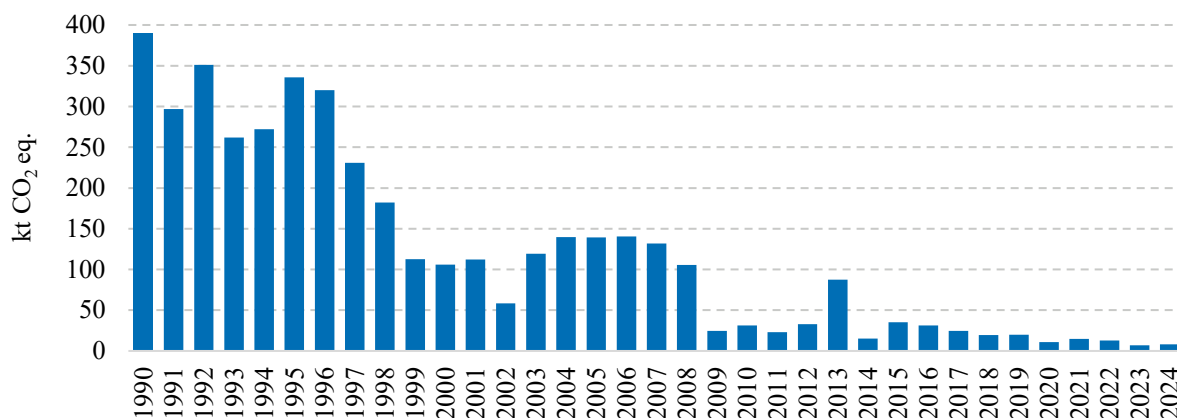


Figure 3.13. Trend of GHG emissions from Chemicals in 1990–2024, kt CO₂ eq.

1.A.2.d Pulp, paper and print

The CRT sub-category 1.A.2.d Pulp, paper, and print formed about 11.25% of the Manufacturing industries GHG emissions in 2024 with emissions of 29.29 kt CO₂ eq., increasing by 15.29% compared to the previous year mainly due to higher natural gas consumption.

There are only a few pulp and paper factories in Estonia: Horizon Tselluloosi ja Paberi AS, Kohila Paber AS, Räpina Paberivabrik AS and Estonian Cell AS.

During 1992–1998 the production of paper fluctuated because some factories halted, and ownerships changed. During 1999–2003 the production of paper grew every year. In 2004 manufacturing of wood pulp lowered. In 2005 paper and paper products manufacturing increased due to lively investments and export growth. Since 2010, emissions from the sector have shown year-to-year variability, reflecting changes in production volumes and market conditions, as well as changes in fuel use, particularly natural gas consumption and the use of alternative fuels.

The trend of GHG emissions of 1.A.2.d Pulp, paper, and print in 1990–2024 is presented in Figure 3.14.

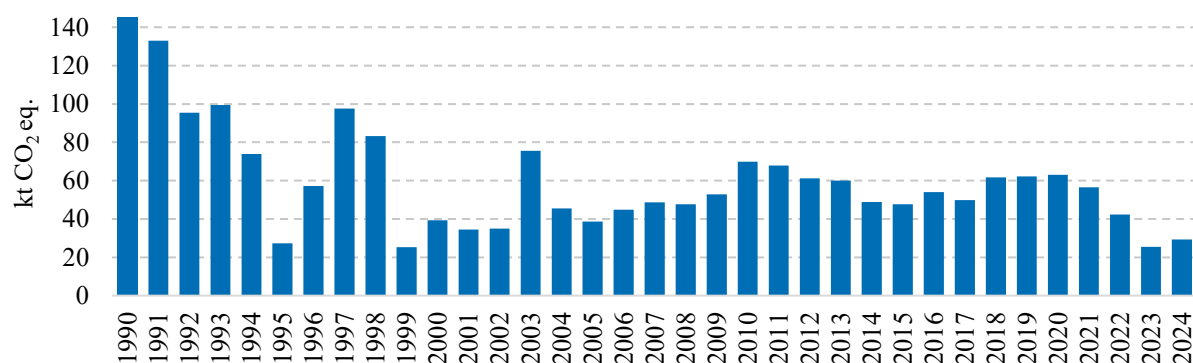


Figure 3.14. Trend of GHG emissions from Pulp, paper and print in 1990–2024, kt CO₂ eq.

1.A.2.e Food processing, beverages and tobacco

The 1.A.2.e Food processing, beverage, and tobacco CRT sub-category shares about 28.04% of the Manufacturing industries and construction with GHG in 2024, with emissions of 73.01 kt CO₂ eq., increasing by 57.08% compared to the previous year mainly due to higher natural gas and LPG consumption.

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 production growth 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. The 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. The sector remains cyclical and is influenced by evolving import and export dynamics of food and beverage products.

Figure 3.15 describes GHG emissions trend in 1.A.2.e Food processing, beverages, and tobacco in 1990–2024.

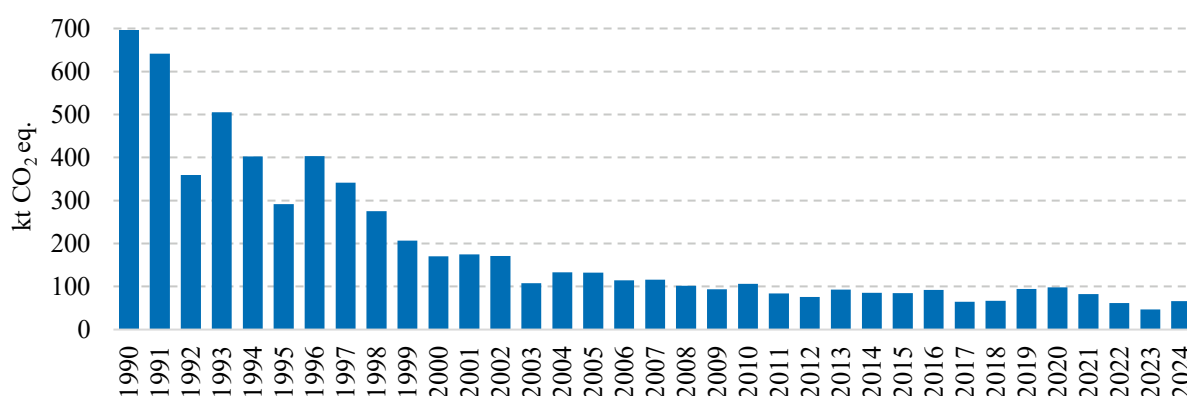


Figure 3.15. Trend of GHG emissions from Food processing, beverages, and tobacco in 1990–2024, kt CO₂ eq.

1.A.2.f Non-metallic minerals

The 1.A.2.f Non-metallic minerals CRT category accounted for 21.38% of Manufacturing industries and construction GHG emissions in 2024 with emissions amounting to 55.66 kt CO₂ eq. The main share of GHG emissions in this sub-category was historically cement production. Therefore, the trend of GHG emissions follows the trend of fuels used in cement production. In 2015, the emissions decreased about 50.47% compared to 2014 due to an unfavorable cement market. In 2020 emissions decreased about 76.29% compared to the previous year as a decrease of waste and solid fuel consumption due to an unprofitable production, since EU ETS allowance prices increased. Clinker production in Kunda Nordic Cement was ceased in 2020 as it wasn't economically feasible anymore, as the EU ETS price was increasing. In 2024, total emissions decreased mainly due to lower use of waste-derived fuels, including solid biomass waste, and the fact that solid fuel consumption fell to zero, while natural gas consumption and LPG use increased.

The trend of GHG emissions in 1.A.2.f Non-metallic minerals in 1990–2024 is presented in Figure 3.16.

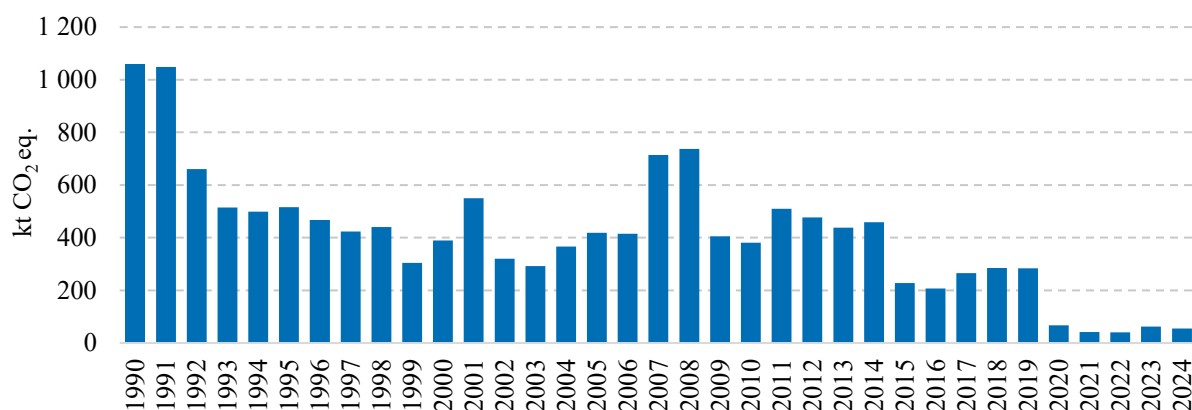


Figure 3.16. Trend of GHG emissions from Non-metallic minerals in 1990–2024, kt CO₂ eq.

1.A.2.g Other

The 1.A.2.g Other sub-category has the biggest share in Manufacturing industries and construction sector with close to 35.75% share in 2024, 93.09 kt CO₂ eq., increasing by 8.03% compared to the previous year.

In Estonia the Manufacturing industries and construction sector's sub-category 1.A.2.g Other includes following sub-sectors: 'Transport equipment'; 'Machinery'; 'Mining and quarrying'; 'Wood and wood products'; 'Textiles leather, and clothing industry', 'Construction', and 'Other industry'. Emissions from other miscellaneous mobile equipment (Excavators, loaders, road work machines, etc) are reported in Chapter 1.A.3.e Other transportation.

In general, the GHG emission trend matches the trend of fuel consumption. The fluctuations are determined by the export possibilities of the factories. The decrease in emissions in 2009 and 2010 relates to the economic depression which started in 2008. Despite the recovery of the economy in some branches of manufacturing industries, the total volume of output in the manufacturing industry decreased in 2010. There was still 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 for the decline in emissions. In 2011 GHG emissions increased about 18.86% compared to 2010 because of overall economic upturn. Emission downtrend from 2016 in Wood and wood products industry sub-sector is due to introduction of new economical technologies in wood processing and switching to a different fuel (mainly using wood residues instead of fossil fuels). In 2024 GHG emissions increased compared to 2023, mainly due to higher natural gas and LPG consumption.

Figure 3.17 presents the trend of GHG emissions of 1.A.2.g Other in 1990–2024.

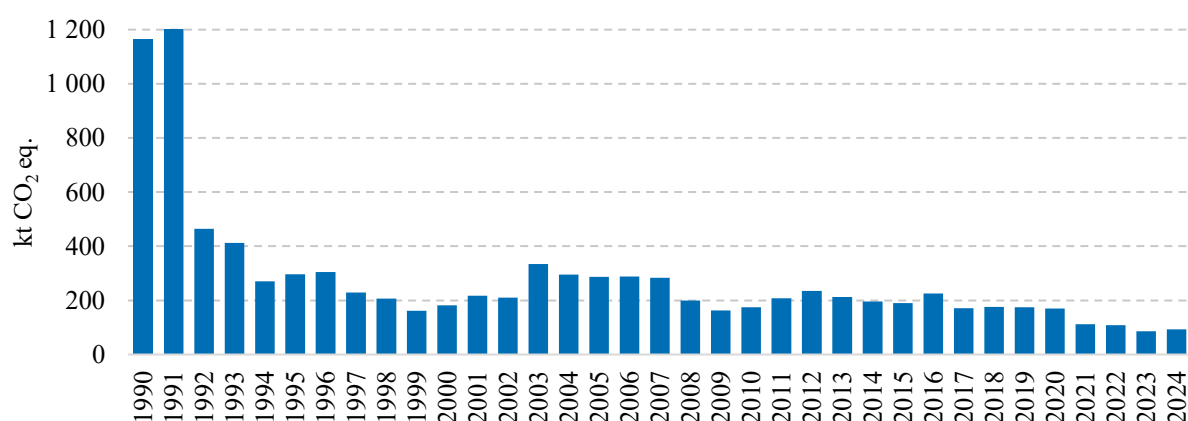


Figure 3.17. Trend of GHG emissions from Other in 1990–2024, kt CO₂ eq.

3.2.5.2. Methodological issues

Choice of methods

Emissions from Fuel combustion 1.A.2 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 is applied. For domestic fuels – oil shale and peat – Tier 1 approach is used for milled and sod peat CO₂ and oil shale CH₄ and N₂O.

1.A.2.a Iron and steel

Tier 2 method is used for CO₂, CH₄ and N₂O emission calculations for natural gas; for CH₄ and N₂O emission calculations for solid biofuels; and for CO₂ emission calculations for coal and coke oven coke Tier 1 method is used for CH₄ and N₂O emission calculations for coal and coke oven coke and for CO₂ emission calculations for solid biofuels.

1.A.2.b Non-ferrous metals

Tier 2 method is used for CO₂, CH₄ and N₂O emission calculations for natural gas and gas oil (LFO) and for CO₂ emission calculations for coal. Tier 1 method is used for CH₄ and N₂O emission calculations for coal.

1.A.2.c Chemicals

Tier 2 method is used for CO₂, CH₄ and N₂O emission calculations for natural gas, gas oil (LFO) and residual fuel oil; for CH₄ and N₂O emission calculations for solid biofuels; and for CO₂ emission calculations for LPG.

Tier 1 method is used for CH₄ and N₂O emission calculations for coal and LPG and for CO₂ emission calculations for solid biofuels.

1.A.2.d Pulp, paper and print

Tier 2 method is used for CO₂, CH₄ and N₂O emission calculations for natural gas, gas oil (LFO), residual fuel oil and peat briquette; for CH₄ and N₂O emission calculations for solid biofuels, milled peat, and biogases; and for CO₂ emission calculations for LPG and gasoline.

Tier 1 method is used for CH₄ and N₂O emission calculations for LPG and gasoline and for CO₂ emission calculations for solid biofuels, biogases, and milled peat.

1.A.2.e Food processing, beverages and tobacco

Tier 2 method is used for CO₂, CH₄ and N₂O emission calculations for natural gas, residual fuel oil and peat briquette; for CH₄ and N₂O emission calculations for solid biofuels and milled peat; and for CO₂ emission calculations for LPG, coal, diesel oil and gasoline.

Tier 1 method is used for CH₄ and N₂O emission calculations for LPG, diesel oil, coal and gasoline; and for CO₂ emission calculations for solid biofuels and milled peat.

1.A.2.f Non-metallic minerals

Tier 2 method is used for CO₂, CH₄ and N₂O emission calculations for natural gas, residual fuel oil, solid biomass waste and peat briquette; for CH₄ and N₂O emission calculations for solid biofuels and milled peat; and for CO₂ emission calculations for LPG, coal, coke oven coke, diesel oil, waste oils, plastics solid waste, oil shale and gasoline.

Tier 1 method is used for CH₄ and N₂O emission calculations for LPG, diesel oil, coal, coke oven coke, oil shale, plastics, waste oils, solid waste, and gasoline; and for CO₂ emission calculations for solid biofuels and milled peat.

1.A.2.g Other

Tier 2 method is used for CO₂, CH₄ and N₂O emission calculations for natural gas, residual fuel oil, gas oil (LFO), and peat briquette; for CH₄ and N₂O emission calculations for solid biofuels and milled peat; and for CO₂ emission calculations for LPG, coal, coke oven coke, diesel oil, plastics solid waste, and gasoline.

Tier 1 method is used for CH₄ and N₂O emission calculations for LPG, coal, coke oven coal, solid waste, and gasoline; and for CO₂ emission calculations for solid biofuels and milled peat.

Activity data

Activity data for GHG emission calculations are collected from several sources. The final fuel consumption data by sectors, including sub-sectors, is received from Joint Questionnaire (JQ) dataset made by Statistics Estonia. This data is also presented in the SE database³⁰ and added to Annex V (A.V.2.4).

Other fossil fuels, plastics, and waste oils incinerated in 1.A.2.f Non-metallic minerals is taken from Estonian waste database (Tableau).

Fuel consumption in Manufacturing industries and construction (CRT 1.A.2) in 1990–2024 is presented in Figure 3.18 and in Table 3.9. The sharp reduction of biomass use from 2016 is due to the fact that several CHP plants using wood were completed in the wood industry (1.A.2.g sector) and this means that any wood burned in these CHP plants were no longer reported under 1.A.2.g, but in the transformation sector (1.A.1.a) instead. From 2021 onwards, solid biomass consumption in 1.A.2 increased again in several subcategories, reflecting higher use of solid biofuels.

Updated activity data for manufacturing industries and construction are only partially available for the 15th of April 2026 submission. Therefore, the inventory applies the latest verified data (2023) for selected fuels, including liquid fuels (diesel oil, light fuel oil, residual fuel oil) and biomass fuels (solid biomass). The dataset and time series will be revised in the 2027 submission once verified information becomes available. See further details in Section 3.2.5.6.

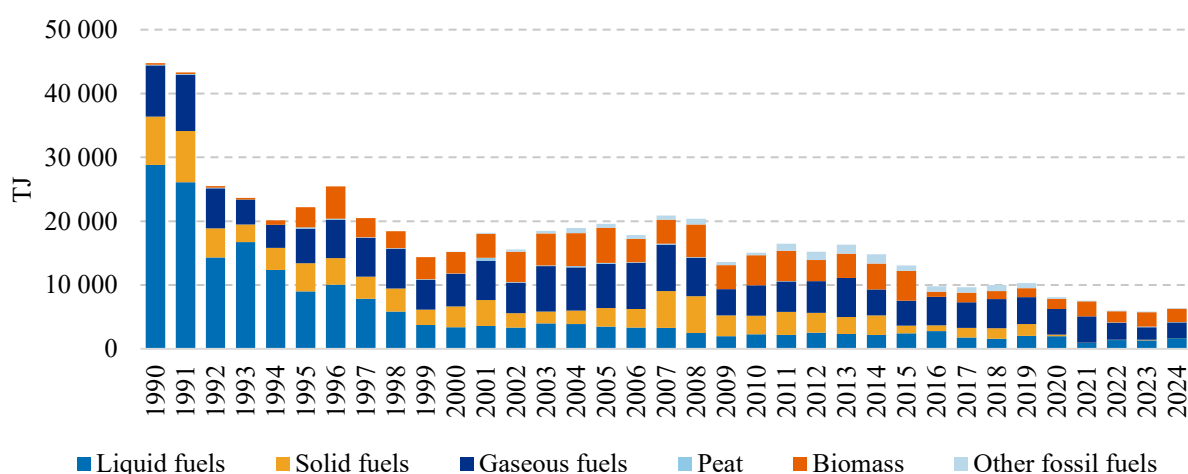


Figure 3.18. Trend of fuel consumption in Manufacturing and construction, TJ

³⁰Statistics Estonia database. [www] <https://andmed.stat.ee/et> (27.02.2026)

Table 3.9. Fuel consumption in Manufacturing industries and construction in 1990, 2005, and 2021–2024, TJ

Category/activity data	1990	2005	2021	2022	2023	2024
1.A.2 Manufacturing and construction Total, TJ.	44 759	19 575	7540	5985	5832	6375
Liquid fuels, TJ	28 817	3495	962	1372	1321	1689
Solid fuels, TJ	7585	2884	7	67	105	2
Gaseous fuels, TJ	8004	6934	4134	2679	1967	2458
Peat, TJ	90	148	NO	40	96	37
Biomass, TJ	264	5509	2371	1755	2254	2104
Other fossil fuels, TJ	NO	606	66	73	90	84

Emission factors

Carbon emission factors, oxidation factors, and net calorific values used in the emission calculations in 1.A.2 are presented below in Table 3.10.

Table 3.10. Carbon emission factors, oxidation factors, and net calorific values in 2024

Fuels	NCV average	Unit	CEF, tC/TJ	Oxi-dation factor	Source of emission factor
Liquid fuels					
LPG	45.5	GJ/t	17.33	1	CS (Estonia)
Motor gasoline	44	GJ/t	19.16	1	CS (Estonia)
Light fuel oil	42.3	GJ/t	19.99	1	CS (Estonia)
Diesel oil	42.3	GJ/t	19.99	1	CS (Estonia)
Residual fuel oil (heavy fuel oil)	39.25	GJ/t	21.15	1	CS (Estonia)
Solid fuels					
Coal	24.94	GJ/t	25.90	1	CS (Estonia)
Coke oven coke	28.5	GJ/t	29.02	1	CS (Estonia)
Oil shale	8.11	GJ/t	28.9	1	PS (Estonia)
Milled&sod peat ³¹	10.33	GJ/t	28.9	1	D, IPCC 2006
Peat briquette	16	GJ/t	26.45	1	FI (Finland)
Gas gasoline	44	GJ/t	19.16	1	CS (Estonia)
Waste oils (CRT 1.A.2.f)*	25.67	GJ/t	20.18	1	PS, Kunda Nordic Cement
Other fossil based solid waste (MSW) (CRT 1.A.2.f)	17.79	GJ/t	21.82	1	PS, Kunda Nordic Cement
Plastic waste (CRT 1.A.2.f)	21.12	GJ/t	20.45	1	PS, Kunda Nordic Cement
Natural gas	35.76	GJ/1000 m ³	14.59	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
Solid biomass waste (CRT 1.A.2.f)	16.69	GJ/t	21.82	1	PS, Kunda Nordic Cement
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; *biogenic and non-biogenic origin

³¹A processed form of peat that is compressed into mall (40–70 mm) pieces.

CH₄ and N₂O emission factors for 1.A.2 Manufacturing industries and construction for different fuels are presented in Table 3.11. In 2021 Estonia developed country-specific CH₄ and N₂O emission factors for 1-50 MW combustion plants for natural gas, biogas, light fuel oil, residual fuel oil, peat, biomass, and municipal solid waste. The emission factors are used in the Energy Industry sector 1.A.1.a, Manufacturing industries and construction subsectors, 1.A.4.a, and 1.A.4.c. CH₄ and N₂O emission factors for less than 1 MW and larger than 50 MW combustion plants are IPCC 2006 default values.

Table 3.11. CH₄ and N₂O emission factors by fuel, kg/TJ

Fuels	CH ₄	N ₂ O	Source
LPG (liquefied petrol gas)	1	0.1	D, IPCC 2006
Motor gasoline	3	0.6	D, IPCC 2006
Light fuel oil	3/0.003*	0.6/0.17*	D, IPCC 2006/CS
Diesel oil	3	0.6	D, IPCC 2006
Residual fuel oil (heavy fuel oil)	3/0.003*	0.6/0.17*	D, IPCC 2006/CS
Waste oil	30	0.6	D, IPCC 2006
Coal	10	1.5	D, IPCC 2006
Coke oven coke	10	1.5	D, IPCC 2006
Oil shale	10	1.4	CS/ D, IPCC 2006
Milled&sod peat	2/1.7*	1.5/2.5*	D, IPCC 2006/CS
Peat briquette	2/1.7*	1.5/2.5*	D, IPCC 2006/CS
Waste oils	30	4	D, IPCC 2006
Other fossil based waste (MSW)	30	4	D, IPCC 2006
Plastic waste	30	4	D, IPCC 2006
Natural gas	1/0.003*	0.1/0.12*	D, IPCC 2006/ CS
Solid biomass (solid, includes e.g. firewood, bark, chips, sawdust, and other industrial wood residues, pellets, and briquettes)	30/0.29*	4/0.21*	D, IPCC 2006/CS
Biogas (landfill gas and biogas from wastewater treatment)	1.75	0.11	CS

D – IPCC default value; CS – country-specific; * – country-specific

In 1.A.2.g Other emissions from off-road vehicles such as excavators, loaders, and road work machines are reported under 1.A.3.e Other transportation, starting from 2024 submission and this change is made for the whole timeseries. Activity data of off-road vehicles and emission factors used for estimating GHG emissions can be found in Chapter 3.2.6.2. In Table 3.31, Table 3.32 and Table 3.33 the respective carbon, CH₄ and N₂O emission factors of motor fuels used for off-road vehicles are presented.

The NO_x, CO, and NMVOC emissions are calculated by Estonian Environmental Agency. Emission factors come from different sources. If possible, a country-specific and plant-specific emission factor is used, if not, the emission factors from EMEP/EEA Guidebook 2023 are used³². The oil shale direct combustion data is plant-specific. The NO_x, CO, and NMVOC emissions are calculated by using Equation 3.3.

³² EMEP/EEA air pollutant emission inventory guidebook – 2023. [www]
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-2-combustion-in> (05.03.2026)

$$EF_{pollutant} = AR_{activity} \times EF_{pollutant}$$

Where:

$E_{pollutant}$ = the emission of the specific pollutant;
 $AR_{activity}$ = the activity rate;
 $EF_{pollutant}$ = the emission factor for this pollutant.

3.2.5.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Energy industries subcategory, please see Annex A.II.1 Energy, 1.A.2 Manufacturing industries and construction chapter.

3.2.5.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Chapter 1.5. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for Manufacturing industries and construction sectors according to the IPCC Tier 1 method.

There are several QC procedures. The most resource-demanding is checking the fuel consumption data in Joint Questionnaires received from Statistics Estonia:

Fuel consumption data in natural units (tons or thousand cubic meters) and energy units (TJ) is available in Joint Questionnaires from Statistics Estonia (www.stat.ee). Year average net calorific values are received from Statistics Estonia. 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 presented in the statistical database. Sometimes there are some small differences due to the rounding the values. The second step is to check all activity data on previous years because Statistics Estonia sometimes corrects old data. The third step is to verify national energy balance data with IEA data. IEA uses constant NCV-s but national energy data uses TJ that are calculated using year-specific NCV-s. Some differences also occur in produced heat. IEA reports only fuels used for sold heat produced by district heating power plants and auto-producers in the Energy conversion sector, but fuels used for heat production by auto-producers (used for their own consumption) are reported under the final consumption.

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

There is a more comprehensive list of Tier 1 and Tier 2 QC activities in the Energy sector in the internal documentation.

3.2.5.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

There were no category-specific recalculations.

3.2.5.6. Category-specific planned improvements, if applicable including tracking of those identified in the review process

In cooperation with the inventory compiler, Statistics Estonia will review the manufacturing industries and construction fuel quantities reported in the energy balance and the underlying compilation methodology, with the aim of improving year-to-year consistency and transparency of the data. If necessary, Statistics Estonia will introduce methodological adjustments and provide revised fuel time series, which will be implemented in the GHG inventory together with appropriate documentation and explanations in 2027 submission.

3.2.6. Transport (1.A.3)

In the 15th of April 2026 submission, updated activity data for transport sector are only partially available. The inventory continues to apply the latest available verified activity data (2023) for selected fuels, including some liquid fuels (diesel oil, light fuel oil, residual fuel oil). The data will be revised in the 2027 submission once verified information becomes available, together with any necessary time-series consistency updates and explanations.

A more detailed overview of category-specific recalculations and planned improvements is provided in sections 3.2.6.5 and 3.2.6.6.

3.2.6.1. Category description

In 2024 the greenhouse gas emissions from Transport sector amounted for 2702.46kt CO₂ eq. The share of the Transport sector in the Energy sector was 33.20% and approximately 26.39% of the total greenhouse gas emissions (without LULUCF) in 2024. Emissions from Transport include all domestic transport sectors, including 1.A.3.e Other transportation, which was added starting from 2024 submission (change was made for the whole time series) (Table 3.12):

- Domestic aviation (CRT 1.A.3.a)
- Road transportation (CRT 1.A.3.b)
- Railways (CRT 1.A.3.c)
- Domestic navigation (CRT 1.A.3.d)
- Other transportation (CRT 1.A.3.e)

Table 3.12. Reporting categories in the Transport sector

CRT category	Description	Remarks
CRT 1.A.3		
1.A.3.a Domestic 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 transportation	Transportation on roads by vehicles with combustion engines: passengers cars, vans, buses, lorries, motorcycles, and mopeds.	Military vehicles are included in 1.A.4.a Commercial/institutional.
1.A.3.c Railways	Railway transport operated by steam and diesel locomotives.	Coal was used in steam locomotives in 1990–1998.
1.A.3.d Domestic navigation	Merchant ships, passenger ships, technical ships, leisure, tour ships, and other inland vessels.	-

CRT category	Description	Remarks
1.A.3.e Other transportation	Tractors, excavators, loaders, road work machines, ATV-s, forklifts, cranes, harvesters, forestry machines.	Includes emissions from off-road vehicles from 1.A.2.g Other, 1.A.4.a Commercial/institutional, and 1.A.4.c Agriculture/forestry/fisheries – starting from 2024 submission. Before 2024 submission emissions from off-road vehicles were reported under the respective subcategories 1.A.2.g, 1.A.4.a and 1.A.4.c.

Emission trends from Transport sector by subcategories are given in Figure 3.19.

GHG emissions decreased strongly after 1991 because of the fast growing fuel prices after regaining independence in 1991 and also difficulties in fuel supply. At the beginning of the 1990s Estonia imported all transport fuels from Russia. The low hit in 1992 and after that the increase has been fairly constant reaching the 1990 emission levels in 2007. The increase has taken place mainly in road transport. In 2010 emissions from transportation sector grew comparing to the previous year. The reason for this advance was the expansion of the economic environment after the economic depression in 2008 and 2009.

In 2009 the emissions dropped about 7.2% compared to 2008 as a consequence of economic recession that caused a sharp decline in a number of transported goods a lower number of public transport users. In 2020 emissions decreased in all Transport subsectors because of the internal movement restrictions due to COVID-19 pandemic and decreased fuel consumption in Road transport sector. In 2021 the GHG emissions from Transport sector increased 3.3% compared to the previous year due to increased diesel use in Road transport and aviation gasoline in Domestic aviation, and lifting the moving restrictions. Normalization to the pre-pandemic trends continued in 2022, which resulted in an increase of GHG emissions by 4.5%, mainly due to increased use of diesel and gasoline in Road transport and diesel in Other transportation (formerly reported under 1.A.2.g, 1.A.4.a and 1.A.4.c). Transport sector emissions in 2024 increased 1.25% compared to 2023.

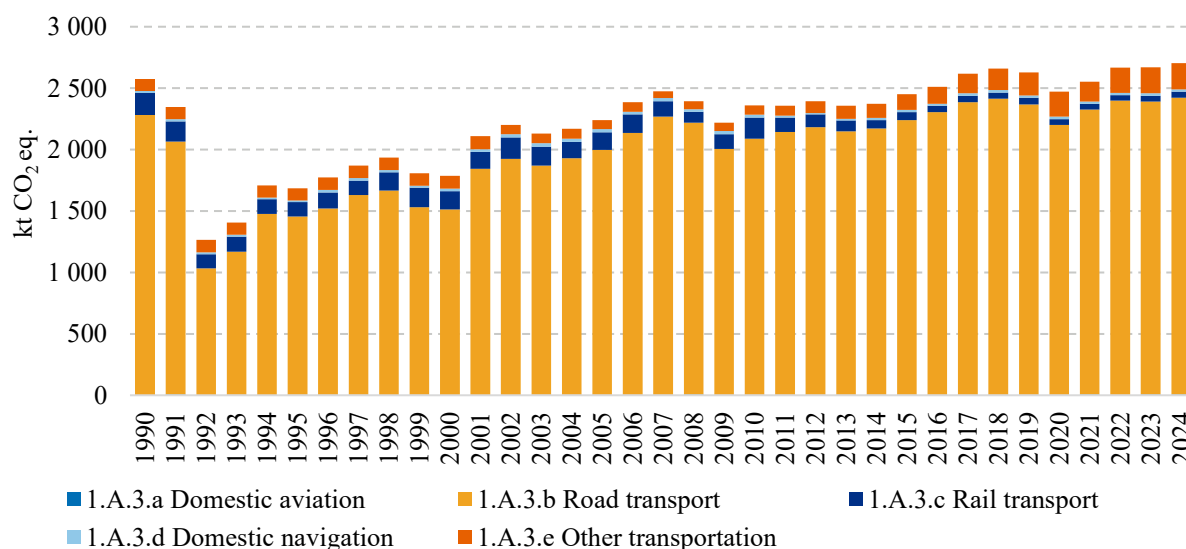


Figure 3.19. Emissions from Transport sector by subcategory in 1990–2024, kt CO₂ eq.

Road transportation is an essential emission source in the Transport sector covering 89.47% of the sector's emissions (see Figure 3.19). The fuel consumption and the emissions from the

Transport sector are presented in Table 3.13 and Table 3.14. Significant drop in other fossil fuel consumption in 2022 was due to extensive replacement of FAME biodiesel (which contains fossil part that is counted under other fossil fuels) with HVO renewable diesel by fuel retailers. No FAME consumption was reported for 2024.

Table 3.13. Emissions from the Transport sector by subcategories in 1990, 2005, and 2021–2024, kt CO₂ eq.

Category	1990	2005	2021	2022	2023	2024
1.A.3 Transport Total, CO₂ eq.	2571.04	2239.03	2552.00	2666.80	2668.98	2702.46
1.A.3.a ii Domestic aviation	5.56	4.71	5.62	4.86	5.55	5.47
1.A.3.b Road transport, CO ₂ eq.	2278.37	1992.86	2319.83	2394.57	2386.21	2418.00
1.A.3.c Rail transport, CO ₂ eq.	174.41	143.60	47.54	42.75	46.90	47.08
1.A.3.d. ii Domestic navigation, CO ₂ eq.	21.87	24.99	18.47	17.95	20.14	20.22
1.A.3.e Other transportation, CO ₂ eq.	90.84	72.87	160.55	206.66	210.18	211.70

Table 3.14. Fuel consumption in Transport sector in 1990, 2005, and 2021–2024, TJ

Activity data	1990	2005	2021	2022	2023	2024
1.A.3.a Domestic aviation						
Jet Kerosene	78	66	78	68	78	76
1.A.3.b Road transport						
Gasoline	21 567	12 522	8226	8713	8642	8751
Diesel oil	9473	14 707	22 276	23 019	23 119	23 107
LPG	9	62	437	455	348	605
CNG	NO	NO	755	483	518	490
Biomass*	NO	3	1919	1649	1613	1987
Other fossil fuels*	NO	3	439	1	NO	NO
1.A.3.c Railways						
Coal	179	NO	NO	NO	NO	NO
Light fuel oil	1946	1777	587	529	581	581
1.A.3.d Domestic navigation						
Diesel oil	296	338	250	243	273	273
1.A.3.d Other transportation						
Gasoline	26	18	82	88	64	74
Diesel oil	1201	967	2088	2707	2783	2783

NO - no consumption occurred, * - under Other fossil fuels the fossil part of liquid biofuels (biodiesel and bioethanol) are presented and under biomass the biogenic part of liquid biofuels and biomethane (bio-CNG) is presented.

1.A.3.a Domestic aviation

The emissions from Domestic aviation (CRT 1.A.3.a) include all domestic aviation transport within Estonian flight regions, generally islands (Figure 3.20). Helicopters are not included in the calculations due to the small number of flights and the lack of emission factors, however, the fuel consumption is included as part of sector 1.A.3.a.

The share of Domestic aviation in Transport sector was only 0.20% with 5.47 kt CO₂ eq. in 2024, which was 1.56% lower compared to last year. Fuel consumption in 2024 decreased slightly, mainly due to lower aviation gasoline consumption in cruise mode. The corresponding emissions were 5.56 kt CO₂ equivalent in 1990.

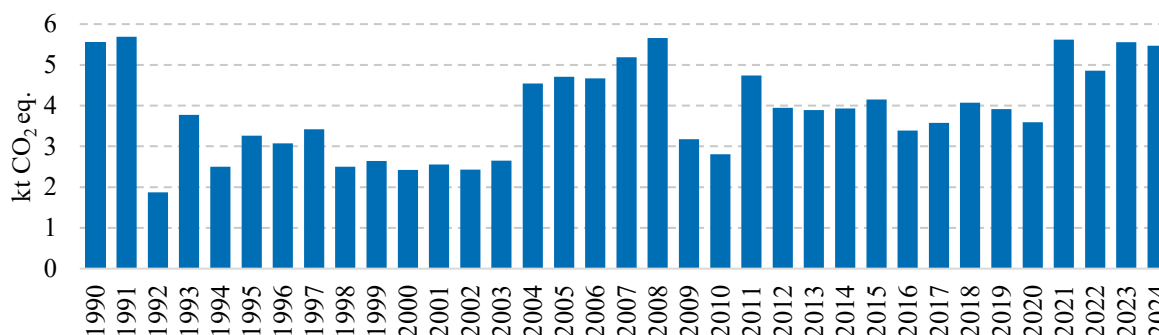


Figure 3.20. GHG emissions from Domestic aviation in 1990–2024, kt CO₂ eq.

1.A.3.b Road transportation

Road transport (CRT 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, since they are included starting from 2024 submission in the CRT category 1.A.3.e Other transportation. For Road Transport, CH₄ and N₂O emissions are calculated using COPERT 5. Compared with the previous submission, the current submission includes a recalculated 1990–2023 time series reflecting a COPERT version upgrade, revised vehicle stock data from the Estonian Transport Administration and an expanded representation of vehicle categories and technologies.

Road transport is the most important emission source in the Transport sector. The emissions from Road transportation of 2418.00 kt CO₂ eq. in 2024 is about 89.47% of total Transport sector emissions and 29.70% of the Energy sector. In 2024 the GHG emissions of the Road transport sector were about 6.13% higher than in 1990 (2278.37 kt CO₂ eq.).

The trend of GHG emissions follows, in general, the fuel consumption trend in the Road transport sector. The total emissions of Road transport can be seen in Figure 3.21. The lowest emissions in Road transportation were reached in 1992, caused by the rapid increase of fuel prices after regaining independence in 1991 and difficulties in fuel supply (at the beginning of the 1990s Estonia imported all transport fuels from Russia). The second decrease in the emissions 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 slight decline of emissions (in 2008/2007 about 2.2% and in 2009/2008 9.5%) started which reflects the overall economic depression in Estonia. Since 2014 the GHG emissions have gradually increased reaching their peak in 2018.

The GHG emission decrease in 2020 was due to the extended consumption of biofuels and a fall in total mileage compared to the previous year as decreased usage of fuels due to the state of emergency established by the Government of Estonia. In 2021 the emissions in Road transport sector increased 5.6% due to increased use of diesel oil and increased mileage of heavy duty trucks. In 2022 the recovery from Covid-19 pandemic continued and the increased consumption of diesel and gasoline in Road transport and diesel in Other transportation resulted in 3.2% GHG emission increase. There was a slight increase of 1.33% in 2024 emissions compared to the previous year mainly due to higher road transport activity, especially increased mileage of heavy duty trucks and buses, together with a small rise in overall gasoline consumption.

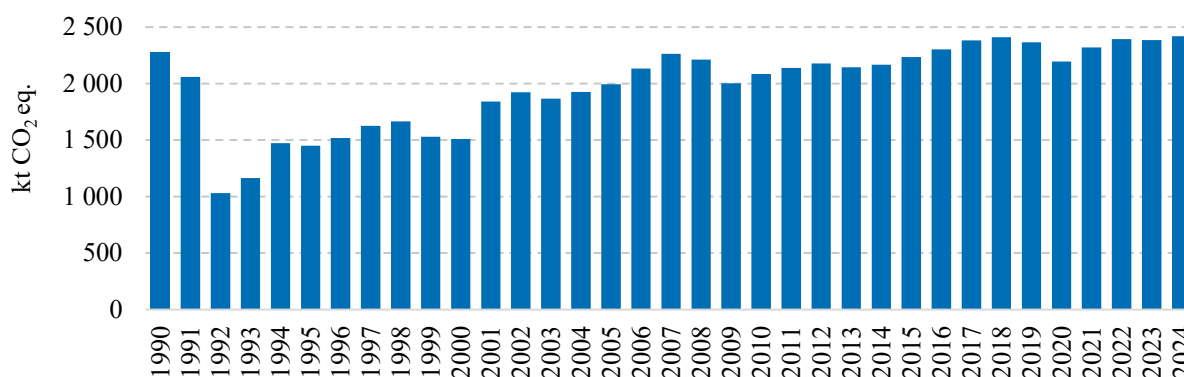


Figure 3.21. Emissions from the Road transport in 1990–2024, kt CO₂ eq.

1.A.3.c Railways

New trains started to run on Estonian railways in 2013 after several years of railway reconstructions. All non-electric locomotives use diesel oil in Estonia. From 1990 to 1998 also coal-burning locomotives were used in Estonia.

Railway transportation in Estonia has a small share of emissions in the Transport sector. The emissions were 47.08 kt CO₂ eq. in 2024 with the share of 1.74% in the Transport sector. In 1990 the corresponding figure was 174.41 kt CO₂ eq.

The passenger rail transport in Estonia is not so widely used compared to other countries. Also, the rail network density (meters per km²) is one of the smallest in Europe.

In general, the CO₂ emissions trend matches the fuel consumption trend in the Rail transport sector (Figure 3.22). Rail transport is principally used for transporting goods. The lowest emission level in Rail transport before 2016 was reached in 2008, because of a rapid decrease in the amount of goods carried by Estonian transport enterprises. The decrease in the goods transported by rail started in 2007 and continues falling in the 2026 submission, fuel consumption was kept unchanged for the reasons explained above. The small difference in emissions results from the updated CO₂ emission factor.

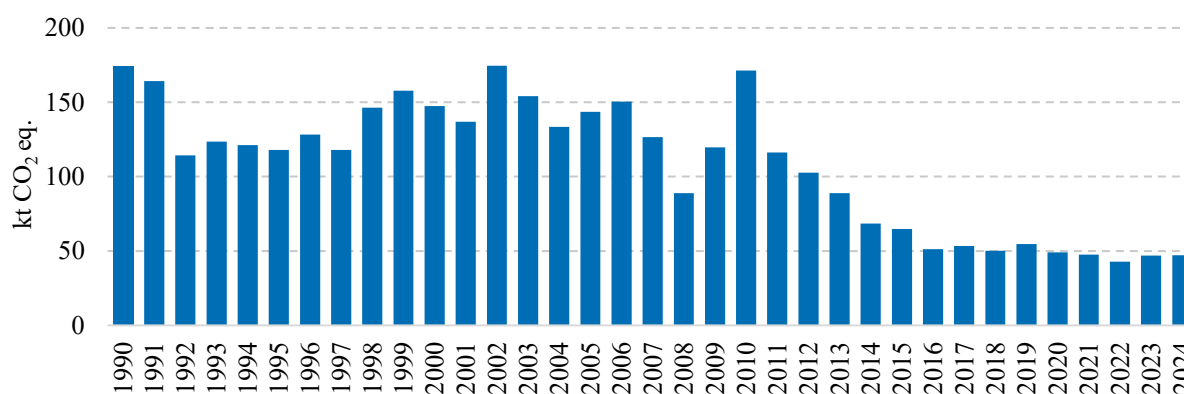


Figure 3.22. Emissions from Railways in 1990–2024, kt CO₂ eq.

1.A.3.d Domestic navigation

At the end of 2024, the Estonian Transport Administration's Ship Register included 97 ships, comprising 16 passenger ships, 6 merchant ships, 38 fishing vessels and 37 technical and ancillary vessels. In addition, 9 ships were listed in the Register of Bareboat Chartered Ships.

Domestic navigation in Estonia is also a minor emission source in Transport sector. The emissions of Domestic navigation were 20.22 kt CO₂ eq. in 2024 (0.75% of Transport sector emissions). In the 2026 submission, fuel consumption was kept unchanged for the reasons explained above. The small difference in emissions results from the updated CO₂ emission factor. In 1990 the corresponding figure was 21.87 kt CO₂ eq.

Emissions from deep sea fishing are not included in the reporting of Domestic navigation.

The trend of GHG emissions is presented in Figure 3.23.

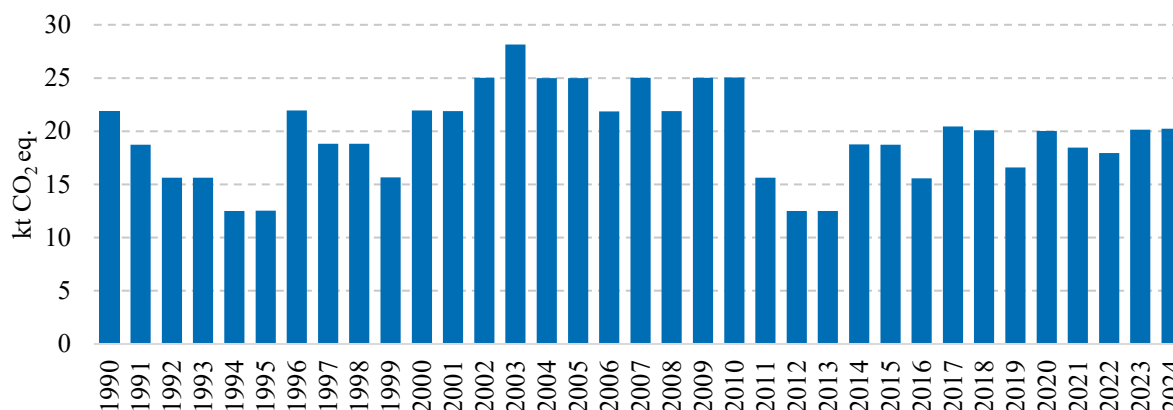


Figure 3.23. Emissions from Domestic navigation in 1990–2024, kt CO₂ eq.

1.A.3.e Other transportation

Off-road vehicles are used in industry, agriculture, forestry, and for household purposes (Table 3.15).

Table 3.15. Reporting categories of off-road vehicles sources reported under 1.A.3.e Other transportation (until 2023 submission reported under different categories)

Previous CRT category	Description
1.A.2.g Other	Excavators, loaders, road work machines
1.A.4.a Commercial/institutional	Other miscellaenous equipment (e.g. ATV-s, forklifts, cranes, etc.)
1.A.4.c Agriculture/forestry/fisheries	Tractors, harvesters, forestry machines

Emissions of off-road mobile equipment in 1990-2024 are shown in Figure 3.24. The overall GHG consumption trend follows the fuel consumption trend (Figure 3.25). The biggest share of emissions from off-road vehicles comes from Agriculture/forestry/fisheries since most of the fuel (mostly diesel oil) is consumed in tractors in agriculture. Gasoline is only consumed in tractors in agricultural sector.

The GHG decrease in from 1999 was directly caused by the economic crisis in Russia. In 2007 economic crisis in Estonia showed the downwards trend in GHG emissions. Since 2010 the GHG emissions have increased together with the growth of the economy. The trend of GHG emissions matches the trend of fuel consumption. In 2024 emissions from off-road vehicles accounted for 211.70 kt CO₂ eq., which is a 0.73% increase compared to the previous year (Table 3.16).

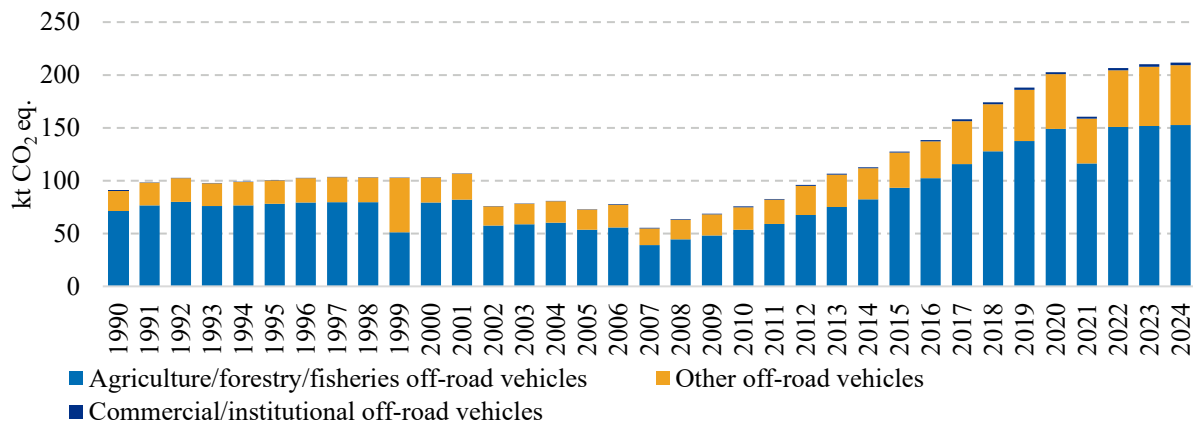


Figure 3.24. Emissions from off-road vehicles in Estonia in 1990-2024, kt CO₂ eq.

Table 3.16. Emissions from off-road vehicles by subcategories in 1990, 2005, and 2021–2024, kt CO₂ eq.

Category	1990	2005	2021	2022	2023	2024
1.A.3.e Other transportation Total, CO₂ eq.	90.84	72.87	160.55	206.66	210.18	211.70
Other off-road vehicles, CO ₂ eq.	19.84	18.96	42.37	53.43	55.94	56.55
Commercial/institutional off-road vehicles, CO ₂ eq.	0.12	0.34	1.89	2.30	2.56	2.57
Agriculture/forestry/fisheries off-road vehicles, CO ₂ eq.	70.88	53.57	116.29	150.93	151.68	152.58

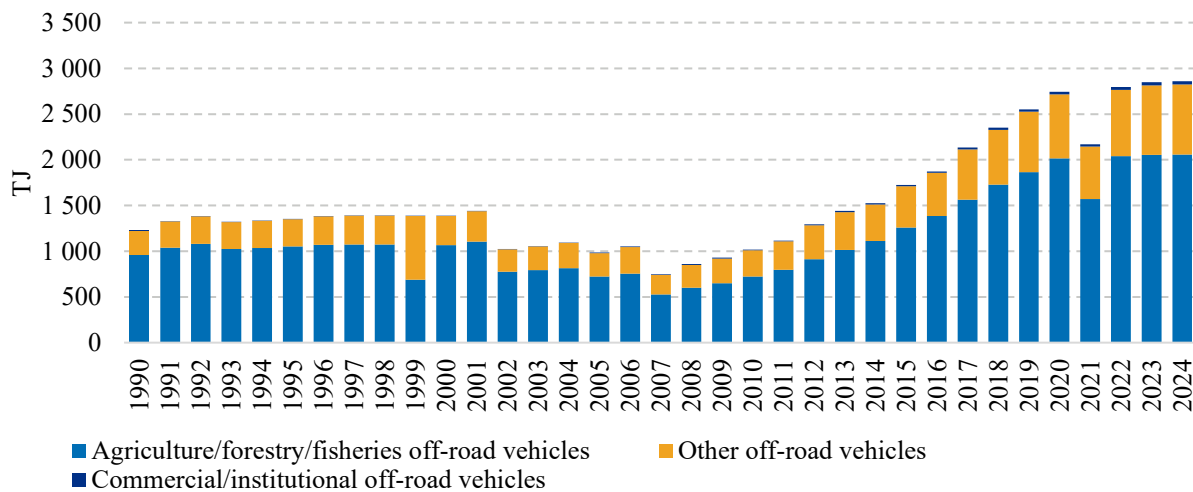


Figure 3.25. Fuel consumption of off-road vehicles in Estonia in 1990-2024, TJ

3.2.6.2. Methodological issues

Choice of methods

1.A.3.a Domestic aviation

Tier 2 approach is used to estimate emissions from Domestic aviation operations of aircraft which is divided into LTO and cruise phases. *Tier 2* separates the calculation of emissions from aviation into the following steps using Equation 3.4, Equation 3.5, and Equation 3.6:

Equation 3.4³³

$$1. \text{ Total Emissions} = \text{LTO Emissions} + \text{Cruise Emissions}$$

Equation 3.5³⁴

$$2. \text{ LTO Emissions} = \text{Number of LTOs} \times \text{Emission Factor of LTOs}$$

Equation 3.6³⁵

$$3. \text{ Cruise Emissions} = (\text{Total Fuel Consumption} - \text{LTO Fuel Consumption}) \times \text{EF Cruise}$$

1.A.3.b Road transportation

CO₂ emissions from Road transport are estimated using the IPCC 2006 Tier 2 methodology.

In the current inventory report the emissions of CO₂ is calculated on basis of combusted fuels and their carbon content. Tier 2 calculates CO₂ emissions by multiplying the estimated fuel sold times a country-specific emission factor. This approach is expressed in Equation 3.7:

Equation 3.7³⁶

$$\text{Emission} = \sum_a [\text{Fuel}_a \times \text{EF}_a]$$

Where:

Emission = emissions of CO₂, 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).

CH₄ and N₂O emissions are calculated separately using the COPERT 5 model in accordance with the IPCC 2006 Tier 3 methodology for fossil diesel, gasoline, LPG, and liquid biofuels, which is based on EMEP/EEA air pollutant emission inventory guidebook 2023 sector 1.A.3.b Road transport³⁷. The calculations in the COPERT 5 model are done in the Estonian Environment Agency. The mileage (km/y) of each vehicle type and model on different road types and in different speed classes are multiplied with corresponding CH₄ and N₂O emission factors. CO₂, CH₄, and N₂O emissions from CNG in Road transport are calculated using the IPCC Tier 2 method and country-specific emission factors.

From 2023 submission Estonia also reports the fossil part of biofuels consumption and CH₄ and N₂O emissions in CRT tables under Other fossil fuels in 1.A.3.b.

COPERT 5 is a software tool used worldwide to calculate air pollutants and GHG emissions from road transport. The development is coordinated by the European Environment Agency, in the framework of the European Topic Centre for Air Pollutant and Climate Change Mitigation.

³³ IPCC 2006 Guidelines, Volume 2, Chapter 3; Mobile Combustion, page 3.59, equation 3.6.2.

³⁴ IPCC 2006 Guidelines, Volume 2, Chapter 3; Mobile Combustion, page 3.59, equation 3.6.3.

³⁵ IPCC 2006 Guidelines, Volume 2, Chapter 3; Mobile Combustion, page 3.59, equation 3.6.5.

³⁶ IPCC 2006 Guidelines, Volume 2, Chapter 3; Mobile Combustion, page 3.12, equation 3.2.1.

³⁷ EMEP/EEA air pollutant emission inventory guidebook – 2023 1.A.3.b.i-iv Road Transport. [www] <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i> (03.03.2026).

Necessary input for the model to calculate emissions is number of vehicles, annual mileage per vehicle, annual statistical fuel consumption, speed (urban, rural, highway), driving share (urban, rural, highway), monthly minimum and maximum average temperatures, monthly Reid vapour pressure (RVP), etc. COPERT 5 (version 5.9.2) contains 530 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 407 vehicle types.

Road vehicles are classified according to their level of emission control technology that is defined in emission legislation. Therefore, the emission factors are differentiated per vehicle category and Euro standard. N₂O emission factors depend on vehicle category and on fuel sulphur content³⁸.

The emission equation of Tier 3 for CH₄ and N₂O is described in the Equation 3.8:

Equation 3.8³⁸

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

Where:

Emission = emission of CH₄ or N₂O, kt CO₂ 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).

The NO_x, CO, and NMVOC emissions are calculated by Estonian Environmental Agency using COPERT 5 model and EMEP/EEA air pollutant emission inventory guidebook 2023 sector 1.A.3.b Road transport methodology. The NO_x, CO, and NMVOC emissions are calculated by using Equation 3.9.

Equation 3.9

$$EF_{pollutant} = AR_{activity} \times EF_{pollutant}$$

Where:

E_{pollutant} = the emission of the specific pollutant;
 AR_{activity} = the activity rate;
 EF_{pollutant} = the emission factor for this pollutant.

³⁸ IPCC 2006 Guidelines, Volume 2, Chapter 3; Mobile Combustion, page 3.15, equation 3.2.5.

1.A.3.c Railways

CO₂ emissions from Railways are calculated by multiplying the estimated fuel consumption with a country-specific emission factor using IPCC 2006 *Tier 2* method. CH₄ and N₂O emissions are calculated using emission factors from 2006 IPCC Guidelines and *Tier 1* method.

1.A.3.d Domestic navigation

CO₂ emissions from Domestic navigation are calculated by multiplying the estimated fuel consumption with a country-specific emission factor for light fuel oil using IPCC 2006 *Tier 2* method. CH₄ and N₂O emissions are calculated using emission factors from 2006 IPCC Guidelines and *Tier 1* method.

1.A.3.e Other transportation

Emissions from Off-road vehicles are estimated using IPCC 2006 *Tier 2* methodology for CO₂ emissions and the EMEP/EEA air pollutant inventory guidebook 2023 1.A.4 Non road mobile machinery *Tier 3* methodology³⁹ for CH₄ and N₂O emissions, and fuel consumption. The emissions of CO₂ is calculated on the basis of combusted fuels and their carbon content. *Tier 2* calculates CO₂ emissions by multiplying the estimated fuel consumed times a country-specific emission factor.

CH₄ and N₂O emissions are calculated separately for gasoline and diesel vehicles. Workload of each vehicle type and model on different road types and in different speed classes are multiplied with corresponding CH₄ and N₂O emission factors. Off-road mobile vehicles are classified according to their level of emission control technology that is defined in emission legislation. Therefore, the emission factors are differentiated per vehicle category and Euro standard.

Activity data

Updated activity data for transport sector are only partially available for the 15th of April 2026 submission. Therefore, the inventory applies the latest verified data (2023) for selected fuels including liquid fuels (diesel oil, light fuel oil, residual fuel oil). The dataset and time series will be revised in the 2027 submission once verified information becomes available. See further details in Section 3.2.6.6.

1.A.3.a Domestic aviation

The activity data on aviation gasoline used in civil aviation is provided by Statistics Estonia and Tallinn Airport. Aviation fuel is not presented separately in the national energy balance for national and international flights. This 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.

Estonia separates the fuel consumption further into the landing and take-off (LTO) phase and the cruise phase using the following principle: in LTO phase fuel consumption is based on representative aircraft type. 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 with the corresponding number of LTOs (Equation 3.10). 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 3.11).

³⁹ EMEP/EEA air pollutant emission inventory guidebook –2023 1.A.4. Non road mobile machinery. [www] <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-4-non-road> (03.03.2026).

Equation 3.10⁴⁰

$$LTO \text{ Fuel Consumption} = \text{Number of LTOs by aircraft type} \times \text{Fuel Consumption per LTO by aircraft type},$$

Equation 3.11⁴¹

$$Cruise \text{ Fuel Consumption} = Total \text{ Fuel Consumption} - LTO \text{ Fuel Consumption Cruise},$$

Detailed aircraft data with take-off and landing activity is provided by airports. Estonian aircraft movement statistics consider landing and take-offs as two different activities. However, the 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 requires information on the number of LTOs grouped by representative aircraft types. This kind of detailed knowledge is hard to obtain (individual aircraft with their specific engines) and, therefore, data is aggregated for practical reasons. Assumptions are made if there is missing data in some situations.

Despite 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 2023 methodology and other referred sources in guidebook (IPCC, FOCA, ICAO engine database etc.).

A complete calculations have been carried out by Estonian Environment Agency for the years 1992–2024 (Table 3.17). An extrapolation has been made for 1990 and 1991.

Table 3.17. Number of LTO cycles

Year	Domestic LTO	International LTO
1992	2249	5247
2005	7740	17 907
2019	8014	21 391
2021	7676	10 265
2022	7683	16 336
2023	6962	16 453
2024	6998	18 889

1.A.3.b Road transportation

The activity data for calculating the CO₂ emissions is based on the amount of fuel consumed in road traffic. The data is received from Statistics Estonia. The 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 CH₄ and N₂O emission calculations the Estonian Environment Agency has concluded a contract with the Estonian Transport Administration.

In Estonia a small amount of liquid biofuels are used since 2005. The liquid biofuels inland consumption data and information regarding the types of bioethanol and biodiesel is collected from the Estonian Environment Agency. The Estonian Environment Agency is making its calculations based on assumption that biodiesel is marked as B7 (7% of biodiesel) and bioethanol as E5 (5% of bioethanol). Bioethanol is only allowed mixed with petrol and biodiesel both mixed and pure form.

⁴⁰ IPCC 2006 Guidelines, Volume 2, Chapter 3; Mobile Combustion, page 3.59, equation 3.6.4.

⁴¹ IPCC 2006 Guidelines, Volume 2, Chapter 3; Mobile Combustion, page 3.59, equation 3.6.5.

According to the Estonian Liquid Fuel Act⁴² from the 1st of April 2020 the total energy content of the petrol, diesel, and biofuel released for consumption, as well as of the electricity supplied for use in road transport, by any seller of fuel or for the import of fuel must include a total energy content of biofuels, biomethane or electricity supplied for final consumption, at the value, as a weighted average for the calendar year, of 10 percent by the end of that year. Since 1st of January 2022 the total energy content is 7.5% since a revision of Liquid Fuel Act was adopted.

The biofuel consumption is reported in Table 3.18.

Table 3.18. Consumption of bioethanol, biodiesel, and biomethane in Estonia in 2005–2024, TJ

Year	Bioethanol	Biodiesel	Biomethane
2005	NO	6.50	NO
2021	176.57	1734.87	446.34
2022	84.92	1087.61	478.31
2023	94.97	841.36	676.70
2024	88.13	841.31	1057.39

NO – no consumption occurred

The activity data for CNG and biomethane (bio-CNG) is taken from Joint Questionnaire provided by Statistics Estonia.

LPG vehicles run on bi-fuel system that uses diesel or gasoline as a second fuel. Therefore, vehicles that are using LPG are not extracted from the total number of vehicles used in the COPERT 5 model to ensure the accounting of the emissions from the second fuel.

In Table 3.19 the number of vehicles and in Table 3.20 road traffic mileage is presented following COPERT 5 model.

Table 3.19. Number of vehicles in Estonia, thousand vehicles

Number of vehicles	Passenger cars	Light Commercial Vehicles	Heavy Duty Trucks and Buses	Motorcycles and Mopeds	Total Vehicles
1990	241	31	45	2	319
2005	355	34	26	9	423
2021	634	81	31	45	791
2022	650	84	31	48	813
2023	661	86	31	49	827
2024	669	88	30	51	838

Table 3.20. Road traffic mileage in Estonia, million km/y

Road traffic mileage	Passenger cars	Light Commercial Vehicles	Heavy Duty Trucks and Buses	Motorcycles and Mopeds	Total Mileage
1990	5720	695	1600	7	8022
2005	5782	951	890	29	7652
2021	9027	1444	954	86	11 511
2022	8760	1553	1082	94	11 489
2023	9187	1532	1013	88	11 820
2024	9042	1477	1238	81	11 838

⁴² Riigi Teataja. Liquid fuel act. [www] <https://www.riigiteataja.ee/en/eli/516122024007/consolide> (03.03.2026)

Until 2021 submission the Statistics Estonia's number of motorcycles was used, which included motorcycles that had been demolished, but were not taken out from the national registry by the owners. Since the 2022 submission data from COPERT 5 model is used (as in the model demolished motorcycles have been deducted and the data is more precise). An analysis of high statistical number of motorcycles in use during the period 1990-1994 was carried out, and as a result the number of vehicles was corrected to ensure that the data no longer reflects vehicles which have not been in use and technically inspected. The number of mopeds was adjusted for 1995-2012 based on the corrections for 1990-1994 period. Also, the timeseries for the number of motorcycles has been updated according to COPERT 5 model.

The number of vehicles increased between 1991 and 1992 by 5.6% while the kilometers driven decreased by 53.9%. This surge in the number of vehicles and decrease in mileage is the result of Estonia regaining independence in 1991. Before, only people with special permits could buy a vehicle. Since 1992 no permits were needed anymore. Still, there was a shortage of motor fuels and the prices were rather high. Therefore, there was a significant decrease in the mileage. Since 2010 there has been an increase in the number of passenger cars, which is attributable to the increment of economic wealth in Estonia.

1.A.3.c Railways

The activity data on fuel consumption used in Railways is obtained from Joint Questionnaire dataset managed by Statistics Estonia and is presented in Table 3.14.

1.A.3.d Domestic navigation

The activity data on fuel consumption used in Domestic navigation is gained from the Statistics Estonia and presented in Table 3.14.

Statistics Estonia acquires the amounts of fuel used from relevant reports that are presented by water transport companies. Statistics Estonia is aware about the large variation in the activity data and looking into the matter to improve consistency.

1.A.3.e Other transportation

The number of off-road vehicles is obtained from different sources. The data for the years 2010-2024 is obtained from Estonian Transport Administration that provides the number of vehicles by vehicle category, brand, model, type, year of first registration, engine type, engine capacity, engine power, and mass. To construct the number of vehicles by emission technology for the whole time series of 1990-2024, the 1990-2009 timeline needed to be established. The total number of off-road vehicles was obtained from Statistics Estonia for the years 1990-2009. A linear interpolation was made between 1990 and 2009 based on the trend of distribution of emission technology for the years 2010-2024. In Figure 3.26 number of vehicles by vehicle type is presented⁴³.

⁴³ Number of vehicles are based on “Revision of calculation principles for emissions from other mobile sources”. The report is available upon request.

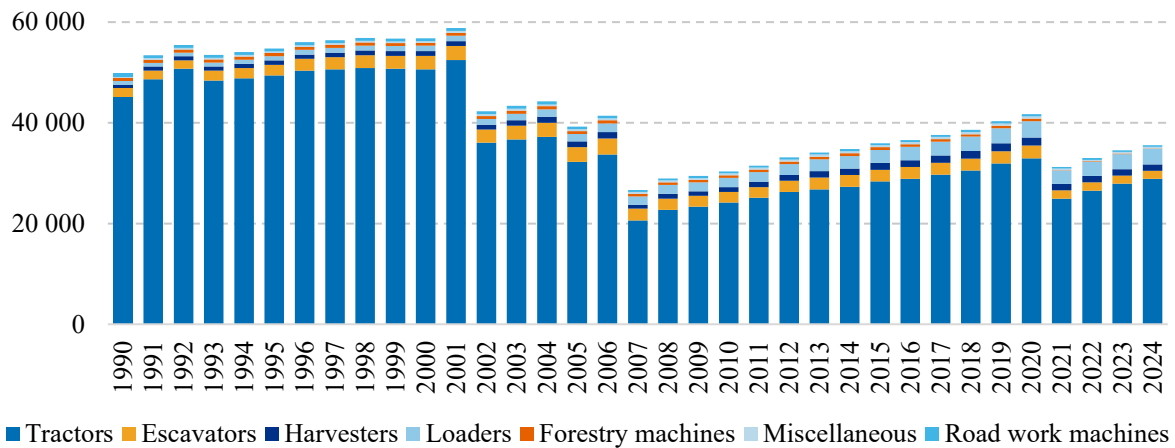


Figure 3.26. Number of off-road vehicles in 1990-2024

The NCVs for the fuels used for off-road vehicles are for diesel 42.3 GJ/kg and gasoline 44.0 GJ/kg. In Table 3.21 the consumption of fuels in off-road vehicles is presented.

Table 3.21. Consumption of fuels from off-road vehicles, TJ

Year	Diesel	Gasoline
1990	1201	26
2005	967	18
2022	2707	88
2023	2783	64
2024	2783	74

Emission factors

1.A.3.a Domestic aviation

Cruise and LTO emission factors of CO₂, CH₄, and N₂O used in the emission calculations from national aviation are taken from the IPCC 2006 Guidelines.

Cruise emission factors of NO_x, CO, NMVOC, and SO₂ used in the emission calculations from national aviation are taken from the EMEP/EEA 2023 air pollutant emission inventory guidebook (Ch. 1.A.3.a Aviation, Table 3–3, p. 21).

LTO emission factors of NO_x, CO, NMVOC, and SO₂ used in the emission calculations from national aviation are taken from the EMEP/EEA 2023 air pollutant emission inventory guidebook (Ch. 1.A.3.a Aviation, table 3–3, p. 21) and other referred sources in guidebook (IPCC, FOCA, ICAO engine database etc). The share of different aircraft types varies every year and the average emission factor changes from year to year. Average emission factors used for 2022 emission calculations are presented in Table 3.22.

Table 3.22. Emission factors used in the calculations of emissions from Civil aviation (1.A.3.a)

	CO ₂	CH ₄	N ₂ O	NO _x	CO	NMVOC	SO ₂
Cruise ⁴⁴	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
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/tonne of aviation gasoline are converted to kg/TJ using net average calorific value of aviation gasoline. The results for 2024 are presented in Table 3.23.

⁴⁴ EMEP/EEA air pollutant emission inventory guidebook 2023, Table 3-3, p.21 (average fleet).

Table 3.23. Emission factors from Civil aviation (1.A.3.a)

	CO₂	CH₄	N₂O	NO_x	CO	NMVOC	SO₂
	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	23.3
LTO	73.5	5	2.0	128.9	2 708.1	202.1	21.0

1.A.3.b Road transportation

CO₂ emission factors of gasoline, LPG, and diesel oil for Road transport are presented in Table 3.24. In 2013 Estonia developed country-specific CEF calculation methodology for gasoline, LPG, and diesel oil for Road transport. The CEFs are calculated using weighted average method using CEFs of countries that Estonia imports the fuel from. Since there was no import data for the years 1990–1994, these values are calculated based on 1995–1997 data. All submissions after 1997 are based on these CEFs.

Table 3.24. Carbon emission factors, tC/TJ; CH₄ emission factors, kg/TJ; and N₂O emission factors, kg/TJ for fuels used in Road transport

Year	Gasoline			Diesel			LPG		
	CEF	CH ₄ EF	N ₂ O EF	CEF	CH ₄ EF	N ₂ O EF	CEF	CH ₄ EF	N ₂ O EF
1990	19.50	36.80	2.26	19.94	7.47	2.53	17.72	19.02	0.00
2005	19.27	22.68	3.47	19.95	6.14	1.59	17.75	17.77	3.45
2022	19.22	7.31	0.71	19.95	1.07	5.69	17.23	10.35	1.06
2023	19.20	7.02	0.67	19.91	1.00	5.65	17.22	10.25	0.92
2024	19.16	7.05	0.63	19.99	0.90	6.34	17.33	10.81	0.95

The amounts of fuels imported in 2024 are presented in Table 3.25.

Table 3.25. Imported fuel amounts in 2024 by country

	Gasoline (kg)	Diesel (kg)	LPG (kg)
Belgium	29 255 804	30 370 923	8
Czechia			900
Denmark		8 840 560	
Finland	40 482 991	181 187 443	2 184 164
France	2184	46 162	485
Germany		59 151	4593
Greece			977
Ireland			68
Italy	23 655	1	12 736
Latvia		57 505 480	3 250 108
Lithuania	243 300 112	417 725 056	166 119
Netherlands	12 678	3 525 638	1182
Norway		16 488 526	
Poland	7 497	45 938	2197
Russia			2 317 764
Slovenia		204	
Sweden	18 497 790	22 138 118	41 738
United States		1 995 073	

Oxidation factors for all fuels in Road transport are equal to 1. The NCVs for the fuels used in Road transport are following: diesel – 42.3 GJ/kg, LPG – 45.5 GJ/kg, and gasoline – 44.0 GJ/kg.

The CEFs used for the calculation of the country-specific CO₂ emission factor in 2024 by country are presented in Table 3.26.

Table 3.26. Carbon emission factors used in the calculation of the country-specific CO₂ emission factor for liquid fuels in Road transport, tC/TJ

	Gasoline	Diesel	LPG
Belgium	18.90	20.20	17.20
Czechia	-	-	17.97
Denmark	-	20.21	-
Finland	19.50	20.00	17.70
France	19.77	20.32	17.21
Germany	-	20.19	18.09
Greece	-	-	17.20
Ireland	-	-	17.37
Italy	18.90	20.20	17.20
Latvia		20.40	17.13
Lithuania	19.10	19.90	18.21
Netherlands	19.69	19.77	18.19
Norway	-	20.06	-
Poland	19.19	19.76	17.04
Russia			17.21
Slovenia	-	20.20	-
Sweden	19.64	20.25	17.75
United States	-	19.16	-

* Countries for whom CEF data was not available, the defaults have been used.

CH₄ and N₂O emissions from liquid fossil fuels are calculated using COPERT 5 model. CH₄ and N₂O emission factors are described in the EMEP/EEA air pollutant emission inventory guidebook 2023³⁷. Since every EURO class has different emission factors, the CH₄ and N₂O emissions are highly dependent on the share of vehicles used in road transport.

Gaseous fuels

In 2021 Estonia developed CNG country-specific emission factors for CH₄ and N₂O for passenger cars, buses, and light duty vehicles. The EFs are calculated using Handbook Emission Factors for Transport⁴⁵ (HBEFA) database which aggregates emission factors for different types of vehicles by emission technologies and fuel types taking into account the road type and weather conditions. The database includes emission factors for Austria, Germany, Switzerland, France, Norway, and Sweden.

The activity data for Estonia is available from 2010 as CNG was first used in passenger cars in 2010 and in buses in 2011. The first biomethane buses started to run in Estonia in 2018.

The arithmetic mean of the specific emission factors of the emission technologies was taken for each road type: urban road, rural road, and motorway. In order to make the specific emission factors as closely as possible comparable to Estonian conditions, the specific emission factors were calculated using the weighted average method for the years 2010-2024 using the existing shares of Estonian road types available at COPERT 5 model. To conclude the selection a

⁴⁵Handbook Emission Factors for Transport. [www] <https://www.hbefa.net/e/index.html> (03.03.2026).

comparison of weather conditions between Estonia and selected countries was made. The meteorological data was taken from HBEFA database and for Estonia from COPERT 5. In GHG inventory, the emission factors for passenger cars and buses are used. HBEFA includes N₂O emission factors for city buses from the EMEP/EEA 2023 guidebook³⁷, which lists the specific N₂O emission factors for city buses as 0 or n.a. The same emission factors for CNG and biomethane are used in estimating CH₄ and N₂O emissions in Road transport using IPCC *Tier 3* method.

The CEF used for calculating CO₂ emissions from CNG and biomethane is country-specific for natural gas. According to the Regulation No. RT I, 29.07.2017, 6⁴⁶ of the Minister of Economic Affairs and Infrastructure biomethane used in transport must meet the quality requirements of natural gas. Table 3.27 presents the CEF-s, CH₄ and N₂O emission factors for CNG and biomethane.

Table 3.27. Carbon emission factors, tC/TJ; CH₄ and N₂O emission factors, g/km for CNG and biomethane used in passenger cars and buses in Road transport

Year	CNG					Biomethane		
	CEF	Passenger cars		Buses		CEF	Buses	
		CH ₄ EF	N ₂ O EF	CH ₄ EF	N ₂ O EF		CH ₄ EF	N ₂ O EF
2010	15.07	0.028	0.0004	–	–	–	–	–
2011	15.07	0.028	0.0004	0.028	0.0004	–	–	–
2012	15.07	0.029	0.0004	0.029	0.0004	–	–	–
2013	15.07	0.029	0.0004	0.029	0.0004	–	–	–
2014	15.07	0.029	0.0004	0.029	0.0004	–	–	–
2015	15.07	0.027	0.0004	0.027	0.0004	–	–	–
2016	15.07	0.027	0.0004	0.027	0.0004	–	–	–
2017	15.07	0.027	0.0004	0.027	0.0004	–	–	–
2018	15.07	0.027	0.0004	0.027	0.0004	15.07	0.26	NA
2019	15.07	0.027	0.0004	0.027	0.0004	15.07	0.26	NA
2020	15.07	0.027	0.0004	0.027	0.0004	15.07	0.26	NA
2021	15.07	0.027	0.0004	0.027	0.0004	15.07	0.26	NA
2022	15.07	0.027	0.0004	0.027	0.0004	15.07	0.26	NA
2023	14.73	0.027	0.0004	0.027	0.0004	14.73	0.26	NA
2024	14.59	0.027	0.0004	0.027	0.0004	14.59	0.26	NA

Liquid biofuels

The emissions from bioethanol and biodiesel use are reported separately from fossil-based diesel oil and gasoline emissions. The fossil CO₂, CH₄ and N₂O emissions are reported under Other Fossil Fuels and biogenic CO₂, CH₄ and N₂O emissions under Biomass in 1.A.3.b Road Transportation in CRT tables. The biogenic CH₄ and N₂O emissions are accounted for in national total. CH₄ and N₂O emissions from biofuels are calculated using COPERT 5 model. CH₄ and N₂O emission factors in COPERT 5 are described in the EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 1.A.3.b Road transport³⁷.

⁴⁶Riigi Teataja. Network Code on the Operation of the Gas Market. [www] <https://www.riigiteataja.ee/en/eli/510032021005/consolide> (03.03.2026).

In 2022 Estonia carried out a development work to specify CO₂ emissions from fossil part of liquid biofuels. The fossil carbon origin of FAME (fatty-acid methylether) and ETBE (ethyl tert-butyl ether) was specified and the distribution of biodiesel into FAME and HVO (hydrotreated vegetable oil) and the ETBE part of bioethanol was taken into account in calculations. The shares of FAME and HVO in biodiesel and ETBE in bioethanol are taken from the COPERT 5 model which are calculated by Estonian Environment Agency. ETBE is consumed only in 2019 in Estonia and its share in bioethanol is very small. The consumption data of liquid biofuels in Estonia is available from 2005.

Bioethanol is 100% bio-origin. ETBE is a bioether that is synthesized by mixing bioalcohols and isobutylene over a catalyst. Isobutylene is currently derived from fossil sources and therefore is considered to have a fossil part. The CO₂ emission factor for bioethanol and ETBE are based on the stoichiometric C-contents of 52% for bioethanol (C₂H₆O) and 71% for ETBE. The CO₂ emissions factors for bioethanol and ETBE (C₆H₁₄O). The fossil part of ETBE is considered to be 66.7% and is taken from the fossil carbon content calculation method prepared by Sempos⁴⁷. The calorific value for bioethanol is 27.7MJ/kg is taken from COPERT 5 model and is country-specific. For ETBE it is 36.2MJ/kg which is taken from EMEP/EEA 2023 Guidebook⁴⁸.

FAME is also considered to have a fossil carbon part since fossil derived methanol is used in production. For analysing FAME composition, the fossil diesel fuel samples (since FAME is always blended into fossil diesel) were analysed in gas chromatography in Estonian Environmental Research Centre fuel laboratory. Based on the results the country-specific fossil part of FAME was calculated which is 5.28%. The country-specific calorific value of 37.5 MJ/kg was also calculated based on these results. The results are available upon request⁴⁹.

HVO is also considered 100% bio-origin. For the HVO the average carbon content of 84.8% and calorific value of 44 MJ/kg.⁵⁰

In 2024 the fossil CO₂, CH₄, and N₂O emissions from transportation biofuels totalled 1.84 kt CO₂ eq., constituting 0.02% of Estonia's total GHG emissions.

1.A.3.c Railways

The CO₂ emissions from Railway transportation are calculated using the country-specific carbon emission factors of diesel oil. This emission factor is calculated using the weighted average method using CEFs of countries that Estonia imports fuels from. Emission factors of CH₄, and N₂O are taken from the IPCC 2006 Guidebook. NO_x, CO, and NMVOC for coal from EMEP/EEA Guidebook 2023, and SO₂ EF is country-specific (expert estimation). Emission factors are presented in Table 3.28.

Table 3.28. Emission factors used in the calculation of emissions from Railways

Fuel	GHG	EF	Source
Diesel Oil	CO ₂	19.99 tC/TJ	CS
	CH ₄	4.15 kg/TJ	IPCC 2006, Vol.2, Chapter 3, Table 3.4.1
	N ₂ O	28.6 kg/TJ	IPCC 2006, Vol.2, Chapter 3, Table 3.4.1

⁴⁷ Note on fossil carbon content in biofuels. Ioannis Sempos, 2019

⁴⁸ EMEP/EEA 2023 Guidebook, Part B, 1. Energy, 1.A Combustion, 1.A.3.b.i-iv Road Transport, Table 3-28

⁴⁹ The fossil part of FAME and other parameters used in liquid biofuels is based on development work: Analysis of biofuels in the transport sector. The report is available upon request.

⁵⁰ HYDROTREATED VEGETABLE OIL (HVO) AS A RENEWABLE DIESEL FUEL: TRADE-OFF BETWEEN NO_x, PARTICULATE EMISSION, AND FUEL CONSUMPTION OF A HEAVY DUTY ENGINE. H. AATOLA, M. LARMI, T. SARJOVAARA, 2008

Fuel	GHG	EF	Source
	NO _x	52.4 kg/t	EMEP/EEA Guidebook 2023
	CO	10.7 kg/t	EMEP/EEA Guidebook 2023
	NM VOC	4.65 kg/t	EMEP/EEA Guidebook 2023
	SO ₂	141.2 kg/t	CS
Coal	CO ₂	25.90 tC/TJ	CS
	CH ₄	2 kg/TJ	IPCC 2006, Vol.2, Chapter 3, Table 3.4.1
	N ₂ O	1.5 kg/TJ	IPCC 2006, Vol.2, Chapter 3, Table 3.4.1
	NO _x	173 kg/TJ	EMEP/EEA Guidebook 2023
	CO	931 kg/TJ	EMEP/EEA Guidebook 2023
	NM VOC	88.8 kg/TJ	EMEP/EEA Guidebook 2023
	SO ₂	1028 kg/TJ	CS

CS – country-specific

1.A.3.d Domestic navigation

CO₂ emissions from Domestic navigation are calculated using the country-specific carbon emission factor for diesel oil. This emission factor is calculated with weighted average method using CEFs of countries from which Estonia imports this fuel. CH₄ and N₂O emission factors for diesel oil are taken from the IPCC 2006 guidelines. NO_x, CO, and NM VOC emission factors for diesel oil are taken from the EMEP/EEA Guidebook 2023⁵¹. SO₂ EF is country-specific. All emission factors are presented in Table 3.29.

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

Fuel	GHG	EF	Source
Diesel Oil	CO ₂	19.99 tC/TJ	CS
	CH ₄	7 kg/TJ	IPCC 2006
	N ₂ O	2 kg/TJ	IPCC 2006
	NO _x	9.4 kg/t	EMEP/EEA Guidebook 2023
	CO	573.9 kg/t	EMEP/EEA Guidebook 2023
	NM VOC	181.5 kg/t	EMEP/EEA Guidebook 2023
	SO ₂	141.2 kg/TJ	CS

CS – country-specific

1.A.3.e Other transportation

Carbon emission factors for gasoline and diesel oil for off-road vehicles are presented in Table 3.30. In 2013 Estonia developed country-specific CEF calculation methodology for gasoline, LPG, and diesel oil for Road transport. The CEFs are calculated using weighted average method using CEFs of countries that Estonia imports the fuel from. Since there was no import data for the years 1990–1994, these values are calculated based on 1995–1997 data. All submissions after 1997 are based on these CEFs. The same fuels are also used in Road transport sector.

Table 3.30. Carbon emission factors for fuels used for off-road vehicles, tC/TJ

Year	Gasoline	Diesel
	CEF	CEF
1990	19.50	20.01
2005	19.27	19.95
2021	19.14	19.98
2022	19.22	19.95

⁵¹ EMEP/EEA air pollutant emission inventory guidebook –2023 1.A.3.a. Aviation. [www]
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023> (11.03.2026).

Year	Gasoline	Diesel
	CEF	CEF
2023	19.20	19.91
2024	19.16	19.99

CH₄ emission factors by vehicle type used in calculations are presented in Table 3.31 and N₂O emission factors in Table 3.32.

Table 3.31. CH₄ emission factors used for off-road vehicles, kg/TJ

Year	Gasoline		Diesel						
	Tractors	Other	Tractors	Excavators	Harvesters	Loaders	Forestry	Other	Road work
1990	15.0	28.8	4.3	4.4	3.0	3.6	3.9	3.8	3.2
2005	13.0	24.4	4.0	2.8	1.6	2.4	2.1	2.2	2.6
2021	10.1	24.4	3.2	0.7	0.4	0.6	0.5	0.5	0.9
2022	9.8	24.5	0.9	0.6	0.3	0.6	0.4	0.5	0.9
2023	9.7	24.8	0.9	0.6	0.3	0.6	0.4	0.4	0.9
2024	9.6	24.9	0.9	0.6	0.3	0.6	0.4	0.4	0.9

Table 3.32. N₂O emission factors used for off-road vehicles, kg/TJ

Year	Gasoline		Diesel						
	Tractors	Other	Tractors	Excavators	Harvesters	Loaders	Forestry	Other	Road work
1990	1.3	1.1	3.0	2.9	3.1	3.0	3.0	3.0	3.1
2005	1.4	1.1	3.0	3.2	3.2	3.1	3.2	3.2	3.1
2021	1.4	1.3	2.8	3.2	3.3	3.2	3.3	3.3	3.3
2022	1.4	1.3	3.2	3.2	3.3	3.2	3.3	3.3	3.3
2023	1.4	1.3	3.2	3.2	3.3	3.2	3.3	3.3	3.3
2024	1.4	1.3	3.2	3.2	3.3	3.2	3.3	3.3	3.3

CH₄, N₂O, NO_x, CO, and NMVOC emission are estimated using EMEP/EEA air pollutant inventory guidebook 2023 1.A.4 Non road mobile machinery *Tier 3* methodology. Emissions are estimated for gasoline and diesel separately and for each vehicle type³⁹. Emissions are calculated by using Equation 3.12.

Equation 3.12

$$EF_{pollutant} = AR_{activity} \times EF_{pollutant}$$

Where:

E_{pollutant} = the emission of the specific pollutant;
AR_{activity} = the activity rate;
EF_{pollutant} = the emission factor for this pollutant.

3.2.6.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Transport subcategory, please see Annex A.II.1 Energy, 1.A.3 Transport chapter.

3.2.6.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Chapter 1.5. A complete Quality Assurance (QA) and Quality Control (QC) was carried out in the Transport sector according to the IPCC *Tier 1* method.

COPERT 5 model includes vehicle data and annual mileage per vehicle and is collected from the Estonian Transport Administration and the fuel consumption by Statistics Estonia. A check for fuel and mileage statistics is performed by the inventory compiler and data is adjusted, if necessary. The calculated fuel consumption in COPERT 5 model is compared against the statistical fuel consumption data in Joint Questionnaires. This data is also presented in the SE database³⁰ and added to Annex 3 (A.3.2).

The statistical fuel consumption is fitted into the COPERT 5 model by distributing it between vehicle categories based on annual mileage per vehicle category from odometer readings taken during the annual technical inspection to maintain a balance between calculated and statistical fuel consumption levels as calculated by COPERT 5 model. Meteorological data is provided by Estonian Weather Service.

3.2.6.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

For the 2026 submission the Road transport emissions have been recalculated due to updated activity data and methodological improvements.

For the 2026 submission the Road transport emissions have been recalculated due to updated activity data and methodological improvements. The Estonian Transport Administration provided revised vehicle stock data for 2014–2023. Compared to the dataset previously transmitted to the Estonian Environment Agency under historical arrangements, the updated dataset includes a more detailed split of the vehicle stock. Most notably, heavy-duty vehicles are separated into rigid and articulated categories from 2014 onwards, while in the previous submission this split was applied from 2022 onwards. As a result, the methodological step in the vehicle stock split has shifted to 2013–2014. During the comparison of the datasets it was also confirmed that vehicles with suspended status had been excluded from earlier data deliveries. The inventory continues to apply the same approach when open data are used. The Estonian Transport Administration has noted that the revised historical values are not fully consistent with the datasets used earlier, especially for earlier years, because corrections are introduced into the database without versioning.

In addition, the Road transport calculations were updated due to the use of COPERT 5.9.2 in the 2026 submission. Compared to the version used in the previous submission, recent COPERT updates include, among other changes, a revision of the consumption of light-duty vehicles running on liquid fuels, updated VOC and CH₄ emission factors for diesel light-duty vehicles, and updated emission factors for diesel heavy-duty vehicles and buses. The representation of vehicle technologies was also expanded through the inclusion of battery electric vans and LNG heavy-duty vehicles in earlier years of the time series. These changes were reflected in the recalculated time series.

Table 3.33. Quantitative overview of recalculations compared to the 15.04.2025 submission

Year	Emissions from 1.A.3.b Road transportation, kt CO ₂ eq.		
	2025	2026	difference
1990	2278.43	2278.37	-0.06
1991	2059.48	2059.42	-0.06

Year	Emissions from 1.A.3.b Road transportation, kt CO ₂ eq.		
	2025	2026	difference
1992	1031.87	1031.85	-0.02
1993	1164.12	1164.09	-0.02
1994	1473.11	1473.08	-0.03
1995	1451.57	1451.52	-0.05
1996	1518.33	1518.29	-0.04
1997	1626.78	1626.73	-0.05
1998	1665.31	1665.25	-0.06
1999	1528.98	1528.91	-0.07
2000	1510.71	1510.59	-0.12
2001	1842.24	1842.08	-0.16
2002	1923.48	1923.34	-0.14
2003	1867.72	1867.60	-0.13
2004	1925.61	1925.42	-0.19
2005	1993.18	1992.86	-0.32
2006	2131.90	2131.77	-0.14
2007	2262.67	2262.35	-0.33
2008	2212.78	2212.72	-0.06
2009	2002.85	2002.90	0.05
2010	2086.15	2086.27	0.13
2011	2138.57	2138.76	0.18
2012	2178.22	2179.03	0.81
2013	2143.63	2144.58	0.94
2014	2163.00	2167.59	4.60
2015	2228.35	2234.68	6.34
2016	2293.32	2302.37	9.06
2017	2370.64	2381.02	10.38
2018	2397.85	2410.56	12.71
2019	2350.72	2364.79	14.08
2020	2182.89	2195.98	13.09
2021	2303.21	2319.83	16.61
2022	2371.76	2394.57	22.82
2023	2365.18	2386.21	21.03

3.2.6.6. Category-specific planned improvements, if applicable including tracking of those identified in the review process

Planned improvements for the Road transport (CRT 1.A.3.b) category focus on improving time-series consistency and transparency of the underlying activity data. Estonia will develop a methodology to review and correct historical vehicle stock data for 2013 and earlier. This includes obtaining and documenting explanations from the Estonian Transport Administration for the observed changes in vehicle numbers over time in the database.

In cooperation with the inventory compiler, Statistics Estonia will review the transport fuel quantities reported in the energy balance and the underlying compilation methodology, with the aim of improving year-to-year consistency and transparency of the data. If necessary, Statistics Estonia will introduce methodological adjustments and provide revised fuel time series, which will be implemented in the GHG inventory together with appropriate documentation and explanations in 2027 submission.

3.2.7. Other sectors (1.A.4)

3.2.7.1. Category description

Sub-categories of CRT 1.A.4 includes emissions from the small combustion of fuels in stationary equipment:

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

These sectors cover mainly fuels used in heating commercial, institutional, and agriculture buildings. Off-road vehicles used in 1.A.4.a Commercial/institutional and 1.A.4.c Agriculture/forestry/fisheries sectors are covered under 1.A.3.e Other transportation since 2024 submission.

In 2024 emissions in CRT 1.A.4 Other sectors were 417.96 kt CO₂ eq., about 5.13% of the Energy sector's emissions and 4.08% of total GHG emissions in Estonia. Corresponding emissions in 1990 were 1800.34 kt CO₂ equivalent (see Figure 3.27 and Table 3.34). Fuel consumption in Other sectors in 1990, 2005, and 2021-2024 is presented in Table 3.35.

In the 15th of April 2026 submission, updated activity data for Other sectors (1.A.4) are only partially available. The inventory continues to apply the latest available verified activity data (2023) for selected fuels, including liquid fuels (diesel oil, light fuel oil, residual fuel oil) and biomass fuels (solid biomass). The data will be revised in the 2027 submission once verified information becomes available, together with any necessary time-series consistency updates and explanations.

A more detailed overview of planned improvements is provided in 3.2.7.6

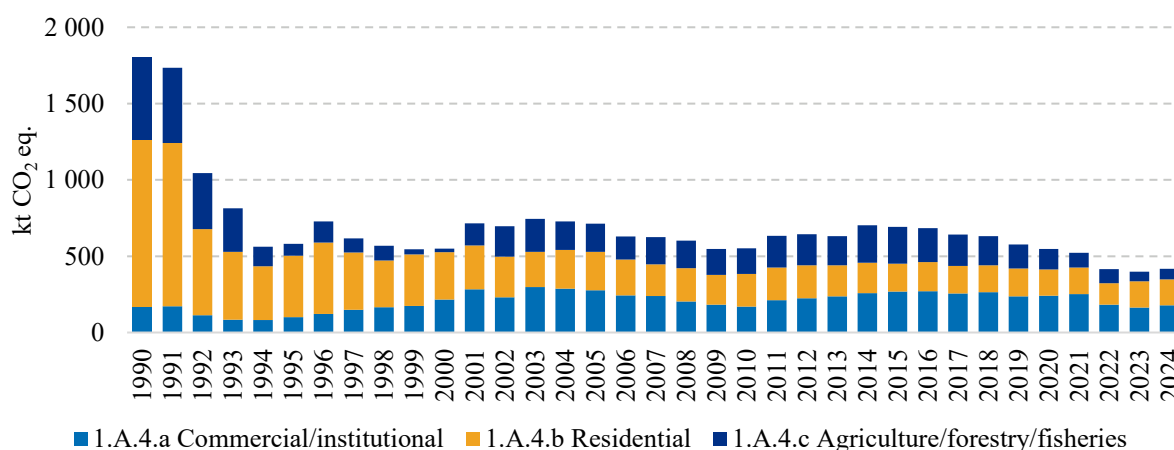


Figure 3.27. Trend of GHG emissions from Other sectors, kt CO₂ eq.

Table 3.34. Emissions from Other sectors by relevant subcategories in 1990, 2005, and 2021-2024, kt CO₂ eq.

Sector	1990	2005	2021	2022	2023	2024
1.A.4 Other sectors Total, CO₂ eq.	1800.34	713.91	522.96	414.62	399.16	417.96
1.A.4.a Commercial/institutional, CO ₂ eq.	172.22	276.62	252.22	182.30	164.32	177.49
1.A.4.b Residential, CO ₂ eq.	1090.14	251.40	174.14	141.42	170.33	169.88
1.A.4.c Agriculture/forestry/fisheries, CO ₂ eq.	537.98	185.89	96.60	90.90	64.50	70.59

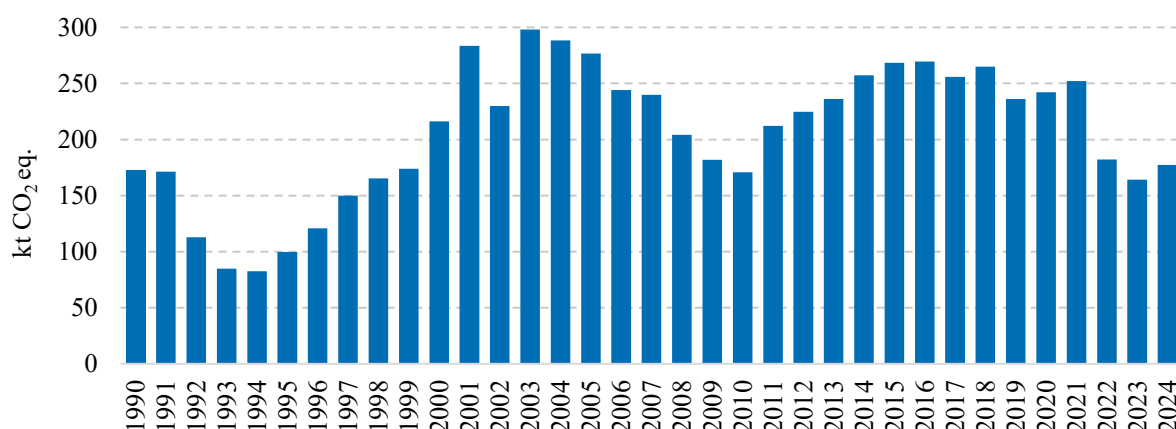
Table 3.35. Fuel consumption in Other sectors in 1990, 2005, and 2021-2024, TJ

Category/activity data	1990	2005	2021	2022	2023	2024
1.A.4 Other Total, TJ.	29 453	23 140	25 341	24 224	22 117	22 429
Liquid fuels, TJ	12 053	4 476	2 222	2 212	2 213	2 258
Solid fuels, TJ	3 749	1 086	80	NO	30	17
Gaseous fuels, TJ	2 786	4 089	5 986	4 095	3 997	4 348
Peat, TJ	3 264	227	NO	41	NO	NO
Biomass, TJ	7 601	13 263	17 053	17 875	15 877	15 806

1.A.4.a Commercial/institutional

GHG emissions from CRT 1.A.4.a Commercial and institutional sub-sector include 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.

The decreasing trend of GHG emissions in Commercial/institutional at the beginning of the 90s (from 1992 up to 1994) reflects the general economic development trend after regaining independence in 1991 (Figure 3.28). The increase of emission trend in 2001 is connected to a large growth of some sub-sectors like financial intermediation, real estate, hotels, and restaurants, etc. The faster decrease in 2006 was caused by structural changes in the use of wood fuels which increased about 16.2% and liquid fuels which decreased about 29.6%. From 2007 to 2010 the economic crisis showed a downwards trend in GHG emissions. In 2022, emissions decreased compared to 2021, largely due to the energy crisis and high natural gas prices, which led to lower natural gas consumption. In 2023 the GHG emissions decreased 5.62 %, compared to previous year, being 164.32 kt CO₂ eq. as natural gas consumption decreased significantly due to high prices. In 2024 emissions increased by 8.0% to 177.49 kt CO₂ eq., caused mainly by overall increase in fuel consumption due to lower prices.

**Figure 3.28.** Trend of GHG emissions from Commercial and institutional sector, kt CO₂ eq.

1.A.4.b Residential

The category 1.A.4.b Residential sub-sector includes GHG emissions from fuel combustion in households. Emissions from other miscellaneous mobile equipment (ATV-s, forklifts, cranes, etc) are reported in Chapter 1.A.3.e Other transportation. The overall trend of GHG emissions have generally declined in recent years, closely following trends in the sector's fuel consumption and a slight decrease was observed in the most recent year. The decreasing trend is a consequence of energy efficiency and saving measures, renovation, and building more new energy efficient houses, weather conditions, etc (Figure 3.29). Foremost, the decrease shows a

relevant change in the fuel consumption structure in the Residential sector. Consumption of fuel oils decreased rapidly after 1991, but consumption of wood fuels has been increasing since 1990 and increased in 2024 more than three times in comparison with 1990/1991 (Figure 3.33). In 2024 the emissions in Residential sector were 169.88 kt CO₂ eq. which is about 0.27% decrease compared to the previous year. LPG consumption and gasoline consumption decreased as changes in household energy use in 2024.

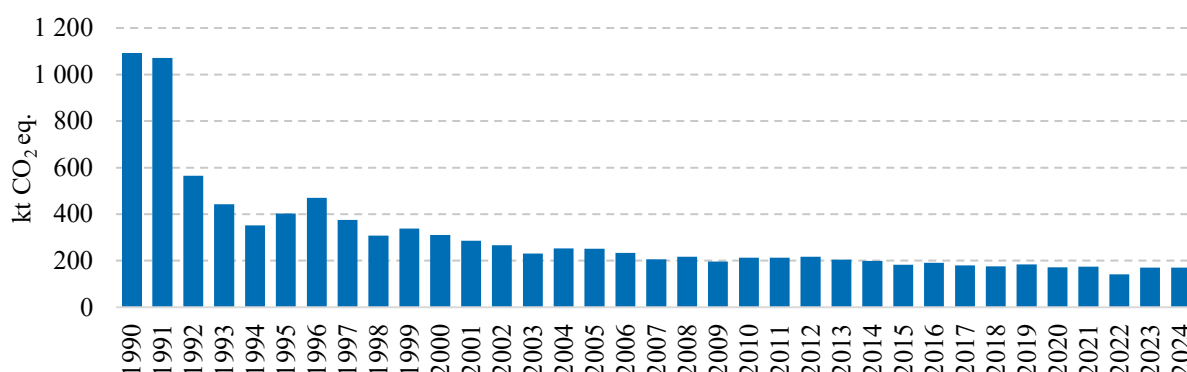


Figure 3.29. Trend of GHG emissions from Residential sector, kt CO₂ eq.

1.A.4.c Agriculture/forestry/fishing

Under category 1.A.4.c Agriculture/forestry/fisheries GHG emissions from stationary fuel combustion are reported. Emissions from mobile sources include tractors, harvesters, and forestry machines and are reported in Chapter 1.A.3.e Other transportation. The trend of GHG emissions follows the fuel consumption trend and reflects the development trend in the sector. The number of farms decreased since 1994 drastically and reached a bottom in 1999 as well as the agricultural production decreased. Since 2002 the production in agriculture stabilized and small fluctuations in different years is explained mainly with different weather conditions (Figure 3.30). The increase in emissions and use of fuels in 2011 is explained by the growth in the production of agricultural products. In 2012 and 2013 the emissions stayed about the same level as in 2011.

In 2014 a rise in emissions occurred, about 28,9% compared to the previous year. This was related to an increase in diesel consumption. In 2016 emissions fell 7.8% compared to the previous year mainly due to the falling consumption of light fuel oil and the same trend continued until 2020 when the GHG emissions decreased 14.7% compared to 2019. In 2021 emissions decreased about 28.3% compared to previous year as production in agriculture sector decreased (decrease in farm animals, and large-scale price increase of production inputs). In 2024 the emissions in agricultural sector were 70.59 kt CO₂ eq. which is about 9.4% increase compared to the previous year as the sector stabilized.

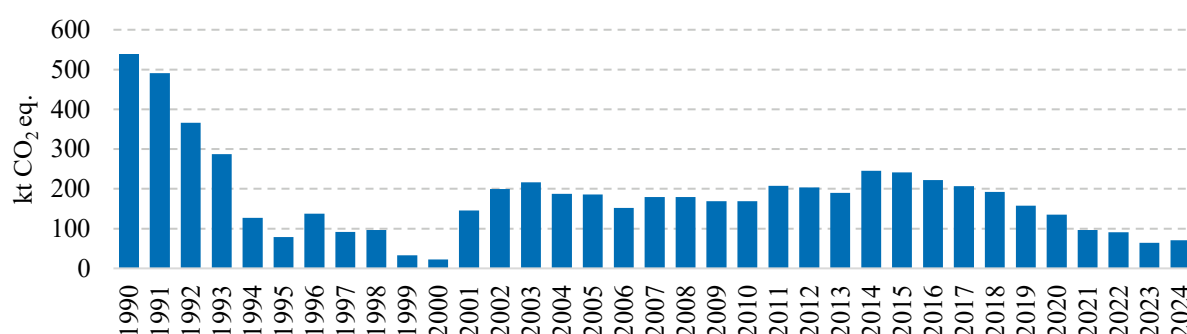


Figure 3.30. Trend of GHG emissions from Agriculture/forestry/fisheries sector, kt CO₂ eq.

3.2.7.2. Methodological issues

Choice of methods

CO₂ emissions from 1.A.4.a Other sectors are estimated using the IPCC 2006 *Tier 2* methodology. The emissions of CO₂ is calculated on basis of combusted fuels and their carbon content. *Tier 2* calculates CO₂ emissions by multiplying the estimated fuel sold times a country-specific emission factor.

For CH₄ and N₂O emission calculations country-specific and IPCC 2006 default emission factors are used (Table 3.37).

Activity data

In the 15th of April 2026 submission, updated activity data for Other sectors (1.A.4) are only partially available. The inventory continues to apply the latest available verified activity data (2023) for selected fuels, including liquid fuels (diesel oil, light fuel oil, residual fuel oil) and biomass fuels (solid biomass). The data will be revised in the 2027 submission once verified information becomes available, together with any necessary time-series consistency updates and explanations.

The activity data is taken from Joint Questionnaire (JQ) dataset made by Statistics Estonia (also sent to IEA and Eurostat). It covers fuels used in Commercial/institutional, Residential, and Agricultural/forestry/fisheries sectors. Statistics Estonia gathers data from energy and fuel producers and consumers. In the case of energy consumers, sampling questionnaire is used. The general assembly of participants includes economically active companies/organisations. Furthermore, companies with at least 50 employees are questioned; a random selection is made from smaller companies. There are separate questions for liquid fuel consumption in road, water, air, and rail transport, other use (industrial production, construction works, etc.), and consumed fuel on the territory of the company (e.g. in agriculture on the fields, in greenhouses, etc.). The fuel for other uses is observed through EMTAK (The Estonian Classification of Economic Activities) categories. This data is also presented in the SE database²⁶⁰ and added to Annex III.

The fuel consumption data by main fuel groups is presented in Figure 3.31.

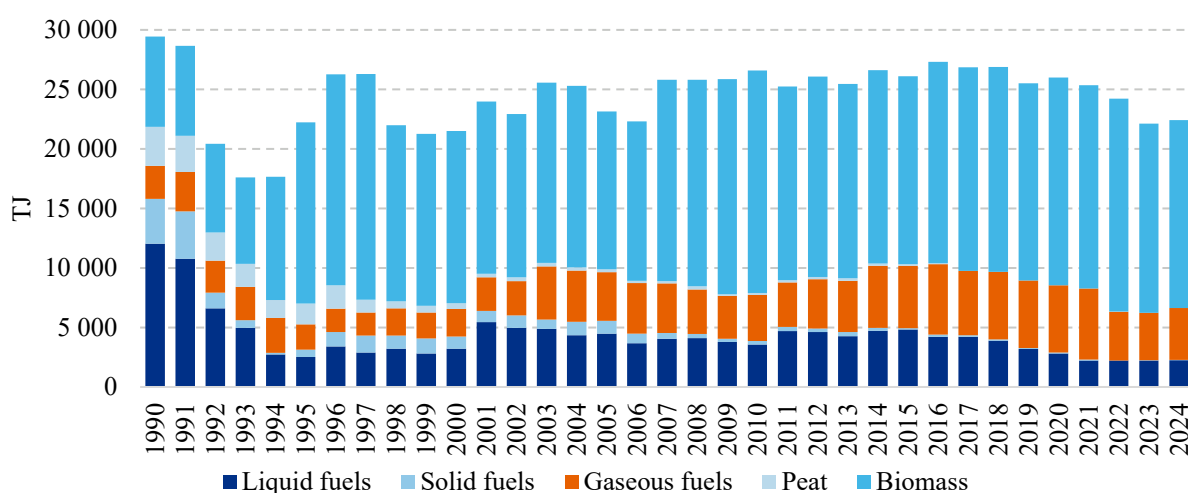


Figure 3.31. Fuel consumption in CRT 1.A.4 Other sectors, TJ

The trend of fuel consumption in Commercial/institutional sector shows a big increase of natural gas use since 2002 as the construction boom started in Estonia. Many new logistics

buildings and hypermarkets (using gas heating) were built. Consumption of other fuels: liquid, solid, and biomass fuels was steady, some fluctuations are in the liquid fuel consumption trend in 1992, 2001, and 2002. The decrease of fuel consumption in 2009/2010 corresponds to the consequence of economic recession and increase from 2011 the upturn of economy. In 2022 natural gas consumption decreased significantly due to high prices (Figure 3.32). In 2023 natural gas consumption decrease continued, although the price of gas was lower compared to the previous year. This is mostly related to the special permits received in 2022 to burn residual fuel oil in heating plants instead of natural gas. Residual fuel consumption increased more than 15 times from 16.5 TJ to 284.9 TJ. In 2024, fuel consumption increased compared to 2023, driven partly by an increase in natural gas, which contributed to the overall rise in energy use in the sector. This increase was driven by lower fuel prices in 2024, which led to higher consumption.

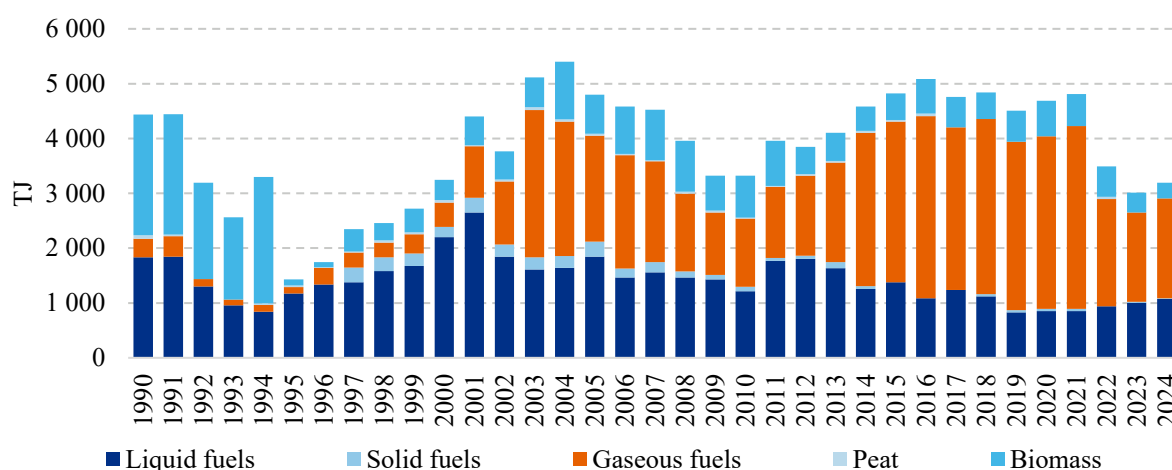


Figure 3.32. Fuel consumption in Commercial/institutional sector, TJ

Figure 3.33 presents the fuel consumption in Residential sector. The most defining fuel is biomass (used for space heating). The major increase of biomass is most likely caused by the methodologies used to estimate household fuel use in the post-controlled economy in Estonia, as great changes were 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 relates to the methodology change of the Statistics Estonia and decreases in 2005/2006 with warm winters. Since 2007 the use of biofuels in residential sector has been slightly increasing. Considering the warmer-than-average winter, the use of biomass in households for heating decreased in 2011 compared to 2010. In recent years, fuel consumption in the Residential sector has stayed on a stable level with solid fuels being substituted with liquid fuels and biomass. Biomass use increased and natural gas consumption decreased significantly due to high natural gas prices in 2022. In 2023 natural gas consumption increased to levels similar to the period before 2022 energy crises in Europe. At the same time biomass consumption decreased, which can be explained by switching back to natural gas as more convenient source of heat, compared to biomass heating, as natural gas prices normalized. Overall decrease in 2023 fuel consumption in the sector was influenced by warmer than usual winter months, with January being the warmest and 2° C warmer than long-term norm. Another reason could be the result of wider adoption and usage of heat pumps, which was supported by reconstruction grant for small households, which was opened in second half of 2022. In 2024 there was an increase use of gaseous fuels by 6.83% due to lower gas prices.

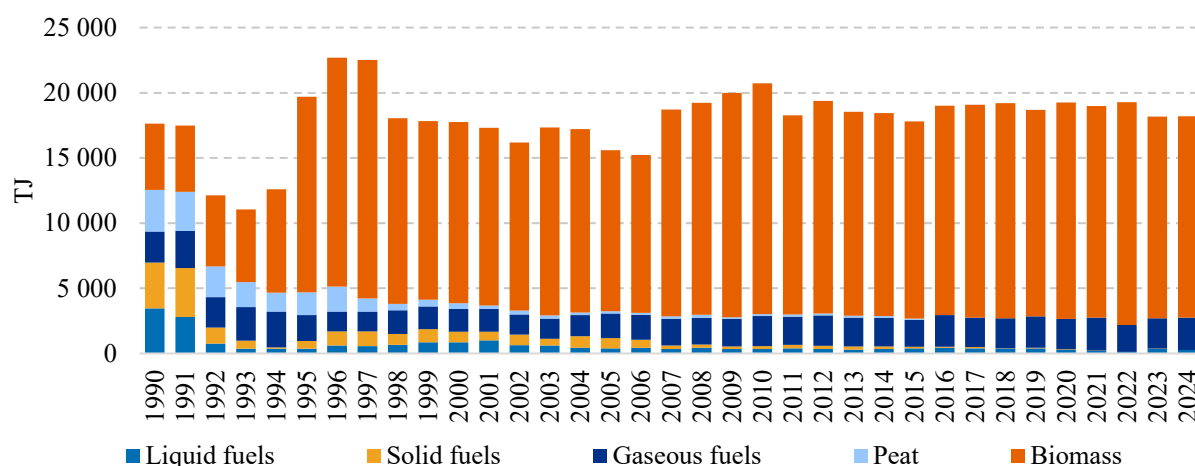


Figure 3.33. Fuel consumption in Residential sector, TJ

Figure 3.34 presents the fuel consumption trend of the Agriculture/forestry/fisheries sector. The largest fuel group in agriculture is liquid fuels, other fuel groups have smaller shares. The liquid fuels use decreased since 1990 up to 1995 almost 85%, mostly due to the decreasing of the agricultural production caused by the structural changes in the economy after Estonia became independent in 1991. After 2000 the agricultural production started to increase, bringing on the increase of liquid fuel consumption. Fuel consumption has been quite stable through the years 2005–2010. Due to the growth in the 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 2011–2013 stability, in 2014 the fuel consumption grew about 27.8% next to 2013. In 2019 fuel consumption decreased by 18.3% and in 2020 11.6% compared to the respective previous year mainly because of decreased use of diesel oil. In 2021 fuel consumption decreased about 24.5% because of decreased production in Agriculture sector and the same trend continued to 2022, with fuel consumption decreasing by 5.63%. Downtrend in gas oil consumption continued in 2023 – consumption was 29.11 % lower than previous year, because fertilizer use and overall crop yields fell in 2023, compared to 2022. In 2024, LPG and gasoline consumption increased compared to 2023. The increase is consistent with higher use of these fuels in agricultural and other off-road activities.

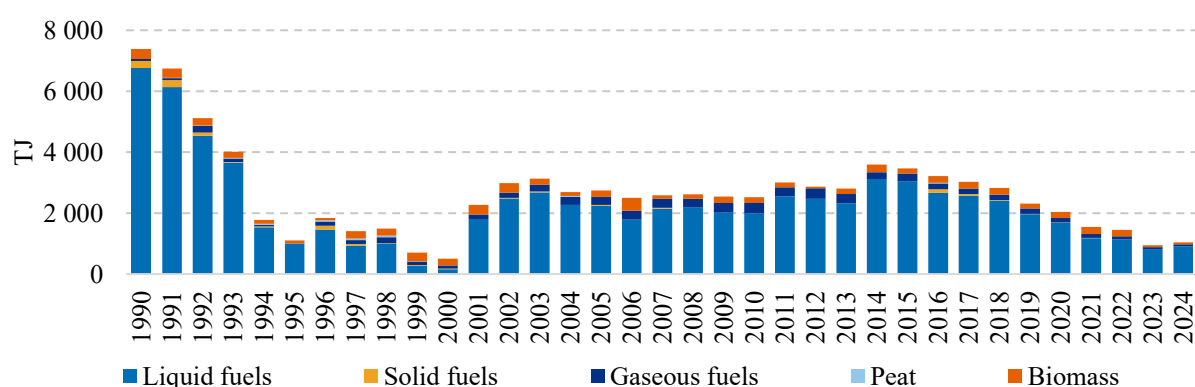


Figure 3.34. Fuel consumption in Agriculture/forestry/fisheries sector, TJ

Emission factors

Both IPCC default and country-specific emission factors are used. Estonia uses the country-specific weighted average CEFs for LPG, light fuel oil, diesel oil, gasoline, residual fuel oil, and coal, and IPCC 2006 default emission factors for solid biomass to calculate CO₂ emissions.

For CH₄ and N₂O emission calculations country-specific and IPCC 2006 default emission factors are used (Table 3.36).

In 2023 a project (2020-2023) on developing country-specific factors for heating appliances in households in 1.A.4.b Residential sector was finalized, and Estonia has now developed country-specific CH₄ and N₂O emissions factors for solid biomass in 1.A.4.b Residential sector.

Table 3.36. CH₄ and N₂O emission factors for stationary combustion in 1.A.4 by subsector and fuel, kg/TJ

Fuel	Sector	CH ₄	N ₂ O	Source
Natural gas	1.A.4.a	1.25	0.11	CS ²⁹
	1.A.4.b	5	0.1	IPCC 2006
	1.A.4.c	1.00	0.12	CS ²⁹
Biogases	1.A.4.a	1.75	0.11	CS ²⁹
	1.A.4.c	5	0.10	CS ²⁹
Light fuel oil, residual fuel oil	1.A.4.a	9.38	0.57	CS ²⁹
	1.A.4.b	10	0.6	IPCC 2006
	1.A.4.c	8.16	0.52	CS ²⁹
Diesel oil	1.A.4.b	10	0.6	IPCC 2006
Gasoline	1.A.4.a	3	0.6	IPCC 2006
	1.A.4.b	10	2	IPCC 2006
	1.A.4.c	10	0.6	IPCC 2006
LPG	1.A.4.a, 1.A.4.b, 1.A.4.c	5	0.1	IPCC 2006
Coal	1.A.4.a	10	1.5	IPCC 2006
	1.A.4.b, 1.A.4.c	300	1.5	IPCC 2006
Milled&sod peat, peat briquette	1.A.4.a	6.69	1.82	CS ²⁹
	1.A.4.b, 1.A.4.c	300	1.4	IPCC 2006
Solid biomass	1.A.4.a	69.23	1.08	CS ²⁹
	1.A.4.b	29.64	1.12	CS ²⁹
	1.A.4.c	177.12	2.45	CS ²⁹

CS – country-specific

3.2.7.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Energy industries subcategory, please see Annex A.II.1 Energy, 1.A.4 Other sectors chapter.

3.2.7.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Chapter 1.5. A complete Quality Assurance (QA) and Quality Control (QC) was carried out for 1.A.4 Other sectors according to the IPCC *Tier 1* method. The same QA/QC procedures are used as in 1.A.1 and 1.A.2 categories as described in Chapter 3.2.4.4 and Chapter 3.2.5.4.

3.2.7.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

There were no category-specific recalculations.

3.2.7.6. Category-specific planned improvements, if applicable including tracking of those identified in the review process

In cooperation with the inventory compiler, Statistics Estonia will review the manufacturing industries and construction fuel quantities reported in the energy balance and the underlying compilation methodology, with the aim of improving year-to-year consistency and transparency of the data. If necessary, Statistics Estonia will introduce methodological adjustments and provide revised fuel time series, which will be implemented in the GHG inventory together with appropriate documentation and explanations in 2027 submission.

3.2.8. Other (1.A.5)

3.2.8.1. Category description

No emissions are reported under category 1.A.5 Other.

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

3.3.1. Solid Fuels (1.B.1)

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

Unlike coal mines, there are no fugitive emissions (CO₂ and CH₄) from oil shale mines, because methane is non-existent in Estonian oil shale (see Explanation Letter from the Department of Mining of Tallinn University of Technology in Annex V.1.1).

3.3.2 Oil and Natural Gas and other emissions from energy production (1.B.2)

3.3.2.1. Category description (e.g. characteristics of sources)

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

Estonia reports CO₂ and CH₄ emissions from natural gas venting, transmission, and distribution, which are reported in following sub-sectors in CRT 1.B.2 Oil and Natural gas sector:

- 1.B.2.c.i Venting
- 1.B.2.b.iv Transmission and storage
- 1.B.2.b.v Distribution

Reported emissions, calculation methods, and type of emission factors for the subcategory Fugitive Emissions in the Estonian GHG inventory can be found in Table 3.37.

Table 3.37. Reported emissions, calculation methods, and type of emission factors

CRT	Source	Emissions	Method	Emission factor
1.B.2.c.i	Venting	CO ₂	T1	D
		CH ₄		
1.B.2.b.iv	Transmission and storage	CO ₂	T1	D
		CH ₄		
1.B.2.b.v	Distribution	CO ₂	T1	D
		CH ₄		

T1 – Tier 1 method, D – IPCC 2006 default

In 2024 fugitive emissions from oil and natural gas were 18.33 kt CO₂ eq, of which CO₂ is 0.02 kt and CH₄ 18.30 kt CO₂ eq. It is about 0.23% of the Energy sector's emissions and 0.18% of total GHG emissions in Estonia. Corresponding emissions were 71.73 kt CO₂ eq. in 1990.

1.B.2.a Oil

The fugitive emissions from oil distribution are not estimated, as no valid methodology for calculations is currently available.

1.B.2.b Natural gas

Historically natural gas was imported into Estonia from Russia and the Inčukalns underground gas storage in Latvia. AS Eesti Gaas has two gas metering stations on the border of Estonia (in Värskas and Karksi) which measure the imported gas volumes. In 29.09.2022 Estonian Government decided to sanction Russian gas imports, but the enforcement date was 31.12.2022. From 2024 Estonia imports its natural gas via pipeline connections with Finland and Latvia. In 2024 imports of Russian-origin LNG were still legal for to an end-user's own storage facilities or use in the processing industry under applicable restrictions. Most of the natural gas in 2024 originated from the United States and the second biggest supplier was Norway (Table 3.38).

Table 3.38. Imported natural gas amounts in 2024 by country

	Natural gas (TJ)
European Union	58
Finland	699
Germany	22
Latvia	2
Lithuania	477
Norway	15 030
Poland	3
Russia	287
United States	17 765

In 2020 a new pipeline Balticconnector was opened between Estonia and Finland with a new gas metering and compression station in Paldiski, and a compression station in Kiili, allowing two-way natural gas movement. Gas is distributed to customers through gas pipelines, distribution stations, and gas pressure reducing stations.

Figure 3.35 presents the map of the natural gas distribution network in Estonia.

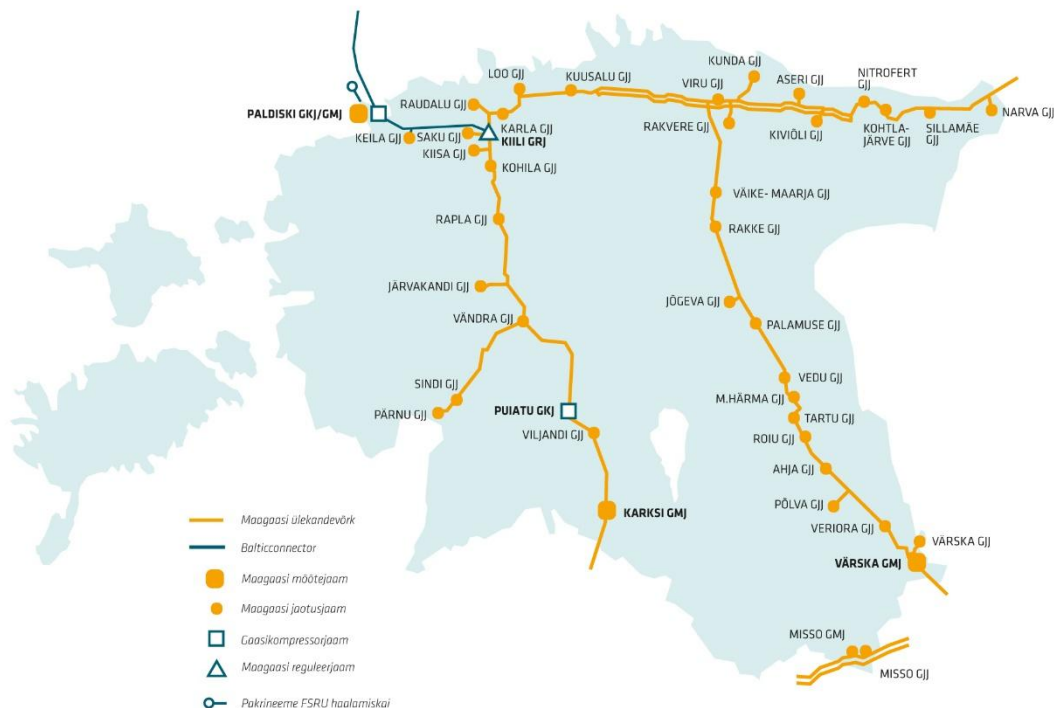


Figure 3.35. Natural gas distribution network in Estonia

Natural gas inland consumption increased about 18.13% in 2024 compared to 2023, due to lower prices (compared to longer term averages), higher economic activity, colder weather and fuel switching (Table 3.39).

Table 3.39. Natural gas consumption in 1990, 2005, and 2021-2024, TJ

Activity Data	1990	2005	2021	2022	2023	2024
Natural gas consumption, TJ	51 174	33 481	16 575	12 280	10 686	12 623

Table 3.40 shows CO₂ and CH₄ emissions from natural gas transmission, and Table 3.41 from natural gas distribution.

Table 3.40. CO₂ and CH₄ emissions from natural gas transmission in 1990, 2005, and 2021-2024

Sector	1990	2005	2021	2022	2023	2024
Natural gas transmission total, kt CO ₂ eq.	8.21	5.32	2.67	1.97	1.76	2.10
Natural gas transmission CO ₂ , kt	0.002	0.001	0.001	0.0004	0.0003	0.0004
Natural gas transmission CH ₄ , kt	0.29	0.19	0.10	0.07	0.06	0.07

Table 3.41. CO₂ and CH₄ emissions from natural gas distribution in 1990, 2005, and 2021-2024

Sector	1990	2005	2021	2022	2023	2024
Natural gas distribution total, kt CO ₂ eq.	54.51	35.33	17.69	13.08	11.68	13.93
Natural gas distribution CO ₂ , kt	0.09	0.06	0.03	0.02	0.02	0.02
Natural gas distribution CH ₄ , kt	1.94	1.26	0.63	0.47	0.42	0.50

1.B.2.c Venting and flaring

Table 3.42 shows CO₂ and CH₄ emissions from natural gas venting.

Table 3.42. CO₂ and CH₄ emissions from natural gas venting in 1990, 2005, and 2021-2024

Sector	1990	2005	2021	2022	2023	2024
Natural gas venting total, kt CO ₂ eq.	9.01	5.84	2.92	2.16	1.93	2.30
Natural gas venting CO ₂ , kt	0.01	0.004	0.002	0.001	0.001	0.001
Natural gas venting CH ₄ , kt	0.32	0.21	0.10	0.08	0.07	0.08

3.3.2.2. Methodological issues

Choice of methods

The calculation of CH₄ emissions from oil and gas activities is presented in Equation 3.13:

Equation 3.13⁵²

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

Where:

Emissions = CH₄ 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 category CRT 1.B.2 is taken from the Joint Questionnaire dataset made by Statistics Estonia.

Emission factors

CO₂ and CH₄ emission factors for calculating natural gas venting, transmission and distribution emissions are taken from the IPCC 2006 Guidelines (developed countries and economies in transition).

There were two new gas compression stations added to the system in 2020. This does not affect the emission factors since the new compressors are of the same type as the previous compressors (centrifugal compressors) according to which the emission factors are used. Therefore, the emission factors remain the same.

Emissions from natural gas storage are not occurring since there are no natural gas storage facilities in Estonia. Estonia uses storage facilities located in Latvia.

3.3.2.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Energy industries subcategory, please see Annex A.II.1 Energy, 1.B.2 Oil and Natural Gas and other emissions from energy production chapter.

3.3.2.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Chapter 1.5. A complete Quality Assurance (QA) and Quality Control (QC)

⁵² IPCC 2006 Guidelines, Volume 2, Chapter 2; Stationary Combustion, page 2.11, equation 2.1.

was carried out for 1.B.2 Oil and Natural Gas and other emissions from energy production according to the IPCC *Tier 1* method. The same QA/QC procedures are used as in 1.A.1 category as described in Chapter 3.2.4.4.

3.3.2.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

There were no category-specific recalculations.

3.3.2.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

There are no category-specific improvements planned.

3.4. Carbon dioxide transport and storage (CRT 1.C)

Up to 2024 no CO₂ transport and storage has been used in Estonia.

4. INDUSTRIAL PROCESSES AND PRODUCT USE (CRT SECTOR 2)

4.1. Overview of the sector (e.g., quantitative overview and description, including trends and methodological tiers by category) and background information

Greenhouse gas emissions from the Industrial processes and product use sector contributed 2.524 % the total anthropogenic greenhouse gas emissions in 2024 (Figure 4.1), totalling 257.66 kt CO₂ eq. with indirect CO₂ and 235.82 kt CO₂ eq. without indirect CO₂. Indirect CO₂ emissions in the sector is 21.85 kt CO₂ eq.

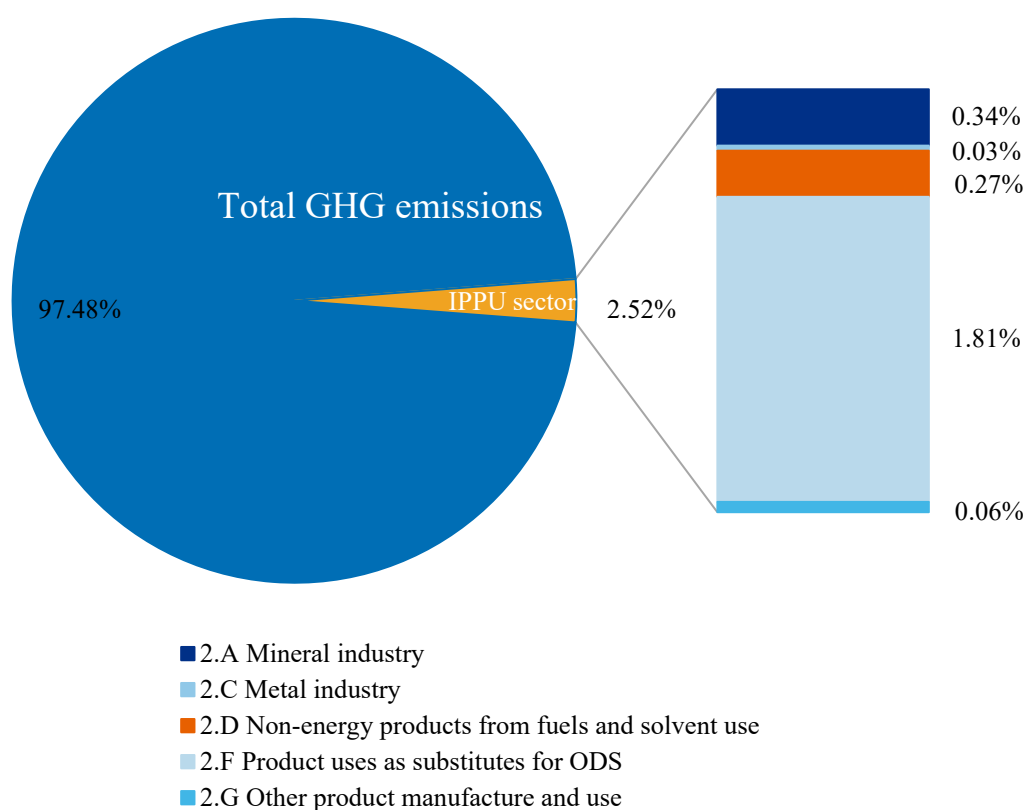


Figure 4.1. Emissions from Industrial processes and product use compared with total emissions in 2024, %

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

- Mineral industry (CRT 2.A) including CO₂ emissions from cement (historical data), lime and glass production, other process uses of carbonates (ceramics);
- Historical chemical industry's emissions (CRT 2.B) – CO₂ emissions from ammonia production;
- Metal industry (CRT 2.C) including CO₂ emissions from secondary lead production (aggregated with CO₂ emissions from soda ash used by rare metals and rare earth metal industry);

- Non-energy products from fuels and solvent use (CRT 2.D) including CO₂ emissions from use of 1) lubricants 2) paraffin waxes and 3) urea-based catalysts for motor vehicles, NMVOC emissions from solvent use and road paving with asphalt;
- Products used as substitutes for ODS (CRT 2.F) including HFC emissions from refrigeration and air conditioning, foam blowing agents, fire protection and aerosols.
- Other product manufacture and use (CRT 2.G) including SF₆ emissions from electrical equipment, SF₆ and PFC emissions from other product use and N₂O emissions from product uses;
- Other (CRT 2.H) including NO_x, CO, NMVOC and SO₂ emissions from pulp and paper and NMVOC emissions from food and beverages;
- Indirect CO₂ emissions calculated from NMVOC emissions from CRT 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 1990-2024

GHG SOURCE AND SINK CATEGORIES	Method applied/EF used				
	CO ₂	HFCs	N ₂ O	SF ₆	Indirect CO ₂
2.A.1 Cement production (historically)	T2/PS				
2.A.2 Lime production	T1,T2/D,PS				
2.A.3 Glass production	T1,T3/D,PS				
2.A.4 Other process uses of carbonates	T1,T2/D,PS				
2.B.1 Ammonia production (historically)	T3/PS				
2.C.5 Lead production	T3/PS				
2.D.1 Lubricant use	T1/D				
2.D.2 Paraffin wax use	T1/D				
2.D.3 Other (Urea based catalysts for motor vehicles)	T2/D				
2.D.3 Solvent use					T1/D
2.D.3 Road paving with asphalt					T1/D
2.F.1 Refrigeration and air conditioning		T2/CS			
2.F.2 Foam blowing agents		T2/CS			
2.F.3 Fire protection		T2/CS			
2.F.4 Aerosols		T2/CS			
2.G.1 Electrical equipment				T3/CS	
2.G.2 SF ₆ and PFCs from other product use				T2,T3/CS	
2.G.3 N ₂ O from product uses			T2/CS		

T1 – Tier 1 method, T2 – Tier 2 method, T3 – Tier 3 method, D – IPCC default, PS – plant specific, CS – country-specific

Compared to 2023, the emissions from the Industrial processes and product use sector (with indirect CO₂) decreased by 2.87 % in 2024.

Regarding chemical industry (2.B)–ammonia production has completely ceased since 2014 and the company has announced that it has sold all production equipment and no longer plans to continue with ammonia production.

Industrial CO₂ emissions have fluctuated strongly since 1990 (Figure 4.2 and Table 4.2) reaching its lowest level in 2024. 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 the years 1991 and 1993. In 1994, the economy began to recover, and production increased. Since 1995 F-gas emissions have significantly increased. The decrease in CO₂ 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 CO₂ emissions in 2007 was mainly caused by a rise in cement production, as the only cement factory renovated its third kiln. In 2009, the industrial processes sector was affected by the global economic recession. The decline in production was mainly due to insufficient demand on both the domestic and external markets. The increase in 2011 emissions was attributable to rising cement production. CO₂ emissions grew in 2012 and 2013, because a power plant used large quantities of limestone for flue gas desulphurisation. Decrease in mineral industry output was the main driver in overall decrease of industrial CO₂ emissions from 2014 to 2016. Decrease in 2020 was caused by the closure of clinker production in the only cement plant in Estonia in March 2020. Decrease in 2022 was mainly due to decreased lime production caused by higher prices of natural gas. Following decrease in 2023 and 2024 was due to the decrease in the usage of HFCs. The biggest decrease was in the commercial refrigeration sector because there was less F-gas in total in the 15-year-old equipment (installed in 2008 and 2009) that was decommissioned in 2023 and in 2024. The other factor is that environmentally friendly alternatives are used instead of F-gases in the commercial sector.

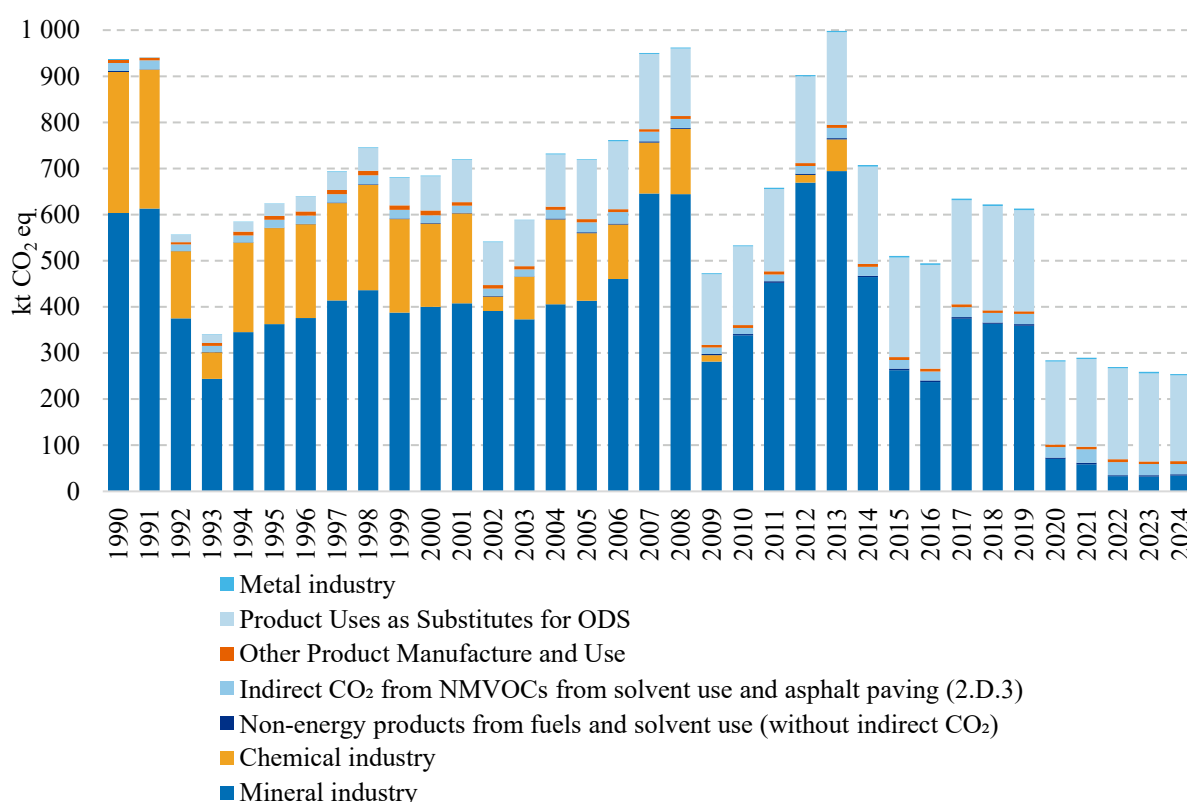


Figure 4.2. Emissions from Industrial processes and product use in 1990–2024 (with indirect CO₂), kt CO₂ eq.

Table 4.2. Trends in the greenhouse gas emissions from Industrial processes and product use in 1990–2024, kt CO₂ equivalent

	1990	2005	2021	2022	2023	2024
Mineral industry	603.1	413.6	58.8	32.6	32.2	34.3
Chemical industry	307.7	146.4	NO	NO	NO	NO
Metal industry	0.8	1.5	3.0	2.7	3.0	3.1
Non-energy products from fuels and solvent use (without indirect CO ₂)	17.4	5.1	7.9	8.3	9.3	6.3
Indirect CO ₂ from solvent use and road paving with asphalt	18.5	21.9	29.3	28.0	23.9	21.9
Other product manufacture and use (from N ₂ O use)	4.9	6.0	2.4	3.1	2.8	2.8
HFCs	NO*	128.2	190.2	197.1	190.9	185.9
PFCs	NO**	NO	NO	NO	NO	NO
SF₆	NO***	1.1	3.1	3.1	3.2	3.5
Total (with indirect CO₂)	952.4	723.7	294.6	274.9	265.2	257.7
Total (without indirect CO₂)	933.8	701.8	265.3	246.9	241.3	235.8

*The use of HFCs started in 1992 in Estonia

**The use of PFCs took place in 2006–2008 in Estonia

***The use of SF₆ started in 1991 in Estonia

4.2. Mineral industry (CRT 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;
 - Emissions that previously were reported under subcategory 2.A.4.b Other uses of soda ash have been relocated to 2.C.5 Lead production and recalculated.
 - Other (2.A.4.d) – use of limestone for flue gas desulphurisation at power plant until 2017.

CO₂ emissions from the Mineral industry have fluctuated since 1990 (Figure 4.3 and Table 4.3) decreased in 1993, 2009–2010, 2015–2016 and continued to decrease in 2020–2023. In 2024 emissions increased by 6.7 % compared to 2023 due to use of urea in scrubbing in one power plant. The decrease in the emissions during the early 1990s was caused by the transition from a planned economy to market economy after 1991 when Estonia became independent. This led to a decrease in industrial production and to an overall decrease in emissions from the Mineral industry between 1991 and 1993. In 1994, the economy began to recover, and production increased.

The increase in the mineral industry during 2007–2008, 2010–2011 and 2017 is attributable to an increase in cement production. In 2009, the Mineral industry sector was affected by economic recession. The decrease in 2015–2016 was mainly caused by insufficient demand in cement markets. In 2017, the output of cement industry recovered, and emissions were higher. In 2020 emissions decreased sharply as in March 2020 clinker production was ceased. The wet

process technology was causing high CO₂ emissions and as the CO₂ quota prices started to rise, cement production using previously mentioned technology was not economically feasible anymore.

CO₂ emissions increased in 2012 and 2013 as a power plant used limestone for flue gas desulphurisation. Since 2014 they have been using novel integrated desulphurisation (NID), which uses lime as a reagent. From the year 2014, the use of limestone for flue gas desulphurisation has decreased every year and the last power plant ceased its use in 2017.

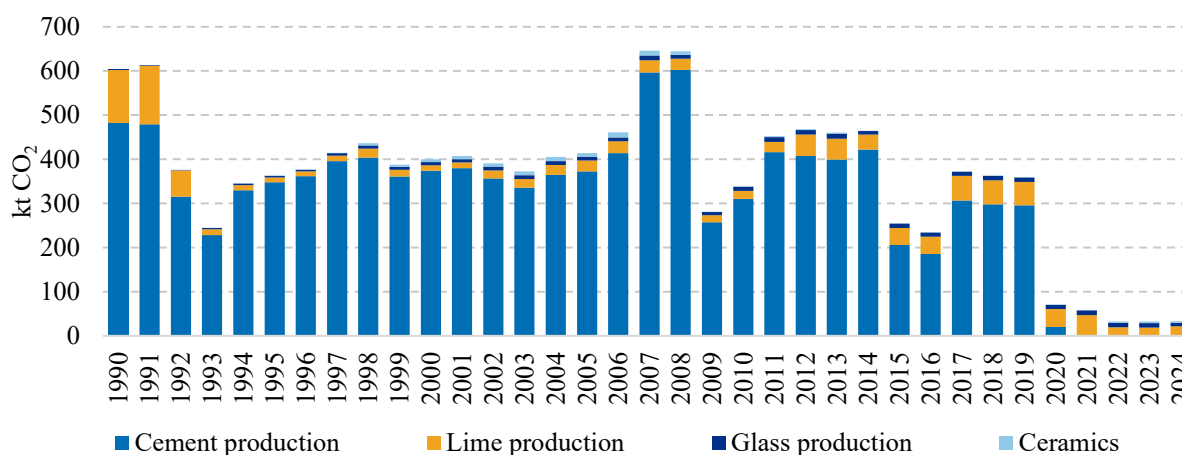


Figure 4.3. CO₂ emissions from Mineral industry in 1990–2024, kt

Table 4.3. CO₂ emissions from Mineral industry in 1990–2024, kt

	1990	2005	2021	2022	2023	2024
2.A.1 Cement production	483.0	372.9	NO	NO	NO	NO
2.A.2 Lime production	118.8	24.1	46.8	19.3	18.8	21.6
2.A.3 Glass production	1.2	8.1	11.1	10.2	9.9	8.0
2.A.4.a Ceramics	NA	8.5	1.0	3.2	3.6	3.8
2.A.4.b Soda ash use	NO	IE ⁵³	IE	IE	IE	IE
2.A.4.d Other	NO	NO	NO	NO	NO	0.92
Total	603.1	413.6	58.8	32.6	32.2	34.3

4.2.1. Category description

2.A.1 Cement production⁵⁴

In cement production, CO₂ 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 and calcinates into calcium oxide and carbon dioxide. Limestone contains small amounts of magnesium carbonate (MgCO₃), which will also calcinate in the process causing CO₂ emissions.

In Estonia, there was only one plant producing clinker and cement until March 2020. Clinker production with wet process was not economically feasible anymore as EU ETS CO₂ price rose rapidly in 2019 and in 2020, therefore clinker production was ceased.

In previous years clinker burning process took place in rotary kilns. Dust caught with rotary kilns electric filters was partly directed into a kiln and partly into dust silo. Oil shale, coal and refuse-derived fuels were the most important fuels in the production process.

⁵³ All emissions previously reported under 2.A.4.b are included into emissions reported under 2.C.5 from 2005

⁵⁴ Historical category

SO₂ emissions from cement production were also reported in the CRT and were calculated by the plant and reported to the Estonian Environmental Decisions Information System (KOTKAS⁵⁵).

2.A.2 Lime production

CO₂ emissions from lime production are due to calcination of calcium and magnesium carbonates at high temperatures. Historically there have been several lime producing plants, but in 2024 only one plant was producing lime.

Production in 2020 decreased because of decreased consumption. Main reason for the decreased consumption was the price increase of lime mainly due to EU ETS CO₂ price increase. In 2022 production decreased due to the high prices of natural gas and remained at the same level in 2023-2024

2.A.3 Glass production

Under this category, Estonia reports CO₂ emissions from flat glass and container glass production. Currently only container glass is produced in Estonia in one production plant. The plant started to produce container glass in 1992. Flat glass was produced in Estonia from 1990 to 1996.

2.A.4 Other process uses of carbonates

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

- 2.A.4.a Ceramics;
- 2.A.4.d Other – Limestone use for flue gas desulphurization.

2.A.4.a Ceramics

Subcategory 2.A.4.a Ceramics consists of

- Bricks and roof tiles production;
- Lightweight gravel production.

The emissions from different ceramic products are aggregated in the CRT.

Process-related CO₂ emissions result from the calcination of carbonates in clay or additives, e.g., limestone filler. Carbonates are heated to high temperatures in a kiln, producing oxides and CO₂.

Bricks and roof tiles production

Historically in Estonia there have been multiple plants that have produced either bricks or roof tiles or both. The output has been fluctuating a lot because of the variance in export demand. Starting from 2012 there has been only one big producer. In 2024 they were not producing bricks or tiles. Instead, the company who was producing light weight gravel was also producing bricks in 2024.

Lightweight gravel production

In lightweight gravel production process-related CO₂ emissions result from the calcination of carbonates in clay. The carbonates are heated to high temperatures in a kiln, producing oxides and CO₂. In the lightweight gravel production plant dolomite is used as a flux. Therefore, CO₂ emissions occur from carbonates in the clay as well from dolomite used as a flux. In 2009–

⁵⁵ Estonian Environmental Decisions Information System. <https://kotkas.envir.ee/> (22.12.2025)

2021, there was no production of lightweight gravel in Estonia. Starting from 2022 one company has been producing lightweight gravel.

2.A.4.d Other – Limestone use for flue gas desulphurisation

The limestone used for flue gas desulphurisation is one of the by-products from oil shale mining and therefore may contain organic carbon, which is oxidised to CO₂, the majority of which comes from the MgCO₃ and CaCO₃ contained in the limestone.

Limestone was used by:

1. One of Estonian oil shale firing power plant in large quantities (up to 491 kt yearly) for flue gas desulphurisation only in 2012 and 2013 (afterwards the operator discontinued burning lime in the desulphurisation process and replaced this with novel integrated desulfurisation (NID) technology using quicklime (CaO) as sorbent). The quicklime was purchased from an Estonian lime producer;
2. Two other power plants in 2015–2017 (up to 18 kt yearly).

In 2024 no limestone was used for flue gas desulphurisation in power plants. Instead, oil shale with higher calcium carbonate content was used. Because this calcium carbonate-rich oil shale is fueling the emissions arising from it are accounted for under the Energy sector.

4.2.2. Methodological issues

Choice of methods

2.A.1 Cement production

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

Equation 4.1⁵⁶

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

Activity data, emission factor and cement kiln dust (CKD) correction factor were given by the cement plant. All measurements and calculations were done according to Regulation (EU) 2018/2066⁵⁷ on the monitoring and reporting of greenhouse gas emissions and verified according to EU Directive 2003/87/EC. The plant operators calculated emissions with special software (Cement CO₂ and Energy Protocol software from the World Business Council for Sustainable Development⁵⁸).

2.A.2 Lime production

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

⁵⁶ IPCC 2006 Guidelines, Volume 3, Chapter 2: Mineral Industry, page 2.9, equation 2.2.

⁵⁷ Regulation (EU) 2018/2066 [www] <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018R2066> (22.12.2025)

⁵⁸ Cement CO₂ and Energy Protocol software from the World Business Council for Sustainable Development [www] <https://docs.wbcsd.org/2011/05/CSI-CO2-Protocol.pdf> (22.12.2025)

Equation 4.2⁵⁹

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

Where:

CO ₂ emissions =	emissions of CO ₂ from lime production, tonnes;
EF _{lime,i} =	emission factor for lime of type <i>i</i> , tonnes CO ₂ /tonne lime;
M _{l,i} =	lime production of type <i>i</i> , tonnes;
CF _{lkd,i} =	correction factor for LKD for lime of type <i>i</i> , dimensionless;
C _{h,i} =	correction factor for hydrated lime of the type <i>i</i> of lime, dimensionless;
<i>i</i> =	each of the specific lime types.

2.A.3 Glass production

There are two methods in use for calculating CO₂ emissions from glass production.

1. For flat glass production Tier 1 method according to the IPCC 2006 Guidelines is used (Equation 4.3).

According to the Tier 1 method:

Equation 4.3⁶⁰

$$CO_2 \text{ emissions} = M_g \times EF \times (1 - CR)$$

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 the carbonates used in flat glass manufacturing are not known and only national-level production statistics were available.

2. For container glass production Tier 3 method is used (Equation 4.4).

Equation 4.4⁶¹

$$CO_2 \text{ emissions} = \sum_i (M_i \times EF_i \times F_i)$$

Where:

M _i =	weight or mass of the carbonate <i>i</i> consumed, tonnes;
EF _i =	emissions factor for the particular carbonate <i>i</i> , tonnes CO ₂ /tonne carbonate;
F _i =	fraction calcination achieved for the carbonate <i>i</i> , fraction.

⁵⁹ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.21, equation 2.6.

⁶⁰ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.28, equation 2.10.

⁶¹ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.28, equation 2.12.

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

2.A.4 Other process uses of carbonates

2.A.4.a Ceramics

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

Bricks and roof tiles production

Emissions from ceramic bricks and roof tiles production were calculated using the Tier 1 (emissions of small producers) and Tier 2 (large producer) methodology from the IPCC 2006 Guidelines. In the case of the large production plant, from the years 2001-2020 the emissions arose only from limestone filler. From 2021 the emissions are calculated based on the amount of organic carbon used in the clays and BaCO₃, as well as on the CaCO₃ content of the limestone filler. The organic carbon content of the clay and BaCO₃ were declared in the EU ETS report for the first time. The plant uses the same method for reporting their process emissions for EU ETS.

According to the Tier 1 method (Equation 4.5):

Equation 4.5⁶²

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

Where:

CO₂ emissions = emissions of CO₂ 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 CO₂/tonne carbonate.

and Tier 2 method (Equation 4.6):

Equation 4.6⁶³

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

Where:

CO₂ emissions = emissions of CO₂ 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 CO₂/tonnes carbonate.

⁶² IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.34, equations 2.14-2.15.

⁶³ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.34, equations 2.15

Lightweight gravel production

Emissions from lightweight gravel production were calculated using the Tier 1 methodology from the IPCC 2006 Guidelines (Equation 4.7). According to the Tier 1 method:

Equation 4.7⁶⁴

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

Where:

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

2.A.4.d Other – Limestone use for flue gas desulphurization

Emissions from limestone use for flue gas desulphurisation were calculated by multiplying the number of carbonates (e.g., $CaCO_3$) and organic carbon in limestone with respective emission factors and oxidised fractions.

Activity data was gathered directly from the industry. The method for calculating emissions from limestone is consistent with the Tier 3 level method according to the IPCC 2006 Guidelines⁶⁵.

Activity data

2.A.1 Cement production

During emissions calculating from the cement production, the annually produced amount of clinker was 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 for the years 1990–2020. The cement producing plant has calculated uncertainties of EF-s of clinker and kiln dust since weighted average CaO , MgO and free lime content according to the WBCSD Cement Sustainability Initiative standard. The cement kiln dust (CKD) correction factor calculation done by the plant is compliant with the Tier 2 method from the IPCC 2006 Guidelines⁶⁶.

The plant has stated that each year the CKD correction factor differed mainly due to different quantities of cement kiln dust, but also calcination rate of CKD, CaO and organic content of the clinker and ash content of the alternative fuels used in kilns are slightly different in various years. The plant followed the national legislation on the best available technology⁶⁷ and European Commission's best available techniques (BAT) reference document⁶⁸ to reduce emissions and continuously improve the dust control technology of the production. There is no BAT reference document nor any legal act that specifies how much kiln dust should be recycled. The plant optimised clinker burning process to recycle maximal amounts of dust to kiln. In 1990–2006 the calcination rate of CKD was 82% and in 2007–2020 the corresponding rate was 79%.

⁶⁴ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.34, equation 2.14.

⁶⁵ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.36.

⁶⁶ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.13, equation 2.5.

⁶⁷ Industrial Emissions Act, <https://www.riigiteataja.ee/en/eli/ee/510012019010/consolide/current>, (22.12.2025)

⁶⁸ European Commission's best available techniques (BAT) reference document, https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/CLM_Published_def_0.pdf, (22.12.2025)

Data on clinker production as well as CKD correction factors between 1990–2020 are presented in Table 4.4.

Table 4.4. Activity data for clinker production in 1990–2020 (no production afterwards)

2.A.1 Cement production	1990	2005	2015	2019	2020
Clinker production, kt	790.3	635.4	356.3	503.6	35.0
CKD correction factor	1.113	1.073	1.034	1.055	1.037

2.A.2 Lime production

Activity data for lime production is collected mainly directly from industry and taken partly from industrial statistics (1990–1996). From 1990–1996 several lime producing plants were operating in Estonia and industrial statistics together with direct activity data from the industry have been used to calculate emissions. From 1997 two lime producing plants continued operation and a third one started operation in 2014 and their activity data has been collected directly from the industry and EU ETS reports (1997–2024).

Data on lime production between 1990–2024 is available in Table 4.5.

Table 4.5. Activity data for lime production in 1990–2024

2.A.2 Lime	1990	2005	2021	2022	2023	2024
Lime production, kt	185.0	37.2	63.8	24.9	23.9	27.5

2.A.3 Glass production

The consumption of limestone, sodium carbonate and coke has been used as activity data when calculating emissions from container glass production. Activity data (1993–2024) was collected directly from the glass producing plant and EU ETS reports.

Activity data for calculating emissions from the flat glass production is based on national statistics, however the numbers were corrected for the quantity of cullet used in glass production. The default cullet ratio of 50% was considered and national level data on the mass of flat glass produced was multiplied by $0.20 \times (1 - 0.50) = 0.10$ tonnes CO₂/tonnes glass produced.

Data on glass production between 1990–2024 are available in Table 4.6.

Table 4.6. Activity data and emission factors for container and glass production in 1990–2024

2.A.3 Glass	1990	2005	2021	2022	2023	2024
Container glass production, kt	NO	62.1	76.9	78.6	68.8	61.0
Limestone consumption, kt	NO	8.6	12.85	11.73	11.23	9.22
Sodium carbonate consumption, kt	NO	10.20	12.92	11.97	11.60	9.37
Coke consumption, t	NO	36.33	26.86	24.4	20.8	18.8
Flat glass production, kt	12.3	NO	NO	NO	NO	NO

2.A.4 Other process uses of carbonates

2.A.4.a Ceramics

Bricks and roof tiles production

Mass of carbonates in consumed clay has been used as activity data when calculating CO₂ emissions from small brick plants.

The emissions from the large plant were calculated based on limestone filler, which is in line with the method used by the plant calculating the emissions from the years 2001–2023 (no production by this plant in 2024). For calculation based on limestone filler, the exact CaCO₃ content of the limestone filler used is provided by the plant. The same goes for barium carbonate

and the organic C content of the clays, which were declared by the larger producer for the first time in 2021. The EF and process-related emissions from the Estonian bricks and tiles industry result from the calcination of carbonates in the clay or used additives, e.g., limestone filler, the content of which is small and fluctuates depending on customer request (e.g., a higher limestone filler content produces more yellowish bricks and tiles). The MgCO_3 content is negligible.

Data on the amount of clay, organic carbon content of the clays used (in case of the larger producer), barium carbonate (in case of the larger producer), and limestone filler used in brick production were directly collected from the plants in 1992 to 2024. The amount of clay consumed in brick 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 the 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, the default carbonate content of 10%⁶⁹ was applied for the clays used by small producers. It was assumed that 85% of the carbonates consumed are limestone and 15% of the carbonates consumed are dolomite⁷⁰.

For the years 1992–2024 data about bricks production was directly collected from the plants. This includes the precise amounts of the organic carbon used in the clays, BaCO_3 and limestone filler used by one producer and amounts that are estimated by the *Tier 1* method for other producers. The amounts of bricks produced between the years 1990–2000 was taken from industrial statistics for one company. Data on the production of ceramic roof tiles were received directly from the plant for all the years (Table 4.7).

As in 1990–1991, the only operational tile producer used a type of clay that did not contain carbonates, there was no CO_2 emission from production.

Table 4.7. Activity data of bricks and tiles and lightweight gravel production in 1990–2024

	1990	2005	2021	2022	2023	2024
Production of ceramics, kt including:	251.1	184.6	36.2	107.7	119.1	176.2
Production of bricks and tiles, kt	251.1	69.0	36.2	47.2	17.0	90.3
Production of lightweight gravel, kt	NO	115.6	NO	60.5	102.1	85.9
High-calcium limestone consumption for all ceramics (limestone filler + 85% of carbonate component of some type of clay), kt	NO	14.13	1.28	0.63	0.21	NO
Dolomite consumption (15% of carbonate component of some type of clay), kt	NO	4.8	0.0001	1.1	1.6	1.5

Lightweight gravel production

Mass of carbonates consumed has been used as an activity data when calculating CO_2 emissions from lightweight gravel production (see Table 4.7). Data about the amount of clay used for lightweight gravel production was directly collected from the plant from 1998 to 2008. As no other information was available, the default carbonate content of 10% was applied to clays. It was assumed that 85% of the carbonates consumed are limestone and 15% are dolomite⁷¹. In 2022–2024 data about the amount of clay used was received from the EU ETS report.

Data on production of lightweight gravel was received directly from the plant for all years in 1998–2008 and in 2022–2024 (Table 4.7).

⁶⁹ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.34

⁷⁰ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.36.

⁷¹ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.36.

2.A.4.d Other – Limestone use for flue gas desulphurization

Activity data on limestone use was provided by the three power plants.

Data on limestone use for flue gas desulphurisation in 2012–2013 and 2015–2017 is presented in CRT.

Emission factors

2.A.1 Cement production

Emission factors used in calculating the emissions from cement production were provided by the plant. Emission factors varied 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 were based on the actual CaO and MgO contents of clinker. Cement kiln dust and bypass dust as well as the amounts of CaO and MgO that were already calcinated before the process (and therefore do not cause emissions) were considered at the plant.

Data on emission factors between 1990–2020 are presented in Table 4.8.

Table 4.8. Emission factors for clinker production in 1990–2020 (no production afterwards)

2.A.1 Cement production	1990	2005	2015	2019	2020
EF, t/t	0.549	0.547	0.558	0.556	0.555
EF _{default}	0.52				
CKD correction factor	1.113	1.073	1.034	1.055	1.037
CKD correction factor _{default}	1.02				

2.A.2 Lime production

Four different emission factors were used to calculate emissions from lime production. The first of them is used for historical lime plants (for the years 1990-1996). For the years 1990-1996 activity data was collected directly from plants producing lime and industrial statistics were used to calculate emissions from plants closed during 1990-1996. For the years 1990-1996 we used production data from Statistics Estonia and the implied emission factor to calculate emissions for those plants for which we did not receive company-based information. This data was combined with data received from lime plants from which we did get information from and for which we used company-based emission factors.

From 1997 onwards we have received data from all lime producing plants working in Estonia and have thereafter used company-based data. The emission factors used for all the lime plants from which we have received company-based data have stayed the same throughout the time series. Two bigger plants that have had the obligation to submit their EU ETS reports have calculated emission factors: 1) using values from national regulation as allowed by EU Regulation (EU) No 601/2012 on monitoring and reporting. The Estonian Minister of the Environment Regulation No 86 of 27th December 2016 on calculation methods of the amount of CO₂ discharged into the ambient air⁷² or 2) based on chemical analyses of carbonate content. Since 2005 the biggest plant started giving emission factors based on actual CaO and MgO contents. The EFs of CaO and MgO are calculated based on the ratio of molecular weight of CO₂ to CaO/MgO.

⁷² Calculation methods of CO₂ emitted to ambient air, <https://www.riigiteataja.ee/akt/1080320190006?leiaKehtiv>, (22.12.2025)

Table 4.9. Emission factors used in 1990-2024 and comparison with IPCC default values

2.A.2 Lime	Emission factors (years)						
IEF, t/t*I	0.64 (1990-1996)						
EF _{plant-specific} , t/t**	0.79 (2014-2024)						
EF _{plant-specific} , t/t***	0.64 - 0.70 (1990-2022)						
EF _{plant-specific} , t/t****	0.82 (1994-2022)						
Year	1990	2005	1999	2021	2022	2023	2024
IEF _{lime} ,t/t	0.70	0.65	0.72	0.73	0.77	0.79	0.79
IPCC default values ⁷³ :	0.77						
*For historical lime plants in 1990–1996 the implied emission factor was used **One of the bigger plants uses value from national regulation as allowed by EU Regulation (EU) No 601/2012 on monitoring and reporting. The Estonian Minister of the Environment Regulation No 86 of 27th December 2016 on calculation methods of the amount of CO₂ discharged into the ambient air stipulates the emission factor 0.7857 t CO₂/t for lime. This emission factor is appropriate for producing lime from Estonian limestone, which has high calcium content and contains maximally 3% of magnesium oxide. ***The biggest plant's emission factors of CaO and MgO are calculated based on the ratio of molecular weight of CO₂ to CaO/MgO and have been available since 2005. As this emission factor differs from the default emission factor, emission factors for 1990–2004 are established as a mean value from the emission factors in 2005–2008. ****The smallest lime plant has been estimating their emission factor since 1994.							

Historical recalculations done in this category can be found in the previous submissions (NIR 2010).

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

Historically, the operator of the biggest (until 2021) plant explained that all products that leave the kiln (including kiln dust) are sold, and these products have already been considered when calculating CO₂ emissions. One part of dust is returned to the kiln, and another part is sold as a product. Product of low quality is sold for filling mines. In the environmental permit of the plant (number 20971⁷⁴) it is explained that lime kiln dust is captured in different stages of production by flue gas filters, bag filters and aspiration system more efficiently than required by BREF⁷⁵. This complies with the 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.

The only operator confirms that almost all of kiln dust arises from crushing the burnt lime after the lime is weighed. CO₂ emissions are calculated based on this weight. If there is inferior lime generated it is recycled to the kiln. The operator confirms that CO₂ emission from the calcination process of inferior lime (including kiln dust) is accounted for in their EU-ETS report.

The correction factor for hydrated lime is 1 because all plants give data on produced quicklime before it is hydrated.

Glass production (CRT 2.A.3)

Emission factors for calculating emissions from limestone use are based on the actual CaCO₃, MgCO₃ content of limestone and this data is provided by the plant. The plant operators provided exact carbonate content of limestone for the years 2006–2024. 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, the average values of the CaCO₃ and MgCO₃ contents of the

⁷³ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.22

⁷⁴ Database of Estonian environmental permits, https://kotkas.envir.ee/permits/public_view?permit_id=129739, (22.12.2025).

⁷⁵ BAT reference documents, <https://eippcb.jrc.ec.europa.eu/reference>, (13.11.2025).

limestone used in 2006–2012 were applied for 1992–2005. The emission factors used for CaCO_3 , MgCO_3 and Na_2CO_3 are the ones from the IPCC 2006 Guidelines and are based on stoichiometric ratios. The emission factor for limestone is then (Equation 4.9):

Equation 4.9⁷⁶

$$EF_{\text{limestone}} = EF_{\text{CaCO}_3} \times \text{part of CaCO}_3 + EF_{\text{MgCO}_3} \times \text{part of MgCO}_3$$

Where:

part of $\text{CaCO}_3/\text{MgCO}_3$ = fraction of CaCO_3 or MgCO_3 in limestone.

The emission factors for calculating emissions from flat glass production are based on the IPCC default factors⁷⁷. For the calculation of CO_2 emissions from flat glass, an emission factor 0.20 t of CO_2 per tonne of glass is used.

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

2.A.4 Other process uses of carbonates

2.A.4.a Ceramics

Bricks and roof tiles production

Data on emission factors are available in Table 4.10 and as it can be seen from there that IPCC default EF-s for calcium carbonate (0.43971) and dolomite (0.47732) are used. The proportion of these substances in raw material is actually small – corresponding amounts are shown in Table 4.7 row ‘High-calcium limestone consumption for all ceramics (limestone filler + 85% of carbonate component of some type of clay), kt.

Table 4.10. Emission factors for bricks and roof tiles production in 1990–2024

	1990	2005	2021	2022	2023	2024
IEF of bricks and roof tiles, t CO_2 /t products	NA	0.008	0.029	0.030	0.017	0.004
EF _{default} t/t (CaCO_3)	0.43971					
EF _{default} t/t ($\text{CaMg}(\text{CO}_3)_2$)	0.47732					

Lightweight gravel production

Emission factors for calculating emissions from limestone and dolomite use are based on the IPCC default factors⁷⁸. For the calculation of CO_2 emissions from limestone use, the 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 the 0.47732 t of CO_2 per tonne of dolomite is used. In 2022-2024 emission factor from ETS report was used as it was received with the laboratory analysis.

Table 4.11. Emission factors for lightweight gravel production in 1990–2024

	1990	2005	2019	2021	2022	2023	2024
IEF of lightweight gravel, t CO_2 /t product	NO	0.068	NO	NO	0.029	0.032	0.036
EF _{default} t/t (CaCO_3)	0.43971						
EF _{default} t/t ($\text{CaMg}(\text{CO}_3)_2$)	0.47732						

⁷⁶ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.7, table 2.1.

⁷⁷ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.29, equation 2.13.

⁷⁸ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.7, table 2.1.

2.A.4.d Other – Limestone use for flue gas desulphurization

Calculation methods for emission factors are adapted from verified EU ETS reports from three power plants and modified in the case of two plants. All EF-s are based on the carbonate content of the limestone. As EU Regulation No 601/2012 allows several methods for emission factor calculations and due to differences in burning processes (e.g., temperatures), the methodology applied for the different plants vary somewhat.

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 of 0.52197 t CO_2 /t was used⁷⁹. The oxidised fraction was provided by the plant and was 100% (because of high temperature burning). For CO_2 from the oxidation of organic carbon, the emission factor was based on relation of molecular weights of carbon dioxide and carbon ($44/12=3.66667$) and data on the oxidised fraction was provided by the plant.

The smaller plants have determined the carbonate content of limestone by chemical analysis. They have used either plant-specific oxidation factor of the carbonates (because of low-temperature burning) or default oxidation factor best suitable for their burning process as stipulated in the relevant national regulation (“Calculation methods of CO_2 emitted to ambient air”).⁷²

4.2.3. Uncertainty assessment and time-series consistency

For uncertainty assessment please see Annex A.II.2 IPPU, 2.A Mineral industry chapter.

4.2.4. Category-specific QA/QC and verification, if applicable

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

2.A.1 Cement production

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

Activity data was compared with the data from Statistics Estonia to exclude the possibility of other cement production plants. The completeness of the category was also checked from the Estonian Environmental Decisions Information System (KOTKAS⁵⁵).

The emissions of 2005–2020 were compared to the EU ETS data. Differences were zero to 0.00009 % at the most during this period. The cause of the differences was that the emissions in the EU ETS reports were rounded to the nearest ton (according to the Regulation (EU) 2018/2066 the emissions must be submitted with the accuracy of 1 ton).

In 2021-2024 the plant had no obligation to submit its EU ETS report as no production took place during those years.

⁷⁹ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.7, table 2.1.

2.A.2 Lime production

The completeness of the category was checked from the Estonian Environmental Decisions Information System (KOTKAS), national database of environmental permits and EU-ETS reports. No other lime production plants were found.

Lime production reported in the GHG inventory was compared with data from Statistics Estonia. Statistics Estonia has somewhat different methodology regarding lime production.

The emissions been compared with EU ETS data in the period of 2005-2024. Differences between emissions reported to the EU ETS and GHG inventory have been 0.005% at the most in this period. The cause of the differences was that the emissions in the EU-ETS reports were rounded to the nearest ton (according to the Regulation (EU) 2018/2066 the emissions must be submitted with the accuracy of 1 ton) but the emissions in the GHG inventory are not rounded.

2.A.3 Glass production

The completeness of the category was checked from the Estonian Environmental Decisions Information System (KOTKAS), national database of environmental permits and EU-ETS reports.

Data on produced glass provided by the plant was compared with data on produced glass from Statistics Estonia. The data from both sources agreed. It can be concluded that there are no other glass production plants in Estonia.

The CO₂ emission from glass production and amounts of raw materials used as reported in 2025 submission were compared with respective data from EU ETS. The amounts of limestone, soda ash and coke were identical in ETS and GHG inventory.

2.A.4 Other process uses of carbonates

2.A.4.a Ceramics

Bricks and roof tiles production, Lightweight gravel production

For completeness check, the Estonian Environmental Decisions Information System (KOTKAS) was checked and no other plants were found.

The activity data was compared with the data from Statistics Estonia but as some plants are providing aggregated data on their production and imports to Statistics Estonia, the data does not match 100%.

2.A.4.d Other – Limestone use for flue gas desulphurisation

The Estonian Environmental Decisions Information System (KOTKAS) and EU ETS reports were checked and no other plants that use limestone for flue gas desulphurisation, were found.

CO₂ emission reported in the CRT were compared with emissions reported to EU ETS. The differences are caused by the conformation of different emission factor calculation methods of different companies (more information in paragraph Emissions factors).

4.2.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

There were no category-specific recalculations.

4.2.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

There are no planned category-specific improvements.

4.3. Chemical industry (CRT 2.B)

4.3.1. Category description

2.B.1 Ammonia production

This category of the inventory includes the non-fuel emissions from natural gas used for ammonia production. In Estonia, there has been one ammonia production plant.

In 2014–2024, no NH₃ production took place at this plant. The plant operator has announced that it has sold all its production equipment and no longer plans to continue ammonia production activities, as ammonia production in Estonia has not been profitable since 2014 due to low global market prices for ammonia and rising natural gas prices.

Regarding earlier years, CO₂ emissions from ammonia production have decreased considerably since 1990, having the lowest values in 1993, 2002 and 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 restarted ammonia production at the beginning of December in 2012 and production continued until September 2013. The decrease in the emissions during the early 1990's was caused by the transition from planned economy to a market economy after 1991 when Estonia became independent. This led to a 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 stabilised till 2002 and 2003 when there was a sudden decrease in emissions. In 2002, 2003 and 2008, reconstructions of the plant took place that strongly affected production. The lowest point in production and in emissions was in 2009.

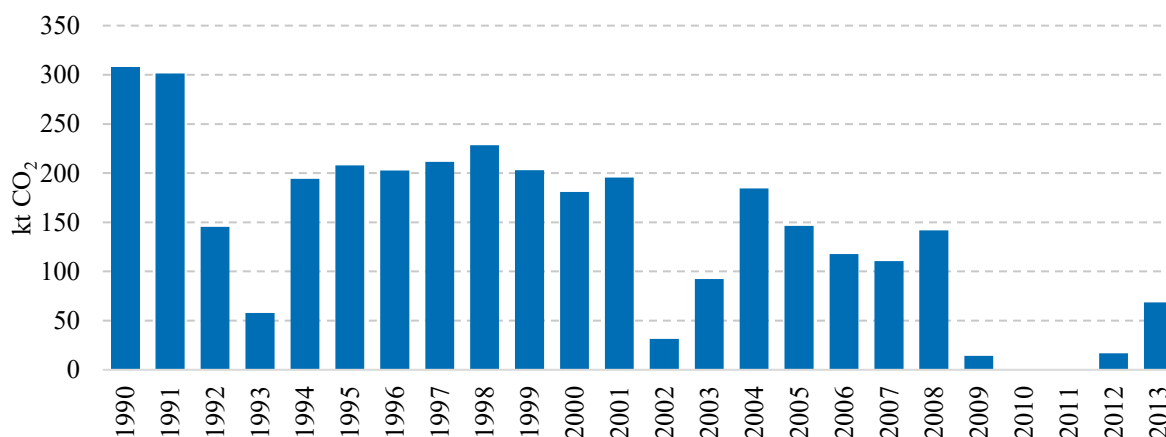


Figure 4.4. CO₂ emissions from Chemical industry in 1990–2013 (no production afterwards), kt

4.3.2. Methodological issues

Choice of methods

2.B.1 Ammonia production

Estonia has accounted under Industrial processes and product use sector only the natural gas used as feedstock for primary steam reforming. The amount of natural gas combusted was 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 the Joint Questionnaire dataset. In the Joint Questionnaire dataset provided by Statistics Estonia, it is not possible to split by single plants.

Emissions of CO₂ 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 CO₂ from ammonia production was captured for urea (carbamide) production. The most part of CO₂ captured in urea is subtracted as following:

1. Since 2015 submission the carbon dioxide captured in urea which was sold in Estonia as fertilizer is subtracted from emissions. It is accounted for under the Agriculture sector, 3.H. Urea application together with imported urea that was used as fertilizer.
2. CO₂ 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 for under subsector 2.D.3 Other.

Estonia uses method Tier 3 in calculating CO₂ emissions from ammonia production (Equation 4.10. According to the Tier 3 method:

Equation 4.10⁸⁰

$$CO_2 \text{ emissions} = \sum_i (TFR_i \times CCF_i \times COF_i \times 44/12) - R_{CO_2}$$

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 CO₂ for urea production is 0.75 t CO₂/t urea.

Activity data

2.B.1 Ammonia production

The annual ammonia production figures for the years 1990–2013 have been provided by the production plant. Consumption of natural gas feedstock in millions m³ at 1 atm pressure and 20 degrees C and in terajoules (TJ) in the years 1990–2003 and 2005–2013 have been provided by the production plant to Statistics Estonia. This data was included in the 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

⁸⁰ IPCC 2006 Guidelines, Volume 3, Chapter 3, page 3.13.

correction has been made concerning statistical data. Corrected gas feedstock quantity for the year 2004 was used in the GHG inventory.

The plant also provided data on the amount of the urea exported and the urea sold in Estonia as fertilizer in years 2004–2013, but data in 1990–2003 were not available.

- It was assumed, that the urea sold in Estonia as fertiliser between 1990–2003 constituted the same per cent from total yearly production of urea as the average of the years 2004–2009.

It was assumed that urea exported between 1990–2003 constituted the same per cent from the total production of urea each year than in 2003–2005.

Activity data from ammonia production in 1990–2013 (no production afterwards) are in Table 4.12.

Table 4.12. Activity data (and its differences to statistical data ammonia production in 1990–2013, no production afterwards)

2.B.1	1990	2005	2010–2011	2012	2013
Ammonia production, kt	294.0	212.6	NO	17.2	120.9
Amount of natural gas used as feedstock, million m ³	227	146	NO	13	83
Amount of natural gas used as feedstock, TJ	7 657	4 915	NO	448	2789
Carbon content of natural gas, t C/TJ	15.1	15.0	NO	14.8	15.1
Difference of natural gas feedstock AD (TJ) to statistical data, %	0.0	0.0	NO	0.0	0.0

Emission factors

2.B.1 Ammonia production

Emission factors were calculated by dividing CO₂ emissions (without subtracting recovered amounts) from technological process with the amount of ammonia produced.

Emissions were calculated based on the amount of natural gas used as feedstock and the carbon content of gas. Data on the carbon content of the gas was provided by the industry directly to the inventory compilers. The amount of gas feedstock was provided by the industry to Statistics Estonia and from Statistics Estonia to inventory compilers. The emission factors for calculations of CO₂ emissions from ammonia production were plant specific throughout time series. In Estonia, ammonia production emission factors have varied between 1.276–1.516 t CO₂/tonne of NH₃ produced.

The carbon content of the gas was calculated by the gas supply network operator using the results of monthly gas compositional analyses. The carbon content was 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 was used.

Emission factors from ammonia production in 1990–2013 (no production afterwards) are in Table 4.13.

Table 4.13. Emission factors for ammonia production in 1990–2013 (no production afterwards)

2.B.1	1990	2005	2010–2011	2012	2013
EF _{ammonia} , t/t (recovered amounts subtracted)	1.4	1.3	NO	1.4	1.3

4.3.3. Uncertainty assessment and time-series consistency

For uncertainty assessment please see Annex A.II.2 IPPU, 2.B Chemical industry chapter.

4.3.4. Category-specific QA/QC and verification, if applicable

Ammonia production (CRT 2.B.1)

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

The emissions in 2008–2013 have been compared with respective 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 in 2008–2009 and 2013. In 2012, the difference was 2.5% because the consumption of natural gas was very small, and statistical data is rounded to millions m³. Quantitative comparison can be provided to the ERT on request.

The completeness of the category was checked from the Estonian Environmental Information Decisions Information System (KOTKAS) and no other ammonia production plants were found.

The 2016 UNFCCC Review Team also asked Estonia to provide an outcome of the comparison between operator data on gas feedstock AD and the allocation of non-energy use of fuels in the Joint Questionnaire dataset from Statistics Estonia⁸¹. The differences in gas feedstock AD that Statistics Estonia used in the Joint Questionnaire dataset non-energy use of fuels and that is used for GHG inventory 2.B.1 are included in Table 4.12. For 1990–2003 and 2005–2013 Estonia uses the data provided by the operator to Statistics Estonia and for that dataset and there are no differences. The difference in year 2004 is because the plant operator retrospectively corrected natural gas quantity – recalculated from 0 degrees C and 1 atm to 20 degrees C and 1 atm. In the GHG inventory the corrected gas amount is used for emission calculation.

4.3.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

2.B.1 Ammonia production

No category-specific recalculations were done.

4.3.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

2.B.1 Ammonia production

There are no planned category-specific improvements.

⁸¹ ARR2016/ Table 5. I.9 IPPU

4.4. Metal industry (CRT 2.C)

In this category Estonia reports emissions from:

1. production of secondary lead;
2. soda ash and ammonium bicarbonate use and from calcination of rare earth metal carbonates into oxides in rare metals and rare earth metals and compounds industry.

In CRT CO₂ emissions from both categories are aggregated and reported under 2.C.5 – Lead production. Most emissions arise from lead production.

In CRT, on the row Activity Data, the production volume of secondary lead aggregated with production volume of rare earth element (REE) compounds is provided. Before 2003 when the lead recycling plant production started, the rare metals and rare earth metals production plant was the only one in this category. Its production volumes are confidential and notation key 'C' is reported in CRT for the years 1990–2002.

The reason why emissions from soda ash used in rare metals and rare earth element production are aggregated with emissions from lead production is that there is only one plant in each category and majority of their data on production volumes, intermediates, hints to technologies (e.g., process reactions) are confidential. Estonia has reported emissions solely from the beforementioned two production plants under category 2.A.4.b Other uses of soda ash in submissions before 2017. The reason why these emissions are now reported under subsector 2.C is that coal used as reducing agent could not be reported in category 2.A.4.b.

The methodology of calculation of emissions from secondary lead production and soda ash use in rare metals and rare earth metals and compounds industry is described separately in following subparagraphs.

4.4.1. Category description

2.C.5 Lead production

In Estonia lead is produced only by one plant which started production in 2003.

Lead is produced from scrapped lead acid batteries using soda ash desulphurisation and pyrometallurgical process.

Spent batteries are scrapped and sulphuric acid is drained. Lead paste (PbSO₄) is desulphurised with Na₂CO₃. Desulphurised lead paste consisting mainly of PbCO₃ is subjected to thermal reduction with anthracite in rotary furnace and metallic lead is produced.

Sulphuric acid drained from batteries and residual solutions are neutralised with Na₂CO₃.

The lead battery recycling plant was launched in autumn 2003 and therefore emissions were small in the first year.

Emissions arise from:

- 1) neutralisation of sulphuric acid with soda ash and;
- 2) reduction-oxidation reaction between coal and lead carbonate in the smelting process.

In 2024 emissions from the category 2.C were 3.1 kt CO₂.

[Emissions from rare metals and rare earth metals and compounds industry \(reported under CRT category 2.C.5 Lead production aggregated with emissions from lead production\)](#)

Separation and production of rare metals and rare earth metals and compounds started in 1970 in Estonia in one production plant. The same plant is operating to this day. Rare earth metal raw material is dissolved in acid and then precipitated with sodium carbonate and ammonium bicarbonate. Some of the produced rare earth metal carbonates are calcinated to oxides.

4.4.2. Methodological issues

[Choice of methods](#)

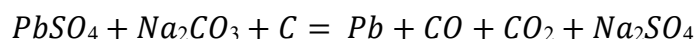
[2.C.5 Lead production](#)

Estonia uses the *Tier 3*⁸² method in calculating CO₂ emissions from lead production. Data on raw materials and products is supplied by the production plant. Calculations have been done considering the following:

1. Emissions from soda ash reaction with sulphuric acid in neutralisation process are calculated by multiplying the stoichiometric ratio of CO₂/Na₂CO₃ with the amount of used carbonates (Equation 4.11). 100% of soda ash is reacting with acid;
2. Emissions from anthracite used for the reduction of lead paste are calculated by multiplying the stoichiometric ratio of CO₂/C with quantity of used anthracite and carbon content of anthracite.

The summarised reaction can be described by the following equation:

Equation 4.11



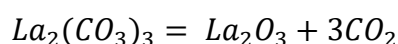
[Emissions from rare metals and rare earth metals and compounds industry \(reported under CRT category 2.C.5 Lead production aggregated with emissions from lead production\)](#)

Emissions are calculated based on soda ash and ammonium bicarbonate consumption in: 1) rare earth element (REE, mostly La and Ce) separation (mostly) and 2) neutralisation of residual solutions and gases in rare metals production. In addition, there are emissions arising from calcination of rare earth metal carbonates to oxides.

Estonia uses the Tier 3 method of category 2.A.4 Other process uses of carbonates for calculating CO₂ emissions from soda ash and ammonium bicarbonate used in rare metals and REE compounds production. Emissions from soda ash use are calculated by multiplying emission factor (0.41492) with the amount of used soda ash. Emissions from ammonium bicarbonate are calculated by multiplying the emission factor with the amount of used ammonium bicarbonate (the EF – 0.278481013 is the same for precipitating La as well as Ce(III) carbonates). The emission factor is derived based on chemical equation of ammonium bicarbonate reacting with rare earth metal nitrates. The exact calculation can be provided to the review when requested.

Emissions from rare earth metal carbonate calcination occur according to the formula:

⁸² IPCC 2006 Guidelines, Volume 3, Chapter 4, page 4.73



[Activity data](#)

[2.C.5 Lead production](#)

The quantity of soda ash used for sulphuric acid neutralisation as well as the quantity and carbon content of anthracite used as a reducing agent are provided by the plant. Table 4.14 presents the quantities of consumed anthracite in lead production and aggregated quantities of soda ash and ammonium bicarbonate used in lead and rare metals and rare earth metals production. Aggregation is because of confidentiality reasons.

Table 4.14. Quantities of anthracite consumed in lead production and soda ash and ammonium bicarbonate consumed in lead production and rare and rare earth metal production

Material use	1990	2005	2021	2022	2023	2024
Anthracite use kt	NO	0.309	0.676	0.554	0.670	0.713
Soda ash and ammonium bicarbonate use, kt	1.87	1.48	2.44	2.51	2.38	1.52

[Emissions from rare metals and rare earth metals and compounds industry \(reported under CRT category 2.C.5 Lead production aggregated with emissions from lead production\)](#)

The quantities of soda ash used by the plant in 1998, 2002-2021 (the rest of the years the quantities are interpolated) and the production volume of REE compounds since 1995 are supplied by Statistics Estonia. Quantities of ammonium bicarbonate used in 2000 and 2006-2021 were obtained from the air pollution reports (supplied by the Environmental Board) and the possible quantities consumed in 1990-2005 were derived from the relation of REE concentrate use as raw material and quantity of ammonium bicarbonate used in 2000. In 2022-2024 quantities of ammonium bicarbonate and REE concentrate was asked from the manufacturing plant.

The quantities of REE concentrate in 2004-2021 are from reports on air pollution and quantities in 1990-2006 are from old newspaper articles (e.g., Äripäev, 1995 , Äripäev, 1998).

[Emission factors](#)

[2.C.5 Lead production](#)

The emission factor of soda ash is 0.41492⁸³. The emission factor of anthracite is carbon content multiplied with EF of the carbon – 44/12.

⁸³ IPCC 2006 Guidelines, Volume 3, Chapter 2, page 2.7, table 2.1

Emissions from rare metals and rare earth metals and compounds industry (reported under CRT category 2.C.5 Lead production aggregated with emissions from lead production)

The emission factor of ammonium bicarbonate is 0.278481013. The fractions of reacted soda ash and ammonium bicarbonate are assumed to be 1.

The emission factor of rare earth metal carbonate calcination is 0.139240506. This is calculated as follows:

Equation 4.13

$$\frac{44(M_{CO_2}) * 3(stoich. coefficient) * 0.5 (50\% of carbonates are calcined)}{79 (M_{NH_4(HCO_3)}) * 6(stoich. coefficient)}$$

where M is molecular mass.

4.4.3. Uncertainty assessment and time-series consistency

2.C.5 Lead production

For uncertainty assessment please see Annex A.II.2 IPPU, 2.C Metal industry chapter.

4.4.4. Category-specific QA/QC and verification, if applicable

2.C.5 Lead production

The inventory compiler asked Statistics Estonia if anthracite use is accounted in the national energy balance, and it was not the case.

The quantities of consumed soda ash and anthracite were checked from the Estonian Environmental Decisions Information System (KOTKAS). No differences were found

Emissions from rare and rare earth metals and compounds industry (reported under CRT category 2.C.5 Lead production aggregated with emissions from lead production)

The quantities of consumed soda ash and volumes of REE compounds were checked from the Estonian Environmental Decisions Information System (KOTKAS). No significant differences were found.

4.4.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No category-specific recalculations were done.

4.4.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

There are no planned category-specific improvements.

4.5. Non-energy products from fuels and solvent use (CRT 2.D)

This category includes:

- 2.D.1 – CO₂ emissions from the use of lubricants (industrial and motor oils) during their use time;
- 2.D.2 – CO₂ emissions from paraffin waxes;
- 2.D.3 Other – CO₂ emissions from urea-based catalysts for motor vehicles;
- 2.D.3 – NMVOC emissions from 1. Solvent use and 2. Road paving with asphalt. Indirect CO₂ emissions are calculated from NMVOC emissions from this category and reported under 2.D.3 on the row of CO₂ emissions.

CO₂ emissions from lubricants, paraffin waxes and urea based catalytic converters for motor vehicles are shown in Figure 4.5.

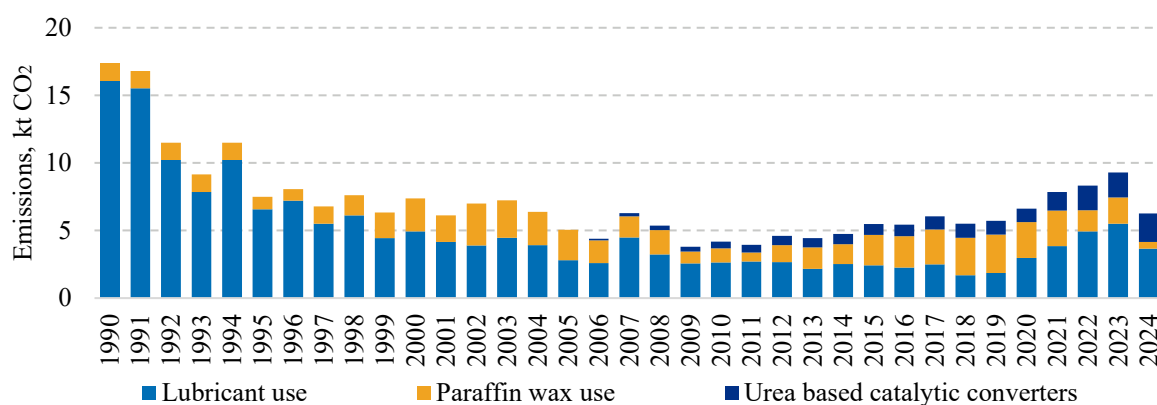


Figure 4.5. CO₂ emissions from lubricants, paraffin waxes and urea based catalytic converters for motor vehicles in 1990–2024, kt CO₂

Table 4.15. CO₂ emissions from lubricants, paraffin waxes and urea based catalytic converters for motor vehicles

	1990	2005	2021	2022	2023	2024
2.D.1 Lubricant use						
CO ₂ emission, kt	16.11	2.80	3.85	4.94	5.51	3.66
2.D.2 Paraffin wax use						
CO ₂ emission, kt	1.29	2.26	2.62	1.57	1.94	0.49
2.D.3 Urea based catalysts for motor vehicles						
CO ₂ emission, kt	NO	NO	1.38	1.82	1.84	2.12
Sum of CO₂ emissions from 2.D.1-2.D.3, kt (excl. indirect CO₂)	17.40	5.06	7.85	8.33	9.29	6.27

More information about subcategories is found in the following paragraphs.

4.5.1. Category description

2.D.1 Lubricant use

Lubricant use covers industrial and motor oils and greases that were produced from fossil fuels. This paragraph is about emissions from the primary use of lubricants in industry, households, and vehicles. The lubricants that are lost during primary use are oxidised and result in CO₂

emissions. The waste oils that are incinerated are accounted under the Energy sector's sectoral approach.

In 2024 the apparent consumption of lubricants was 6.2 kt and the CO₂ emission from this category (2.D.1) was 3.7 kt.

2.D.2 Paraffin wax use

The category includes such products as candles, petroleum jelly, paraffin waxes and other waxes, including osokerite. Most of the CO₂ emissions in this category derive when the waxes or derivatives of paraffin are combusted during use (e.g., candles). In Estonia, candles are produced from paraffin waxes. No production of paraffin waxes has occurred.

In Estonia, there is one major candle producer, which started production in 1997 and has produced most of the total candle production in Estonia since 1998. Before 1998 there was another candle producer, which was closed in 1998. Candle production in Estonia has multiplied after 2005 and exports constitute approximately 90% of the producers' turnover.

In 2024, the apparent consumption of paraffin waxes (including candles) was 0.8 kt and the CO₂ emission from this category (2.D.2) was 0.5 kt.

2.D.3 Other

The subsector 2.D.3 covers:

- Other – CO₂ emissions from urea-based catalysts for motor vehicles;
- NMVOC and indirect CO₂ emissions from use of solvents and other products;
- NMVOC and indirect CO₂ emissions from road paving with asphalt.

Urea based catalysts for motor vehicles

The consumption of urea-based DEF (AdBlue) was 8.9 kt and the CO₂ emission from this category (2.D.3.d) was 2.12 kt.

Directive 2005/55/EC of the European Parliament and of the Council introduced Euro IV maximum limit of NO_x 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) stipulate requirements for type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6). New light vehicles placed on the EU market and registered after 1st September 2015 must meet strict limits of exhaust NO_x and need a catalyst system. Euro 6 upper limit on NO_x is over twice smaller than Euro 5 upper limit.

SCR is the dominant technology in the market of trucks and buses, constituting 75% of sales⁸⁴. Larger trucks have been equipped with SCR+EGR (exhaust gas recirculation). Most of Euro 6

⁸⁴ EAA air pollutant inventory emission guidebook 2023, page 77
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i> (22.12.2025)

compliant light commercial vehicles were SCR-equipped in 2019. The market share of passenger cars equipped with SCR was estimated at *ca* 40% in 2014⁸⁵.

Solvent use

The use of solvents and products containing solvents results in emissions of non-methane volatile organic compounds (NMVOCs) when emitted into the atmosphere. Indirect CO₂ emissions are calculated from NMVOCs.

NMVOC-s are not greenhouse gases but air pollutants which are reported in the Air pollutant emission inventory according to the NEC Directive and the UNECE CLRTAP (United Nations Economic Commission for Europe's Convention on Long-Range Transboundary Air Pollution). The Air pollutant emission inventory is compiled by the Estonian Environmental Agency every year by 15th of February.

In CRT Estonia also reports CO which arises mainly from tobacco use, fireworks and less from some processes using solvents.

Use of solvents and other products covers emissions from:

SNAP 0601: Coating 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: Other product use (e.g., tobacco, fireworks) (SNAP 060602). Under this SNAP emissions from lubricant use are also reported in the NEC/CLRTAP inventory but not in the GHG inventory because emissions from lubricants are already reported under category 2.D.1.

Under categories of paint application (SNAP 0601), degreasing and dry cleaning (SNAP 0602), chemical products, manufacture, and processing (SNAP 0603) and other (SNAP 0604 and SNAP 0606), Estonia reports indirect greenhouse gas emissions (NMVOCs) and indirect CO₂ emissions from NMVOC emissions (Table 4. 17).

The NMVOC and indirect CO₂ emissions from solvents by the EMEP/EEA Air pollutant emission inventory NRF code are shown in Table 4.16. Indirect CO₂ emissions from: 1) paint application (2D3d; SNAP 0601); 2) domestic solvent use (e.g., fungicides) (2D3a; SNAP 0604); 3) other solvent use (2D3i; SNAP 0604) and 4) printing (2D3h; SNAP 0604) made up the main share of total emissions from the sector 1) 47.4%; 2) 33.7%; 3) 13.8% and 4) 2.6%, respectively, in 2023.

Table 4.16. Reported emissions from Solvent use in 2024

SNAP	NRF	Source	Emissions
0601	2D3d	Coating application (e.g., paint)	NMVOC, indirect CO ₂ , CO
0602	2D3e	Degreasing	NMVOC, indirect CO ₂
0602	2D3f	Dry cleaning	NMVOC, indirect CO ₂
0603	2D3g	Chemical products, manufacturing and processing	NMVOC, indirect CO ₂ , CO

⁸⁵ Yang,L., Franco,V et al. 2015. NOx control technologies for Euro 6 diesel passenger cars. https://www.theicct.org/sites/default/files/publications/ICCT_NOx-control-tech_revised%2009152015.pdf, (22.12.2025).

SNAP	NRF	Source	Emissions
0604	2D3h	Printing	NMVOC, indirect CO ₂
0604	2D3a	Domestic solvent use (e.g., fungicides)	NMVOC, indirect CO ₂
0604	2D3i	Other solvent use	NMVOC, indirect CO ₂
0606	2G	Other product use (e.g., tobacco, fireworks)	NMVOC, indirect CO ₂ , CO

A large increase in NMVOC emissions in 2021 has been in paint application (industrial and domestic) and the amounts were similar in 2022. In 2023 the increase of emissions from paint application has been somewhat curbed by decreasing emission factors and further decrease in this sector continued in 2024. Content of NMVOCs in paints and therefore emission factors have decreased mainly as an effect of Directive 2004/42/CE on limitation of VOCs in paints. Emission factors of domestic solvent use (other than paints) have not been decreased in time series because according EMEP/EEA Air Pollutant Inventory Guidebook 2023 they should remain constant during time series. In real life it could be that the emission factors might have decreased as effect of Regulation (EC) No 1223/2009 on cosmetic products (requirement of safety assessment and bans of certain hazardous components) and Regulation (EU) No 528/2012 concerning the making available on the market and use of biocidal products (imposing bans of certain hazardous components). Compared to the base year 1990 the emissions from indirect CO₂ from Solvent use category in 2024 were 18.1% larger because emissions from coating applications (e.g. paint) have increased in sub-category 2D3d.

The fluctuation of total NMVOC emissions during the period 1990–2024 has mostly occurred due to the economic condition of the country. The decrease in the emissions between 1992 and 1993 was attributable to the economic crisis that was conditioned by the fall of the Soviet Union and the regaining of independence of the Republic of Estonia. Between 1993 and 1998 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 economic crisis, which affected the construction sector and as a consequence the usage of decorative coatings diminished. From 2001 the economy turned again into growth until in 2008 when Estonia suffered badly from the global economic depression. Because of that, compared with the year 2007, the NMVOC emissions and indirect CO₂ emissions decreased respectively in 2008 and 2009 (please see Figure 4.6). From 2018-2021 there were an increase mostly in the use of coating applications following decrease in 2022-2024 that resulted in overall decrease of NMVOC emissions.

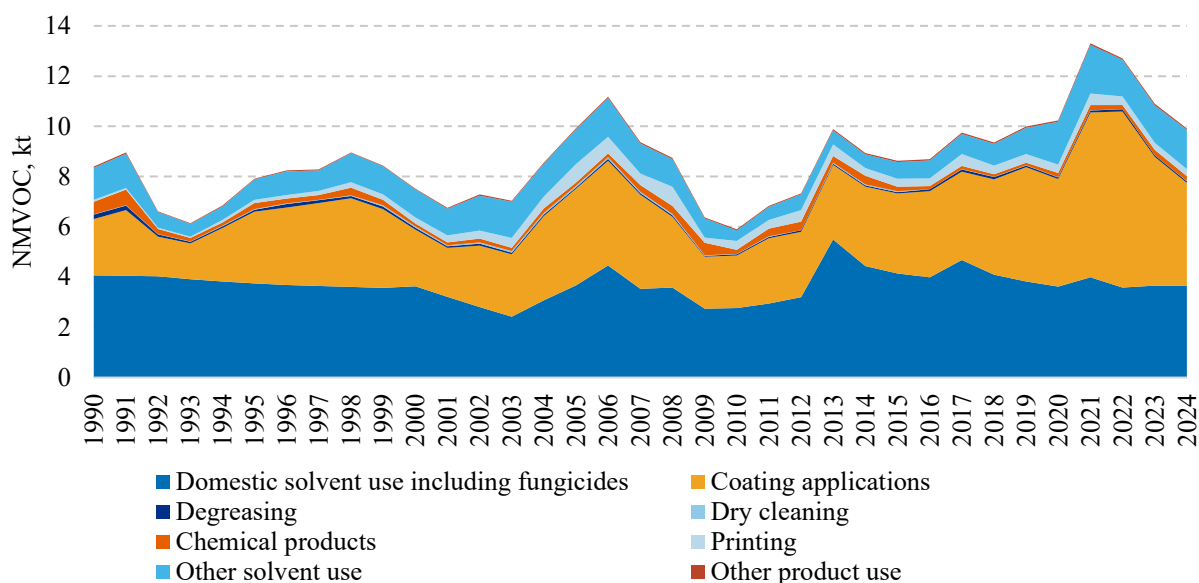


Figure 4.6. Total NMVOC emissions from Solvent use in 1990–2024, kt

Table 4.17. Emissions from Solvent use and Road paving with asphalt in 1990–2024, kt

Emissions from Solvent use and Road paving with asphalt, kt		1990	2005	2021	2022	2023	2024
2D3a	NMVOC emissions from Domestic solvent use (e.g., fungicides), kt	4.07	3.68	3.99	3.58	3.65	3.66
2D3d	NMVOC emissions from Coating applications (e.g., paint), kt	2.24	3.84	6.56	7.02	5.12	4.09
2D3e	NMVOC emissions from Degreasing, kt	0.18	0.05	0.08	0.08	0.07	0.06
2D3f	NMVOC emissions from Dry cleaning, kt	0.01	0.06	0.01	0.004	0.006	0.009
2D3g	NMVOC emissions from Chemical products, manufacture, and processing, kt	0.50	0.13	0.21	0.17	0.21	0.19
2D3h	NMVOC emissions from Printing, kt	0.08	0.75	0.45	0.34	0.28	0.28
2D3i	NMVOC emissions from Other solvent use, kt	1.26	1.38	1.95	1.47	1.50	1.57
2G	NMVOC emissions from Other product use (e.g. tobacco), kt	0.05	0.04	0.05	0.05	0.06	0.05
Total NMVOC from solvent use, kt		8.40	9.93	13.30	12.71	10.89	9.92
Indirect CO ₂ emissions from NMVOCs from Solvent use, kt		18.47	21.85	29.27	27.96	23.97	21.82
NMVOC emissions from Road paving with asphalt, kt		0.03	0.02	0.03	0.02	0.02	0.02
Indirect CO ₂ emissions from NMVOCs from Road paving with asphalt, kt		0.05	0.03	0.04	0.04	0.03	0.03
Total indirect CO ₂ emissions from Solvent use and Road paving with asphalt, kt		18.52	21.88	29.31	28.00	24.00	21.85

Road paving with asphalt

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

Indirect CO₂ emissions from road paving with asphalt: 0.03 kt.

NMVOC and indirect CO₂ emissions in 1990–2024 are shown in Table 4.17.

4.5.2. Methodological issues

Choice of methods

2.D.1 Lubricant use

Emissions from lubricants were calculated using the Tier 1 method according to the IPCC 2006 Guidelines (Equation 4.14). Total consumption of solid and liquid lubricants (TJ) is multiplied with the emission factor. The emission factor is based on default values of carbon content and oxidation during use (ODU) factor⁸⁶.

Equation 4.14⁸⁷

$$CO_2 \text{ emissions} = \sum (LC \times CC_{\text{lubricant}} \times ODU_{\text{lubricant}}) \times 44/12$$

Where:

CO ₂ emissions =	CO ₂ emissions from lubricants, tonne CO ₂ ;
LC =	total lubricant consumption, TJ;
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.

2.D.2 Paraffin wax use

Emissions from paraffin waxes were calculated using the *Tier 1* method according to the IPCC 2006 Guidelines (Equation 4.15), because no sufficient data on oxidation factors of different paraffin wax products were found.

Total consumption of paraffin waxes (TJ) is multiplied with the emission factor.

Equation 4.15⁸⁸

$$CO_2 \text{ emissions} = PW \times CC_{\text{wax}} \times ODU_{\text{wax}} \times 44/12$$

Where:

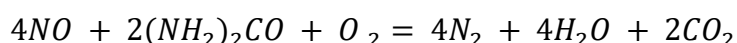
CO ₂ emissions =	CO ₂ emissions from waxes, tonne CO ₂ ;
PW =	total wax consumption, TJ;
CC _{wax} =	carbon content of paraffin wax (default), tonne C/TJ (= kg C/GJ);
ODU _{wax} =	ODU factor for paraffin wax, fraction;
44/12 =	mass ratio of CO ₂ /C.

2.D.3 Other

Urea based catalysts for motor vehicles

Summary reaction of urea in SCR systems (Equation 4.16):

Equation 4.16



⁸⁶ IPCC 2006 Guidelines, Volume 3, Chapter 5, page 5.9, section 5.2.2.2.

⁸⁷ IPCC 2006 Guidelines, Volume 3, Chapter 5, page 5.7, equation 5.2.

⁸⁸ IPCC 2006 Guidelines, Volume 3, Chapter 5, page 5.11, equation 5.4.

The Tier 2 method from the IPCC 2006 Guidelines was used.

According to the Tier 2 methodology:

Equation 4.17⁸⁹

$$Emission = Activity \times 12/60 \times Purity \times 44/12$$

Where:

12/60 = stoichiometric coefficient of carbon in urea;

44/12 = stoichiometric coefficient of conversion of carbon to CO₂.

Solvent use

The compiling of NMVOC emission data from the Solvent use category is performed by the Estonian Environment Agency. An inventory of air pollutants is being carried out to meet the obligations of UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP).

NMVOC emission estimations from Solvent use are based on several data sources and methods. Emissions from point sources are gathered from the Estonian Environmental Decisions Information System (KOTKAS) 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 2023.

Indirect CO₂ emissions from Solvent use were calculated using methodology from the IPCC 2006 Guidelines (Equation 4.18). According to the method:

Equation 4.18⁹⁰

$$CO_2 \text{ emissions} = Emissions_{NMVOC} \times \% \text{ carbon in NMVOCs by mass} \times 44/12$$

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.

Road paving with asphalt

NMVOC emissions from road paving with asphalt were calculated using the Tier 1 default approach from the renewed EMEP/EEA Guidebook 2023 (Equation 4.19).

According to the Tier 1 method:

Equation 4.19⁹¹

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

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.

⁸⁹ IPCC 2006 Guidelines, Volume 2, Chapter 3 page 3.12.

⁹⁰ IPCC 2006 Guidelines, Volume 1, Chapter 7, page 7.6, box 7.2.

⁹¹ EMEP/EEA air pollutant emission inventory guidebook 2023, page 9,
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023> (22.12.2025)

Indirect CO₂ emissions from road paving with asphalt were calculated using methodology from the IPCC 2006 Guidelines (Equation 4.18).

Activity data

2.D.1 Lubricant use

Data on production of lubricants in 1990–2024 was provided by Statistics Estonia. No production of motor and industrial oils was present in Estonia during 1990–2024 according to Statistics Estonia and the Eurostat database⁹².

The apparent consumption of lubricants was calculated with the formula: import minus export, as no lubricant production occurred.

The quantities in tonnes were converted into TJ using the default net calorific value – 40.2 TJ/kt in line with the IPCC 2006 Guidelines⁹³.

Activity data on lubricants are presented in Table 4.18.

Table 4.18. Activity data concerning lubricants

	1990	2005	2021	2022	2023	2024
2.D.1 Lubricant use, kt	27.3	4.8	6.5	8.4	9.3	6.2
Lubricant use, TJ	1 098	191	262	337	374	250

2.D.2 Paraffin wax use

According to Statistics Estonia, no production of paraffin waxes has taken place in Estonia, instead, candles are produced from paraffin waxes. The data on candle production in 2006–2024 was obtained from Statistics Estonia. No data was available for the years 1990–2005 and therefore the average apparent candle consumption (import minus export) of the years 2006–2013 was used for the years 1990–2005.

The apparent consumption of paraffin waxes was calculated with formula: import minus export plus 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 1995–2024 was obtained from the Eurostat database. 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/kt⁹⁴.

Activity data on paraffin waxes are presented in Table 4.19.

Table 4.19. Activity data concerning paraffin waxes

	1990	2005	2021	2022	2023	2024
2.D.2 Paraffin wax use, kt	2.2	3.8	4.4	2.7	3.3	0.82
Paraffin wax use, TJ	88	154	179	107	133	33

⁹² Eurostat database, <https://ec.europa.eu/eurostat/web/main/data/database> (22.12.2025)

⁹³ IPCC 2006 Guidelines, Volume 2, Chapter 1, page 1.18, table 1.2.

⁹⁴ IPCC 2006 Guidelines, Volume 2, Chapter 1, page 1.18, table 1.2.

2.D.3 Other

Urea based catalysts for motor vehicles

Activity data consists of:

- diesel fuel consumption of vehicles (data from Estonian Environmental Agency);
- consumption of urea containing diesel exhaust fluid (DEF) per fuel consumption.

Data on diesel fuel consumption by new vehicles complying with Euro standards were compiled by the Estonian Environment Agency (EstEA). The EstEA 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 Transport Administration.

Until 2015 only heavy vehicles were accounted for, from 2015 light vehicles have also been accounted for.

Solvent use

NMVOC emission estimations from Solvent use are based on several data sources and methods. Emissions from point sources are gathered from the Estonian Environmental Decisions Information System (KOTKAS) 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 2023.

Road paving with asphalt

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 Infra Construction Association (ESTICA) for the years 1990–2024.

Emission factors

2.D.1 Lubricant use

According to Tier 1 the weighted average ODU factor 0.2 for lubricants is used⁹⁵.

The default carbon content for lubricants 20.0 t C/TJ was applied⁹⁶.

Emission factor 0.5896 was used for all the years.

2.D.2 Paraffin wax use

Default oxidation factor (ODU) of 0.2 and carbon content 20.0 t C/TJ were applied according to the IPCC 2006 Guidelines⁹⁷.

Emission factor 0.5896 was used for all the years.

2.D.3 Other

Urea based catalysts for motor vehicles

The default average consumption of DEF per fuel consumption is 1–3%. Estonia uses 3% when calculating emissions because Estonia wholesalers of catalyst fluid estimate that it is not under 3%.

⁹⁵ IPCC 2006 Guidelines, Volume 3, Chapter 5, page 5.9, table 5.2.

⁹⁶ IPCC 2006 Guidelines, Volume 2, Chapter 1, page 1.21, table 1.3.

⁹⁷ IPCC 2006 Guidelines, Volume 2, Chapter 1, page 1.21, table 1.3.

The emission factor consists of the concentration of urea in it (purity) and stoichiometric coefficient of conversion of C in urea into CO₂.

The emission factor is the concentration of urea in DEF (32.5%) multiplied with 0.73333 - stoichiometric coefficient for conversion of C from urea into CO₂ (44/60).
 $EF = 0.325 \times 0.73333 = 0.238332255$.

Solvent use

The main database of emission factors for NMVOC emissions is the EMEP/EEA Guidebook 2023.

Road paving with asphalt

Default NMVOC factors are taken from EMEP/EEA Guidebook 2023. 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 CO₂ 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%.

4.5.3. Uncertainty assessment and time-series consistency

For uncertainty assessment please see Annex A.II.2 IPPU, 2.D Non-energy products from fuels and solvent use chapter.

4.5.4. Category-specific QA/QC and verification, if applicable

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

2.D.1 Lubricant use

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 data from the Estonian Transport Administration. Approximately 40 000 motor scooters that are not over 20 years old (a large part of them are with 2-stroke engines) are registered in the Estonian Transport Administration. It was concluded that the use of lubricants in 2-stroke engines is marginal.

Activity data on lubricants are obtained from Statistics Estonia and Eurostat; both data sources have similar information on imports and exports.

2.D.2 Paraffin wax use

All possible CN 8-digit codes for paraffin waxes were checked from Eurostat to make sure that all of them were included.

2.D.3 Other

Urea based catalysts for motor vehicles

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

Solvent use

Normal statistical quality checking related to the assessment of magnitude and trends is carried out. Calculated emissions and emission data from the KOTKAS database are compared to previous years to detect calculation errors, errors in the reported data or in allocation of data under subcategories. The reasons behind any fluctuation in the emission figures are studied. The data reported and entered the KOTKAS database by operators are first checked by specialists from the Estonian Environmental Board and then by the specialists in the Estonian Environment Agency.

Road paving with asphalt

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

4.5.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

Recalculations were done in 2.D.3 Solvent use category in four subsectors. In 2D3a the recalculations in 2022-2023 were caused by small changes in production data. In 2D3d changes in 2020-2023 happened due to the correction of the mistake in the calculations. In 2D3g the facility reported their emissions for the year 2023. In the air pollutant emissions category 2G the changes in 1990-2023 occurred due to the changes in the amount of lubricants.

Table 4.20. Recalculations in solvent use sector in 1990-2023

Year	NMVOC emissions. kt		Difference. kt	Indirect CO2 emissions. kt		Difference. kt
	2023	2024		2023	2024	
1990	8.397585	8.39754	0.00005	18.474687	18.474588	0.00010
1991	8.958829	8.958783	0.00005	19.7094238	19.7093226	0.00010
1992	6.620016	6.620003	0.00001	14.5640352	14.5640066	0.00003
1993	6.147472	6.147455	0.00002	13.5244384	13.524401	0.00004
1994	6.839767	6.839745	0.00002	15.0474874	15.047439	0.00005
1995	7.918422	7.918387	0.00004	17.4205284	17.4204514	0.00008
1996	8.247468	8.247439	0.00003	18.1444296	18.1443658	0.00006
1997	8.284764	8.28473	0.00003	18.2264808	18.226406	0.00007
1998	8.966165	8.966119	0.00005	19.725563	19.7254618	0.00010
1999	8.44156	8.441511	0.00005	18.571432	18.5713242	0.00011
2000	7.524146	7.524057	0.00009	16.5531212	16.5529254	0.00020
2001	6.750796	6.750674	0.00012	14.8517512	14.8514828	0.00027
2002	7.287398	7.287285	0.00011	16.0322756	16.032027	0.00025
2003	7.038356	7.038245	0.00011	15.4843832	15.484139	0.00024
2004	8.552387	8.552216	0.00017	18.8152514	18.8148752	0.00038
2005	9.931198	9.931016	0.00018	21.8486356	21.8482352	0.00040
2006	11.17622	11.17626	-0.00004	24.587684	24.587772	-0.00009
2007	9.366976	9.36739	-0.00041	20.6073472	20.608258	-0.00091
2008	8.740692	8.741499	-0.00081	19.2295224	19.2312978	-0.00178
2009	6.379135	6.380077	-0.00094	14.034097	14.0361694	-0.00207
2010	5.898921	5.899991	-0.00107	12.9776262	12.9799802	-0.00235

Year	NMVOC emissions. kt		Difference. kt	Indirect CO2 emissions. kt		Difference, kt
	2023	2024		2023	2024	
2011	6.833434	6.834728	-0.00129	15.0335548	15.0364016	-0.00285
2012	7.334442	7.336128	-0.00169	16.1357724	16.1394816	-0.00371
2013	9.886264	9.888268	-0.00200	21.7497808	21.7541896	-0.00441
2014	8.933937	8.937264	-0.00333	19.6546614	19.6619808	-0.00732
2015	8.628981	8.632028	-0.00305	18.9837582	18.9904616	-0.00670
2016	8.688537	8.691877	-0.00334	19.1147814	19.1221294	-0.00735
2017	9.752342	9.755879	-0.00354	21.4551524	21.4629338	-0.00778
2018	9.351664	9.355497	-0.00383	20.5736608	20.5820934	-0.00843
2019	9.989827	9.993759	-0.00393	21.9776194	21.9862698	-0.00865
2020	10.227513	10.235648	-0.00813	22.5005286	22.5184256	-0.01790
2021	13.295041	13.303724	-0.00868	29.2490902	29.2681928	-0.01910
2022	12.701137	12.709936	-0.00880	27.9425014	27.9618592	-0.01936
2023	10.845559	10.894956	-0.04940	23.8602298	23.9689032	-0.10867

4.5.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

There are no planned category-specific improvements.

4.6. Product uses as substitutes for ODS (CRT 2.F)

In 2024 greenhouse gas emissions under the category CRT 2.F Product uses as substitutes for ODS amounted to 185.9 kt CO₂ equivalent, which was about 1.81% of the total greenhouse gas emissions in Estonia.

Under this category, Estonia reports HFC emissions from refrigeration and air-conditioning equipment (CRT 2.F.1), HFC emissions from foam blowing agents (CRT 2.F.2), HFC emissions from fire protection (CRT 2.F.3) and HFC emissions from aerosols (CRT 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.

In recent years, imports of F-gases to Estonia have decreased due to the EU phasedown (and related diminishing HFC quotas) (related to previous F-gas Regulation (EU) No 517/2014⁹⁸). In addition, wholesalers have bought more HFC-s from other EU countries. An exemption is the high-GWP R-404A which sales have fluctuated in recent years but has decreased in 2022-2024. R-404A previously was almost the only gas used in commercial refrigeration but not anymore. Imported quantities in pre-filled equipment have not decreased. Importers of pre-filled equipment purchased HFC quota authorizations mostly from companies trading with quotas and therefore this did not affect the Estonian wholesalers of HFC-s.

⁹⁸ Regulation (EU) No 517/2014, <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014R0517&from=en> (22.12.2025)

The total emissions of HFCs increased rapidly between 1993-2015, especially HFC emissions from refrigeration and air-conditioning equipment, which is the major source of halocarbons in Estonia (Figure 4.7).

As it can be seen from Figure 4.7, the increase of HFC emissions have halted two times – in 2008 and 2016-2018 reaching highest emissions in 2018. In 2024 there was a decrease in HFC emissions 2.61% % compared to 2023.

In 2008, one-component polyurethane foams with R-134a were banned by Regulation (EU) No 842/2006⁹⁹ and large foam producers in Estonia replaced propellant R-134a (GWP 1300, AR5) with R-152a (GWP 138, AR5), which has a significantly lower GWP, thus emissions decreased sharply. This has been elaborated in 4.6.2. Methodological issues under ‘One-component PU foam’. HFC use and emissions also declined in 2008 due to the global economic recession that affected Estonia severely.

The reason for a halt in emissions growth in 2016 was that fewer new commercial and industrial refrigeration equipment were installed. The probable cause for this could be the EU HFC phasedown and other restrictions of Regulation (EU) No 517/2014 on placing on the market certain commercial refrigeration systems with high-GWP HFCs (GWP 2500 and more) and ban to top up existing equipment with virgin HFCs with a GWP 2500 and more.

The cause for the second halt in emissions growth in 2016-2018 is the effect of the EU HFC phasedown and other restrictions of Regulation (EU) No 517/2014 on placing on the market certain commercial refrigeration systems with high-GWP HFCs (GWP 2500 and more) and ban to refilling existing equipment with virgin HFCs with a GWP 2500 and more. Since the refilling ban in 2020 the service companies reported much lower refilling rates and explain that the most leaking equipment has been decommissioned, and that only minimal amounts of refrigerants needed for functioning were filled into equipment. Hence the steep decrease in HFC emissions in 2020. There has been an increase in emissions in 2021-2022 because decommissioning emissions of 15 years old equipment consisting of higher amount of F-gases than in previous years. The emission factor of decommissioning older equipment is 50% (from the amount of F-gases filled into equipment originally). In 2023-2024 there was a decrease in emissions, because there were less amounts of HFCs in decommissioned equipment reaching their end-of-life emissions.

Since 2015, alternative and lower GWP refrigerants, e.g., CO₂-based systems for larger commercial systems have increasingly gained market in Estonia and the stock of HFCs has declined. In 2020 a quarter of supermarkets had CO₂ equipment (this information is based on data collected from service companies for the GHG inventory; for methods, please see section 4.6.2. Methodological issues).

Concerning industrial refrigeration, the Regulation (EU) No 517/2014 did not impose such strict bans on HFC-s like for commercial refrigeration equipment. That is the main reason why the decrease of R-404A stock and emissions have been slower than in commercial refrigeration. New F-gas Regulation (EL) 2024/573 does not distinguish commercial or industrial use in the bans of placing on the market.

In mobile air conditioning the MAC Directive’s (2006/40/EC) ban on bringing onto market new passenger cars and vans with HFC-134a in their air conditioners since 2017 has had a pronounced effect on emissions.

⁹⁹ Regulation (EC) No 842/2006, <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32006R0842&from=EN> (22.12.2025)

HFC emissions from the A/C and HP sector have not decreased yet but use of lower GWP refrigerant R-32 is slowly increasing. There has been an increase in the emissions due to installation of additional heat pumps each year and therefore more heat pumps in total are in operation leading to higher emissions occurring from the operation. Emissions from the stationary air-conditioning have been increasing continuously from 1995 from 0.03 kt CO₂ eq. to 41 kt CO₂ eq. in 2024.

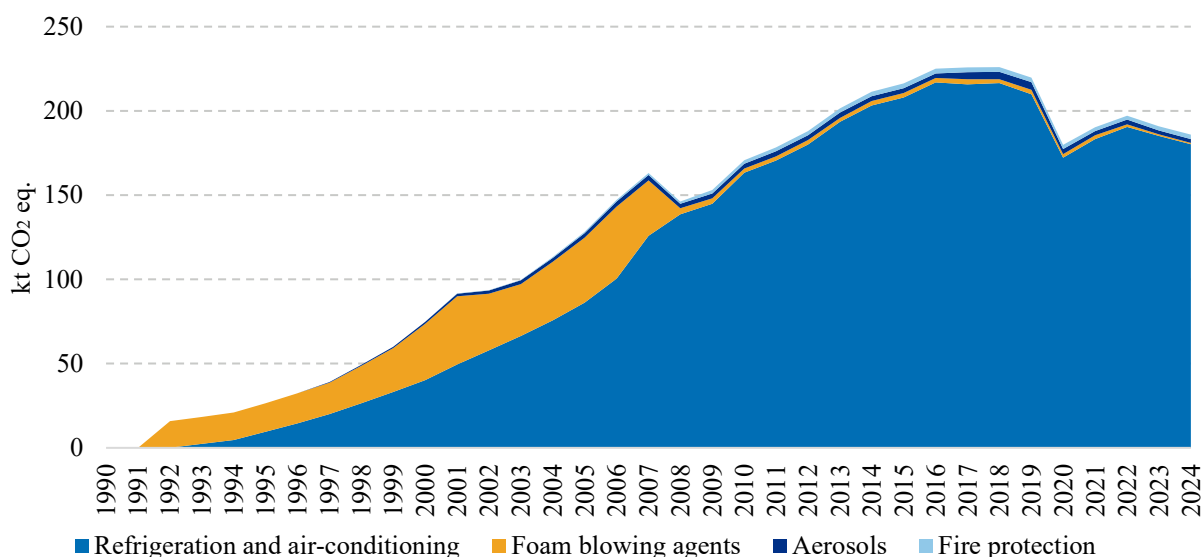


Figure 4.7. Actual emissions of HFCs by subcategory in 1990–2024, kt CO₂ equivalent

4.6.1. Category description

2.F.1 Refrigeration and air-conditioning

Refrigeration and air-conditioning (RAC) are responsible for about 97.0% of the Estonian F-gas emissions (180.21 kt CO₂ eq. in 2024). The important subsectors are:

- Commercial refrigeration (refrigeration units of supermarkets and smaller shops, restaurants etc.);
- Domestic refrigeration (fridges and freezers for domestic use);
- Industrial refrigeration (refrigeration units in the food and other industries);
- Transport refrigeration (refrigerated vehicles and reefer containers);
- Stationary air-conditioning (heat pumps and room air-conditioning systems);
- Mobile air-conditioning (AC systems for passenger cars, trucks, buses, ships, railcars, wheel tractors/mobile machinery).

2.F.1.a Commercial refrigeration (CRT 2.F.1.a)

Commercial refrigeration and its main subsector, 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 centralised 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). About one quarter of supermarkets are equipped with new CO₂ systems. The main HFC refrigerant in other supermarkets is R-404A, but also R-448A, 449A, R-134a (the latter 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). The main HFC refrigerants are R-134a and R-404A.
- 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's HFCs are dominated by the refrigerants R-404A, which make 84% of the 2024 HFC stock (mostly used in supermarket systems), R-134a – about 10% (mainly used in vending machines, small shops and restaurants), R-407F – 3% (substitute for R-404A) and R-448/R-449 (combined, same GWP) – 2%.

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, hotels, restaurants, canteens, etc.) was 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 beverages and other goods (stand-alone equipment) was estimated at ca 15 000 units.

The amount of R-404A, R-134a and R-407C filled in new equipment in 2009 was decommissioned according to 15 years lifetime in 2024.

Total HFC emissions from commercial refrigeration in 2024 amounted to 14.57 t (51.95 kt CO₂ eq.) as shown in Table 4.21.

Table 4.21. HFC emissions by HFC components from commercial refrigeration

HFC	Filled in new equipment, t	Emissions (filling), t	Stock, t	Emissions. (stock), t	Remaining at decommissioning, t	Emissions from disposal, t	Total emissions, t	Total emissions, kt CO ₂ eq.
HFC-32	0.03	0.0001	2.9	0.34	0.01	0.004	0.35	0.23
HFC-125	0.19	0.001	27.8	3.27	5.44	2.72	5.99	18.99
HFC-134a	0.06	0.0006	15.9	1.67	0.53	0.27	1.94	2.52
HFC-143a	0.06	0.0003	28.9	3.4	5.78	2.89	6.29	30.20
HFC-152a	NO	NO	NO	NO	NO	NO	NO	NO
Total							14.57	51.95

2.F.1.b Domestic refrigeration

Refrigerators (fridges and freezers) for domestic use that are containing HFCs are not manufactured in Estonia but were imported from 1993–2009 (new and second hand). To some degree, R-134A was used as a refrigerant and in foam insulating gas. R-134A as a refrigerant was introduced by industry at the end of 1993 as a replacement for CFC-12. In the following years, its replacement by R-600A (isobutane), which is a functional replacement for refrigerants

R-12, R-22 and R-134A in this category, started in some countries (e.g., 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 stock of domestic refrigeration equipment consists of all the afore-mentioned types of refrigerants.

2.F.1.c Industrial refrigeration

Industrial refrigeration is a big application sector of fluorinated greenhouse gases, mainly of HFC blend R-404A. The dominant application area is the food industry (fish, meat, dairy, beverage industries, breweries, etc.), which is Estonia's one of the most important industrial sectors. 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 NH₃ – play a major role. The number of industrial refrigeration systems operating with NH₃ is ca 50 while the number of these containing more than 250 kg HFCs is in the same magnitude. Regarding the HFC stock, R-404A is still the prevailing refrigerant with about 79.8% of the stock. HFC-134a makes up 4.5% of the stock, R-407F 3.1% and R-407C 2.9%. Other HFC refrigerants (R-410A, R-422A, R-422D, R-448A etc.) are of minor importance. The new equipment is with lower GWP HFC-s R-448A, R-452A and R-134A.

In between years 2010 and 2011 significant inter-annual changes occurred for HFC-143a filled into new manufactured products for industrial refrigeration. The Expert Review Team (ARR2022/I.4) recommended to include the explanation for this change. In 2011 one bigger servicing company reported in their questionnaire that they filled in 3.66 t of HFC-404a into the new equipment of their industrial clients (food industry). As HFC-143a is 52% of HFC-404a blend therefore the amount of HFC-143a were significantly higher. In 2010 the reported amounts of R-404a filled in into new equipment were significantly lower.

The refrigeration systems are very often serviced by bigger service companies. However, self-maintenance and cooperation with smaller (locally based) service companies are more used compared to the supermarket and food retail sectors.

The amount of R-404A, R-134a and R-407C filled in new equipment in 2009 was decommissioned according to 15 years lifetime in 2024.

In 2024, total HFC emissions from industrial refrigeration amounted to 8.93 t (30.85 kt CO₂ eq.) as shown in Table 4.22.

Table 4.22. HFC emissions by HFC components from industrial refrigeration

HFC	Filled in new equipment, t	Emissions (filling), t	Stock, t	Emissions. (stock), t	Remaining at decommissioning, t	Emissions from disposal, t	Total emissions, t	Total emissions HFC, kt CO ₂ eq.
HFC-32	0.15	0.001	4.62	0.42	0.01	0.003	0.42	0.29
HFC-125	0.04	0.0002	39.47	3.59	0.65	0.33	3.92	12.42
HFC-134a	0.98	0.005	11.23	1.02	0.15	0.08	1.10	1.43
HFC-143a	NO	34.05	34.05	3.10	0.76	0.38	3.48	16.71
HFC-152a	NO	NO	NO	NO	NO	NO	NO	NO
Total							8.93	30.85

2.F.1.d Transport refrigeration

Total HFC emissions from transport refrigeration was 22.50 kt CO₂ eq. in 2024 as shown in Table 4.23.

Table 4.23. HFC emissions by HFC components in transport refrigeration (refrigerated vehicles and reefers)

HFC	All the emissions, t		All the emissions, kt CO ₂ eq.		Total emissions, t	Total emissions, kt CO ₂ eq.
Category	Refrigerated vehicles	Reefer containers	Refrigerated vehicles	Reefer containers	Both categories	Both categories
HFC-32	0.063	0.0004	0.042	0.00029	0.063	0.043
HFC-125	3.17	0.071	10.06	0.23	3.24	10.29
HFC-134a	0.30	0.70	0.38	0.91	0.99	1.29
HFC-143a	2.19	0.081	10.49	0.39	2.67	10.88
Total	5.72	0.85	20.98	1.52	6.57	22.50

In this category and in the table above the emissions of refrigerated vehicles and reefer containers are additionally calculated separately in the following subparagraphs.

Refrigerated vehicles

As of 31.12.2024, 1573 refrigerated vans and trucks and 1067 refrigerated trailers were registered in Estonia. Most of these vehicles are second-hand vehicles imported from Western Europe. Many of the refrigeration units fitted to the imported second-hand trucks and trailers are replaced with new pre-filled equipment but some are refilled within the country. Mostly pick-up trucks are fitted with empty refrigeration units first in Estonia and first filled in the country. The refrigerants in use are R-452A in all types of vehicles, R-134a in the case of vans and smaller trucks, and the blend R-404A in bigger trucks and trailers.

According to national experts, the lifetime of refrigerated vehicles is about 10 years.

Total HFC emissions from refrigerated vehicles amounted to 5.72 t (20.98 kt CO₂ eq.) in 2024 as shown in the table above (Table 4.23).

Reefer containers

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. Consequently, 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. According to the World Trade Organization, Estonia's share in the world trade amounted to 0.084% in 2024¹⁰⁰, thus Estonian reefer containers constituted 0.084% of the world HFC stock and HFC emissions of the worldwide reefer container fleet in the same year.

The lifetime for reefer containers is according to experts about 14 years.

Total HFC emissions from reefer containers amounted to 0.85 t (1.52 kt CO₂ eq.) in 2024 as shown in the table above (Table 4.23).

2.F.1.e Mobile air-conditioning (CRT 2.F.1.e)

Total MAC HFC emissions from mobile air-conditioning in 2024 amounted to 32.73 kt CO₂ eq. as shown in Table 4.24.

¹⁰⁰ World Trade Organization database, <https://stats.wto.org/> (22.12.2025)

Table 4.24. HFC emissions by HFC components from mobile air-conditioning

HFC	All the emissions, t						Total emissions, t	Total emissions, kt CO ₂ eq.
Category	Passenger cars	Trucks	Buses	Ships	Rail-cars	Wheelcars and mobile machinery		
HFC-32	NO	NO	NO	0.72	NO	NO	0.72	0.49
HFC-125	NO	NO	NO	0.90	NO	NO	0.90	2.84
HFC-134a	6.84	3.508	3.93	3.14	0.003	4.58	22.00	28.60
HFC-143a	NO	NO	NO	0.13	NO	NO	0.13	0.61
HFC-227ea	NO	NO	NO	0.053	NO	NO	0.053	0.18
Total	6.84	3.508	3.93	4.97	0.003	4.58	23.83	32.73

Passenger cars

In Western Europe, systematic air-conditioning (A/C) of passenger cars with refrigerant HFC-134A started in 1994. As the lifetime of passenger cars is estimated to be 12 years, most cars are supposed to have an air conditioner. According to EU directive 2006/40/EC (MAC Directive), since 1 January 2017, the air conditioning systems of new types of M₁ and N₁ category vehicles placed on the EU market shall be filled with a refrigerant that has a GWP 150 or less. The most common refrigerant meeting this criterion is HFO-1234yf. Type approval end of series vehicles were exempted until end 2018. Individually reconstructed vehicles approvals allow A/C with HFC-134A in the future. New cars with HFO-1234yf were already marketed in Estonia in 2013–2014 and their proportion has increased until 100% in 2019.

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 at 10%.

Total MAC HFC emissions from passenger cars in 2024 amounted to 6.84 t (8.89 kt CO₂ eq.).

Trucks

In Western Europe, systematic air-conditioning of trucks with the refrigerant R-134a had started in 1994/95. Therefore, about half of Estonian trucks are potentially air-conditioned. Equipment of these newer vehicles with air-conditioners is relatively high – 79-100% of new trucks depending on the category.

Total MAC HFC emissions from trucks in 2024 amounted to 3.508 t (4.561 kt CO₂ eq.).

Buses

In Western Europe, the large-scale use of buses with HFC-134a A/Cs (air conditioners) started in 1995. Most Estonian buses were built in 1995 or later and are therefore potentially equipped with HFC containing A/Cs. The proportion of newer buses with A/Cs is relatively high (e.g., ca 74% of buses initially registered in 2011–2020). The relevant MAC (mobile air conditioners) 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. MAC systems in buses are big, containing 10-18 kg of refrigerant. The emission rate is high mainly because of the up to 50 meters long refrigerant pipes but also due to vibration.

Total MAC HFC emissions from buses in 2024 amounted to 3.93 t (5.11 kt CO₂ eq.).

Ships

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. The refrigerants in use are R-407C, R-404A, R-407F, R-507A, R-442A and HFC-134a. Other HFC refrigerants (R-427A, R-417A, R-434A, R-438A) 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-407F, R-404A, R-407C). The cooling and freezing systems of most Estonian deep-sea freezer trawlers operate without HFC, instead, ammonia is used.

In 2024, the total MAC HFC emissions from ships amounted to 4.97 t (8.21 kt CO₂ eq.).

Railcars

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 1.30 kg to 11.09 kg.

Total MAC HFC emissions from railcars in 2024 amounted to 3.27 kg (0.0043kt CO₂ eq.).

Wheel tractors and mobile machinery

The first agricultural machines (wheel tractors, combine harvesters) equipped with mobile air-conditioners on the Estonian market were sold in 1997/1998. Regarding construction machines (excavators, loaders) and other mobile machinery (forestry vehicles, roadwork machines) A/C equipment appeared later, in 2000.

The A/C equipment quota of the new agricultural machines has been estimated to be at least 75% since 2005.

The refrigerant used was 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 2.3 kg. The emission rate is high due to the powerful vibration of these machines causing amongst others the connections in the MAC system to become loose.

In 2024, the total MAC HFC emissions from wheel tractors and mobile machinery amounted to 4.58 t (5.96 kt CO₂ eq.).

2.F.1.f Stationary air-conditioning

Total HFC emissions from stationary and room air-conditioning in 2024 amounted to 24.77 t (40.83 kt CO₂ eq) including emissions from heat pumps and stationary and room air-conditioning. Activity data and emissions from these equipments are shown in Table 4.25.

Table 4.25. Activity data and emissions from the heat pumps and stationary and room air-conditioning in 2024

HFC	Filled in new equipment, t	Emissions (filling), t	Stock, t	Emissions. (stock), t	Remaining at decommissioning, t	Emissions from disposal, t	Total emissions, t	Total emissions HFC, kt CO ₂ eq.
HFC-32	5.92	0.001	247.85	8.98	2.57	0.77	9.75	6.6
HFC-125	0.90	0.001	164.36	7.04	2.75	0.82	7.86	24.9
HFC-134a	20.00	0.01	227.21	4.78	7.91	2.37	7.15	9.3
Total							24.77	40.83

Heat pumps

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, older air heat pumps with HFC-410A and the newer ones with R-32. In general, heat pumps are imported to the country and are already charged with refrigerant. In 2024, no heat pumps were manufactured and filled with refrigerant in Estonia.

Total HFC emissions from heat pumps in 2024 amounted to 6.79 t (10.68 kt CO₂ eq.).

Stationary and room air-conditioning

Stationary and room air-conditioning systems including chillers, ventilation and split systems are generally imported to Estonia. Split systems are imported prefilled with HFC, newly installed chillers and ventilation systems are first filled inside the country. In these cases, emissions from filling (manufacturing) must be considered. The most common refrigerant used for new chillers is R-134a and most chillers contain it. Some new chillers are installed with R-410A and some with R-1234ze. In older equipment, smaller amounts R-407C remains, whereas in newer equipment R-410A can be found. The usual refrigerants for ventilation systems and split systems are mainly R-410A. In 2018 the first split systems with R-32 came to the Estonian market and now the majority of new equipment is with this refrigerant.

As 1995 was the starting point of using HFCs in stationary air-conditioning equipment in Estonia, the first decommissioning emissions occurred in 2010.

Total HFC emissions from heat pumps in 2024 amounted to 17.98t (30.18 kt CO₂ eq.).

2.F.2 Foam blowing agents

Total HFC emissions from foam blowing agents in 2024 amounted to 4.19 t (0.81kt CO₂ eq.) as shown in the Table 4.26.

Table 4.26. HFC emissions by HFC components from foam blowing agents

HFC/ Category	All emissions, closed cells foams, t			All the emissions, open cells foams, kt CO ₂ eq.		Total emissions, t	Total emissions, kt CO ₂ eq.
	PU insulation panels, t	Spray and injection PU foam, t	XPS insulation foam, t	One component PU foam	PU integral skin foam		
HFC-134a	0.071	0.00027	0.051	NO	NO	0.12	0.16
HFC-227ea	NO	0.0069	NO	NO	NO	0.069	0.023
HFC-365mfc	NO	0.11	NO	NO	NO	0.11	0.086
HFC-152a	NO	NO	NO	3.96	NO	3.96	0.55
Total	0.071	0.11	0.051	3.96	NO	4.19	0.81

In this category and in the table above the emissions are additionally calculated separately according to the type of the foam.

2.F.2.a Closed cells

Total HFC emissions from closed cell foams in 2024 amounted to 0.24 t (0.27 kt CO₂ eq.).

PU insulation panels

In 2024, 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/CO₂ reaction. The only manufacturer of industrially prefabricated insulation panels for buildings (some type of sandwich element) combining PU spray foam with polystyrene changed the blowing agent in 2004 from HCFC-141b to CO₂/water and methyl formate. From 1998 onwards, a certain amount of PU sandwich elements manufactured with HFC-134a as a 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.

Spray and injection PU foam

PU spray foam systems are used for in-site insulation of buildings and soil-laid heating pipes. This sector of on-site insulation with spray and respectively injection foam blown with HFC-365mfc (with HFC-227ea add-on to reduce the flammability) is small. In Estonia HFC-containing spray foam was used in 2006-2008 and 2017-2019. For the period 2009-2018 I who sold this foam were interviewed and they answered that they sold water- or air- or HFO-based foams.

The inventory compilers in Estonia have searched for enterprises who insulate buildings with spray polyurethane foam and manufacturers of polyurethane (PU) foam products. The companies reported that they use air as a propellant.

XPS insulation foam

The 2024 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 CO₂. The main XPS suppliers to the Estonian market are using CO₂. One international manufacturer currently using both CO₂ and HFC-134a blowing agents supplies the Estonian market from a Scandinavian factory with CO₂ 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. There is data from producers that in case of HFC-134a some 27% of the blowing agent is released to the atmosphere on manufacturing ($EF_{\text{manu}} = 27\%$). Therefore, 73% of the blowing agent remains in the panels as insulating cell gas, in the long term. Thus, in Estonia, a HFC bank in the XPS board stock was considered as a source of domestic emissions.

2.F.2.b Open cells

Total HFC emissions from open cell foams in 2024 amounted to 3.96t (0.55 kt CO₂ eq.).

One component PU foam

Estonia is amongst the biggest polyurethane one-component foam (OCF) producers in the EU. To a considerable part, the propellant gases in the foam cans are HFCs (R-152a) that are added to halogen-free flammable gases. By far most of the domestically used fluorinated greenhouse gases (HFCs) are imported for filling more than 4.5 million 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 a lesser

degree – foreign companies. Due to the restrictions of one 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 R-134a in the EU, using mainly hydrocarbons instead, but also R-152a for some special applications. In 2010–2012, one Estonian producer manufactured OCF with R-134a as propellant but all the R-134a products were exported from the EU. From 2013 onwards R-134a has not been used in OCF production in Estonia and no emissions have occurred.

Total HFC emissions from One component PU foams in 2024 amounted to 3.96t (0.57 CO₂ eq.).

PU integral skin foam

In Estonia, the PU Integral Skin Foam production started in 2004 with HFC-365mfc. Beforehand, ozone-depleting HCFC-141b was used, which is no longer allowed from 2004 onwards. All blowing agents applied in manufacturing are 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 2010–2024, PU Integral Skin Foam was neither manufactured nor used in Estonia, thus no emissions were occurring.

2.F.3 Fire protection

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 CO₂, and furthermore HFC-23.

The popularity of HFCs in fire protection systems has a decreasing trend and in the last six years no or very little new systems were installed. HFC-23 in fire extinguishing system was banned by the Regulation (EU) no 517/2014 in 2018. Another reason for decreasing popularity is that HFCs are much more expensive than environmentally friendlier substances for firefighting in indoor flooding systems (e.g., nitrogen, argon). The latter are characterized as gases under pressure of 200-300 bar. Compared to them, the advantage of HFCs is their lower pressure (30-50 bar) and that is one reason why in some applications HFC-s could be a better choice for smaller rooms where the higher pressure of e.g., argon could cause damage. Another alternative is Novec 1230 extinguishing fluid with GWP 1 and pressure of ca 30-40 bar. HFCs for fire protection are still popular on aircraft and some military vehicles.

HFCs for fire protection 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 on site does normally not take place. Emptied cylinders are replaced by full cylinders.

Total HFC emissions from fire protection in 2024 amounted to 0.61 t (2.67 kt CO₂ eq.) as shown in the Table 4.27.

Table 4.27. HFC emissions by HFC components from fire protection equipment

HFC	Filled in new equipment, t	Emissions (filling), t	Stock, t	Emissions (stock), t	Remaining at decommissioning, t	Emissions from disposal, t	Total emissions, t	Total emissions, kt CO ₂ eq.
HFC-23	NO	NO	3.80	0.08	NO	NO	0.08	0.94
HFC-125	NO	NO	0.15	0.0030	NO	NO	0.030	0.0095
HFC-134a	NO	NO	1.31	0.03	NO	NO	0.03	0.034
HFC-227ea	NO	NO	25.10	0.50	NO	NO	0.50	1.68
Total							0.61	2.67

2.F.4 Aerosols

Total HFC emissions from aerosols in 2024 amounted to 1.66 t (2.16kt CO₂ eq.) as shown in Table 4.28.

Table 4.28. HFC emissions by components from aerosols

HFC	Filled in new equipment, t	Emissions (filling), t	Stock, t	Emissions (stock), t	Total emissions, t	Total emissions, kt CO ₂ eq.
HFC-134a	0.52	0.02	1.65	1.65	1.66	2.16
HFC-227ea	NO	NO	NO	NO	NO	NO

2.F.4.a Metered dose inhalers

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.

2.F.4.b Technical aerosols

R-134a is used as a 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 placing on the market of novelty aerosols such as signal horns for sports events or hunting. The Estonian manufacturer stopped producing signal horns in 2009. Solvent and cleaning sprays with R-134a were imported until 2010. The use of HFC-134a in solvent and cleaning sprays then stopped in Estonia due to supplier exchange and changes in product prescription. Placing technical aerosols containing HFC-s with GWP value of 150 or more on the EU market has been banned since 2018.

4.6.2. Methodological issues

Choice of methods

The first assessment of F-gas consumption in Estonia was made in 2006 under 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). 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 in detail. The methods developed during the Twinning Project are used until today and the validity of the methods is evaluated each year with quality assessment activities.

Compiling of the Estonian F-gas inventory is bottom-up orientated. The main sources of information are manufacturers and traders of F-gas containing equipment and products, bulk F-gas suppliers as well as consumers of such goods in industry and tertiary sector and the F-gas trade itself, including experts from domestic and international companies, from associations and public institutions (e.g., Statistics Estonia, Estonian Transport Administration etc.).

Data collection and examination of data quality is carried out in 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).

In the Product uses as substitutes for ODS categories 2.F.1, 2.F.2 and 2.F.4 the method used is Tier 2a with country-specific determination of EF as described in the IPCC 2006 Guidelines.

Activity data

Refrigeration and air-conditioning (CRT 2.F.1)

2.F.1.a Commercial refrigeration

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. Stock and refilling data was collected from a national database of F-gas equipment set up according to Regulation (EU) 517/2014 (named 'FOKA' database). The 2024 stock data (63.75 t of HFC) had to be completed by the estimation of the stock by supplementary 1.67 t which makes a total sum of 65.42 t of HFC. This estimated amount should also cover small shops, whose HFC stock is under-represented in databases. The estimation is conservative and low with the aim not to overestimate the stock.

The total amount of HFC refrigerants was 76.11 t for the 2024 stock of supermarkets and small shops (reported and estimated) and includes non-HFC components of refrigerant blends, e.g., R-448A, R-449A. Refrigerant from decommissioned equipment is mostly re-used for servicing the remaining equipment or sometimes sent for destruction.

Restaurants, etc.: The stock of HFC refrigerants in restaurants, canteens and similar institutions was estimated based on some of 4825 possible clients (with on average three devices with a refrigerant charge of 350 g/device), resulting in about 5.07t of HFC- and HC-refrigerants. Estonian experts estimated that R-404A constituted 30% (1.52 t) and R-134a 33% (1.65t) in this subcategory. The share of other HFC refrigerants (R-422A, R-422D, R-452A) is ca 4%. The rest of the stock (1.70t) consists of HC-refrigerants.

The number of vending machines in Estonia (ca 13 000 at 250 g refrigerant) was extrapolated based on the data from the three biggest Estonian manufacturers and importers of beer and other beverages delivering such machines to Estonian shops. A large percentage of them are already HFC free with R-290. The HFC-charge in vending machines amounted to 2.33t of R-134a and 0.26 t of R-404A, respectively.

According to the above experts, the lifetime of refrigeration systems in supermarkets and small shops, including kitchen systems in Estonia is on average about 15 years (in case of vending machines 5–10 years).

2.F.1.b Domestic refrigeration (CRT 2.F.1.b)

According to Statistics Estonia, there were about 655 500 households in Estonia in 2024. The number of domestic refrigerators was estimated at 650 256 and the number of newly imported fridges/freezers was received from the Register of Products of Concern (abbreviation: PROTO) and the Estonian Association for Recycling of Electrical and Electronic Equipment (EES Ringlus) by the Estonian Environment Agency).

The stock of HFC-134a containing fridges/freezers is based on the estimation of HFC-134a containing fridges/freezers decommissioned in 2024 which in turn is estimated via lifetime. The average lifetime of fridges/freezers was estimated to be 9 years in 2024. The stock of domestic refrigerators consists of equipment with isobutane (R-600A), HFC-134A, and even CFC-s (e.g., R-12).

Wholesalers and EES Ringlus estimated the lifetime of domestic refrigeration equipment as follows: isobutane – 5-8 years, HFC-134A – up to 15 years, HCFC – up to 25–30 years. In the waste refrigerant removed from the fridges in 2019-2024 there was no more HCFC. The proportion of HFC-134A containing refrigerators brought to market was maximally 1% each year in 2006-2009. Since the lifetime of HFC-134a containing fridges is 15 years, new equipment of the years 2006-2009 is accounted in the stock. Since only 1% of new fridges brought to market in 2006-2009 were with HFC-134a, it could be concluded that the stock of HFC-134A is nearing to zero.

2.F.1.c Industrial refrigeration (CRT 2.F.1.c)

Information on potential HFC users in the food and other industries was compiled in cooperation with experts from refrigeration service providers/companies specialised in industrial application. Activity data was collected from FOKA database and also previous years' data from questionnaires was used. Basic data about the Estonian food industry can be found in the statistics of the Agriculture and Food Board (PTA¹⁰¹) as companies handling foodstuff shall be approved by the PTA and the data is available online.

As the refrigerant stock based on the data from service companies and the national PTA database covers the total stock to only a certain part, the remaining stock had to be estimated by the inventory compilers in cooperation with national sectoral experts. Thus, the estimated percentage of HFC stock in industrial refrigeration was estimated to constitute 4.3% or 3.78 t of the total HFC stock of 85.16t (reported and estimated, including non-HFC ingredients of some refrigerant blends, e.g., R-448A, R-422D, etc.).

According to the national sectoral experts, the average lifetime of industrial refrigeration systems in Estonia is about 15 years or more. Therefore, calculating 15 years back, the amount of R-404A, R-134a, R-407C filled in new equipment in 2009 was decommissioned in 2024.

Calculating refrigerants in pure forms and in blends

Table 4.29 shows as an example how the amounts of refrigerants are calculated in pure forms and in blends that sum up in table 2(II)B-Hs2 in case of R-134a (Industrial refrigeration). Information about these calculations of certain F-gases in pure forms and in blends was asked additionally by 2022 UNFCCC review team and added thereafter as a table to clarify more in detail the recalculations of 2019 data that was reported in 2022 submission.

¹⁰¹ Database of Agriculture and Food Board, <https://jvis.agri.ee/jvis/avalik.html#/toitKaitlemisettevotedparing> (22.12.2025)

Table 4.29. R-134a amounts calculated in pure forms and in blends.

HFC	Filled in new manufactured products	In operating systems (average annual stocks)
HFC-134a (in pure form)	1.2	4.98
HFC-404A (blend)	0.16	66.02
HFC-143a	0.08	34.33
HFC-125	0.07	29.05
HFC-134a	0.01	2.64
HFC-407C (blend)	0	3.54
HFC-134a	0	1.84
HFC-32	0	0.81
HFC-125	0	0.89
HFC-407F (blend)	0.16	1.96
HFC-134a	0.06	0.78
HFC-32	0.05	0.59
HFC-125	0.05	0.59
HFC-422A (blend)	NO	0.59
HFC-125	NO	0.5
HFC-134a	NO	0.07
HFC-422D (blend)	NO	0.46
HFC-125	NO	0.3
HFC-134a	NO	0.14
HFC-417A (blend)	NO	0.3
HFC-125	NO	0.14
HFC-134a	NO	0.15
HFC-448A (blend)	0.2	0.22
HFC-32	0.05	0.06
HFC-125	0.05	0.06
HFC-134a (blend)	0.04	0.05
HFC-134a (In pure form and in blend)	1.31	10.66 (4.98+2.64+1.84+0.78+0.76+0.07+0.14+0.15+0.05)
	(1.20+0.01+0.06+0.04)	

2.F.1.d Transport refrigeration (CRT 2.F.1.d)

Refrigerated vehicles

The Estonian Transport Administration provided a list of all vehicles registered at the end of 2024, subdivided into weight classes (N₁, N₂, and N₃ according to Regulation 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, all linked to the leading international manufacturers of refrigeration units for trucks and trailers. The service companies provide the amount of refrigerants filled into the equipment of first registered vehicles 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 and R-452A systems (average charge 2.0 kg/unit), bigger trucks (half of class N₂ and class N₃) run equipment with R-404A and new lower-GWP refrigerant R-452A (average charge 5.8 kg/unit). For trailers, an average charge of 8.0 kg of R-404A and R-452A is supposed. The

proportion of different refrigerants in stock is estimated by service companies. Over 70% of vehicles still have R-404A based refrigeration systems and a lower proportion have R-452A and R-134A.

Reefer containers

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, our research into the 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 online¹⁰²;
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 lifetime for reefer containers is according to experts about 14 years.

2.F.1.e Mobile air-conditioning

Passenger cars

The Estonian Transport Administration provided a list of all passenger cars registered at the end of 2024, subdivided into production years (dating back to 1994 and beyond). In 2024 no cars with HFC-134a were registered in accordance with the EU directive 2006/40/EC (MAC Directive).

In 2024, there were 622 066 passenger cars in the traffic register kept by Estonian Transport Administration.

From 2006 onward Estonia has used country-specific number of new makes and models of cars for cross-checking of congruence with German new car fleet. In addition, incomplete data on HFO-1234yf for mobile air conditioning in passenger cars in 2014 was used for the validation of German data. There was congruence between new car makes and models of Estonian and German car fleets. For this reason, German quota and charges for HFC-134a were used before 2016. The Estonian MAC charges were considered 2% smaller than the analogous German charges.

Detailed German data on new cars using HFC-134a (charged amounts and share of use) could not be shared with the Estonian inventory compiler for 2016 and subsequent years owing to confidentiality reasons. Using German data without validation was out of question because it would have caused an inaccuracy in estimation. In consequence of lack of German data, Estonian country-specific data was collected for the years 2016-2018. Data was collected from all car brands importers in Estonia.

Significant differences were identified in the share of HFC-134a in German and Estonian new cars in 2016 (e.g., for 2016 the Estonian HFC-134a share was 54 per cent while in Germany the share was 43.7 per cent). Collecting country-specific data for 2016–2017 from Estonia's car sellers enabled it to use more accurate data compared to using German data without validation. This also enabled to avoid errors at the end of the time series regarding the share of cars with

¹⁰² „Lessors maintain a positive mood“, World Cargo News. [www] <https://www.worldcargonews.com/container-industry/2021/02/lessors-maintain-a-positive-mood/> (22.12.2025)

HFC-134a, which could have been purchased according to article 27 of the EU directive 2007/46/EC.

The Association of Estonian Car Dealers (AMTEL) gave an expert opinion that both validated German data and Estonian-specific data in 2016-2018 have minimal error and therefore guarantee best consistency of time series that is possible.

In 2017-2018, only end of series vehicles with HFC-134A were placed on the Estonian market according to article 27 of the Directive 2007/46/EC. In 2019 no cars with HFC-134a were brought onto market according to the Association of Estonian car Dealers (AMTEL).

Trucks

The Estonian Transport Administration provided a list of all trucks registered at the end of 2024, subdivided into weight classes (N_1 , N_2 , and N_3), makes, models and production years dating back to 1995 and beyond. No official data about air conditioning was available.

In 2024, there were about 125 700 trucks of the weight classes (according to 2002/16/EC) N_1 , N_2 , and N_3 in the national vehicles' registry of Estonia (including vehicles with suspended registry entry).

As the 2006 investigation results had shown 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 N_1 , N_2 , and N_3 trucks in the country. The same truck models as in Germany were identified in the Estonian truck park for each weight category (N_1 , N_2 , N_3). 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 N_1 , N_2 and N_3 trucks in Estonia result from the extrapolation of model values according to the share that these models have in the total Estonian fleet, by the three different weight classes N_1 , N_2 and N_3 .

In 2020 and onwards, Estonian specific data on A/C charges and quota of N_2 and N_3 category vehicles was collected from Estonian truck sellers and used in calculation. None of the N_1 category vehicles had HFC-134a in their air conditioners because of the ban of such new registrations according to the Directive 2006/40/EC.

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 0.77 kg to 1.2 kg, the emission rate is 10–15% depending on the weight class.

Buses

The Estonian Transport Administration provided a list of all buses registered at the end of 2024 (M_3 category), subdivided into makes, models and production years dating back to 1992 and beyond. Data on the city-intercity-tourist bus split were not included, nor is there official data available about air conditioning.

In 2024, 3867 buses were in the national vehicles register of Estonia (including vehicles with suspended registry entry). A large part of the Estonian bus fleet consists of second-hand vehicles from Western Europe.

Several big national and local bus operators were interviewed in 2020 about the MAC data of their fleet and 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)¹¹ in consequence of the extensive importation of second-hand vehicles from there.

Ships

Ships under the Estonian flag with GT 100 or more and fishing vessels >18 m is listed in the Estonian Ship Register (Estonian Transport Administration). Data on AC and provision cooling systems of these ships and additionally data on all ferries of the two relevant Estonian ferryboat companies were collected from the operating companies via reporting forms. The data on the type of refrigerant, charge and refilling in 2024 were provided directly by the ship owners. The estimation of the stock emissions is based on the average refilling rate.

According to the Estonian Transport Administration, tugboats >100 GT have no air-conditioning devices.

Railcars

The Estonian Technical Regulatory Authority was contacted to establish the size of the countrywide railcar fleet.

In 2024, there were 158 railcars and engines in the Estonian fleet equipped with a working air conditioner.

For obtaining MAC data in Estonian railcars local rail operators involved in passenger transport were interviewed in 2020. Dining cars, sleeping cars and coaches of international trains (historically) had much higher refrigerant charges (30 kg) than standard cars (average 11.09 kg). The average charge in engines MAC is 0.68 kg.

Wheel tractors and mobile machinery

The Estonian Transport Administration provided a list of all wheel tractors and mobile machinery registered at the end of 2024. Official data about air-conditioning of the vehicles was not available.

In 2024, there were 31 577 wheel-tractors and 8781 mobile types of machinery in the national vehicles register of Estonia (including vehicles with suspended registry entry), over half of which were older than 10 years.

The data on average charges and quotas were collected from the wholesalers of the new machines registered in 2021. 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 number of leakages and refills.

2.F.1.f Stationary air-conditioning

Heat pumps

Estonian Heat Pump Association provided expert report on heat pumps in Estonia in 2024. The report is based on data from member companies of the association (most of heat pump suppliers and service companies with larger market share). 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, is discussed together with experts from the Estonian Refrigeration Association.

In 2024, the stock of installed heat pumps in Estonia amounted to approximately 223 899 systems (23 899 ground, 21 957 water, 172 717 air and 1126 other heat pumps) out of which 13 050 were installed in 2024. Air heat pumps have become a very popular substitution for stove heating. It is assumed that heat pumps which reach the end of lifetime (15 years) are decommissioned each year. The average charge in a heat pump (HP) was estimated at 2.0 kg for ground, air to water and other HP. For air-to-air HP-s the average charge was estimated at 1.0 kg refrigerant.

Stationary and room air-conditioning

2024 year's data was used which was supplied by the Estonian Refrigeration Association and companies (manufacturers, traders, service companies) belonging to this association. The data included newly installed systems, the total 2024 equipment stock, refrigerant charges by weight and HFC types and EF for domestic manufacturing and operating stock.

The numbers of operating systems are the following: 2956 chillers, 7445 ventilation systems and 39 605 split systems.

Foam blowing agents (CRT 2.F.2)

2.F.2.a Closed cells

PU insulation panels

The present bank of HFC-134a as an 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 Statistics Estonia (annual import of sandwich elements minus export), Estonian experts/importers (average quota of imported sandwich elements with PU-core in 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%, 2002: 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 approximately 230 tons PU with HFC-134a with the HFC-134a content in the foam-stock of 6.75%¹⁰³.

Spray and injection PU foam

In the EU, for on-site applied foam the blowing agent HCFC-141b (ozone depleting substance) 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 was 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 due to problems in his production plant. Consequently, in the EU the HCFC-141b was still in use after 2004 and according to PU system suppliers also in Estonia.

In 2006–2008, 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 was 7.5% in the years 2006–2008. In 2017–2019 another company has sold HFC-containing closed-cell polyurethane spray foam blend in Estonia. The HFC content in this foam was 8.7% (93% HFC-365mfc and 7% HFC-227ea) according to the producer.

XPS insulation foam

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 period. 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 m³ XPS, thereof 3 600 m³ HFC-containing

¹⁰³ 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.

XPS). As the HFC quantity used to produce one m³ XPS foam is known (3.3 kg), the HFC bank was calculated from the volume of XPS sold in 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 the IPCC 2006 Guidelines, 0.75%.

[Open cells \(CRT 2.F.2.b\)](#)

One component PU foam

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.

PU integral skin foam

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

[Fire protection \(2.F.3\)](#)

Data on the amount of the three mentioned HFC-based fluids for fire protection in the 2024 stock was acquired from the database set up according to article 6 of the Regulation No 517/2014. The first HFC installation dates to 2000.

[2.F.4 Aerosols](#)

[2.F.4.a Metered dose inhalers](#)

The domestic manufacturer provided the data on manufacturing, domestic consumption and export of MDIs for natural drug products including the emissions rate from manufacturing (EF_{manu} = 3% in 2024). Use-phase emissions: The number of MDIs for both anti-asthma and natural medicines sold to the domestic market in 2024 (production + import - export) is the stock of the year 2024. As the consumption of the products follows the purchase immediately, annual stock and the annual emissions are the same. HFC-134a and HFC-227ea are 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.

The 2024 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.

Emission factors

Refrigeration and air-conditioning (CRT 2.F.1)

2.F.1.a Commercial refrigeration

The actual refilling rate 11.7% is used as operating emission factor in 2021-2024. This is lower than in years before that (15%). The refilling rates of all service companies were significantly lower than in previous years and the service companies substantiate it that the most leaking equipment was replaced with CO₂ equipment first and the remaining equipment is leaking less. Another reason could be that according to Regulation (EU) no 517/2014 article 13 larger equipment must not be serviced with virgin R-404A since 1st January 2020 and that is why only minimal amounts of (recycled) R-404A were refilled.

The amount of R-134a, R-404A and R-407C filled in new equipment in 2009 was decommissioned according to 15 years lifetime in 2024.

2.F.1.b Domestic refrigeration (CRT 2.F.1.b)

Emission factors: EES Ringlus estimated that about 6% of the original charge has already emitted by the time when 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 in the IPCC 2006 Guidelines¹⁰⁴.

2.F.1.c Industrial refrigeration (CRT 2.F.1.c)

The results of the surveys in 2021 showed that the refilling ratios of the individual companies range from 2 to 38%. The average refilling rate was 9.1% which is lower than the prior value of 15%. In 2024 refilling rate of 9.1% was used as in 2021-2024. The service companies explained that the low refilling ratio has two reasons: 1) because of service ban with virgin R-404A recycled refrigerant is used very sparingly; 2) the most leaking equipment has been exchanged with R-134A, R-448A and R-452A containing equipment. The latter substantiation cannot be extrapolated to the whole stock because only 3% of the old equipment with R-404A has been replaced with R-448A and R-452A.

The emission factor 9.1% is in the range of the IPCC 2006 Guidelines and the 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 the IPCC 2006 Guidelines¹⁰⁵ estimates of recovery efficiency and estimates from service companies. 50% of HFC containing refrigerants are recovered.

- Country-specific EF_{manu} (filling): 0.5%;
- Country-specific operating emission factor EF_{op}: 9.1%;
- Country-specific disposal emission factor EF_{disp}: 50%.

2.F.1.d Transport refrigeration (CRT 2.F.1.d)

Refrigerated vehicles

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

¹⁰⁴ IPCC 2006 Guidelines, Volume 3, Chapter 7, table 7.9, page 7.52.

¹⁰⁵ IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

Guidelines¹⁰⁶. These emissions are equated to the CRT emission category ‘emissions from manufacturing’. The annual losses from the operating systems (emissions from stocks) including service emissions on refilling amount to an average of 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 the IPCC 2006 Guidelines. The disposal emission factor is based on estimates from service companies and is at the high end of the IPCC 2006 Guidelines estimates.

- Country-specific average refrigerant charges per unit (for estimating the stock): weight classes N₁ and half N₂: 2.0 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%.

Reefer containers

The emissions of R-134A and R-404A are calculated by means of emission factors. The operating emission factor is 10%¹⁰⁷. The disposal emission factor is 30%, which lies at the upper boundary of the range given by the *Tier2a* method in the IPCC Good Practice Guidance¹⁰⁸. Manufacturing emissions are not distributed by world trade shares but are estimated in the (few) countries of container manufacturing. Method was also validated by the German Öko-Recherche experts in 2006.

2.F.1.e Mobile air-conditioning

Passenger cars

The emissions from the refrigerant stock in the Estonian car fleet are estimated applying the leakage rate established in the 2003 EU study (Schwarz & Harnisch, 2003)¹⁰⁹, where the authors claim the data published in it to be representative of all EU countries.

Different types of vehicles have different product life factors (PLF). PLF for different types of vehicles (passenger cars, trucks, buses, ships, railcars, wheel tractors and mobile machinery) that have mobile air-conditioning were calculated as follows:

$$\text{emissions from stocks} \div \text{average annual stocks} \times 100.$$

Total PLF for mobile air-conditioning category is calculated as follows:

$$\text{total actual emissions from stocks} \div \text{average annual stocks} \times 100.^{110}$$

- Country-specific average refrigerant charge;
- Emission factor: 10%, which is in accordance with the IPCC 2006 Guidelines;
- MAC quotas: In the total fleet, the MAC quotas vary by the production years;
- Disposal emission factor 50% is based on the IPCC 2006 Guidelines estimates of recovery efficiency and estimates from service companies.

¹⁰⁶ IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

¹⁰⁷ 2002 report of the refrigeration, air conditioning and heat pump technical options committee (RTOC) <https://wedocs.unep.org/handle/20.500.11822/7796>, (22.12.2024)

¹⁰⁸ IPCC 2006 Guidelines, Volume 3, Chapter 7.5.2.2 "Choice of emission factors" and 7.5.2.3 "Choice of activity data"

¹⁰⁹ 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.

¹¹⁰ 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.

Trucks

- Country-specific average refrigerant charges: weight class N₁: 0.77 kg; weight class N₂: 0.91 kg; and weight class N₃: 0.91 kg.
- Emission factors (Schwarz, 2007)¹¹¹: weight class N₁: 10%; weight classes N₂ and N₃: 15%, which are likewise in accordance with the IPCC 2006 Guidelines and the IPCC Good Practice Guidance¹¹².
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.
- Disposal emission factor 50% is based on the IPCC 2006 Guidelines¹¹³ estimates of recovery efficiency and estimates from service companies.

Buses

Method according to the IPCC 2006 Guidelines¹¹⁴: *Tier 2a* with country-specific determination of EF.

- Country-specific average refrigerant charges: City and tourist (single) buses: 10 kg, intercity buses: 4 kg; articulated buses and double-deckers: 18 kg.
- Country-specific emission factors: city, tourist single buses 1.5 kg/year; intercity buses 0.6 kg/year; articulated buses and double-deckers: 3 kg/year, which are likewise in accordance with the IPCC 2006 Guidelines and the IPCC Good Practice Guidance.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years. For all types of buses Estonian quota was used which was obtained from interviews with bus sellers.
- The disposal emission factor of 50% is based on the IPCC 2006 Guidelines estimates of recovery efficiency and estimates from service companies.

Ships

- Country-specific HFC refrigerant blend 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 based on data from waste collecting companies.

Railcars

The refrigerant charges and emission factors used:

- Country-specific average refrigerant charges: 30 kg of R-134a for cars of international trains, 11.09 kg for standard cars and 0.68 kg 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 0.2% for all railcars in 2024, which is in accordance with the IPCC Good Practice Guidance¹¹⁵.

Wheel tractors and mobile machinery

The refrigerant charges and emission factors used:

- Country-specific average refrigerant charges of new vehicles: excavators, loaders: 1.5 kg, roadwork machines 1.0 kg, wheel tractors 1.25 kg, forestry machines 2.3 kg and combine harvesters: 2.2 kg.

¹¹¹ 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).

¹¹² IPCC 2006 Good Practice Guidance and Uncertainty Management, Chapter 3, table 3.23, page 3.110.

¹¹³ IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

¹¹⁴ IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

¹¹⁵ IPCC 2006 Good Practice Guidance, Chapter 3, page 3.110, table 3.23.

- Country-specific emission factors: wheel tractors 20% (EF is in the range of the IPCC 2006 Guidelines and the 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, MAC quotas vary by production years.

2.F.1.f Stationary air-conditioning

Heat pumps

The discussion with Estonian experts resulted in emission factors for manufacturing (EF_{manu}) of 2.0%, which lies above the value range proposed in the IPCC 2006 Guidelines and the IPCC Good Practice Guidance (0.2–1%); for operating systems (EF_{op}) of 2.5%, which is in accordance with the IPCC 2006 Guidelines¹¹⁶ and the IPCC Good Practice Guidance¹¹⁷. The disposal emission factor is 30.0%, which lies in the lower part of the range proposed in the IPCC 2006 Guidelines. The disposal emission factor considers estimates from service companies. It is estimated that 70% of the refrigerant is recovered.

- Country-specific EF_{manu} : 2%;
- Country-specific EF_{op} : 2.5%;
- Country-specific EF_{disp} : 30%.

Stationary and room air-conditioning

The EF_{manu} (first filling loss) was established at 20 g/system for chillers (0.019%) and 40 g/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 the values presented by 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 Guidelines¹¹⁸. The country-specific emission factor used for disposal ($EF_{\text{disp}}=30\%$) is at the low end of the range proposed in the IPCC 2006 Guidelines. The disposal emission factor is based on the IPCC 2006 Guidelines estimates of recovery efficiency and estimates from service companies.

- 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%.

Foam blowing agents (CRT 2.F.2)

2.F.2.a Closed cells

PU insulation panels

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 Guidelines¹¹⁹ and the IPCC Good Practice Guidance.

- Country-specific EF_{op} : 0.5%.

¹¹⁶ IPCC 2006 Guidelines, Volume 3, chapter 7, page 7.52, table 7.9.

¹¹⁷ IPCC Good Practice Guidance 2000, Chapter 3, page 3.106, table 3.22.

¹¹⁸ IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.52, table 7.9.

¹¹⁹ IPCC 2006 Guidelines, Volume 3, Chapter 7, page 7.37, table 7.7.

Spray and injection PU foam

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 remains in the foam cells during the use-phase¹²⁰. The product life factor (EF_{op}) is according to chemical suppliers 1%.

- Country-specific EF_{manu} : 20%;
- Country-specific EF_{op} : 1%.

XPS insulation foam

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 the IPCC 2006 Guidelines, 0.75%.

- Country-specific EF_{op} : 0.66%;

Open cells (CRT 2.F.2.b)

One component PU foam

The EF_{manu} (0.52%) 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 the sale). The row 'stock' in CRT Reporter is equated to the HFC content of OFC cans sold to the Estonian market and used in the relevant year. Hence only emissions from manufacturing and use (= stock) are entered in the CRT table, no emissions from disposal. EF_{op} is 100%, which is higher than the value given in the IPCC Good Practice Guidance and IPCC 2006 Guidelines (95%).

- Country-specific EF_{manu} : 0.52% (HFC-152a);
- Country-specific EF_{op} : 100%;

PU integral skin foam

For manufacturing of PU integral skin foam, small quantities (1–2%) of HFC are added as an auxiliary blowing agent 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.

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

- Country-specific EF_{manu} : 100%.

2.F.3 Fire protection

According to the IPCC 2006 Guidelines, the annual emissions from installed flooding systems are in the range of 2 ± 1 per cent of the installed base. As there are no detailed indications on

¹²⁰ 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).

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. Based on interviews done in 2020 with fire protection systems service companies it has been concluded that they use the decommissioned/removed F-gas cylinders in another object, if possible, return to the manufacturers or send to the F-gas recycling/destruction facilities. Therefore due to the long lifetime of flooding systems (15–20 years) and the possibilities of recovery, no end-of-life emissions are assumed.

Method Tier 2a according to IPCC 2006 Guidelines, using IPCC default EF_{op} .

- Operating emission factor EF_{op} : 2%.

[2.F.4 Aerosols \(2.F.4\)](#)

[2.F.4.a Metered dose inhalers](#)

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

- Country-specific EF_{manu} : 3%;
- Country-specific EF_{op} : 100%;

[2.F.4.b Technical aerosols](#)

As in case of MDIs, the HFC-consumption for freezing spray in a year is equated to the emission in the same year (EF_{op} 100%), which is in accordance with the IPCC 2006 Guidelines and IPCC Good Practice Guidance.

4.6.3. Uncertainty assessment and time-series consistency

For uncertainty assessment please see Annex A.II.2 IPPU, 2.F Product uses as substitutes for ODS chapter.

4.6.4. Category-specific QA/QC and verification, if applicable

The data for this report was collected by the expert of the 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 the IPCC *Tier 1* method.

4.6.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No category-specific recalculations were done.

4.6.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

There are no planned category-specific improvements.

4.7. Other product manufacture and use (CRT 2.G)

4.7.1. Category description

This category includes:

- SF₆ emissions from Electrical equipment (CRT 2.G.1);
- SF₆ emissions from Accelerators (CRT 2.G.2b), historical SF₆ and PFC emissions from Sport shoes and Car tires (CRT 2.G.2.d);
- N₂O emissions from Medical applications (CRT 2.G.3.a) and from Propellant for pressure and aerosol products (CRT 2.G.3.b).

Emissions from category Other product manufacture and use are shown in Figure 4.8.

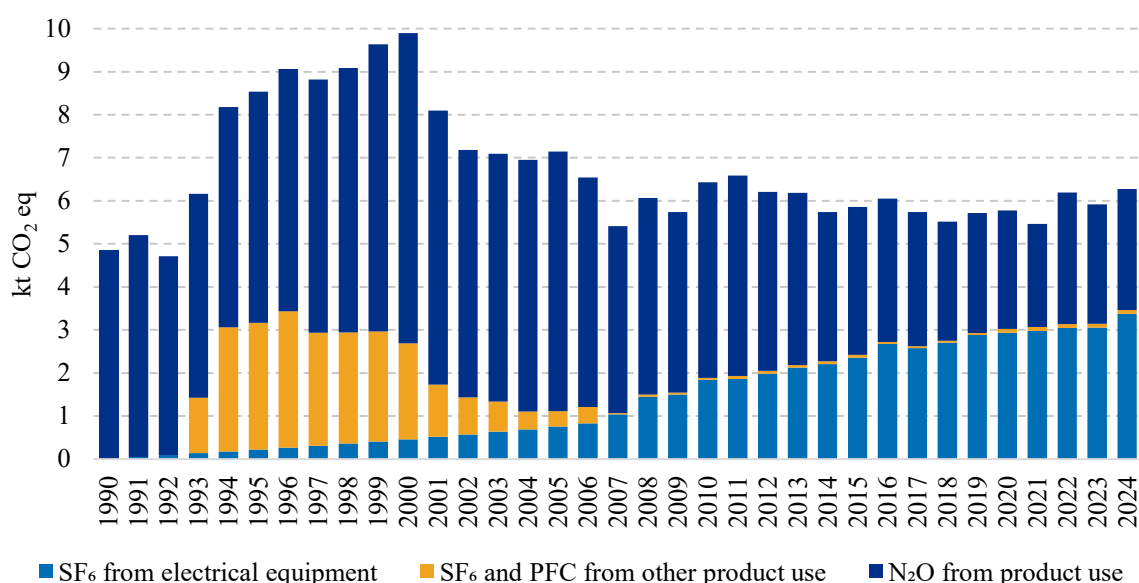


Figure 4.8. Emissions from Other product manufacture and use in Estonia in 1990–2024, kt CO₂ eq.

2.G.1 Electrical equipment

SF₆ 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 SF₆ 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) operates with low over-pressure and little gas quantities of only some kg/system. They are already SF₆ 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') must be replenished in their lifetime. They are imported with a transport filling and are filled up in site (on site erection).

Although vacuum switchgear gain popularity in medium-voltage networks, the operator of the biggest distribution network in Estonia is still preferring SF₆ insulated switchgear, mainly because of its lower price.

In 2024, total stock in operating systems amounted to 36.31 t of SF₆. Manufacturing emissions amounted to 2.15 kg. Total emissions from stock were 0.14 t. 55.7 kg of SF₆ was disposed and emissions from it were 1.11 kg in 2024.

Total emissions from switchgear in 2024 were 0.14 t of SF₆ which is 3.37 kt CO₂ equivalent.

2.G.2 SF₆ and PFCs from Other product use

2.G.2.b Accelerators

Under this source category, Estonia reports emissions of SF₆ from radiotherapy devices. Two hospitals in Estonia use SF₆ insulated radiotherapy equipment for oncology purposes. One hospital operates four devices, which are of the same size. Two smaller devices are used in another hospital. Other applications, e.g., SF₆ insulated particle accelerators or gas impregnation of power capacitors, do not occur in Estonia.

The 2024 stock of SF₆ totalled 42.0 kg, with 2024 operating emissions of 3.97 kg. There were no emissions from disposal, as no equipment was decommissioned in 2024.

Emissions from accelerators totalled 3.97 kg (or 0.093 kt CO₂ equivalent) in 2024.

2.G.2.d Adiabatic properties: Shoes and Tires

Under this category aggregated SF₆ from both Shoe soles and Car tires are reported. PFC emissions occurred only from Shoe soles in Estonia in the past.

Sport shoes

Sports shoes using soles with SF₆-gas cushions were introduced to the European market in the early 1990s. From 2003 to 2005 SF₆ was replaced by PFC-218 (perfluoro propane). Footwear with SF₆/PFC-cushions has not been manufactured in Estonia but were imported. 100% of the F-gases in the soles are emitted at the end-of-life of the shoes. The lifetime of such shoes is calculated at three years. 100% of the F-gases in these soles are considered to have emitted to the atmosphere at the end-of-life of the shoes.

Car tires

In Estonia, SF₆ has never been filled into car tires. This was, however, to some extent practice in Germany in the 1990s. As a considerable part of the Estonian passenger cars are imported second-hand vehicles from Germany, SF₆ in tires transferred to Estonia via imported vehicles. The gas is assumed to have completely released to the atmosphere on disposal three years after the filling¹²¹ or one year after importation.

2.G.3 N₂O from product uses (CRT 2.G.3)

2.G.3.a Medical applications

Under this source category, Estonia reports N₂O emissions from the use of N₂O in medical and other applications. N₂O emissions from aerosol cans are reported under category Propellant for pressure and aerosol products.

The amount of medical N₂O sold and emitted in Estonia in 2024 was 7.75t (2.06 kt CO₂ eq.). The amount of N₂O sold and emitted was 1.3 % lower than in 2023.

¹²¹ IPCC 2006 Guidelines, Volume 3, Chapter 8, page 8.31.

[2.G.3.b Propellant for pressure and aerosol products](#)

Under this source category, Estonia reports N₂O emissions from aerosol cans.

The amount of N₂O used as propellant in aerosol cans in Estonia in 2024 was 0.0029 kt (0.76 kt CO₂ eq).

4.7.2. Methodological issues

[Choice of methods](#)

[2.G.1 Electrical equipment](#)

The method used for calculations is *Tier 3*, as described in the IPCC 2006 Guidelines.

[2.G.2 SF₆ and PFCs from Other product use](#)

Method according to IPCC 2006 Guidelines: *Tier 2a* with country-specific EF.

[2.G.3 N₂O from product uses](#)

Method according to IPCC 2006 Guidelines: *Tier 2a* with country-specific EF.

Estonia has reported N₂O emissions from aerosol cans starting from 2019 submission using country-specific data as during the EU internal annual review of national greenhouse gas inventory data pursuant to Article 19(2) of Regulation (EU) No 525/2013 (for period 2013-2020) (ESD review) the Technical Expert Review Team (TERT) recommended to estimate the emissions either from country-specific data or average t N₂O/capita factor from Member States that report country-specific data using amount of gas as activity data.

[Activity data](#)

[2.G.1 Electrical equipment](#)

Estonian companies of electrical power distribution provided data on their equipment, on their SF₆ consumption in total and on refilling every year.

[2.G.2 SF₆ and PFCs from Other product use](#)

[2.G.2.b Accelerators](#)

Data on charge and use-phase losses were directly submitted from the medical operators.

[2.G.2.d Adiabatic properties: Shoes and Tires](#)

Sport shoes

Data on the Estonian market of sports shoes with PFC gas cushion was provided by the manufacturer. New footwear on the Estonian market has been clear of SF₆ 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.

New footwear on the Estonian market has been clear of SF₆ 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 the IPCC 2006 Guidelines (Emissions in year t = Sales in year t-3).

Car tires

The Öko-Recherche archives include the time series from 1990 for the annual number of German cars whose tires were filled with SF₆ (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 SF₆ from the tires of these cars rose (1 kg per car). The simplified assumption is that in a particular year the imported cars show the same SF₆ 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, a rough estimation of the SF₆ emissions in Estonia can be given.

2.G.3 N₂O from product uses

2.G.3.a Medical applications

Activity data was collected directly from the companies importing N₂O for medical use and other applications to Estonia from 1992 to 2024. Activity data for 1990–1991 was estimated based on the surrogate data method. It is assumed that all N₂O sold to the Estonian market in a year is used in the same year.

2.G.3.b Propellant for pressure and aerosol products

N₂O containing whipped cream cans were not produced in Estonia and were imported since 1992 when Estonia started international trade of consumer goods. Data on international trade of all kinds of whipped cream were collected from Eurostat database. Data was available for 2005–2024. For 1992–2004 surrogate data was created using average consumption of whipped cream in 2005–2019 per capita and multiplying this number with population in 1992–2004.

N₂O containing technical aerosol cans are not produced in Estonia but were imported and sold to the Estonian market from 2007 until 2024. The total quantity of N₂O supplied to the Estonian market was asked from the distributors of N₂O products. In 2024, 367 aerosol cans containing N₂O were sold to the Estonian market.

Emission factors

2.G.1 Electrical equipment

Estonian companies of electrical power distribution provided data on their equipment, on their SF₆ consumption in total and on refilling every year. The refilling data of the HV equipment reported from different power suppliers ranged from 0.1% to 0.7%/year. In the 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) to 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.

- 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 quantity¹²².

¹²² Wartmann, S; Harnisch, J. (2005). Reduction of SF₆ emissions from high and medium voltage electrical equipment in Europe. Report to CAPIEL. <https://www.tandfonline.com/doi/pdf/10.1080/15693430500402234>

2.G.2 SF₆ and PFCs from Other product use

2.G.2.b Accelerators

Method according to IPCC 2006 Guidelines: *Tier 2a* with country-specific EF.

- Country-specific EF_{op}: 4.9%.
- Disposal emissions are estimated to be ca 5%, which is in the same magnitude as in the case of switchgear.

2.G.2.d Adiabatic properties: Shoes and Tires

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

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

2.G.3 N₂O from product uses

N₂O emissions from N₂O used in medical and other applications are estimated considering the amount of N₂O sold to the Estonian market.

2.G.3.a Medical applications

According to the IPCC 2006 Guidelines¹²³, it is assumed that none of the administered N₂O is chemically changed by the body and therefore the emission factor of 1.0 was applied.

2.G.3.b Propellant for pressure and aerosol products

From interviews with supermarket chains in 2020, it was learned that only 2% of all kinds of whipped cream sold in supermarkets were cans with propellant.

From ingredient lists of whipped cream cans it was found out that percentage of N₂O is maximally 5% and this was used for calculation.

According to the IPCC 2006 Guidelines, none of the N₂O is reacted during the process and all the N₂O is emitted to the atmosphere resulting in the emissions factor of 1.0 for this source.

4.7.3. Uncertainty assessment and time-series consistency

For uncertainty assessment please see Annex A.II.2 IPPU, 2.G Other product manufacture and use chapter.

4.7.4. Category-specific QA/QC and verification, if applicable

2.G.1 Electrical equipment

The data for 2.G, 2.G.2.b and 2.G.3 for this report was collected by the expert of the Estonian Environmental Research Centre. The data for 2.G.2.d 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 the Industrial processes and product use sector according to the IPCC *Tier 1* method.

(22.12.2024)

¹²³ IPCC 2006 Guidelines, Volume 3, Chapter 8, page 8.36.

4.7.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No category-specific recalculations have been done.

4.7.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

There are no planned category-specific improvements.

4.8. Other production (CRT 2.H)

4.8.1. Category description

2.H.1 Pulp and paper

This source category includes the NMVOC emissions from the Pulp and paper (CRT 2.H.1) and Food industries (CRT 2.H.2). In addition, NO_x, CO and SO₂ emissions from the Pulp and paper industry are reported under 2.H Other production. The non-fuel-based CO₂ emissions from pulp and paper industry are estimated to be negligible in Estonia. All N₂O emissions from the pulp and paper and food industry are reported as fuel-based emissions under CRT 1 – 1.A.2.d Pulp, paper and print and 1.A.2.e Food processing, beverages and tobacco.

4.8.2. Methodological issues

Choice of methods

Emissions are based on the data reported in NEC/CLRTAP inventories by the Estonian Environment Agency (EstEA). The emissions from pulp and paper industry are calculated by using actual emissions data reported by the production plants. The incomplete time series before the year 2006 is complemented with interpolated data (calculated on production volumes).

Activity data

Activity data for the years 1990–1994 is obtained from the annual proceeding of Statistics Estonia ‘Industry’ and for the years 1995–2024 from the electronic database on the website of Statistics Estonia.

Emission factors

The NMVOC emissions from food industry are calculated as diffuse sources based on statistical data and using the EMEP/EEA Guidebook 2023.¹²⁴

4.8.3. Uncertainty assessment and time-series consistency

For uncertainty assessment please see Annex A.II.2 IPPU, 2.H Other production chapter.

¹²⁴ EMEP/EEA air pollutant emission inventory guidebook 2023. [www]
<https://www.eea.europa.eu/publications/emep-eea-guidebook-2023> (22.12.2024)

4.8.4. Category-specific QA/QC and verification, if applicable

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

The activity data from Estonian Environmental Decisions Information database KOTKAS was compared with the data from Statistics Estonia. The number of pulp and paper plants was checked from the Estonian database of environmental permits of enterprises and from newspapers and the internet.

4.8.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No category-specific recalculations have been done.

4.8.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

There are no planned category-specific improvements.

5. AGRICULTURE (CRT SECTOR 3)

5.1. Overview of the sector (e.g. quantitative overview and description, including trends and methodological tiers by category) and background information

The total GHG emissions reported in the Agricultural sector for Estonia were 1551.74 kt CO₂ eq. in 2024. The sector contributed about 15.2% to the total CO₂ eq. (without LULUCF) emissions in Estonia (Figure 5.1). In 2024, the emissions from Enteric fermentation increased by 0.16% compared to the previous year, emissions from Manure management decreased by 2.9%. The decrease of emissions is mostly because of the lower livestock population of cattle, sheep and goats, and increased biogas production from animal manure, the increase of emissions is mostly caused by the increased milk yield per dairy cow and swine population. Emissions from Agricultural soils increased by 2.20% in 2024 compared to 2023. This is caused by the increased crop production because of better weather conditions, and due to increased amounts of compost and biowaste-based digestates applied to fields. Emissions from Liming and Urea application sub-categories decreased by 3.68% and 99.96%, respectively, in 2024 compared to the previous year. This is caused by the decreased usage of lime and urea fertilizers on the fields.

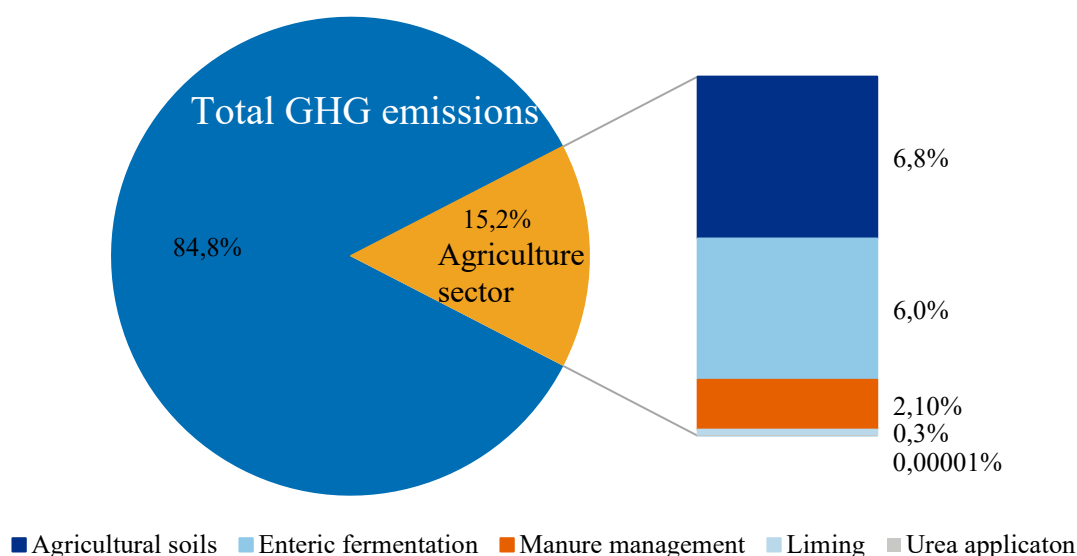


Figure 5.1. Emissions from the Agriculture sector compared to the total CO₂ eq. emissions in 2024, %

Agricultural GHG emissions in Estonia consist of:

- CH₄ emissions from enteric fermentation of domestic livestock (for 16 subcategories of livestock);
- CH₄, direct and indirect N₂O emissions from manure management systems (for 18 subcategories of livestock);
- direct and indirect N₂O emissions from agricultural soils (direct N₂O emissions include emissions from synthetic fertilizers, animal waste, compost, and sludge applied to agricultural soils, crop residues, mineralization associated with the gain or loss of soil organic matter; cultivation of organic soils and emissions from urine and dung deposited

by grazing animals. Indirect N₂O emissions include emissions due to atmospheric deposition and leaching and run-off.);

- liming;
- urea application.

Direct emissions from agricultural soils and enteric fermentation of livestock were the highest contributors to the total emissions from the Agricultural sector (Figure 5.2).

As a result of the Soviet Union markets collapsing, Estonia was left with a large excess supply of agricultural production. Western markets remained closed to Estonian agricultural products, mostly for two reasons – high customs barriers and non-compliance with the requirements and practices abroad. Prices for agricultural products in Estonia fell up to 50% lower than prices on world markets and became insufficient to cover production costs.¹¹ This led to a 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 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 average. In 1996–2001 because 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 (Situationsbericht 2002, DVB, Bonn), in Central and Eastern European countries, the total agricultural production decreased the most in Bulgaria with a 55% decline during the years of 1990–2000, followed by Estonia with 54%.¹¹

Between 2002 and 2008 the essential driving force for Estonian agriculture was the EU accession and the application of supporting the EU's common agricultural policy.¹² The positive impact on agricultural production manifested itself in the years preceding the EU accession and is reflected in the falling GHG emissions trend that began in the 1990s.

Consequently, CO₂ eq. emissions from the Agricultural sector (Table 5.1) declined by 43.88% in 2024 compared with the base year (i.e. 1990), mostly due to a decrease in the livestock population and thus animal manure applied to agricultural fields. The trend in emissions in CO₂ eq. by category is presented in Figure 5.2.

The agricultural production is in a declining trend in Estonia as the population of cattle, sheep and goats decreased in 2024 compared to the previous year. This is mostly caused by the current difficulties in the agriculture sector that started in 2021, as production costs exceed the profit. This is in turn caused by the energy crisis in EU, leading to higher prices for fertilizers, energy, and feed.¹³ The dairy industry has suffered a decline in production due to economic sanctions imposed by Russia on the EU starting from August 2014, when Russia announced import restrictions for food supply coming from the EU. According to the restrictions, it is prohibited to import beef, pork, poultry, fish, milk and dairy, cheese, sausages, fruits, and nuts etc. from EU countries to Russia.¹⁴ Consequently, the number of dairy cattle in 2024 fell by 13.4% in comparison with 2014. The number of dairy cattle was record low in 2024 – being only 82,800 heads. The number of swine has fallen by 20.8% in 2024 compared to 2014 in Estonia because of the outbreak of African swine fever in the region in 2015. Regarding the spread of the disease, Baltic countries and Poland are a buffer zone for the whole EU, meaning it was necessary to apply measures to prevent the spreading of the African swine fever to other European countries. Prevention measures included population control that led to lower number of swine population in the country.¹⁵ Then, starting from 2017, the number of swine started steadily growing again. This was mainly caused by the improved economic situation in the country. Also, a high

demand for pork in both inland and foreign markets as pork being the most popular meat in Estonia helped, to some extent, to recover the number of swine after the low point that started after the African swine fever in 2015. Then, after 2020, the number of swine started decreasing again. This was caused by more outbreaks of African swine fever occurred in 2021.^{16 17 18} What is more, as pork meat's free market purchase prices have been at least 1/3 lower than the actual production costs, several pork producers have been forced to close down their production.¹³ Furthermore, imported pork is cheaper for the buyer, so people have started to prefer it to domestic pork.¹⁹ However, compared to last year, swine numbers have risen by 3.1% in 2024.

Emissions from Agricultural soils, Liming and Urea application sub-categories also decreased in 2024 compared to the previous year. This is caused by the decreased usage of lime, mineral and organic fertilizers on the fields, and a lower production of agricultural crops.

Table 5.1. Estonia's agricultural GHG emissions by sources in 1990–2024, kt

Year	Enteric fermentation	Manure management		Agricultural soils	Liming	Urea application	Total CO ₂ eq. emissions
	CH ₄	CH ₄	N ₂ O ¹²⁵	N ₂ O ¹²⁶	CO ₂	CO ₂	CO ₂ eq.
1990	50.74	6.64	0.38	3.94	12.11	1.00	2765.12
2005	21.22	3.44	0.18	1.78	7.22	1.41	1218.00
2021	21.99	6.04	0.22	2.58	28.48	0.23	1555.92
2022	21.99	5.87	0.22	2.66	36.04	0.02	1579.57
2023	21.77	5.88	0.22	2.58	27.49	2.28	1545.47
2024	21.81	5.74	0.21	2.64	26.48	0.001	1551.74

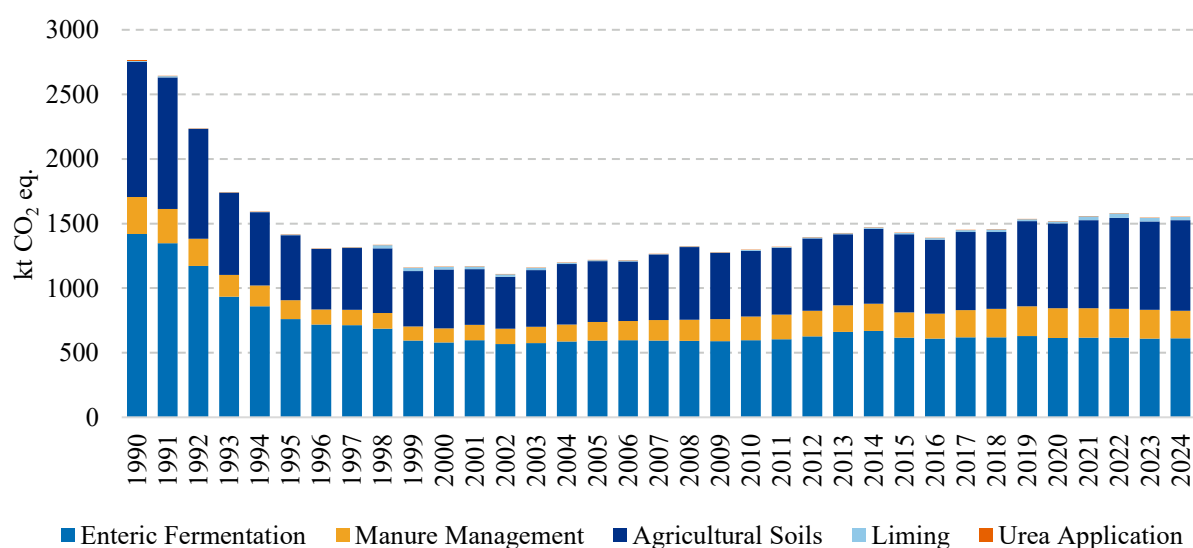


Figure 5.2. Trends in emissions by categories in Estonia in 1990–2024, kt CO₂ eq.

The following is a short overview of the results in the nitrogen balance in Estonia in 2024.

The total amount of nitrogen excreted with manure was 23 399 tons in 2024. The total nitrogen that volatilized from manure management as NH₃, NO₃ and N₂ was 4 218 tons. The total nitrogen from nitrogen leaching and run-off from manure management was 37 tons.¹²⁷ Liquid storage manure management system (MMS) was the main source of N₂O emissions from

¹²⁵ N₂O emissions include Indirect N₂O emissions from the Manure management category.

¹²⁶ N₂O emissions include Indirect N₂O emissions from the Agricultural soils category.

¹²⁷ Leaching and run-off are calculated only for the share of solid manure storage facilities identified as leaking (32%), while no leakage was detected for liquid manure storage.

manure management. Nitrogen that contained synthetic fertilizers applied to agricultural soils made up for 36 257 kilotons and from crop residues 33 375 kilotons of the total amount. Nitrogen in other sources, which were accounted for in the Agriculture sector, was noticeably lower than nitrogen excreted with manure and contained in fertilizers and crop residues. The total amount of nitrogen that volatilized from agricultural soils as NH₃, NO₃, and N₂ was 8 614 kilotons. The total nitrogen from nitrogen leaching and run-off from agricultural soils was 30 583 kilotons in Estonia.

Category description and methodology

The Tier 1 and Tier 2 approaches were implemented to estimate GHG emissions from the Agriculture sector in Estonia. A list of methods and emission factors employed in the estimates for each subcategory of the Agriculture sector is presented in Table 5.2. Rice is not cultivated in Estonia. Savannah areas do not exist in Estonia.

Some recalculations were carried out to improve the quality of the inventory in the following sub-sectors of the Agriculture sector:

- CH₄ emissions from manure management of poultry for the year 2023;
- N₂O emissions from manure management of poultry for the whole time-series;
- N₂O emissions from Animal manure applied to soils for the whole time-series;
- N₂O emissions from Crop Residues for the years 2021-2023;
- N₂O emissions from organic soils cultivation;
- N₂O emissions from mineralization;
- Indirect N₂O emissions from agricultural soils;
- CO₂ emissions from Urea application for the year 2023.

Table 5.2. Methods and emission factors used for estimating GHG emissions of the Agriculture sector

GHG SOURCE AND SINK CATEGORIES	Method applied / EF used		
	CO ₂	CH ₄	N ₂ O
3. AGRICULTURE			
3.A.1 Cattle		T2/ CS, D	
3.A.2 Sheep		T1/D	
3.A.3 Swine		T2/CS, D	
3.A.4 Other livestock		T1/D, OTH*	
3.B Cattle		T2/CS, D	T2/CS, D
3.B Sheep		T1/D	T1/D
3.B Swine		T2/CS, D	T2/CS, D
3.B Other livestock		T1/D	T1/D
3.B.5 Indirect N ₂ O emissions			T2/CS
3.D.1.a Inorganic N fertilizers			T1/D
3.D.1.b Organic N fertilizers			T1/D
3.D.1.c Urine and dung deposited by grazing animals			T1/D
3.D.1.d Crop residues			T1/D
3.D.1.e Mineralization/immobilization associated with loss/gain of soil organic matter			T1/D
3.D.1.f Cultivation of organic soils			T1/D
3.D.2 Indirect N ₂ O emissions from managed soils			T1/D
3.G Liming	T1/D		
3.H Urea application	T1/D		

T1 – Tier 1; T2 – Tier 2; D – IPCC default; CS – Country-specific; NA – Not applicable; OTH* – Other, applies for historical emissions.

References – source information

The estimations were carried out based on approaches presented in the 2006 IPCC Guidelines and IPCC 2019 Refinement for National Greenhouse Gas Inventories.

Activity data was obtained from Estonian national statistics, default emission factors (EFs) were taken from the 2006 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/	- activity data handling; - estimation of emissions; - reporting (CRT, NID).
Statistics Estonia – Agricultural Statistics (SE)	www.stat.ee	- collection and reporting of data on livestock population; - location of animal waste management systems; - milk production per cow; - quantities of crop produced; - amounts of fertilizers, compost, urea, and carbonate lime applied to fields.
Estonian Animal Recording Centre (EARC)	https://www.epj.ee/	- collection and reporting of data on milk production, fat and protein content in milk; - collection of data on dairy cattle population by dairy-cattle breed; - percentage of cows that give birth in a year.
Estonian Environment Agency (EstEA)	https://www.keskkonnaagentuur.ee/en	- providing data on areas of organic soils under cultivation; - data on mineralization associated with loss of soil organic matter; - data on NH ₃ , NO _x and N ₂ emissions from manure management; - data on sewage sludge applied to agricultural soils; - average air temperature during winter months; - collection and reporting of data on composted organic waste and amounts of sewage sludge used in agricultural fields.
Agricultural Registres and Information Board (ARIB)	https://www.pria.ee/en	- data on horse population since 2019 - data about manure distribution from grazing for mature female cattle - data on animal manure sent to biogas plants
Agriculture and Food Board	https://pta.agri.ee/	- sales records of urea and lime fertilizers
Nitrofert Ltd.	-	- plant-specific activity data on urea fertilizers produced in Estonia in 2004-2009 and 2013
Environmental Decisions Information System KOTKAS	https://kotkas.envir.ee/	- manure management system splits since 2021
Mineral fertilizer producers and resellers	-	- urea fertilizers sold to Estonian markets, since 2016

NMVOC and NO_x emissions

NMVOC emission from Manure management and NO_x emission originating from Agricultural soils have been reported in the CRT (Table 5.4). The emissions are in compliance with the data submitted under the Convention on Long-Range Transboundary Air Pollution in the Estonian Informative Inventory Report 1990–2024 compiled by the EstEA. In the Agriculture sector, NO_x emission from Agricultural soils and NMVOC emissions from Manure management decreased by 51.2% and 65.6%, respectively, compared to the base year (1990) (Table 5.4). The decrease in air pollution is mainly the result of the rapid economic changes in the 1990s. Emission calculations from Manure management and Agricultural soils are based mainly on the *Tier 1* method from the renewed EMEP/EEA Guidebook 2023. The *Tier 2* method was used to calculate NMVOC and NO_x emissions from cattle and NO_x emissions from swine and poultry. For further insight regarding the trends and activity data and methodology applied for NMVOC and NO_x emission estimations, see Estonian Informative Inventory Report 1990–2024 submitted under the Convention on Long-Range Transboundary Air Pollution¹²⁸.

Table 5.4. NMVOC and NO_x emissions originating from the Agriculture sector in 1990–2024, kt

Gas	1990	2005	2021	2022	2023	2024
NO _x	4.64	1.58	2.74	2.54	2.37	2.26
NMVOC	12.57	4.92	4.34	4.41	4.35	4.33

5.2. Enteric fermentation (CRT 3.A)

5.2.1. Category description (e.g. characteristics of sources)

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 CH₄ emissions arising from animal husbandry in Estonia are caused by cattle. Dairy cattle livestock was the main contributor to CH₄ emissions from cattle enteric fermentation in Estonia in 2024 (Table 5.6). The number of dairy cows, which has been decreasing in Estonia over the last 20 years, was around 95.6–97.9 thousand in 2009–2014. The decrease in the dairy cattle population in 2015–2024 compared to 2014 is the result of Russia's economic sanctions against the EU. In fact, the population of dairy cows was recording low in 2024, being only 82.8 thousand heads. But due to the milk yield per dairy cow being in an increasing trend over the years, the emissions from enteric fermentation increased by 0.16% in 2024 compared to the previous year. The CO₂ eq. emissions from enteric fermentation of Estonian livestock made up 39.4% of the total CO₂ eq. emissions from the Agricultural sector in 2024. CH₄ emissions from enteric fermentation in 2024 were 57.0% lower than the emissions of the base year due to the decrease in the number of the livestock population (Table 5.5, Figure 5.3).

¹²⁸ Estonian Environment Agency. Estonian Informative Inventory Report 1990–2024, Ch. 5 Agriculture (NFR 3).

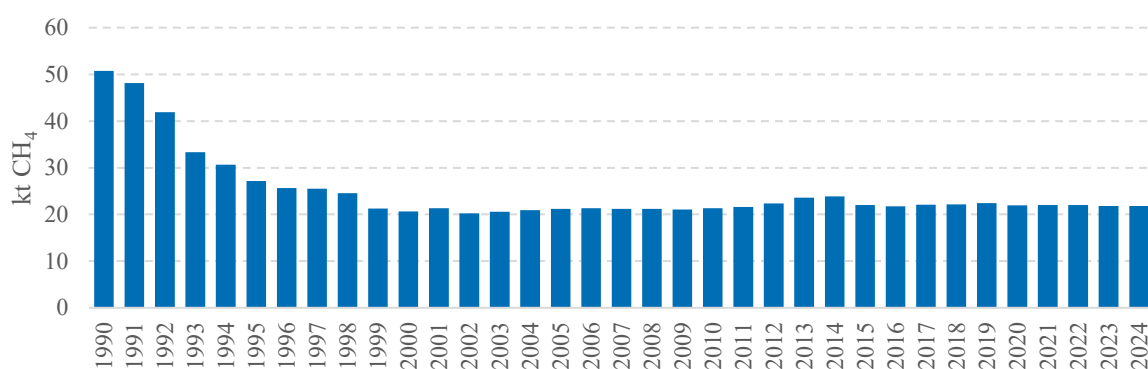


Figure 5.3. Enteric fermentation CH₄ emissions from Estonian livestock in 1990–2024, kt

Table 5.5. CH₄ emissions from Enteric fermentation by animal type in 1990–2024 in Estonia, kt

Livestock category	1990	2005	2021	2022	2023	2024
Cattle	48.39	20.30	20.93	21.01	20.82	20.94
Swine	0.89	0.37	0.34	0.30	0.31	0.31
Sheep	1.27	0.44	0.60	0.56	0.53	0.44
Goats	0.01	0.02	0.02	0.02	0.02	0.02
Horses	0.15	0.09	0.09	0.09	0.09	0.10
Poultry	NE	NE	NE	NE	NE	NE
Rabbits	NE	NE	NE	NE	NE	NE
Fur animals	0.02	0.01	0.00004	0.00002	NO	NO
Total CH ₄ , kt	50.74	21.22	21.99	21.99	21.77	21.81

3.A.1 Enteric fermentation of cattle

Total CH₄ emissions from cattle enteric fermentation were 20.94 kt in 2024. Dairy cattle livestock was the main contributor to CH₄ emissions from cattle enteric fermentation in Estonia in 2024 (Table 5.6). The number of dairy cows, which has been decreasing in Estonia over the last 20 years, was 95.6–97.9 thousand heads during 2009–2014. In 2015, the dairy industry faced a decline in production due to the economic sanctions imposed by Russia on the EU starting from August 2014, when Russia announced import restrictions for food supply coming from the EU. According to the restrictions, it is prohibited to import meat, pork, poultry, fish, milk and dairy, cheese, sausages, fruits, and nuts etc. from EU countries to Russia. The influence was apparent also in 2024, when the number of dairy cattle fell by 13.4% in comparison with 2014, consequently. In fact, the number of dairy cattle was recording low in 2024—being only 82,800 heads. However, milk yield per cow set a record in 2024, being the highest in the last 32 years.¹²⁹

The continuous growth of CH₄ emissions per dairy cow has been contributed by the yearly increase in milk production per cow. The growth of milk yield is a result of investments made into advanced housing and milking technologies, successful breeding, and the use of more qualitative feeding strategies. The milk yield per cow in Estonia is in the 1st place in Europe.¹²⁹ CH₄ emissions from cattle enteric fermentation decreased by 57.0% in 2024 compared with the base year.

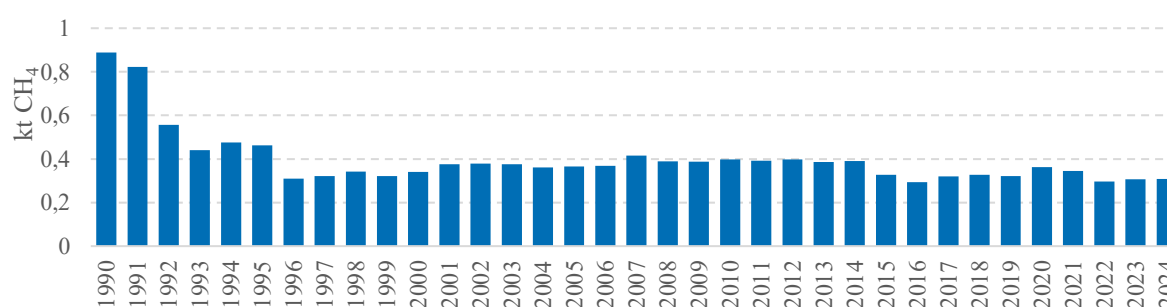
¹²⁹ Äripäev. Agriculture. Statistics Estonia. Average milk production of Estonian cows continues to increase (in Estonian). [www] <https://www.pollumajandus.ee/uudised/2025/02/17/eesi-lehmade-keskmise-piimatoodang-suureneb-uhu> (30.10.2025).

Table 5.6. CH₄ emissions from Enteric fermentation of cattle in 1990–2024 in Estonia, kt

Year	Cattle ¹³⁰			Total, CH ₄ , kt
	Dairy cattle	Other mature cattle	Growing cattle	
1990	29.32	4.88	14.18	48.39
2005	14.43	1.60	4.26	20.30
2021	13.11	4.15	3.68	20.93
2022	13.30	4.16	3.55	21.01
2023	13.57	3.85	3.41	20.82
2024	14.05	3.68	3.22	20.94

3.A.3 Enteric fermentation of swine

The total CH₄ emissions from swine enteric fermentation were 0.31 kt in 2024. The emissions have decreased by 65.3% since the base year (Figure 5.4). The main reason for this is the decline in pork production in Estonia compared to the base year due to the decreasing population of swine after the collapse of Soviet Union and, thus, collective farms. During 2002–2010, the Estonian swine population started to slowly recover and grew 0.8–0.9% per year. The number of swine fell by 20.8% in 2024 compared to 2014 in Estonia because of the outbreak of African swine fever in the region in 2015. Regarding the spread of African swine fever, Baltic countries and Poland are a buffer zone for the whole EU, meaning it was necessary to apply measures for preventing the spreading of the African swine fever to other European countries. Prevention measures included population control that led to lower number of swine population in the country. Then, starting from 2017, the number of swine started steadily growing again. This was mainly caused by the improved economic situation in the country. Also, a high demand for pork in both inland and foreign markets as pork being the most popular meat in Estonia helped, to some extent, to recover the number of swine after the low point that started after the African swine fever in 2015. Then, after 2020, the number of swine started decreasing again. This was caused by more outbreaks of African swine fever occurred in 2021. What is more, pork meat's free market purchase prices have been at least 1/3 lower than the actual production costs, several pork producers have been forced to close their production. What is more, imported pork is cheaper for the buyer, so people have started to prefer it to domestic pork. However, compared to last year, swine numbers have risen by 3.1% in 2024.

**Figure 5.4.** CH₄ emissions from Enteric fermentation of swine in 1990–2024 in Estonia, kt

3.A.2 and 3.A.4 Enteric fermentation of sheep and other livestock

The total CH₄ emissions from Enteric fermentation of sheep and other livestock were 0.56 kt in 2024. CH₄ emissions have declined by 61.8% in 2024 compared with the base year due to a decrease in the number of other livestock population (Figure 5.5).

¹³⁰ CH₄ emissions are reported according to the classification of the CRT Reporter since Option B was implemented to report emissions from enteric fermentation of cattle.

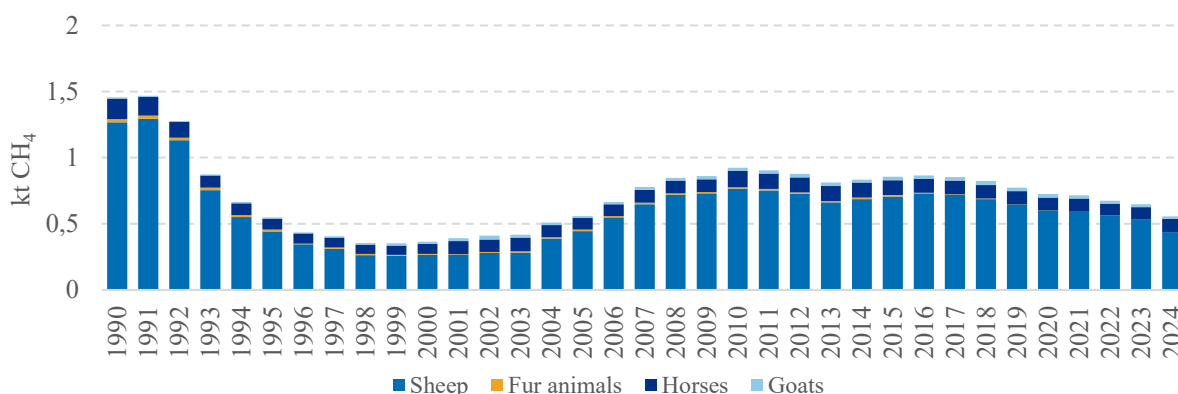


Figure 5.5. CH₄ emissions from Enteric fermentation of other livestock categories in 1990–2024, kt

5.2.2. Methodological issues

Choice of methods

3.A.1 Enteric fermentation of cattle

The *Tier 2* method of IPCC 2006 (Equation 5.1–Equation 5.10) was used to estimate CH₄ emissions from enteric fermentation of dairy cattle and mature non-dairy and growing cattle (bovine cattle, calves aged 0–6 months and 6–12 months). Since the 2013 submission, two key recalculations have been performed: namely, the population of calves (less than 1 year old) has been split into two groups: calves aged 0–6 months and calves aged 6–12 months. Methane emissions from enteric fermentation have been estimated separately for these two groups of calves (a recommendation of ERT, see ARR2011, para 70). In addition, the way of reporting emissions in the ETF Reporting Tool has changed: CH₄ emissions from enteric fermentation of bovine animals have been excluded from the category 'Mature cattle' and included in and reported under the 'Growing cattle' category. Starting from the 2019 submission, the number of calves less than 6 months and 6–12 months old are distributed according to the recommended methodology of the European Commission 2018 Effort Sharing Decision (ESD) review team. Since the 2019 submission, the calculations for finding the share of 0–6 and 7–12-month-old calves are based on the number of calves which are slaughtered (based on national statistics and considering that the number of births is similar for males and females and that males are much more frequently slaughtered in their first year than females) and on the number of calves raised for breeding.

Net energy for maintenance – Net energy required to keep the animals in energy equilibrium (Equation 5.1)

Equation 5.1¹³¹

$$NE_{mj} = C_{fj} \times (weight_j)^{0.75}$$

Where:

NE_{mji} = net energy for maintenance by *j* category of cattle; MJ/head/day;
Weight = live weight of *j* category of cattle, kg.

¹³¹ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.15, equation 10.3.

Equation 5.2¹³²

$$Cf \text{ (in cold)} = Cf_i + 0.0048 \times (20 - ^\circ\text{C})$$

Where:

Cf = coefficient for calculating NE_m (Table 5.8);
 °C = mean daily temperature during the winter season.

Net energy for activity for animals (Equation 5.3)Equation 5.3¹³³

$$NE_{aj} = C_a \times NE_{mj}$$

Where:

NE_{aj} = net energy intake by *j* category of cattle, MJ/head/day;
 C_a = coefficient corresponding to animals' feeding situation (Table 5.9);
 NE_m = net energy required for maintenance by *j* category of cattle (Equation 5.1).

Net energy for growing – net energy needed for growth (live weight gain) (Equation 5.4). According to the 2006 IPCC Guidelines, mature animals are generally assumed to have no net weight gain or loss over an entire year. Thus, data on weight gain are used only in calculations of growing cattle.

Equation 5.4¹³⁴

$$NE_g = 22.02 \times \left(\frac{BW}{C \times MW} \right)^{0.75} \times WG^{1.097}$$

Where:

NE_{gj} = 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 lactationEquation 5.5¹³⁵

$$NE_{li} = kg\_of\_milk/day_i \times (1.47 + 0.40 \times Fat_i)$$

Where:

NE_{li} = net energy for lactation by dairy cattle, MJ/head/day;
 Fat = fat content of milk, %.

¹³² IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.13, equation 10.2.

¹³³ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.16, equation 10.4.

¹³⁴ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.17, equation 10.6.

¹³⁵ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.18, equation 10.8.

Net energy for pregnancy

Equation 5.6¹³⁶

$$NE_{pregnancy} = C_{pregnancy} \times NE_m$$

Where:

$NE_{pregnancy}$ = net energy required for pregnancy, MJ/head/day;

$C_{pregnancy}$ = pregnancy coefficient = 0.1⁽¹³⁷⁾;

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 5.7¹³⁸

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

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 5.8¹³⁹

$$REG = 1.164 - (5.160 \times 10^{-3} \times DE_{ji} \%) + (1.308 \times 10^{-5} \times (DE_{ji} \%)^2) - 37.4/DE_{ji} \%$$

Where:

REG = ratio of net energy available for growth in a diet 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.

Gross energy for cattle

Equation 5.9¹⁴⁰

$$GE = \frac{(NE_{mji} + NE_{feedji} + NE_l + NE_{workji} + NE_{pregnancyj}) \times (\frac{100}{DE_{ji} \%})}{(NE/DE)_{ji} + (NE_{gji}/\{NE_g/DE\}_{ji})}$$

Where:

GE = gross energy intake by j category of cattle, MJ/head/day;

¹³⁶ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.20, equation 10.13.

¹³⁷ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.20, table 10.7.

¹³⁸ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.20, equation 10.14.

¹³⁹ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.21, equation 10.15.

¹⁴⁰ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.21, equation 10.16.

NE _m =	net energy required by the animal for maintenance by <i>j</i> category of cattle, MJ/head/day;
NE _a or N _{feed} =	net energy for animal activity by <i>j</i> category of cattle, MJ/day;
NE _l =	net energy for lactation by dairy cattle, MJ/head/day;
NE _{work} =	net energy for work by <i>j</i> category of cattle ¹⁴¹ , MJ/head/day;
NE _p or NE _{pregnancy} =	net energy required for pregnancy by dairy cattle, MJ/head/day;
NE =	net energy for cattle, MJ/head/day;
NE _g =	net energy needed for growth by <i>j</i> category of cattle, MJ/head/day;
DE% =	digestible energy as a percentage of gross energy of <i>j</i> category of cattle, %.

Methane emission factor from the livestock category

Equation 5.10¹⁴²

$$EF = [GE \times Y_m \times (365 \text{ days/yr})] / [55.65 \text{ MJ/CH}_4 \text{ kg}]$$

Where:

EF =	methane emissions from enteric fermentation of <i>j</i> category of cattle, kg CH ₄ /year;
GE =	gross energy intake by <i>j</i> 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 CH₄ EF for Enteric fermentation by subcategories of cattle are the following:

Weight, kg – data on the weight of dairy-cattle were calculated based on the data of EARC, an expert judgment on the weight of the main categories of dairy-cattle and from scientific literature (Table 5.11, Annex A.V.3_III.1);

Milk production per day, kg/day – a source of data is SE (Annexes A.V.3_II.1-2);

Fat content of milk, % – data was obtained from EARC (Annexes A.V.3_II.3.);

Percentage of cows that give birth in a year, % – data were employed from EARC (Annex A.V.3_II.5);

Feed digestibility, % – data were obtained from Kaasik, A. report, 2020;

Methane conversion rate, Y_m % (Table 5.10) – the values of Y_m of mature dairy and non-dairy cattle and bovine animals were obtained from the 2006 IPCC Guidelines.

3.A.3 Enteric fermentation of swine

The *Tier 2* method (Equation 5.11–Equation 5.14) was used to estimate CH₄ emissions from Enteric fermentation of swine. The estimation was carried out for the main subcategories of pigs broken down by the weight of animals.

¹⁴¹ Net energy for work was not calculated.

¹⁴² IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.31, equation 10.21.

Gross energy intake by swine

Equation 5.11¹⁴³

$$GE_j = ME_j / (DE_j - Y_m - UE)$$

Where:

GE = gross energy intake by *j* swine category, MJ/head/day;
DE = digestible energy as a percentage of gross energy of *j* category of swine, %;
Y_m = methane conversion rate, which is the factor of gross energy in feed converted to methane, 0.6% for swine¹⁴⁴;
UE = urinary energy excretion, 2% for swine¹⁴⁵.

Equation 5.12¹⁴⁶

$$ME_j = 2.0 \times w_j^{0.63}$$

Where:

ME_j = energy intake for maintenance and growth of *j* swine category, MJ/head/day;
w_j = live weight of *j* category, kg.

Methane emission factor from the livestock category

Equation 5.13¹⁴⁷

$$CH_4Emission = EF_j \times population_j / (10^6 kg/Gg)$$

Where:

CH₄ Emission_j = methane emissions from Enteric fermentation from *j* category of swine, kt CH₄/year.

Equation 5.14¹⁴⁸

$$EF = [GE \times Y_m \times (365days/yr)] / [55.65 MJ/CH_4kg]$$

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.

¹⁴³ Oll, Ü., Nigul, L. (1991). Feeding pigs (in Estonian). Tallinn: Valgus, lk 267; Turnpenny J. R., Parsons, D. J., Armstrong, A. C., Clark, J. A., Cooper, K., Matthews, A. M. (2001). Integrated models of livestock systems for climate change studies. 2. Intensive systems. Global Change Biology no. 7, p. 163–170. ; Y_m and UE in this calculation were added due to the recommendation of ESD review in 2018.

¹⁴⁴ Revised 1996 IPCC Guidelines, Volume 3, Chapter 4: Agriculture, page 4.35, table A-4.

¹⁴⁵ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, p 10.42.

¹⁴⁶ Oll, Ü., Nigul, L. (1991). Feeding pigs (in Estonian). Tallinn: Valgus, lk 267; Turnpenny J. R., Parsons, D. J., Armstrong, A. C., Clark, J. A., Cooper, K., Matthews, A. M. (2001). Integrated models of livestock systems for climate change studies. 2. Intensive systems. Global Change Biology no. 7, p. 163–170..

¹⁴⁷ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, p 10.28, equation 10.19.

¹⁴⁸ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.31, equation 10.21.

3.A.2 and 3.A.4 Enteric fermentation of sheep and other livestock

Tier 1 of IPCC 2006 (Equation 5.15) was used to estimate CH₄ emissions from Enteric fermentation of other livestock.

Equation 5.15¹⁴⁹

$$CH_4Emission = EF_j \times population_j / (10^6 kg/Gg)$$

Where:

CH₄ Emission_j = methane emissions from Enteric fermentation from *j* category of animals, kt CH₄/year;
 EF_j = methane emission factor for *j* category of animals, CH₄ kg/head/year;
 Population_j = number of *j* category of animals, head.

Activity data

For most animal categories, activity data is obtained from Statistics Estonia (SE) database, only for horses the Agricultural Registers and Information board (ARIB) Equine database is used, since SE does not collect activity data on horse population in Estonia since 2019.

Livestock population decreased in 2024 in comparison with the base year (Figure 5.6): the number of dairy cattle decreased by 70.5%, i.e., from 280.7 thousand heads to 82.8 thousand heads (Figure 5.6, Figure 5.7), the number of non-dairy cattle decreased from 475.2 thousand heads in 1990 to 149.6 thousand heads in 2024 (Figure 5.6, Figure 5.7). The total number of swine decreased by 67.0%, i.e., from 859.9 thousand heads in 1990 to 283.6 thousand heads in 2024 (Figure 5.6, Figure 5.7). The number of horses decreased from 8.6 thousand heads in 1990 to 5.5 thousand heads in 2024 – by 36.5%. The number of sheep decreased by 65.4% – from 158.5 thousand heads in 1990 to 54.8 thousand heads in 2024 (Figure 5.6). However, the population of goats increased from 2.1 thousand heads to 3.8 thousand from 1990 to 2024 (Figure 5.6) – 81.7%.

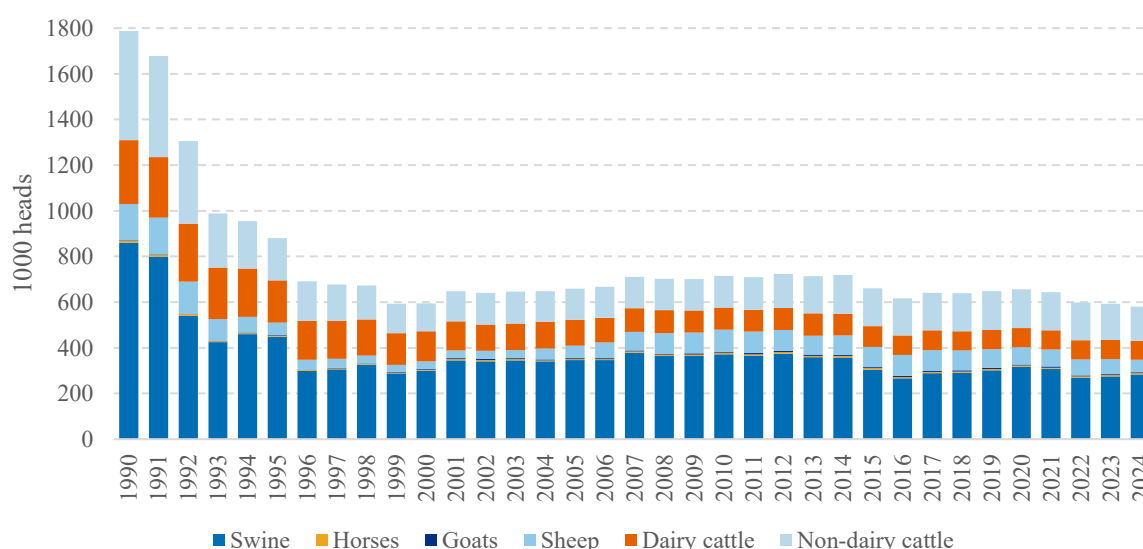


Figure 5.6. Population of livestock in Estonia in 1990–2024 (December 31st), 1000 heads

¹⁴⁹ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.28, equation 10.19.

Table 5.7. The number of livestock population in Estonia in 1992–2024, in accordance with SE (as of 31 December) and FAO datasets, 1000 heads¹⁵⁰

Category	Source	1992	2005	2021	2022	2023	2024
Cattle	SE	614.6	249.5	250.8	249.6	241.3	232.4
	FAO	708.3	249.8	250.8	249.6	241.4	232.4
Pigs	SE	541.1	346.5	308	269.4	275	283.6
	FAO	798.6	340.1	308	269.4	275	283.6
Sheep	SE	123.1	49.6	65.6	63.1	55.1	46.1
	FAO	141.9	38.8	65.6	63.1	55.1	46.1
Goats	SE	1.1	2.8	4.3	4	3.7	3.2
	FAO	NR	2.9	4.3	4	3.7	3.2
Horses	SE/ARIB	6.6	4.8	5.2	5.0	5.3	5.5
	FAO	7.8	5.1	NR	NR	NR	NR
Poultry	SE	3 418.1	1 878.7	2 105.1	2 151	2 211.8	2 352.7
	FAO	5 704	2 183	2 032	2 092	2 132	2 274

NR – data is not reported by the FAO.

The activity data used in the estimations differed from those reported in the FAO statistic dataset due to different methods of data reporting until 2015 (Table 5.7). In the framework of the FAO datasets, the data on the livestock population are reported according to the following methodology: the total number of live animals is given for the year ending with 30 September (e.g., the 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, the total number of live animals is presented for the year ending on 31 December. The data of SE were used in the estimates of the 2024 submission, except for data on horse population that was taken from the ARIB database starting from 2019; data from ARIB Equine database on horse population is also fixed each year on the 31st of December to ensure consistency in the methodology.

Seasonal births or slaughter 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.

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 a part of a complete year. Animals should be included in the populations regardless of if they are slaughtered for human consumption or die of natural causes¹⁵¹. In the Estonian GHG inventory, the annual average population Equation 5.16 has been used in estimates of the annual average of livestock population for broiler chickens, fur animals killed for fur and broiler rabbits.

¹⁵⁰ Statistics Estonia. Livestock and poltry by county (quarters) [www] https://andmed.stat.ee/en/stat/majandus_pellumajandus_pellumajandussaaduste-tootmine_loomakasvatussaaduste-tootmine/PM09 (30.10.2025); FAO. FAOSTAT data. Crops and livestock products. [www] <https://www.fao.org/faostat/en/#data/QCL> (28.01.2026).

¹⁵¹ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, p 10.8.

$$AAP = Days\_alive \times \frac{NAPA}{365}$$

Where:

AAP = annual average population;

NAPA= number of animals produced annually.

3.A.1 Enteric fermentation of cattle

The data on mature non-dairy cattle population were collected and reported by SE according to two methodologies: for 1990–1998 – livestock population data were reported for two subcategories (bovine animals and mature males) and since 1999 the population of three subcategories of non-dairy mature cattle were reported by SE (bovine animals, mature males, and mature females). To guarantee consistency in activity data used, the data for 1990–1998 were updated based on the assumptions made in the 2010 submission; the results are illustrated in Figure 5.8. The number of non-dairy cattle reported in the CRT tables (Figure 5.8, Annex A.V.3_I.1) consists of calves, bovine animals, mature males and mature females, of which calves and bovine animals belong to the subcategory of Growing cattle, while mature males and mature females fall in the subcategory of Other mature cattle.

Currently, Statistics Estonia does not collect separate data on calves aged 0–6 months and 6–12 months, they collect and report aggregated data on the population of calves less than 1-year-old. Starting from the 2019 submission, the numbers of calves less than 6 months and 6–12 months old are distributed according to the recommended methodology of the European Commission 2018 Effort Sharing Decision (ESD) review team. The calculations for the share of 0–6 and 6–12-month-old calves are based on the number of calves slaughtered (based on national statistics and considering that the number of births is similar for males and females and that males are much more frequently slaughtered in their first year than females) and on the number of calves raised for breeding. GHG emissions from enteric fermentation and manure management were estimated for calves 0–6 months and calves 6–12 months old.

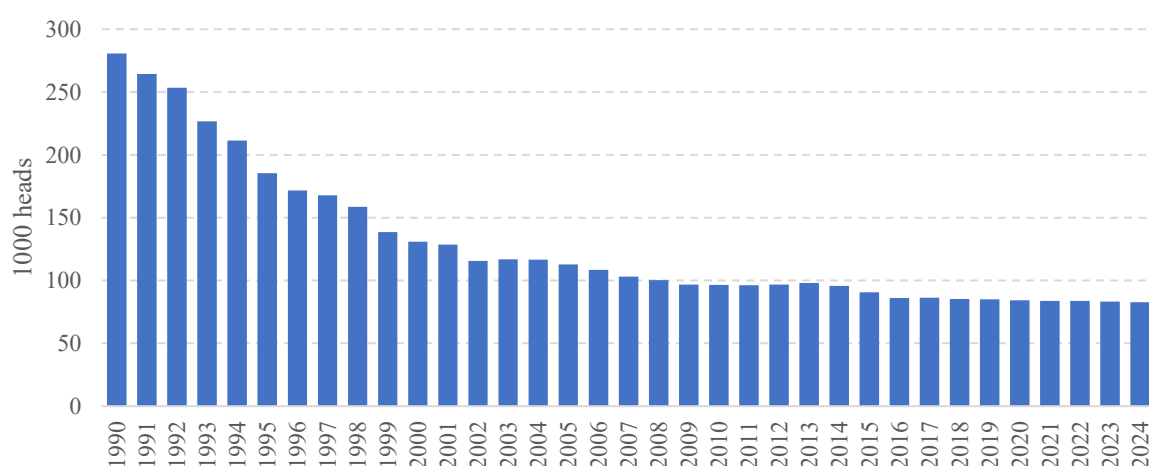


Figure 5.7. Population of dairy cattle in Estonia in 1990–2024 (December 31st), 1000 heads

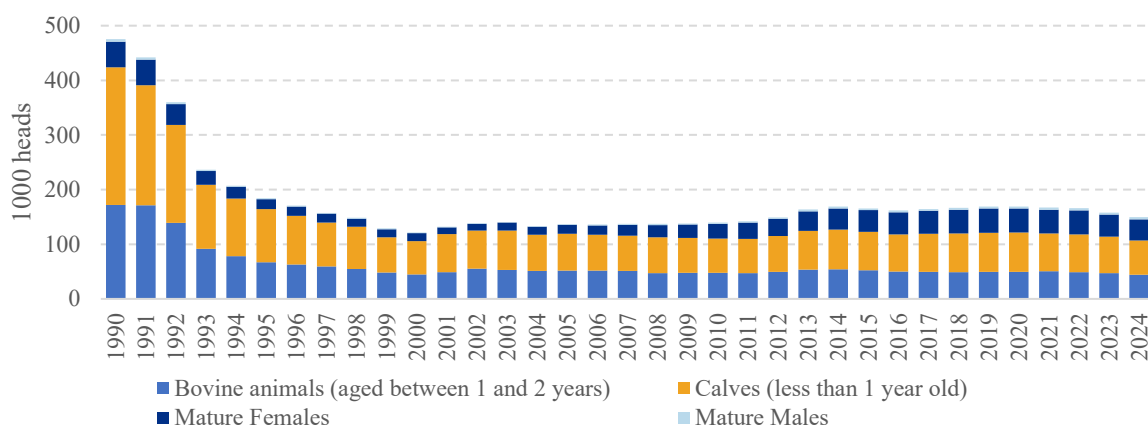


Figure 5.8. Population of non-dairy cattle in Estonia in 1990–2024 (December 31st), 1000

3.A.3 Enteric fermentation of swine

Activity data on the swine population in 1990–1998 were updated in the 2009 submission. Since then, the number of the swine population for 1990–1998 has been reported for three subcategories of swine (breeding sows, fattening pigs and young swine); however, the number of the swine population for 1999–2008 has been reported for six subcategories 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 the swine population (by categories) of 1999–2008, activity data on the swine population in 1990–1998 were recalculated for six subcategories instead of three reported earlier (Figure 5.9, Annex A.V.3_I.2).

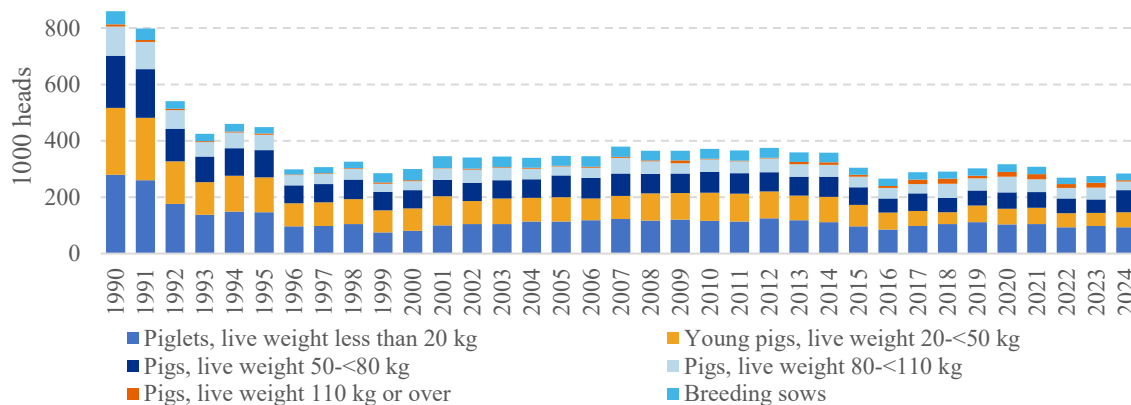


Figure 5.9. Population of swine in Estonia in 1990–2024 (December 31st), 1000 heads

3.A.2 and 3.A.4 Enteric fermentation of sheep and other livestock

Sheep and goats

The SE has been producing four censuses of aggregated sheep and goat numbers per year since 2007.¹⁵² The censuses are conducted in March, June, September, and December. The quarterly

¹⁵² All sheep and goats in Estonia are subject to mandatory identification and registration requirements under European Union and national legislation. Estonia implements Regulation (EC) No 21/2004 and Regulation (EU) 2016/429 (Animal Health Law), which require that all ovine and caprine animals be individually identified and registered. Animal keepers are legally obliged to: Register their holding in the national animal register; Individually identify all sheep and goats using approved identification means; Report births, deaths and

mean total is adjusted according to the ratio of sheep and goats for the separately collected sheep and goat data of December. Preceding years' population numbers were gathered in the framework of a once-a-year census; therefore, the annual average population was adjusted according to the calculated annual average population of 2007–2024. The data used in the calculations of the average yearly population of sheep and goats are presented in Annex A.V.3_I.5.

The annual average population for a year t was calculated with Equation 5.17 by using the chronological mean of censuses, as follows:

Equation 5.17

$$NoA = (NoA_{March} + NoA_{June} + NoA_{Sep} + NoA_{Dec})/4$$

Where:

NoA = chronological mean of the annual population of a livestock category in a year [1000 heads];

NoA_{March} = population of a livestock category in March [1000 heads];

NoA_{June} = population of a livestock category in June [1000 heads];

NoA_{Sep} = population of a livestock category in September [1000 heads];

NoA_{Dec} = population of a livestock category in December [1000 heads].

Horses

The number for horse population was updated in 2023 submission for the years 2019–2020 as Statistics Estonia stopped collecting horse population data in 2019. From 2023 submission, Estonia has switched to the Agricultural Registers and Information Board (ARIB) Equine database. The database provides the current numbers of horse population and does not provide historical overviews. Horse population number is fixed as of 31st December every year (for keeping the consistency with other animal groups). For the years 2019–2021, an interpolation was made for keeping the time series consistency with the SA database.

Fur animals

In Estonia, the population of fur animals decreased remarkably by 1999 compared to 1990 due to the absence of markets. In 1998, Estonian fur farmers established a relationship with colleagues from the Nordic countries. These new partners provided Estonian farmers with valuable assistance regarding breeding programmes, improving basic herds etc.¹⁵³. During 2000–2015, the number of fur animals increased steadily. However, in 2016, the population of fur animals fell as much as 57% compared to 2015 due to the diminished areas of living space, as cages were being renovated. The extensive renovating process was driven by the Regulation of the Minister of Rural Affairs (now Ministry of Regional Affairs and Agriculture) no. 88 of 6/09/2010, according to which the cages of fur animals had to be increased in size by 2017¹⁵⁴.

movements of animals to the national database within prescribed deadlines; Maintain an up-to-date holding register. This ensures the censuses to have complete data on sheep and goats' population.

¹⁵³ Saveli, O. (2004). Fur farming of Estonia. Animal Breeding in Estonia. Tartu: Paar OÜ.

¹⁵⁴ Riigi Teataja. Requirements for keeping fur animals and for the space or building intended for this purpose (in Estonian). [www] <https://www.riigiteataja.ee/akt/13356899?leiaKehtiv> (30.10.2025).

Fur animal population has been in a strong decreasing trend the past years as since fur farming will be banned in Estonia by 2026.

For the estimation of the average annual population of fur animals the statistical data on seasonal births and the number of animals killed for fur were used.

December–March is the time of year that farmers focus on bringing mink (both male and female) into good breeding condition. In preparation for breeding, minks are positioned within the barns depending on the breeding system practiced in the farm. Most farms breed a ratio of 4–5 females for every male¹⁵⁵. Gestation varies from 40–70 days (due to delayed implantation). Major birthing of minks usually takes place at the end of April. A litter of mink ranges from 2 to 10 kits, but five or six is typical. Most minks are graded in November or early December, depending on the colour-type and sex.

Foxes are bred once a year and the breeding season of the silver fox is from January to March. Their pregnancy lasts for 54 days, and a litter of 1 to 9 youngsters (average of 3/litter) is born during March–May¹⁵⁶. The average fertility rate for Ltd. Balti Karusnahk in 2005 was 3.8/litter¹⁵⁷. The vixen nurses her youngsters for about 6 weeks, and they 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 the average yearly fur animals' population are presented in Annex A.V.3_I.8.

Since 2023, there are no fur animal breeders in Estonia (e-mail with the expert from Statistics Estonia documented in the archive (in Estonian)). Fur farms will be banned in Estonia from 2026.¹⁵⁸

Emission factors

3.A.1 Enteric fermentation of cattle

Default coefficients used to calculate Net energy for maintenance for cattle are presented in Table 5.8.

Table 5.8. C_{fi} coefficients used¹⁵⁹

Animal category	C_{fi}
Cattle (non-lactating)	0.322
Cattle (lactating)	0.386
Cattle (bulls)	0.370

Default coefficients corresponding to animals' feeding situation for cattle are presented in Table 5.9.

¹⁵⁵ Piirsalu, P. Mink color mutants and their breeding (in Estonian). [www] http://www.eau.ee/~alo/karusloomad/mingid/?Minkide_sigimine/Poegimine (30.10.2025).

¹⁵⁶ Fur Institute of Canada. Fox farming. [www] <https://fur.ca/fur-farming/fox-farming/> (30.10.2025).

¹⁵⁷ Piirsalu, P. Silver and blue fox color mutants and their breeding (in Estonian). [www] <http://www.eau.ee/~alo/karusloomad/rebased/?Rebased> (30.10.2025).

¹⁵⁸ ERR. The Riigikogu banned fur farms (in Estonian). [www] available: <https://www.err.ee/1608232770/riigikogu-keelustas-karusloomafarmid> (30.10.2025).

¹⁵⁹ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.16, table 10.4.

Table 5.9. Activity coefficients corresponding to animals' feeding situation¹⁶⁰

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
Pasture	Animals are confined in areas with sufficient means to forage, requiring a modest energy expense to acquire feed.	0.17

Default values for Methane conversion rates for cattle are presented in Table 5.10.

Table 5.10. Methane conversion rate, %¹⁶¹

Cattle category	Y _m , %
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

The value of Y_m for calves (0–6 months) was estimated considering feed intake, the 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 weeks¹⁶², which stipulate markedly lower methane emissions. Additionally, the consumption of milk (only) assumes zero methane emissions from the rumen¹⁶³. 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 fodder¹⁶⁴. Hence, it was assumed that the methane conversion rate of calves (0–6 months) is 3.25%, the rate was estimated as an arithmetic mean based on the rate of calves between 0 and 3 months (which is zero) and from 3 to 6 months (Y_m is 6.5%). Since the 2019 submission, Y_m of young cattle (reported in CRT Table 3.A.1) is calculated as a weighted average Y_m s of bovine cattle, calves aged 0–6 months and 6–12 months.

The values of CH₄ EFs for Enteric fermentation of non-dairy cattle (mature and young) are presented in Table 5.11.

Table 5.11. CH₄ EF of Enteric fermentation of non-dairy cattle in 2024, kg CH₄/head/year

Livestock category of non-dairy cattle	Emission factor, kg CH ₄ /head/year
Mature males (2 years and over)	73.4
Mature females (2 years and over)	88.1
Bovine animals (aged between 1 and 2 years)	57.5

¹⁶⁰ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.17, table 10.5.

¹⁶¹ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.30, table 10.12.

¹⁶² Federal Environment Agency. National Inventory Report for the German Greenhouse Gas Inventory 1990–2010. [www] <https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories/submissions-of-annual-greenhouse-gas-inventories-for-2017/submissions-of-annual-ghg-inventories-2012> (30.10.2025).

¹⁶³ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.30.

¹⁶⁴ Lehtsalu, S., Kaart, T., Kiiman, H. (2010). Raising heifer calves from birth to insemination. Agricultural science, 21 (1), lk 14–23 (in Estonian).

Livestock category of non-dairy cattle	Emission factor, kg CH ₄ /head/year
Calves (6–12 months)	18.8
Calves (0–6 months)	3.3

The values of CH₄ EF have increased in the period of 1990–2024, mainly due to the increased milk production per cow (Figure 5.10). Figure 5.10 illustrates the trend of annual changes in CH₄ EFs for dairy cattle, milk yield per cow and the number of dairy cattle populations in relation to the base year (1990 = 1). The values of CH₄ EFs estimated for Enteric fermentation of dairy cattle are presented in Table 5.12.

Table 5.12. Weight, milk yield per cow and fat content of milk, gross energy intake and enteric fermentation CH₄ EFs for dairy cattle in 1990–2024 (Annexes A.V.2 II.1–4, A.V.3 III.1)

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	245	105
2005	588.7	4.21	5 886	300	128
2021	636.3	3.90	9 966	367	157
2022	636.5	3.95	10 144	373	159
2023	636.6	3.91	10 608	382	163
2024	636.7	3.89	11 350	398	170
IPCC default					
EE ¹⁶⁵	550 ¹⁶⁶		2 555 ¹⁶³		99 ¹⁶⁷
WE	600		5 986		117

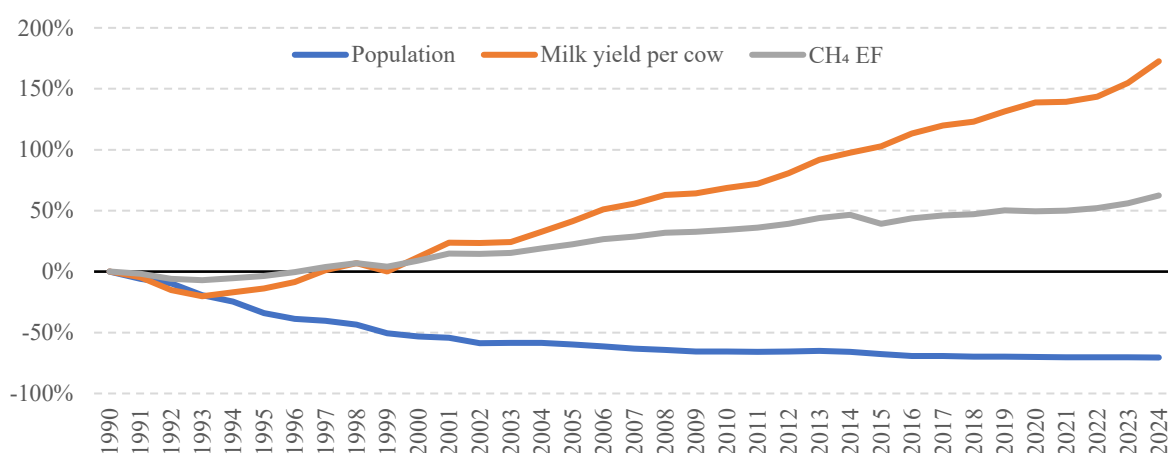


Figure 5.10. Changes in dairy cattle population, milk yield per cow and CH₄ EF in the period of 1990–2024 in relation to the base year (1990), %

3.A.3 Enteric fermentation of swine

Table 5.13 demonstrates CH₄ emission factors for each category of swine and the IPCC default EF for swine recommended for developed countries. Methane conversion factors are taken from the 2006 IPCC Guidelines.

¹⁶⁵ EE – Eastern Europe, WE – Western Europe.

¹⁶⁶ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.72, table 10A.1.

¹⁶⁷ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.29, table 10.11.

Methane emission factors in Table 5.13 were taken from the 2006 IPCC Guidelines; ratios of feed digestibility were obtained from a study by A. Kaasik¹⁶⁸.

Table 5.13. Methane emission factors for swine enteric fermentation, kg CH₄/head/year

Swine category	Emission factor, kg CH ₄ /head/year	
	Calculated	IPCC default ¹⁶⁹
Total		1.5
Piglets, live weight less than 20 kg	0.42	
Young pigs, live weight 20–<50 kg	0.92	
Fattening pigs		
live weight 50–<80 kg	1.41	
live weight 80–<110 kg	1.79	
live weight 110 kg or more	1.96	
Breeding pigs, live weight 50 kg or more	1.96	

3.A.2 and 3.A.4 Enteric fermentation of sheep and other livestock

CH₄ emission factors, recommended by the 2006 IPCC Guidelines for developed countries, were used to estimate CH₄ 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 CH₄/head/year¹⁷⁰

Livestock category	Emission factor, kg CH ₄ /head/year
Sheep	8
Goats	5
Horses	18
Poultry	Not estimated
Fur animals	0.1 ¹⁷¹
Rabbits	Not estimated

5.2.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Enteric fermentation subcategory, please see Annex A.II.3 Agriculture, 3.A Enteric fermentation chapter.

5.2.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for Estonian GHG inventory at the national level are presented in Chapter 1.5.

¹⁶⁸ Kaasik, A. Report of the project „ Study of livestock feeding plans 1990–2020“ (in Estonian). [www] <https://kliimaministeerium.ee/media/1415/download> (30.10.2025).

¹⁶⁹ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.28, table 10.10.

¹⁷⁰ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.28, table 10.10 (developed countries).

¹⁷¹ For fur animals, the Norwegian emission factor was used (0.1 kg/animal/year). The emission factor was derived by scaling the emission factor of swine based on a comparison between the average weights of swine and fur animals. Swine emission factors were assumed to be similar to fur animals' with regard to their digestive system and feeding. The emission factor of Norwegian fur animals has been developed for the reporting purposes of fur animals similar to those in Estonia. The species of the reported Norwegian fur animals include foxes and minks as in Estonia.

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 10¹⁷². The activities are carried out every year during the inventory. The QC check list is used during the inventory.

5.2.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

There are no category-specific recalculations.

5.2.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

Estonia is conducting an inventory development project in the period of 2024-2027 to measure CH₄ emissions for the most represented ruminants in Estonia and thus develop county-specific methane conversion factors.

5.3. Manure management (CRT 3.B)

5.3.1. Category description (e.g. characteristics of sources)

CH₄ emissions from Manure management

CH₄ is produced from the decomposition of the organic matter remaining in the manure under anaerobic conditions. CH₄ emission rates from Manure management directly depend on the manure management system (MMS) and temperature¹⁷³.

CH₄ emissions from Manure management formed 13.9% of the total agricultural emissions in Estonia in 2024.

The largest contributor to the CH₄ emissions in manure management in 2024 was the cattle subcategory. The total CH₄ emissions from livestock manure management were 5.74 kt in Estonia in 2024, the emissions have decreased by 13.6% in comparison with the base year (Table 5.15, Figure 5.11). The main reason for this decline is the decrease in livestock population numbers for all animal categories and amounts of animal manure applied to soils. Another reason for decreased emissions compared to the base year is biogas production that started in Estonia in 2006, and the production volumes have increased since then. Biogas is produced from animal manure and waste-based co-substrates. The emission factor for manure that is anaerobically digested is lower than for liquid manure that is the dominant manure management system in Estonia for most animal categories.

In the 2024 submission, biogas production was considered for the first time in the national inventory and emission calculations. This is a result of a project (2020-2023) during what Estonia developed a methodology to estimate GHG emissions from the production of biogas from agricultural (and waste) sources. Considering biogas production under Agriculture sector reduces CH₄ emissions from manure management as the emission factor for anaerobic digester is lower than for the liquid manure that is mostly used in biogas reactors. Manure from cattle,

¹⁷² IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, pages 10.33-10.34.

¹⁷³ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.35.

pigs and poultry is used to produce biogas. Country-specific emission factors for biogas production were calculated according to IPCC 2019 Refinement, equation 10.23 (Equation 5.20). For methane conversion factor, IPCC 2019 Refinement default factor was used, and a country-specific methane conversion factor for anaerobic digester is being developed. Emissions from biogas use are reported under the Energy sector and emissions from biogas production from waste sources are reported under the Waste sector. Biogas production also includes adding waste-based co-substrates to the manure into the biogas reactor. This waste-based digestate is after applied to agricultural soils as a fertilizer – that increases the N₂O emissions from Agricultural Soils sub-category. Estonia uses default values for Methane Conversion Factor (MCF) from IPCC 2019 Refinement, Table 10.17 (Updated), Cool climate, Low leakage, High quality industrial technology, open storage: 3,55%.¹⁷⁴ And according to that, leakages are already considered when calculating methane emissions from Manure Management and are included in the MCF value used in calculations.

Table 5.15. CH₄ emissions from Manure management in 1990–2024 in Estonia, kt

Livestock category	1990	2005	2021	2022	2023	2024
Cattle	2.14	1.71	4.21	4.28	4.17	4.06
Swine	4.14	1.57	1.75	1.50	1.62	1.59
Sheep	0.03	0.01	0.01	0.01	0.01	0.01
Goats	0.0003	0.0004	0.0006	0.0006	0.0006	0.0005
Horses	0.01	0.007	0.008	0.008	0.008	0.009
Poultry	0.15	0.05	0.06	0.06	0.07	0.06
Fur animals	0.16	0.09	0.0002	0.0001	NO	NO
Rabbits	0.01	0.01	0.001	0.0008	0.0004	0.0004
Total	6.64	3.44	6.04	5.87	5.88	5.74

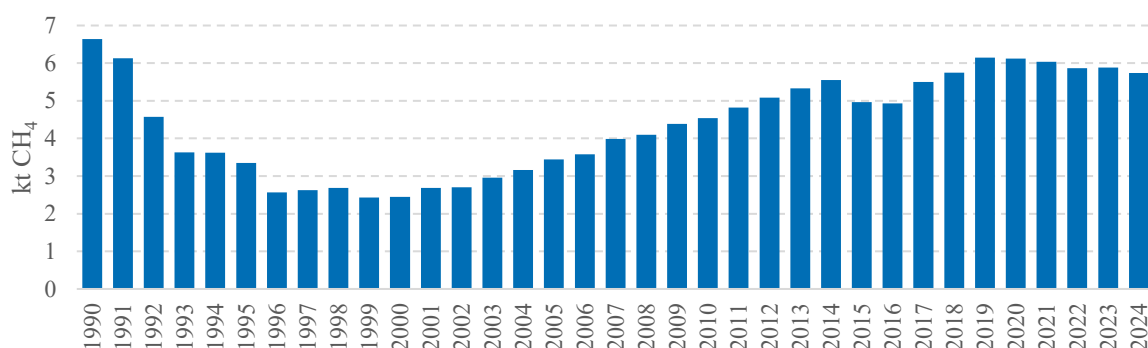


Figure 5.11. CH₄ emissions from Estonian livestock manure management in 1990–2024, kt

3.B.1 Manure management of cattle

The total CH₄ emissions from cattle manure management were 4.06 kt in Estonia in 2024, the emissions increased by 89.53% by 2024 in comparison with the base year (Table 5.16). This is mostly due to the decreased proportion of solid manure and the more widespread use of liquid manure and deep litter systems for growing cattle, which IEFs are higher.

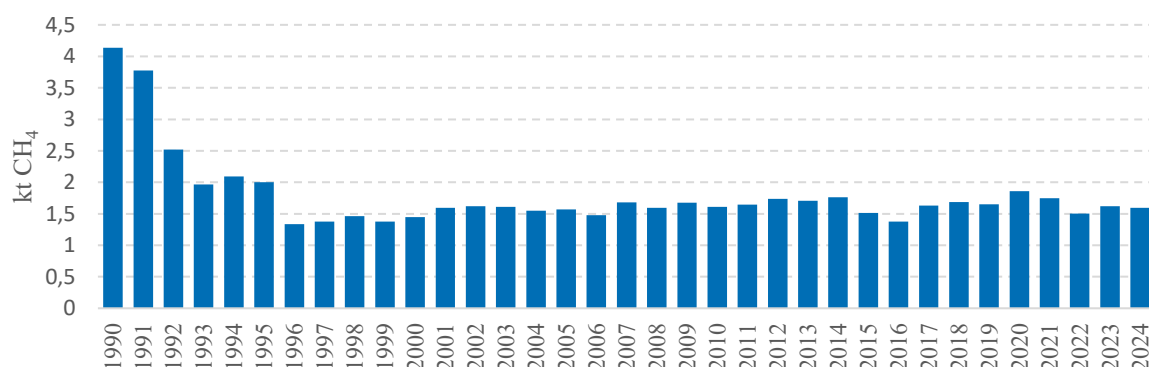
¹⁷⁴ The IPCC 2019 Refinement states that "MCFs depend on the amount of B₀ (maximum methane producing capacity per kg of VS, m³ CH₄ kg⁻¹ VS) that is released under farm conditions and on the amount of produced biogas that leaks from the biogas plant either during storage or energy production. Calculations to identify default factors were carried out by varying the level of leakage from the biogas installations. [...] Methane emissions from biogas digesters include the unused biogas (can be defined as leakage) and emissions from storage of the digestate."

Table 5.16. CH₄ emissions from cattle manure management in 1990–2024 in Estonia, kt

Livestock category	1990	2005	2021	2022	2023	2024
Dairy cattle	1.43	1.31	2.74	2.82	2.86	2.87
Other mature cattle	0.18	0.06	0.67	0.69	0.60	0.53
Growing cattle	0.54	0.34	0.79	0.77	0.71	0.66
Total emissions	2.14	1.71	4.21	4.28	4.17	4.06

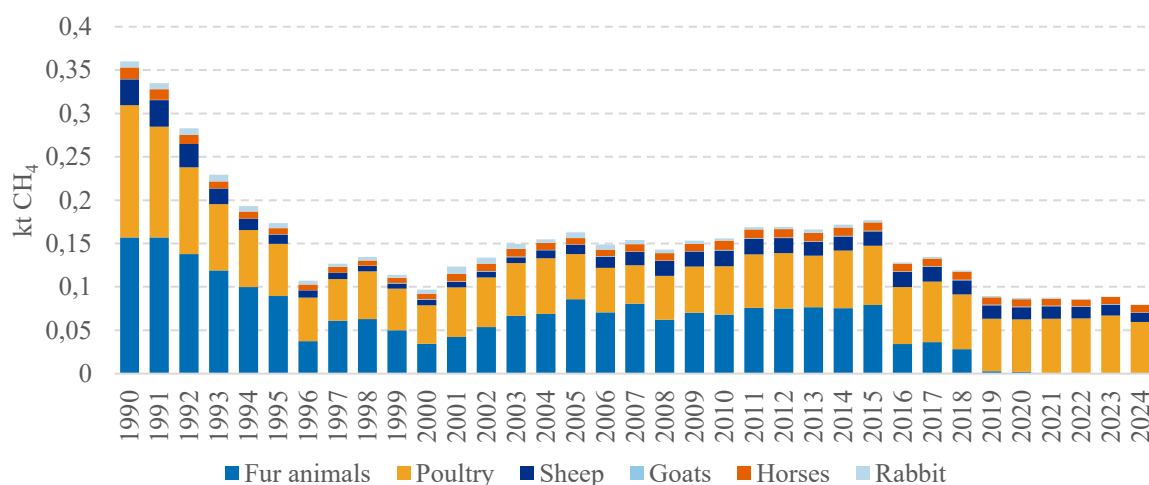
3.B.3 Manure management of swine

The total CH₄ emissions from swine manure management were 1.59 kt in Estonia in 2024 (Figure 5.12). Emissions decreased by 61.5% in 2024 compared with the base year due to the decrease in the number of the swine population.

**Figure 5.12.** CH₄ emissions from swine MMSs in 1990–2024 in Estonia, kt

3.B.2 and 3.B.4 Manure management of sheep and other livestock

The total CH₄ emission from the MMS of other livestock categories was 0.08 kt in Estonia in 2024 (Figure 5.13). The emission declined by 77.9% in 2024 compared with the base year due to the decrease in the number of other livestock population. The emissions in 2024 decreased compared to the previous year, mostly because of a decrease in sheep and goat population.

**Figure 5.13.** CH₄ emissions from other livestock MMSs in 1990–2024 in Estonia, kt

Direct N₂O emissions from Manure management

Production of N₂O during the storage and treatment of animal wastes can occur via combined nitrification-denitrification of nitrogen contained in the wastes¹⁷⁵.

The total quantity of nitrogen generated by livestock and stored in solid, liquid, and deep litter types, as well as in anaerobic digester, of MMSs was 21 152 tons in 2024 (Table 5.18) and 0.13 kt of direct N₂O emissions (Table 5.17) occurred from the stored manure. The fall in N₂O emissions from Manure management is associated with changes in the MMS structure and the shrinking of animal husbandry compared to the 1990 emissions.

Table 5.17. Total direct N₂O emissions from MMSs in Estonia during 1990–2024, kt

MMS system	1990	2005	2021	2022	2023	2024
Liquid/slurry	NO	0.02	0.09	0.09	0.09	0.09
Solid storage	0.21	0.08	0.01	0.01	0.01	0.01
Deep bedding	NO	0.01	0.05	0.05	0.04	0.03
Anaerobic digester	NO	NO	0.002	0.002	0.002	0.003
Total ¹⁷⁶	0.21	0.10	0.14	0.14	0.14	0.13

Table 5.18. Total nitrogen (in manure) excreted by livestock in Estonia during 1990–2024, kg

MMS system	1990	2005	2021	2022	2023	2024
Liquid/slurry	6 622 353	4 829 865	13 875 771	13 759 011	14 030 733	13 812 526
Solid storage	33 473 076	12 827 865	2 761 416	2 552 065	2 446 206	2 359 114
Deep bedding	NO	391 544	2 927 270	2 943 365	2 471 110	2 191 200
Anaerobic digester	NO	NO	1 814 220	1 875 717	2 003 310	2 789 216
Total ¹⁷⁷	40 095 428	18 049 274	21 378 677	21 130 158	20 951 359	21 152 056

3.B.1 Manure management of cattle

The total quantity of nitrogen generated by cattle was 18 322 tons in Estonia in 2024. The allocation of nitrogen excreted among different types of MMSs is presented in Table 5.19.

Table 5.19. The allocation of the quantity of nitrogen (in manure) excreted by cattle, kg

MMS system	1990	2005	2021	2022	2023	2024
Liquid system	NO	2 219 634	11 300 591	11 526 552	11 645 686	11 359 552
Solid storage	25 894 721	9 025 257	740 545	633 029	559 899	661 206
Deep bedding	NO	391 544	2 820 906	2 846 004	2 336 958	2 078 916
Pasture, range and paddock	7 302 122	3 319 052	2 017 127	1 868 622	1 733 437	1 662 938
Anaerobic digester	NO	NO	1 671 410	1 723 489	1 953 970	2 559 430
Total nitrogen	33 196 843	14 955 488	18 550 580	18 597 696	18 229 949	18 322 041

3.B.3 Manure management of swine

The total quantity of nitrogen generated by pigs was 2 679 tons in Estonia in 2024. The allocation of nitrogen excreted among different types of MMSs is presented in Table 5.20. As the formation of a natural crust cover for uncovered pig slurry is highly unlikely, Estonia has applied a value of 0 kg N₂O–N (kg N ex)^{–1} since the 2016 submission to estimate N₂O emissions from pig slurry management.

¹⁷⁵ Background Papers – IPCC Expert Meetings on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2003). CH₄ and N₂O emissions from livestock manure, page 322.

¹⁷⁶ N₂O emissions from 'Pasture/range and paddock' were considered under Direct soil emissions.

¹⁷⁷ N₂O emissions from 'Pasture/range and paddock' were considered under Direct soil emissions.

Table 5.20. The allocation of the amount of nitrogen (contained in manure) excreted by pigs and stored in different types of MMSs, kg N/year

MMS system	1990	2005	2021	2022	2023	2024
Liquid system	6 622 353	2 610 231	2 575 180	2 232 460	2 385 048	2 452 974
Solid storage	1 009 930	718 517	136 393	109 567	56 858	10 822
Deep bedding	NO	NO	106 365	97 362	134 153	112 284
Pasture, range and paddock	NO	NO	NO	NO	NO	NO
Anaerobic digester	NO	NO	86 557	91 378	NO	102 956
Total nitrogen	7 632 283	3 328 747	2 904 496	2 530 766	2 576 058	2 679 037

3.B.2 and 3.B.4 manure management of sheep and other livestock

The total amount of nitrogen generated by sheep and other livestock was 2 398 tons in 2024. The breakdown of the quantity of nitrogen excreted by other livestock categories is reported in Table 5.21.

Table 5.21. Nitrogen (in manure) excreted by other livestock categories, kg N/year

Year	Livestock category						Total nitrogen
	Sheep	Goats	Horses	Poultry	Fur animals	Rabbits	
1990	2 424 573	39 133	517 935	2 620 274	1 698 262	696 219	7 996 396
2005	848 211	58 493	289 080	908 166	869 845	676 293	3 650 088
2021	1 142 473	91 478	311 664	1 008 192	2 004	121 597	2 677 408
2022	1 076 446	83 367	301 065	1 022 569	1 022	81 608	2 566 077
2023	1 015 972	83 348	316 302	1 093 742	NO	41 610	2 550 974
2024	838 283	71 089	329 130	1 117 579	NO	41 610	2 397 691

Indirect N₂O emissions from Manure management

Indirect N₂O emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NO_x and N₂. Nitrogen is also lost through run-off and leaching into soils from the solid storage of manure in outdoor areas, feedlots, and pastures where animals are grazing. Pasture losses are considered separately in the Agricultural soils category.

The total amount of 0.06 kt of indirect N₂O occurred from the stored manure (Table 5.22).

Table 5.22. Indirect N₂O emissions from Manure management in 1990–2024, kt

Category	1990	2005	2021	2022	2023	2024
N losses due to volatilization from manure management	0.10	0.05	0.06	0.06	0.06	0.06
N losses due to leaching from MMSs	0.01	0.004	0.0005	0.0005	0.0005	0.0004
Total Indirect N ₂ O emissions from manure management	0.11	0.05	0.07	0.06	0.06	0.06

5.3.2. Methodological issues

Choice of methods

CH₄ emissions from Manure management

3.B.1 Manure management of cattle

CH₄ production from the 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-Equation 5.21).

$$CH_4\_Emission_j = EF_j \times Population_j / (10^6 kg/Gg)$$

Where:

CH₄ Emissions_j = methane emissions from Manure management of *j* category of cattle, kt CH₄/year;
 EF_j = methane emission factor for *j* category of cattle, kg CH₄/head/year;
 Population_j = the number of head in *j* category of cattle, heads.

$$EF_j = VS_j \times 365 \text{ days/yr} \times B_{oj} \times 0.67 \text{ kg/m}^3 \times \sum_{nK} MCF_{nK} \times MS\%_{jK}$$

Where:

EF_(T) = annual methane emission factor for *T* category of cattle, kg CH₄ animal⁻¹ yr⁻¹;
 VS_(T) = daily volatile solid excreted for *T* category of cattle, kg dry matter animal⁻¹ day⁻¹;
 Bo_(T) = maximum CH₄ producing capacity for manure produced by *T* category of cattle, m³ CH₄ kg⁻¹ of VS excreted (Table 5.27);
 MCF_{nk} = CH₄ conversion factors for each MMS *n* by climate region *k*;
 MS_{njk} = fraction of animal species/category *j*'s manure handled using manure system *n* in climate region *k*.

$$EF_{(T)} = (VS_T \times 365)[B_{o(T)} \times 0.67 \times \sum_{s,k} MCF_{s,k} \times AWMS_{(T,s,k)}]$$

Where:

EF_(T) = annual methane emission factor for livestock category of cattle, kg CH₄ animal⁻¹ yr⁻¹;
 VS_T = volatile solid excreted for *j* category of cattle, kg dry matter animal⁻¹ day⁻¹;
 Bo_(T) = maximum CH₄ producing capacity for manure produced by *j* category of cattle, m³ CH₄ kg⁻¹ of VS excreted¹⁸¹;
 MCF_(s,k) = CH₄ conversion factors for each MMS *S* by climate region *k*, percent;

¹⁷⁸ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.37, equation 10.22.

¹⁷⁹ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.41, equation 10.23.

¹⁸⁰ IPCC 2019 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.64, equation 10.23.

¹⁸¹ IPCC 2019 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.67, Table 10.16a.

$AWMS_{(T,s,k)}$ = fraction of livestock category T 's manure handled using animal waste management system S in climate region k .

Equation 5.21¹⁸²

$$VS = [GE \times (1 - (DE\%)/100) + (UE \times GE)][((1 - ASH)/18.45)]$$

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, %;
 ASH = ash content of the manure as a percentage, % (8%);
 $(UE \times GE)$ = urinary energy expressed as fraction of GE. Typically, 0.04 GE can be considered urinary energy excretion by most ruminants.

3.B.3 Manure management of swine

Methane production from the manure management of swine by subcategories was estimated based on the algorithm described under 3.B.1.1 Manure management of cattle.

3.B.2 and 3.B.4 Manure management of sheep and other livestock

CH₄ emissions from manure management of 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.

Direct N₂O emissions from Manure management

3.B.1 Manure management of cattle

The key methodology used for the estimation of N₂O emissions from Manure management was the Tier 2 method (Equation 5.22-Equation 5.23).

Equation 5.22¹⁸³

$$N_2O_{D(mm)} = \sum_{(S)} \{ [\sum_{(T)} N_{(T)} \times Nex_{(T)} \times MS_{(T,S)}] \times EF_{3(S)} \} \times \frac{44}{28}$$

Where:

$N_2O_{D(mm)}$ = direct N₂O emissions from Manure management in the country, kg N₂O/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;

¹⁸²IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.42, equation 10.24.

¹⁸³ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.54, equation 10.25.

$MS_{(T, S)}$ = fraction of total annual excretion for each livestock species T that is managed in the MMS S in the country;
 $EF_{3(S)}$ = N_2O emission factor for the MMS S in the country, kg N_2O-N /kg N in the MMS S ;
 S = MMS;
 T = species of livestock.

Nitrogen excretion factors for all categories of cattle were calculated based on the nitrogen balance described in Equation 5.23¹⁸⁴:

$$N_{excreta_j} = N_{feed_j} - (N_{milk} + N_{weight\_gain} + N_{embryo})_j$$

Equation 5.23

Where:

$N_{excreta_j}$ = nitrogen excreted per j category of cattle, kg/head/year;
 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 considering the values of gross intake (kg/head/yr); the algorithm is described in 5.3.2. Methodological issues as well as the average rates of nitrogen content in animal feed (Annex A.V.3_V.1). N_{milk} , N_{gain} and N_{embryo} were estimated as follows¹⁸⁵:
 N_{milk} = kg milk protein per cow per year / 6.38
 N_{gain} = kg weight 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.V.3_V.2. Values of the average milk protein content in Estonia in 1990–2023 were obtained from EARC.

3.B.3 Manure management of swine

The key methodology used for the estimation of N_2O emissions from Manure management was the *Tier 2* method (Equation 5.21–Equation 5.22).

3.B.2 and 3.B.4 Manure management of sheep and other livestock

The *Tier 1* method was used to estimate direct N_2O emissions from other livestock (Equation 5.21, using IPCC 2006 Default parameters).

Indirect N_2O emissions from Manure management

N losses due to volatilization from manure management

The *Tier 2* method (Equation 5.24) of the IPCC 2006 Guidelines¹⁸⁶ was applied to estimate indirect N_2O emissions from manure management due to volatilization:

¹⁸⁴ The amount of nitrogen excreted by cattle can be estimated as the difference between the total nitrogen taken in by the animal and the total nitrogen retained for growth and milk production, according to IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.58.

¹⁸⁵ DIAS. Standard Values for Farm Manure. [www] <https://dcapub.au.dk/djfpublikation/djfpdf/djfh7.pdf> (12.11.2025).

¹⁸⁶ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, pages 10.54–10.56.

$$N_2O_{G(mm)} = (N_{volatilization-MMS} \times EF_4) \times 44/28$$

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 volatilized)⁻¹; default value is 0.01 kg N_2O-N (kg NH_3-N + NO_x-N volatilized)⁻¹;

$$N_{volatilization-MMS} = NO_x - N + NH_3 - N;$$

Where:

- $N_{volatilization-MMS}$ = amount of manure nitrogen that is lost due to volatilization of NH_3 and NO_x , kg N yr⁻¹. Estimates of NO_x and NH_3 are received from EstEA and are in line with the respective estimates reported in the Estonian Informative Inventory Report. The emission estimates have been calculated with the methodology provided by the EMEP/EEA guidebook 2023.

N losses due to leaching from manure management

The *Tier 2* methodology for the estimation of N losses due to leaching from MMSs is applied and the respective IPCC 2006¹⁸⁷ equations are used:

$$N_2O_{L(mm)} = (N_{leaching-MMS} \times EF_5) \times \frac{44}{28}$$

Where:

- $N_2O_{L(mm)}$ = indirect N_2O emissions due to leaching and run-off from Manure management in the country, kg N_2O yr⁻¹;
 EF_5 = emission factor for N_2O emissions from nitrogen leaching and run-off, kg N_2O-N /kg N leached and run-off (default value 0.0075 kg N_2O-N (kg N leaching/run-off)⁻¹).

$$N_{leaching-MMS} = \sum_S \left[\sum_T \left[(N_T \times Nex_T \times MS_{T,S}) \times \left(\frac{Frac_{leachMS}}{100} \right)_{T,S} \right] \right]$$

Where:

- $Frac_{leachMS}$ = percent of managed manure nitrogen losses for livestock category T due to run-off and leaching during solid and liquid storage of manure (typical range 1–20%).

¹⁸⁷ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, pages 10.56–10.57.

Activity data

CH₄ emissions from Manure management

3.B.1 Manure management of cattle

For livestock numbers and characteristics for cattle, please see info under Chapter 5.2.2. Methodological issues Activity Data 3.A.1 Enteric fermentation of cattle.

The complete information about manure management system distributions for the years 1990-2024 for cattle is presented Annex A.V.3_IV, a module on MMS distributions is presented in Table 5.23.

Table 5.23. Manure management system distributions for dairy cattle in 1990-2024, %

MMS	1990	2005	2021	2022	2023	2024
Liquid/slurry	NO	20.12	79.73	80.99	80.20	76.21
Solid storage	82.73	63.01	4.05	2.40	1.99	2.28
Pasture/range	17.27	16.87	1.23	1.34	0.81	0.78
Deep bedding	NO	NO	3.14	3.21	3.03	3.0
Anaerobic digester	NO	NO	11.85	12.06	13.97	17.73

In Estonia, the types of housing used for dairy cows are tie-stall housing and loose-housing. In tie-stall housing systems, solid manure forms. In loose-housing systems 1) the formation of liquid manure is dominant, and it forms when litter is not used or a very small amount of litter is used, and 2) less frequently solid manure forms when litter is used. The share of loose housing, which has become a dominant means of housing, has been increasing since 2003. In a loose-housing system animals can move freely in feeding or resting areas. The slurry from loose-housing systems is mostly removed by tractors or screepers. Screepers are the only means of removing manure from the barns where robotic milking systems are used. In Estonia, according to the Estonian Environmental Decisions Information System KOTKAS¹⁸⁸, the share of slurry stored in pit storage below dairy cows is zero. In addition, the Estonian document on best available techniques (BAT)¹⁸⁹ for the intensive rearing of cows and its annex claim that 1) tie-stall housing where liquid manure is produced is not BAT and 2) pit storage (fully slatted floor – a prerequisite for a pit storage) below the cows in loose-housing systems is not BAT. In Estonia, using BATs is obligatory for operators owning Air or Integrated Pollution Prevention and Control (IPPC) permit according to the Atmospheric Air Protection Act¹⁹⁰.

The transition from tie-stall housing technology to loose-housing technology launched in Estonian farms in the beginning of the 2000s saw a switch from solid storage MMS to liquid/slurry MMS in dairy cattle farms (see Annex A.V.3_IV). Since 2021 submission, MMS distributions for most cattle groups are obtained from KOTKAS database.¹⁸² However, for mature female cattle, the share of Pasture/Range and Paddock (PRP) manure was calculated based on the data received from ARIB that is a national statistics that are constantly updated. Data on the movements of mature female cattle and their grazing days were used to calculate the more reliable share of grazing for this animal group. That is because in the KOTKAS

¹⁸⁸ KOTKAS, [www] <https://kotkas.envir.ee/> (30.10.2025).

¹⁸⁹ Estonian University of Life Sciences. Comprehensive pollution prevention and control. Best available techniques in intensive cattle farming (in Estonian). [www] <https://kliimaministeerium.ee/sites/default/files/documents/2021-07/Parim%20v%C3%B5imalik%20tehnika%20veiste%20intensiivkasvatustes%20%282013%29.pdf> (30.10.2025).

¹⁹⁰ Riigi Teataja. Atmospheric Air Protection Act (in Estonian). [www] <https://www.riigiteataja.ee/akt/A%C3%95KS> (30.10.2025).

database there are only agricultural producers (threshold capacity 400 and more adult cattle), and among them there are only a few beef cattle breeders in the country – so the actual share of grazing for mature female cattle is higher than presented in the database.

Amounts of manure from cattle delivered to biogas plants were calculated based on animal numbers in the agricultural facilities who sent their manure to biogas plants. Estonia started producing biogas from cattle manure from 2012. In biogas plants, liquid manure from dairy cattle is mostly used for biogas production.

In 1990–2000, a share of mature non-dairy cattle manure stored in solid storage MMS constituted about 68% and manure from pasture about 32%. Since 2001, the MMSs of mature non-dairy cattle have made a shift from solid MMS towards liquid MMS and deep litter MMS. Hence, in 2024, the share of mature non-dairy cattle manure was the following: 40.02% manure from pasture, 27.67% liquid, 23.11% deep litter, 8.74% solid storage, and 0.46% anaerobic digester MMS fraction.

The MMS distributions for growing cattle in Estonia are presented in Table 5.24

Table 5.24. Manure management system distributions for growing cattle in Estonia in 2024, %

MMS	Bovine animals (1-2 years old)	Calves (6–12 months old)	Calves (0–6 months old)
Liquid/slurry	45.40	9.74	9.74
Solid storage	4.63	NO	NO
Pasture/range	10.37	12.79	12.79
Deep bedding	26.61	66.56	66.56
Anaerobic digester	12.89	10.91	10.91

3.B.3 Manure management of swine

For livestock numbers and characteristics for swine, please see info under Chapter 5.2.2. Methodological issues Activity Data 3.A.3 Enteric fermentation of swine.

The dataset used to develop the country-specific module on MMS in Estonia is described in Annex A.V.3_IV and the results are presented in Table 5.25.

Amounts of manure from swine delivered to biogas plants were calculated based on animal numbers in the agricultural facilities who sent their manure to biogas plants. Estonia started producing biogas from swine manure from 2006. In fact, the first biogas production plant in Estonia started operating in 2006 and only used pig slurry for biogas production.

Table 5.25. Manure management system distributions for swine in Estonia in 2024, %

MMS	Young pigs	Fattening pigs	Breeding pigs
Liquid/slurry	97.02	86.44	1.83
Solid storage	NO	NO	94.68
Pasture/range	NO	NO	NO
Deep bedding	NO	9.36	NO
Anaerobic digester	2.98	4.20	3.49

3.B.2 and 3.B.4 Manure management of sheep and other livestock

The module on MMS for sheep, goats and horse livestock categories was developed based on the animals' grazing period (Annex A.V.3_IV). Animal waste generated by livestock categories are mostly stored in 'solid MMS' (Table 5.26).

Amounts of manure from poultry delivered to biogas plants were calculated based on animal numbers in the agricultural facilities who sent their manure to biogas plants. Estonia started using poultry manure in biogas production in 2019.

Table 5.26. MMS distributions from Manure management of other livestock categories in Estonia in 2024

Livestock category	MMS, %		
	Solid storage	Pasture/range/yards	Anaerobic digester
Sheep	50.68	49.32	NO
Goats	50.68	49.32	NO
Horses	58.9	41.1	NO
Poultry			
Layers	84.2	0.6	15.3
Broilers	85.6	0.6	13.9
Other hens and roosters	99.4	0.6	NO
Other Poultry	99.4	0.6	NO
Rabbits	100	NO	NO

Poultry

The annual average poultry population decreased 48% by 2024 compared to the base year – from 4 337.7 thousand heads in 1990 to 2 240.1 thousand heads in 2024.

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 the number of layers was not available, the total production of eggs and production per layer was used in the calculations. The average rearing period of the Estonian broiler is 42 days¹⁹¹ which was also used in the estimation of the average annual population using the Equation 5.16. The data used in the calculations of the average yearly poultry population are presented in Annex A.V.3_I.6.

Poultry population by all sub-categories of poultry are presented in Figure 5.14.

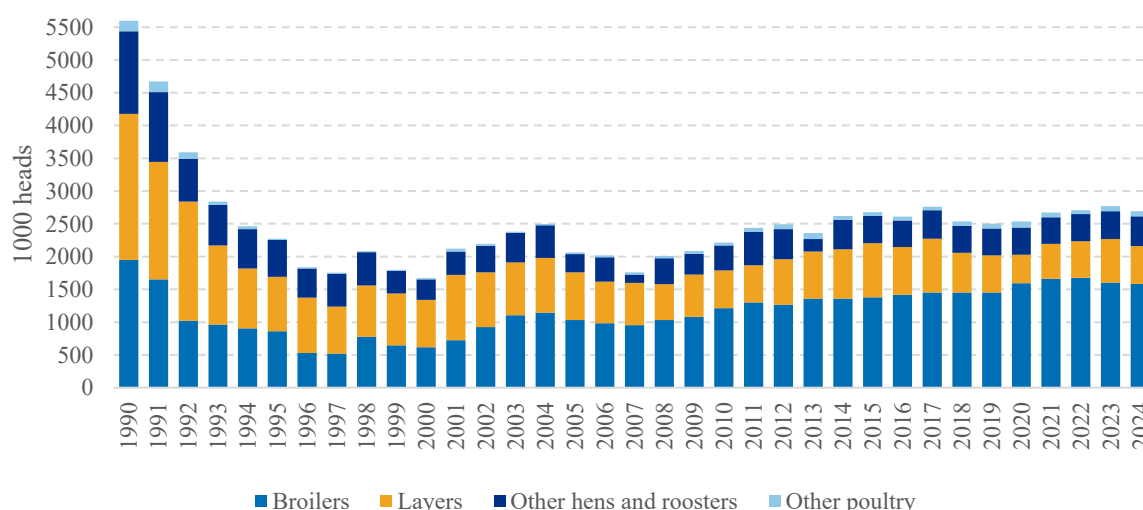


Figure 5.14. Population of poultry by animal group in Estonia in 1990–2024, 1000 heads

¹⁹¹ Tikk, H., Tikk, V., Piirsalu, M., Hämmal, J. (2007). Poultry farming I. Tartu: OÜ Tartumaa Trükkikoda, lk 32 (in Estonian).

Rabbits

For the years 1990–2000 the number of rabbits originates from the records of agricultural production statistics according to the leading expert of Statistics Estonia. This data primarily represents rabbits kept in private households. There was practically no industrial level farming of rabbits in collective farms, later rabbits in homesteads accrued.

In the period of 2001–2019, only one census for the total number of rabbits was conducted (July 2001); in 2020 and 2023, two other censuses were carried out. The mentioned surveys covered only the number of breeding females in compliance with the EU regulation 2018/1091¹⁹² or the respective earlier regulations, and only the census conducted in 2001 covered both female rabbit numbers and the total population of rabbits.

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 youngsters per year¹⁹³. 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 the annual average population of rabbits was estimated.

Direct N₂O emissions from Manure management

The data on the livestock population by categories were obtained from the database of SE (Annex A.V.3_I). Activity data on other livestock population were obtained from national statistics, the module on MMS was used from Table 5.26.

Indirect N₂O emissions from Manure management

Amounts of NO_x, NH₃ and N₂ emissions were obtained from the compiler of the agricultural expert from Environment Agency. The emissions are in compliance with the data submitted under the Convention on Long-Range Transboundary Air Pollution in the Estonian Informative Inventory Report 1990–2023, compiled by the EstEA.

Emission factors

3.B.1 Manure management of cattle

Parameters used in the estimates are presented in Table 5.27.

Table 5.27. Parameters used in the estimates

Cattle category	Digestibility of feed, % ¹⁹⁴	Bo ¹⁹⁵
		m ³ CH ₄ /kg VS
Mature cattle ¹⁹⁶		
Dairy	70.2	0.24
Non-dairy cattle:		
Mature females	63	0.17
Mature males	63	0.17

¹⁹² EUR-Lex. Regulation (EU) 2018/1091 of the European Parliament and of the Council of 18 July 2018 on integrated farm statistics and repealing Regulations (EC) No 1166/2008 and (EU) No 1337/2011 (Text with EEA relevance.). [www] <https://eur-lex.europa.eu/eli/reg/2018/1091/oj> (30.10.2025).

¹⁹³ Home page of Härma Küülikud. Caring for and keeping rabbits (in Estonian). [www] <http://www.rabbitfarm.planet.ee/kasulikinfo.html> (30.10.2025).

¹⁹⁴ Kaasik, A. (2020) Report of the project "Study of livestock feeding plans 1990–2020", pages 18–19 (in Estonian).

¹⁹⁵ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, pages 10.77–10.78, table 10A-4.

¹⁹⁶ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, pages 10.72 and 10.77, tables 10A.1 and 10A.4 (dairy cows); pages 10.73 and 10.7, tables 10A.2 and 10 A.5 (other cattle for Eastern European countries).

Cattle category	Digestibility of feed, % ¹⁹⁴	Bo ¹⁹⁵
		m ³ CH ₄ /kg VS
Bovine animals (aged between 1 and 2 years)	65.1	0.17
Calves (6–12 months old)	65.1	0.17
Calves (0–6 months old)	63	0.17

CH₄ EFs employed in the estimations are presented in Table 5.28. The country specific CH₄ EFs are higher than IPCC default CH₄ EFs, because the amount of manure stored in the liquid/slurry system is higher than IPCC default share (for Eastern Europe).

Table 5.28. Methane conversion factors (MCFs) and manure management emission factors for dairy cattle in 2024 in Estonia

Parameter	Liquid/slurry	Solid storage	Pasture/range	Anaerobic digester	Deep litter
Emission factor, kg CH ₄ /head/yr	30.06	0.18	0.03	2.48	2.01
MCFs, % ¹⁹⁷	10	2	1	3.55	17

Estonia uses MCF of 10% for the liquid/slurry MMS in the inventory as crust is the main coverage for the dairy cattle and non-cattle storages. Although no official national statistics are consistently gathered about the covering of manure storage facilities, this statement is confirmed by a study of the Estonian University of Life Sciences.¹⁹⁸

Estonia uses default values for MCF from IPCC 2019, Table 10.17 (Updated), Cool climate, Low leakage, High quality industrial technology, open storage.¹⁷⁴

In 2024, CH₄ EFs applied in the estimations of mature non-dairy cattle were the following: mature males – 13.87 kg CH₄/head/year and mature females – 12.35 kg CH₄ per head/year. MMSs used to store animal waste generated by growing cattle (bovine animals and calves) and average CH₄ EFs in Estonia are presented in Table 5.29. (See also Annex A.V.3_IV).

Table 5.29. Methane conversion factors and manure management emission factors for growing cattle in 2024 in Estonia

Parameter	Animal group	Liquid/slurry	Solid storage	Pasture/range	Anaerobic digester	Deep bedding
Emission factor, kg CH ₄ /head/yr	Bovine animals (1-2 years old)	4.93	0.10	0.11	0.50	4.92
	Calves (6-12 months old)	0.35	0	0.05	0.14	4.03
	Calves (0-6 months old)	0.13	0	0.02	0.05	1.51
MCFs, % ¹⁹⁹	Growing cattle	10	2	1	3.55 ²⁰⁰	17

¹⁹⁷ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.45, table 10.17.

¹⁹⁸ Kaasik, A., Möls, M. Improving inventory methods for emissions from livestock farming and mapping emission reduction technologies (in Estonian). [www] <https://envir.ee/media/5276/download> (30.10.2025).

¹⁹⁹ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.45, table 10.17.

²⁰⁰ 2019 Refinement to the 2006 IPCC Guidelines, Chapter 10: Emissions from Livestock and Manure Management.

3.B.3 Manure management of swine

Methane conversion factors and the use of different systems of manure management for swine manure storage are presented in Table 5.30.

MCFs related to each type of MMS and CH₄ EFs are reported in Table 5.31.

Since the 2016 submission, the 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 natural crust cover for uncovered pig slurry is highly unlikely.

Estonia uses 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) in calculations. CH₄ EFs increase from the least weighing category to the most weighing category. For example, in 1999 there was a sharp decrease in the number of swine compared to 1998 as buying-in prices of pork had fallen. As a result, compared to 1998, in 1999 the number of swine in the youngest age groups fell, whereas the number of swine in the three most weighing swine groups increased remarkably.

Table 5.30. Parameters used in the estimates

Swine category	Feed digestibility, % ¹⁶⁵	VS, kg/h/d	Bo, m ³ CH ₄ /kg VS ²⁰¹	MCF, % ²⁰²
Piglets, live weight less than 20 kg	83	0.11	0.45	0.6
Young pigs, live weight 20–<50 kg		0.24		
Fattening pigs	80			
...live weight 50–<80 kg		0.42		
...live weight 80–<110 kg		0.53		
...live weight 110 kg or more		0.58		
Breeding pigs, live weight 50 kg or more		0.32		

Table 5.31. Manure management methane conversion factors for swine manure management systems, %

MMS	MCFs ²⁰³ , %
Liquid/ slurry	17
Solid storage	2
Deep litter	17
Anaerobic digester	3.55 ²⁰⁰

3.B.2 and 3.B.4 Manure management of sheep and other livestock

Emission factors used in the estimates for other livestock are presented in Table 5.32.

²⁰¹ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, pages 10.80-10.81, tables 10A-7 and 10A-8.

²⁰² Revised 1996 IPCC Guidelines, Volume 3, Chapter 4: Agriculture, page 4.35, table A-4.

²⁰³ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.45, table 10.17.

Table 5.32. Manure management emission factors of other livestock categories²⁰⁴

Livestock category	Emission factor ²⁰⁵ , kg CH ₄ /head/year
Sheep	0.19
Goats	0.13
Horses	1.56
Poultry	
Broilers	0.02
Layers and other chickens	0.03
Other Poultry	0.055
Fur animals	
Foxes and raccoons	0.68
Minks	0.68
Rabbits	0.08

Direct N₂O emissions from Manure management

The breakdown of the emission factors used to estimate N₂O emissions released from different types of MMSs is reported in Table 5.33. These apply for all animal categories.

Table 5.33. Applied emission factors of manure management, kg N₂O–N/kg Nitrogen excreted²⁰⁶

MMS	EF ₃ (kg N ₂ O–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
Dry lot	0.02
Anaerobic digester ²⁰⁷	0.0006

3.B.1 Manure management of cattle

The trends in average weight of dairy cattle, milk yield per cow and protein content in milk and (implied) nitrogen excretion rates reported in the CRT are presented in Table 5.34.

Table 5.34. Weight, milk yield per cow and protein content of milk in 1990–2024 (Annexes A.V.3 III.1, A.V.3 II.1–2, A.V.3 V.3–4)

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	74.28
2005	588.7	5 886	3.34	93.22
2021	636.3	9 966	3.40	140.22
2022	636.5	10 144	3.51	142.04

²⁰⁴ The module was applied only in the estimation of N₂O emissions from manure management of other livestock, since CH₄ emission from manure management was estimated based on *Tier 1* of the IPCC Guidelines.

²⁰⁵ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, pages 10.40–10.41, tables 10.15–10.16 (developed countries, cool climate region).

²⁰⁶ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.62, table 10.21.

²⁰⁷ IPCC 2019 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.62, table 10.21.

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
2023	636.6	10 608	3.39	143.09
2024	363.7	11 350	3.40	149.11
IPCC default				
EE ²⁰⁸	550	2 555 ²⁰¹	-	96.4 ²⁰⁹
WE	600	5 986	-	105.1

The N excretion rates are reported in Table 5.35.

Table 5.35. Country-specific nitrogen excretion rates of non-dairy cattle in 2024, kg N/head/year

Livestock category of non-dairy cattle	Nitrogen excretion rate, kg N/head/yr
Mature males (2 years and over)	73.3
Mature females (2 years and over)	75.0
Bovine animals (aged between 1 and 2 years)	51.0
Calves (6–12 months) ²¹⁰	16.0
Calves (0–6 months)	2.9

3.B.3 Manure management of swine

Nitrogen excretion rates were taken from the Regulation of the Minister of the Environment no 66, 14/12/2016²¹¹ (Table 5.36). Applied emission factors are indicated in Table 5.33. Nitrogen (implied) excretion rates reported in the CRT are demonstrated in Figure 5.15. The rate has slightly changed over the entire time series due to changes in the structure of the swine population.

Table 5.36. 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 ²¹²	–	–
Market (average 50 kg)	–	10
Breeding (average 180 kg)	–	30

²⁰⁸ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.72, table 10A.1.

²⁰⁹ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.59, table 10.19.

²¹⁰ 2-round production cycle was applied for calves (0–6 months and 6–12 months).

²¹¹ Riigi Teataja. Regulation No. 66 of the Minister of the Environment of 14 December 2016 "Methods for measuring and calculating emissions of pollutants released into the outdoor air from animal and poultry farming Annex." (in Estonian). [www] https://www.riigiteataja.ee/akti/isa/1221/2201/6004/KKM_m66_Lisa.pdf# (12.11.2025).

²¹² IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.59, table 10.19.

3.B.2 and 3.B.4 Manure management of sheep and other livestock

Nitrogen excretion rates (Table 5.37) were obtained from the IPCC 2006 Guidelines.

Table 5.37. Nitrogen excretion rates per head of animal, kg N/head/year

Livestock category ²¹³	Nitrogen excretion rate, kg N/head/year
Poultry	
Layers (1.8 kg)	0.54
Broilers (0.9 kg)	0.36
Other chickens (1.8 kg)	0.39
Other poultry (4.75 kg)	1.36
Sheep (65 kg)	21
Goats (40 kg)	19
Horses (550 kg)	60
Fur farming	
Foxes and raccoons	12.09
Minks	4.59
Rabbits	8.1

Indirect N₂O emissions from Manure management

Leaching and run-off of manure nutrients is prevented when the manure storage facility is compacted and sealed. According to an expert opinion by A. Kaasik, a docent of the Chair of Animal Nutrition in Estonian University of Life Sciences, leakage may be presumed for 70% of solid manure storage in 1990s, as most of the manure was kept in manure stacks.²¹⁴

The leak-tightness of manure storage facilities was studied in a 2010 survey²¹⁵ 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 the case of solid manure storage. Leaching and run-off appeared to be a problem for 23% of solid storage facilities. In the case of liquid manure storage, no leaking facilities were detected. It should be noted that the leakage was determined by visual inspection and on the grounds 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 basis 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 have been constructed according to the respective project requirements (circular drainage, manholes, etc). Hence, leak-tightness of liquid manure storage facilities should be provided.

Leaching and run-off were 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 of 2000–2009 have been found via interpolation.

²¹³ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, pages 10.59 and 10.82, tables 10.19 and 10A-9 (average weight).

²¹⁴ A. Kaasik, M. Möls. Improving inventory methods for emissions from livestock farming and mapping emission reduction technologies (in Estonian). [www]
<https://kliimaministeerium.ee/sites/default/files/documents/2021-12/Loomakasvatusest%20eralduvate%20saasteainete%20heitkoguste%20inventuurimetoodikate%20t%C3%A4iendamine%20ja%20heite%20v%C3%A4hendamistehnoloogiate%20kaardistamine.pdf> (30.10.2025)

²¹⁵ Ministry of Climate. Manure management inventory begins (in Estonian). [www]
<https://kliimaministeerium.ee/uudised/algab-sonnikukaitluse-inventuur> (30.10.2025).

The value of $\text{Frac}_{\text{leachMS}} = 5\%$ is taken from the *Best Available Technique manual for intensive cattle farming*²¹⁶ for Estonian farmers.

5.3.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Manure management subcategory, please see Annex A.II.3 Agriculture, 3.B Manure management chapter.

5.3.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for the Estonian GHG inventory at the national level are presented in Chapter 1.5.

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.

5.3.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

CH₄ emissions from Manure management

Correcting poultry manure sent to biogas production plants in 2023

Layers' population numbers whose manure was sent to biogas plants in 2023 was corrected for emission calculations for the 2026 submission due to a calculation error in previous submission.

A comparison of the changed values of direct CH₄ emissions due to the recalculations between 2026 and 2025 submissions is shown in Table 5.38.

Table 5.38. Reported CH₄ emissions in the 2025 and 2026 submissions from manure management, kt

Manure management	2023
2025 submission	5.881
2026 submission	5.879

Direct N₂O emissions from Manure management

Correcting the Nex values for poultry for the whole timeseries

According to observation (EE-3B-2025-0004) made by the TERT conducting EU internal annual review of national greenhouse gas inventory data, Nitrogen excretion rates for Layers and Pullets were corrected for emission calculations for the years 1990-2023 due to a misuse of IPCC 2006 Default Nex values in previous submissions.

A comparison of the changed values of direct N₂O emissions due to the recalculations between 2026 and 2025 submissions is shown in Table 5.39.

²¹⁶ Estonian University of Life Sciences. Comprehensive pollution prevention and control. Best available techniques in intensive cattle farming (in Estonian). [www] <https://dspace.emu.ee/items/01e3b65f-5f35-476e-8edb-fd306a210583> (30.10.2025).

Table 5.39. Reported direct N₂O emissions in the 2025 and 2026 submissions from manure management, kt

Manure management	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
2025 submission	0.38	0.36	0.31	0.25	0.23	0.20	0.17	0.17	0.17	0.15	0.15	0.17
2026 submission	0.38	0.36	0.31	0.25	0.23	0.20	0.17	0.18	0.17	0.15	0.15	0.17

Table 5.39. Reported direct N₂O emissions in the 2025 and 2026 submissions from manure management, kt (continued)

Manure management	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
2025 submission	0.16	0.16	0.17	0.18	0.18	0.18	0.18	0.19	0.21	0.21	0.21	0.21
2026 submission	0.16	0.16	0.16	0.18	0.18	0.18	0.18	0.19	0.21	0.21	0.21	0.21

Table 5.39. Reported direct N₂O emissions in the 2025 and 2026 submissions from manure management, kt (continued)

Manure management	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
2025 submission	0.21	0.22	0.21	0.22	0.22	0.22	0.22	0.22	0.22	0.21
2026 submission	0.21	0.22	0.21	0.22	0.22	0.22	0.22	0.22	0.22	0.21

5.3.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

Estonia is working on developing country-specific methane conversion factors for animal manure sent to biogas digesters.

5.4. Agricultural soils (CRT 3.D)

5.4.1. Category description (e.g. characteristics of sources)

Direct N₂O emissions from managed soils (CRT 3.D.1)

N₂O is produced naturally in soils through the microbial processes of nitrification and denitrification. Several agricultural activities add nitrogen to soils, increasing the amount of nitrogen available for nitrification and the amount of N₂O²¹⁷.

The following agricultural activities influence N flows in agricultural soils:

- synthetic fertilizers;
- animal excreta nitrogen used as fertilizer (including manure digestates);
- sewage sludge application on agricultural soils;
- application of other organic waste on agricultural soils (compost, and waste digestates);
- crop residues;
- mineralization associated with the loss/gain of soil organic matter;
- cultivation of high organic content soils; and
- urine and dung deposited by grazing animals.

²¹⁷ IPCC 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Chapter 4: Agriculture, page 4.53.

Even though the cereal production in Estonia has revived following the EU accession to 1990 levels, the usage of mineral fertilizers has decreased since the collapse of the collective farms. Accordingly, direct N₂O emissions from managed soils decreased by 31.9% in 2024 compared with the base year due to the decrease in the number of the livestock population (i.e., amount of animal manure applied on agricultural soils and emissions from grazing animals) and due to the decline in the quantity of fertilizers applied on agricultural land (Figure 5.15). In 2024, the main contributor to the direct N₂O emissions from agricultural soils was the use of synthetic fertilizers (27%), followed by emissions originating from crop residues left on the fields (25%), the cultivation of organic soils (24%), animal manure applied to soils (including manure digestates) (12%), mineralization associated with the loss/gain of soil organic matter (5%), the use of other organic fertilizers (including digestates from co-substrates) (4%), urine and dung deposited by animals grazing (3%), and sludge application on agricultural fields (0.3%) (Figure 5.16). The total direct N₂O emissions from Agricultural soils were 2.1 kt in Estonia in 2024 (Figure 5.15).

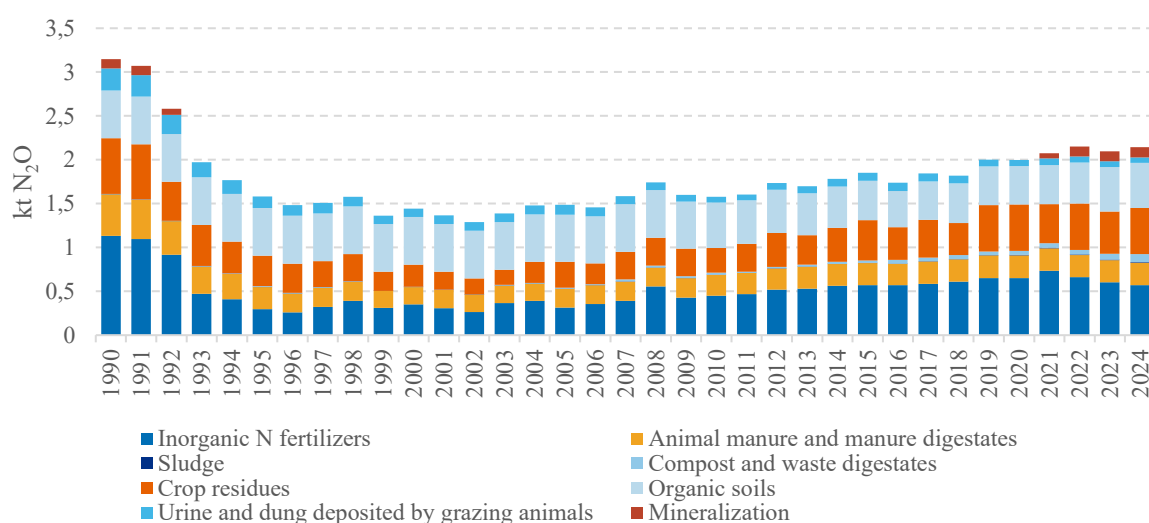


Figure 5.15. Direct N₂O emissions from Agricultural soils in Estonia in 1990–2024, kt

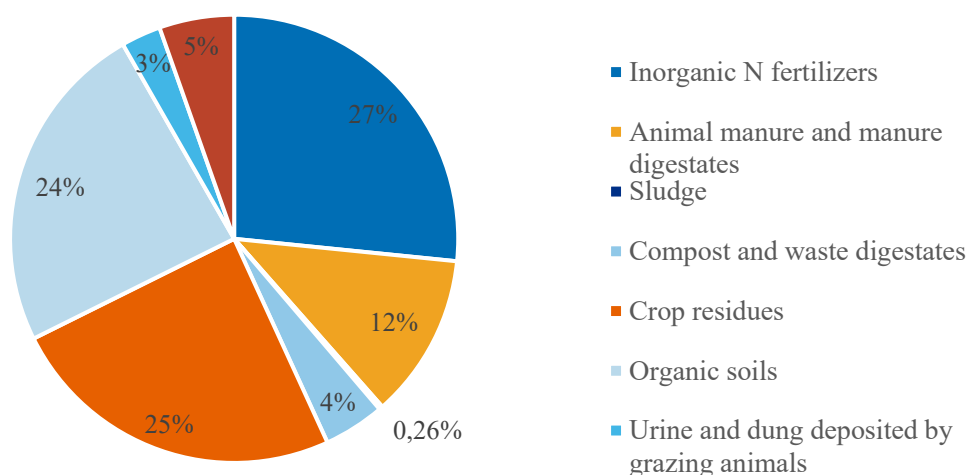


Figure 5.16. Direct N₂O emissions from Agricultural soils in Estonia in 2024, %

3.D.1.a N₂O emissions from Inorganic nitrogen fertilizers applied to soils

The total N₂O emissions from synthetic fertilizers applied onto agricultural soils were 0.57 kt in Estonia in 2024 (Figure 5.17). The emissions declined by 49.7% in 2024 compared with the

base year due to the decrease in the amounts of synthetic fertilizers applied to agricultural fields (Figure 5.17, Annex A.V.3_VI). Emissions from mineral fertilizers have been increasing with a few fluctuations since 2009. This is due to the increase of agricultural crop production area, and it's been in correlation with the economic situation in the country. What is more, the structure of agricultural households has been changing – the number of larger households that use more fertilizer and have a larger area for crop production, is rising. However, mineral fertilizer prices have been in a growing trend as well over the past few years – that is why mineral fertilizers' usage have been decreasing since 2022.²¹⁸ Compared to 2023, emissions from mineral fertilizers decreased by 5.6% in 2024.

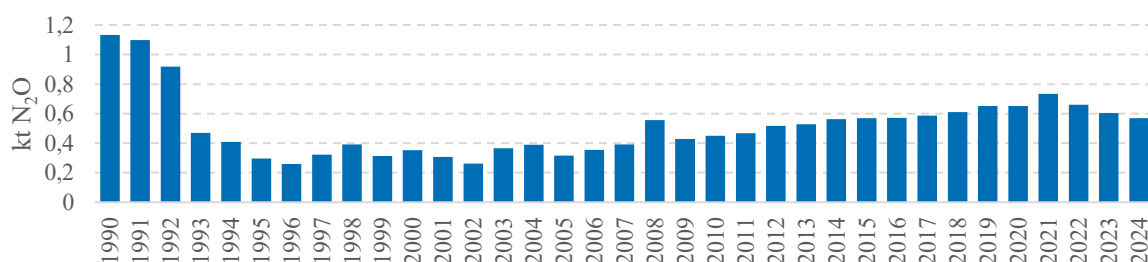


Figure 5.17. Emissions from synthetic fertilizers applied to agricultural soils in 1990–2024 in Estonia, kt N₂O

3.D.1.b.i N₂O emissions from Animal manure applied to soils (including manure digestates)

N₂O emits from agricultural soil through manure application to fields as organic fertilizer. That includes manure digestates that are applied to soils after going through the biogas reactor.

Direct N₂O emissions from animal manure applied on agricultural soils were 0.26 kt in Estonia in 2024 (Figure 5.18). The emissions decreased by 46.0% in 2024 compared to the base year, due to the decline in the number of the livestock population.

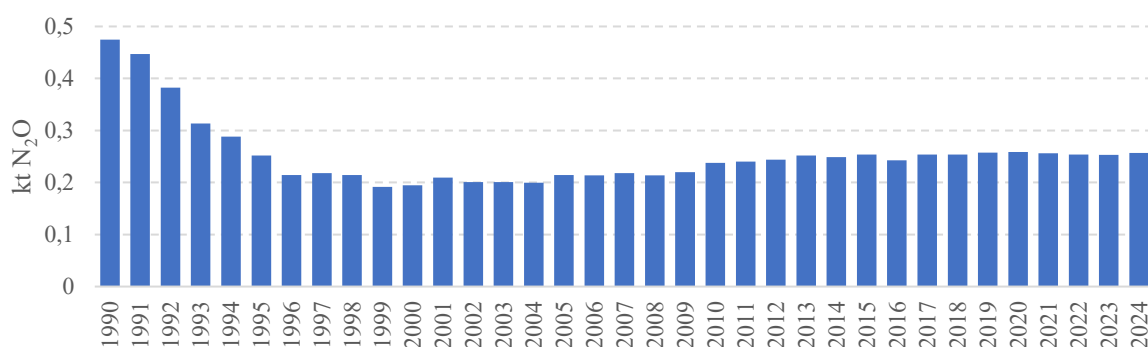


Figure 5.18. N₂O emissions from animal manure applied to soils in Estonia in 1990–2024, kt

3.D.1.b.ii N₂O emissions from Sewage sludge applied to soils

Sludge from domestic wastewater treatment plants is used on agricultural land.

²¹⁸ Estonian Chamber of Agriculture and Commerce. The past year increased uncertainty in the sector, with no quick solution in sight. (in Estonian). [www] <https://epkk.ee/sormus-mooduv-aasta-suurendas-sektori-ebakindlust-millest-kiiret-paasu-ei-paista/> (30.10.2025).

The total N₂O emissions from sewage sludge applied on agricultural land were 0.006 kt in Estonia in 2024 (Figure 5.19). For explanations about emissions fluctuations, please see Chapter 5.4.2 Methodological issues, Activity data.

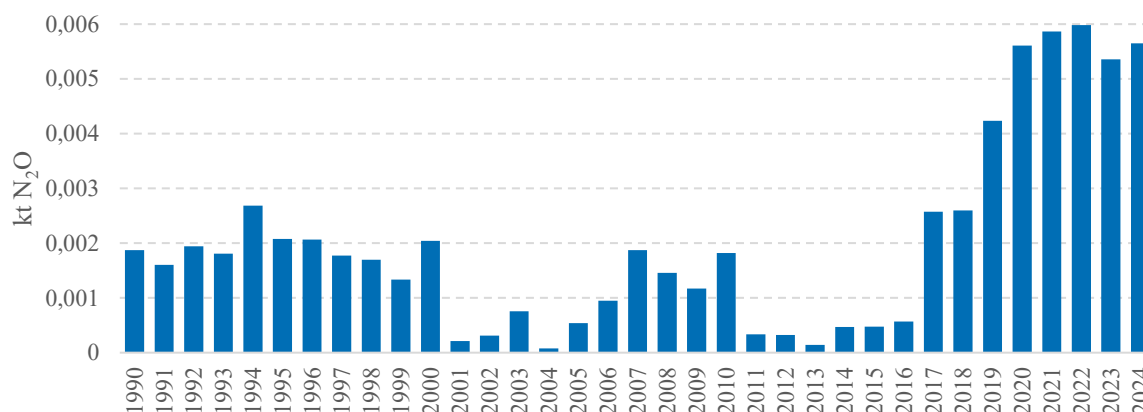


Figure 5.19. N₂O emissions from sewage sludge applied on agricultural land in Estonia in 1990–2024, kt

3.D.1.b.iii N₂O emissions from Other organic fertilizers applied to soils (compost and waste digestates)

The total N₂O emissions from compost and waste digestates applied on agricultural land were 0.09 kt in Estonia in 2024, that is the highest throughout the whole timeseries (Figure 5.20). This can be explained by the amounts of waste digestates applied to soils that have been growing in time – biogas producers have been adding more co-digestates into the biogas reactor besides animal manure – the amounts have reached its peak in 2024.

Additional information on the fluctuations of composted waste can be found in Chapter 7.3 Biological treatment of solid waste (CRT 5.B). In addition to the amounts of compost, amounts of waste-source digestates that are applied to agricultural land are also accounted there.

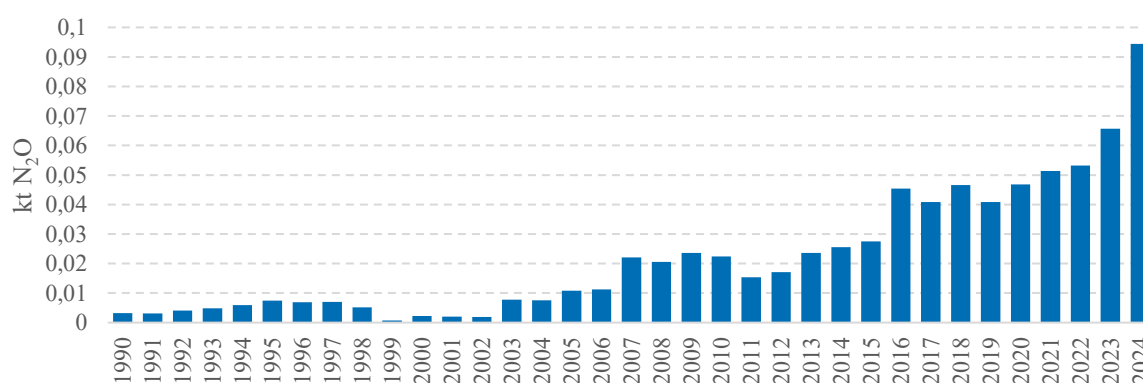


Figure 5.20. N₂O emissions from compost and waste digestates applied on agricultural land in Estonia in 1990–2024, kt

3.D.1.c N₂O emissions from Urine and dung deposited by grazing animals

The total N₂O emissions from pasture, range and paddock made up 0.06 kt in 2024. The emission decreased by 75.6% compared to the base year due to the decline in the number of the livestock population and due to the decline in animal grazing (Figure 5.21).

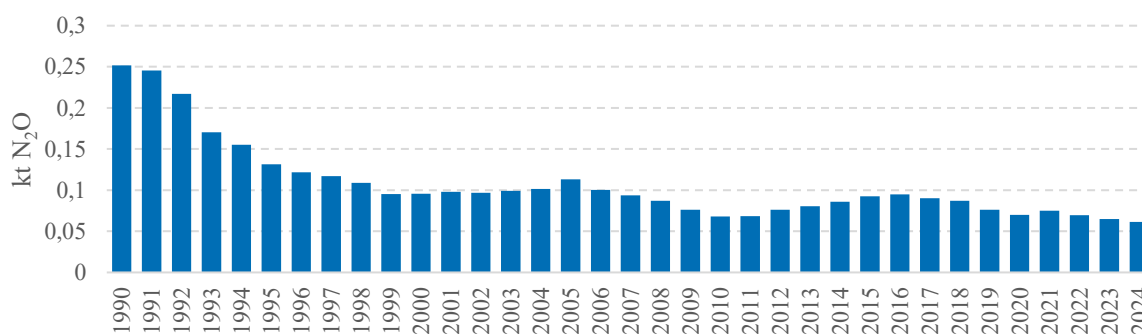


Figure 5.21. N₂O emissions from urine and dung deposited by grazing animals in 1990–2024, kt

3.D.1.d N₂O emissions from nitrogen input from Crop residues

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

The total N₂O emissions from crop residues left on agricultural land was 0.52 kt in 2024 (Figure 5.22). The respective emissions have declined by 17.4% compared with the base year. The recuperation of crop production following the transition to market economy has been more prominent compared to animal husbandry. Increased crop production has been favoured by the steady growth of cereals export in recent years.

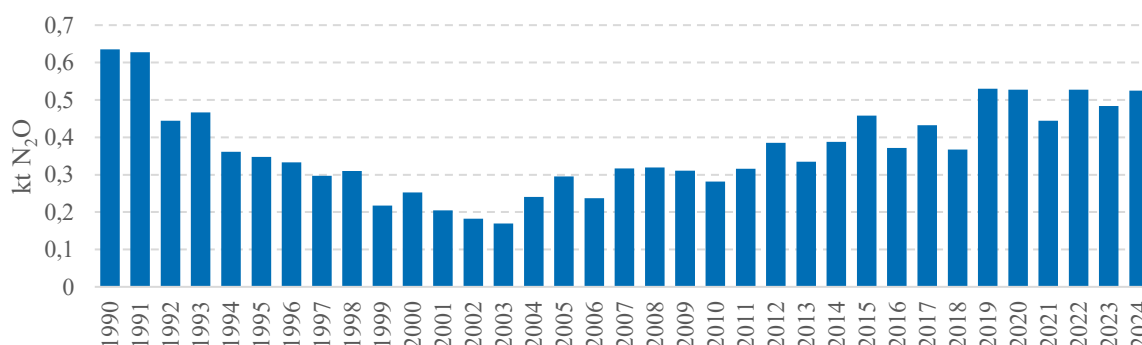


Figure 5.22. N₂O emissions from crop residues left on agricultural fields in 1990–2024 in Estonia, kt

3.D.1.e N₂O emissions from Mineralization/immobilization associated with the loss/gain of soil organic matter

N mineralization associated with the loss of soil organic matter resulting from changes in land use is one of the N₂O emission sources. When soil C is lost through oxidation because of land-use change, the loss of C is accompanied by simultaneous mineralization of N. This mineralized N is an additional resource of N available for conversion to N₂O. Consequently, N₂O emissions are being reported only about the years when carbon stock in mineral soils has decreased compared to the previous year.

In 2024, N₂O emissions from mineralization of the loss of soil organic matter were 0.12 kt, that is 0.2% less than a year before. Since 1990, the emissions have occurred only in 1990, 1991, 1992, 2021, 2022, 2023 and 2024. In other years, the carbon stock in mineral soils has increased compared to the previous year and thus the N₂O emissions have not occurred.

3.D.1.f N₂O emissions from Cultivation of organic soils

N₂O 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.²¹⁹

N₂O emissions from cultivation of organic soils were 0.52 kt in 2024 in Estonia (Figure 5.23). The estimation was carried out based on the data received in the framework of the National Forest Inventory (see Chapter 6 Land use, land-use change and forestry (CRT sector 4)).

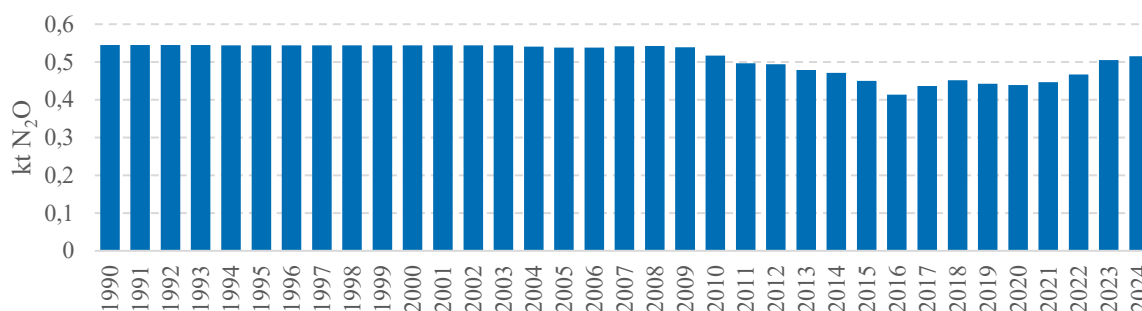


Figure 5.23. N₂O emissions from cultivation of organic soils in Estonia in 1990–2024, kt

Indirect N₂O emissions from managed soils (CRT 3.D.2)

Nitrous oxide is produced naturally in soils and aquatic systems through the microbial processes of nitrification and denitrification. Several 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 N₂O emitted²²⁰.

The total indirect N₂O emissions from agricultural soils were 0.50 kt in 2024 (Figure 5.24). The emissions declined compared to the base year (1990) by 37.74% in 2024 due to the decrease in the number of the livestock population and synthetic and organic fertilizer application onto agricultural land.

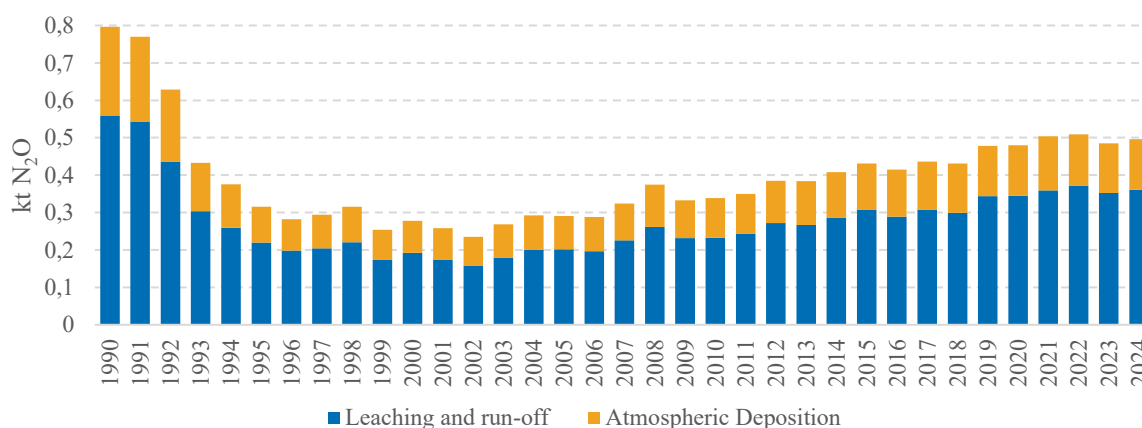


Figure 5.24. Indirect N₂O emissions from Agricultural soils in Estonia in 1990–2024, kt

²¹⁹ Revised 1996 IPCC Guidelines, Volume 3, Chapter 4: Agriculture, page 4.91.

²²⁰ IPCC 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Chapter 4: Agriculture, page 4.53.

3.D.2.a Atmospheric deposition of NO_x and NH₃

Atmospheric deposition of nitrogen compounds such as nitrogen oxides (NO_x) and ammonium (NH₃) fertilize soils and surface waters, which results in enhanced biogenic N₂O formation²²¹. Total N₂O emissions from atmospheric deposition were 0.13 kt in 2024 in Estonia.

3.D.2.b Leaching/run-off of applied or deposited nitrogen

A large proportion of nitrogen is lost from agricultural soils through leaching and run-off. This nitrogen enters the groundwater, riparian areas and wetlands, rivers, and eventually the ocean, where it enhances the biogenic production of N₂O²²¹. The total N₂O emissions from leaching and run-off were 0.36 kt in 2024 in Estonia.

5.4.2. Methodological issues

Choice of methods

Direct N₂O emissions from managed soils (CRT 3.D.1)

3.D.1.a N₂O emissions from Inorganic nitrogen fertilizers applied to soils

N₂O emissions are estimated from the annual synthetic nitrogen applied to soils. The algorithm reported in IPCC 2006 was used to estimate the nitrogen input into agricultural soils adjusted for volatilization.

Frac_{GASF} = Fraction of the total synthetic fertilizer nitrogen that is emitted as NO_x+NH₃, kg N/kg N (Table 5.41);

N₂O emissions into the atmosphere from the use of synthetic nitrogen were calculated based on the Equation 5.26:

Equation 5.27

$$N_2O_{direct} = F_{SN} \times EF \times \frac{44}{28}$$

Where:

F_{SN} = total use of synthetic fertilizers in a country, kg N/year;

EF = emission factor (Table 5.41).

3.D.1.b.i N₂O emissions from Animal manure applied to soils (including manure digestates)

N₂O emissions into the atmosphere from animal waste applied to agricultural fields as organic fertilizer was estimated according to the algorithm proposed by the IPCC 2006 (Equation 5.27-Equation 5.29):

²²¹ IPCC 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Chapter 4: Agriculture, page 4.70.

Equation 5.28²²²

$$N_2O_{direct} - N = F_{AM} \times EF_l$$

Equation 5.29²²³

$$F_{AM} = N_{MMS\ Avb} \times [1 - (Frac_{FEED} + Frac_{FUEL} + Frac_{CNST})]$$

Where:

- EF_l = emission factor (Table 5.41);
 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 5.30²²⁴

$$N_{MMS\ Avb} = \sum_S \left\{ \sum_{(T)} \left[\left[\langle N_{(T)} \times Nex_{(T)} \times MS_{(T,S)} \rangle \times \left(1 - \frac{Frac_{LossMS}}{100} \right) \right] + [N_{(T)} \times MS_{(T,S)} \times N_{beddingMS}] \right] \right\}$$

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 MMS S in the country, dimensionless;
 $Frac_{LossMS}$ = amount of managed manure nitrogen for livestock category T that is lost in the MMS S , %;
 $N_{beddingMS}$ = amount of nitrogen from bedding (to be applied for solid storage and deep bedding MMS if organic bedding usage is known), kg N animal⁻¹ yr⁻¹;
 S = MMS;
 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.

3.D.1.b.ii N₂O emissions from Sewage sludge applied to soils

The IPCC 2006 Tier 1 (Equation 5.31) approach was employed to estimate N₂O emissions from sludge applied on agricultural land:

²²² IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, page 11.7, equation 11.1.

²²³ IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, page 11.13, equation 11.4.

²²⁴ IPCC 2006 Guidelines, Volume 4, Chapter 10: Emissions from Livestock and Manure Management, page 10.65, equation 10.34.

Equation 5.31²¹⁴

$$N_2O_{direct} = F_{SL} \times EF_1 \times \frac{44}{28}$$

Where:

F_{SL} = annual amount of sewage sludge N applied to soils, kg N yr⁻¹;

EF_1 = emission factor (Table 5.41).

3.D.1.b.iii N₂O emissions from Other organic fertilizers applied to soils (compost, and waste digestates)

The IPCC 2006 *Tier 1* (Equation 5.32) approach was employed to estimate N₂O emissions from organic fertilizers applied to agricultural land:

Equation 5.32²¹⁴

$$N_2O_{direct} = F_{ON} \times EF_1 \times \frac{44}{28}$$

Where:

F_{ON} = annual amount of organic fertilizer N applied to soils, kg N yr⁻¹;

EF_1 = emission factor (Table 5.41).

Since 2021 submission, the emission calculations from compost are based on dry weight of compost instead of formerly used wet weight. Since 2024 submission, N₂O emissions from waste digestates applied to soils are also considered in this subcategory. The emissions are calculated using the same equation (Equation 5.31).

3.D.1.c N₂O emissions from Urine and dung deposited by grazing animals

The method reported in Chapter 5.3.2. Methodological issues, Choice of methods, Direct N₂O emissions from Manure management was used to estimate N₂O emissions from animal pasture, range, and paddock.

3.D.1.d N₂O emissions from nitrogen input from Crop residues

The IPCC *Tier 1* (Equation 5.33) method was used to estimate emissions from crop residues returned to the soil.

Equation 5.33²²⁵

$$F_{CR} = \sum_T \{ Crop_T \times Frac_{Renew(T)} \times [(Area_{(T)} - Area_{burnt(T)} \times C_f) \times R_{AG(T)} \times N_{AG(T)} \times (1 - Frac_{Remove(T)}) + Area_{(T)} \times R_{BG(T)} \times N_{BG(T)}] \}$$

Where:

Data for $Frac_{Remove}$ are not available in Estonia, therefore no removal was assumed. Also, as no agricultural burning practices have been carried out in Estonia, $Area_{burnt(T)}$ is zero. IPCC

²²⁵ IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, page 11.14, equation 11.6.

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 Guidelines²²⁶.

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;
 C_f = combustion factor, dimensionless
 $Frac_{Renew(T)}$ = fraction of total area under crop T that is renewed annually. 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 dry matter of above-ground residues ($AG_{DM(T)}$) to harvested yield for crop T ($Crop_{(T)}$), kg d.m. (kg d.m.)⁻¹, = $AG_{DM(T)} \times 1000 / Crop_{(T)}$;
 $N_{AG(T)}$ = 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-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, $R_{BG(T)}$ may be calculated by multiplying R_{BG-BIO} by the ratio of total above-ground biomass to crop yield (= $[(AG_{DM(T)} \bullet 1000 + Crop_{(T)}) / Crop_{(T)}]$);
 $N_{BG(T)}$ = N content of below-ground residues for crop T , kg N (kg d.m.)⁻¹;
 T = crop or forage type.

Annual N₂O emissions from crop residues were calculated using the Equation 5.34.

Equation 5.34²¹⁴

$$N_2O_{direct} = F_{CR} \times EF_1 \times \frac{44}{28}$$

Where:

F_{CR} = annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N yr⁻¹;
 EF_1 = emission factor (Table 5.41).

3.D.1.e N₂O emissions from Mineralization/immobilization associated with the loss/gain of soil organic matter

For calculating N₂O emissions from mineralization/immobilization associated with the loss/gain of soil organic matter, the data on land-use change of Cropland remaining Cropland were used. Annual N mineralized in mineral soils because of the loss of soil C through change in land use was calculated using the Equation 5.35 from the *Tier 1* method.

²²⁶ IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, pages 11.17–11.18, table 11.2.

$$F_{SOM} = \sum_{LU} \left[\left(\Delta C_{Mineral, LU} \times \frac{1}{R} \right) \times 1000 \right]$$

Where:

$$N_2O - N = F_{SOM} \times EF_1$$

F_{SOM} = the net annual amount of N mineralized 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), tons C;

R = C:N ratio of the soil organic matter;

LU = land-use and/or management system type.

3.D.1.f N₂O emissions from Cultivation of organic soils

The 2006 IPCC *Tier 1* method was applied to estimate N₂O emissions from organic soils cultivation (Equation 5.36). Since the 2019 submission, in addition to croplands, areas of drained grasslands have been included in emission estimates of cultivated organic soils.

$$N_2O_{direct} = F_{OS} \times EF_2 \times \frac{44}{28}$$

Where:

F_{OS} = area of cultivated organic soils, ha;

EF_2 = emission factor for organic soil mineralization due to cultivation, kg N₂O–N ha/year (Table 5.41).

Indirect N₂O emissions from managed soils (CRT 3.D.2)

3.D.2.a Atmospheric deposition of NO_x and NH₄

The *Tier 1* (Equation 5.37) method was used to estimate emissions from the Atmospheric deposition.

$$N_2O_{(ATD)} - N = \left[(F_{SN} \times \text{Frac}_{GASF}) + ((F_{ON} + F_{PRP}) \times \text{Frac}_{GASM}) \right] \times EF_4$$

Where:

$N_2O_{(ATD)} - N$ = annual amount of N₂O–N produced from atmospheric deposition of N volatilized from managed soils, kg N₂O–N yr⁻¹;

F_{SN} = annual amount of synthetic fertilizer N applied to soils, kg N yr⁻¹;

Frac_{GASF} = fraction of synthetic fertilizer N that volatilizes as NH₃ and NO_x, kg N volatilized (kg of N applied)⁻¹ (Table 5.41);

²²⁷ IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, page 11.16, equation 11.8.

²²⁸ IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, page 11.16.

²²⁹ IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, page 11.21, equation 11.9.

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 ;
$Frac_{GASM}$ =	fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilizes as NH ₃ and NO _x , kg N volatilized (kg of N applied or deposited) ⁻¹ (Table 5.41);
EF_4 =	emission factor for N ₂ O emissions from atmospheric deposition of N on soils and water surfaces, [kg N–N ₂ O (kg NH ₃ –N + NO _x –N volatilized) ⁻¹] (Table 5.41).

3.D.2.b Leaching/run-off of applied or deposited nitrogen

The *Tier 1* method from the IPCC 2006 Guidelines was used to estimate emissions from Leaching/run-off (Equation 5.38).

Equation 5.38²³⁰

$$N_2O_{(L)} - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \times Frac_{LEACH-(H)} \times EF_5$$

Where:

$N_2O_{(L)} - N$ =	annual amount of N ₂ O–N produced from leaching and run-off of N additions to managed soils in regions where leaching/run-off occurs, kg N ₂ O–N yr ⁻¹ ;
F_{SN} =	annual amount of synthetic fertilizer N applied to soils in regions where leaching/run-off 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/run-off occurs, kg N yr ⁻¹ ;
F_{PRP} =	annual amount of urine and dung N deposited by grazing animals in regions where leaching/run-off 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/run-off occurs, kg N yr ⁻¹ ;
F_{SOM} =	annual amount of N mineralized in mineral soils associated with the loss of soil C from soil organic matter as a result of changes in land use or management in regions where leaching/run-off occurs, kg N yr ⁻¹ ;
$Frac_{LEACH-(H)}$ =	fraction of all N added to/mineralized in managed soils in regions where leaching/run-off occurs that is lost through leaching and run-off, kg N (kg of N additions) ⁻¹ (Table 5.41);
EF_5 =	emission factor for N ₂ O emissions from N leaching and run-off, kg N ₂ O–N (kg N leached and run-off) ⁻¹ (Table 5.41).

²³⁰ IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, page 11.21, equation 11.10.

Activity data

Direct N₂O emissions from managed soils (CRT 3.D.1)

3.D.1.a N₂O emissions from Inorganic nitrogen fertilizers applied to soils

Activity data on the amounts of synthetic fertilizers used on agricultural lands in Estonia was obtained from the datasets of Statistics Estonia from the table PM065.²³¹ Before 2015, the data about the usage of mineral fertilizers were gathered by statistical enquiry. Since 2015, SE has used indices calculated by using the data on the amounts of mineral fertilizers gathered by the Centre of Estonian Rural Research and Knowledge (former Agricultural Research Centre) in the framework of the Farm Accountancy Data Network (FADN). FADN data were also reported to the European Commission by SE.

3.D.1.b.i N₂O emissions from Animal manure applied to soils (including manure digestates)

Amounts of managed manure Nitrogen available for soil application, kg N yr⁻¹, is calculated based on Equation 5.29 from IPCC 2006 Guidelines.

3.D.1.b.ii N₂O emissions from Sewage sludge applied to soils

The data on the amounts of sludge used on agricultural lands was received from the EstEA.

Table 5.40 illustrates the amounts of sewage sludge used for improving the environmental situation (R10).

The methodology of sewage sludge treated according to the R10 category in 1990-1998 was formerly developed and given by the Tallinn University of Technology (TalTech) compiling the GHG inventory until 2012. During that period, limited waste related data was gathered by the predecessor of Estonian Environment Agency (EstEA) – Estonian Environment Information Centre – and therefore an assumption was made that 50% of the total amount of generated sewage sludge was used for improving the environmental situation. In accordance with the 2022 ERT review's recommendation ARR2022/A.7, Estonia has received an expert judgement for the evaluation made by TalTech in 2012. The expert, an authorized engineer in water supply and sewerage, Dr. Kuusik used all available preserved materials to compile an expert opinion on the usage of sewage sludge in the years 1990-1998 and conducted an evaluation on the amounts of sludge being used on agricultural lands and the amounts composted during these years. The complete expert judgement, including the references to supporting documents, are stored in the Inventory archive (in Estonian).

Data for the years 1999–2019 were obtained from datasets of EstEA and national online waste reporting system, JATS. EstEA started to collect data in accordance with the Estonian waste classification in 1992, but in 1999 the adapted classification system changed, and the European Waste Catalogue was adopted. Starting from 2020, companies submit their waste data through Environmental Decisions Information System KOTKAS, managed by Environmental Board. Reports are stored in Data Warehouse, managed by Ministry of Climate and published in EstEA's Tableau.²³²

²³¹ Statistics Estonia. PM065: USE OF MINERAL FERTILIZERS FOR THE PRODUCTION IN THE ACCOUNTING YEAR. [www]

https://andmed.stat.ee/en/stat/majandus_pellumajandus_pellumajandussaaduste-tootmine_taimakasvatussaaduste-tootmine/PM065 (12.11.2025).

²³² The Information Technology Centre of the Ministry of the Environment Waste data visualizing system (Tableau). [www]

EstEA is doing data processing and validating its accuracy. Estonian Environmental Research Centre waste expert is validating the data by asking companies and EstEA to clarify the amounts of R10 sewage, if there are significant fluctuations occurring. The fluctuation in the sewage sludge applied to the fields time series is due to the variability in the amount of sewage sludge generated each year and also how much of the generated sludge was used in composting and anaerobic digestion processes (reported under Waste sector, 5.B). Please note that “sludge” in the Waste sector considers sludge sent to biological treatment (reported under R3o, R5o and R12o) and does not include sludge reported under R10.

In the second half of the 1990’s, developments in the sewage sludge treatment technologies made it possible to purify the sewage water to a higher degree, therefore more sludge was generated. However, sludge management in Estonian wastewater treatment plants consisted mainly of making sludge transportable (solidification) and transporting sludge to landfills, less frequently to agricultural fields, for use in landscaping, and the recultivation of quarries, industrial sites and old military camps. Sludge collected and deposited on the sites of sewage treatment plants and landfills was also used for the closure of old landfills, landfill cover and landscaping.²³³ Since 2001, the amount of sewage sludge treated biologically started to increase. Therefore, the amounts of sewage sludge directly used for improving the environmental situation, i.e applying it to soils, decreased. This was due to a rising trend in recycling, i.e composting, sludge in waste-water treatment plants.²³⁴

Since 2017, especially large amounts of R10 are reported by two companies due to the construction works of an industrial park and larger landscaping activities.

The usage of sludge on agricultural fields in Estonia can be seen in Table 5.40.

Table 5.40. Amounts of municipal sludge application on agricultural land, tons²³⁵

Year	R10
1990	24 287
1991	20 860
1992	25 227
1993	23 509
1994	34 890
1995	27 000
1996	26 800
1997	23 000
1998	22 000
2000	26 489
2005	6992
2010	23 663
2011	4317
2012	4193
2013	1825
2014	6114
2015	6131
2016	7361

https://tableau.envir.ee/views/Avalikud_pringud_Jtmed/Riigitasand?%3Aembed=y&%3Aiid=1&%3AisGuestRedirectFromVizportal=y (30.10.2025).

²³³ A. Kuusik, (PhD). Expert judgement, stored in the Inventory archive (in Estonian).

²³⁴ Information obtained from an email exchange between M. Leevik, former Chief specialist of the Data Management Department of EstEA and M. Möls, former Agriculture sector specialist in EERC.

²³⁵ R10 of the European Waste Catalogue (2002) – Land treatment resulting in benefit to agriculture or improvement.

Year	R10
2017	33 437
2018	33 733
2019	54 971
2020	72 795
2021	76 140
2022	77 694
2023	69 536
2024	73 401

3.D.1.b.iii N₂O emissions from Other organic fertilizers applied to soils (compost, and waste digestates)

For the years 1990-1998, the amounts of compost applied on agricultural fields were revised based on the expert opinion²³³ by Dr. Aare Kuusik.

From 1999, data on the amounts of compost and waste digestates applied on agricultural fields was obtained from the datasets of EstEA.

Waste handling companies are obligated to report the amount of waste biologically treated to EstEA which checks the accuracy of the data. Starting from 2020, companies submit their waste data through Environmental Decisions Information System KOTKAS, managed by Environmental Board. Reports are stored in Data Warehouse, managed by Ministry of Climate and published in EstEA's Tableau²²⁴. Tableau provides information about the entire waste stream, including quantities of compost (recovery code R3o and R12o) and waste digestates applied to agricultural soils (see Waste sector, Chapter 7).

The practice of adding co-digestates to biogas reactors besides animal manure has been increasing over the years and has reached its peak in 2024, therefore the amounts of waste-based digestates applied on agricultural land are also increasing. This is because of the continuously increasing production volumes of biogas and the lack of animal manure near the production plant; therefore, biogas producers are obligated to add more co-digestates into the reactor. Additionally, a continuous increase in obligation to recycle waste is contributing to the increasing usage of co-digestates in biogas production. Typical co-digestates added to manure are silo, garden waste, waste from food industry, etc.

3.D.1.c N₂O emissions from Urine and dung deposited by grazing animals

Nitrogen Excretion by pasture, range and paddock by animal category, kg N yr⁻¹, is calculated based on Equation 5.29.

3.D.1.d N₂O emissions from nitrogen input from Crop residues

Activity data on crop production, yield and production area in Estonia was obtained from the datasets of SE.

Crop production increased for cereals and dry pulses in 2024 compared to last year, but decreased for potatoes.²³⁶ According to Statistics Estonia, the total production of cereals was 1 303 530 tons, which is 9% more than a year before. The total production of cereals in 2024 included 744 748 tons of wheat, 315 195 tons of barley and 72 623 tons of rye. Cereal yield per hectare was 3.7 tons – 9.5% more than a year before. Both yield and sown area increased for most crop types in 2024 compared to 2023. Winter crops accounted for almost 56% both for sown area and production of cereals. The importance of winter crops has been in a rising trend

²³⁶ Statistics Estonia. Cereal production increased by 9% in 2024 (in Estonian). [www] <https://www.stat.ee/et/uudised/teraviljatoodang-suurenes-2024-aastal-9> (07.07.2025).

because of the higher production amounts over spring crops. Total production of dry pulses was 148 742 tons, which is 25.5% more than last year. Production of winter rape and turnip rape seeds decreased – being 74 228 tons. That is as much as 41.9% less than a year before. The sown area of winter rape and winter turnip rape decreased to 47 489 hectares; the yield of winter rape seeds and turnip rape seeds decreased to 1.6 tons per hectare. The sown area of dry pulses was 60 414 hectares, which is 13.3% more than last year. The yield per hectare of dry pulses was 2.5 tons, which is 10.8% more than a year before. The total production of potatoes, however, decreased – being 74 668 tons, which is 12% less than last year. The production of open-field vegetables decreased from 38 051 tons in 2023 to 28 117 tons in 2024. The sown area of potatoes and open-field vegetables was 3176 and 1658 hectares, respectively. In 2024, the average yield per hectare for potatoes was 23.5 tons per hectare, which is 4.2% less than last year. The yield per hectare of open-field vegetables was of 17.0 tons, which is 30% less than a year before.^{237 238}

The production of different crops throughout the time-series is illustrated in Figure 5.25 and Figure 5.26 and in the tables of Annexes A.V.3_VII. The inter-annual changes in crop production are explained by changes in the total sown area (Annex A.V.3_VII.2) and by weather conditions (Annex A.V.3_X).

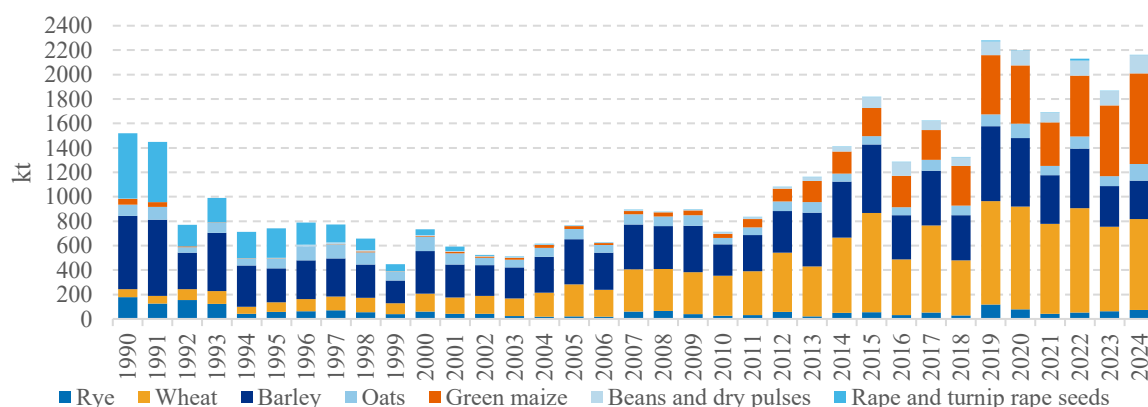


Figure 5.25. Cereals, maize, dry pulses and rape seed production in 1990–2024 in Estonia, kt

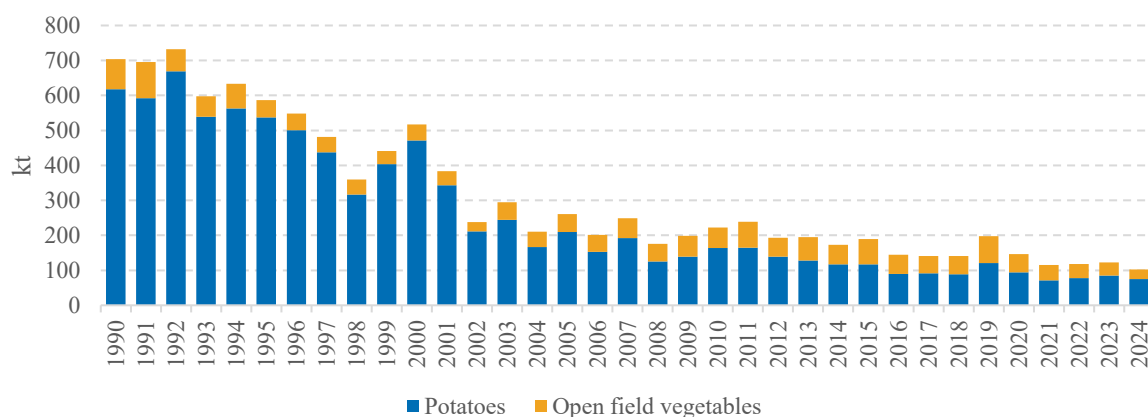


Figure 5.26. Potato and open-field vegetables production in 1990–2024, kt

²³⁷ Statistics Estonia. Agricultural land and crops by county. [www] https://andmed.stat.ee/en/stat/majandus_pellumajandus_pellumajandussaaduste-tootmine_taimekasvatussaaduste-tootmine/PM0281 (07.07.2025).

²³⁸ Statistics Estonia. Agriculture. [www] <https://www.stat.ee/en/find-statistics/statistics-theme/agriculture-fisheries-and-hunting/agriculture> (07.07.2025).

3.D.1.e N₂O emissions from Mineralization/immobilization associated with the loss/gain of soil organic matter

The activity data of carbon stock change in mineral soils on the area of cropland remaining cropland were received from the EstEA.

3.D.1.f N₂O emissions from Cultivation of organic soils

The data on areas of histosols under cultivation in Estonia were obtained in the framework of the National Forest Inventory (see Chapter 6 LULUCF).

Indirect N₂O emissions from managed soils (CRT 3.D.2)

3.D.2.a Atmospheric deposition of NO_x and NH₄

The amounts of volatilized N from agricultural inputs of N NH₃ and NO_x are calculated based on the activity data on 3.D.1.a Inorganic N fertilizers applied to soils, 3.D.1.b Organic N fertilizers applied to soils and 3.D.1.c Urine and Dung deposited by grazing animals.

3.D.2.b Leaching/run-off of applied or deposited nitrogen

The amounts of N from fertilizers and other agricultural inputs that is lost through leaching and run-off are calculated based on the activity data on 3.D.1.a Inorganic N fertilizers applied to soils, 3.D.1.b Organic N fertilizers applied to soils, 3.D.1.c Urine and Dung deposited by grazing animals, 3.D.1.d Crop residues and 3.D.1.e Mineralization.

Emission factors

Table 5.41. N₂O emission factors for Agricultural soils used in Estonian GHG Inventory

Category	Emission factor			Source
3.D.1 Direct N ₂ O emissions				
N additions from mineral fertilizers, organic amendments and crop residues, and N mineralized from mineral soil as a result of loss of soil carbon	EF ₁	0.01	kg N ₂ O–N (kg N) ⁻¹	IPCC (2006), table 11.1
Temperate organic crop and grassland soils	EF ₂ CG, Temp	8	kg N ₂ O–N ha ⁻¹	IPCC (2006), table 11.1
Cattle (dairy, non-dairy and buffalo), poultry and pigs	EF ₃ PRP, CPP	0.02	kg N ₂ O–N (kg N) ⁻¹	IPCC (2006), table 11.1
Sheep and 'other animals'	EF ₃ PRP	0.01	kg N ₂ O–N (kg N) ⁻¹	IPCC (2006), table 11.1
3.D.2 Indirect N ₂ O emissions				
N volatilization and re-deposition	EF ₄	0.01	kg N ₂ O–N	IPCC (2006), Table 11.3
			(kg NH ₃ –N + NO _x –N volatilized) ⁻¹	
Leaching/run-off	EF ₅	0.0075	kg N ₂ O–N	IPCC (2006), Table 11.3
			(kg N leaching/run-off)	

Category	Emission factor			Source
Volatilization from synthetic fertilizers	Frac _{GASF}	0.1	(kg NH ₃ -N + NO _x -N) (kg N applied) ⁻¹	IPCC (2006), Table 11.3
Volatilization from all organic N fertilizers applied, and dung and urine deposited by grazing animals	Frac _{GASM}	0.2	(kg NH ₃ -N + NO _x -N) (kg N applied or deposited) ⁻¹	IPCC (2006), Table 11.3
N losses by leaching/run-off	Frac _{LEACH(H)}	0.3	kg N (kg N additions or deposition by grazing animals) ⁻¹	IPCC (2006), Table 11.3

Direct N₂O emissions from managed soils (CRT 3.D.1)

3.D.1.a N₂O emissions from Inorganic nitrogen fertilizers applied to soils

Default emission factor was used to estimate emissions from mineral fertilizers applied to soils (see Table 5.41).

3.D.1.b.i N₂O emissions from Animal manure applied to soils (including manure digestates)

Nitrogen excreted per head of different categories of animals and per waste management systems was estimated in N₂O emissions from the 3.B Manure management chapter. IPCC default factors were used to estimate nitrogen input to Agricultural soils (see Table 5.42).

Table 5.42. IPCC default factors used in the estimation of N₂O 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
Frac _{CONST}	0.0 kg N/kg nitrogen excreted

3.D.1.b.ii N₂O emissions from Sewage sludge applied to soils

Parameters and factors used in the estimates are presented in Table 5.41 and Table 5.43.

Table 5.43. Parameters used in the estimates

Factor	Value	Unit
N content of sewage sludge ²³⁹	4.9	% dry matter

3.D.1.b.iii N₂O emissions from Other organic fertilizers applied to soils (compost, and waste digestates)

The factors used in the estimates are presented in Table 5.41 and Table 5.44.

²³⁹ Milieu Ltd, WRc and RPA. Environmental, economic and social impacts of the use of sewage sludge on land. [www] <https://rpald.co.uk/wp-content/uploads/2023/03/j661-sewagesludge-finalreport-pubd.pdf> (30.10.2025).

Table 5.44. Parameters used in the estimates

Factor	Value	Unit
N content of compost ²⁴⁰	1.83	% dry matter
N content of waste digestates ²⁴¹	2	% dry matter

3.D.1.c N₂O emissions from Urine and dung deposited by grazing animals

Default emission factor was used to estimate emissions from Urine and dung deposited by grazing animals (see Table 5.41).

3.D.1.d N₂O emissions from nitrogen input from Crop residues

The 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 N₂O emissions from crop residues, kg N/kg crop-N²⁴²

Factor	Value
FracREMOVE	0 ²⁴³
FracRENEW annual	1
FracRENEW herbaceous	8
FracRENEW legumes	4

3.D.1.e N₂O emissions from Mineralization/immobilization associated with the loss/gain of soil organic matter

The *Tier 1* method and the same emission factor (EF₁=0.01 kg N₂O-N/kg N) that is used for direct emissions from agricultural land and the default C:N ratio [10 kg C (kg N)⁻¹] were applied from IPCC 2006 to estimate N₂O emissions from mineralization/immobilization associated with the loss/gain of soil organic matter (see Table 5.41 above).

3.D.1.f N₂O emissions from Cultivation of organic soils

Default emission factors from IPCC 2006 are used to estimate N₂O emissions from cultivation of organic soils (see Table 5.41 above).

Indirect N₂O emissions from managed soils (CRT 3.D.2)

3.D.2.a Atmospheric deposition of NO_x and NH₄

Default emission factors from IPCC 2006 are used to estimate indirect N₂O emissions from atmospheric deposition of NO_x and NH₄ (see Table 5.41 above).

3.D.2.b Leaching/run-off of applied or deposited nitrogen

Default emission factors from IPCC 2006 are used to estimate indirect N₂O emissions from Leaching/run-off of applied or deposited nitrogen (see Table 5.41 above).

²⁴⁰ Linnasmägi, M.-L. (2012). Overview of waste composts produced in Estonia. Bachelor thesis, page 53 (in Estonian).

²⁴¹ Riigi Teataja. Calculated values of nutrient content in different types of manure, conversion factors for livestock units and methodology for calculating manure storage capacity (in Estonian). [www] <https://www.riigiteataja.ee/akt/101102019011> (30.10.2025).

²⁴² Expert opinion of the Estonian Agricultural Research Centre.

²⁴³ FracREMOVE at a value of 0 was applied because of a recommendation made by the TERT during EUs internal annual review of national greenhouse gas inventory data (conducted in 2012).

5.4.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Agricultural soils subcategory, please see Annex A.II.3 Agriculture, 3.D Agricultural soils chapter.

5.4.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for the Estonian GHG inventory at the national level are presented in Chapter 1.5.

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 checklist is used during the inventory.

5.4.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

N₂O emissions from managed soils (CRT 3.D.1)

- Emissions from Animal manure applied to soils (CRT 3.D.1.b.i) were recalculated for the whole time-series due to recalculations and corrections made in 3.B Manure management category. Emissions from Crop Residues (3.D.1.d) were recalculated for the years 2021-2023 due to a correction in temporary grassland production area.
- The N₂O emissions from Mineralization/Immobilization Associated with the Loss/Gain of Soil Organic Matter (CRT 3.D.1.e) and from Cultivation of organic soils (CRT 3.D.1.g) for the whole timeseries were updated in the framework of updating the land area activity data in the NFI (see Chapter 6 LULUCF). This impacts also the direct N₂O emissions from managed soils for the whole time series.
- Indirect N₂O emissions from Agricultural Soils (3.D.2) were recalculated for the whole timeseries due to corrections and recalculations mentioned above.

A comparison of the recalculated N₂O emissions from Agricultural soils between 2025 and 2026 submissions is shown in Table 5.46.

Table 5.46. Reported N₂O emissions in 2025 and 2026 submissions from Agricultural soils, kt

N ₂ O emissions from Agricultural soils	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
2025 submission	3.83	3.75	3.14	2.42	2.15	1.91	1.77	1.81	1.90	1.63	1.74
2026 submission	3.94	3.84	3.21	2.41	2.14	1.90	1.76	1.80	1.89	1.62	1.72

Table 5.46. Reported N₂O emissions in 2025 and 2026 submissions from Agricultural soils, kt (continued)

N ₂ O emissions from Agricultural soils	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2025 submission	1.64	1.54	1.67	1.78	1.79	1.76	1.92	2.12	1.94	1.95	2.01
2026 submission	1.62	1.52	1.66	1.77	1.78	1.75	1.91	2.12	1.93	1.92	1.95

Table 5.46. Reported N₂O emissions in 2025 and 2026 submissions from Agricultural soils, kt (continued)

N ₂ O emissions from Agricultural soils	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
2025 submission	2.18	2.15	2.27	2.38	2.29	2.39	2.34	2.58	2.58	2.63	2.67	2.54
2026 submission	2.12	2.08	2.19	2.28	2.16	2.28	2.25	2.48	2.48	2.58	2.66	2.58

5.4.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

Estonia is conducting an inventory development project to develop county-specific emission factors for emission calculations from Crop residues and Grazing.

What is more, Estonia is planning an inventory development project to develop country-specific emission factors for emission calculations from Cultivation of organic soils.

5.5. Field burning of agricultural residues (CRT 3.F)

In 2007, the burning of crop residues was prohibited by Estonian law²⁴⁴. Until the 2015 submission, the default value of the fraction of the crop residues burned had been used in the estimates of emissions, since to date there was no reliable quantitative data developed. The IPCC good practice guidance suggests that an estimate of 10% of residues 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 of crop residues burned varies substantially by country and crop type. This is an area where locally developed, country-specific data is highly desirable'²⁴⁵.

As no other official records of agricultural burning of crop residues exist in Estonia, then for the reporting period of 1990–2007, an inquiry to the Estonian Ministry of Regional Affairs and Agriculture (documented in an archive in accordance with the 2006 IPCC Guidelines (Volume 1, Chapter 2, Annex 2A.1)) 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. For 2023 submission, the expert opinion was renewed by the Estonian Ministry of Regional Affairs and Agriculture (MoRAA) in accordance with the ERT 2022 review's recommendation. MoRAA confirms that no widespread practice of agricultural residue burning has taken place during the reporting period. It is a common practice in Estonia for a farmer to plough crop residues into the soil to enrich it with nitrogen if the farmer has no animals or no straw buyers located in the vicinity. Using straw for litter or as a fertilizer has been economically more feasible than burning it. Estonia uses straw also for heat production, and CH₄ and N₂O emissions from this process are reported under the Energy sector (Chapter 3 and CRT 1.A.4).

Since 2021 submission, notation key 'NO' was applied for the whole time series.

5.6. CO₂ emissions from liming (CRT 3.G)

5.6.1. Category description (e.g. characteristics of sources)

In Estonia, annual precipitation exceeds evapotranspiration, causing calcium and magnesium carbonates to leach out from the surface levels of the soil by percolating water. As a result of the leaching carbonates, soil becomes deprived of calcium and magnesium. Acidificated soils

²⁴⁴ Riigi Teataja. Requirements for maintaining land in good agricultural and environmental condition (in Estonian). [www] <https://www.riigiteataja.ee/akt/129122022006?leiaKehitiv> (30.10.2025).

²⁴⁵ IPCC 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Chapter 4: Agriculture, page 4.89.

(pH <6.5) cover 54.5% of arable land in Estonia. Though, not all this area needs liming due to the different calcium contents.²⁴⁶ Total CO₂ emissions from lime applied on agricultural land were 26.5 kt in Estonia in 2024, from which CO₂ emissions from dolomite were 1.58 kt and 24.91 kt from limestone (Figure 5.27). The emissions have decreased by 3.7% compared to the previous year.

Overall, liming emissions are in correlation with the Estonian economic situation and subsidies during the entire time series. During 1992–1997, CO₂ emissions caused by liming were 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. The lowest point of emissions in 2009 can be explained by the economic recession in Estonia during 2008–2010. After the economic recession, the emissions had been growing steadily until 2018, then, after a small decrease in the amounts used in 2019–2020, emissions from liming started growing again and reached its peak in 2022, being record high in the whole timeseries. However, after the peak the emissions started slowly decreasing again, which is again in correlation with the Estonian economic situation and the capacity of subsidies.

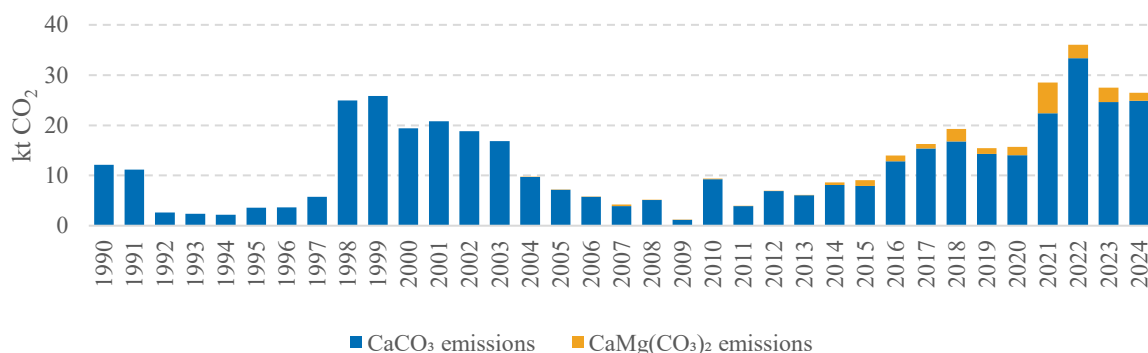


Figure 5.27. CO₂ emission from CaMg(CO₃)₂ and CaCO₃ in 1990–2024, kt

5.6.2. Methodological issues

Choice of methods

The Tier 1 (Equation 5.39) method was used to estimate CO₂ emissions from the liming of croplands.

Equation 5.39²⁴⁷

$$\Delta C_{CC \text{ Lime}} = M_{\text{Limestone}} \times EF_{\text{Limestone}} + M_{\text{Dolomite}} \times EF_{\text{Dolomite}}$$

Where:

$\Delta C_{CC \text{ Lime}}$ = annual C emissions from agricultural lime application, tons C yr⁻¹;
M = annual amount of calcic limestone (CaCO₃) or dolomite (CaMg(CO₃)₂), tonnes yr⁻¹;
EF = emission factor, tons C (ton limestone or dolomite)⁻¹; these are equivalent to carbonate carbon contents of the materials (12% for CaCO₃, 13% for CaMg(CO₃)₂).

²⁴⁶ Loide, V. (2019). Calcium content and liming of agricultural soils. Presentation, 10th World Soil Day, Tartu, Estonia (in Estonian).

²⁴⁷ IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, page 11.27, equation 11.12.

Activity data

Activity data on agricultural land areas on which lime was applied were obtained from the Estonian Ministry of Regional Affairs and Agriculture for the period of 1990–2003. Data about liming was then not implicit, as it was based on applied agricultural subsidies only and liming performed at a landowner's own expense was left out of the statistics. However, the scope of liming carried out at a landowner's own expense was marginal according to the Estonian Ministry of Regional Affairs and Agriculture²⁴⁸. Data about the average quantity of lime applied per one hectare (5 t/ha) were taken from a report published by the Agricultural Research Centre²⁴⁹. Since 2005, Statistics Estonia has been collecting detailed data about the area and applied amount of liming. Data for 2004 has been interpolated from the data of MoRAA in 2003 and from the data of SE in 2005. The area of liming has fluctuated widely over the years, depending significantly on government subsidies and on the economic situation.

To estimate the fractions of different fertilizer types used for neutralization of acidic soils resulting in CO₂ emissions, data reported by E. Turbas²⁵⁰ for the period of 1990–2001 and the sales records obtained from the Agriculture and Food Board for the years of 2002–2014 were applied, as until 2014 Statistics Estonia collected only aggregated data for lime used on Estonian agricultural lands. Since 2015, Statistics Estonia collects data about different lime fertilizer types. The amounts of lime fertilizers applied on agricultural soils are reported in Annex A.V.3_VIII.

The emissions resulting from limestone application were calculated using data on clinker dust, powdered limestone, other meliorate and dolomite. Oil shale ash and ash are also reported in agricultural statistics; however, CO₂ emissions are not estimated for these under the liming category as emissions from liming are estimated from the carbonate (CaCO₃ and MgCO₃) content applied. Materials that do not contain carbonates at the time of application do not generate CO₂ under this category.²⁵¹

Yearly differences in the use of specific fertilizer types used for liming contribute to the CO₂ emission fluctuations in the time series (Table 5.47). No CO₂ emissions occur from the use of some lime fertilizers (oil shale ashes, ash) as they do not contain inorganic carbon.

Table 5.47. Amounts of lime fertilizers applied on the fields 1990–2024, kt/yr

Fertilizer	1990	2005	2021	2022	2023	2024
Clinker dust	68	22.9	0	0	0	0
Other ameliorant	NO	NO	2.2	1.6	2.4	10.5
Limestone fines	NO	7	48.7	74.2	53.6	46.1
Oil shale ash	68	NO	17.6	29.8	23.4	10.4
Ash	NO	NO	9.4	15.4	15.3	18.9
Dolostone fines	NO	0.1	12.8	5.6	6.0	3.3
Total	136	30	90.7	126.6	100.7	89.2

²⁴⁸ Estonian Rural Development Plan 2014-2020 (in Estonian). [www] https://energiatalgud.ee/sites/default/files/images_sala/a/ac/P%C3%B5llumajandusministeerium_Eesti_maaelu_arengukava_%28MAK%29_2014-2020_eeln%C3%B5u_2014.pdf (08.07.2025).

²⁴⁹ Järvan, M. (2005). Lime spreading on fields. Saku: Maalehe Kirjastus, lk 6 (in Estonian).

²⁵⁰ Turbas, E. (2000). The idea of soil liming and the development of liming practices in Estonia. Agricultural science, nr 11 (2), lk 117–131 (in Estonian).

²⁵¹ IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, page 11.27: "Note that while carbonate limes are the dominant liming material used in managed systems, oxides (e.g., CaO) and hydroxides of lime are used to a limited extent for soil liming. These materials do not contain inorganic carbon and are not included in calculations for estimating CO₂ emissions from application to soils (CO₂ is produced in their manufacture but not following soil application)." Therefore, oil shale ash and ash are not included in the limestone application calculations, because they are typically dominated by CaO and other alkaline oxides, not CaCO₃, and CaO contains no carbon.

Emission factors

The default emission factor from IPCC 2006 Guidelines was used to estimate emissions from liming: 12% for CaCO_3 , 13% for $\text{CaMg}(\text{CO}_3)_2$.

The fraction of CaCO_3 in the cement clinker dust (40.48%) was received by a personal inquiry as a result of an analysis and is validated by an expert judgement (documented in archive according to the instruction of the 2006 IPCC Guidelines (Volume 1, chapter 2, Annex 2A.1)) from the Estonian Kunda Cement factory (as requested by the 2022 ERT review's recommendation).

5.6.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Liming subcategory, please see Annex A.II.3 Agriculture, 3.G Liming chapter.

5.6.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for the Estonian GHG inventory at the national level are presented in Chapter 1.5.

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 checklist is used during the inventory.

5.6.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

There were no category-specific recalculations.

5.6.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

There are no category-specific planned improvements.

5.7. Urea application (CRT 3.H)

5.7.1. Category description (e.g. characteristics of sources)

Adding urea to soils during fertilization leads to a loss of CO_2 that was fixed in the industrial production process. Urea ($\text{CO}(\text{NH}_2)_2$) is converted into ammonium (NH_4^+), hydroxyl ion (OH^-), and bicarbonate (HCO_3^-), in the presence of water and urease enzymes. Emissions have been fluctuating for the whole time series in Urea application category (Figure 5.28). In 2023, however, the emissions from urea application were record high – 2.28 kt CO_2 . That can be explained by higher prices for mineral fertilizers in 2023 and lower for urea fertilizers – the two are in correlation. The large purchase of urea fertilizers in 2023 left the farmers with a large excess supply in 2024 and that is why, in 2024, the emissions decreased majorly – from 2.28 kt CO_2 to 0.001 kt CO_2 , being the lowest in the whole timeseries.

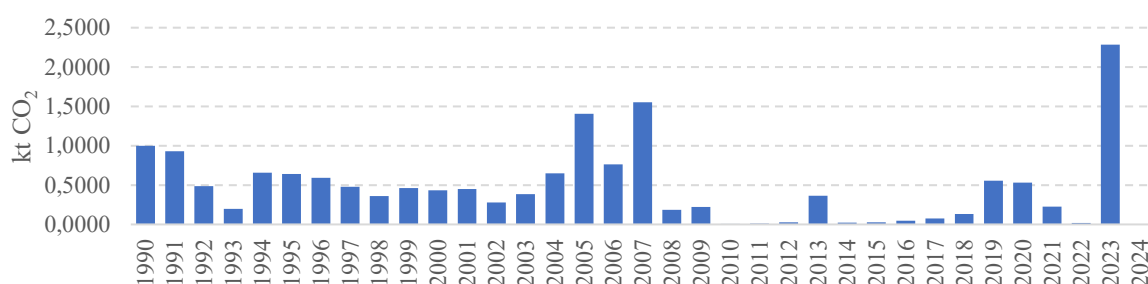


Figure 5.28. CO₂ emissions from urea fertilizer application 1990–2024, kt

5.7.2. Methodological issues

Choice of methods

The Tier 1 (Equation 5.40) method was used to estimate CO₂ emissions from urea application to croplands.

Equation 5.40²⁵²

$$CO_2 \text{ Emission} = M \times EF \times \frac{44}{12}$$

Where:

CO₂–C Emission = annual C emissions from urea application, tons C yr⁻¹;

M = annual amount of urea fertilization, tons urea yr⁻¹;

EF = emission factor, tons of C (tons of urea)⁻¹

Activity data

For the years 1990-2003, urea fertilizers' production data was obtained from Statistics Estonia database. For the years 2004-2009 and for 2013, data was obtained from the only urea fertilizer producer in Estonia – LLC Nitrofert. LLC Nitrofert shut down their production in 2014. An approximate estimate of the amount of urea applied to soils on an annual basis was obtained using domestic production records, import/export data and Equation 5.39 (see also Annex A.V.3_IX.1). In compliance with the IPCC 2006 Guidelines, it was assumed that all urea fertilizers produced annually minus annual exports are applied to soils²⁵³. The emission estimation was compiled based on LLC Nitrofert production data and import-export statistical data provided by SE. In 2011, 2012 and 2014–2018, there was no production of urea fertilizers in Estonia, nor did the records of SE show urea-based fertilizer import activity, therefore emission estimations for the years with absent data was developed using urea fertilizer marketing data provided by the Agriculture and Food Board. Until the 2018 submission, it was assumed that all imported urea fertilizers were applied to soils in Estonia. A part of imported fertilizers is exported again, but its proportion or amounts are not known. Due to the lack of valid data and suggestions made by the ERT review team (2018) to homogenize urea fertilizer time series, a surrogate method was used to find more realistic values for the emissions from urea fertilizer application since the 2019 submission. Therefore, since the 2019 submission, data series were homogenized by correcting the values of the emissions from urea fertilizers from the year 2010, when only marketing data was available, except the year 2013, when data from LLC Nitrofert was used.

In accordance with the 2022 ERT review's recommendation ARR2022/A.10, urea resellers and manufacturers have been contacted and their sales data have been validated. Additionally,

²⁵² IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, page 11.32, equation 11.13.

²⁵³ IPCC 2006 Guidelines, Volume 4, Chapter 11: N₂O emissions from managed soils, and CO₂ emissions from lime and urea application, page 11.34, equation 11.1.

Estonian inventory team had capacity building consultations with external experts facilitated by Umweltbundesamt (UBA) within the Effort Sharing Regulation sectors capacity-building support, on the proposed approach to use the manufacturers' sales data in Estonia's emission estimates. The external experts concluded that emissions between using the approach used before and the new beforementioned approach do not differ significantly so that there is no need to apply any model for this shift of databases. Data on urea fertilizers sold to Estonian markets can be used from 2016 (the year that the data is available) and assumed that all urea sold on Estonian markets is used on Estonian agricultural lands. Therefore, since 2024 submission, the emissions from urea application starting from the year 2016 have been calculated using the manufacturers' and resellers' data on sold fertilizers to Estonian markets. The new approach, validated by an expert judgement, is documented in archive according to the instruction of the 2006 IPCC Guidelines (Volume 1, chapter 2, Annex 2A.1).

Emission factors

For emission factor, IPCC 2006 GL default value of 0.20 is applied.

5.7.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Urea application subcategory, please see Annex A.II.3 Agriculture, 3.H Urea application chapter.

5.7.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for the Estonian GHG inventory at the national level are presented in Chapter 1.5

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 checklist is used during the inventory.

5.6.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

Correcting the urea fertilizers used in 2023

Due to a corrected amount of urea fertilizers used in 2023 in the emission calculations, the emissions from Urea application to fields were recalculated for the 2026 submission, although the change in emissions was minor.

A comparison of the recalculated CO₂ emissions from Urea application between 2025 and 2026 submissions is shown in Table 5.48.

Table 5.48. Reported CO₂ emissions in 2025 and 2026 submissions from Urea application, kt

Urea application	2023
2025 submission	2.284
2026 submission	2.283

5.6.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including tracking of those identified in the review process

There are no category-specific planned improvements.

6. LAND USE, LAND-USE CHANGE AND FORESTRY (CRT SECTOR 4)

6.1. Overview of the sector (e.g. quantitative overview and description, including trends and methodological tiers by category, and coverage of pools) and background information

The methodology used for calculating emissions and removals from the Land use, land-use change, and forestry (LULUCF) sector follows the 2006 IPCC Guidelines, 2013 Supplement to the 2006 IPCC Guidelines (Wetlands Supplement) and the 2019 Refinement to the 2006 IPCC Guidelines. Emissions and removals from the LULUCF sector are divided into the following categories: Forest land, Cropland, Grassland, Wetlands, Settlements, Other land and Harvested wood products (HWP). Each category, except HWP, is further divided into 'land remaining' and 'land converted to' subcategories.

In 2024, LULUCF sector acted as a net CO₂ source, resulting in net GHG emissions of 1906.55 kt CO₂ equivalent, meaning that total emissions arising from the sector exceeded total removals (Table 6.1, Figure 6.1). The LULUCF sector sink is mainly affected by the age structure of forests, management practices in forestry and agriculture, area of drained organic soils, production of horticultural peat, and C sequestration in HWP. Forest land covers more than half of the Estonian land area and generally has the greatest impact on the LULUCF sector GHG balance. The age structure of managed forests in Estonia is dominated by mature stands, and the proportion of forest area belonging to the first development classes (treeless area, area under regeneration and young stands) has increased (mostly due to fellings)²⁵⁴. Therefore, the capacity of carbon sequestration in living biomass has decreased in recent decade, i.e the ratio of mortality to increment has increased. The fluctuations in annual carbon stock changes in Forest land living biomass are mainly caused by the felling rates. In 2024, only categories sequestering CO₂ were Forest land, HWP and Grassland, but it did not compensate for emissions from the other LULUCF categories. The highest net emitter was Wetlands category with emissions from peat extraction areas and horticultural use of peat.

Table 6.1. Net emissions from the LULUCF sector by categories in 1990–2024, kt CO₂ eq.

Year	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	HWP	Total LULUCF
1990	-5614.99	862.37	-323.48	393.07	498.56	297.45	-156.27	-4043.28
2005	-3168.92	498.74	-264.00	905.14	1028.99	127.78	-608.41	-1480.68
2021	-778.32	904.58	-258.99	1206.14	755.92	79.93	-938.31	970.95
2022	-1894.57	996.10	-279.42	1277.93	680.83	620.89	-609.41	792.35
2023	201.90	1026.88	-280.34	1164.75	613.26	146.94	-379.96	2493.42
2024	-627.07	1032.86	-256.55	1296.85	701.69	316.13	-557.36	1906.55

²⁵⁴ Estonian Environment Agency (2025). NFI 2024. Distribution of forest land area by development classes. (In Estonian) [www]
<https://tableau.envir.ee/views/SMI/17Vanuseklassidaegrida?%3Aembed=y&%3Aiid=1&%3AisGuestRedirectFromVizportal=y> (23.12.2025)

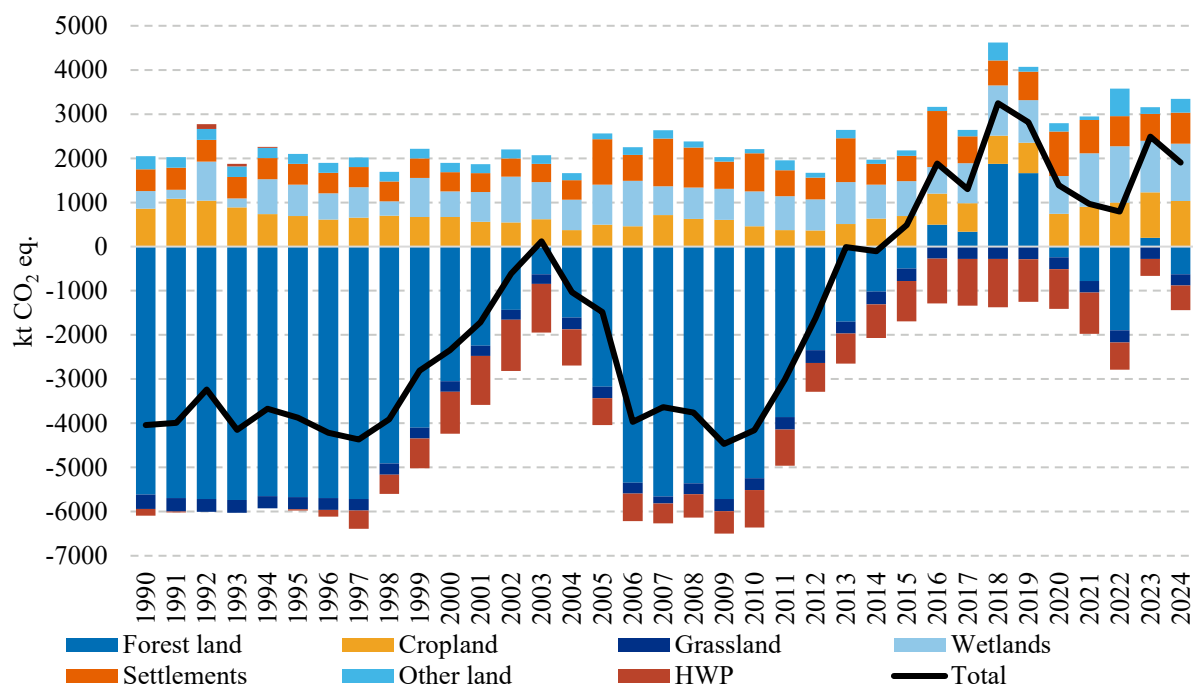


Figure 6.1. Trend in GHG emissions (+) and removals (-) from land use, land-use change and forestry sector 1990–2024, kt CO₂ eq.

The net CO₂ emissions/removals of the Estonian LULUCF sector are presented in Figure 6.2. Forest is the prevailing land-use category in Estonia and carbon flows derived from the forest category have the largest influence on the LULUCF sector's total carbon balance trends. Emissions and uptake of Forest land are predominantly determined by changes in forest growing stock. Further explanations are provided in Chapter 6.4.

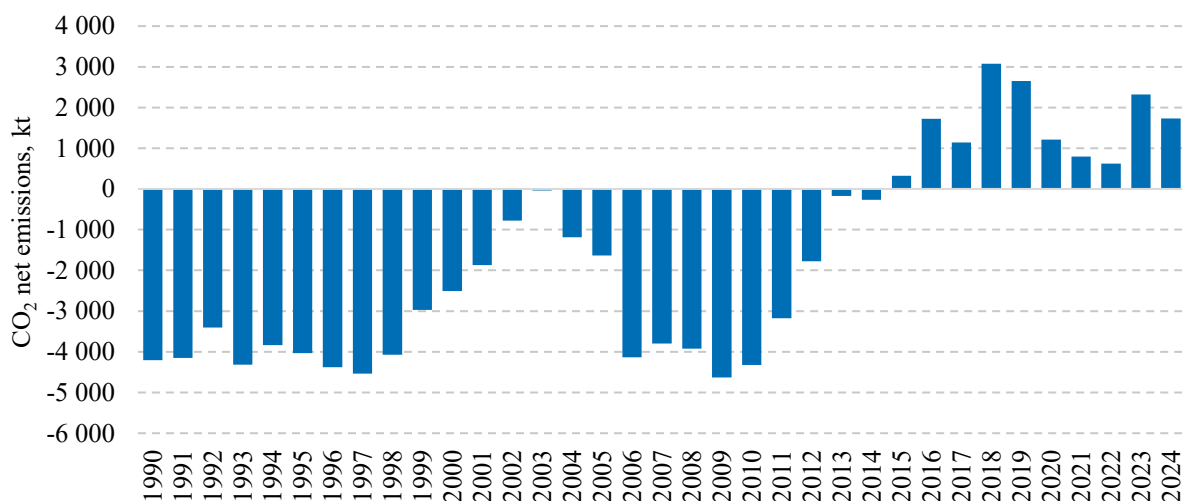


Figure 6.2. Annual change in emissions/removals of CO₂ from the Estonian LULUCF sector in 1990–2024

Figure 6.3 and Figure 6.4 show total emitted quantities of CH₄ and N₂O during the period 1990–2024. CH₄ emissions originate from forest, grassland and wetland wildfires, and drained organic soils (Forest land and peat extraction areas). N₂O emissions comprise emissions from wildfires, peat extraction, drainage of organic forest soils, and direct and indirect N₂O emissions resulting

from land-use change on mineral soil. In 1992, 2002, 2006 and 2018, extensive wildfires spread, having an impact on the annual GHG emissions of these years.

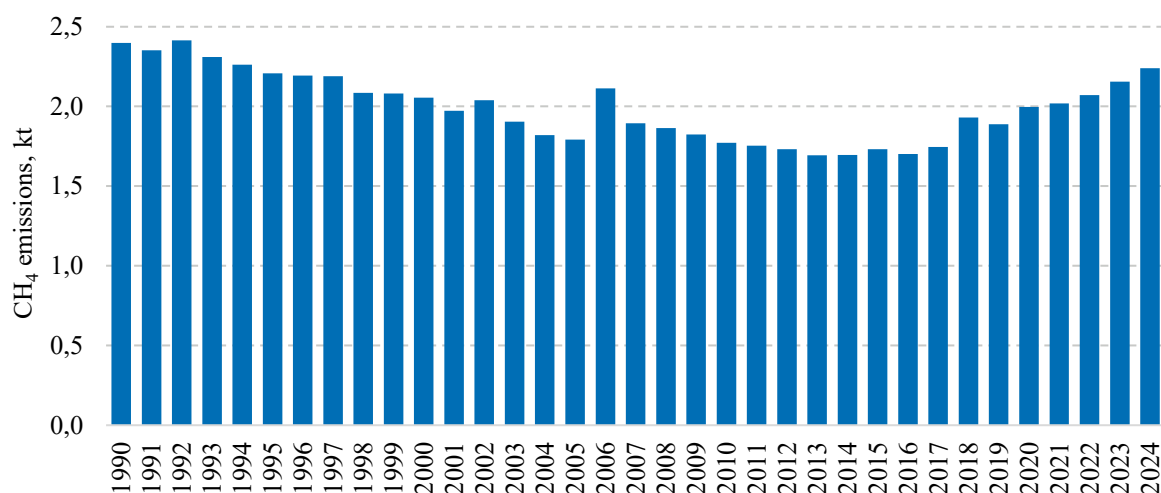


Figure 6.3. Emissions of CH₄ from the LULUCF sector in Estonia in 1990–2024, kt CH₄

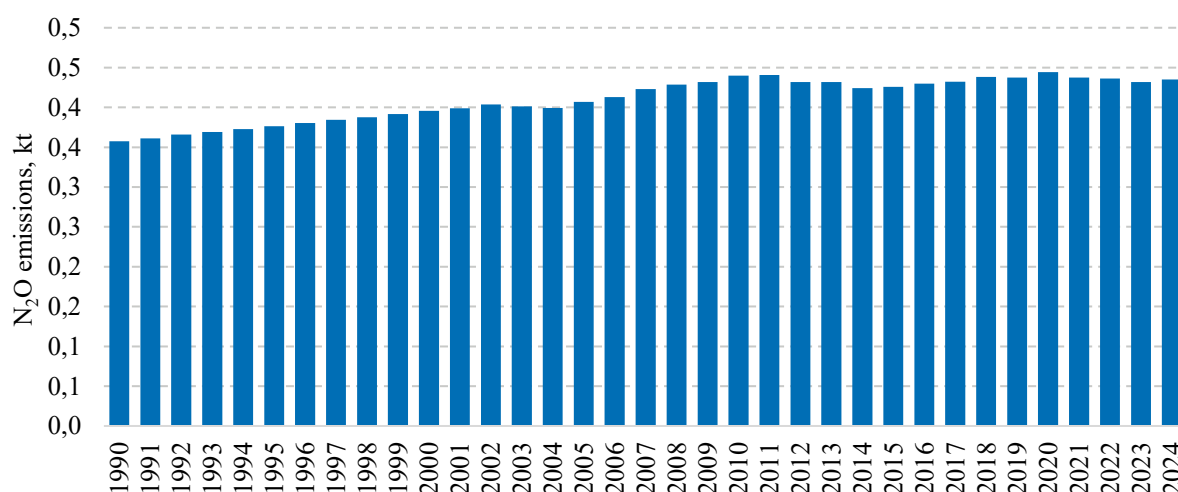


Figure 6.4. Emissions of N₂O from the LULUCF sector in Estonia in 1990–2024, kt N₂O

In the 2026 annual submission, Estonia reports following emissions and removals:

- Forest land (FL; CRT 4.A): C stock changes in living biomass, deadwood, mineral and drained organic soils, CH₄ and N₂O emissions from drained organic soils, N₂O emissions from N mineralization due to land conversion to Forest land, and non-CO₂ emissions from wildfires;
- Cropland (CL; CRT 4.B): C stock changes in living biomass, dead organic matter (only on Land converted to CL), mineral and organic soils, and N₂O emissions related to land conversion to cropland. N₂O emissions from cultivated organic soils and from N mineralization in the Cropland remaining cropland category are reported under the Agriculture sector (CRT 3.D);
- Grassland (GL; CRT 4.C): C stock changes in living biomass, dead organic matter, mineral soils (only on Land converted to GL), drained organic soils, and non-CO₂ emissions from wildfires;

- Wetlands (WL; CRT 4.D): CO₂, N₂O and CH₄ emissions related to peat extraction and horticultural use of peat, and loss of living biomass and dead organic matter due to land conversion to peat extraction areas or other wetlands. Emissions from wildfires are reported under the Grassland category;
- Settlements (SL; CRT 4.E): CO₂ emissions related to Forest land, Cropland, Grassland and Other land conversion to Settlements in living biomass, dead organic matter and soil carbon pools, N₂O emissions related to land conversion to Settlements;
- Other land (OL; CRT 4.F): CO₂ and N₂O emissions from Forest land, Cropland, Grassland and Wetlands conversion to Other land; and
- Harvested wood products (HWP; CRT 4.G): C stock changes in Solid wood (sawnwood and wood panels), Paper and paperboard and Bleached semi-chemical wood pulp.

Since the 2024 submission, *Tier 3* methods have been applied to estimate carbon stock changes in living biomass and deadwood (Table 6.2). Also, studies by Kõlli et al. (2004²⁵⁵, 2007²⁵⁶, 2009²⁵⁷, 2010²⁵⁸) were used to develop country-specific factors for estimating C stock changes in mineral soils during land-use changes, and country-specific EF-s by Salm et al. (2012²⁵⁹) have been implemented for peat extraction sites (*Tier 2*). *Tier 1* methodologies with default emission factors (EFs) are applied for organic soils. Currently, Estonia does not have country-specific emission factors for litter and mineral soils in Forest land remaining forest land category. As an interim approach, C stock change estimates for forest mineral soils are based on the IEF from the Swedish National Inventory Submission 2025²⁶⁰ (considered as a *Tier 2* method). Estonia has launched several projects aimed at elaborating on country-specific data regarding litter and soil pools for future submissions (see Chapters 6.4.6, 6.5.6, and 6.6.6, Category-specific planned improvements).

Table 6.2. Methods and emission factors used for estimating the emissions/removals of GHG from the LULUCF sector in Estonia

GHG SOURCE AND SINK CATEGORIES	Method applied / EF used		
	CO ₂	CH ₄	N ₂ O
4.LULUCF	T1,T2,T3/ CS,D,OTH		
4.A.1 Forest land remaining forest land	T1,T2,T3/ CS,D,OTH		
4.A.2 Land converted to forest land	T1,T2,T3/ CS,D		
4.B.1 Cropland remaining cropland	T1,T2/ CS,D		
4.B.2 Land converted to cropland	T1,T2,T3/ CS,D		
4.C.1 Grassland remaining grassland	T1,T2,T3/ CS,D		
4.C.2 Land converted to grassland	T1,T2,T3/ CS,D		
4.D.1 Wetlands remaining wetlands ²⁶¹	T2/ CS		
4.D.2 Land converted to wetlands	T2,T3/ CS,D		

²⁵⁵ Kõlli, R., Asi, E., Köster, T. (2004). Organic carbon pools in Estonian forest soils. *Baltic Forestry* 10, 19–26.

²⁵⁶ Kõlli, R., Köster, T., Kauer, K. (2007). Organic matter of Estonian grassland soils. *Agronomy Research* 5, 109–122.

²⁵⁷ Kõlli, R., Ellermäe, O., Köster, T., Lemetti, I. Asi, E., Kauer, K. (2009). Stocks of organic carbon in Estonian soils. *Estonian Journal of Earth Sciences*, 58, 95–108.

²⁵⁸ Kõlli, R., Köster, T., Kauer, K., Lemetti, I. (2010). Pedoecological regularities of organic carbon retention in Estonian mineral soils. *International Journal of Geosciences*, 1, 139–148.

²⁵⁹ Salm, J-O., Maddison, M., Tammik, S., Soosaar, K., Truu, J., Mander, Ü. (2012). Emissions of CO₂, CH₄ and N₂O from undisturbed, drained and mined peatlands in Estonia. *Hydrobiologia*, 692, 41–55

²⁶⁰ This approach is approved by ERT (FCCC/ARR/2012/EST para.94, 104; FCCC/ARR/2013/EST para. 63).

²⁶¹ Wetlands are divided into managed and unmanaged wetlands. Emissions from unmanaged wetlands are not reported, since it is not mandatory according to the IPCC 2006 Guidelines.

GHG SOURCE AND SINK CATEGORIES	Method applied / EF used		
	CO ₂	CH ₄	N ₂ O
4.E.1 Settlements remaining settlements ²⁶²	T1/NA		
4.E.2 Land converted to settlements	T1,T2,T3/ CS,D		
4.F.2 Land converted to other land	T2,T3/ CS,D		
4.G. HWP	T2/ CS,D		
4(II) Emissions from drainage	NA/NA	T1,T2/ CS,D	T1,T2/CS,D
4(III) Direct and indirect N ₂ O emissions from N mineralization			T1/D
4(IV) Biomass burning	NA ²⁶³ /NA	T2/D	T2/D

EF – Emission Factor, NA – not applicable, T1 – *Tier 1* method, T2 – *Tier 2* method, T3 – *Tier 3* method, CS – country-specific, D – IPCC default, OTH – other, in the case of missing country-specific data, EFs from Sweden were applied.

The inventory in the LULUCF sector is carried out by the Estonian Environment Agency (EstEA), Forest Department. Annual reports published by different institutions (EstEA, Statistics Estonia (SE), etc.; see Table 6.3) have been used in the estimation of greenhouse gas fluxes related to the LULUCF sector.

Table 6.3. List of institutions (datasets) involved in the inventory of the LULUCF sector

References	Link	Abbreviation	Activity
Estonian Environment Agency	keskkonnaagentuur.ee/en	EstEA	- EstEA carries out National Forest Inventory - collecting and providing data on areas of land-use categories (Forest land, Cropland, Grassland, Wetlands, Settlements, Other land) - areas of land-use changes - areas of peat extraction - Forest land, Grassland and Cropland woody biomass and deadwood stocks - felling volumes - field inventories of wildfires (started in 2012)
Estonian Rescue Board	rescue.ee/en	ERB	- collecting and publishing data on forest fires (location, type, cause, etc.)
Statistics Estonia	stat.ee/en	SE	- providing data for calculating Cropland mineral soil emissions (areas with different land use and input regimes within the Cropland category; share of areas with different tillage practices) - data on peat extraction and production of energy peat - foreign trade and production data for HWP calculations
Agricultural Registers and Information Board	pria.ee/en	ARIB	- providing data for calculating Cropland mineral soil emissions (operates Land Parcel Identification System in Estonia)

²⁶² It is assumed that C stocks do not change in Settlements remaining settlements.

²⁶³ Biomass C stock change estimates include CO₂ loss from burning.

References	Link	Abbreviation	Activity
Centre of Estonian Rural Research and Knowledge	metk.agri.ee/en	METK	- providing know-how for calculating Cropland mineral soil emissions (C input of different cropping systems, share of areas with different tillage practices)
Geological Survey of Estonia	https://www.egt.ee/en	EGT	- providing data on peat extraction
Estonian Land and Spatial Development Board	maaruum.ee/	ELSDB	- collecting and providing additional data on land areas
Estonian Forest and Wood Industries Association	empl.ee		- expert assessment of sawnwood production data for HWP calculations

The LULUCF sector key categories in 1990 and 2024 by level and trend (*Tier 1*) are presented in Table 1.2.

6.2. Land-use definitions and the land representation approach(es) used and their correspondence to the land use, land-use change and forestry categories (e.g. land use and land-use change matrix)

LULUCF land categories presented in the inventory report are consistent with the land-use categories defined in the 2006 IPCC Guidelines. Area estimates for land-use categories are obtained from the National Forest Inventory (NFI), which is conducted by the Forest Department of the Estonian Environment Agency. For the 2026 submission, data from the Mineral Resources Register, maintained by the Geological Survey of Estonia, were used to estimate the total area of peat extraction fields.

The NFI is a systematic collection of forest information on randomly based sample plots that cover the whole country (Figure 6.5) and all land-use categories. The NFI also provides information on soils, including the distribution of mineral and organic soils as well as the division of land into drained and undrained areas. The nationally classified NFI sample plots are reclassified into IPCC land-use categories (Table 6.7). The sampling design of the Estonian NFI and the method of estimation of land-use changes are described in Chapter 6.3.1.

6.2.1. Definitions of land categories

Forest land

Forest area is estimated according to the FRA (UNFAO – Forest Resources Assessment) definition²⁶⁴ (Table 6.4). All temporarily unstocked forest areas and regeneration areas which have yet to reach a crown density of 10 per cent and a tree height of 5 meters are also included as forest, as are areas which are temporarily unstocked because of human intervention such as

²⁶⁴ FAO (2023). Terms and definitions FRA 2025. Forest resources assessment working paper 194. [www] <https://openknowledge.fao.org/server/api/core/bitstreams/a6e225da-4a31-4e06-818d-ca3aeaddfd635/content> (23.12.2025)

harvesting, or natural causes (fires, etc.) but which are expected to revert to the forest. Forest land also includes abandoned shifting cultivation land with a regeneration of trees that have, or are expected to reach, a canopy cover of 10 percent and tree height of 5 meters. It does not include land that is predominantly under agricultural or urban land use.

Table 6.4. Parameters for forest definition

Minimum tree crown cover	10%
Minimum land area	0.5 ha
Minimum tree height	5 m

National forest definition differs from the FRA definition and is not applied in the international reporting. Estonian Forest Act stipulates forest land as land which meets at least one of the following requirements:

- forest land use has been registered in the 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 of at least 30 percent.

To meet the requirements of UNFCCC reporting, the NFI is compiling statistical analyses based on both the national and the UNFCCC definition of a forest regarding the minimum area of a forest.

All forest land is considered managed in Estonia – the total forest land in Estonia is or has been covered with forest management plans. In addition, protected forests are covered with a protection scheme.

Cropland

According to the definition used by the NFI, Cropland is ‘arable land, area where annual or perennial crops are growing (incl. fallows, 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.

Grassland

According to the national definition, this category includes rangelands and pastureland 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’).

Wetlands

Wetland’s category includes mires, inland water bodies, including larger bog holes, and peat extraction sites. Mires are defined as land that is permanently saturated by water and/or areas where the peat layer is at least 30 cm thick and that does not fall into the Forest land, Cropland, Grassland or Settlements categories. Also, smaller bog holes are considered under mires area.

Wetlands are divided into unmanaged and managed wetlands. Natural lakes, rivers and undrained mires are considered unmanaged land whereas peat extraction sites and flooded areas are reported under managed wetlands. Also, all land areas that have been converted to wetlands are considered managed.

Settlements

Built-up areas, wide 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 for peat extraction areas) are reported under the Settlements land-use category.

Other land

Land areas that do not fall into any of the other five land-use categories. For example, areas with a closed regime for which the land category cannot be determined. Other land also includes unusable mineral land, i.e., land that is not economically usable without the application of special measures and that has soil organic layer thickness less than 30 cm. Consistent with the IPCC Guidelines, this land-use category is used to allow the total of identified land areas to match the national area.

6.2.2. Land use trends

The areas of land-use categories in the 2026 inventory submission are reported in Table 6.5. Areas of managed wetlands include peat extraction sites, flooded lands and lands that have been converted to wetlands.

Table 6.5. The area of different land-use categories in 1990–2024²⁶⁵ (NFI and Mineral Resources Register), kha

Year	Forest land	Cropland	Grassland	Unmanaged wetlands	Managed wetlands	Settlements	Other land
1990	2228.75	960.90	440.19	516.90	78.24	243.34	65.61
2005	2290.49	1057.28	348.34	432.45	79.84	274.06	51.46
2021	2434.40	1011.18	277.74	326.81	100.21	343.61	39.99
2022	2441.50	1005.75	275.03	321.86	100.04	346.67	43.09
2023	2450.91	996.79	273.09	321.49	102.02	346.35	43.28
2024	2459.74	989.93	267.21	319.50	103.44	349.07	45.05

Table 6.6 gives an overview of land-use transitions between 31.12.1989 and 31.12.2024. The largest decrease in area has occurred in the Grassland category (-176.62 kha). At the same time, Forest Land area has increased by 10.6%. These changes result mostly from the reallocation of grasslands to the Forest land category when their tree crown cover begins to meet the Forest land definition in the course of natural succession. Significant part of natural grasslands has been also converted to arable land. The area of Wetlands has decreased almost at the same extent, also mainly due to the establishment or expansion of tree cover. The growth of settlements has largely taken place on former forest land.

Table 6.6. The land-use change matrix for IPCC land-use categories from 31.12.1989 to 31.12.2024 (kha)

	To						Initial area
From	FL	CL	GL	WL	SL	OL	
Forest land	2072.28	48.08	26.60	11.50	50.99	13.74	2223.20
Cropland	58.89	796.11	68.52	5.41	35.98	4.37	969.27
Grassland	163.05	118.98	118.91	4.78	32.31	5.81	443.83
Wetlands	117.72	22.13	39.71	393.89	9.14	10.58	593.18
Settlements	15.42	4.02	2.09	3.07	215.06	0.93	240.59
Other land	32.38	0.60	11.38	4.29	5.58	9.62	63.85
Final area	2459.74	989.93	267.21	422.94	349.07	45.05	4533.93
Change since 1990, kha	236.54	20.66	-176.62	-170.24	108.47	-18.80	
Change since 1990, %	10.6	2.1	-39.8	-28.7	45.1	-29.4	

6.3. Country-specific approaches

6.3.1. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Estonia uses *Approach 3* - geographically-explicit land-use conversion data for representing land-use areas (in accordance with the 2006 IPCC Guidelines). Information on current land use and its changes are collected during the NFI (starting from 1999) and stored in the NFI database. Estonian NFI network of sample plots cover the whole country and consists of both permanent plots that are revisited after every 5 years, and temporary plots (Figure 6.5). In 2024, one inventory plot represents ca 156 ha of land. Data on the Estonian total land area comes from the geoportal of the Estonian Land and Spatial Development Board²⁶⁵. The area of Estonia, 4533.930 kha, includes land divided between counties and the undivided area of the Narva River, Lake Peipsi, Lake Lämmi, Lake Pihkva, Lake Võrtsjärv and Kulje Bay.

The methodology applied to assess land use and land-use change for the period 2003–2024 is based on the NFI data and work of the Institute of Mathematics and Statistics of the University of Tartu²⁶⁶. On permanent NFI sample plots, land-use changes have been identified based on differences in the land use category determined at two consecutive measurement occasions. On temporary plots, land-use changes have been identified on the basis of recorded changes in land-use categories that occurred during the previous five years. To reduce the impact of random changes in NFI plots, land use and land use change data are 10-year averages. For example, the land use reported for 2024 represents the average of land-use determinations for the period 2015–2024. Since data from temporary plots are also used the Iterative Proportional Fitting Procedure (IPFP) has been applied to align the changes with the actual land-use distribution.

²⁶⁵ Administrative and Settlement Division. Geoportal. Estonian Land Board [www] <https://geoportaal.maaamet.ee/eng/spatial-data/administrative-and-settlement-division-p312.html> (23.12.2025).

²⁶⁶ Pärna, K. (2024). Development of the National Forest Inventory (NFI). Final report of the Institute of Mathematics and Statistics, University of Tartu. (In Estonian) [www] <https://keskkonnaportaal.ee/sites/default/files/2024-07/SMI%20arendusprojekt%202023-24%20L%C3%95PPARUANE.pdf> (23.12.2025).

This method uses minimal adjustments to transform the initial, potentially inconsistent transition matrix into a form that is fully consistent with the given distributions.

Land use on NFI permanent plots in 1970 and 1990 was reconstructed using historical maps, orthophotos and satellite imagery. Land use for the periods 1970–1989 and 1990–2003 was interpolated linearly, and land-use changes were also estimated using the IPFP procedure.

The IPFP method consists of alternately renormalizing the rows and columns of the initial area-based transition matrix, ensuring at each step that one marginal distribution (row or column) is matched. The procedure involves a large number of iterations, since adjusting the row totals typically disrupts the column totals and vice versa, ultimately converging to a matrix that is fully consistent with the specified marginal distributions. The IPFP method seeks to preserve the structure of the initial transition matrix as much as possible, making only the minimal adjustments needed to achieve consistency with the marginal distributions.

Cumulative areas for categories remaining under the same land-use and conversion categories are calculated for each reporting year on the basis of the previous year's land-use status and the current year's land-use change matrix, assuming 20-year conversion period (5 years for peat extraction sites).

Compared to the previous methodology, under which the areas of land-use categories were back-calculated from the most recent year's status using land-use changes, the new methodology results in larger areas under land-use change, as the extent of changes on temporary sample plots has been underestimated. In addition, land-use data from 1970 onwards have been taken into account since the current submission, as recommended by the ERT²⁶⁷. As a result, the cumulative area of remaining land categories in the reporting period (up to 2010) decreased, while the area of land under transition increased.

National Forest Inventory

Until the end of the 1990s, the national estimation of forest resources was based on stand-wise forest inventories. Regular inventories were carried out every 10 years 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 the program was the 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 according to the situation in 1940, and the remaining land was left for privatisation. Changes were also carried out in forest survey. The planned economy, which had existed for 50 years, was replaced by a market economy resulting in intensive cutting of forests. As the land reform was not quick enough (it took almost 25 years and is now in final stages), a situation occurred where valid, current information was available only about one-third of Estonian forests. Changed ownership structure and stopping of the former centralised forest management planning system created a need for new inventory methods. Long lasting land reform is partly also the reason why forests in Estonia have unbalanced age structure.

The first National Forest Inventory covering the whole country commenced in 1999. With rather modest means, the NFI can give quite a precise assessment of forest area, resources and cutting volume. The main objective of the NFI is to provide estimates about major characteristics of forests, but nowadays the NFI also gives information about topics such as the distribution of land by land-use categories and the afforestation and growing stock of non-forest land, etc.

²⁶⁷ FCCC/ARR/2022/EST L.1.

Methodologically, the NFI is designed as an annual research effort, which, using optimal methods, must ensure continuous updating of information and the forest database. An increased frequency network (starting from 2014)²⁶⁸ of sample plots (Figure 6.5), covering the whole country, has been planned for five years with 20% or approximately 370 clusters (ca 5500 sample plots) measured each year, so that permanent plots will be re-measured in 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.

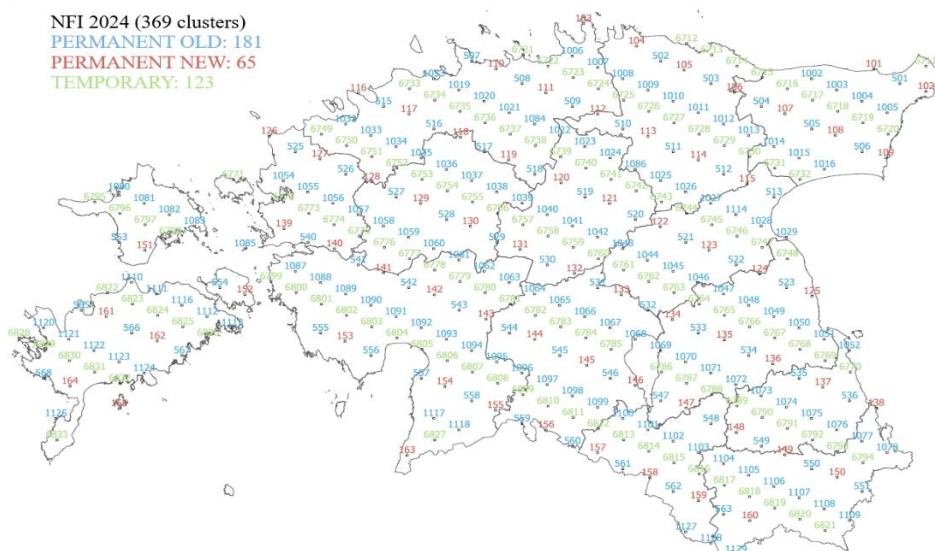


Figure 6.5. Cluster network of the Estonian National Forest Inventory

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 estimating the optimum cutting level. The Estonian NFI covers all land-use categories, 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 statistical reporting in Estonia, such as the United Nations/FAO Forest Resources Assessment procedure, the Ministerial Conference on the Protection of Forests in Europe (Forest Europe MCPFE). The NFI also produces information on forest carbon pools and changes for the LULUCF sector in the GHG inventory.

Design of the Estonian NFI is a systematic sample without pre-stratification. 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 the national level. The sampling intensity is the same throughout the whole country. The sample (cluster) distribution is based on a national 5-km x 5-km quadrangle grid, determined by the L-EST co-ordinates system.

Sample plots are concentrated into clusters (Figure 6.6) 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 after 5 years. The sample plot radius depends on the assessed

²⁶⁸ In FCCC/ARR/2014/EST, paragraph 68, the ERT recommended increasing the sampling frequency.

variables, as well as their values (e.g., tree diameter). In addition to plots with the main radii of 10 m and 7 m, where the land-use category is determined, plots of other radii are also used.

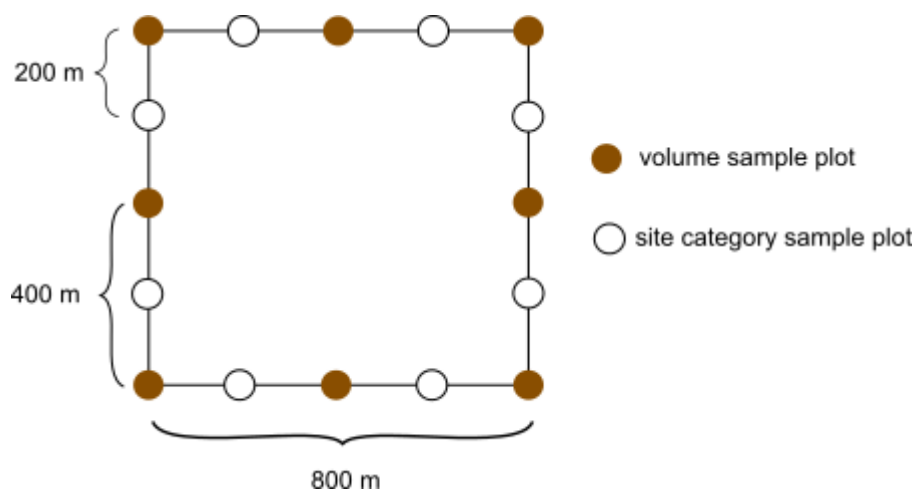


Figure 6.6. Estonian NFI cluster design

All population units have an equal probability of being selected 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.

The sampling scheme and design are described in more detail by Adermann (2010)²⁶⁹.

The present status and change of land use is assessed during the NFI fieldworks. Collected data provides information on different land-use categories (on 20 years, retrospectively), the year of changes, and soil types. During land category registration, “LULUCF former land category” is registered on every sample plot to see if the land category has changed after the 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.

An illustrative example of how land-use changes are verified with maps and relevant materials are presented as follows. In the cluster in Figure 6.7, Figure 6.8 and Figure 6.9, there are 6 identified land-use changes on the NFI sample plots since 1990:

- N02 – Grassland to forest land, LUC in 1995
- E06 – Cropland to forest land, LUC in 1999
- S02 – Cropland to forest land, LUC in 2009
- W04 – Cropland to forest land, LUC in 2005
- W06 and W08 – Cropland to forest land, LUC in 2008.

²⁶⁹ Adermann, V. (2010). Estonia. In: Tomppo, E., Gschwantner, T., Lawrence, M., McRoberts, R. (eds). National forest inventories: Pathways for common reporting. Dordrecht: Springer, pp. 171–184.

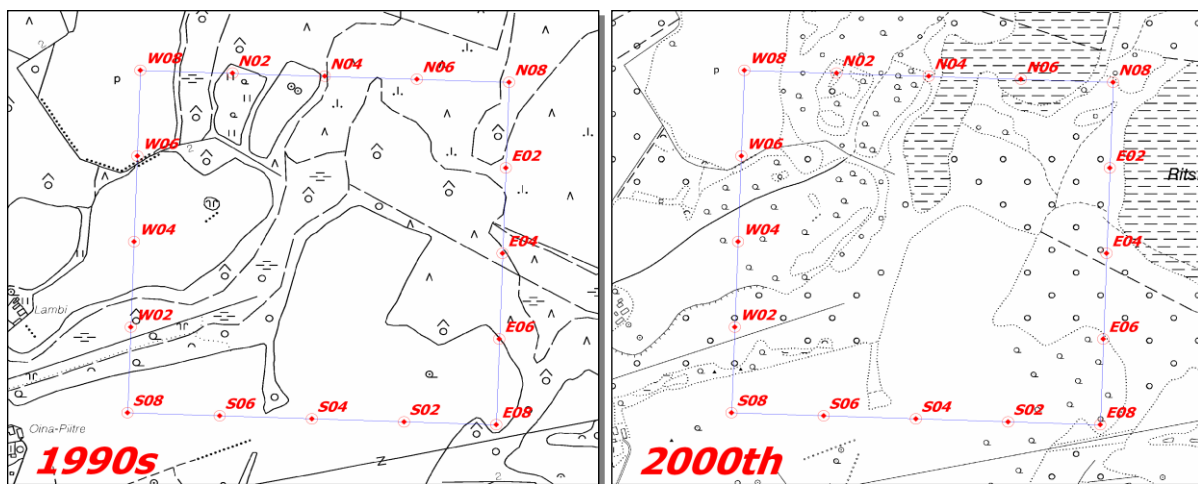


Figure 6.7. Base maps of the 1990s and the year 2000

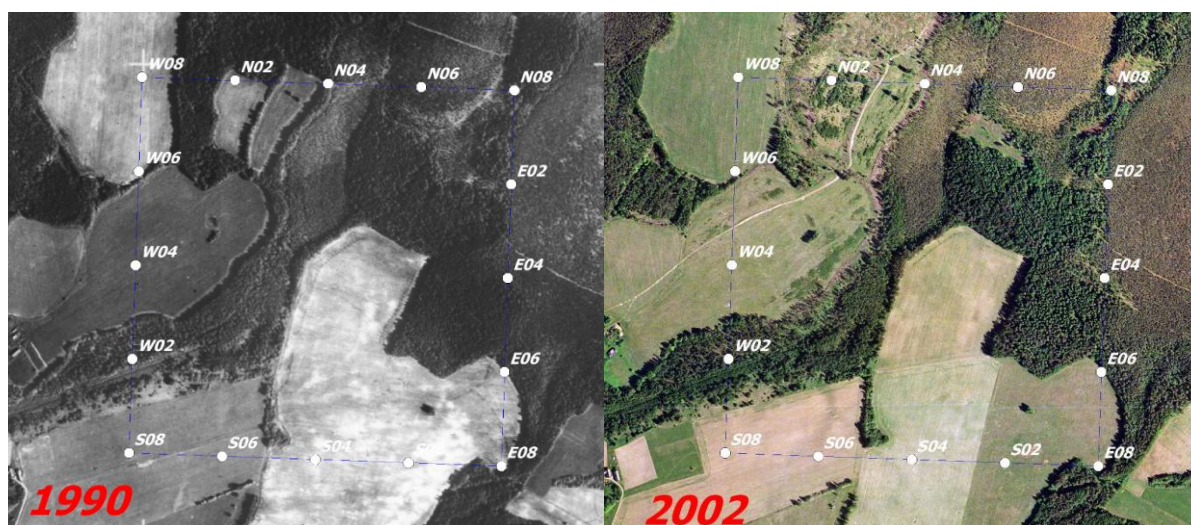


Figure 6.8. Orthophotos of 1990 and 2002

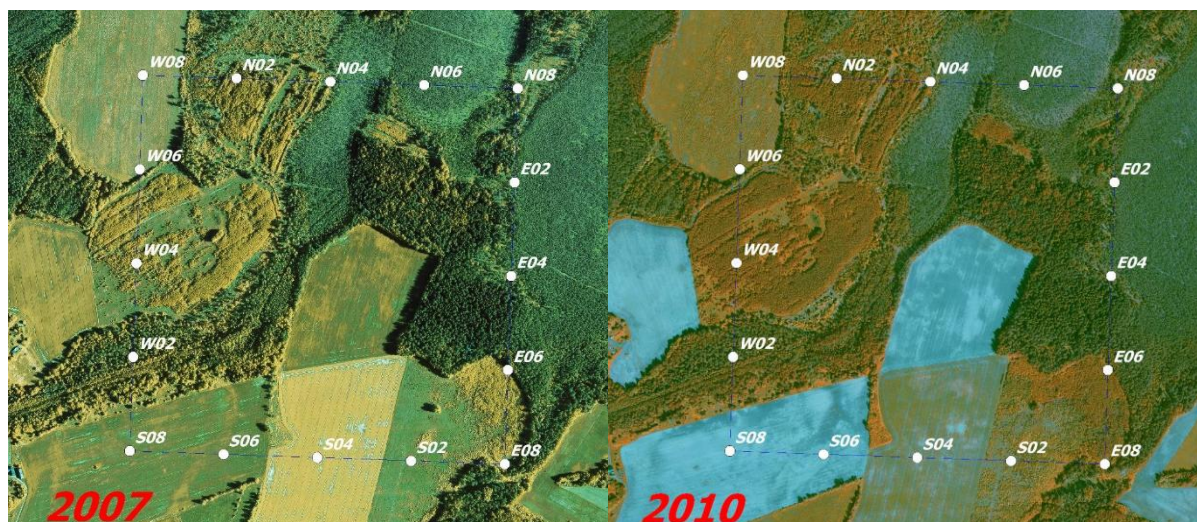


Figure 6.9. Orthophotos of 2007 and 2010

Since 1999, information on permanent sample plots has been available. The resulting data set is a matrix with previous and the current land-use categories in the timeline.

During a field study, soil types (mineral/organic) are also estimated, and all sample plots are assigned with the soil type ‘mineral’ or ‘organic’. For undrained soils the ‘organic’ soil type is defined with an organic layer of more than 30 cm in depth and for drained soils more than 25 cm in depth. The soil is drained when the distance from the functioning drainage ditch is up to 100 m.

The NFI determines more land categories than in the IPCC 2006 Guidelines, therefore an aggregation has been made, which is shown in Table 6.7. Not all national and IPCC land-use categories have an exact match, few national land-use categories can be forest land or grassland, which is specified in the field.

Table 6.7. National definitions for land-use categories and relevant land-use categories defined by IPCC 2006 in 2024 (kha)

	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land
Forest land (M)	2140.24					
Unstocked forest land (MM)	202.82					
Arable land (excluding PK, PR) (PM)		667.95				
Permanent crops (PK)		2.83				
Long-term cultural grassland (PR)		319.16				
Bushes (P)	18.02		41.27			
Natural grassland (RM)	33.90		198.96			
Mire (S)	60.51		23.61	137.52		
Inland water bodies (SV)				264.05		
Peat quarry (KT)				21.36*		
Opencast pit (excl. KT) (K)					8.36	
Settlements (excl. T, TR) (A)					192.49	
Roads and railways (T)					68.91	
Lines, power lines, etc. (TR)					77.01	
Wooded settlements area (PA)					2.30	
Solar park (PP)			0.55			
Unusable mineral land (KK)	4.25		2.81			34.82
Other land (Y)						10.22
Total	2 459.74	989.93	267.21	422.94	349.07	45.05

* Area from the Mineral Resources Register

6.3.2. Information on approaches used for natural disturbances, if applicable

Estonia is estimating emissions from biomass burning and these emissions are included in the national total. More information is available in Chapter 6.11.

6.3.3. Information on approaches used for reporting harvested wood products

Estonia applies the production approach for reporting emissions and removals from harvested wood products. More information is available in Chapter 6.12.

6.4. Forest land (CRT 4.A)

6.4.1. Category description

Forest land category covered 2459.74 kha in 2024, which is more than half of Estonia's territory. In total the Forest land area has increased by 236.54 kha compared to the 1990 initial area (Table 6.6, Figure 6.10). After Estonia regained its independence in 1991, the soviet agricultural system fell apart, and a significant part of the agricultural land was abandoned. When the tree crown cover of grasslands and wetlands satisfies criteria for Forest land, the land is reallocated, which has been the main reason for the increase in Forest land area. Afforestation of settlements and other land categories has been less important.

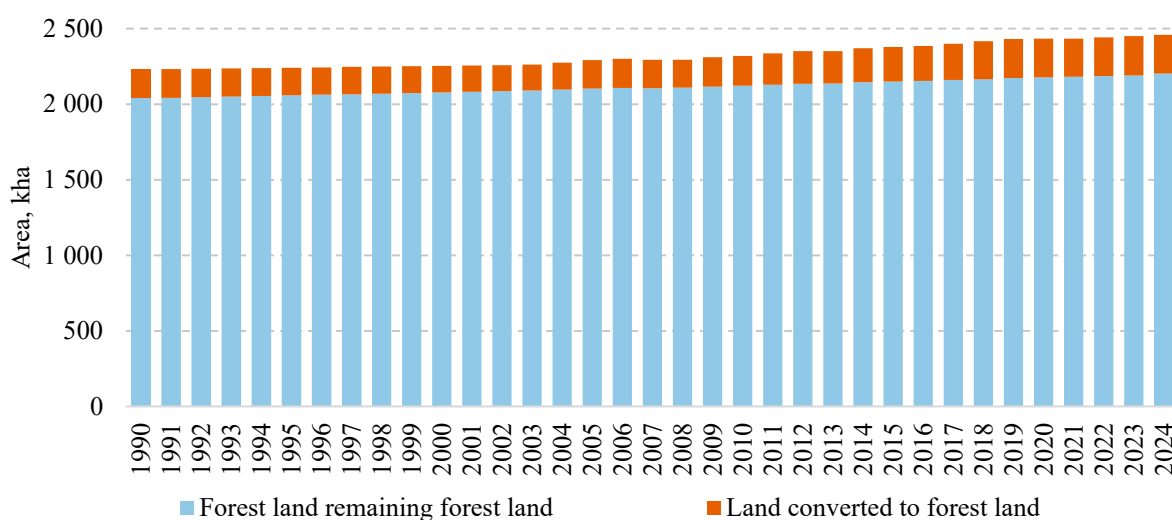


Figure 6.10. Forest land area in Estonia in 1990–2024, kha

The net emissions from Forest land were -627.07 kt CO₂ eq. (Figure 6.11) in 2024. Estimations include CO₂ emissions and removals from living biomass, dead organic matter, mineral and organic soils, non-CO₂ emissions from drained organic forest soils, direct and indirect N₂O emissions from N mineralization and emissions from wildfires.

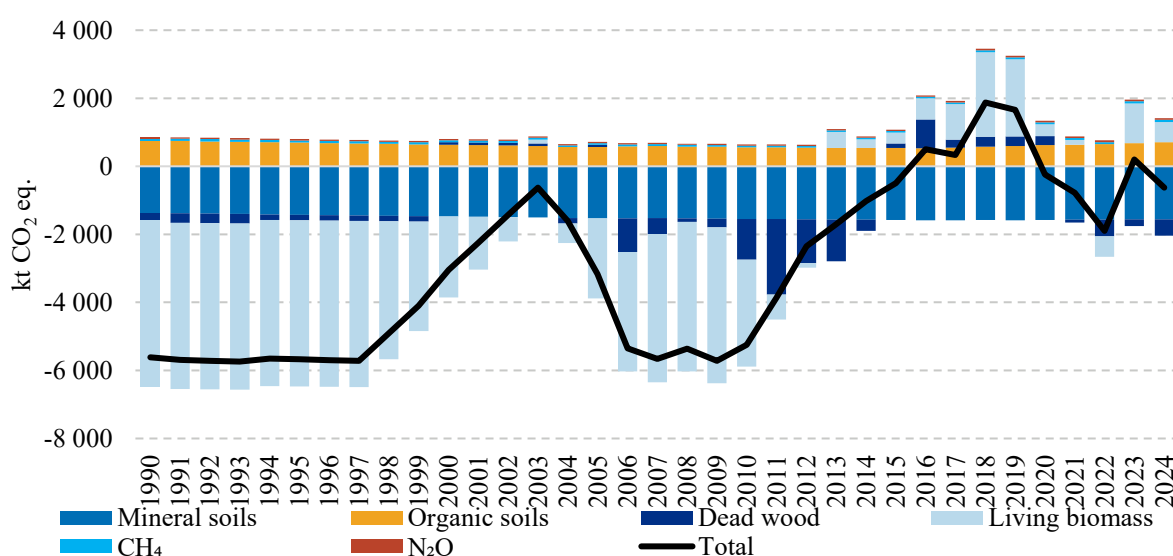


Figure 6.11. Annual net change in GHG emissions (+) and removals (-) from the Forest land category in 1990–2024, kt CO₂ eq.

Forest land is the most important category that affects LULUCF sector trends and is generally keeping LULUCF sector GHG emissions and removals balance on a sink side. The age structure of managed forests in Estonia is dominated by mature stands as approximately 39.5% of forest stands are more than 60 years old²⁷⁰, also the proportion of forest area belonging to the first development classes (treeless area, area under regeneration and young stands) has increased. Therefore, the capacity of carbon sequestration in living biomass has decreased in recent decade, i.e the ratio of mortality to increment has increased.

6.4.2. Methodological issues

The carbon stock change in the category 4.A.1 Forest land remaining forest land is given by the sum of changes in above- and below-ground biomass, deadwood, litter, and soils. The algorithm employed to estimate carbon flows related to the category Forest land remaining forest land is presented below:

Equation 6.1²⁷¹

$$\Delta C_{LU} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{LI} + \Delta C_{SO}$$

Where:

ΔC_{LUi} = carbon stock change for a stratum of land-use category;
 AB = above-ground biomass;
 BB = below-ground biomass;
 DW = dead wood;
 LI = litter; and
 SO = soils.

Equation 6.1 is also used for calculations on the subcategory of land converted to Forest land.

Carbon stock change in living biomass

Living biomass on Forest land includes the biomass of perennial woody plants. Starting from 2025 year's submission, Estonia uses a new approach, the *Gain-Loss Method*, for estimating carbon stock changes in living biomass (Equation 6.2, *Tier 3*):

Equation 6.2²⁷²

$$\Delta C_{LU} = \Delta C_G - \Delta C_L$$

Where:

ΔC_{LUi} = carbon stock change for a stratum of land-use category;
 ΔC_G = annual gain of carbon; t C yr⁻¹.
 ΔC_L = annual loss of carbon; t C yr⁻¹.

The methodology is described in detail in Annex A.V.4.1 In short, C stock changes in Forest land living biomass are estimated as follows.

²⁷⁰ Estonian Environment Agency (2025). NFI 2024. Table 13. Distribution of stands by age classes and dominant tree species, 10-year age classes (in Estonian). [www]
https://keskkonnaportaal.ee/sites/default/files/Teemad/Mets/SMI2024/SMI_2024.xlsx (13.02.2026).

²⁷¹ IPCC 2006 Guidelines, Volume 4, Chapter 2: Genetic Methodologies Applicable to Multiple Land-Use Categories, page 2.7, Equation 2.3.

²⁷² IPCC 2006 Guidelines, Volume 4, Chapter 2: Genetic Methodologies Applicable to Multiple Land-Use Categories, page 2.23, Equation 2.12.

- 1) The current growing stock (stem volume) per hectare of FL is estimated based on the distribution of stand age and site quality index of the forest stands assessed by NFI during the last five years' field measurements. Growing stock is calculated using model that predicts plot-level growing stock (tree stem volume) per hectare given the average age of the dominant tree species and the site quality index.
It should be noted that this essentially estimates the average difference between the increment (tree growth) and growing stock reductions due to intermediate loggings (thinnings, cleanings, selection fellings) and natural mortality – i.e., reductions, where the age of the dominant species is not altered – since the volumes used to fit model include the impacts of these.
- 2) From the plot measurement time the stock is projected to the reporting year using the same model and assuming that the site quality index remains the same. Years of growth were adjusted by the coefficient of real change in average age (usually, the forest becomes five years older in five years, but due to natural disturbances or intermediate fellings, the age change may be different).
- 3) The annual average gains (in stem volume) per hectare of FL are obtained as the annual average change between the projected and original stocks.
- 4) Annual losses of stem volume are reported as an average over the last three harvest seasons. Thus, the new methodology reflects short-term changes in harvest levels, as recommended by ERT²⁷³. Mean volume lost per hectare of clear-felled FL is estimated by projecting the pre-harvest volumes of the clear-felled plots with the same model that is used for gains, and subtracting from this projected value the average share of volume remaining in clear-felling areas (seed trees, retention trees etc). Other fellings due to which the age drops to zero were also added to clear fellings.
- 5) Stem volume is converted to whole tree biomass using nationally developed factors of growing stock volume to above-ground biomass (BCEF) and ratios of below-ground to above-ground biomass, and further to carbon stocks by applying default carbon fractions from the 2006 IPCC Guidelines.
- 6) Based on Estonian NFI data (average annual growing stock change in Land converted to FL plots), the average annual increase of stem volume in young stands is estimated to be 2.14 m³ ha⁻¹. Growing stock was converted to C by applying average woody biomass C stock/growing stock ratio from FL remaining FL (0.324 t C m⁻³). C gains on Land converted to FL, based on this estimate and the area converted to FL, are subtracted from C change on total FL to obtain C change on FL remaining FL.
- 7) As the first NFI cycle ended in 2003, NFI growing stock data is available from that year onwards. For the period 1990–1997, C stock change in FL living biomass was estimated using stand-wise inventory based growing stock data from Statistics Estonia and felling volumes from felling documentation. Growing stocks change were smoothed using linear trend; exponential trend was applied for felling data. For the period 1998–2002, C stock change in FL living biomass was interpolated.

Total net emissions from Forest land living biomass sub-category were 593.54 kt CO₂ in 2024 (Figure 6.12). The fluctuation in annual carbon stock changes in Forest land living biomass is mainly caused by the felling rates (losses). Total and regeneration felling rates for years 1991–2023 are presented in Figure 6.13. Estimates for fellings in 1991–2001 are based on the felling documentary data, NFI data is available from 2002 onwards. Growing stock and fellings based on stand-wise forest are systematically underestimated (e.g., Arumäe & Lang 2016²⁷⁴; Kulješić et

²⁷³ FCCC/ARR/2022/EST L.16.

²⁷⁴ Arumäe, T., Lang, M. (2016). ALS-based wood volume models of forest stands and comparison with forest inventory data. *Forestry Studies*, 64, 5–16.

al. 2016²⁷⁵), but trends can be considered correct, thus, they can be used to assess the change. The one-year number from NFI comes from the measurements in three felling seasons based on the May to April (e.g. 2023 estimate is the average from felling seasons 2021/2022, 2022/2023, and 2023/2024).

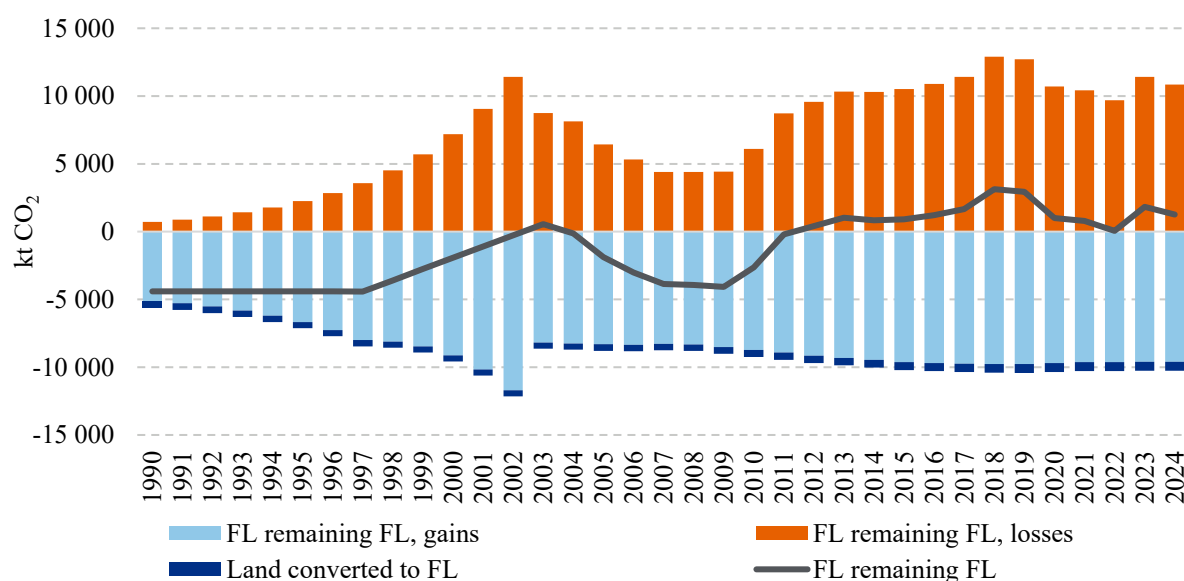


Figure 6.12. Annual carbon stock changes in Forest land living biomass in 1990–2024, kt CO₂

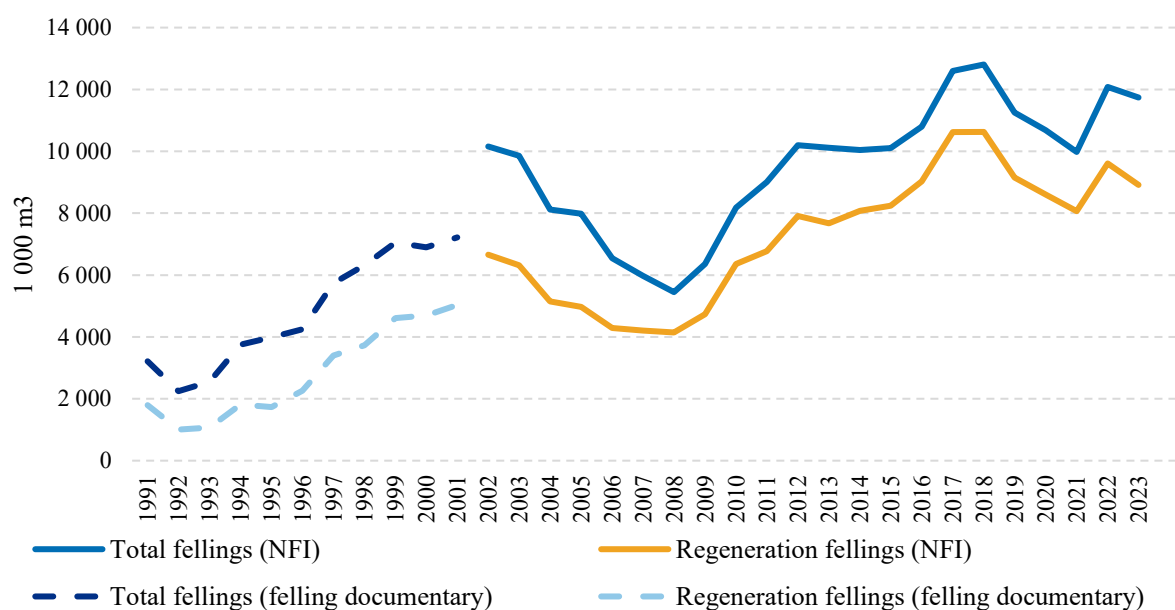


Figure 6.13. Total and regeneration fellings in 1990–2023, 1000 m³

Carbon stock change in dead wood

Dead wood includes wood lying on the surface, standing deadwood, dead roots and stumps and dead branches. For estimating carbon stock changes in the dead wood pool, the *Tier 3* and stock difference method was applied. The NFI annually provides data about the volume of dead wood

²⁷⁵ Kuliešis, A., Tomter, S.M., Vidal, C. & Lanz, A. (2016). Estimates of stem wood increments in forest resources: comparison of different approaches in forest inventory: consequences for international reporting: case study of European forests. *Annals of Forest Science*, 73, 857–869.

for the entire forest area (land remaining FL and conversion to FL). Dead wood stems are measured if their diameter is over 8 cm (stemwood has utilization value) or over 15 cm (stemwood has no utilization value). Stem biomass was expanded to whole-tree biomass using 16% for branches²⁷⁶ and IPCC default factors for roots²⁷⁷. Dead wood volumes were converted to C stocks by using the dead wood densities and C contents by decay classes from Köster *et al.* 2015²⁷⁸. For dead wood with utilization value, the averages of decay classes 1–2 and for dead wood without utilization value the averages of decay classes 3–5 were applied (Table 6.8 and Table 6.9).

Table 6.8. Dead wood (DW) density by tree species and existence of utilization value, t m⁻³

DW class	Pine	Spruce	Birch	Aspen	Grey Alder	Black Alder	Others
DW with utilization value	0.359	0.382	0.397	0.361	0.386	0.356	0.374
DW without utilization value	0.211	0.199	0.173	0.151	0.186	0.156	0.179

Table 6.9. Dead wood (DW) carbon fraction by tree species and existence of utilization value

DW class	Pine	Spruce	Birch	Aspen	Grey Alder	Black Alder	Others
DW with utilization value	0.491	0.483	0.474	0.473	0.480	0.481	0.481
DW without utilization value	0.498	0.496	0.488	0.468	0.482	0.482	0.486

Carbon stock change in the deadwood 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.

Equation 6.3²⁷⁹

$$\Delta C_{DW} = A \times \frac{(DW_{t_2} - DW_{t_1})}{T}$$

Where:

ΔC_{DW} = annual change in carbon stocks in deadwood (DW), t C yr⁻¹;

A = area of Forest land remaining forest land, ha;

DW_{t_1} = average dead wood C stock at t_1 for Forest land remaining forest land, t C ha⁻¹;

DW_{t_2} = average dead wood C stock at t_2 (the previous time) for Forest land remaining forest land, t C ha⁻¹; and

$T = (t_2 - t_1)$ = time period between time of the second stock estimate and the first stock estimate, yr.

According to the NFI on Land converted to forest land areas, dead wood stock was assumed to increase at rate of 0.076 m³ ha⁻¹ yr⁻¹ (average annual change in Land converted to FL NFI plots). Dead wood volume was converted to C by applying average dead wood C stock/volume ratio from FL-FL (0.252 t C m⁻³).

²⁷⁶ Based on Estonian Wood Balance 2022, Table 3 (in Estonian). [www]

<https://keskkonnaportaal.ee/sites/default/files/Teemad/Mets/Puidubilanss%202022.pdf> (27.12.2024)

²⁷⁷ IPCC 2006 Guidelines, Volume 4, Chapter 4: Forest Land, page 4.49, Table 4.4.

²⁷⁸ Köster, K., Metslaid, M., Engelhart, J., Köster E. (2015). Deadwood basic density, and concentration of carbon and nitrogen for main tree species in managed hemiboreal forests. Forest Ecology and Management, 354, 35–42.

²⁷⁹ After IPCC 2006 Guidelines, Volume 4, Chapter 2: Genetic Methodologies Applicable to Multiple Land-Use Categories, page 2.23, Equation 2.19.

Figure 6.14 illustrates annual dead wood stock changes on Land remaining forest land and Land converted to forest land. Average dead wood volume for Forest land remaining forest land was calculated based on five-year measurements. For earlier years, for which the NFI measurements were not available, dead wood stocks were extrapolated using linear trends. All subsequent NFI measurements were used to construct a linear trend. The current NFI system assesses four types of dead wood: 1. standing dead wood with utilization value, 2. lying dead wood with utilization value, 3. standing dead wood without utilization value, 4. lying dead wood without utilization value. A comparable and consistent time series of these types of dead wood began in different years: type 1 in 2003, type 2 in 2013, type 3 in 2009 and type 4 in 2009. The dead wood carbon stock decreased in 2015–2020 due the increase in felling volume and thus increasing proportion of forest area belonging to the first development classes (treeless area, area under regeneration and young stands). In addition, dead wood is also removed from the forest during harvesting. The stumps and roots of harvested trees are immediately included in the emissions, as the pre-harvesting growing stocks on NFI plots that have been clear-felled have been converted to the whole-tree biomass, although the extraction of stumps with roots is not practiced in Estonia. Since 2021, C sequestration in dead wood pool has increased due to the higher mortality, as forest age structure is shifting toward mature forests, and the intensity of natural disturbances (like spruce bark beetle) is increasing.

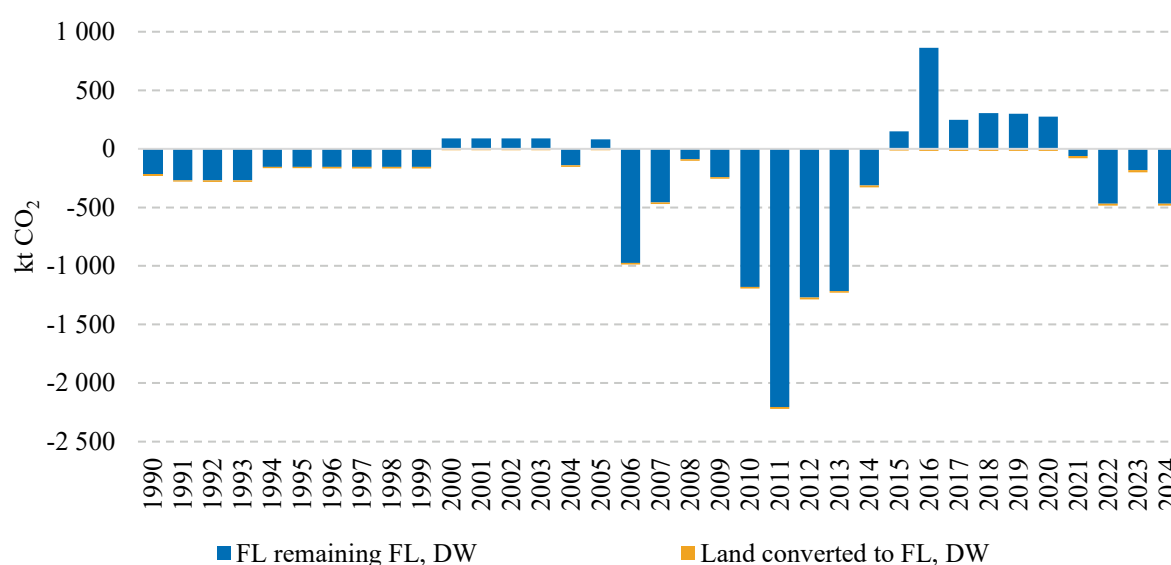


Figure 6.14. Net carbon stock change in forest dead wood and litter pools in 1990–2024, kt CO₂

Carbon stock change in 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. C stock reductions in litter for land converted to forest land were included in soil emission factor (Table 6.10), since differences between the initial and final SOC stocks were estimated for the whole soil profile (Kõlli et al. 2004, 2009, 2010).

Carbon stock change in mineral soils

In Table 6.10, the areas of Forest land remaining forest land and Lands converted to forest land in 2024 are shown, as well as applied emission factors for mineral and organic soils.

Table 6.10. Areas of cumulative Forest land subcategories in 2024 and implemented soil emission factors

Land-use category	Mineral soils, kha	Organic soils, kha	Drained organic soils, kha	EF mineral soil t C ha ⁻¹	EF organic soil t C ha ⁻¹
Forest land remaining forest land	1733.81	468.27	246.81	0.24	-0.68
Cropland→ Forest land	38.72	4.86	37.25 ²⁸⁰	0.18	-0.68
Grassland→ Forest land	75.69	28.66		-0.12	-0.68
Wetlands→ Forest land	5.38	84.67		-0.18	-0.68
Settlements→ Forest land	3.26	4.78		1.08	-0.68
Other land→ Forest land	11.62	0.02		1.08	-0.68
Total Forest land	1868.48	591.26			

Due to insufficient country-specific data regarding carbon stock changes in forest mineral soil, the emission factor from Sweden²⁸¹ (0.24 t C ha⁻¹ yr⁻¹) was implemented for Land remaining forest land (Table 6.10). Implementation of emission factors from a neighbouring country is a temporary solution suggested by the ERT (FCCC/ARR/2012/EST para.94). Currently Estonia is working on developing *Tier 3* methods for reporting on Forest land litter and soil carbon stock changes (Chapter 6.4.6).

Country-specific EFs were applied for areas under land-use change to forests. The methodology is described in detail in Annex A.V.4.2. Changes in mineral soil SOC stocks due to land-use conversions from Cropland and Grassland to forest land were obtained from the literature (Kõlli et al. 2010) and divided by 20 years to find the annual C stock change. Emission factors were estimated separately for different soil types, and the weighted average EF was calculated based on the distribution of soil types in previous land use (Kõlli et al. 2009). As there is currently lack of data about wetlands' mineral soil SOC stocks in Estonia, the difference between mean SOC stock values for hydromorphic mineral soils in grasslands and forests (134.0 and 130.3 t C ha⁻¹, respectively; Kõlli et al. 2009) was applied for land conversion from Wetlands to forest land. In case of Settlements and Other land converted to forest land, it was assumed that the net gain of SOC is the same as is lost due to conversion of Forest land to settlements (see Chapter 6.8.2) or other land (Chapter 6.9.2).

In 2024, there was a C uptake in forest mineral soils by -1556.6 kt CO₂, of which -1508.86 kt CO₂ was contributed by Forest land remaining forest land. Under the Land converted to forest land subcategory, net emissions were -47.71 kt CO₂. Overall, the annual carbon sequestration by forest mineral soils has increased by 13.2% compared to 1990 (Figure 6.15).

²⁸⁰ Estimated at the Land converted to Forest land level. The same share of drained areas is assumed for each subcategory.

²⁸¹ The average implied emission factor of 1990–2023 in Sweden CRT 4.A tables, Sweden 2025 Submission.

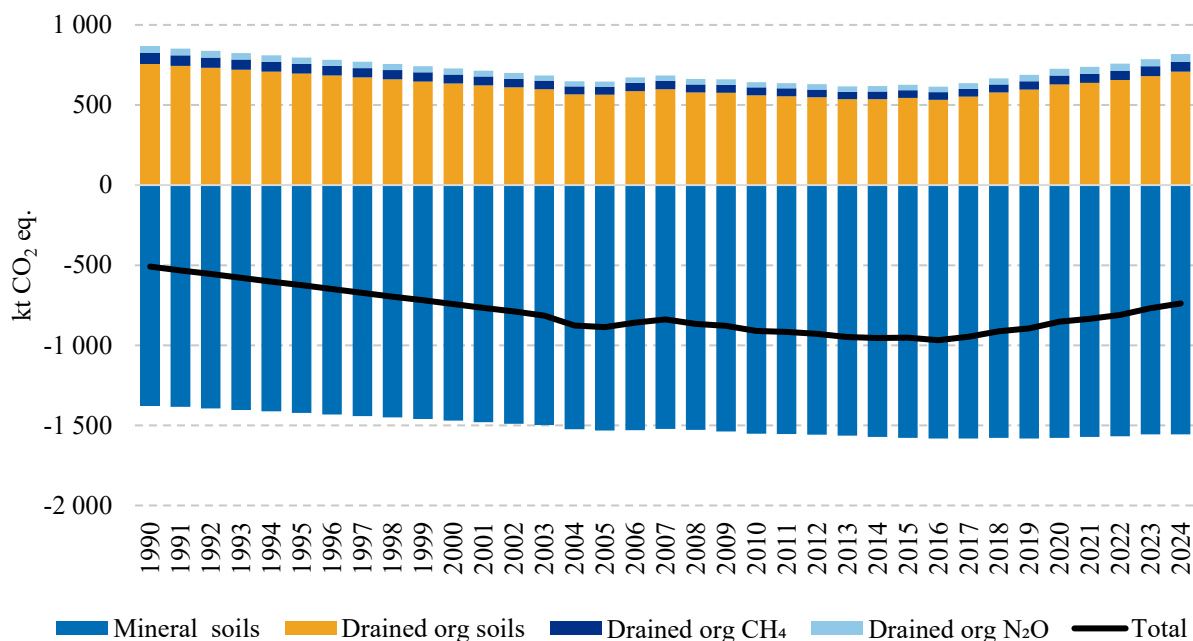


Figure 6.15. Annual stock change in Forest land mineral and drained organic soil pools including non-CO₂ emissions from drained soils in 1990–2024, kt CO₂ eq.

Carbon stock change in drained organic soils

For undrained soils the ‘organic’ soil type is defined with an organic layer of more than 30 cm in depth and for drained soils more than 25 cm in depth. The soil is drained when the distance from the functioning drainage ditch is up to 100 m. Equation 6.4 was applied for estimating carbon loss from drained organic forest soils.

Equation 6.4²⁸²

$$L_{Organic} = A \times EF$$

Where:

$L_{Organic}$ = annual carbon loss from drained organic soils, tonnes C yr⁻¹;
 A = area of drained organic soils, ha;
 EF = emission factor for CO₂ from drained organic soils, tonnes C ha⁻¹ yr⁻¹

Equation 6.4 is also used for calculating emissions from organic forest soils after Land is converted to forest land.

The default emission factor for drained organic forest soils from the 2006 IPCC Guidelines²⁸³ was applied according to the 2022 ERT recommendation²⁸⁴.

As average for the period 1990–2024, 23.7% of all Estonian forest soils are organic soils, of which 45.4% are drained according to the NFI. In 2024, 52.7% and 30.3% of organic soils were drained on Forest land remaining forest land and on Land converted to forest land areas, respectively (Table 6.10). CO₂ emissions from drained organic forest soils have decreased by 6.3% since 1990 (Figure 6.15).

²⁸² IPCC 2006 Guidelines, Volume 4, Chapter 2: Generic Methodologies Applicable to Multiple Land-Use Categories, page 2.35, Equation 2.26.

²⁸³ IPCC 2006 Guidelines, Volume 4, Chapter 4: Forest Land, page 4.53, Table 4.6 (Temperate).

²⁸⁴ FCCC/ARR/2022/EST L.13.

Non-CO₂ emissions from drained organic soils

Non-CO₂ emissions from drained organic soils depend on soil nutrient status. Forest land was divided into nutrient-rich and nutrient-poor areas based on site quality class (SQC²⁸⁵). SQC I and II are categorized as nutrient-rich and III–V are categorized as nutrient-poor. Respective areas in 1990 and 2024 are presented in Table 6.11. It was assumed that the share of nutrient-poor and nutrient-rich sites from the total drained areas is the same for Forest land remaining forest land and Land converted to forest land categories.

Equation 6.5 with factors from the IPCC 2013 Wetlands Supplement²⁸⁶ (*Tier 1*) was applied for estimating CH₄ emissions from drained organic forest land and drainage ditches. Emission factors from the Wetlands Supplement were used for CH₄, since 2006 IPCC Guidelines do not provide methodologies for calculating these emissions.

Equation 6.5²⁸⁷

$$CH_{4\_OS} = \sum_n A_n \times \left((1 - Frac_{ditch}) \times EF_{CH_4\_land_n} + Frac_{ditch} \times EF_{CH_4\_ditch} \right)$$

Where:

- CH₄_OS = annual CH₄ loss from drained organic forest soils, kg CH₄ yr⁻¹;
A_n = area of drained organic forest soils in nutrient status n, ha;
EF_{CH₄_land_n} = emission factors for direct CH₄ emissions from drained organic forest soils by nutrient status n, kg CH₄ ha⁻¹ yr⁻¹ (Table 6.11);
EF_{CH₄_ditch} = emission factor for CH₄ emissions from drainage ditches, kg CH₄ ha⁻¹ yr⁻¹ (Table 6.11);
Frac_{ditch} = fraction of the total area of drained organic soils which is occupied by ditches (where “ditches” are any area of manmade channel cut into the peatland) (Table 6.11).

Equation 6.6 with default emission factors from the IPCC 2006 Guidelines (Tier 1) was used for estimating N₂O emissions from drained organic forest land.

Equation 6.6²⁸⁸

$$N_2O_{OS} = \left[(A_{NR} \times EF_{N_2O-N,NR}) + (A_{NP} \times EF_{N_2O-N,NP}) \right] \times \frac{44}{28}$$

Where:

- N₂O_{OS} = annual direct N₂O-N emissions from drained organic forest soils, kg N₂O yr⁻¹;
A = area of drained organic forest soils, ha (the subscripts NR and NP refer to Nutrient-Rich and Nutrient-Poor, respectively);

²⁸⁵ Site quality class is determined based on the average height attained at a given age by the dominant tree species of the stand. Calculated according to the Forest Survey Guidelines, appendix 7. (In Estonian) [www.riigiteataja.ee/akt/131052024011 (15.12.2025)].

²⁸⁶ IPCC (2014b). 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (*IPCC 2013 Wetlands Supplement*).

²⁸⁷ IPCC 2013 Wetlands Supplement, Chapter 2: Drained Inland Organic Soils, page 2.22, Equation 2.6.

²⁸⁸ After IPCC 2006 Guidelines, Chapter 11: N₂O Emissions from Managed Soils, and CO₂ Emissions from Lime and Urea Application, page 11.7, Equation 11.1.

EF_{N_2O-N} = emission factor for N_2O emissions from drained organic forest soils, $kg\ N_2O-N\ ha^{-1}\ yr^{-1}$ (the subscripts NR and NP refer to Nutrient-Rich and Nutrient-Poor, respectively) (Table 6.11).

In 2024, non- CO_2 emissions from drained organic forest soils were equal to 109.49 kt CO_2 eq., which is 0.5% lower compared to the base year (Figure 6.15).

Table 6.11. Areas of drained organic forest soils with different nutrient status and associated emission factors for non- CO_2 emissions

Nutrient status	Area 1990, kha	Area 2024, kha	Emission factors			Frac _{ditch} ²⁸⁹
			N_2O-N ²⁹⁰ , $kg\ N\ ha^{-1}\ yr^{-1}$	CH_4 land ²⁹¹ , $kg\ CH_4\ ha^{-1}\ yr^{-1}$	CH_4 ditch ²⁹² , $kg\ CH_4\ ha^{-1}\ yr^{-1}$	
Nutrient-rich	147.45	168.71	0.6	2.5	217	0.025
Nutrient-poor	155.79	115.35	0.1	2.5		

6.4.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Forest land subcategory, please see Annex A.II.4 LULUCF, Forest land (4.A) chapter.

6.4.4. Category-specific QA/QC and verification, if applicable

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for the LULUCF sector according to the IPCC *Tier 1* method. The activities are carried out every year during the inventory and the QC check list is used (Table Annex IV.3).

The new methodology for Forest land living biomass compared to the 2023 submission was evaluated by an external expert before the 2024 submission, when the gain-loss method was first applied. The assessment was made by Juha Heikkinen, Research Professor in statistical methods in Natural Resources Institute Finland (Luke). The assessment has been published²⁹³ and stored in the archive. The methodology applied in the inventory has been supplemented with recommendations suggested in the report.

Country-specific emission factors for mineral soil under Land converted to forest land were compared to the values found in published studies. A large part of abandoned agricultural land in Estonia has been naturally afforested with silver birch. A study by Varik et al. (2015) found that in a 13-year-old silver birch stand growing on fertile former arable land, soil C exchange was in equilibrium, thus the soil C pool remained stable. However, in a young grey alder stand, which are also common on abandoned fields, the average C accumulation in the soil was 0.32 t C $ha^{-1}\ year^{-1}$ (Aosaar et al. 2013). Our emission factor for the CL to FL category falls between these values (Table 6.10) There is a lack of studies on grassland afforestation in Estonia, but

²⁸⁹ IPCC 2013 Wetlands Supplement, Chapter 2: Drained Inland Organic Soils, page 2.30, Table 2.4 (boreal/temperate).

²⁹⁰ IPCC 2006 Guidelines, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, page 11.11, Table 11.1.

²⁹¹ IPCC 2013 Wetlands Supplement, Chapter 2: Drained Inland Organic Soils, page 2.25, Table 2.3 (temperate).

²⁹² IPCC 2013 Wetlands Supplement, Chapter 2: Drained Inland Organic Soils, page 2.30, Table 2.4 (boreal/temperate).

²⁹³ Heikkinen, J. (2023). Report for the 2023 Estonian national greenhouse gas inventory LULUCF (Land-use, land use change and forestry) sector forest land remaining forest land subcategory biomass pool. [www] <https://keskkonnaportaal.ee/et/kasvuhoonegaaside-lulucf-sektori-biomassi-tekke-kao-metoodika-analuus-2023-eng> (27.12.2024).

Lutter et al. (2016) found a small decrease in the total SOC stock on grasslands converted to hybrid aspen plantations, which agrees with our emission factor for the GL to FL category.

6.4.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

A quantitative overview of recalculations is shown in Table 6.12. Changes compared to the previous submission result mainly from the new methodology for compiling annual land use change matrices (see Chapter 6.3.1). Since the current submission, also land-use changes from 1970 have been considered, as recommended by the ERT²⁹⁴. The effect of these methodological changes on the areas of Forest land subcategories has been shown in Figure 6.16.

Activity data from NFI, such as annual average C stock gains and losses in living biomass and average dead wood stocks in Forest land remaining forest land category were updated, as well as increase of living biomass and dead wood volumes on Land converted to forest land areas. C accumulation in litter pool in Land converted forest land category was not estimated in the current submission, since it is already included in the soil C stock change. EF for Forest land remaining forest land mineral soils has been revised according to the latest Swedish NIR, which has resulted in somewhat higher C sequestration. In addition, the area of drained organic soils was specified for Land converted to Forest land subcategories. This resulted in reduced CO₂ emissions, since in the previous submission all organic soils on conversion areas were assumed to be drained.

Several methodological changes resulted from the EU internal comprehensive review of member states greenhouse gas inventories in 2025²⁹⁵. For the Forest land category, the recommendation with the most significant impact was to apply temperate zone emission factors consistently across all gases for organic soils. Estonia recalculated N₂O emissions from drained organic forest soils using default emission factors from the 2006 IPCC Guidelines and CH₄ emissions using EFs for temperate zone from the 2013 IPCC Wetlands supplement, as 2006 IPCC Guidelines do not provide a default value for the CH₄ EF. In addition, Estonia revised the calculation of mineral soil carbon stock changes for lands converted from Wetlands, Settlements, and Other Land categories to Forest land.

Table 6.12. Quantitative overview of recalculations compared to the 15.04.2025 submission

Year	Forest land remaining forest land C stock change, kt CO ₂			Land converted to forest land C stock change, kt CO ₂			Total Forest land Net emissions, kt CO ₂		
	2025	2026	difference	2025	2026	difference	2025	2026	difference
1990	-5927.02	-5364.76	562.26	-8.11	-362.28	-354.17	-5622.52	-5614.99	7.53
1991	-5916.80	-5431.80	485.00	-21.31	-371.35	-350.04	-5625.60	-5693.01	-67.40
1992	-5902.52	-5444.78	457.74	-39.74	-380.40	-340.66	-5626.52	-5713.68	-87.16
1993	-5883.71	-5457.78	425.92	-63.88	-389.43	-325.55	-5633.51	-5739.38	-105.87
1994	-5731.34	-5354.83	376.51	-88.37	-398.45	-310.08	-5505.58	-5647.44	-141.86
1995	-5710.09	-5367.64	342.45	-115.39	-407.45	-292.07	-5511.43	-5671.42	-159.99
1996	-5686.93	-5380.48	306.45	-144.95	-416.44	-271.49	-5516.72	-5694.20	-177.48

²⁹⁴ FCCC/ARR/2022/EST L.1.

²⁹⁵ EEA (2025). Final Review Report. 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841. Estonia. [www] https://climate.ec.europa.eu/document/download/c2331bcf-4d75-4679-a364-0d2489ad82eb_en?filename=lulucf_2025_report_ee_en.pdf (23.12.2025).

Year	Forest land remaining forest land C stock change, kt CO ₂			Land converted to forest land C stock change, kt CO ₂			Total Forest land Net emissions, kt CO ₂		
	2025	2026	difference	2025	2026	difference	2025	2026	difference
1997	-5663.05	-5393.33	269.72	-175.72	-425.41	-249.69	-5522.24	-5716.66	-194.42
1998	-4812.83	-4574.32	238.51	-205.17	-434.36	-229.20	-4703.08	-4910.26	-207.19
1999	-3961.13	-3755.33	205.80	-236.41	-443.30	-206.89	-3881.07	-4100.88	-219.81
2000	-2850.04	-2693.28	156.76	-265.04	-452.22	-187.17	-2797.62	-3049.02	-251.40
2001	-2004.85	-1873.87	130.98	-287.32	-461.12	-173.80	-1975.45	-2241.53	-266.07
2002	-1161.49	-1054.48	107.01	-306.67	-470.00	-163.33	-1147.69	-1429.56	-281.87
2003	-316.70	-235.11	81.59	-327.44	-478.86	-151.42	-326.07	-625.04	-298.97
2004	-1293.26	-1184.38	108.88	-346.42	-502.97	-156.56	-1320.81	-1601.81	-281.00
2005	-2918.90	-2713.75	205.15	-364.56	-539.50	-174.94	-2965.12	-3168.92	-203.80
2006	-5304.20	-4894.71	409.49	-384.07	-548.37	-164.31	-5362.06	-5347.37	14.69
2007	-5622.61	-5209.09	413.53	-401.83	-541.49	-139.66	-5705.76	-5660.95	44.81
2008	-5242.53	-4907.40	335.12	-416.54	-542.21	-125.68	-5339.17	-5361.81	-22.65
2009	-5563.32	-5226.69	336.64	-428.92	-573.22	-144.31	-5673.07	-5712.69	-39.62
2010	-5017.68	-4738.02	279.66	-432.02	-592.79	-160.76	-5130.40	-5245.13	-114.73
2011	-3593.20	-3336.80	256.41	-429.43	-610.35	-180.92	-3703.13	-3861.54	-158.41
2012	-1941.02	-1797.12	143.90	-422.13	-633.09	-210.95	-2043.35	-2344.94	-301.60
2013	-1257.31	-1166.07	91.24	-407.97	-618.73	-210.77	-1345.25	-1700.98	-355.73
2014	-512.99	-459.43	53.55	-392.52	-646.06	-253.54	-585.19	-1021.10	-435.91
2015	39.74	56.84	17.10	-373.55	-642.00	-268.45	-12.89	-498.42	-485.53
2016	1118.48	1056.70	-61.78	-351.85	-643.37	-291.53	1087.91	499.48	-588.42
2017	855.40	903.39	47.99	-328.47	-657.36	-328.89	847.77	335.34	-512.43
2018	2365.18	2443.60	78.42	-309.15	-665.29	-356.14	2379.98	1874.92	-505.07
2019	2107.33	2248.48	141.15	-288.76	-681.22	-392.46	2139.46	1663.58	-475.88
2020	126.93	324.78	197.85	-272.43	-666.18	-393.76	175.50	-239.87	-415.37
2021	-473.96	-230.01	243.95	-260.60	-651.31	-390.72	-413.60	-778.32	-364.72
2022	-1665.90	-1353.59	312.30	-249.86	-646.50	-396.63	-1594.76	-1894.57	-299.81
2023	409.31	738.96	329.65	-233.38	-646.26	-412.88	497.06	201.90	-295.17

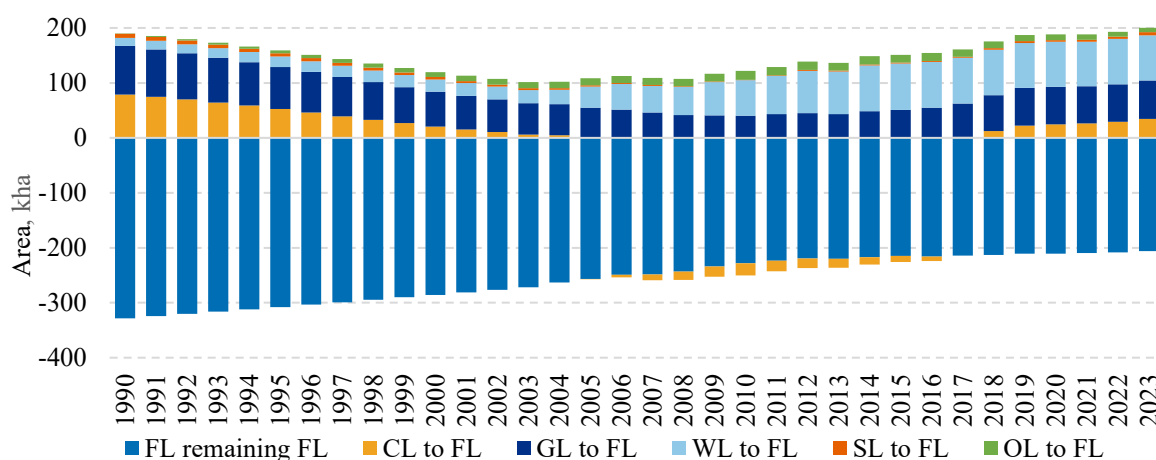


Figure 6.16. Differences between the 2026 and 2025 submissions in the areas of Forest land subcategories in Estonia in 1990–2023, kha

6.4.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

Various remote sensing projects for forest resources have been launched with the purpose of annually calculating country-wide tree cover maps (tree species, growing stock, etc.). These maps will help to monitor annual tree cover gain and identify areas converted to other wooded land (grassland) or to forest land. Areas with tree cover loss can be identified and, in combination with our forest notice system, clear-cut and deforestation can be distinguished. Tree cover change will be monitored also in other wooded land where usually tree cover loss means land use changes to cropland.

Several completed, ongoing and planned NFI developments support more accurate estimates of annual biomass C stock changes, such as „Development of data collection methodologies for the NFI and LULUCF“ by the Institute of Mathematics and Statistics from University of Tartu, which ended in 2025. The project addressed a new approach to constructing height curves as well as a new methodology for assessing growth and mortality. The results will be used for developing a more detailed gain-loss methodology for living biomass. In addition, Estonia is developing a decay function for stumps and roots. Analysis will be based on NFI permanent plots.

In 2024, a project for developing a governance system for land and soil management²⁹⁶ was launched. The project aims to update and consolidate land use-related datasets and to develop higher tier methodologies for estimating SOC changes in all land-use categories. The project has already initiated the updating of the Estonian soil map (2024–2026). In 2025, a project was initiated with the goal of implementing *Tier 3* methodology to assess GHG fluxes from mineral and organic forest soils, as well as litter. The project is planned to run until the end of 2027.

Estonia has recently concluded a research project (conducted by University of Tartu) to specify the activity data and emissions from drainage ditches in all land use categories: “Creation of a map layer of operational ditches and development of GHG emission factors for ditches”. The map layer of ditches is based mainly on the Estonian Topographic Database (ETAK) and supplemented on the basis of other public spatial data and digital elevation model. In addition, the actual condition and type of ditches will be assessed for a sample of ditches during the fieldworks in order to refine the map layer through GIS analysis. Results will be evaluated and implemented in the GHG inventory.

Project “Demonstration of climate change mitigation potential of nutrients rich organic soils in Baltic States and Finland” (LIFE OrgBalt, LIFE18 CCM/LV/001158)²⁹⁷ aims to improve the GHG accounting methods and activity data for nutrient-rich organic soils in the temperate cool & moist climate region. GHG emissions from nutrient-poor drained organic forest soils are specified during the project “Assessment of emissions and carbon stock dynamics in Estonian drained organic forest soils in the national greenhouse gas inventory” led by the University of Tartu.

6.5. Cropland (CRT 4.B)

6.5.1. Category description

Total net emissions from croplands were 1032.86 kt CO₂ eq. in 2024 (Figure 6.17). The Cropland category includes carbon stock changes in living biomass, dead organic matter,

²⁹⁶ Land and soil use research and development project. [www] <https://keskkonnaportaal.ee/en/topics/soil-and-land-use/land-and-soil-use-research-and-development-project> (11.02.2026).

²⁹⁷ LIFE OrgBalt project. [www] <https://www.orgbalt.eu/> (23.12.2025).

mineral and organic soils and N₂O emissions related to the land conversion to croplands (see Chapter 6.10). The highest CO₂ emissions result from the cultivation of organic soils, which has remained relatively stable since 1990. Inter-annual emission fluctuations in the Cropland category are mainly caused by the changes in the mineral soil C stocks, and to smaller extent also deforestation. C stock changes in mineral soils depend on the land use on croplands. After 1991, when Estonia regained its independence, opening of the markets and availability of cheap import goods reduced demand for local food products, causing the decrease in actively managed croplands and C accumulation in mineral soils. Since accession to the European Union in 2004, the share of cultivated areas has been growing due to increased investments and subsidies from the European Union to Estonia's agricultural sector, expansion of export opportunities and popularization of organic farming, leading to the declining SOC stocks.

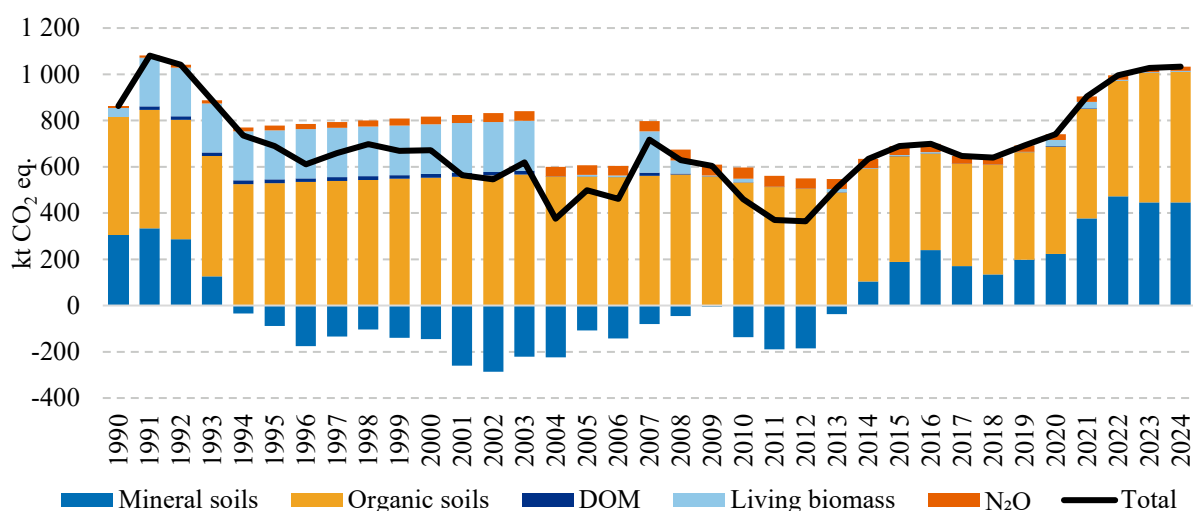


Figure 6.17. Annual GHG emissions (+) and removals (-) from the Cropland category in 1990–2024, kt CO₂ eq.

The area of Cropland category was 989.93 kha in 2024 (Figure 6.18). Although the total cropland area has increased by 2.1 % since 1990, significant part of it has been converted to grasslands, forest land, and also settlements (Table 6.6). Conversions to cropland occur mainly from the Grassland category.

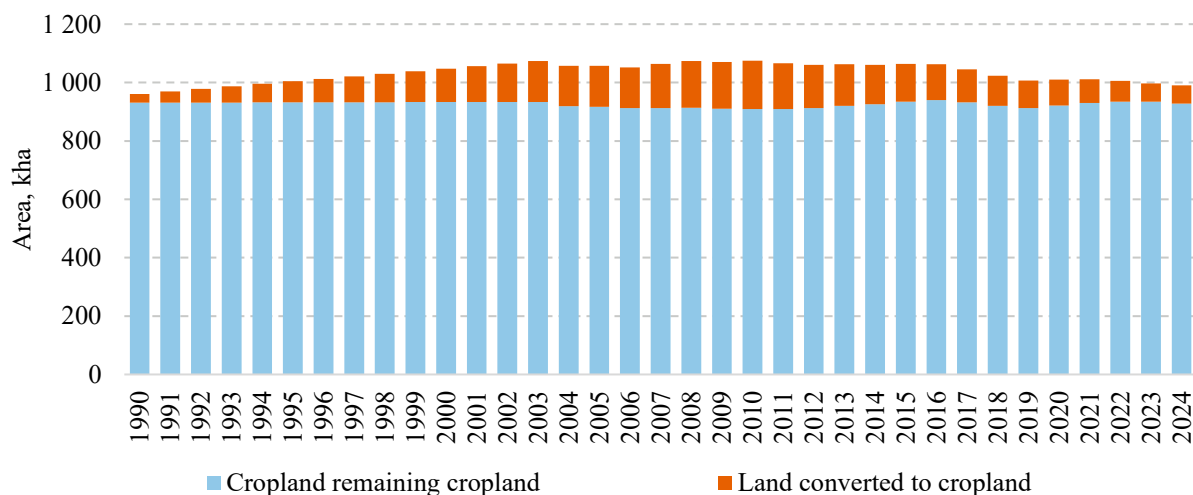


Figure 6.18. Cropland area in Estonia in 1990–2024, kha

6.5.2. Methodological issues

Carbon stock change in living biomass

Since the 2026 submission, C stock changes in perennial woody biomass were estimated for Cropland remaining cropland category using *Tier 1* methodology and default factors from the 2019 Refinement to the 2006 IPCC Guidelines (Equation 6.7, Table 6.13). It was assumed that there is no change in below-ground biomass.

Equation 6.7

$$\Delta C_{LB} = A_{total} \times G - A_{harvested} \times L_{max}$$

Where:

- ΔC_{LB} = annual change in living biomass carbon stock under the Cropland remaining cropland subcategory, tonnes C yr⁻¹;
- A_{total} = total area of orchards, ha;
- G = above-ground biomass accumulation rate, tonnes C ha⁻¹ yr⁻¹ (Table 6.13);
- $A_{harvested}$ = area of cropland on which perennial woody crops are harvested/replaced, ha; and
- L_{max} = maximum above-ground biomass carbon stock at harvest/maturity state, tonnes C ha⁻¹ (Table 6.13).

The area of orchards was obtained from Statistics Estonia. Data were smoothed due to high variability. The area of orchards has declined from 9 198 ha in 1990 to 1 3854 ha in 2024. Area, on which the woody crops were harvested was estimated as the total area divided by harvest/maturity cycle value (Table 6.13).

Table 6.13. Parameter values for estimating C stock changes in woody biomass in orchards²⁹⁸

Parameter	Value	Uncertainty
G, t C ha ⁻¹ yr ⁻¹	0.43	± 46%
L_{max} , t C ha ⁻¹	8.5	± 19%
Harvest/maturity cycle, yr	20	± 42%

The biomass of perennial woody crops has been previously measured in main market gardens and privately owned orchards in Estonia²⁹⁹. Based on these measurements, it was considered that the updated methodology provided in the 2019 Refinement (Ch 5, Section 5.2.1) is more suitable for the Estonian conditions than the parameter values provided in the 2006 IPCC Guidelines. For instance, the default value for mean aboveground biomass carbon stock of orchards is 6.4 t C ha⁻¹ (± 25%) in Table 5.3 of the 2019 Refinement, which is close to the value of 7.8 t C ha⁻¹ (assuming C fraction 0.47) measured in Estonian orchards.

Net emissions from living biomass in orchards has been close to zero, declining from -0.17 kt CO₂ in 1990 to -0.02 kt CO₂ in 2024. C stock changes in living biomass pool result mainly due to the land use change to croplands, especially deforestation.

When Forest land and Grassland are converted to cropland, biomass losses occur in the year of transition. These carbon losses were estimated according to Equation 6.8.

²⁹⁸ IPCC 2019 Refinement, Volume 4, Chapter 5: Cropland, page 5.12, Table 5.3 (Temperate, Orchard).

²⁹⁹ Metsaruum OÜ (2012). Assessment of woody biomass growing on agricultural land. Report, unpublished. (In Estonian)

$$\Delta C_{CONVERSION} = \sum_i (C_{AFTER_i} - C_{BEFORE_i}) \times \Delta A_{TO\_OTHERS_i}$$

Where:

$\Delta C_{CONVERSION}$ = initial change in biomass carbon stocks on land converted to another land category;

C_{AFTER_i} = C stocks on land type i immediately after the conversion, t C ha⁻¹;

C_{BEFORE_i} = biomass stocks on land type i before the conversion, t C ha⁻¹;

$\Delta A_{TO\_OTHERS_i}$ = area of land use i converted to another land-use category in a certain year, ha; and

i = type of land use converted to another land-use category.

C_{AFTER} - C_{BEFORE} values were estimated for Forest land and Grassland converted to cropland categories as average initial C stocks in NFI plots, where such conversions have occurred (Table 6.14). Calculation of living biomass C stocks on NFI plots is described in Chapter 6.4.2. Conversions from other categories to croplands were expected to increase living biomass C pool in the year of conversion from zero to the average C stock of crops. Annual average C stocks for each crop were calculated based on average yields using the same yield-to-biomass ratios, and humidity and C contents as in Kauer et al. (2022)³⁰¹. For each year, a weighted average biomass C stock was calculated based on crop areas. Overall average for the period 2004–2024 was applied in calculations (Table 6.14). data from earlier years was not used, since it was not fully consistent with the latter period. Crop yield and area data were obtained from Statistics Estonia³⁰².

Table 6.14. Average living biomass and dead wood C stock changes after conversion to croplands, t C ha⁻¹

C pool	Forest land converted to cropland	Grassland converted to cropland	Wetlands, settlements and other land converted to cropland
Living biomass	-19.49	-0.16	3.30
Dead wood	-1.36	0	0

Carbon stock change in dead organic matter

Dead organic matter (DOM) C pool comprises deadwood and litter pools. C stock change in DOM under the Cropland remaining cropland subcategory was not estimated and reported as “NE”. Small changes in DOM pool occur due to removal or establishment of orchards, but these emissions or removals would be insignificant in terms of the overall level and trend in national emissions (as are changes in orchards’ living biomass).

³⁰⁰ After IPCC 2006 Guidelines, Volume 4, Chapter 2: Generic Methodologies Applicable to Multiple Land-Use Categories, page 2.20, Equation 2.16.

³⁰¹ Kauer, K. et al. (2022). Assessment of SOC change in agricultural mineral soils using a simulation model. Final report. (In Estonian) [www] https://klab.ee/wp-content/uploads/2023/03/Lopparunne_EMU_loplik.pdf (20.12.2025).

³⁰² PM0281: Agricultural land and crops by county. Statistical database, Statistics Estonia. [www] https://andmed.stat.ee/en/stat/majandus_pellumajandus_pellumajandussaaduste-tootmine_taimakasvatussaaduste-tootmine/PM0281 (20.12.2025).

Under the Land converted to cropland subcategory, the loss of dead wood was estimated for Forest land and Grassland converted to cropland using the *Tier 3* method and Equation 6.8, where C_{BEFORE_i} is the average dead wood C stock before and C_{AFTER_i} after the conversion (equal to zero in Cropland). C_{BEFORE} values were estimated for Forest land and Grassland converted to cropland categories as average C stocks in NFI plots, where such conversions have occurred (Table 6.14). Calculation of dead wood C stocks on NFI plots is described in Chapter 6.4.2.

C stock reductions in litter pool were included in soil emission factors (Table 6.18), since differences between the initial and final SOC stocks were estimated for the whole soil profile (Kölli et al. 2010).

Carbon stock change in mineral soils

The Tier 2 method and Equation 6.9 were applied to estimate changes in soil organic carbon stocks in Cropland remaining cropland mineral soils. Only aggregate land use and cropland management data were available. First, croplands were divided into long-term cultivated, perennial (orchards) and set aside areas. The areas of long-term cultivated lands and orchards were obtained from Statistics Estonia. As definitions for arable lands and methods for data gathering have changed during the inventory period, the estimation of long-term cultivated areas for 1990–2002 is based on the interpolated data. The remaining area of croplands was assumed to be out of active use or under permanent cultural grasslands that are also considered as set aside areas in calculations.

Equation 6.9

$$\Delta C_{\text{Mineral}} = \frac{(SOC_0 - SOC_{(0-T)})}{D}$$

where

$$SOC = \frac{\sum_i (SOC_{\text{REF}} \times F_{\text{LU}_i} \times F_{\text{MG}_i} \times F_{\text{I}_i} \times A_i)}{A_{\text{Mineral}}}$$

Where:

$\Delta C_{\text{Mineral}}$ =	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 ha ⁻¹ ;
SOC_{0-T} =	soil organic carbon stock at the beginning of the inventory time period, tonnes C ha ⁻¹ ;
D =	default time period (20 years) for transition between equilibrium SOC values;
A_{Mineral} =	the area of Cropland on mineral soil, ha;
A_{Mineral_0} =	the area of Cropland on mineral soil in the last year of the inventory period, ha;
SOC_{REF} =	the reference carbon stock, tonnes C ha ⁻¹ (Table 6.17);
$F_{\text{LU}} / F_{\text{MG}} / F_{\text{I}}$ =	stock change factors for land-use systems/ management regime/ input of organic matter, dimensionless (Table 6.17);
A =	land area of the stratum being estimated, ha; and
i =	set of management systems.

Based on the expert judgement from the Centre of Estonian Rural Research and Knowledge (former Agricultural Research Centre), cultivation of multiannual forage crops was assumed to have high C input, and areas under bare fallow, vegetables, potatoes, and fodder roots low input; the remaining crops had medium input. The shares of areas with different input regimes were acquired from Statistics Estonia and Agricultural Registers and Information Board, but due to the lack of data, it was not possible to identify the land category ‘high input with manure’. Areas with different land use and input regimes within the Cropland remaining cropland category are presented in Table 6.15 and their relative shares in Figure 6.19.

Table 6.15. Areas with different land use and input regimes on mineral soils within the Cropland remaining cropland category in 1990 and 2024

Land use	Area in 1990, kha	Area in 2024, kha
Long-term cultivated	878.74	613.14
High input	399.83	141.24
Medium input	413.01	465.14
Low input	65.90	6.77
Perennial	9.20	1.35
Set aside	24.46	283.18
Total CL rem CL, mineral soil	912.41	897.67

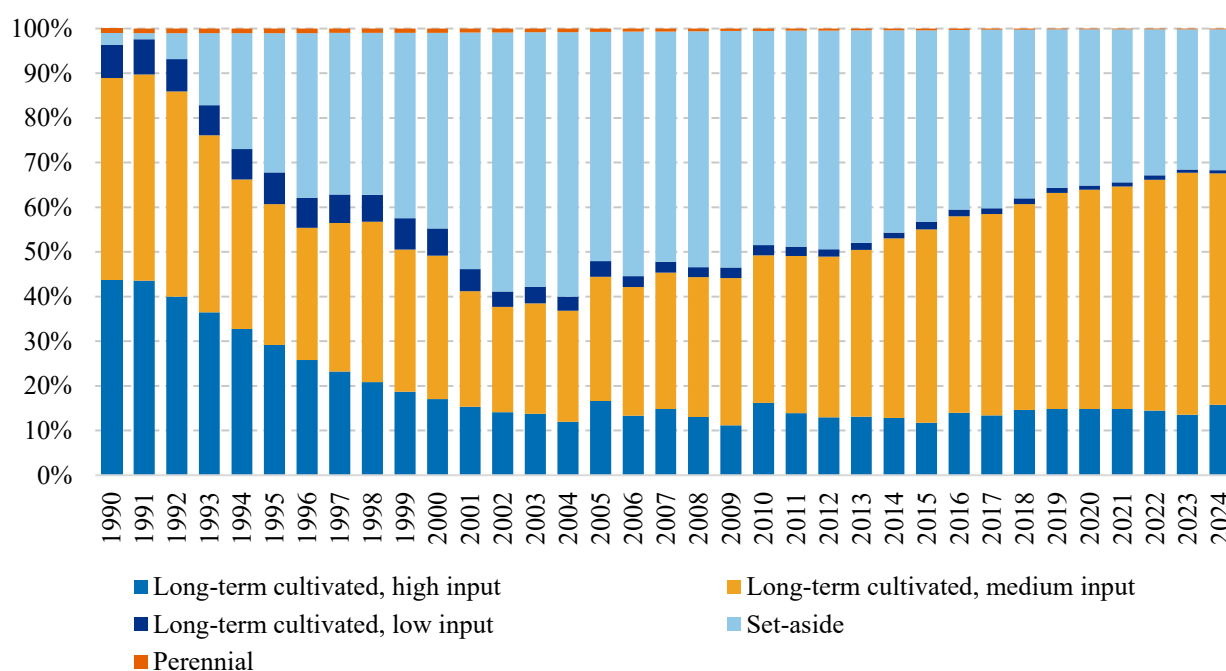


Figure 6.19. Relative shares of areas with different land use and input regimes within the Cropland remaining cropland category (mineral soils) in 1990–2024, %

An overall decline characterised Estonia’s agriculture from 1991, when Estonia regained its independence, until accession to the European Union, causing the decrease in the cultivated area (Figure 6.19). Part of the arable land area was abandoned; however, abandoned croplands are still classified as Cropland (as part of set-aside areas) until they have not lost arable land features. As from 2005, managing croplands has been on the rise again and the share of cultivated areas has increased.

Table 6.16 shows the share of different cropland tillage practices in Estonia. According to the observations of the Centre of Estonian Rural Research and Knowledge (former Estonian Crop

Research Institute), traditional tillage was prevailing practice until 1999. Farm structure surveys (FSS)³⁰³ that also included information about tillage practices, were carried out in Estonia in 2010, 2016 and 2023 by Statistics Estonia. Shares of different tillage practices for the period 2000–2009, 2011–2015 and 2017–2022 were interpolated linearly. The shares from 2023 survey were also applied for 2024.

Table 6.16. Proportions of different tillage practices in crop lands and related stock change factors (F_{MG})

Tillage practice	Full tillage	Reduced tillage	No-till
Proportion of cropland area 1990–1999 ³⁰⁴	1.00	0	0
Proportion of cropland area 2010 ³⁰⁵	0.73	0.18	0.09
Proportion of cropland area 2016 ³⁰⁵	0.54	0.33	0.13
Proportion of cropland area 2023 ³⁰⁶	0.37	0.56	0.08
F_{MG} ³⁰⁷	1.00	1.04	1.09

Since the 2024 submission, Estonia uses updated default stock change factors for land use (F_{LU}), input (F_I) and management (F_{MG}) from the 2019 Refinement to the 2006 IPCC Guidelines. In Estonian conditions, changes in F_{MG} values have the most important effect, as the impact of reduced tillage and no-till practices significantly decreases compared to the 2006 IPCC Guidelines. This is in line with the study conducted in Estonia by Putku and Penu (2018)³⁰⁸ which found no statistical differences in the SOC stocks of the 0–25 cm soil layer between conventional and no-till practices.

When using default stock change factors, management practices are expected to influence soil C stocks to a depth of 30 cm; therefore, SOC_{REF} was estimated based on the measured SOC stocks in the humus cover of Estonian arable soils (Kõlli et al. 2009). The mean thickness of the humus cover in mineral arable land varied from 18 to 29 cm depending on the soil type (Kõlli & Ellermäe 2003³⁰⁹), and its measured area weighted mean SOC stock (67.85 t C ha⁻¹) was assumed to refer to the mean SOC stock of the long-term cultivated areas with medium input in 1990 (Table 6.17).

³⁰³ Glossary: Farm structure survey (FSS). [www] [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Farm_structure_survey_\(FSS\)](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Farm_structure_survey_(FSS)) (19.12.2024).

³⁰⁴ Expert judgement by the Centre of Estonian Rural Research and Knowledge (former Estonian Crop Research Institute) (documented in archive).

³⁰⁵ PMS602: Tillage by legal form of holder and tillage method. Statistical database, Statistics Estonia. [www] https://andmed.stat.ee/en/stat/Lepetatud_tabelid_Majandus.%20Arhiiv_Pellumajandus.%20Arhiiv_pellumajanduse-struktuuriuuringud_2001-2016_tootmismetodid/PMS602 (20.12.2025).

³⁰⁶ PMS649: Soil management practices on outdoor arable land by type. Statistical database, Statistics Estonia. [www] https://andmed.stat.ee/en/stat/majandus_pellumajandus_pellumajanduslike-majapidamiste-struktuur_tootmismetodid/PMS649 (20.12.2025).

³⁰⁷ IPCC 2019 Refinement, Volume 4, Chapter 5: Cropland, page 5.27, Table 5.5 (Temperate/Boreal, moist).

³⁰⁸ Putku, E., Penu, P. 2018. The status of soil organic carbon in no-till and conventional tillage fields. *In*: Alaru, M. (ed.) Agronomy 2018. Tartu: Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences, Estonian Crop Research Institute, pp. 15–21.

³⁰⁹ Kõlli, E., Ellermäe, O. (2003). Humus status of postlithogenic arable mineral soils. *Agronomy Research*, 1, 161–174.

Table 6.17. Stock change factors, SOC_{REF} and estimated SOC stocks for different management categories in Cropland

Land use	Stock change factors ³¹⁰			SOC _{REF} t C ha ⁻¹	IPCC 2006 default SOC _{REF} ³¹¹ , t C ha ⁻¹	Average SOC stocks, t C ha ⁻¹	
	F _{LU}	F _{MG}	F _I			1990	2024
Long-term cultivated							
High input	0.70	1–1.03	1.11	96.93	93.30	75.32	77.50
Medium input	0.70	1–1.03	1.0			67.85	69.82
Low input	0.70	1–1.03	0.92			62.42	64.23
Perennial	0.72					69.79	69.79
Set aside	0.82					79.48	79.48

The methodology for estimating SOC changes in mineral soils on areas under land-use change to croplands is described in detail in Annex A.V.4.2. Changes in mineral soil SOC stocks due to land-use conversions from Forest land and Grassland to cropland were obtained from the literature (Kõlli et al. 2010) and divided by 20 years to find the annual C stock change. Emission factors were estimated separately for different soil types, and the weighted average EF was calculated based on the distribution of soil types in previous land use (data from Kõlli et al. 2009). As there is currently lack of data about wetlands' mineral soil SOC stocks in Estonia, the difference between mean SOC stock values for hydromorphic mineral soils in grasslands and arable land (134.0 and 114.8 t C ha⁻¹, respectively; Kõlli et al. 2009) was applied for land conversion from Wetlands to cropland. In case of Settlements and Other land converted to cropland, it was assumed that the net gain of SOC is the same as is lost due to conversion of Cropland to settlements (see Chapter 6.8.2) or other land (Chapter 6.9.2). EFs for mineral and organic soil are presented in Table 6.18.

Table 6.18. Areas of cumulative Cropland subcategories in 2024, and implemented soil emission factors

Land-use category	Mineral soils, kha	Organic soils, kha	EF mineral soil, t C ha ⁻¹ yr ⁻¹	EF organic soil ³¹² , t C ha ⁻¹ yr ⁻¹
Cropland remaining cropland	897.67	29.86	-0.082 ³¹³	-5.0
Forest land→ Cropland	5.98	NO	-0.930	-5.0
Grassland→ Cropland	48.07	0.79	-0.904	-5.0
Wetlands→ Cropland	3.05	NO	-0.960	-5.0
Settlements→ Cropland	3.78	0.13	0.882	-5.0
Other land→ Cropland	0.60	NO	0.882	Only mineral soils
Total Cropland	959.14	30.79		

Cropland SOC stock started to increase after the collapse of the Soviet Union in 1991 (Figure 6.17) when a significant part of agricultural land was abandoned. Since accession to the

³¹⁰ IPCC 2019 Refinement, Volume 4, Chapter 5: Cropland, page 5.27, Table 5.5 (Temperate/Boreal, moist).; Annual F_{MG} values are calculated based on the proportion of tillage practices and updated default F_{MG} factors (Table 6.16).

³¹¹ IPCC 2006 Guidelines, Volume 4, Chapter 2: Generic Methodologies Applicable to Multiple Land-Use Categories, page 2.31, Table 2.3 (Cold temperate, moist). IPCC 2006 default SOC_{REF} value is presented for verification.

³¹² IPCC 2006 Guidelines, Volume 4, Chapter 5: Cropland, page 5.19, Table 5.6 (Boreal/Cool Temperate).

³¹³ Implied emission factor (IEF) in 2024, varies between years.

European Union in 2004, the share of cultivated areas has been growing (Figure 6.19) and the average SOC stock is on a declining trend. However, mineral soils on arable land continued to sequester carbon until 2013 due to changes in management practices.

Carbon stock change in drained organic soils

All croplands on organic soil are considered drained in Estonia. The *Tier 1* method and was applied to estimate CO₂ emissions from cultivated organic soils, both for the Cropland remaining cropland and Land converted to cropland subcategories. The default emission factor from the 2006 IPCC Guidelines (Table 6.18) was implemented due to the lack of country-specific data.

Emissions from organic soils have been relatively stable over the years (Figure 6.17) since the area of cultivated organic soils has not changed considerably (27.65 kha in 1990 to 30.79 kha in 2024).

6.5.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Cropland subcategory, please see Annex A.II.4 LULUCF, Cropland (4.B) chapter.

6.5.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for the Estonian GHG inventory at the national level are presented in Chapter 1.5. The QC/QA plan for the LULUCF sector includes the QC activities described in the 2006 IPCC Guidelines Volume 1, Chapter 6. The activities are carried out every year during the inventory. The QC checklist is used during the inventory (Table Annex IV.3.).

Country-specific cropland reference soil organic carbon stock (SOC_{REF}) for mineral soil was compared with the estimate following the IPCC 2006 methodology for verification purposes (Table 6.17). The estimate that Cropland mineral soils have mostly been C sinks since 1990 is supported by the study by Tammik et al. 2018³¹⁴. They found that the average mineral soil SOC stock in soil monitoring fields (mainly under cereal-based crop rotations) has increased since the beginning of soil monitoring (1983–1986) from 64.6 t ha⁻¹ to 77.6 t ha⁻¹.

6.5.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

A quantitative overview of recalculations in the Cropland category is shown in Table 6.19. Recalculated N₂O emissions from N mineralization and leaching after land conversion to croplands are presented additionally in Chapter 6.10.5. Changes compared to the previous submission result mainly from the new methodology for compiling annual land use change matrices (see Chapter 6.3.1). In the 2026 submission, also land-use changes in 1970–1990 have been implemented for estimation of land areas in the reporting period, as recommended by the ERT³¹⁵. The effect of these methodological changes on the areas of Cropland subcategories has been shown in Figure 6.20.

³¹⁴ Tammik, K., Kauer, K., Astover, A., Penu, P. (2018). The dynamics of organic carbon stock in Estonian arable soils 1989–2016. *In*: Alaru, M. (ed.) *Agronomy 2018*. Tartu: Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences, Estonian Crop Research Institute, pp. 30–35.

³¹⁵ FCCC/ARR/2022/EST L.1.

C stock changes in perennial cropland biomass were revised using the *Tier 1* methodology from the 2019 Refinement, according to the recommendation of the EU-internal inventory review (EEA 2025). During the same review process, the methodology for calculating CSCs in mineral soil for Settlements converted to croplands was also improved.

In addition, average C stock losses in living biomass and dead wood after land use change from Forest land and Grassland to Cropland category were updated due to the addition of new data, as well as average crop biomass (new values in Table 6.16). On deforested areas, emissions from the litter decomposition were not estimated in the current submission, since they are already included in the soil C stock change.

Table 6.19. Quantitative overview of recalculations compared to the 15.04.2024 submission

Year	Cropland remaining cropland C stock change, kt CO ₂			Land converted to cropland C stock change, kt CO ₂			Total Cropland Net emissions, kt CO ₂		
	2025	2026	difference	2025	2026	difference	2025	2026	difference
1990	646.36	578.18	-68.18	0.00	277.89	277.89	646.36	862.37	216.02
1991	693.70	580.76	-112.94	0.00	491.10	491.10	693.70	1080.80	387.10
1992	658.32	509.45	-148.87	0.00	520.05	520.05	658.32	1041.08	382.76
1993	509.72	324.47	-185.24	0.00	548.98	548.98	509.72	887.68	377.96
1994	380.64	140.31	-240.33	0.26	577.88	577.62	380.90	735.06	354.16
1995	342.91	63.08	-279.83	1.01	606.76	605.75	343.92	689.37	345.45
1996	293.09	-47.52	-340.61	1.76	635.62	633.86	294.85	610.28	315.42
1997	363.38	-29.51	-392.90	2.51	664.45	661.94	365.89	659.77	293.87
1998	412.94	-22.88	-435.82	3.26	693.25	689.99	416.20	697.87	281.67
1999	374.25	-83.10	-457.34	3.76	722.03	718.27	378.01	669.09	291.08
2000	354.02	-112.01	-466.03	3.76	750.78	747.02	357.78	671.59	313.81
2001	197.83	-251.05	-448.88	3.91	779.50	775.58	201.75	563.94	362.19
2002	110.03	-301.02	-411.05	4.05	808.19	804.14	114.11	545.34	431.23
2003	150.55	-259.31	-409.86	4.34	836.84	832.50	154.94	618.38	463.44
2004	111.28	-259.60	-370.88	5.90	594.02	588.13	117.36	375.13	257.77
2005	187.85	-141.73	-329.58	9.70	599.15	589.45	198.06	498.74	300.68
2006	147.24	-170.25	-317.49	17.71	589.89	572.18	165.92	460.98	295.06
2007	190.86	-120.76	-311.62	24.22	794.29	770.07	216.62	717.84	501.23
2008	195.61	-99.74	-295.35	34.76	681.19	646.43	232.55	628.36	395.81
2009	213.25	-61.78	-275.04	46.09	618.39	572.30	262.11	603.83	341.72
2010	214.61	-227.47	-442.08	57.62	638.54	580.92	275.41	459.93	184.52
2011	164.60	-263.17	-427.77	63.34	587.32	523.98	231.45	370.36	138.91
2012	167.75	-230.63	-398.38	74.57	551.34	476.78	246.15	364.31	118.16
2013	305.01	-72.62	-377.63	83.32	539.94	456.62	392.53	509.34	116.81
2014	440.16	99.91	-340.24	98.43	494.12	395.69	543.31	633.66	90.35
2015	523.23	178.35	-344.87	106.33	473.11	366.78	634.86	689.56	54.70
2016	561.44	220.58	-340.86	114.27	442.50	328.23	681.61	699.07	17.46
2017	477.41	214.60	-262.80	119.04	399.60	280.56	602.91	647.32	44.41
2018	419.34	248.52	-170.82	122.46	360.69	238.23	548.76	639.41	90.66
2019	459.67	343.02	-116.65	120.42	321.84	201.43	587.43	692.18	104.75
2020	480.55	388.53	-92.02	131.59	326.83	195.24	619.83	740.97	121.14
2021	625.43	583.83	-41.60	135.51	297.42	161.91	768.93	904.58	135.64
2022	723.14	742.82	19.68	138.59	232.77	94.18	869.95	996.10	126.15
2023	698.25	814.61	116.36	141.16	194.64	53.49	847.79	1026.88	179.09

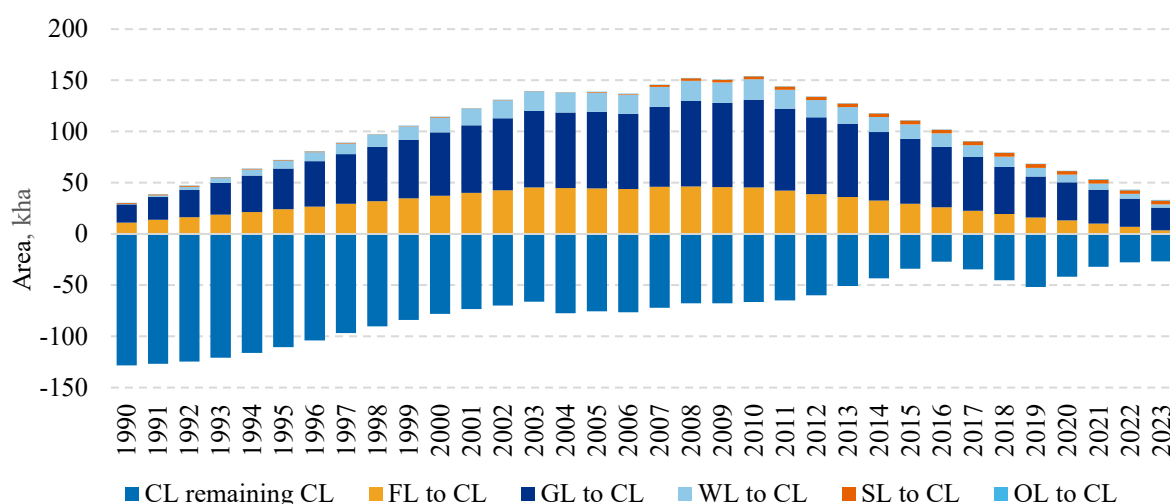


Figure 6.20. Differences between the 2026 and 2025 submissions in the areas of Cropland subcategories in Estonia in 1990–2023, kha

6.5.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

In 2024, a project for developing a governance system for land and soil management³¹⁶ was launched. The project aims to update and consolidate land use-related datasets and to develop higher tier methodologies for estimating SOC changes in all land-use categories. The project has already initiated the updating of the Estonian soil map (2024–2026). In 2025, work began on the implementation of Tier 3 methodologies to quantify carbon stock changes and GHG fluxes in mineral and organic cropland and grassland soils. The project ends in 2027.

Two research projects have recently concluded: “Creation of a map layer of operational ditches and development of GHG emission factors for ditches”, and “Demonstration of climate change mitigation potential of nutrients rich organic soils in Baltic States and Finland” (LIFE OrgBalt, LIFE18 CCM/LV/001158). Both projects aim to improve the GHG accounting methods and activity data for organic soils. Results will be evaluated and implemented in the GHG inventory.

6.6. Grassland (CRT 4.C)

6.6.1. Category description

The Grassland category includes CO₂ emissions and removals from living biomass, dead wood, mineral and organic soils, and non-CO₂ emissions from biomass burning (see Chapter 6.11). Net emissions from Grassland were -256.55 kt CO₂ eq. in 2024 (Figure 6.21). The Grassland category has been a CO₂ sink since 1990, mainly due to C sequestration in living biomass in Grassland remaining grassland areas and to mineral soils after land-use change to grasslands.

³¹⁶ Land and soil use research and development project. [www] <https://keskkonnaportaal.ee/en/topics/soil-and-land-use/land-and-soil-use-research-and-development-project> (11.02.2026).

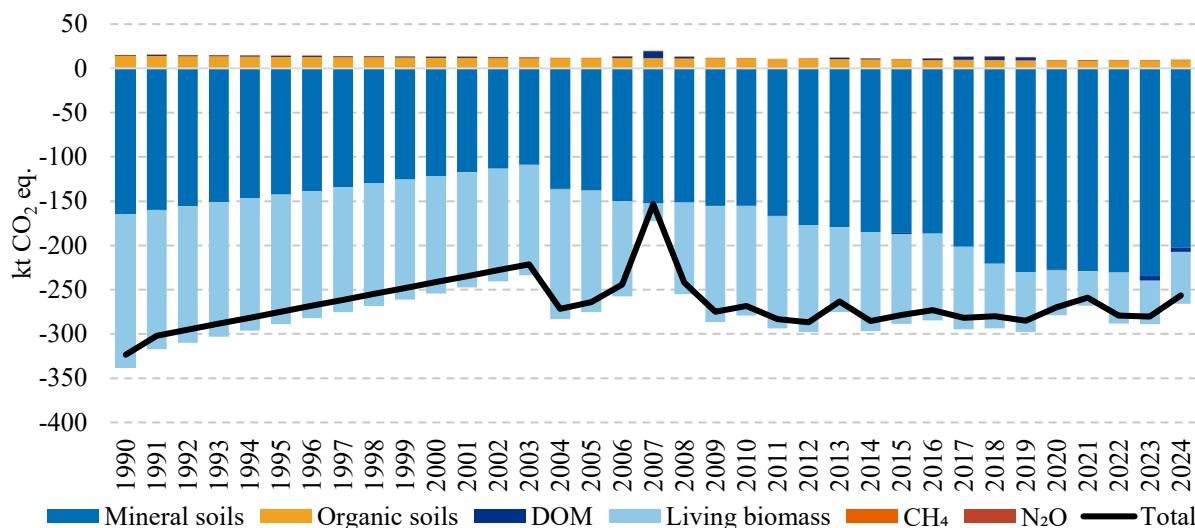


Figure 6.21. Annual GHG emissions (+) and removals (-) from the Grassland category in 1990–2024, kt CO₂ eq.

The area of the Grassland category in 2024 was 267.21 kha, which constituted 6.0% of the overall Estonia's land area. The area of grasslands has decreased by 39.8% compared to the 1990 initial area (Table 6.6, Figure 6.22). These changes result mostly from the reallocation of grasslands to the Forest land category as their growing stock increases and the tree crown cover begins to meet the Forest land definition, but also due to the conversion of natural grasslands to arable lands. The area of grasslands has mainly increased at the expense of croplands.

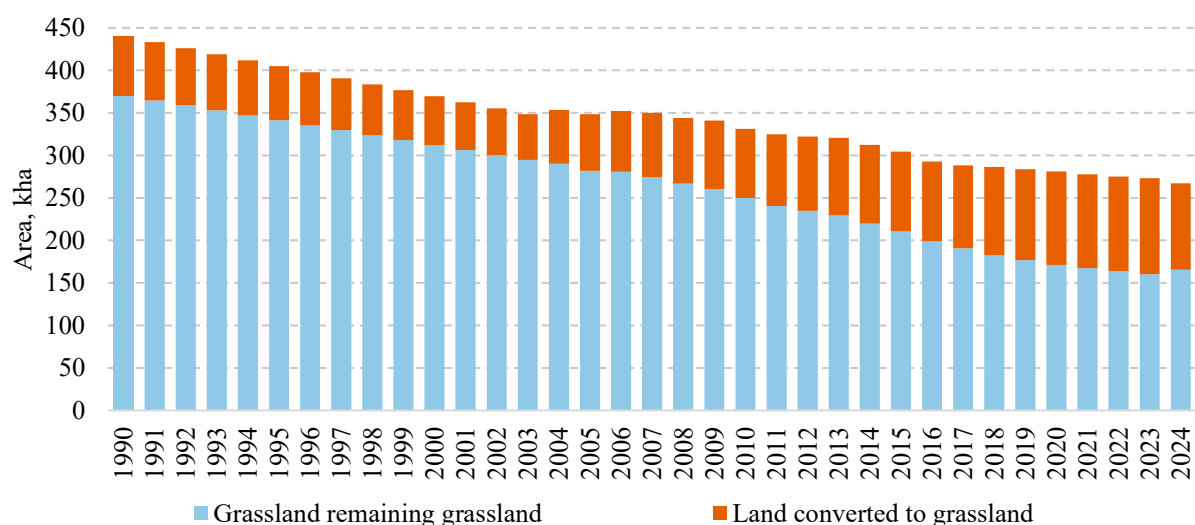


Figure 6.22. Grassland area in Estonia in 1990–2024, kha

6.6.2. Methodological issues

Carbon stock change in living biomass

For the Grassland remaining grassland category, C stock changes in the living woody biomass were calculated for all NFI permanent plots that have remained under Grassland category between two consecutive NFI visits using the stock-difference method (Equation 6.10, *Tier 3*):

$$\Delta C = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$

Where:

ΔC = annual carbon stock change in the pool, tonnes C yr⁻¹;

C_{t_1} = carbon stock in the pool at time t_1 , tonnes C; and

C_{t_2} = carbon stock in the pool at time t_2 , tonnes C.

Calculation of living biomass C stocks in NFI plots is described in Chapter 6.4.2.

Average C stock change of previous ten NFI periods (five-year cycle)³¹⁸ was estimated for each year starting from 2013 (Table 6.20). For earlier years, the same value as in 2013 was applied. Annual C stock change per hectare was multiplied by the area of Grassland remaining grassland category to estimate the total C stock change in living biomass for the category.

The stock-difference method also comprises carbon loss from biomass burning, thus CO₂ emissions from burning are not presented separately, but included in general carbon stock change figures.

Table 6.20. Average annual change in living biomass and dead wood C stocks in Grassland remaining grassland category, t C ha⁻¹yr⁻¹

Year	Living biomass	Dead wood
1990–2013	0.137	0.001
2014	0.13	-0.001
2015	0.13	0.003
2016	0.127	-0.002
2017	0.124	-0.004
2018	0.104	-0.005
2019	0.092	-0.005
2020	0.081	0.003
2021	0.086	0.003
2022	0.096	0.002
2023	0.086	0.011
2024	0.091	0.009

On land converted to grasslands, changes in carbon stock are calculated as a sum of increase in carbon stock due to biomass growth and changes due to actual conversion (Equation 6.11). Only the change in woody biomass has been considered.

$$\Delta C_B = \Delta C_G + \Delta C_{CONVERSION}$$

³¹⁷ IPCC 2006 Guidelines, Volume 4, Chapter 2: Generic Methodologies Applicable to Multiple Land-Use Categories, page 2.10, Equation 2.5.

³¹⁸ For instance, the 2013 estimate is based on the NFI periods 1999–2003, 2000–2004 ... 2009–2013

³¹⁹ After IPCC 2006 Guidelines, Volume 4, Chapter 2: Generic Methodologies Applicable to Multiple Land-Use Categories, page 2.20, Equation 2.15.

Where:

ΔC_B = annual change in carbon stocks in biomass on land converted to other land-use category, tonnes C yr⁻¹;
 ΔC_G = annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, tonnes C; and
 $\Delta C_{\text{CONVERSION}}$ = initial change in carbon stocks in biomass on land converted to other land-use category, tonnes C.

$\Delta C_{\text{CONVERSION}}$ is relevant only for the Forest land converted to grassland subcategory. C losses in biomass occur in the year of transition and are estimated according to Equation 6.8. C_{BEFORE} and C_{AFTER} values were estimated on permanent NFI plots, where conversion from Forest land to Grassland have taken place during the NFI cycle; average value (Table 6.21) is used in calculations. Other conversion types were assumed to have no change in biomass in the year of conversion. After the transition, growing stock was assumed to increase at a rate of 0.128 m³ ha⁻¹ yr⁻¹. Average growing stock and deadwood volume increase rates have been calculated based on all the NFI sample plots classified as Land converted to grassland. Growing stock was converted to C by applying the average woody biomass C stock/growing stock ratio estimated on Grassland remaining grassland plots (0.303 t C m⁻³). Resulting value (Table 6.21) was multiplied by the area of each conversion type to estimate the total C stock change (ΔC_G) in living biomass for the respective subcategory.

Table 6.21. Average annual change in living biomass and dead wood C stocks in Land converted to grassland categories, t C ha⁻¹yr⁻¹

C pool	Forest land converted to grassland ($\Delta C_{\text{CONVERSION}}$ ha ⁻¹)	Land converted to grassland (ΔC_G ha ⁻¹)
Living biomass	-9.293	0.039
Dead wood	-0.654	0.0003

Figure 6.23 illustrates annual changes in the living biomass carbon pool on Grassland remaining grassland and Land converted to grassland subcategories. Emissions due to land-use change arise from deforestation, exceeding in most years the removals in biomass on lands converted to grasslands.

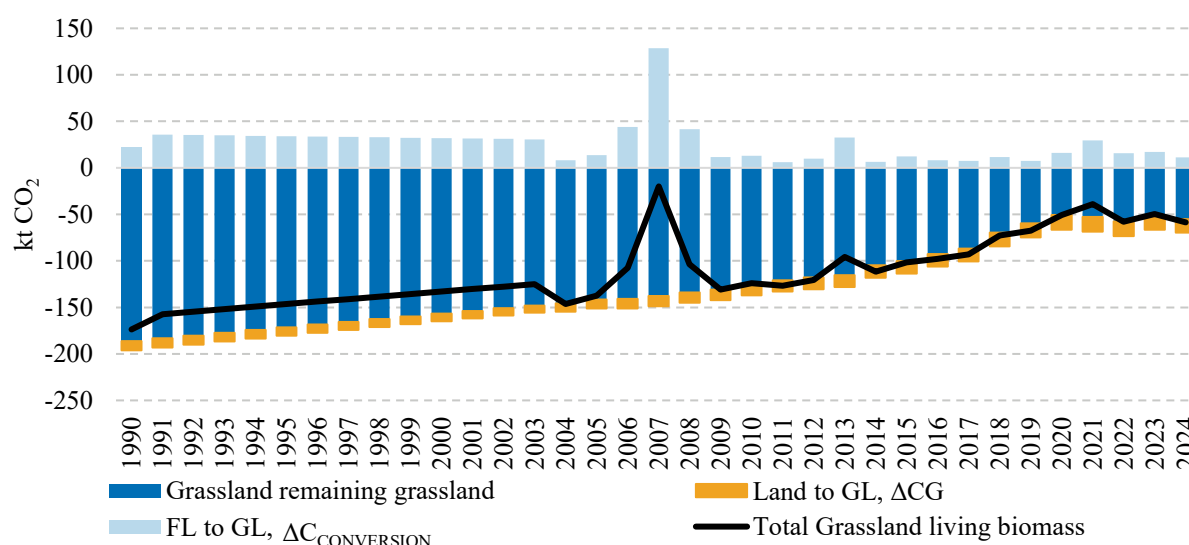


Figure 6.23. Carbon stock changes in Grassland living biomass in 1990–2024, kt CO₂

Carbon stock change in dead organic matter

The DOM pool consists of dead wood and litter pools. Changes in the dead wood C stocks on grasslands were estimated using the same methods and equations as for the living biomass. Calculation of dead wood C stocks on NFI plots is described in Chapter 6.4.2. Table 6.20 shows average changes in C stocks on Grassland remaining grassland, and Table 6.21 C losses ($\Delta C_{\text{CONVERSION}}$) on Forest land converted to grassland and removals (ΔC_G) on Land converted to grassland areas. ΔC_G is a product of the annual dead wood volume increase after land transition ($0.001 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$) and the average dead wood C stock/dead wood volume ratio on GL-GL plots (0.249 t C m^{-3}).

Estonia does not have sufficient country-specific data regarding forest and grassland litter stocks; thus, it was assumed that on Grassland remaining grassland areas the litter C stocks are in equilibrium (*Tier 1* method). For the Land converted to grassland subcategory, C stock reductions in litter pool were included in soil emission factor (Figure 6.24).

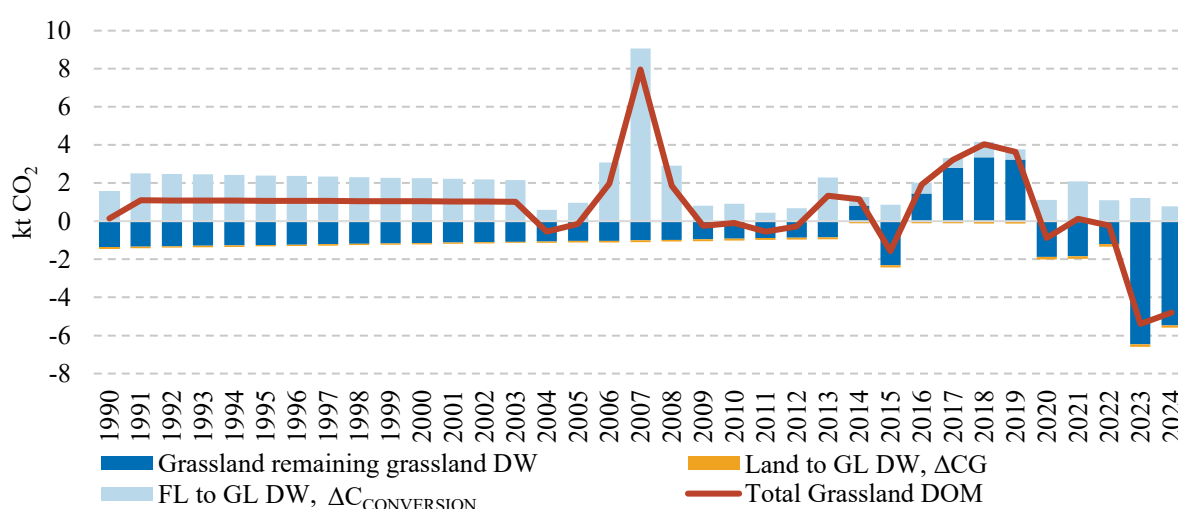


Figure 6.24. Carbon stock changes in Grassland dead wood (DW) and litter in 1990–2024, kt CO₂

As can be seen from Figure 6.24, dead wood pool has been both a small CO₂ source and sink since 1990, depending on deforestation rates and dead wood stocks on grassland remaining grassland areas.

Carbon stock change in mineral soils

Changes in soil organic carbon stocks in Grassland remaining grassland mineral soils were estimated using Equation 6.9 (*Tier 2* method), where the reference C stock (SOC_{REF}) equaled $107.3 \text{ t C ha}^{-1}$, which is the average grassland mineral soil C stock in Estonia (Kõlli et al. 2007)³²⁰. Default stock change factors for land-use systems (F_{LU} ; $F_{\text{LU}} = 1$ for permanent grasslands), management regime (F_{MG}) and input of organic matter (F_{I} ; applies only to improved grassland) from the 2006 IPCC Guidelines³²¹ were applied in calculations. All grasslands were assumed to be nominally managed (non-degraded) throughout the time series ($F_{\text{MG}} = 1$), since natural grasslands are generally sustainably managed in Estonia, receiving no additional

³²⁰ Kõlli, R., Köster, T., Kauer, K. (2007). Organic matter of Estonian grassland soils. *Agronomy Research* 5, 109–122.

³²¹ IPCC 2006 Guidelines, Volume 4, Chapter 6: Grassland, page 6.16, Table 6.2 (Temperate/Boreal).

management inputs. As a result, no changes have been reported in mineral soil C stocks on Grassland remaining grassland areas.

The methodology for estimating SOC changes in mineral soils on areas under land-use change to grasslands is described in detail in Annex A.V.4.2. SOC changes for land conversion from Forest land and Cropland to grassland were calculated according to Equation 6.9 where changes in SOC stocks were obtained from the literature (Kölili et al. 2010). Emission factors were estimated separately for different soil types, and the weighted average EF was calculated based on the distribution of soil types in the original land use (from Kölili et al. 2009). Average SOC stocks for mineral soils in Wetlands category were assumed to be the same as for hydromorphic mineral soils in grasslands (134.0 t C ha⁻¹; Kölili et al. 2009). Therefore, mineral soil C stocks do not change on Wetlands converted to grassland areas. For Settlements and Other land converted to grassland subcategory, it was assumed that the net gain of SOC is the same as is lost due to conversion of the opposite directions (see Chapters 6.8.2 and Chapter 6.9.2). EFs for mineral and organic soil are presented in Table 6.22. Total C sequestration in grassland mineral soils can be seen in Figure 6.25.

Table 6.22. Areas of cumulative Grassland subcategories in 2024, and implemented soil emission factors

Land-use category	Mineral soils, kha	Organic soils, kha	Drained organic soils, kha	EF mineral soil, t C ha ⁻¹ yr ⁻¹	EF organic soil ³²² , t C ha ⁻¹ yr ⁻¹
Grassland remaining grassland	143.90	21.67	4.37	-	-0.25
Forest land→ Grassland	12.69	0.33	5.85 ³²³	0.159	-0.25
Cropland→ Grassland	39.84	8.01		1.080	-0.25
Wetlands→ Grassland	10.89	20.39		NO	-0.25
Settlements→ Grassland	0.64	NO		1.073	-0.25
Other land→ Grassland	8.86	NO		1.073	Only mineral soils
Total Grassland	216.81	50.40			

Carbon stock change in drained organic soils

The *Tier 1* method and were implemented to estimate the loss of carbon from drained organic grassland soils. The default emission factor from the 2006 IPCC Guidelines (Table 6.22) was applied due to the lack of country-specific data.

Total area of grassland organic soils and the sub-area of drained soils were obtained from the NFI database. The proportion of drained organic soils from the total organic soil area has varied from 19.2–22.9% in the Grassland category during 1990–2024. In 2024, 20.2 and 20.4% of organic soils were drained on Grassland remaining grassland and on Land converted to grassland areas, respectively (Table 6.22).

Emissions from grassland organic soils have decreased by 34.1% compared to the base year (from 14.22 to 9.37 kt CO₂; Figure 6.25), due to the decrease in the area of organic soils.

³²² IPCC 2006 Guidelines, Volume 4, Chapter 6: Grassland, page 6.17, Table 6.3 (Boreal/Cold Temperate)

³²³ Estimated at the Land converted to Grassland level. The same share of drained areas is assumed for each subcategory.

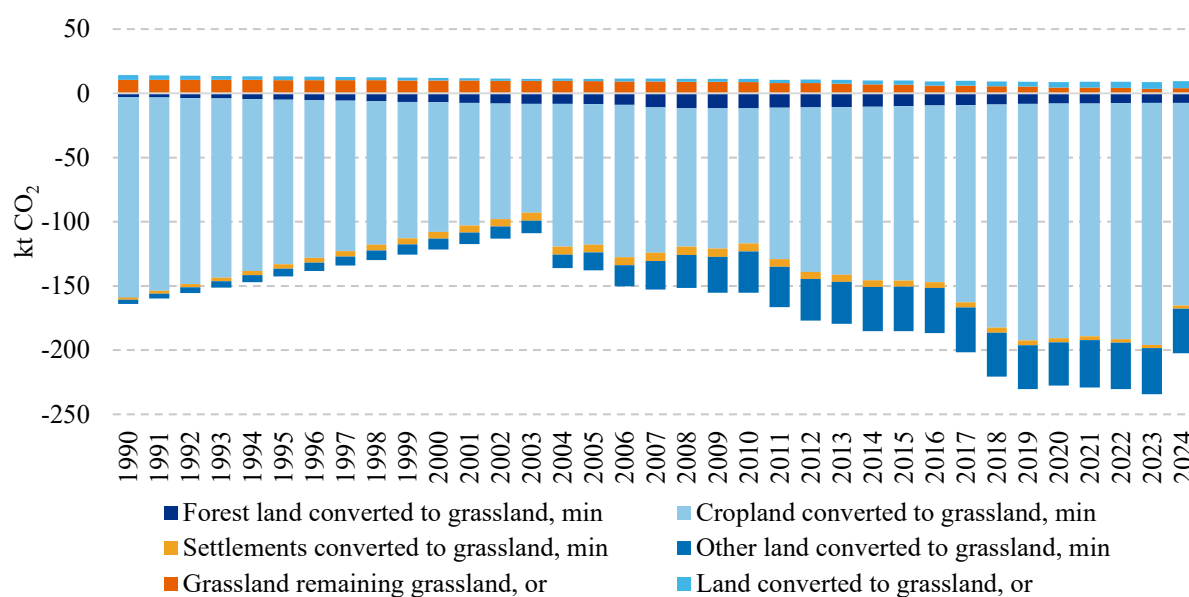


Figure 6.25. Carbon stock changes in Grassland soils in 1990–2024, kt CO₂

6.6.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Grassland subcategory, please see Annex A.II.4 LULUCF, Grassland (4.C) chapter.

6.6.4. Category-specific QA/QC and verification, if applicable

The quality objectives and the QA/QC plan for the Estonian GHG inventory at the national level are presented in Chapter 1.5. The QC/QA plan for the LULUCF sector includes the QC activities described in the 2006 IPCC Guidelines Volume 1, Chapter 6. The activities are carried out every year during the inventory. The QC checklist is used during the inventory (Table Annex IV.3).

6.6.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

A quantitative overview of recalculations is shown in Table 6.23. Changes compared to the previous submission result mainly from the new methodology for compiling annual land use change matrices (see Chapter 6.3.1) and implementation of land-use change data from the 1970–1990 period. The effect of these methodological changes on the areas of Grassland subcategories has been shown in Figure 6.26.

Activity data from NFI, such as average C stock changes in living biomass and dead wood, are updated every year; in the current submission, also the methodology for estimating annual biomass changes in Grassland remaining grassland has been improved, causing higher variation between years. In land converted to Grassland category, emissions from litter and soils have decreased and removals increased due to several methodological changes. First, as C stock changes in litter on deforested areas are included in the soil C stock change, these emissions have not been estimated additionally, as in previous submissions. The accumulation of mineral soil SOC stocks for Settlements and Other land converted to grasslands has been reported based on recommendation of the EU-internal inventory review (EEA 2025). And finally, the area of drained organic soils has been specified for Land converted to Grassland subcategories,

resulting in reduced CO₂ emissions, as previously all organic soils on conversion areas were assumed to be drained.

Table 6.23. Quantitative overview of recalculations compared to the 15.04.2025 submission

Year	Grassland remaining cropland C stock change, kt CO ₂			Land converted to grassland C stock change, kt CO ₂			Total Grassland Net emissions, kt CO ₂ eq.		
	2025	2026	difference	2025	2026	difference	2025	2026	difference
1990	-119.23	-177.09	-57.86	-0.34	-146.39	-146.06	-119.56	-323.48	-203.91
1991	-118.81	-174.13	-55.31	-1.51	-127.99	-126.48	-120.32	-302.11	-181.79
1992	-118.18	-171.17	-52.99	-0.40	-124.12	-123.72	-118.51	-295.23	-176.71
1993	-117.44	-168.23	-50.79	-2.21	-120.27	-118.06	-119.63	-288.47	-168.85
1994	-116.84	-165.29	-48.45	-5.92	-116.43	-110.52	-122.74	-281.70	-158.97
1995	-116.08	-162.37	-46.28	-12.00	-112.60	-100.60	-128.07	-274.96	-146.88
1996	-115.26	-159.45	-44.19	-20.82	-108.77	-87.95	-136.06	-268.20	-132.14
1997	-114.57	-156.55	-41.98	-35.99	-104.96	-68.97	-150.51	-261.46	-110.94
1998	-113.80	-153.65	-39.85	-46.48	-101.15	-54.66	-160.28	-254.80	-94.52
1999	-112.87	-150.77	-37.90	-61.11	-97.35	-36.23	-173.91	-248.04	-74.13
2000	-112.16	-147.90	-35.73	-73.50	-93.55	-20.04	-185.65	-241.43	-55.78
2001	-111.65	-145.04	-33.39	-87.73	-89.75	-2.02	-199.38	-234.79	-35.41
2002	-111.11	-142.19	-31.08	-97.86	-85.97	11.89	-208.87	-228.05	-19.19
2003	-110.47	-139.35	-28.88	-111.06	-82.18	28.88	-221.52	-221.52	NO
2004	-109.62	-137.10	-27.48	-116.53	-134.60	-18.07	-226.14	-271.68	-45.55
2005	-108.21	-133.18	-24.97	-128.33	-130.81	-2.48	-236.55	-264.00	-27.45
2006	-106.40	-132.65	-26.25	-134.75	-111.58	23.17	-241.09	-244.17	-3.08
2007	-104.38	-129.60	-25.22	-140.09	-23.79	116.30	-244.45	-153.36	91.09
2008	-102.40	-125.94	-23.53	-147.76	-116.15	31.61	-250.08	-242.00	8.08
2009	-100.56	-122.80	-22.25	-159.46	-152.28	7.17	-260.01	-275.09	-15.07
2010	-99.20	-117.83	-18.63	-163.50	-150.50	12.99	-262.69	-268.33	-5.64
2011	-98.03	-113.72	-15.68	-168.43	-169.42	-0.99	-266.46	-283.13	-16.67
2012	-96.89	-110.72	-13.83	-173.04	-176.32	-3.28	-269.93	-287.03	-17.10
2013	-96.14	-108.57	-12.43	-170.25	-154.87	15.38	-266.39	-263.44	2.95
2014	-95.73	-97.00	-1.27	-161.47	-188.47	-27.01	-257.20	-285.48	-28.28
2015	-95.42	-96.01	-0.59	-151.69	-182.52	-30.83	-246.98	-278.40	-31.42
2016	-95.34	-85.22	10.11	-140.58	-188.20	-47.62	-235.79	-273.29	-37.51
2017	-95.77	-78.01	17.76	-120.53	-203.91	-83.38	-216.29	-281.91	-65.62
2018	-95.88	-60.71	35.18	-110.11	-219.55	-109.44	-205.90	-280.16	-74.26
2019	-95.77	-51.25	44.52	-101.79	-233.91	-132.12	-197.55	-285.16	-87.61
2020	-95.65	-48.17	47.48	-93.92	-222.03	-128.11	-189.29	-269.92	-80.63
2021	-95.62	-50.11	45.51	-85.51	-208.89	-123.38	-181.12	-258.99	-77.86
2022	-95.61	-54.57	41.04	-86.03	-224.86	-138.82	-181.64	-279.42	-97.79
2023	-95.95	-53.46	42.50	-79.46	-226.89	-147.42	-175.41	-280.34	-104.93

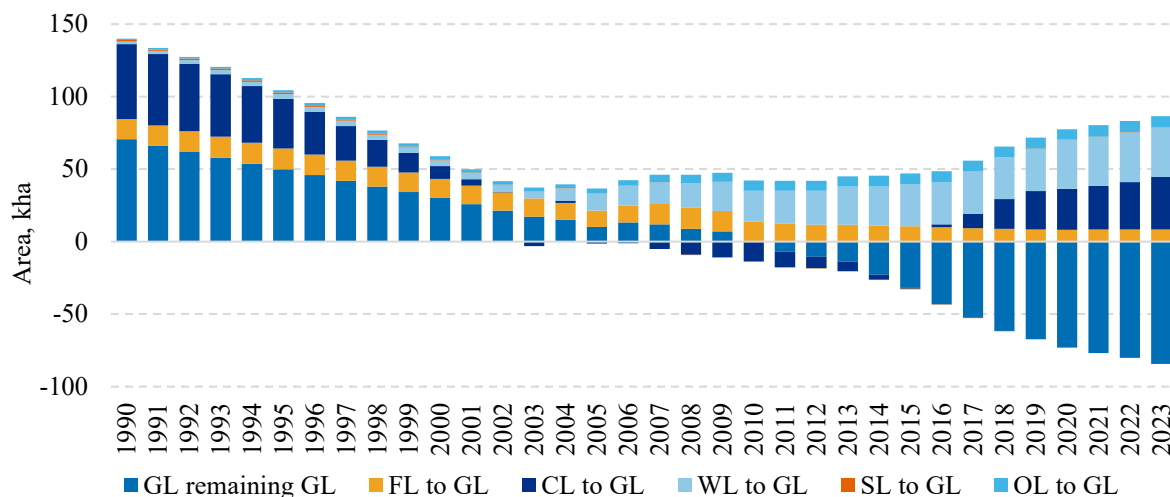


Figure 6.26. Differences between the 2026 and 2025 submissions in the areas of Grassland subcategories in Estonia in 1990–2023, kha

6.6.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

Planned improvements for the Grassland category are the same as for Cropland (Chapter 6.5.6).

6.7. Wetlands (CRT 4.D)

6.7.1. Category description

Wetlands covered 9.3% (422.94 kha) of the Estonia's land territory in 2024 (Table 6.24). The area of wetlands has decreased by 28.7% since 1990 (Table 6.6), mostly due to the drainage of mires for forestry and agricultural purposes. Net emissions from Wetlands were 1296.85 kt CO₂ eq. in 2024. Emissions derive mainly from peat extraction, especially horticultural peat (Figure 6.27), and a smaller part (156.59 kt CO₂ in 2024) from land conversion to other wetlands. Emissions related to peat extraction fluctuate between years due to variation in off-site emissions from the horticultural use of peat.

Table 6.24. Area of Wetlands in Estonia in 1990–2024, kha (NFI; Mineral Resources Register)

Year	Unmanaged wetlands	Peat extraction areas	Flooded land	Other wetlands	Total wetlands
1990	516.90	20.50	6.18	51.56	595.13
2005	432.45	20.55	6.18	53.11	512.30
2021	326.81	22.28	6.18	71.75	427.01
2022	321.86	22.08	6.18	71.77	421.89
2023	321.49	21.90	6.18	73.93	423.51
2024	319.50	21.36	6.18	75.89	422.94

Wetlands remaining wetlands are divided to unmanaged and managed areas. The unmanaged wetlands category consists of natural lakes, rivers, and undrained mires that do not fulfil the definition of Forest land. Unmanaged wetlands are excluded from the CRT Table 4.D and instead reflected in Table 4.1, as recommended by the ERT³²⁴. Peat extraction sites and flooded areas are considered managed wetlands, as well as land that has been converted to or regressed to wetlands. The latter areas (except for lands converted for peat extraction or to flooded land)

³²⁴ FCCC/ARR/2016/EST L.3

are report in CRT Table 4.D under subcategories Land converted to other wetlands and Other wetlands remaining other wetlands for areas where conversion took place more than 20 years ago.

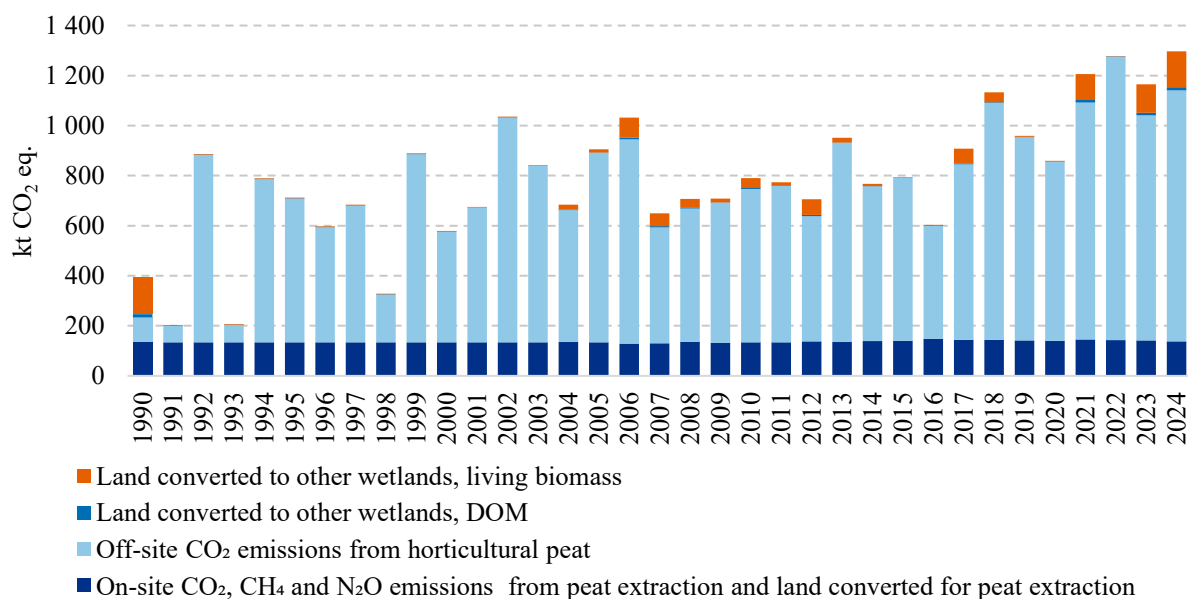


Figure 6.27. Annual GHG emissions from the Wetlands category in 1990–2024, kt CO₂ eq.

Activity data for the estimation of emissions related to peat extraction were obtained from the Mineral Resources Register, which is currently maintained by the Geological Survey of Estonia, Statistics Estonia, and the NFI. According to the Mineral Resources Register, the total area of peat extraction fields was 21.36 kha in 2024 (Table 6.24). The transition period for the Land being converted for peat extraction category is five years, as recommended in the 2006 IPCC Guidelines.

6.7.2. Methodological issues

Carbon stock change in living biomass and dead organic matter

There are no living biomass or dead organic matter pools in peat extraction areas and flooded land, and C stock changes in these pools are not reported under the Other wetlands remaining other wetlands subcategory due to the lack of methodologies and data. However, C losses in living biomass and dead wood pools occur in the year of land conversion to wetlands and were estimated using Equation 6.8. It was assumed that all biomass will be lost after the land-use change. C_{BEFORE} values were estimated for Forest land and Grassland converted to wetlands categories as average C stocks in NFI plots, where such conversions have occurred (Table 6.25). Calculation of living biomass and dead wood C stocks on NFI plots is described in Chapter 6.4.2. For Cropland converted to other wetlands, average biomass C stock for the Cropland category was applied, calculated as described in Chapter 6.5.2. Emissions from living biomass and dead wood result mainly from the Forest land conversion to other wetlands and have been relatively high in recent years (Figure 6.27). Similarly to other land-use categories, litter pool is considered as part of the soil organic C stock.

Table 6.25. Average living biomass and dead wood C stock losses after Forest land, Cropland and Grassland conversion to wetlands, t C ha⁻¹

C pool	Forest land converted to peat extraction	Forest land converted to other wetlands	Cropland converted to other wetlands	Grassland converted to other wetlands
Living biomass	-3.420	-36.706	-3.303	-1.187
Dead wood	0	-3.541	NA	0

CO₂ emissions from peat extraction

CO₂ emissions from peat extraction areas comprise on-site emissions from peat surface and off-site emissions from the horticultural use of peat. On site soil C losses from peatlands and from land cleared for peat extraction were calculated using and a country-specific emission factor by Salm et al. 2012 (Table 6.26). Equation 6.12 was implemented for estimating off-site CO₂-C emissions.

Equation 6.12³²⁵

$$CO_2-C_{WW_{peat_{off-site}}} = \frac{Wt_{dry\_peat} \times Cfraction_{wt\_peat}}{1000}$$

Where:

CO₂-C_{WW_{peat_{off-site}} = off-site CO₂-C emissions from peat removed for horticultural use, kt C yr⁻¹;}

Wt_{dry_peat} = dry weight of extracted peat, tonnes yr⁻¹; and

Cfraction_{wt_peat} = carbon fraction of dry peat by weight, tonnes C (tonnes of dry peat)⁻¹ (country-specific value 0.495).

The amount of peat removed for horticultural use was calculated as the difference of total peat production and the primary production of energy peat. In 2024, 946.1 kt of peat was extracted³²⁶, of which the production of energy peat (including energy peat for export) was 25 kt³²⁷. Estimated production of horticultural peat was 921.1 kt in 2024, which is 5.5% more than in the previous year. A notional moisture content of 40%³²⁸ was used to estimate dry mass of peat. Carbon content in dry peat was analyzed from samples taken from 14 peat production areas in 2023 (methodology EVS-EN 15936).

Cumulative land-use changes to peat extraction sites and other wetlands and applied emission factors are presented in Table 6.26.

³²⁵ After IPCC 2006 Guidelines, Volume 4, Chapter 7: Wetlands, page 7.11, Equation 7.5

³²⁶ Vohta, A (2025). Aggregate balance sheets of the mineral resources of the Republic of Estonia for 2024 (as of 31 December 2024). Tallinn: Geological Survey of Estonia. (In Estonian) [www] https://www.egt.ee/sites/default/files/documents/2025-12/koondbilanss_2024_seletuskiri.pdf (09.12.2025).

³²⁷ Data from Statistics Estonia, KE0230: Energy balance sheet by type of fuel or energy (Eurostat methodology). [www] https://andmed.stat.ee/en/stat/majandus_energeetika_energia-tarbimine-ja-tootmine_aastastatistika/KE0230 (18.12.2025). Emissions related to the usage of peat for energy generation are reported under the Energy sector (Chapter 3).

³²⁸ Regulation No. 52 of 17 December 2018 of Minister of the Environment. [www] <https://www.riigiteataja.ee/akt/114012020009?leiaKehitiv> (18.12.2025).

Table 6.26. Cumulative land-use changes to wetlands and peat extraction sites in 2024, and soil emission factors

Land-use category	Organic soils, kha	EF organic soil, t C ha ⁻¹ yr ⁻¹
Peat extraction remaining peat extraction	19.15	-1.741 ³²⁹ (on-site C emissions) -16.01 ³³⁰ (total C emissions)
Forest land→Peat extraction	0.09	-1.741
Wetlands→ Peat extraction	2.12	
Flooded land remaining flooded land	6.18	NA
Land to flooded land	NO	-
Other wetlands remaining other wetlands	52.62	NA
Forest land→ Other wetlands	5.52	No emissions, soil C is not considered lost after LUC to other wetlands
Cropland→ Other wetlands	4.37	
Grassland→ Other wetlands	3.99	
Peat extraction→ Other wetlands	2.40	
Settlements→ Other wetlands	2.80	
Other land→ Other wetlands	4.19	

Non-CO₂ emissions from peat extraction areas

Equation 6.13 with a country-specific emission factor by Salm et al. 2012 (Tier 2) was implemented for estimating CH₄ emissions from organic soils managed for peat extraction.

Equation 6.13

$$CH_4 WW_{peatExtraction} = (A_{peatExtraction} \times EF_{CH_4}) \times \frac{16}{12} \times 10^{-6}$$

Where:

CH₄ WW_{peatExtraction} = emissions of CH₄ from peatlands managed for peat extraction, kt CH₄ yr⁻¹;
A_{peatExtraction} = area of peat soils managed for peat extraction, including abandoned areas in which drainage is still present, ha; and
EF_{CH₄} = emission factor for organic soils managed for peat extraction, kg CH₄ ha⁻¹ yr⁻¹ (Table 6.27).

Equation 6.14 with a country-specific emission factor by Salm et al. 2012 (*Tier 2*) was used for estimating N₂O emissions from peat extraction sites.

Equation 6.14³³¹

$$N_2O_{WW_{peatExtraction}} = (A_{peatExtraction} \times EF_{N_2O-N}) \times \frac{44}{28} \times 10^{-6}$$

Where:

³²⁹ Salm et al. 2012

³³⁰ Implied EF in 2024, varies between years depending on off-site CO₂ emissions.

³³¹ After IPCC 2006 Guidelines, Volume 4, Chapter 7: Wetlands, page 7.15, Equation 7.7.

$N_2O_{WW_{\text{peatextraction}}}$ = direct N_2O emissions from peatlands managed for peat extraction, kt N_2O yr⁻¹;
 $A_{\text{peatExtraction}}$ = area of peat soils managed for peat extraction, ha; and
 EF_{N_2O-N} = emission factor for organic soils managed for peat extraction, kg N_2O-N ha⁻¹ yr⁻¹ (Table 6.27).

In 2024, non- CO_2 emissions from peat extraction areas were 3.42 t CH_4 and 6.38 t N_2O . Both emissions have increased by 4.2% compared to the base year.

6.7.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Wetlands subcategory, please see Annex A.II.4 LULUCF, Wetlands (4.D) chapter.

6.7.4. Category-specific QA/QC and verification, if applicable

A complete Quality Assurance (QA) and Quality Control (QC) was carried out for the 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 the inventory.

Country-specific soil emission factors for peat extraction areas were compared with default factors from the IPCC 2013 Wetlands supplement (Table 6.27). CO_2-C and N_2O-N emission factors fall within 95% confidence intervals, but Estonian EF for CH_4 is significantly smaller compared to the default value. When new publications become available, the EFs will be re-evaluated.

Table 6.27. Comparison of country-specific (Salm et al. 2012) and IPCC default emission factors for peatlands managed for peat extraction

EF (kg ha ⁻¹ yr ⁻¹)	CO_2-C	CH_4-C	N_2O-N
country-specific	1741	0.12	0.19
IPCC default	1100 ... 4200 ³³²	1.2 ... 8.25 ³³³	-0.03 ... 0.64 ³³⁴

6.7.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

Recalculations in the Wetlands category are shown in Table 6.28. On-site emissions from peat extraction include CO_2 , CH_4 and N_2O emissions from peat extraction areas, as well as losses in biomass and dead wood pools due to land conversion to peat extraction. No changes were made to the estimates of off-site emissions from horticultural use of peat relative to the previous submission.

Recalculations in activity data (Figure 6.28) result mainly from the new methodology for compiling annual land use change matrices (see Chapter 6.3.1) and implementation of land-use change data from the 1970–1990 period. In addition, the area of peat extraction sites was obtained from the Mineral Resources Register, and not from NFI, as in previous submissions.

³³² IPCC 2013 Wetlands Supplement, Chapter 2: Drained Inland Organic Soils, page 2.14, Table 2.1.

³³³ IPCC 2013 Wetlands Supplement, Chapter 2: Drained Inland Organic Soils, page 2.26, Table 2.3.

³³⁴ IPCC 2013 Wetlands Supplement, Chapter 2: Drained Inland Organic Soils, page 2.34, Table 2.5.

Updated data about living biomass and DOM losses due to land use changes were used for estimating GHG emissions for Land converted to other wetlands.

Table 6.28. Quantitative overview of recalculations compared to the 15.04.2025 submission

Year	Peat extraction On-site emissions, kt CO ₂ eq			Land converted to other wetlands C stock change, kt CO ₂			Total Wetlands Net emissions, kt CO ₂ eq		
	2025	2026	difference	2025	2026	difference	2025	2026	difference
1990	179.54	136.72	-42.83	5.59	159.53	153.95	281.95	393.07	111.12
1991	179.54	133.72	-45.82	5.66	2.96	-2.70	251.57	203.04	-48.52
1992	179.27	133.75	-45.53	5.74	2.92	-2.81	935.23	886.89	-48.34
1993	179.54	133.77	-45.77	6.04	2.89	-3.16	255.43	206.50	-48.93
1994	179.03	133.79	-45.23	0.54	2.85	2.31	832.08	789.16	-42.92
1995	178.52	133.82	-44.70	0.54	2.81	2.28	754.88	712.45	-42.42
1996	178.01	133.84	-44.17	0.54	2.78	2.24	639.59	597.67	-41.93
1997	176.44	133.86	-42.58	0.54	2.74	2.20	724.41	684.03	-40.37
1998	174.07	133.89	-40.19	0.30	2.70	2.40	366.39	328.60	-37.79
1999	172.01	133.91	-38.10	0.30	2.66	2.36	924.16	888.42	-35.74
2000	169.95	133.93	-36.01	0.30	2.63	2.32	612.70	579.01	-33.69
2001	167.08	133.96	-33.12	0.30	2.59	2.29	706.65	675.82	-30.83
2002	165.53	133.98	-31.55	0.30	2.55	2.25	1064.66	1035.35	-29.30
2003	164.25	134.00	-30.25	2.17	2.52	0.35	873.12	843.22	-29.90
2004	163.44	134.90	-28.54	2.44	21.36	18.92	693.95	684.33	-9.62
2005	162.63	134.18	-28.46	2.47	14.22	11.75	921.84	905.14	-16.70
2006	166.30	128.80	-37.51	2.49	87.30	84.81	984.50	1031.80	47.30
2007	167.10	130.41	-36.70	4.11	55.88	51.77	634.44	649.51	15.07
2008	167.91	136.95	-30.96	7.88	39.21	31.33	707.01	707.38	0.37
2009	172.26	132.51	-39.75	7.96	16.42	8.46	739.73	708.44	-31.29
2010	174.27	134.62	-39.65	13.44	43.72	30.28	799.66	790.28	-9.37
2011	172.38	134.38	-37.99	17.13	15.25	-1.88	814.17	774.30	-39.87
2012	173.13	137.38	-35.75	20.06	68.13	48.06	693.74	706.05	12.31
2013	173.89	135.56	-38.33	17.99	20.84	2.85	987.24	951.77	-35.47
2014	171.90	139.05	-32.85	17.98	9.95	-8.03	808.57	767.70	-40.88
2015	172.26	140.61	-31.65	15.13	1.77	-13.36	838.17	793.16	-45.00
2016	173.05	147.99	-25.06	19.83	4.19	-15.64	644.80	604.09	-40.71
2017	173.46	144.56	-28.90	20.61	62.27	41.66	895.33	908.09	12.76
2018	173.87	143.69	-30.18	21.66	42.65	20.98	1142.87	1133.68	-9.19
2019	173.47	141.29	-32.17	21.93	4.94	-16.98	1008.49	959.33	-49.15
2020	173.87	140.61	-33.27	25.54	2.26	-23.28	916.01	859.47	-56.54
2021	174.08	144.98	-29.10	18.11	113.82	95.71	1139.53	1206.14	66.61
2022	175.28	142.83	-32.45	13.39	1.40	-11.99	1322.37	1277.93	-44.44
2023	176.09	141.82	-34.27	9.38	124.11	114.73	1084.29	1164.75	80.46

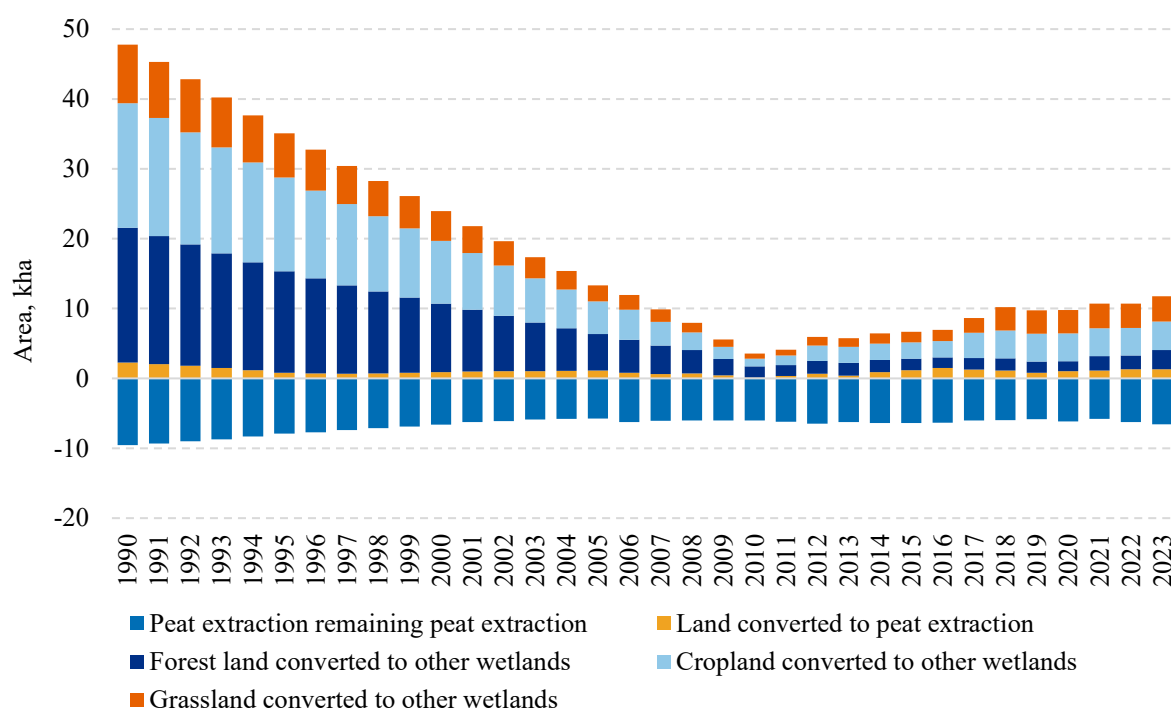


Figure 6.28. Differences between the 2026 and 2025 submissions in the areas of Wetlands subcategories in Estonia in 1990–2023, kha

6.7.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

A research project to specify the activity data and emissions from drainage ditches has recently been completed. Results of the project will be evaluated and implemented in the GHG inventory.

New scientific research has been launched to improve GHG accounting methods for peatlands managed for peat extraction and for restored extraction sites. The project is being carried out by the University of Tartu in 2024–2028. In addition, a project entitled “Nationwide mapping of wetlands and the development of a corresponding science-based and validated methodology” (2026–2027) was recently started to obtain more accurate activity data for reporting under the Wetlands category.

6.8. Settlements (CRT 4.E)

6.8.1. Category description

Settlements, including all built-up areas, covered 7.7% (349.07 kha) of Estonia’s territory in 2024. The area of settlements has been increasing continuously in Estonia (Figure 6.29) mainly on behalf of forests, but also croplands and grasslands (Table 6.6 and Table 6.30). Carbon flows on Settlements remaining settlements have not been estimated due to the lack of detailed data. It is assumed that there is no change in C stocks in biomass and that C inputs equal outputs in mineral soils. Emissions in the Settlements category thus result from Land converted to Settlements, and fluctuations in emissions are mainly related to annual deforestation areas. Total emissions from the Settlements category were 701.69 kt CO₂ eq. in 2024 (Figure 6.30).

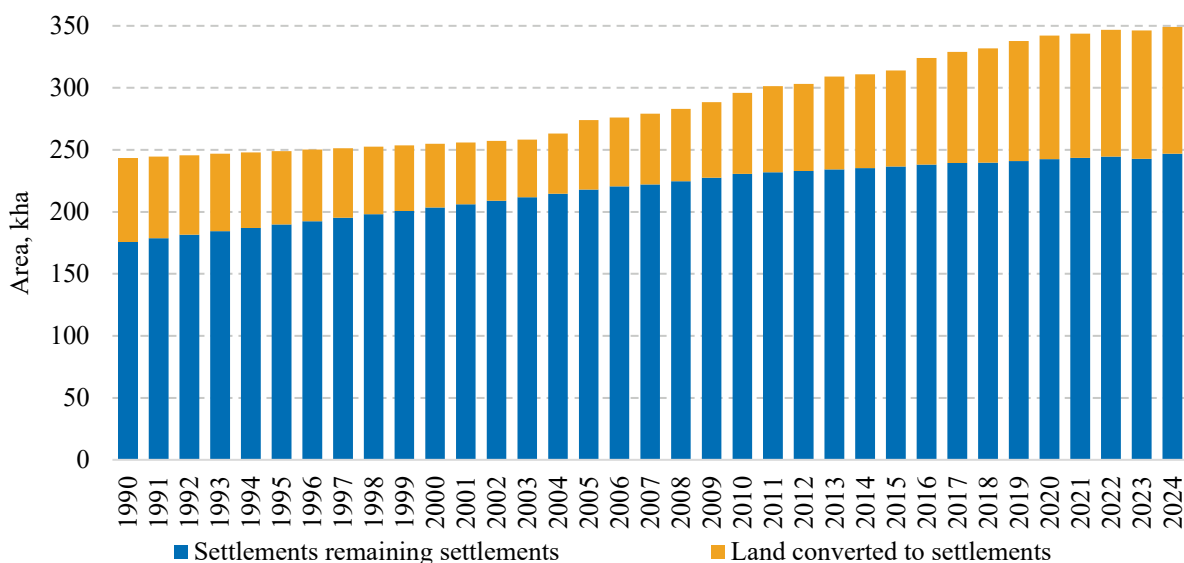


Figure 6.29. Area of Settlements in Estonia in 1990–2024, kha

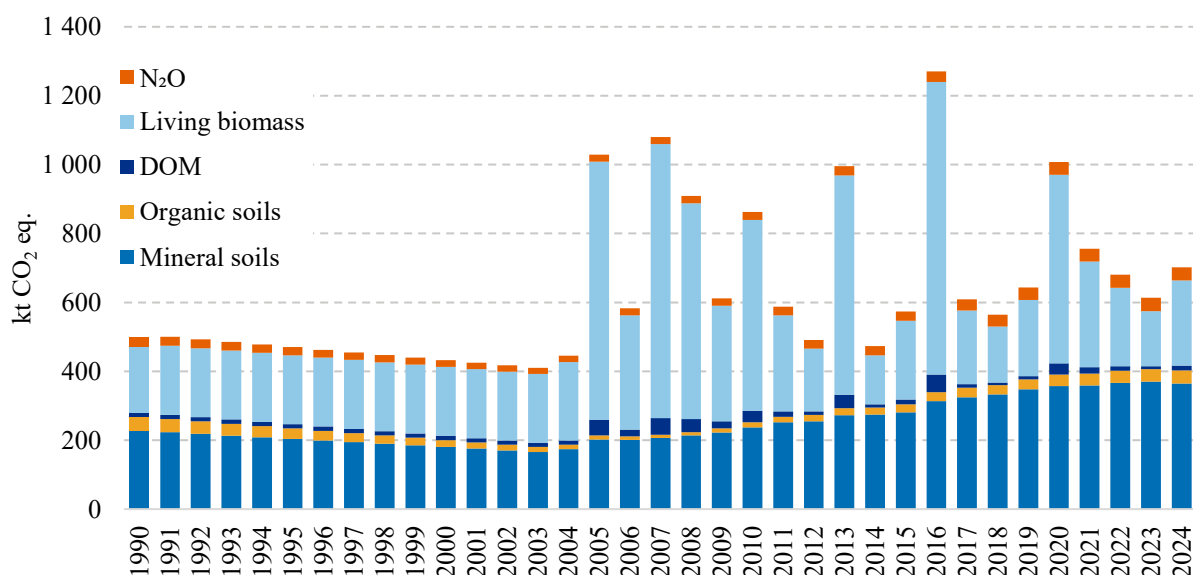


Figure 6.30. Emissions related to land conversion to settlements, 1990–2024, kt CO₂ eq.

6.8.2. Methodological issues

C losses in living biomass and dead wood due to land conversion to Settlements were calculated using Equation 6.8, where C_{AFTER} was equal to zero. C_{BEFORE} values were estimated for Forest land and Grassland converted to settlements categories as average C stocks in NFI plots, where such conversions have occurred (Table 6.29). Calculation of living biomass and dead wood C stocks on NFI plots is described in Chapter 6.4.2. For Cropland converted to settlements, average biomass C stock for the Cropland category was applied, calculated as described in Chapter 6.5.2. C stock changes in the litter pool are included in the soil organic C stock change (Table 6.30).

Table 6.29. Average living biomass and dead wood C stock losses after Forest land, Cropland and Grassland conversion to settlements, t C ha⁻¹

C pool	Forest land converted to settlements	Cropland converted to settlements	Grassland converted to settlements
Living biomass	-54.787	-3.303	-1.135
Dead wood	-3.377	NA	-0.086

As it was not possible to stratify Land converted to settlements areas as suggested in the 2006 IPCC Guidelines³³⁵, it was conservatively assumed that all converted area is paved over and that 20% of the mineral soil carbon relative to the previous land use will be lost within 20 years. The average SOC stock in mineral forest soils (including forest floor) in Estonia is 108.0 t C ha⁻¹ (Kõlli et al. 2004)³³⁶, in Grassland category 107.3 t C ha⁻¹ (Kõlli et al. 2007)³³⁷, and in Cropland 88.2 t C ha⁻¹ (Kõlli et al. 2009)³³⁸. Average SOC stocks for mineral soils in Wetlands category were assumed to be the same as for hydromorphic mineral soils in grasslands (134 t C ha⁻¹; Kõlli et al. 2009). It was also assumed that SOC stocks in Other land are the same as in Settlements, since the Other Land category may include areas with substantial carbon stocks (Chapter 6.9.2). Consequently, no changes in carbon stocks were estimated for land converted from Other Land to Settlements. For organic soils, the same EF as for cultivated organic soils was used³³⁹ (Table 6.30).

Table 6.30. Cumulative land-use changes to settlements in 2024 and implemented soil emission factors. (Assumptions are described in the text.)

Land-use change	Mineral soils, kha	Organic soils, kha	EF mineral soil, t C ha ⁻¹	EF organic soil t C ha ⁻¹
Forest land→ Settlements	34.48	1.92	-1.080	-5.0
Cropland→ Settlements	30.47	0.18	-0.882	-5.0
Grassland→ Settlements	26.69	NO	-1.073	-5.0
Wetlands→ Settlements	5.00	0.004	-1.340	-5.0
Other land→ Settlements	3.58	NO	NO	Only mineral soils
Total Land to settlements	100.21	2.10		

6.8.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Settlements subcategory, please see Annex A.II.4 LULUCF, Settlements (4.E) chapter.

6.8.4. Category-specific QA/QC and verification, if applicable

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 Chapter 1.5.

³³⁵ IPCC 2006 Guidelines, Volume 4, Chapter 8: Settlements, page 8.24.

³³⁶ Kõlli, R., Asi, E., Köster, T. (2004). Organic carbon pools in Estonian forest soils. *Baltic Forestry* 10, 19–26.

³³⁷ Kõlli, R., Köster, T., Kauer, K. (2007). Organic matter of Estonian grassland soils. *Agronomy Research* 5, 109–122.

³³⁸ Kõlli, R., Ellermäe, O., Köster, T., Lemetti, I. Asi, E., Kauer, K. (2009). Stocks of organic carbon in Estonian soils. *Estonian Journal of Earth Sciences*, 58, 95–108.

³³⁹ IPCC 2006 Guidelines, Volume 4, Chapter 5: Cropland, page 5.19, Table 5.6 (Boreal/Cool Temperate).

6.8.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

Recalculations compared to the previous submission result mainly from the new methodology and additional data for estimating annual land use changes (see Chapter 6.3.1). Differences in land areas between the current and 2025 submission are shown in Table 6.31. Deforestation has the highest impact on the Settlements category emissions; therefore, the area of Forest land converted to settlements is presented separately. Recalculated N₂O emissions from N mineralization and leaching after land conversion to settlements have been shown additionally in Chapter 6.10.5

Smaller recalculations result from updating average C stock losses in living biomass and dead wood after land use change from Forest land, Cropland and Grassland to Settlements. On deforested areas, emissions from the litter decomposition were not estimated in the current submission, since they are already included in the soil C stock change. In addition, SOC changes in mineral soils for Wetlands converted to settlements were reported for the first time in the 2026 submission.

Table 6.31. Quantitative overview of recalculations of cumulative land areas and emissions in the Settlements category compared to the 15.04.2025 submission

Year	Forest land converted to settlements, kha			Total land converted to settlements, kha			Settlements net emissions, kt CO ₂ eq		
	2025	2026	difference	2025	2026	difference	2025	2026	difference
1990	NO	16.66	16.66	NO	67.23	67.23	NO	498.56	498.56
1991	NO	16.81	16.81	0.12	65.64	65.52	0.67	500.26	499.60
1992	NO	16.96	16.96	0.24	64.06	63.82	1.00	492.66	491.66
1993	NO	17.10	17.10	0.36	62.47	62.11	1.34	485.13	483.79
1994	0.01	17.25	17.24	0.49	60.88	60.39	4.65	477.60	472.95
1995	0.03	17.40	17.38	0.62	59.29	58.67	5.08	470.09	465.02
1996	0.04	17.56	17.51	0.68	57.70	57.02	5.48	462.60	457.12
1997	0.06	17.71	17.65	0.82	56.11	55.29	6.71	455.03	448.32
1998	0.07	17.86	17.79	0.95	54.51	53.56	7.27	447.55	440.28
1999	0.07	18.01	17.94	1.08	52.92	51.84	4.86	440.07	435.21
2000	0.07	18.16	18.09	1.28	51.32	50.04	6.31	432.59	426.28
2001	0.19	18.31	18.12	1.61	49.72	48.12	34.64	425.11	390.47
2002	0.44	18.46	18.02	2.10	48.13	46.03	64.27	417.61	353.34
2003	0.98	18.62	17.64	3.09	46.53	43.43	131.25	410.09	278.84
2004	1.63	18.74	17.11	4.33	48.50	44.17	164.00	445.70	281.69
2005	2.47	21.48	19.01	6.05	56.16	50.11	214.28	1028.99	814.71
2006	3.49	22.26	18.77	8.37	55.55	47.18	265.38	582.78	317.40
2007	4.57	25.37	20.80	10.81	56.88	46.07	292.31	1080.11	787.80
2008	5.56	27.63	22.07	13.12	58.48	45.37	286.01	909.15	623.14
2009	6.57	28.37	21.80	15.36	60.76	45.40	303.46	611.84	308.38
2010	7.52	30.19	22.67	17.27	65.27	48.00	297.89	862.82	564.93
2011	8.50	30.40	21.91	18.71	69.30	50.60	310.07	587.48	277.41
2012	9.55	30.25	20.70	20.45	70.32	49.88	340.03	490.64	150.61
2013	10.55	32.37	21.82	22.09	74.85	52.76	336.30	995.18	658.88
2014	11.54	32.04	20.50	23.69	75.51	51.82	345.70	473.69	128.00
2015	12.60	32.13	19.53	25.45	77.33	51.89	371.51	574.02	202.50
2016	13.72	35.17	21.45	27.42	85.97	58.55	393.96	1270.49	876.54
2017	14.83	35.00	20.17	29.07	89.63	60.56	401.29	609.23	207.93
2018	16.11	34.61	18.50	31.15	92.16	61.01	451.34	564.18	112.84
2019	17.53	34.40	16.87	33.60	96.87	63.27	493.16	643.44	150.28
2020	18.87	36.08	17.21	35.87	99.57	63.70	490.81	1007.21	516.40
2021	19.81	36.58	16.78	37.62	100.21	62.59	441.60	755.92	314.32

Year	Forest land converted to settlements, kha			Total land converted to settlements, kha			Settlements net emissions, kt CO ₂ eq		
	2025	2026	difference	2025	2026	difference	2025	2026	difference
2022	20.43	36.60	16.16	38.83	102.24	63.41	406.44	680.83	274.40
2023	20.46	36.27	15.81	38.86	103.56	64.71	340.04	613.26	273.22

6.8.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

In 2024, a project for developing a governance system for land and soil management was launched. The project aims to update and consolidate land use-related datasets and to develop higher tier methodologies for estimating SOC changes in all land-use categories. The project has already initiated the updating of the Estonian soil map (2024–2026).

6.9. Other land (CRT 4.F)

6.9.1. Category description

The Other land category includes all land that does not fall into the five previously described land-use categories, comprising 1.0% (45.05 kha in 2024) of the total Estonia's land territory. C stock changes and N₂O emissions from N mineralization and leaching (methodology described in Chapter 6.10) are reported for Forest land, Cropland, Grassland and Wetlands converted to Other land. It was assumed that the change in land use from Settlements to Other land would not lead to changes in C stocks. Fluctuations in the in the Other land category emissions result mainly from deforestation, causing losses especially from the living biomass C pool (Figure 6.31). Total emissions from Land converted to other land were estimated at 316.13 kt CO₂ eq. in 2024.

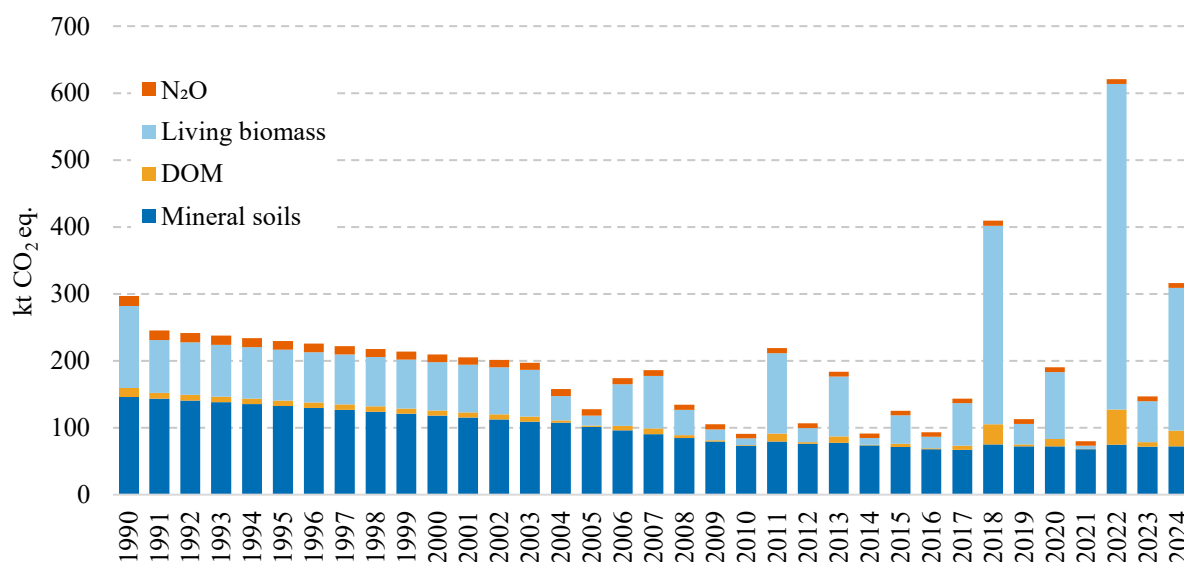


Figure 6.31. Emissions related to land-use changes to other land, 1990–2024, kt CO₂ eq.

6.9.2. Methodological issues

C losses in living biomass and dead wood resulting from land conversion to Other land were calculated using Equation 6.8, where C_{AFTER} was equal to zero. C_{BEFORE} values were estimated for Forest land and Grassland converted to other land categories as average C stocks in NFI plots, where such conversions have occurred (Table 6.32). Calculation of living biomass and

dead wood C stocks on NFI plots is described in Chapter 6.4.2. For Cropland converted to other land, average biomass C stock for the Cropland category was applied, calculated as described in Chapter 6.5.2.

Table 6.32. Average living biomass and dead wood C stock losses after Forest land, Cropland and Grassland conversion to other land, t C ha⁻¹

C pool	Forest land converted to other land	Cropland converted to other land	Grassland converted to other land
Living biomass	-56.546	-3.303	0
Dead wood	-6.154	NA	0

Land use change to other land has not resulted in a complete loss of soil SOC stocks. For instance, Forest land to other land conversions observed in NFI plots include deforestation areas where future land use is unknown, former quarries where afforestation has not been successful, etc. Also, land use changes to areas with a closed regime are included under Other land. As land-use change may cause some losses in soil carbon, the same emission factors mineral soils are applied as in the case of Land converted to settlements, i.e. it was assumed that 20% of the mineral soil carbon relative to the previous land use will be lost within 20 years (Table 6.33).

Table 6.33. Cumulative land-use changes to Other land in 2024 and implemented soil emission factors³⁴⁰

Land-use change	Mineral soils, kha	EF mineral soil, t C ha ⁻¹
Forest land→ Other land	8.35	-1.080
Cropland→ Other land	3.55	-0.882
Grassland→ Other land	4.06	-1.073
Wetlands→ Other land	2.40	-1.340
Settlements→ Other land	0.89	NO, SOC stocks are assumed to be equal
Total Land to other land	19.24	

6.9.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Other land subcategory, please see Annex A.II.4 LULUCF, Other land (4.F) chapter.

6.9.4. Category-specific QA/QC and verification, if applicable

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 Chapter 1.5.

6.9.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

In Table 6.34 a quantitative overview of recalculations is shown. Recalculations of direct and indirect N₂O emissions are presented also separately in Chapter 6.10.5. Changes compared to

³⁴⁰ Same as for Land converted to settlements.

the previous submission result mainly from the new methodology and additional data for estimating annual land use changes (see Chapter 6.3.1), especially recalculation of deforested area. Updated average C stock losses in living biomass and dead wood were applied for land conversions from Forest land, Cropland and Grassland to Settlements. On deforested areas, emissions from the litter decomposition were not estimated in the current submission, since they are already included in the soil C stock change, and SOC changes in mineral soils for Wetlands converted to other land were reported for the first time.

Table 6.34. Quantitative overview of recalculations of cumulative land areas and emissions compared to the 15.04.2025 submission

Year	Forest land converted to other land, kha			Total land converted to other land, kha			Other land net emissions, kt CO ₂ eq		
	2025	2026	difference	2025	2026	difference	2025	2026	difference
1990	NO	11.65	11.65	NO	38.87	38.87	NO	297.45	297.45
1991	NO	11.44	11.44	NO	37.94	37.94	NO	245.45	245.45
1992	NO	11.23	11.23	NO	37.01	37.01	NO	241.56	241.56
1993	NO	11.02	11.02	NO	36.07	36.07	NO	237.64	237.64
1994	NO	10.80	10.80	NO	35.13	35.13	NO	233.69	233.69
1995	NO	10.58	10.58	NO	34.18	34.18	NO	229.72	229.72
1996	NO	10.36	10.36	NO	33.23	33.23	NO	225.72	225.72
1997	NO	10.13	10.13	NO	32.28	32.28	NO	221.72	221.72
1998	NO	9.90	9.90	NO	31.31	31.31	NO	217.66	217.66
1999	NO	9.67	9.67	NO	30.35	30.35	NO	213.58	213.58
2000	NO	9.43	9.43	NO	29.38	29.38	NO	209.48	209.48
2001	NO	9.20	9.20	NO	28.41	28.41	NO	205.35	205.35
2002	NO	8.95	8.95	NO	27.43	27.43	NO	201.19	201.19
2003	NO	8.71	8.71	NO	26.45	26.45	NO	197.01	197.01
2004	0.04	8.28	8.24	0.04	25.84	25.79	10.60	157.78	147.17
2005	0.17	7.77	7.60	0.29	24.20	23.91	33.55	127.78	94.22
2006	0.54	7.49	6.95	0.82	22.74	21.92	97.46	173.96	76.50
2007	0.92	7.29	6.37	1.36	21.25	19.90	100.28	186.26	85.97
2008	1.32	6.89	5.57	1.92	19.68	17.76	110.68	134.56	23.88
2009	1.68	6.39	4.71	2.44	18.20	15.76	103.08	105.00	1.91
2010	1.96	5.86	3.90	2.75	16.46	13.71	83.14	91.05	7.91
2011	1.99	6.01	4.02	2.78	18.26	15.48	22.24	218.88	196.64
2012	2.02	5.73	3.71	2.81	17.59	14.78	22.42	106.55	84.13
2013	2.03	5.78	3.75	2.82	17.96	15.14	16.55	183.76	167.21
2014	2.10	5.46	3.36	2.89	17.09	14.20	33.25	91.55	58.30
2015	2.17	5.30	3.13	2.99	16.62	13.63	34.18	125.29	91.11
2016	2.41	5.02	2.61	3.26	15.86	12.60	76.39	93.22	16.83
2017	2.64	4.93	2.29	3.53	15.96	12.43	77.96	143.32	65.36
2018	2.88	5.92	3.04	3.79	18.41	14.62	78.01	409.30	331.29
2019	3.04	5.70	2.66	3.99	17.82	13.83	62.89	113.02	50.13
2020	3.21	5.84	2.63	4.15	17.85	13.70	63.53	190.43	126.90
2021	3.24	5.52	2.28	4.18	16.90	12.72	30.71	79.93	49.23
2022	3.30	7.52	4.22	4.24	19.06	14.82	38.73	620.89	582.16
2023	3.36	7.48	4.12	4.31	18.71	14.41	39.11	146.94	107.83

6.9.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

There are no planned category-specific improvements.

6.10. N₂O emissions from N mineralization and leaching (CRT 4(III))

6.10.1. Category description

The change of land use or management of mineral soil often enhances mineralization of nitrogen in soil organic matter, resulting in nitrous oxide emissions. In Estonia, soil organic matter losses from mineral soil occur after land conversions to Forest land, Cropland, Settlements and Other land. In some years, management changes also cause carbon emissions from the Cropland remaining cropland category, but associated N₂O emissions from this category are reported under the Agriculture sector (CRT 3.D).

In 2024, direct N₂O emissions from N mineralization were 54.42 kt CO₂ eq. As Estonia is situated in the humid region where annual precipitation exceeds evapotranspiration, some of the mineralized N is lost from soil through leaching and runoff. Since Estonian forests and other non-agricultural lands are not fertilized, this is the only source of indirect N₂O emissions in the LULUCF sector. In 2024, indirect N₂O emissions equalled 12.24 kt CO₂ eq. In recent years, most of the N₂O emissions from N mineralization occurred due to the expansion of Settlements (Figure 6.32).

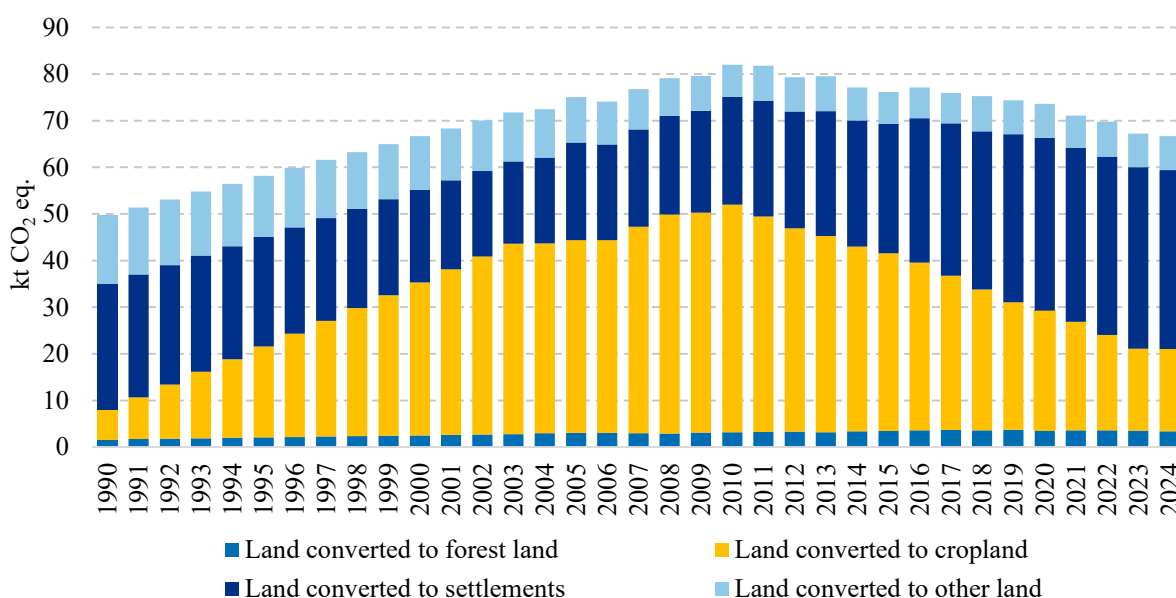


Figure 6.32. N₂O emissions from nitrogen mineralization and leaching, 1990-2024, kt CO₂ eq.

6.10.2. Methodological issues

Direct N₂O emissions from N mineralization

The *Tier 1* method (Equation 6.15) with default emission factors was applied for calculating direct N₂O emissions from N mineralization associated with the loss of soil organic matter resulting from the change of land use.

$$N_2O_{Min} = F_{SOM} \times EF_1 \times \frac{44}{28}$$

where

$$F_{SOM} = \sum_{LU} \left[\left(\Delta C_{Mineral, LU} \times \frac{1}{R} \right) \times 1000 \right]$$

Where:

- N_2O_{Min} = annual direct N_2O emissions from N mineralization, kg N_2O yr⁻¹;
 EF_1 = emission factor for N_2O emissions from N inputs, kg N_2O -N (kg N input)⁻¹. IPCC 2006 default factor 0.01³⁴² was applied;
 F_{SOM} = the net annual amount of N mineralized in mineral soils as a result of the loss of soil carbon through a change in land use or management, kg N yr⁻¹;
 $\Delta C_{Mineral, LU}$ = average annual loss of soil carbon for each land-use type (LU), tonnes C;
 R = C:N ratio of the soil organic matter. A default value of 10 was used for Cropland and 15 for other land-use categories; and
 LU = land use and/or management system type.

Indirect N_2O emissions from leaching/runoff (CRT 4(IV))

Indirect N_2O emissions from leaching and runoff were estimated using Equation 6.16 (*Tier 1*).

Equation 6.16³⁴³

$$N_2O_{(L)} = F_{SOM} \times \text{Frac}_{LEACH-(H)} \times EF_5 \times \frac{44}{28}$$

Where

- $N_2O_{(L)}$ = annual amount of N_2O produced from leaching and runoff of N mineralized in managed soils, kg N_2O yr⁻¹;
 F_{SOM} = annual amount of N mineralized in mineral soils associated with the loss of soil C from soil organic matter as a result of changes in land use, kg N yr⁻¹ (from Equation 6.15);
 $\text{Frac}_{LEACH-(H)}$ = fraction of all N mineralized in managed soils that is lost through leaching and runoff, kg N (kg of N additions)⁻¹. A default value of 0.30³⁴⁴ was applied in calculations; and
 EF_5 = emission factor for N_2O emissions from N leaching and runoff, kg N_2O -N (kg N leached and runoff)⁻¹. IPCC 2006 default value 0.0075³⁴⁴ was used.

³⁴¹ IPCC 2006 Guidelines, Volume 4, Chapter 11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, page 11.10, Equation 11.2, and page 11.16, Equation 11.8.

³⁴² IPCC 2006 Guidelines, Volume 4, Chapter 11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, page 11.11, Table 11.1.

³⁴³ IPCC 2006 Guidelines, Volume 4, Chapter 11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, page 11.21, Equation 11.10.

³⁴⁴ IPCC 2006 Guidelines, Volume 4, Chapter 11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application, page 11.24, Table 11.3.

6.10.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of N₂O emissions from N mineralization and leaching subcategory, please see Annex A.II.4 LULUCF, N₂O emissions from N mineralization and leaching (CRT 4(III)) chapter.

6.10.4. Category-specific QA/QC and verification, if applicable

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 Chapter 1.5.

6.10.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

A quantitative overview of recalculations is shown in Table 6.35. Changes in estimated N₂O emissions compared to the previous submission result from the recalculation of mineral soil C stock changes in Forest land (Chapter 6.4.5), Cropland (Chapter 6.5.5), Settlements (Chapter 6.8.5), and Other land (Chapter 6.9.5) categories.

Table 6.35. Quantitative overview of recalculations of N₂O emissions from N mineralization and leaching/runoff compared to the 15.04.2025 submission

Year	Land converted to forest land, t N ₂ O			Land converted to cropland, t N ₂ O			Land converted to settlements, t N ₂ O			Land converted to settlements, t N ₂ O		
	2025	2026	difference	2025	2026	difference	2025	2026	difference	2025	2026	difference
1990	0.11	6.16	6.05	NO	23.79	23.79	NO	102.28	102.28	NO	55.38	55.38
1991	0.28	6.49	6.21	NO	33.74	33.74	0.11	99.55	99.44	NO	54.21	54.21
1992	0.51	6.83	6.32	NO	43.71	43.71	0.21	96.81	96.60	NO	53.04	53.04
1993	0.78	7.16	6.38	NO	53.68	53.68	0.32	94.07	93.75	NO	51.86	51.86
1994	1.02	7.50	6.48	NO	63.67	63.67	0.45	91.33	90.88	NO	50.67	50.67
1995	1.28	7.83	6.55	NO	73.67	73.67	0.58	88.58	88.01	NO	49.48	49.48
1996	1.56	8.16	6.60	NO	83.69	83.69	0.66	85.83	85.17	NO	48.28	48.28
1997	1.82	8.49	6.67	NO	93.72	93.72	0.88	83.08	82.20	NO	47.07	47.07
1998	2.08	8.82	6.74	NO	103.76	103.76	1.09	80.32	79.23	NO	45.86	45.86
1999	2.37	9.15	6.79	NO	113.81	113.81	1.29	77.56	76.27	NO	44.64	44.64
2000	2.61	9.48	6.87	NO	123.87	123.87	1.61	74.80	73.19	NO	43.41	43.41
2001	2.78	9.81	7.03	0.05	133.95	133.90	1.98	72.03	70.05	NO	42.18	42.18
2002	2.95	10.14	7.19	0.10	144.03	143.94	2.61	69.26	66.65	NO	40.95	40.95
2003	3.17	10.47	7.30	0.19	154.13	153.94	3.88	66.49	62.60	NO	39.71	39.71
2004	3.39	11.22	7.82	0.68	153.61	152.93	5.44	69.49	64.05	0.06	39.08	39.02
2005	3.66	11.56	7.90	1.90	155.92	154.02	7.68	78.94	71.26	0.43	36.80	36.37
2006	3.98	11.41	7.43	3.66	156.02	152.36	10.83	77.61	66.77	1.16	34.73	33.57
2007	4.29	11.16	6.87	5.81	167.22	161.41	14.10	78.69	64.58	1.89	32.60	30.71
2008	4.57	11.07	6.50	8.20	177.01	168.81	17.20	79.98	62.78	2.66	30.39	27.73
2009	4.84	11.62	6.78	10.43	178.19	167.76	20.29	82.32	62.03	3.37	28.36	24.98
2010	4.95	11.97	7.02	12.00	184.37	172.36	22.90	87.07	64.17	3.77	25.92	22.15
2011	5.00	12.35	7.35	13.24	174.39	161.15	24.93	93.34	68.42	3.81	28.60	24.79
2012	5.01	12.40	7.39	14.47	164.52	150.06	27.47	94.77	67.30	3.86	27.52	23.67
2013	4.96	12.10	7.14	15.86	158.59	142.73	29.90	101.27	71.36	3.86	28.09	24.23
2014	4.92	12.66	7.73	17.79	149.53	131.74	32.25	102.12	69.87	3.96	26.69	22.73
2015	4.86	13.03	8.16	20.01	143.77	123.75	34.82	104.69	69.87	4.12	25.89	21.77
2016	4.78	13.54	8.75	22.25	135.81	113.57	37.61	116.92	79.31	4.50	24.65	20.15
2017	4.70	13.76	9.07	24.38	124.97	100.60	39.79	123.24	83.46	4.88	24.74	19.87
2018	4.69	13.65	8.96	26.24	113.97	87.73	42.59	127.93	85.33	5.25	28.43	23.18

Year	Land converted to forest land, t N ₂ O			Land converted to cropland, t N ₂ O			Land converted to settlements, t N ₂ O			Land converted to settlements, t N ₂ O		
	2025	2026	difference	2025	2026	difference	2025	2026	difference	2025	2026	difference
2019	4.67	14.02	9.36	27.69	103.08	75.39	45.91	136.02	90.11	5.53	27.49	21.96
2020	4.71	13.87	9.15	29.03	96.66	67.63	48.87	139.91	91.04	5.76	27.48	21.72
2021	4.79	13.46	8.67	30.16	88.02	57.86	51.19	140.78	89.59	5.80	25.97	20.17
2022	4.84	13.41	8.57	31.01	77.39	46.38	52.85	144.32	91.47	5.89	28.25	22.36
2023	4.72	13.17	8.45	31.63	66.50	34.87	52.86	146.85	93.99	5.98	27.31	21.33

6.10.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

Planned improvements regarding the estimates of land-use category areas and GHG emissions from soils are described in Chapters 6.4.6, 6.5.6 and 6.8.6.

6.11. Non-CO₂ emissions from biomass burning (CRT 4(IV))

6.11.1. Category description

This category includes CH₄ and N₂O emissions from biomass burning on wooded lands after wildfires. CO₂ emissions caused by wildfires are included in living biomass emission estimates, thus CO₂ emissions are not reported under the current category to avoid double accounting.

Controlled burning is not a common practice in Estonia. Furthermore, the standpoint of the public and 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.

6.11.2. Methodological issues

CH₄ and N₂O emissions from biomass burning are reported under the Forest land and Grassland categories, the latter also includes wildfires occurring in Wetlands. The notation key “NE” is used for the Cropland and Settlements categories, as a disproportionate amount of effort would be required to collect the activity data for estimating emissions that would be insignificant in terms of the overall level and trend in national emissions. This argument is based on the fact that according to the latest inventory submission, the average level of emissions from biomass burning reported in the period 1990–2024 is 0.93 kt CO₂ eq. that constitutes less than 0.01% of the national total GHG emissions (without LULUCF) and that the average GHG emissions from the biomass burning in Cropland and Settlements have a very low likelihood to exceed that, as the biomass density and the area in case of Settlements is considerably lower compared to the Forest land.

Information about wildfires is acquired from the Estonian Rescue Service (ERS), which reports the location and type of fire occurred for all forest and terrain fires. EstEA will pick out the wildfires that are over 0.1 ha and inventory those areas to improve and verify data and emissions related to the wildfires. Exact location (georeferenced, area), land use and mass of fuel available for combustion (includes biomass, ground litter and deadwood) are determined during fieldwork. Sometimes the location of a wildfire reported by the ERS is imprecise, in which case EstEA field workers examine the nearby area and try to locate the exact place of the fire (Figure 6.33). The detected burnt area is separated into several land-use categories, if necessary. Wildfires reported in 2024 are indicated in Figure 6.34.



Figure 6.33. Reported fire location (blue circle), actual location (red border) and data analyses

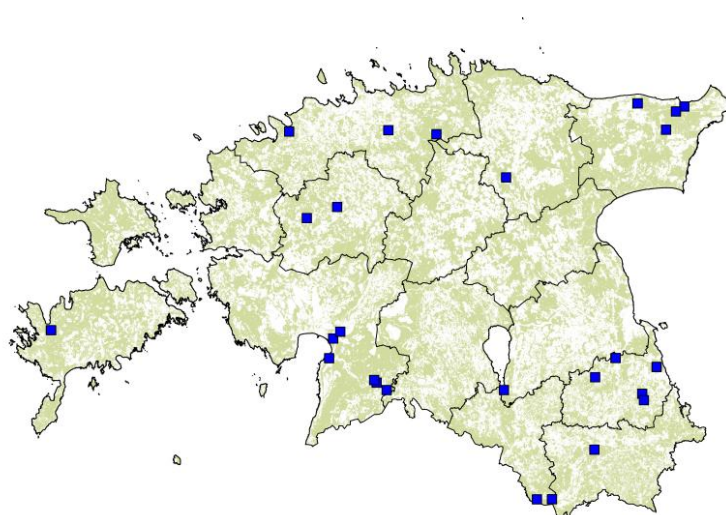


Figure 6.34. Reported wildfires in Estonia in 2024

The *Tier 2* method and Equation 6.17 were used to estimate the emissions of non-CO₂ greenhouse gases. Starting from 2012, in-situ measurements are conducted at each wildfire site to assess the burnt biomass (product of A, M_B and C_f).

Equation 6.17³⁴⁵

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

Where:

L_{fire} = quantity of GHG released due to wildfire, tonnes of GHG;
A = area burnt, ha;
M_B = mass of ‘available’ fuel (living biomass and DOM), kg dry matter ha⁻¹;³⁴⁶

³⁴⁵ IPCC 2006 Guidelines, Volume 4, Chapter 2: Generic Methodologies Applicable to Multiple Land-Use Categories, page 2.42, Equation 2.27.

³⁴⁶ For 1990–2011 year-specific average forest biomass growing stock was used as the basis for M_B.

C_f = combustion efficiency (or fraction of the biomass combusted), dimensionless; for 1990–2011 the value 0.15³⁴⁷ was applied;
 G_{ef} = emission factor, g (kg dry matter burnt)⁻¹.

Emission factors used for biomass burning emission calculations are shown in Table 6.36.

According to ERS and EstEA wildfires occurred on 16.33 ha of forests and 0.26 ha of Grasslands in 2024 (Figure 6.35). Fluctuations in the area burnt are caused mainly by the weather conditions in different years (e.g. extremely hot and dry summers).

Table 6.36. Emission factors (G_{ef} , g kg⁻¹ dry matter burnt) used for estimation of non-CO₂ greenhouse gas emissions from fires³⁴⁸

Land-use category	CH ₄	N ₂ O
Forest land	6.1	0.06
Grassland, Wetland	2.3	0.21

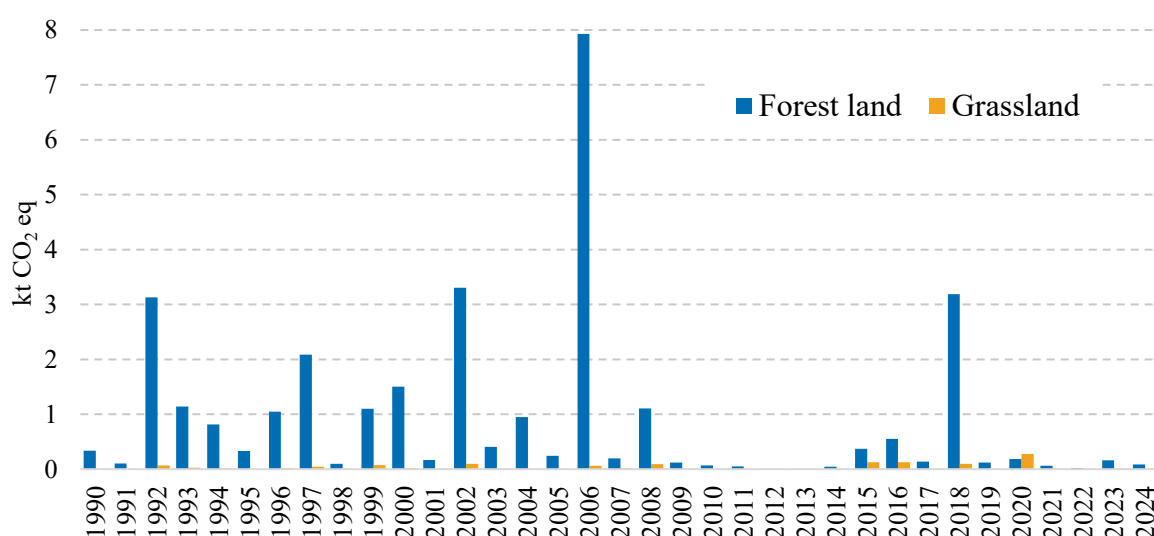


Figure 6.35. Annual emissions from wildfires on Forest land and Grassland (incl. WL areas) in 1990–2024, kt CO₂ eq.

The total amount of CH₄ and N₂O released after wildfires in 2024 was 2.90 t and 0.08 t, respectively (Figure 6.35). Non-CO₂ emissions from Grassland wildfires are rather insignificant compared to the Forest land, since there is approximately 10 times less growing biomass on Grasslands.

6.11.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of non-CO₂ emissions from biomass burning subcategory, please see Annex A.II.4 LULUCF, Non-CO₂ emissions from biomass burning (CRT 4 (IV)) chapter.

³⁴⁷ IPCC 2006 Guidelines, Volume 4, Chapter 2: Generic Methodologies Applicable to Multiple Land-Use Categories, page 2.48, Table 2.6 (Boreal forest, surface fire).

³⁴⁸ IPCC 2006 Guidelines, Volume 4, Chapter 2: Generic Methodologies Applicable to Multiple Land-Use Categories, page 2.47, Table 2.5 (Savanna and grassland, Biofuel burning).

6.11.4. Category-specific QA/QC and verification, if applicable

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 Chapter 1.5.

Activity data obtained from the Estonian Rescue Service is verified and corrected, if necessary, during field inventory carried out by the Estonian Environment Agency.

6.11.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

There are no category-specific recalculations.

6.11.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

There are no planned category-specific improvements.

6.12. Harvested wood products (CRT 4.G)

6.12.1. Description

The carbon balance has been calculated using the production approach for HWP. Domestically produced HWP from domestic harvest is included in the HWP pool. HWP are divided into Solid wood products (sawn wood and wood panels), Paper products (paper and paperboard) and Bleached-Chemi-Thermo-Mechanical aspen pulp (Aspen BCTMP)³⁴⁹. Pulp is an input for paper production. All Bleached semi-chemical wood pulp production is exported. The changes in roundwood stocks and their carbon balance are not considered in the reporting. The carbon balance of HWP in solid waste disposal sites is also excluded from the estimate. As Estonia lacks activity data for the years 1990 and 1991, an extrapolation that was recommended by the ERT in 2018³⁵⁰ was made to get estimates for these years (Chapter 6.12.2).

The net emissions for the HWP category in 2024 were -557.36 kt CO₂ and the net emissions during the reporting period are shown in Figure 6.36. Increases in removals in HWP are associated with the increase in harvest rates. As a result of the estimated total HWP balance during periods when consumption was low (1990–1994), the HWP pool became a source of CO₂. Main part of the HWP sink is from the Sawnwood subcategory. CO₂ sequestration in the wood panels subcategory declined significantly, as Estonia's largest manufacturer of wooden boards went bankrupt in 2023. Due to the short half-life values for the Paper and paperboard and Bleached semi-chemical wood pulp subcategories the contribution and impact to the carbon cycle is short-term and small for those pools.

³⁴⁹Bleached semi-chemical wood pulp is defined as code 4705 00 00 in Combined Nomenclature 2024 (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302364) (06.01.2025)

³⁵⁰ FCCC/ARR/2018/EST KL.12

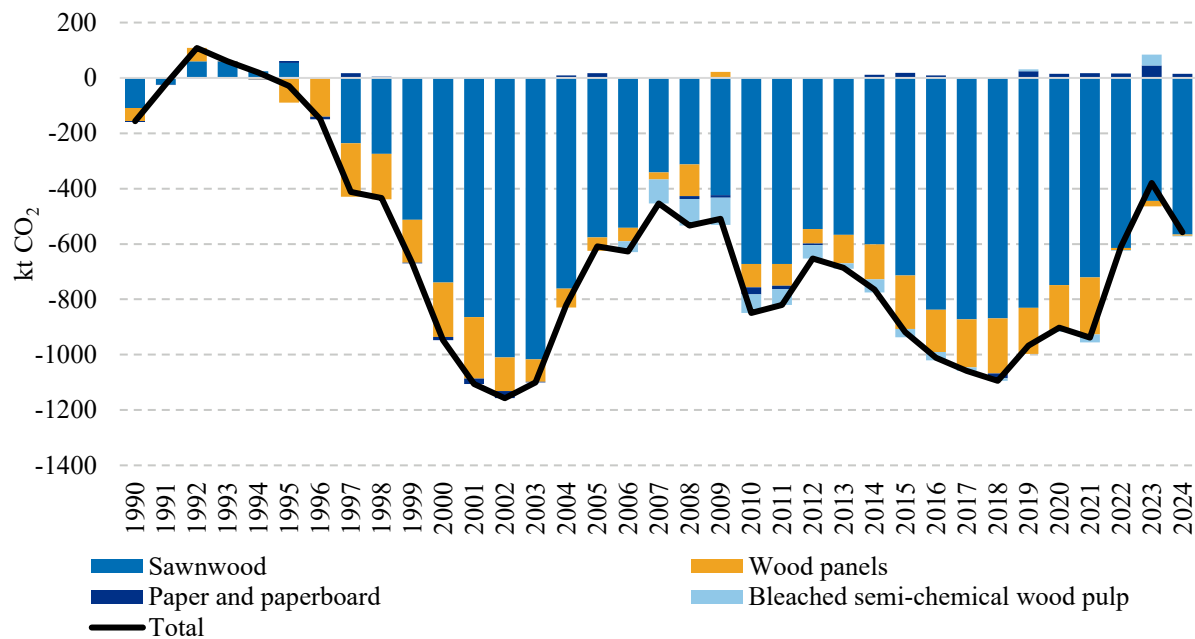


Figure 6.36. Net emissions from HWP categories of Sawnwood, Wood panel, Paper and paperboard and Bleached semi-chemical wood pulp in Estonia in 1990–2024, kt CO₂

6.12.2. Methodological issues

For calculating annual changes in carbon stocks and associated CO₂ emissions and removals from the HWP pool, Chapter 2.8 from the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement) was applied. However, under the Convention reporting, CO₂ emissions due to roundwood production in deforested land were not accounted using the instantaneous oxidation method but were reported similarly to HWP originating from other areas.

Estimation of the annual fraction of feedstock for HWP originating from domestic harvest was calculated using equations 2.8.1–2.8.3³⁵¹, resulting values are presented in Table 6.37. Forestry data originates from the NFI and foreign trade data comes from Statistics Estonia. In order to use equations 2.8.4–2.8.6³⁵², production data from Statistics Estonia were applied. The inherited emissions are included starting from 1990; initial C stocks in 1990 were simulated using equation 2.8.6 and average inflow values during the period 1990–1994. Default conversion factors (Table 6.38) and half-lives from Table 2.8.2³⁵³ were used to calculate Paper and paperboard and Solid wood removals (*Tier 2* method). C stock changes in Bleached semi-chemical wood pulp were estimated with the country-specific C conversion factor (0.4275 t C m⁻³) for 2006–2024. The following inputs were used in the calculations: the water content of the wood pulp is 10%, the wood content from t.d.m wood pulp is 95% and the carbon content of wood dry mass is 50%. Inherited emissions are included in the HWP estimations.

³⁵¹ IPCC 2013 KP Supplement, pp. 2.115 & 2.116

³⁵² IPCC 2013 KP Supplement, pp. 2.118, 2.120 & 2.121

³⁵³ IPCC 2013 KP Supplement, Chapter 2.8.3.2, p. 2.123, Table 2.8.2.

Table 6.37. Key variables used in calculations: C stocks in HWP subcategories at the beginning of year, share of industrial roundwood for the domestic production of HWP originating from domestic forests (f_{IRW}) and share of domestically produced pulp for the domestic production of paper and paperboard (f_{PULP})

Year	Initial stock in Solid wood ³⁵⁴ , t C	Initial stock in Paper and paperboard, t C	Initial stock in Bleached semi-chemical wood pulp, t C	Total initial stock in HWP, t C	f_{IRW} ³⁵⁵	f_{PULP} ³⁵⁶
1990	5 731 831	46 355	NO	5 778 186	1.00	1.00
1991	5 774 449	46 358	NO	5 820 807	1.00	1.00
1992	5 780 616	46 359	NO	5 826 975	1.00	1.00
1993	5 751 147	46 361	NO	5 797 508	1.00	1.00
1994	5 734 743	46 348	NO	5 781 091	1.00	1.00
1995	5 729 438	46 354	NO	5 775 792	0.87	1.00
1996	5 739 105	44 529	NO	5 783 633	0.91	1.00
1997	5 776 781	47 243	NO	5 824 023	0.90	0.89
1998	5 893 855	42 480	NO	5 936 335	0.83	0.99
1999	6 013 326	41 416	NO	6 054 742	0.83	0.99
2000	6 195 442	42 175	NO	6 237 616	0.89	0.99
2001	6 450 634	45 416	NO	6 496 050	0.89	0.92
2002	6 746 846	50 928	NO	6 797 773	0.90	1.00
2003	7 055 447	57 978	NO	7 113 426	0.85	1.00
2004	7 354 884	58 750	NO	7 413 634	0.69	1.00
2005	7 581 142	56 307	NO	7 637 449	0.58	0.99
2006	7 751 686	51 692	NO	7 803 378	0.59	0.96
2007	7 912 797	51 062	10 666	7 974 525	0.59	1.00
2008	8 012 872	50 985	34 433	8 098 291	0.80	0.99
2009	8 129 423	53 837	60 665	8 243 925	0.92	1.00
2010	8 238 972	56 321	87 584	8 382 877	0.91	1.00
2011	8 445 426	63 203	10 5726	8 614 355	0.91	0.98
2012	8 650 165	66 811	12 0984	8 837 960	0.94	0.88
2013	8 813 341	68 497	13 3999	9 015 837	0.94	0.82
2014	8 996 008	67 681	13 9408	9 203 096	0.95	0.74
2015	9 194 558	64 729	15 2424	9 411 711	0.94	0.65
2016	9 442 032	59 700	16 0609	9 662 340	0.97	0.65
2017	9 712 080	57 211	16 8757	9 938 047	0.96	0.69
2018	9 997 293	57 032	17 2311	10 226 636	0.95	0.82
2019	10 288 464	61 808	17 5013	10 525 285	0.94	0.49
2020	10 560 609	55 217	17 3274	10 789 100	0.92	0.59
2021	10 809 207	51 045	17 4969	11 035 221	0.86	0.49
2022	11 061 960	46236	18 2927	11 291 124	0.88	0.54

³⁵⁴ Data about production of the particular HWP commodities are provided by the Statistics Estonia and Estonian Wood Industries Association

³⁵⁵ Data from NFI (production of industrial roundwood) and Statistics Estonia (import and export of roundwood)

³⁵⁶ Data from Statistics Estonia

Year	Initial stock in Solid wood ³⁵⁴ , t C	Initial stock in Paper and paperboard, t C	Initial stock in Bleached semi-chemical wood pulp, t C	Total initial stock in HWP, t C	f _{IRW} ³⁵⁵	f _{PULP} ³⁵⁶
2023	11 231 825	41964	18 3536	11 457 325	0.90	NO
2024	11 358 457	29673	17 2820	11 560 950	0.90	0.32
2025	5 731 831	46355	10 666	11 712 957	-	-

A simple customised approach was developed to gain estimates for 1990 and 1991. An extrapolation for the 1990 and 1991 felling volume and production of industrial roundwood (IRW) was made. Production figures in 1990 for sawn wood, insulating board, fibreboard (compressed), particle board and plywood originate from Statistics Estonia. Production data for these commodities for 1991 is an average of the years 1990 and 1992. Foreign trade data for IRW and production data of veneer sheets, wood pulp, paper and paperboard of 1992 was repeated for 1990 and 1991.

Table 6.38. Default conversion factors for default HWP categories and their subcategories³⁵⁷

HWP categories	Density (t m ⁻³)	Carbon fraction	C conversion factor (t C t ⁻¹)
Sawn wood (aggregate)	0.458	0.5	0.238
Coniferous sawn wood	0.45	0.5	0.225
Non-coniferous sawn wood	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
	(t t ⁻¹)		(t C t ⁻¹)
Paper and paperboard	0.9		0.386
Bleached semi-chemical wood pulp	0.95		0.428

6.12.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Harvested wood products subcategory, please see Annex A.II.4 LULUCF, Harvested wood products (CRT 4.G) chapter.

6.12.4. Category-specific QA/QC and verification, if applicable

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 Chapter 1.5.

³⁵⁷ IPCC 2013 KP Supplement, Chapter 2.8.3.1, page 2.122, Table 2.8.1 (except for Bleached semi-chemical wood pulp).

6.12.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

Activity data (mostly deforestation time series) is being updated and if necessary, corrected each year. In Table 6.39, a quantitative overview of recalculations has been shown.

Table 6.39. Quantitative overview of recalculations compared to the 15.04.2025 submission

Year	Solidwood			Paper and Paperboard			Bleached semi-chemical wood pulp			Total HWP net CO ₂		
	2025	2026	difference	2025	2026	difference	2025	2026	difference	2025	2026	difference
1990	42.54	42.62	0.08	0.00	0.00	-0.001	NE	NE	-	-155.99	-156.27	-0.29
1991	6.22	6.17	-0.05	0.01	0.00	-0.01	NE	NE	-	-22.84	-22.62	0.22
1992	-29.42	-29.47	-0.05	0.00	0.00	0.004	NE	NE	-	107.89	108.05	0.16
1993	-16.43	-16.40	0.03	-0.02	-0.01	0.01	NE	NE	-	60.33	60.19	-0.13
1994	-5.30	-5.31	-0.01	0.01	0.01	-0.001	NE	NE	-	19.40	19.43	0.03
1995	9.58	9.67	0.08	-1.83	-1.83	0.001	NE	NE	-	-28.44	-28.75	-0.31
1996	37.50	37.68	0.18	2.70	2.71	0.01	NE	NE	-	-147.40	-148.10	-0.69
1997	116.89	117.07	0.18	-4.75	-4.76	-0.02	NE	NE	-	-411.20	-411.81	-0.60
1998	119.24	119.47	0.23	-1.06	-1.06	-0.01	NE	NE	-	-433.33	-434.16	-0.83
1999	181.92	182.12	0.20	0.77	0.76	-0.01	NE	NE	-	-669.84	-670.54	-0.70
2000	254.87	255.19	0.32	3.24	3.24	-0.001	NE	NE	-	-946.43	-947.59	-1.16
2001	295.29	296.21	0.92	5.48	5.51	0.03	NE	NE	-	-1102.84	-1106.32	-3.48
2002	306.50	308.60	2.10	6.97	7.05	0.08	NE	NE	-	-1149.39	-1157.39	-8.00
2003	295.27	299.44	4.17	0.65	0.77	0.12	NE	NE	-	-1085.05	-1100.76	-15.72
2004	220.64	226.26	5.62	-2.58	-2.44	0.14	NE	NE	-	-799.54	-820.65	-21.11
2005	163.99	170.54	6.56	-4.73	-4.61	0.12	NE	NE	-	-583.92	-608.41	-24.48
2006	149.29	161.11	11.82	-1.02	-0.63	0.39	10.26	10.67	0.41	-581.30	-627.54	-46.24
2007	89.05	100.08	11.02	-0.46	-0.08	0.38	22.69	23.77	1.07	-408.07	-453.81	-45.74
2008	103.95	116.55	12.61	2.39	2.85	0.46	24.93	26.23	1.30	-481.32	-533.99	-52.67
2009	99.63	109.55	9.92	2.28	2.48	0.20	25.94	26.92	0.97	-468.80	-509.49	-40.69
2010	197.10	206.45	9.36	6.80	6.88	0.09	17.98	18.14	0.16	-813.54	-848.75	-35.21
2011	198.38	204.74	6.36	3.75	3.61	-0.14	15.42	15.26	-0.16	-797.68	-819.88	-22.20
2012	158.11	163.18	5.07	1.83	1.69	-0.14	13.13	13.01	-0.12	-634.59	-652.22	-17.63
2013	177.98	182.67	4.68	-0.64	-0.82	-0.18	5.66	5.41	-0.25	-671.02	-686.62	-15.60
2014	192.81	198.55	5.74	-2.82	-2.95	-0.13	12.92	13.02	0.10	-744.01	-764.92	-20.91
2015	240.37	247.47	7.10	-4.89	-5.03	-0.14	8.08	8.18	0.10	-893.08	-918.97	-25.89
2016	261.02	270.05	9.03	-2.46	-2.49	-0.03	7.85	8.15	0.30	-976.83	-1010.92	-34.09
2017	277.44	285.21	7.77	-0.14	-0.18	-0.04	3.57	3.55	-0.01	-1029.85	-1058.16	-28.31
2018	282.52	291.17	8.65	4.66	4.78	0.11	2.62	2.70	0.08	-1062.62	-1095.05	-32.42
2019	263.49	272.14	8.66	-6.48	-6.59	-0.11	-1.87	-1.74	0.13	-935.50	-967.32	-31.83
2020	247.93	248.60	0.66	-4.12	-4.17	-0.06	1.48	1.69	0.21	-899.44	-902.44	-3.00
2021	245.89	252.75	6.86	-4.66	-4.81	-0.15	7.98	7.96	-0.02	-913.78	-938.31	-24.53
2022	181.97	169.86	-12.10	-4.08	-4.27	-0.19	1.12	0.61	-0.51	-656.37	-609.41	46.97
2023	158.60	126.63	-31.97	-12.03	-12.29	-0.261	-10.12	-10.72	-0.60	-500.35	-379.96	120.39

6.12.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

There are no planned category-specific improvements.

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7. WASTE (CRT SECTOR 5)

7.1. Overview of the sector (e.g. quantitative overview and description, including trends and methodological tiers by category) and background information

Waste management in Estonia is based on the EU and national legislation and the National Waste Management Plan for years 2023-2028³⁵⁸. The main purpose of the national waste policy has been to reduce the volume of waste deposited in landfills, increase the potential of recoverable waste, and minimise the hazardousness of waste to the limit. The National Waste Management Plan supports the 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 the lack of national research on sectors country-specific emission factors, the default values of IPCC 2006 Guidelines and the IPCC 2019 Refinement to the IPCC 2006 Guidelines have mostly been applied in calculations. The process of choosing among methods relies on the decision trees described in IPCC 2006 Guidelines.

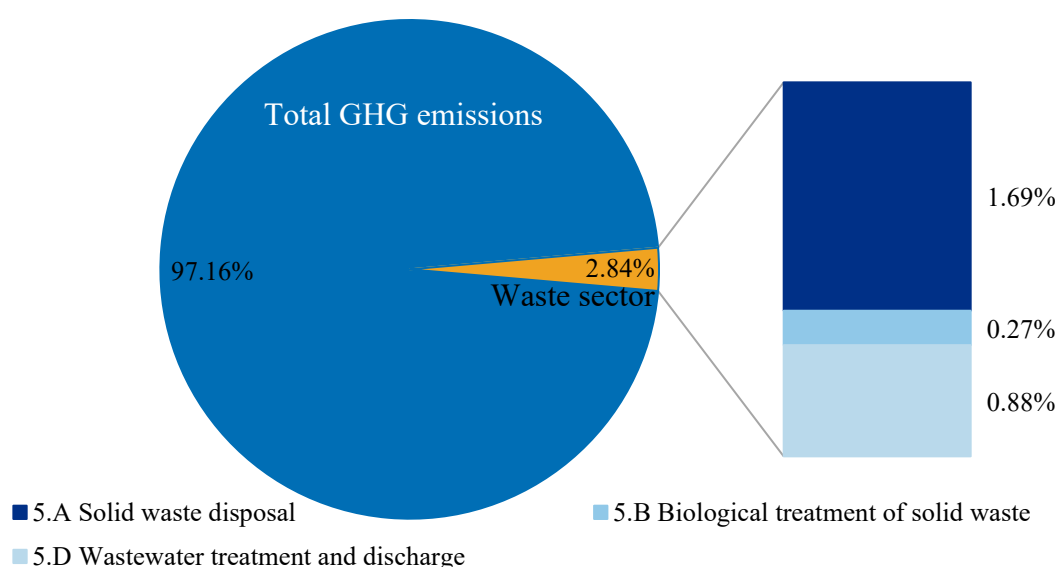


Figure 7.1. CO₂ eq. emissions from the Waste sector compared to total GHG emissions in Estonia in 2024, %

Table 7.1. Methods and emission factors used in estimations of emissions from the Waste sector

GHG SOURCE AND SINK CATEGORIES	Method applied / EF used		
	CO ₂	CH ₄	N ₂ O
5. WASTE			
5.A Solid waste disposal		T2/D	
5.B.1 Composting		T1/D	T1/D
5.B.2 Anaerobic digestion		T1/D	
5.D Wastewater treatment and discharge		T1/D	T1/D

T1 – Tier 1 method, T2 – Tier 2 method, D – IPCC 2006 default value.

³⁵⁸ MoC. (2023). National waste management plan. 2023-2028. (in Estonian) [www]
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CO₂ eq. emissions from the Waste sector were 290.86 kt in 2024 and covered 2.84% of total GHG emissions in 2024 (Figure 7.1).

Total CO₂ eq. emissions from the Waste sector in 2024 decreased by 0.99% compared to 2023. Compared to the base year of 1990, the amount of CO₂ eq. emissions in 2024 were 34.3% smaller. Compared to the base year, CO₂ eq. emissions from Solid waste disposal (SWD) have decreased by 36.8%, from Wastewater treatment and discharge by 43.7%. On the other hand, CO₂ eq. emissions from Biological treatment of solid waste have, compared to the base year of 1990, increased by 456.7%. Emissions from Waste incineration and Open burning in 2024 were 0.31 kt CO₂ eq and were not reported due to being only 0.003% of the national total emissions and therefore considered insignificant.

Since the 2026 submission, the emissions from Anaerobic digestion are also reported for the first time, as although waste related activity in the sector had occurred since 2014, the emissions had stayed below the reporting threshold until now.

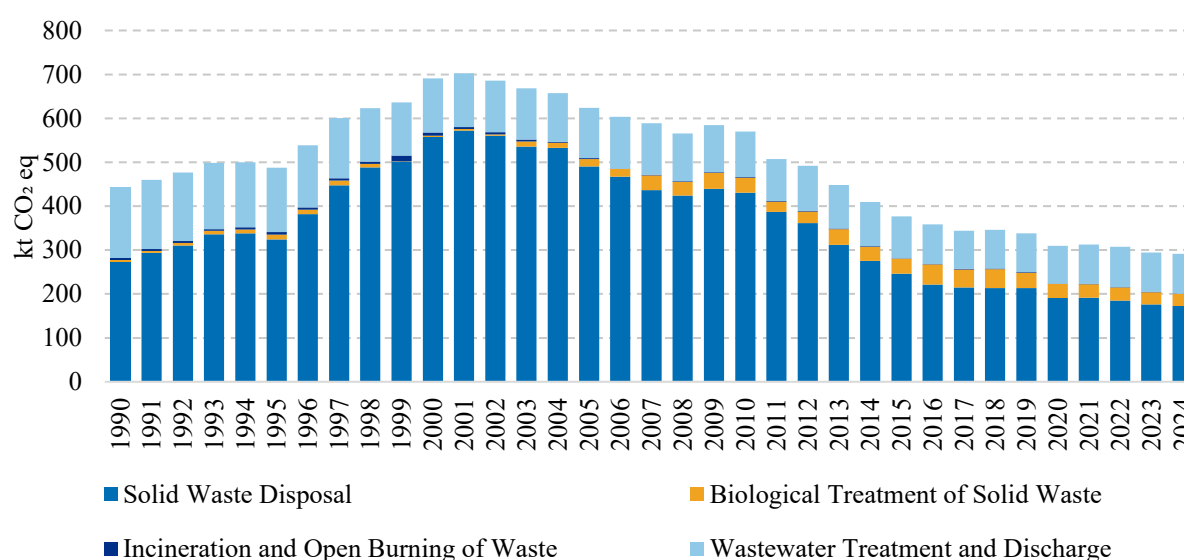


Figure 7.2. Trends of GHG emissions in the Waste sector by source categories in 1990–2024, kt CO₂ eq.

As seen in Figure 7.2 and Table 7.2, GHG emissions from the Waste sector are in a decreasing trend. Low CO₂ eq. emissions in 1995 are related to decreasing CH₄ emissions from paper and sludge disposal. The highest CO₂ eq. in 2000–2001 is related to the significant increase in emissions mainly from Solid waste disposal. The 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 the Waste sector after 2004 relates to the increasing amount of CH₄ recovery from landfills. Emissions decrease starting from 2009 is connected with the financial crisis during 2007–2008. The financial crisis did not affect the Waste sector immediately, because companies had a raw material reserve. The total CO₂ eq. in 2011 decreased significantly compared to previous years, mainly because of the change in the national currency, which raised prices in the country and therefore changed consumption habits and reduced waste generation. Also, opening the Iru waste incineration plant in 2013 had a decreasing effect on the amount of deposited waste trend.

Due to the COVID-19 pandemic, emissions decreased sharply in 2020, as the amount of generated waste decreased. Emissions increased a bit in 2021 but still remained below the 2019

level. The slight increase in 2021 total emissions is mainly driven by 5A (SWD) and 5D (Wastewater treatment) subcategories. In SWD emissions increased, because less landfill gas was collected and therefore methane recovery rate was lower compared to 2020. In addition, emissions in wastewater treatment subcategory increased as the population of low-density settlements increased based on recent census. The lowest CO₂ eq. emissions occurred in 2024, which was mainly connected to the decreasing amount of biogenic waste deposited in landfills.

Table 7.2. GHG emissions from the Waste sector in Estonia in 1990–2024, kt

Year	SWD	Waste incineration and Open burning of waste			Biological treatment of solid waste		Wastewater treatment and discharge				Total CO ₂ eq. emissions (AR5)
		non-biogenic			Composting		Anaerobic digestion	Domestic wastewater		Industrial wastewater	
		CH ₄	CO ₂	CH ₄	N ₂ O	CH ₄	N ₂ O	CH ₄	N ₂ O	CH ₄	CO ₂ eq.
1990	9.78	2.25	0.05	0.0008	0.11	0.01	NO	0.13	4.51	NO	442.96
2005	17.52	1.46	0.03	0.0005	0.37	0.02	NO	0.10	2.84	0.29	623.78
2021	6.85	0.60	0.01	0.0001	0.68	0.04	NE	0.12	2.04	0.06	312.18
2022	6.59	0.33	0.01	0.0001	0.69	0.04	NE	0.12	2.04	0.16	307.68
2023	6.30	NE, NO	NE, NO	NE, NO	0.63	0.04	NE	0.12	1.99	0.07	293.76
2024	6.17	NE, NO	NE, NO	NE, NO	0.53	0.03	0.16	0.12	2.00	0.08	290.86

NO – not occurring, NE – not estimated

NH₃ emissions are based on the data reported in NEC/CLRTAP inventories by the Estonian Environment Agency (EstEA). Total NH₃ emissions presented in Figure 7.3 include emissions from SWD, Biological treatment of solid waste, Industrial waste incineration, Cremation, Industrial and domestic wastewater treatment, and Other waste handling. The total NH₃ emissions from these categories in 2024 were 0.2 kt, remaining on a similar level as the previous years. The emissions are mainly calculated by using actual emissions data reported by the companies as well as by using the EMEP/EEA Guidebook 2023³⁵⁹.

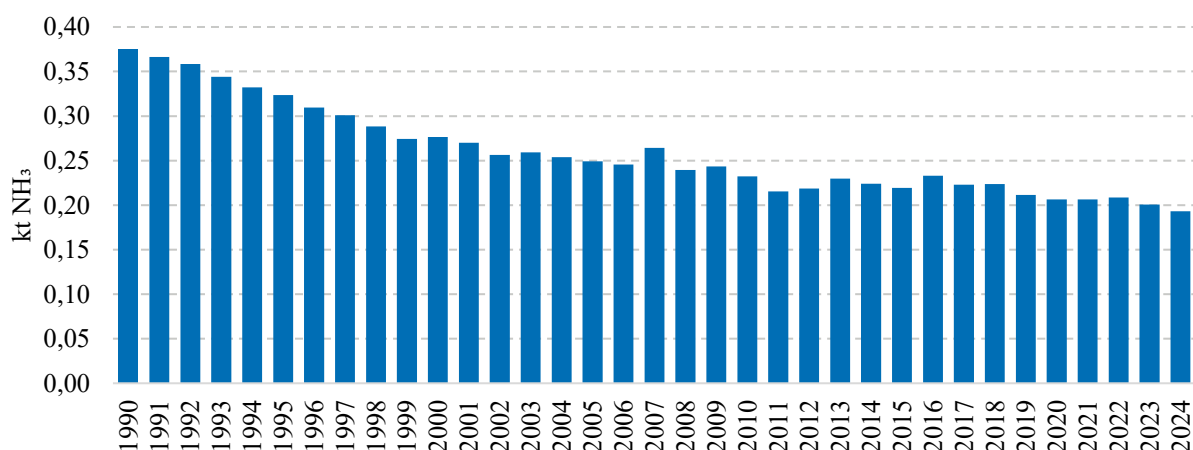


Figure 7.3. NH₃ emissions from SWD, Biological treatment of solid waste, Industrial waste incineration, and Industrial and domestic wastewater treatment, kt

³⁵⁹ EMEP/EEA air pollutant emission inventory guidebook – 2023. [www]
<https://www.eea.europa.eu/publications/emep-eea-guidebook-2023> (30.11.2025).

7.2. Solid waste disposal (CRT 5.A)

7.2.1. Category description

In 2024, Estonia had five functioning landfills (Tallinn Recycling Center, Uikala, Väätsa, Torma and Paikre) classified as managed SWD sites and three landfills for industrial waste. These landfills conform fully to environmental and technical requirements and standards and are capable of servicing more than one county or service area. Due to the strict requirements established for waste landfilling, the number of landfills started decreasing, from 157 landfills in 2001 to five landfills in 2015. Landfills closed for waste depositing were conditioned in accordance with the requirements by the end of 2015.

As seen in Figure 7.4, the quantities of emitted methane from SWD are decreasing.

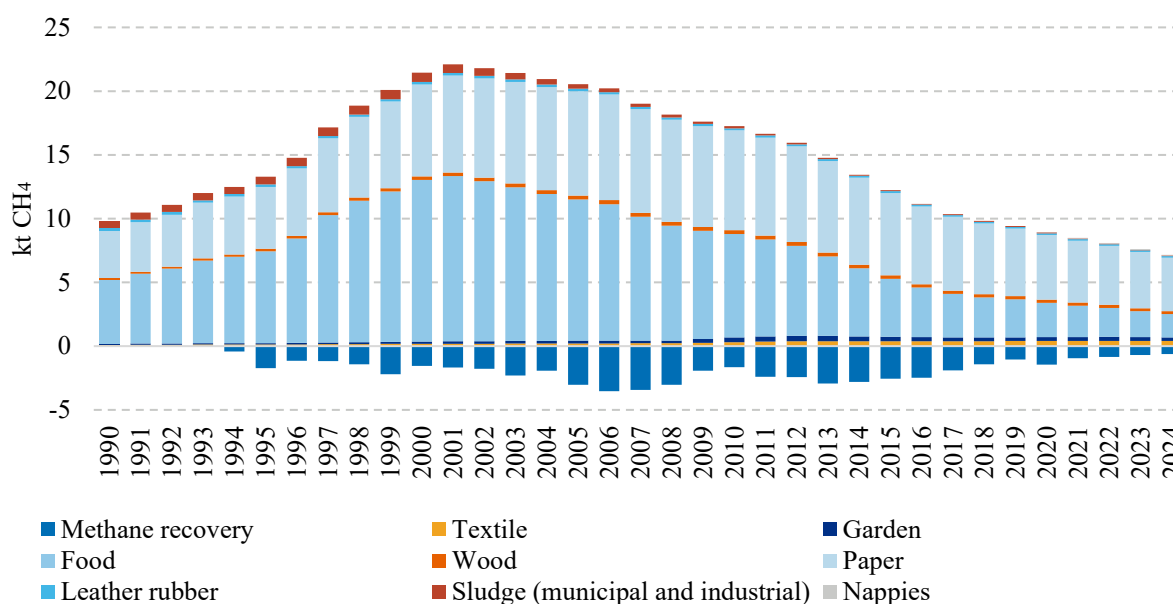


Figure 7.4. CH₄ emissions and recovery from landfills in Estonia in 1990–2024, kt CH₄

Estonia's total CH₄ emissions from SWD into landfills in 2024 amounted to 6.17 kt CH₄ (Table 7.3). Compared to 2023, emissions were 2.03% lower due to less biodegradable waste being deposited in the last previous years. Figure 7.5 shows CH₄ emissions from SWD with and without energy recovery.

Table 7.3. Quantities of CH₄ emissions and recovery from biodegradable solid waste deposited in landfills in 1990–2024, kt

Year	Organic/ Food	Garden	Paper	Wood	Textile	Sludge (municipal + industrial)	Leather	Recovery	Total CH ₄ emissions from SWD sites
1990	5.0	0.1	3.7	0.2	0.1	0.54	0.19	NO	9.78
2005	11.1	0.2	8.2	0.3	0.2	0.36	0.19	-3.0	17.52
2021	2.5	0.3	4.8	0.2	0.4	0.06	0.12	-1.0	6.85
2022	2.3	0.3	4.6	0.2	0.4	0.05	0.12	-0.9	6.59
2023	2.0	0.3	4.4	0.2	0.4	0.05	0.12	-0.7	6.30
2024	1.8	0.3	4.2	0.2	0.4	0.04	0.11	-0.6	6.17

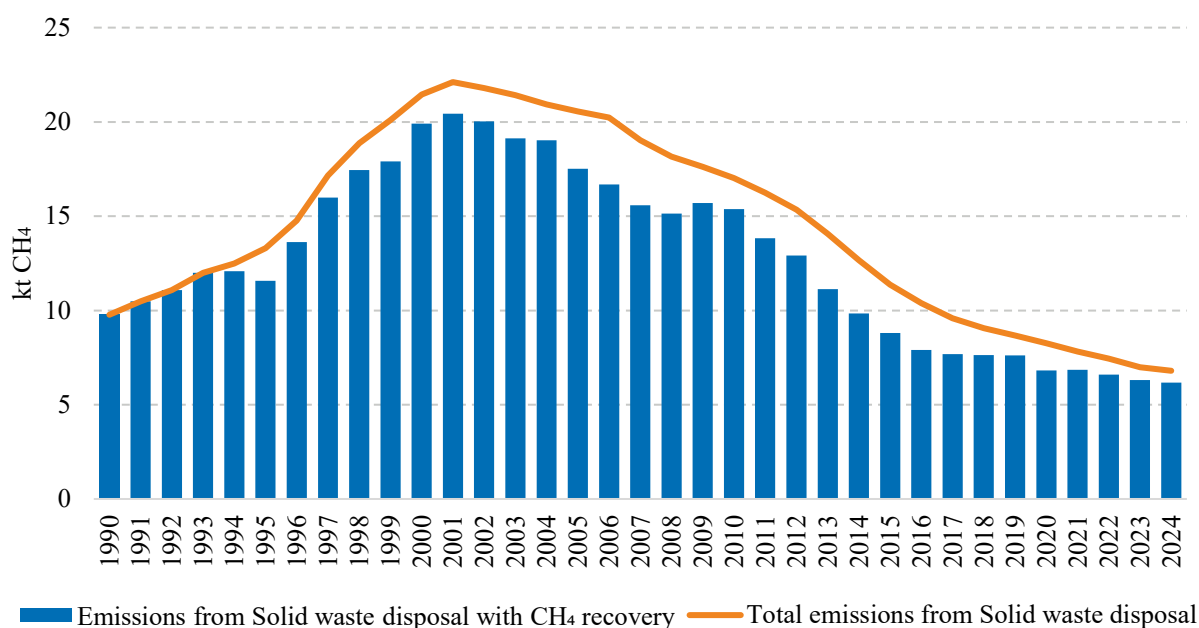


Figure 7.5. CH₄ emissions from SWD with and without energy recovery, kt CH₄

7.2.2. Methodological issues

Choice of methods

To estimate CH₄ emissions from SWD in landfills, the First Order Decay (FOD) approach, which is IPCC 2006 *Tier 2* method, was used. The FOD method with default parameters and country-specific activity data were used due to the unavailability of country-specific key parameters.

Activity data

Activity data for waste generation and depositing used in the calculation is collected from EstEA, which checks the accuracy of data reported by waste handling companies. Starting from 2020 companies submit their waste data through Environmental Decisions Information System KOTKAS, managed by Environmental Board. Reports are stored in Data Warehouse, managed by Ministry of the Climate, and published in Tableau³⁶⁰ managed by The Information Technology Centre of the Ministry of the Environment (KeMIT). Tableau provides information about the entire waste stream, including waste at the beginning of the year, imported, and exported waste, generated waste, recycled waste, incinerated waste, composting of biodegradable waste and the amount of waste left in stock at the end of the year. It is possible that the amount of waste at the end of one year does not correspond to the amount of waste at the beginning of the subsequent year. This distinction is a result of different aspects including the following:

- The waste reporting obligation is new for the company. If a company's waste permit is enforced in 2024, then the amount of waste generated by this company will be included in the total amount of waste at the beginning of 2024 and is not included in the stock of

³⁶⁰ The Information Technology Centre of the Ministry of the Environment Waste data visualizing system (Tableau). [www]

https://tableau.envir.ee/views/Avalikud_pringud_Jtmed/Riigitasand?%3Aembed=y&%3Aid=1&%3AisGuestRedirectFromVizportal=y (30.11.2025).

waste at the end of 2023 (because this company did not have the obligation to report waste in 2023).

- The company does not have to submit waste reports because its waste reporting obligation has ended (the company has changed the profile of its activities etc.). If the company's waste reporting obligation ended in 2023, then the amount of waste is counted in the stock at the end of 2023. This waste is not included in the stock at the beginning of 2024, as this waste will be given to other waste companies which will report the waste as '*received from the company*'. This amount of waste will be accounted for in total waste generation.
- The company has discovered that the data submitted the previous year was given in wrong units. In this case, they correct the error at the beginning of the subsequent year.
- The company is making an inventory at the beginning of the year and if there have been any inconsistencies in the quantities reported at the end of the previous year, then the company corrects the data at the beginning of the subsequent year. If such changes are made, they are tracked and there will be a comment about them in the online waste reporting system.

Differences between the activity data at the end of one year and at the beginning of the following year are characteristic of the national system; nevertheless, all waste data has been considered in doing emission calculations. The matter of activity data at the end of one year and at 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 proposed a method for enhancing the reporting system.

The amount of imported waste in 2024 was 113 013 tonnes, of which the majority was metal (26%), inert (24%), glass (22%), paper (10%), and plastic waste (9%) (Figure 7.6). The rest of the imported waste (9%) included rubber, wood, waste fuel, organic and municipal waste, textile and chemicals. Imported waste is reused, for example, in road construction and filling quarries, wood, glass and plastic packaging is reused. Metal waste is collected, sorted and pre-treated, then exported. All imported waste is recycled and therefore is not a part of the waste sector emission calculation (observation by the 2022 ERT to include the information).

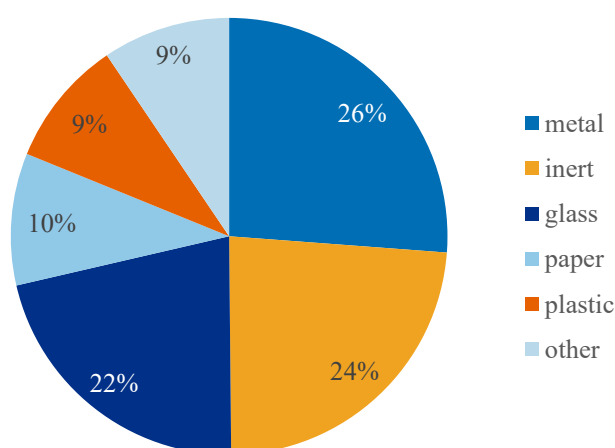


Figure 7.6. Imported waste in Estonia in 2024, %

EstEA started to collect data in accordance with the Estonian waste classification in 1992, but in 1999, the adapted classification system changed, and the European Waste Catalogue was adopted. The data for 1990–1991 was 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 of 1990–1991. For the period of 1950–1990 (historical data needed in the waste model) no data on the generated and deposited waste amount is available. For industrial waste generation, excel forecast function using the data of generated waste and GDP was used and for deposition, an average deposition percentage was used. For MSW waste an extrapolation using population and GDP was done. Data on population and GDP is obtained from the dataset of the SE.

The quantity of total waste generated in 2024 was about 14.4 million tonnes, which is 16.31% lower than in 2023. The proportion of degradable and inert waste in 2024 was 9.31% and 90.69%, respectively. The annual trend of inert and degradable waste generated in Estonia in 1990–2024 is presented in Figure 7.7. The mixed municipal waste contributed only 1.42% of the total waste generated in Estonia in 2024.

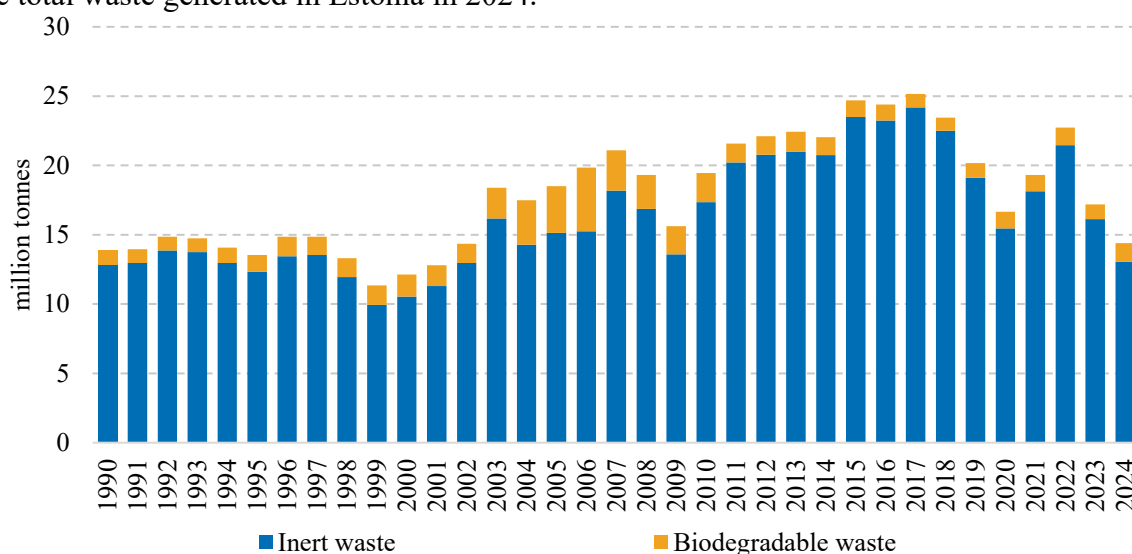


Figure 7.7. Quantities of waste generated in Estonia in 1990–2024, million tonnes

In 2024, waste generated by the oil shale industry constituted 60.9% of the total waste generated. The waste of the oil shale industry includes waste from mining and physical-chemical treatment, thermal processes, and other oil shale waste³⁶¹. Waste from the oil shale industry is not taken into account in the estimation of GHG emissions from SWD.

The quantity of municipal waste (MSW) generated in 2024 was about 204 081 tonnes in addition to a separately collected fraction, which amounted to 88 058 tonnes. The total amount of MSW generated was about 1.4% of the total waste generated. The total amount of waste deposited in landfills was 5.67 million tonnes, from which MSW comprised 63.1 thousand tonnes and industrial waste 5.60 million tonnes (Table 7.4 and Table 7.5). Separately collected MSW and deposited MSW are shown separately in Table 7.4, as the deposited MSW is calculated based on the mixed MSW sorting studies (Table 7.9). Separately collected MSW is separately reported in Tableau.

³⁶¹ Waste from the treatment of oil shale and coal, e.g., pitch. Starting from 2018 submission, oil shale fly and bottom ash are also included under oil shale waste; in previous submissions, these were reported under inert waste.

Table 7.4. Quantities of MSW deposited in SWD sites, kt

Year	Food	Garden	Paper	Wood	Textile	Sludge	Inert	Nappies	Deposited MSW	Separately collected and deposited MSW
1990	147.3	3.5	88.5	11.5	3.1	5.1	95.8	NE*	349.8	NO
2005	152.2	3.6	91.5	11.9	3.3	0.2	99.1	NE*	361.6	6.7
2021	12.8	4.6	9.3	0.7	3.2	NO	21.5	2.7	54.8	10.7
2022	8.1	2.9	5.9	0.4	2.0	NO	13.6	1.7	34.7	3.6
2023	8.1	2.9	5.9	0.4	2.0	NO	13.7	1.7	34.8	2.8
2024	10.6	3.9	13.7	0.7	3.2	NO	27.4	3.6	63.1	3.3

NO – not occurring, NE – not estimated

* The nappies category was not included as a separate category in the sorting studies until 2020 and therefore the amounts of it deposited with mixed MSW until 2019 is not known.

Table 7.5. Quantities of industrial waste deposited in SWD sites, kt

Year	Organic	Textile	Wood	Paper	Leather	Rubber	Sludge	Inert*
1990	36.0	0.7	11.5	2.75	0.49	NO	46.3	10 187.0
2005	4.6	1.2	5.9	NO	0.27	NO	1.0	11 058.9
2021	5.4	0.7	0.2	NO	0.05	NO	0.9	6 444.2
2022	4.8	0.8	0.2	0.12	0.02	NO	0.6	7 353.0
2023	3.1	0.8	0.1	0.01	0.02	NO	1.9	5 930.5
2024	2.6	0.8	0.1	2.75	0.02	NO	3.9	5 589.4

NO – not occurring; * Inert waste includes materials that do not result in CH₄ emissions when landfilled – chemicals, inert clinical waste, glass waste, inert waste, metal waste, oil shale waste, plastic waste, pottery and car tyres.

The quantity of Degradable Organic Carbon (DOC) generated in 2024 (Figure 7.8) increased by approximately 6.2% compared to the base year of 1990. In comparison with the year 2023, the amount of DOC has increased by about 5.1%, due to increased waste generation in 2024. The ratio of DOC landfilled to DOC generated has increased from 3.2% to 5.2%.

Calculated DOC content values for Municipal Waste in Table 7.6 and Table 7.8 are presented to describe the conditions in Estonia – how organic carbon content has changed over time in MSW waste as a 'group of different waste materials'. This estimation is based on the mixed municipal waste sorting studies and no waste content measurements have been made. The GHG calculations are done separately for all waste groups (e.g., food waste, garden, paper, textile etc) and therefore MSW is also divided to different waste groups. Estonia uses IPCC 2006 Guideline's default DOC contents for the FOD model in emission calculations (Table 7.8).

Table 7.6. DOC content of mixed MSW in Estonia in 1950–2024

	1950–1999	2000–2007	2008–2011	2012–2018	2019–2023	2024-onward
DOC content in MSW	0.20	0.20	0.16	0.14	0.16	0.16

Waste generated in DOC tonnes in 1990–2001 increased slightly due to the increasing amount of municipal, organic and industrial wood waste, while the share of other types of waste was smaller. A notable decrease in generated DOC tonnes in 2002 was caused by a sharp decrease in industrial wood waste while the share of other types of waste increased slightly. A notable

increase in the amount of waste generated in DOC tonnes in 2003–2008 was caused by the high but fluctuating generation of industrial wood waste. During this period, separately collected paper and wood waste were also in an increasing trend. On the other hand, the share of municipal waste started to decrease. The decline in generated waste in 2009 is connected to a sharp decrease in industrial wood waste, which, after the increase in 2010, started to decrease again in 2014. During the period of 1990–2000, a high volume of generated waste was deposited in landfills. The decrease in landfilled waste % in 1999–2001 was connected to the decreasing trend of depositing municipal and organic waste, including sludge from industrial and municipal sources. The increase in landfilled waste % in 2002 was connected to the increase in the generation of municipal waste and industrial sludge.

In the calculations Estonia uses Boreal and Temperate Wet Climate zone constants, because according to the Estonian Environmental Agency, the mean annual temperature in Estonia (1991-2020) is 6.4 degrees and precipitation is almost twice as much as evaporation, so the climate is wet.

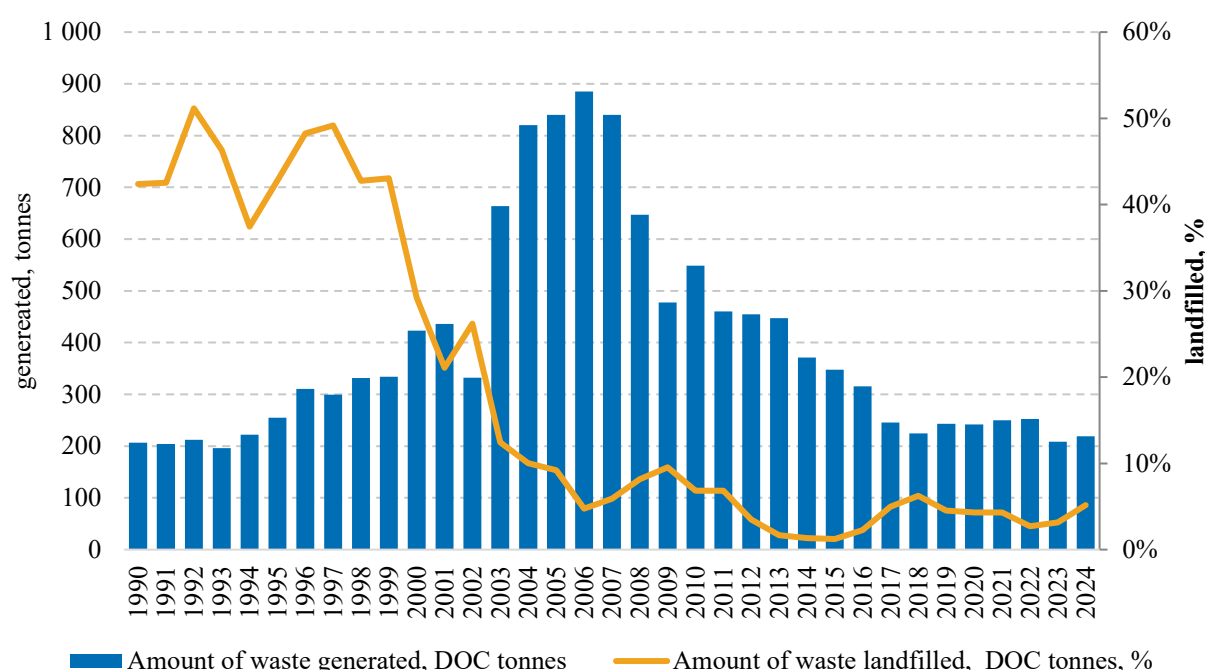


Figure 7.8. Quantity of DOC generated (tonnes) and ratio of DOC landfilled to DOC generated (%) in 1990–2024

Collecting landfill gas

The data on the amount of recovered methane in landfills 1994–2006 is based on REN-Estonia – an annual questionnaire on renewables and waste. Starting from 2007, data was obtained from EstEA’s information system for ambient air pollution sources ‘OSIS’ which is starting from 2019 replaced with database KOTKAS. From the information given by SE, the REN-Estonia report includes for the years 1994-2006 only landfills reporting biogas flaring. From the REN-Estonia report, it is possible to have the total amounts (not the amount per landfill). The control calculation has been made to validate the numbers between REN-Estonia report and KOTKAS, the results showed the same numbers and timeseries consistency between the two sources is therefore covered. The total amount of CH₄ recovered in 2024 was 0.63 kt (Figure 7.9).

The amount of CH₄ is calculated using a density of 0.717 and the CH₄ composition of 55%.

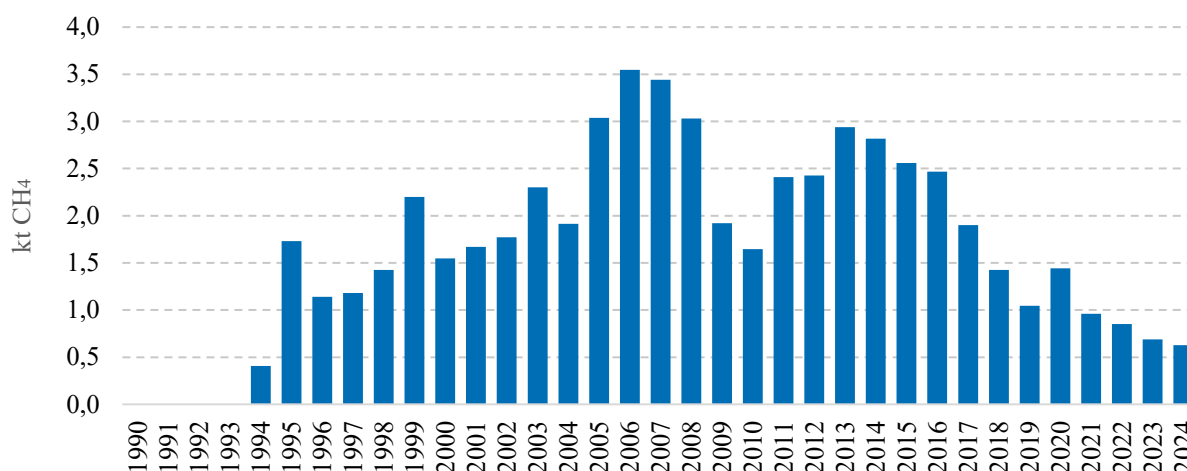


Figure 7.9. CH₄ recovered from landfills in 1994–2024, kt

Methane recovery in landfills started in 1994. In 1994–2006, only one landfill in Estonia collected and recovered methane (Pääsküla landfill in Tallinn). The amount of reused CH₄ during this period fluctuated due to changes in the quantity of waste generated and the percentage of organic waste in the total amount of waste generated. Jõelähtme landfill started to collect landfill gas in 2007. The decrease in recovered CH₄ in 2008 was caused by the decrease in recovered CH₄ from Pääsküla landfill. Additionally, Väätsa landfill and Paikre landfill started to collect biogas in 2009 and 2010, respectively. In 2013, Viljandi and Uikala landfill started to burn biogas and Aardlapalu landfill started to burn biogas with energy recovery in 2014. Burning in Viljandi landfill ended in 2018. Torma landfill started to burn biogas in 2018. The decrease of CH₄ recovered from landfills is mostly related to the decrease in the amounts of biodegradable waste being deposited in landfills.

The amount of recovered landfill gas, waste recycled and unstable population, which fluctuates during the time, also affect the implied emission factor (IEF) of CH₄.

Emission factors

Emission factors used in the calculations of emissions from SWD sites are default emission factors from the 2019 Refinement to the 2006 IPCC Guidelines (Table 7.7). Methane generation rate constants used in the calculations are default values from the 2019 Refinement to the IPCC 2006 Guidelines (Table 7.7).

Table 7.7. Emission factors and parameters used in calculations

Factor/Parameter	Value
MCF – anaerobic ³⁶²	1
MCF – uncategorised SWD sites ³⁶²	0.6
DOCf - less decomposable wastes ³⁶³	0.1
DOCf – moderately decomposable wastes ³⁶³	0.5
DOCf – highly decomposable wastes ³⁶³	0.7
F ³⁶⁴	0.5
OX	0.09

³⁶² 2019 Refinement to the IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.13, table 3.1.

³⁶³ 2019 Refinement to the IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.12, table 3.0.

³⁶⁴ 2019 Refinement to the IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.14.

Factor/Parameter	Value
Methane generation rate constant³⁶⁵	
k1 = paper waste, textile waste	0.06
k2 = wood	0.03
k3 = organic / garden and park waste, disposable nappies	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)³⁶⁶

Waste group	DOC content (fraction)
Municipal solid waste	
Food/Grease	0.15
Municipal	see Table 7.6
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	0.09 ³⁶⁷

Calculations in the FOD model are based on the country-specific data about the waste composition of MSW (Table 7.9). Five studies have been carried out in Estonia about waste composition in MSW: in 2000, 2008, 2013, 2020 and 2025. The last one was based on samples taken in both 2024 and in 2025. The period of 1950–1999 is retroactively covered with composition data derived from studies carried out in Estonia in 2000; the period of 2000–2007 is covered with data from a study carried out in 2000. The period of 2008–2011 is covered with data from a study carried out in 2008, the period of 2012–2018 is covered with data from a study carried out in 2012. The composition data in the period 2019–2023 is based on a 2020 study. From 2024, the MSW composition data from the 2024–2025 study was used.

Calculations made under SWD comprise managed and uncategorised disposal sites. All the landfills in use until 1993 are considered uncategorized because there is no accurate data available, or research conducted in Estonia about the distribution of waste by waste management type (unmanaged shallow or unmanaged deep) for this period. Pääsküla landfill in Tallinn was the first one to be categorized as managed in 1994 which is also when CH4

³⁶⁵ 2019 Refinement to the IPCC 2006 Guidelines, Volume 5, Chapter 3: Solid Waste Disposal, page 3.16, table 3.3.

³⁶⁶ 2019 Refinement to the IPCC 2006 Guidelines, Volume 5, Chapter 2: Waste generation, composition and management data, pages 2.14, 2.16, table 2.4 and 2.5.

³⁶⁷ 2019 Refinement to the IPCC 2006 Guidelines, Volume 5, Chapter 2: Waste generation, composition and management data, page 2.13

recovery started there. The period 1994–2008 is considered a transition time from uncategorized to managed landfills as both existed parallelly. By 2009, all the landfills that continued to be used had been conditioned to be managed landfills and the rest had been closed properly. From the 2026 submission, the emissions from the two types of landfills are calculated and reported separately as required by the EEA/EC review finding EE-5A-2024-0001.

Table 7.9. Composition of MSW, %

	1950–1999 ³⁶⁸	2000–2007 ³⁶⁸	2008–2011 ³⁶⁹	2012–2018 ³⁷⁰	2019–2023 ³⁷¹	2024-onward ³⁷²
Organic household waste and non-defined non-separated waste	43.1	43.1	36.7	31.8	31.7	23
Paper and cardboard	25.3	25.3	17.5	13.5	17	21.8
Wood	3.3	3.3	0.4	2.0	1.3	1.2
Textiles	0.9	0.9	4.4	5.1	5.8	5.0
Inert	27.4	27.4	41	47.6	39.2	43.4
Nappies	-	-	-	-	5	5.7

The composition of furniture waste (Table 7.10) is based on an expert judgement and a study carried out by the Stockholm Environment Institute Tallinn Centre³⁷³.

Table 7.10. Composition of furniture waste, % in 1990–2024

Composition of furniture waste	%
Wood	49.3%
Textile	24.3%
Metal	12.2%
Plastic	14.2%

7.2.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Solid waste disposal subcategory, please see Annex A.II.5 Waste, Solid waste disposal (5.A) chapter.

³⁶⁸ Vaania, (2000). Study on the composition of municipal solid waste including different regions in Estonia (in Estonian).

³⁶⁹ SEI Tallinn, (2008). Analysis of Estonian municipal waste (including separate packaging waste and biodegradable waste) composition and quantity. Study on municipal waste sorting (in Estonian). [www] <https://envir.ee/media/5317/download> (30.11.2025).

³⁷⁰ SEI Tallinn, (2013). Final report – Study on the composition of municipal waste, separately collected paper and packaging and WEEE in 2013 in Estonia (in Estonian). [www] <https://envir.ee/media/5291/download> (30.11.2025).

³⁷¹ SEI Tallinn, (2020). Final report – Study on the composition of municipal waste, separately collected paper and packaging and WEEE in 2020 in Estonia (in Estonian). [www] <https://envir.ee/media/5318/download> (30.11.2025).

³⁷² Jäätmeanalüüs OÜ, (2025). Final Report - Study on the composition of municipal waste (in Estonian). [www] https://keskkonnaportaal.ee/sites/default/files/2025-09/Sortimisuuringu%20aruanne%202025_0.pdf (07.11.2025).

³⁷³ 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 (30.11.2025).

7.2.4. Category-specific QA/QC and verification, if applicable

Complete Quality Assurance (QA) and Quality Control (QC) were carried out pursuant to the procedures described in IPCC 2006 Guidelines³⁷⁴. In addition, the specific documentation and reporting recommendations relevant to SWD described in Section 3.8 of Chapter 3 of IPCC 2006 Guidelines have been considered when carrying out QC activities.

The quality objectives and the QA/QC plan for the Estonian GHG inventory at the national level are presented in Chapter 1.5.

7.2.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process

In accordance with the EEA/EC review (finding EE-5A-2024-0001), Estonia has separated the emissions from managed and uncategorized landfills previously reported together. Additionally, as recommended during the capacity building consultations Estonian inventory team had with external experts facilitated by Umweltbundesamt (UBA) within the Effort Sharing Regulation sectors capacity-building support, Estonia started using waste model from the 2019 refinement to the 2006 IPCC Guidelines. These changes affect the CH₄ emissions and reporting in the Solid waste depositing category for the years 1990-2023.

Additionally, the MSW composition for the years 2008-2011 was corrected as previously the percentages of the different waste fractions had been mistakenly rounded. This affected the emissions for the years 2009-2023.

The emissions shown in Table 7.11 below are final and include all the recalculations and corrections mentioned.

Table 7.11. Change in CH₄ emissions from Solid waste disposal with CH₄ recovery in 2025 and 2026 submission

	2025 submission CH₄ emissions from Solid waste disposal	2026 submission CH₄ emissions from Solid waste disposal
1990	8.55	9.78
1991	9.15	10.48
1992	9.66	11.07
1993	10.47	12.00
1994	10.49	12.07
1995	9.89	11.57
1996	11.71	13.63
1997	13.62	15.98
1998	14.84	17.44
1999	15.18	17.90
2000	16.99	19.90
2001	17.47	20.44
2002	17.25	20.03
2003	16.52	19.12
2004	16.65	19.02
2005	15.33	17.52
2006	14.64	16.68

³⁷⁴ IPCC 2006 Guidelines, Volume 1, Chapter 6: Quality Assurance / Quality Control and Verification.

	2025 submission CH₄ emissions from Solid waste disposal	2026 submission CH₄ emissions from Solid waste disposal
2007	13.82	15.58
2008	13.59	15.13
2009	14.29	15.70
2010	14.08	15.37
2011	12.68	13.83
2012	11.93	12.92
2013	10.37	11.13
2014	9.32	9.83
2015	8.49	8.80
2016	7.76	7.91
2017	7.64	7.68
2018	7.65	7.63
2019	7.67	7.62
2020	6.93	6.82
2021	7.01	6.85
2022	6.79	6.59
2023	6.55	6.30

7.2.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

The activity data is kept under consideration and will be updated as necessary.

7.3. Biological treatment of solid waste (CRT 5.B)

7.3.1. Category description

The total emissions from Biological treatment of solid waste include CH₄ and N₂O emissions from composting both municipal and industrial waste as well as anaerobic digestion of solid waste. In 2024, the total emissions from Biological treatment of solid waste in Estonia were 27.64 kt CO₂eq. Figure 7.10 shows the change in emissions from composting and anaerobic digestion of solid waste in Estonia in the period 1990-2024.

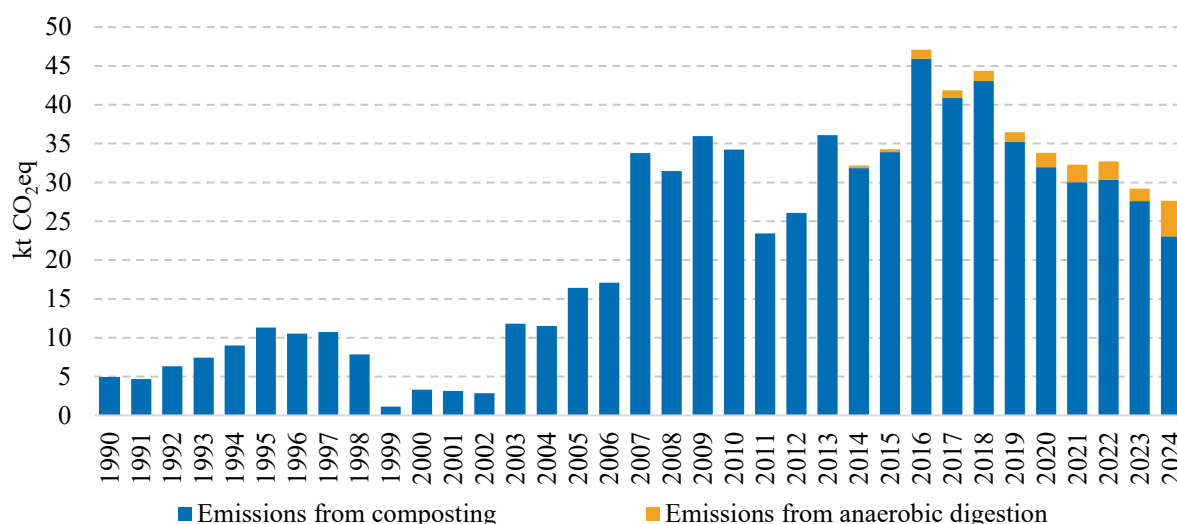


Figure 7.10. Emissions from biological treatment of solids waste in Estonia in 1990-2024, kt CO₂eq

Emissions from composting of solid waste in 2024 comprised 0.53 kt CH₄ and 0.03 kt N₂O emissions. The sharp increases in the quantities of CH₄ emissions since 2003 are related to the large quantities of wood, sludge and organic waste composted during these years. High emissions in 2009 are due to a considerable effect from organic waste composting. The decline in composted waste since 2010 was caused by the opening of the Iru waste incineration facility. Furthermore, the slightly larger amount of landfilled sludge starting from 2010 also contributed to the decreasing emissions from composting. In 2016, the amount of waste composted increased due to the increased amount of composted sludge, garden and wood waste. Compared to 2023, the emissions from composting have decreased in 2024 due to more organic waste being sent to anaerobic digestion (as two new waste-based biogas production plants opened and another one reached full production) and increased mechanical recycling and export of wooden waste.

The emissions from Anaerobic digestion were known to be below the reporting threshold and due to that, the emissions were first considered in the 2024 submission in the national inventory emission calculations. This is a result of a project (2020-2023) during what Estonia developed a methodology to estimate GHG emissions from the production of biomethane from agricultural (and waste) sources. Emissions are allocated under Energy, Agriculture and Waste sectors. Emissions from biogas use will be reported under the Energy sector, emissions from biogas production from manure are reported under Agriculture sector and from waste sources are reported under the Waste sector (5.B.2) as anaerobic digestion also includes some co-digestates added to the manure into the biogas reactor. Based on the IPCC 2006 Guidelines, N₂O emissions from anaerobic digestion at biogas facilities are assumed to be negligible.

Since 2024, the emissions from anaerobic digestion were above the reporting threshold and contributed a total of 0.16 kt CH₄ to the national emissions. Estonia launched anaerobic digestion in biogas facilities in 1994 and has estimated unintentional leakages due to process disturbances or during other unexpected events by using IPCC 2006 default value of 5% of the generated CH₄. Waste as co-substrate in agricultural biogas facilities has been added from 2014. In 2023, the first biogas production plant running entirely on food waste was opened, and in 2024, two more entirely waste-based biogas production plants have started operating. For this reason, the highest emissions from anaerobic digestion of solid waste also occurred in 2024.

7.3.2. Methodological issues

Choice of methods

In order to estimate emissions from biological treatment of waste, IPCC 2006 *Tier 1* approach (Equation 7.1 and Equation 7.2) was used. In addition, 40% of dry weight in compostable waste is included in the calculations based on the remark in IPCC 2006³⁷⁵ noting it is assumed that the moisture content in wet waste is 60%.

Equation 7.1³⁷⁶

$$CH_4 \text{ Emissions} = \sum_i (M_i \times EF_i) \times 10^{-3} - R$$

Where:

CH₄ emissions = total CH₄ emissions in inventory year, kt CH₄;
M_i = mass of organic waste treated by biological treatment type *i*, kt;
EF = emission factor for treatment *i*, g CH₄/kg waste treated;
R = total amount of CH₄ recovered in inventory year, kt CH₄;
i = composting or anaerobic digestion.

Equation 7.2³⁷⁷

$$N_2O \text{ Emissions} = \sum_i (M_i \times EF_i) \times 10^{-3}$$

Where:

N₂O emissions = total N₂O emissions in inventory year, kt N₂O;
M_i = mass of organic waste treated by biological treatment type *i*, kt;
EF = emission factor for treatment *i*, g N₂O/kg waste treated;
i = composting or anaerobic digestion.

Activity data

The quantities of waste biologically treated in 2024 are used as activity data (Table 7.12, Table 7.13). Waste handling companies are obligated to report the amount of waste biologically treated to EstEA, which processes data and checks its accuracy.

In 2024, 52 592 tonnes (dry weight) of waste were composted. Companies report the waste amounts in wet weight basis which are then recalculated to dry weight. Inert waste and petroleum product waste consist of oils and stone; waste from the oil shale industry and plastic waste are not considered in the estimates. Abbreviation NO indicates that the waste type was not composted.

³⁷⁵ IPCC 2006 Guidelines, Volume 5, Chapter 4: Biological treatment of Solid Waste, page 4.6, table 4.1, remark

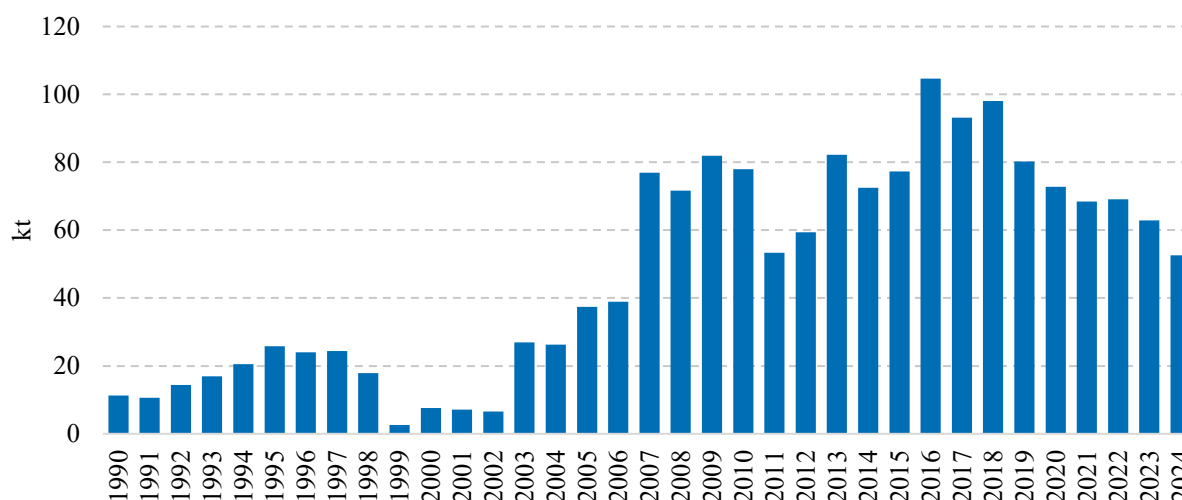
³⁷⁶ IPCC 2006 Guidelines, Volume 5, Chapter 4: Biological treatment of Solid Waste, page 4.5, equation 4.1.

³⁷⁷ IPCC 2006 Guidelines, Volume 5, Chapter 4: Biological treatment of Solid Waste, page 4.5, equation 4.2.

Table 7.12. Quantities of waste composted in 1990–2024, tonnes dry weight³⁷⁸

Year	MSW	Organic waste	Paper	Sludge	Textiles	Wood	Total
1990	NO	1 500	NO	8 651	58	1 101	11 310
2005	NO	1 543	NO	27 056	NO	8 832	37 431
2021	NO	5 820	NO	34 783	NO	27 800	68 403
2022	NO	7 488	NO	35 211	NO	26 417	69 116
2023	NO	3 483	NO	40 199	NO	19 214	62 896
2024	NO	2 775	NO	37 758	NO	12 059	52 592

NO – not occurring

**Figure 7.11.** Composted organic waste in 1990–2024 (kt, dry weight)

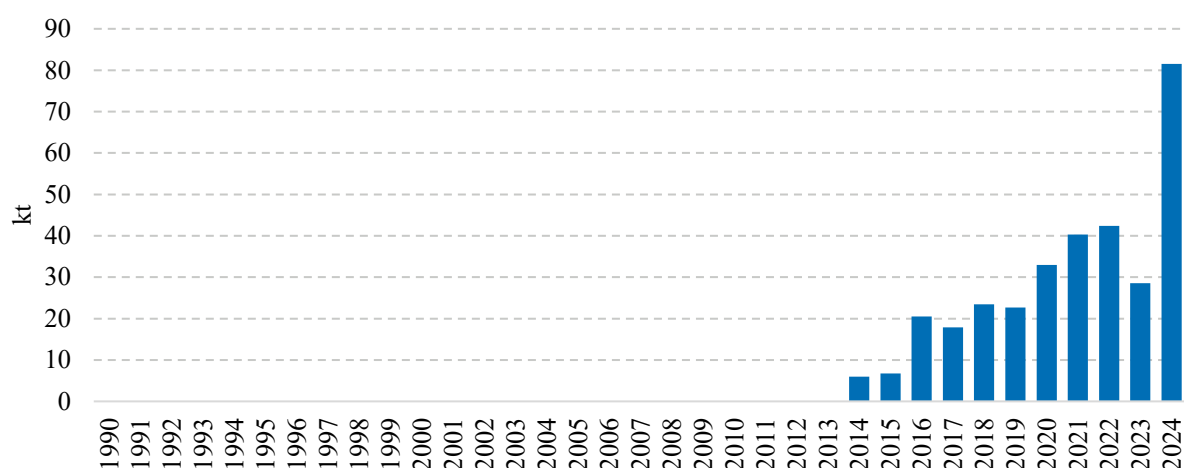
As seen in Figure 7.11, the amount of organic waste used in composting was marginal in the first decade of the period but started to grow rapidly in 2003 and has increased significantly – from 11 310 tonnes (dry weight) in 1990 to 104 642 tonnes (dry weight) in 2016. The decline in composted waste since 2010 was caused by 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 waste for composting has increased significantly in recent years due to the adopted Landfill directive 1999/31/EC, in which the percentage limitation on the quantities of organic waste deposited in landfills is enacted by time periods. The increase in the amount of waste composted in 2016 is connected to the growth of recycling, the slight increase in 2018 is connected to the decreased amount of landfilled sludge. The decrease of composted waste in 2020–2024 is mostly caused by the opening of several waste based biogas production facilities in Estonia. Compared to 2023, the quantities of composted waste have decreased by 16.4%.

In 2024, 81 495 tonnes (dry weight) of waste were sent to anaerobic digestion. Table 7.13 shows the amounts of dry waste sent to anaerobic digestion. Abbreviation NO indicates that the waste type was not sent to anaerobic digestion and NE that the amounts were not estimated for the given year as they were insignificant.

³⁷⁸ The data of 1990–1994 was interpolated as there is no waste reporting data available for those years. An expert judgement which was taken during the compilation of 2008 NIR by the Tallinn University of Technology compiling the waste sector inventory that time. The rough estimation for the period of 1990–1994 is that about 5% yearly increase of organic and wood waste is representing the historical conditions. Because there was no consistent information on the textile waste for that period therefore it remained on the level of 1995. The sludge data for 1990–1998 is based on an expert judgement received in 2024.

Table 7.13. Quantities of waste anaerobically digested in 1990–2024, tonnes dry weight

Year	MSW	Organic waste	Paper	Sludge	Textiles	Wood	Total
1990	NO	NO	NO	NO	NO	NO	NO
2005	NO	NO	NO	NO	NO	NO	NO
2021	NO	NE	NO	NE	NO	NE	NE
2022	NO	NE	NO	NE	NO	NE	NE
2023	NO	NE	NO	NE	NO	NE	NE
2024	NO	41 688	NO	29 640	NO	10 167	81 495

**Figure 7.12.** Anaerobically digested organic waste in 1990–2024 (kt, dry weight)

As seen in Figure 7.12, the waste started to be used as a substrate in anaerobic digestion in 2014 when it was used as a smaller part of the total input in agricultural biogas facilities. Since then, the trend of using waste in anaerobic digestion has been increasing. The drop in 2023 is related to lower generation of biodegradable waste that year. The peak in 2024 is due to the opening of two new waste-input based biogas production plants and the reaching of full production of another one opened in 2023.

Emission factors

IPCC 2006 Guidelines default dry weight emission factors are used in the biological treatment calculations (Table 7.14).

Table 7.14. Default emission factors for calculating CH₄ and N₂O emissions from biological treatment of waste³⁷⁹

	CH ₄ emission factor (g CH ₄ /kg waste treated, dry weight)	N ₂ O emission factor (g N ₂ O/kg waste treated, dry weight)
Composting	10	0.6
Anaerobic digestion	2	Assumed negligible

7.3.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Biological treatment of solid waste subcategory, please see Annex A.II.5 Waste, Biological treatment of solid waste (5.B) chapter.

³⁷⁹ IPCC 2006 Guidelines, Volume 5, Chapter 4: Biological treatment of Solid Waste, page 4.6, table 4.1.

7.3.4. Category-specific QA/QC and verification, if applicable

Complete QA and QC were carried out pursuant to the procedures described in IPCC 2006 Guidelines³⁸⁰. In addition, the specific documentation and reporting recommendations relevant to SWD described in Section 3.8 of Chapter 3 of IPCC 2006 Guidelines have been taken into account when carrying out QC activities, as the activities are also applicable to Biological treatment of waste.

The quality objectives and the QA/QC plan for the Estonian GHG inventory at the national level are presented in Chapter 1.5.

7.3.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process

No category-specific recalculations were done.

7.3.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

The activity data is kept under consideration and will be updated as necessary.

7.4. Waste incineration and open burning (CRT 5.C)

Emissions from waste incineration with energy recovery are reported under the Energy sector.

In the waste sector, the emissions from the subcategory Incineration and open burning of waste are no longer reported due to the emissions from this category being insignificant. In 2024, no incineration of waste without energy recovery occurred and the related emissions were therefore 0. The emissions from open burning of waste in 2024 were 0.31 kt CO₂eq which was only 0.003% of the national total GHG emissions.

The activity data and the emissions for 1990-2022 from incineration of waste without energy recovery and open burning of waste can be seen in the CRT tables 5.C.1 and 5.C.2 accordingly, the methodology used for the calculations can be seen in the 2024 or earlier NID submissions.

On the basis of decision 18/CMA.1 Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement paragraph 32³⁸¹ Party may use the notation key “NE” when the estimates would be insignificant.

7.5. Wastewater treatment and discharge (CRT 5.D)

7.5.1. Category description

Total CH₄ emissions from Wastewater treatment and discharge in 2024 consisted of 2.00 kt from domestic wastewater handling (Figure 7.13) and 0.08 kt from industrial wastewater handling (Figure 7.14).

³⁸⁰ IPCC 2006 Guidelines, Volume 1, Chapter 6: Quality Assurance/Quality Control and Verification.

³⁸¹ Paragraph 32 – emissions should only be considered insignificant if the likely level of emissions is below 0.05% of the total national GHG emissions (without LULUCF).

CH₄ emissions from domestic wastewater handling in 2024 have increased slightly compared to 2023 due to increased population.

The most common wastewater treatment method in developed countries including Estonia is centralised aerobic wastewater treatment which consists of primary, secondary and tertiary treatment. Centralised wastewater treatment (e.g., Paljassaare wastewater plant in Tallinn) for domestic and industrial wastewater takes place as follows:

Wastewater from households and commercial institutions is collected by collecting systems to the main pumping station where primary mechanical clearance takes place. After that the wastewater is channelled 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 an aerobic environment and activated sludge processes with the effluent of phosphorous and nitrogen. Biogas anaerobic digestion of sludge is reused to heat up the buildings situated in the plant's territory as well as in several wastewater treatment processes. Treated wastewater is led into the sea 3 km from the coast with a pipeline reaching 26 m below sea level. A similar wastewater treatment is also used in other Estonian cities. Centralised aerobic treatment plants are not included in the calculations of CH₄ emissions from wastewater as the methane correction factor, based on the IPCC 2006 Guidelines, is considered 0.

The source of domestic CH₄ is divided between anaerobic wastewater systems which include latrines septic systems with filtration systems or infiltration systems and anaerobic shallow lagoons. The decrease in domestic CH₄ emissions in 1990 and 2007 was caused by the increasing development of centralised aerobic treatment plants. The fluctuation of CH₄ emissions from a domestic source is also related to the amount of new residential buildings that at first used anaerobic treatment for their wastewater treatment and later connected to the centralised wastewater treatment system. Since 2000 investments into wastewater treatment systems have led to a decreasing trend in CH₄ emissions.

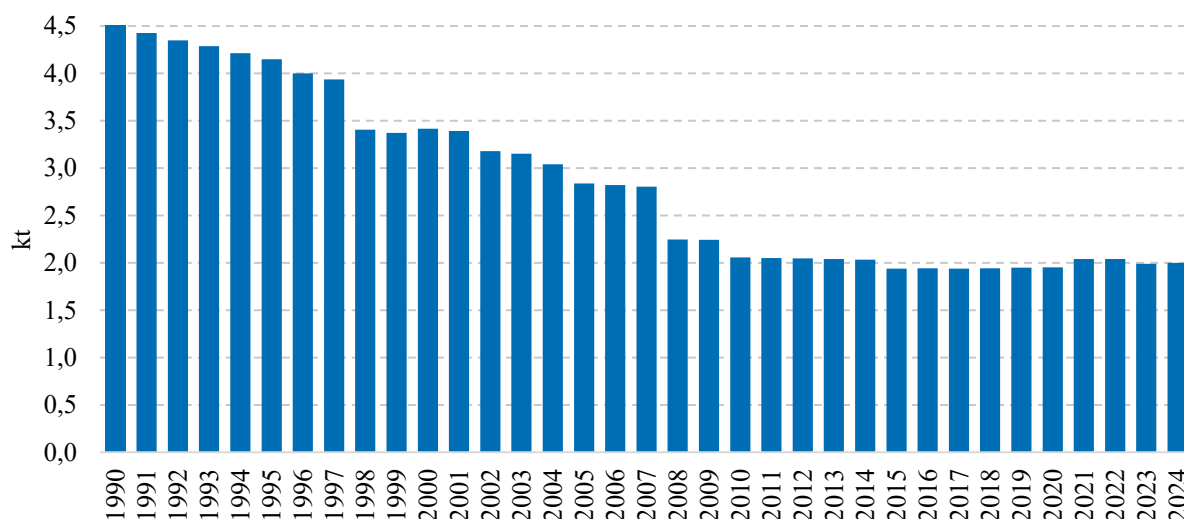


Figure 7.13. CH₄ emissions from domestic wastewater handling in 1990–2024, kt CH₄

Industrial wastewater CH₄ (Figure 7.14) is emitted from a single company in Estonia which has treated its wastewater anaerobically since 2000. CH₄ emissions in 2000 and 2001 were calculated with interpolated activity data on the amount of wastewater data from the period of 2002–2005. Interpolation for industrial wastewater quantities for the years 2000 and 2001 was necessary because cooling water was reported together with industrial wastewater. Fluctuations

in later years were caused by the fluctuation in industry production and the amount of generated wastewater. The company changed the production structure due to labour shortage in 2021. Production emphasize was given to premium products and the share of standard products was decreased. In 2022 the company applied for a new environmental permit due to the changed production technology. According to the revised permit, starting from 2010, not all wastewater goes directly to the wastewater treatment plant, but part of it is produced as a co-product – vinasse. The small peak of emissions in 2022 was related to slightly higher production.

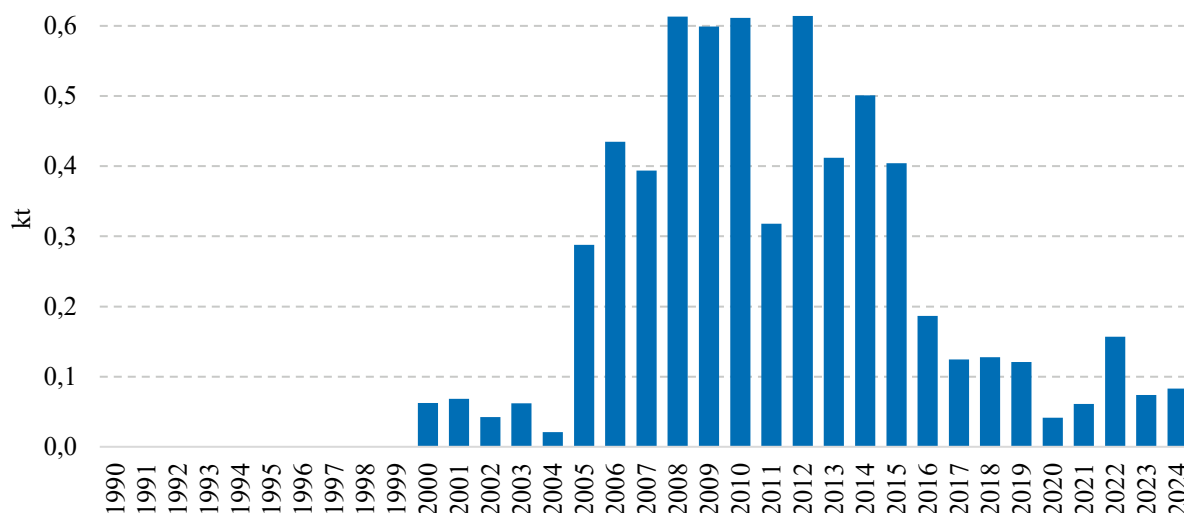


Figure 7.14. CH₄ emissions from industrial wastewater handling in 1990–2024, kt CH₄

N₂O emissions from domestic sources are presented in Figure 7.15. The total amount of N₂O emissions from wastewater in 2024 was 0.12 kt. The minor fluctuation in the time series is related to changes in the amount of nitrogen removed with sludge and protein consumption values per capita.

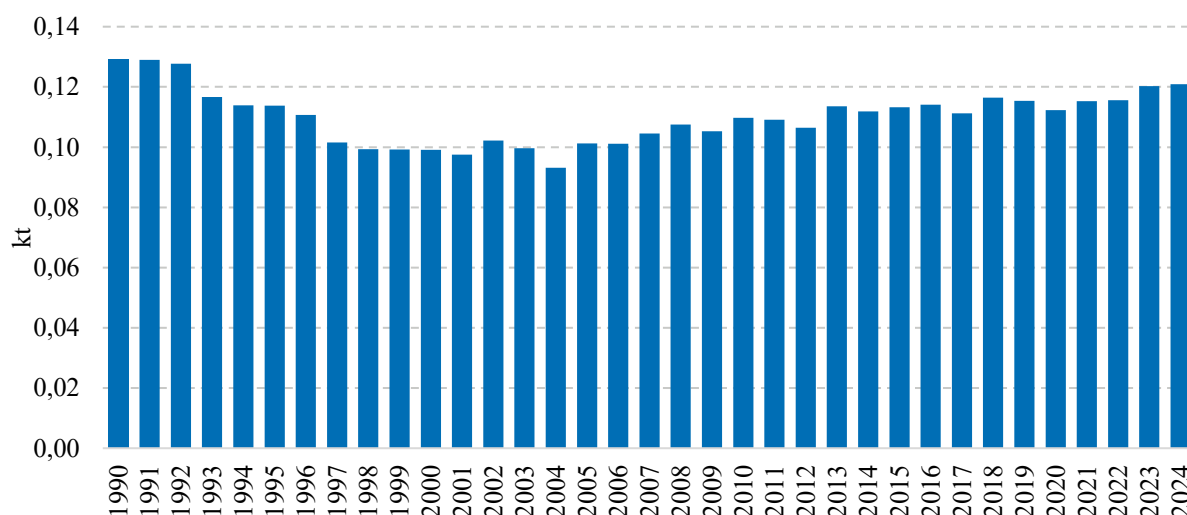


Figure 7.15. N₂O emissions from domestic wastewater handling in 1990–2024, kt N₂O

7.5.2. Methodological issues

Choice of methods

The calculation of CH₄ emissions from domestic and industrial wastewater and N₂O from wastewater is based on IPCC 2006 *Tier 1* method due to unavailable country-specific parameters.

CH₄ emission calculations from domestic sources were done by using Equation 7.3, Equation 7.4 and Equation 7.5. CH₄ emission calculations from industrial sources were done by using Equation 7.4, Equation 7.5 and Equation 7.7.

Equation 7.3³⁸²

$$CH_4 Emissions = \sum (TOW_j \times EF_j) - S - R$$

Equation 7.4³⁸³

$$CH_4 Emissions = \sum_i [(TOW_i - S_i) \times EF_i - R_i]$$

Equation 7.5³⁸⁴

$$EF_{j/i} = B_o \times MCF_{j/i}$$

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>i</i> in inventory year kg COD/yr;
<i>i</i> =	industrial sector;
<i>j</i> =	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>i</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 7.6 is used for calculating TOW in domestic wastewater and Equation 7.7 for calculating TOW in industrial wastewater. The correction factor for additional industrial BOD discharged into sewers is not included in domestic/commercial wastewater TOW calculations. CH₄ emissions are calculated from uncollected wastewater treatment systems with no additional industrial wastewater.

Equation 7.6³⁸⁵

$$TOW = P_j \times BOD_j \times 0.001 \times 365$$

³⁸² Equation proposed by TERT.

³⁸³ IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.20, equation 6.4.

³⁸⁴ IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.12, equation 6.2.

³⁸⁵ Equation proposed by TERT.

Where:

TOW = total organic matter in wastewater in inventory year kg BOD/yr;
 P_j = country population in inventory year (person);
 BOD_j = country-specific BOD per capita in inventory year g/person/day
 j = each treatment/discharge pathway or system;
0.001 = conversion from g BOD to kg BOD.

Equation 7.7³⁸⁶

$$TOW_i = P_i \times W_i \times COD_i$$

Where:

TOW_i = total biodegradable 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 m³/t product;
 COD_i = chemical oxygen demand (industrial degradable organic component in wastewater) kg COD/m³.

N₂O emission calculations from domestic sources were done by using Equation 7.8 and Equation 7.9.

Equation 7.8³⁸⁷

$$N_2O \text{ Emissions} = N_{EFFLUENT} \times EF_{EFFLUENT} \times 44/28$$

Where:

N₂O Emissions = N₂O emissions in inventory year kg N₂O/yr;
 $N_{EFFLUENT}$ = nitrogen in the effluent discharged into aquatic environments kg N/yr;
 $EF_{EFFLUENT}$ = emission factor for N₂O emissions from discharged effluent into wastewater kg N₂O-N/kg N.

The factor 44/28 is the conversion of kg N₂O-N into kg N₂O.

Equation 7.9³⁸⁸

$$N_{EFFLUENT} = (P \times PROTEIN \times F_{NPR} \times F_{NON-CON} \times F_{IND-COM}) - N_{SLUDGE}$$

Where:

$N_{EFFLUENT}$ = total annual quantity of nitrogen in the wastewater effluent kg N/yr;
 P = human population;
Protein = annual protein consumption per capita 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 protein co-discharged into the sewer system;
 N_{SLUDGE} = nitrogen removed with sludge (default = zero) kg N/yr.

³⁸⁶ IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.22, equation 6.6.

³⁸⁷ IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.25, equation 6.7.

³⁸⁸ IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.25, equation 6.8.

Activity data

The calculation of CH₄ emissions from Domestic wastewater is based on the national inventory of wastewater treatment types in low population settlements³⁸⁹. As suggested by the ESD review team in 2017, the balance scheme of wastewater pathways was added (Figure 7.16) which are also shown in Table 7.15 and Table 7.16.

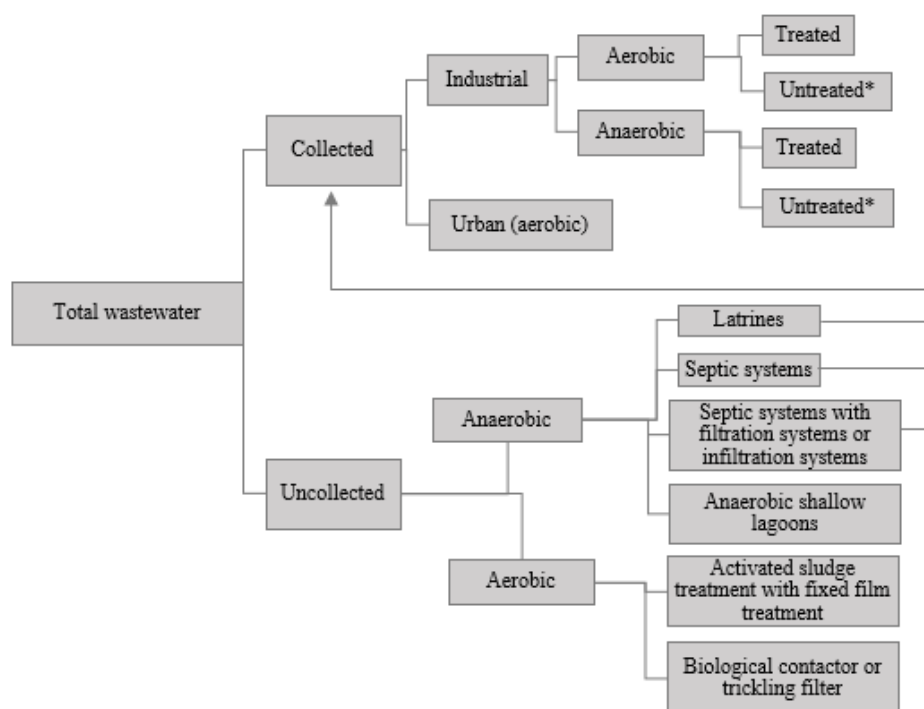


Figure 7.16. Typical balance of wastewater pathways for domestic wastewater in Estonia

This inventory covers the time series of the domestic wastewater treatment types in low population settlements with 50 or less persons. CH₄ emission calculations from domestic sources include anaerobic wastewater treatment systems (Figure 7.16):

- latrines (LT);
- septic systems (SEP);
- septic systems (SEP) with filtration systems (FS) or infiltration systems (IF);
- anaerobic shallow lagoons (ASL).

Latrines and septic systems are emptied into the centralised aerobic wastewater systems based on necessity and local government regulations.

Aerobic systems used for wastewater handling but not included in CH₄ calculations are:

- activated sludge treatment (AST) with fixed film treatment (FFT);
- biological contactor or trickling filter (BC/TF)

³⁸⁹ Table is based on a study by Infragate, (2014). Inventory report on on-site wastewater treatment systems in low-density settlements. (in Estonian) [www] https://kliimaministeerium.ee/sites/default/files/documents/2021-10/Hajaasustuste%20reovee%20kohtka%20lustruste%20inventuuri%20aruanne_0.pdf (28.11.2025)

Table 7.15. Wastewater treatment systems in low population settlements, %

Year	AST + FFT	AS T	AS L	BC/TF	LT (1–6 persons)	LT (6 or more 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
2005	0.06	0.8	1.9	0.7	19.2	2.2	56.1	0.5	18.7	100
2021	0.07	0.7	1.5	0.7	15.7	1.8	47.5	1.1	31.0	100
2022	0.07	0.7	1.5	0.7	15.5	1.7	46.9	1.1	31.9	100
2023	0.07	0.7	1.5	0.7	15.2	1.7	46.3	1.1	32.7	100
2024	0.07	0.7	1.5	0.7	15.0	1.6	45.7	1.1	33.6	100

NO – not occurring

Anaerobic wastewater treatment systems in high population settlements (Table 7.16) (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 the expert judgement of MoC. Data from 1998–2024 has been obtained from EstEA.

Table 7.16. Wastewater treatment systems in high population settlements, %

Year	LT (1–6 persons)	SEP SEP+FS SEP+IF	Centralised aerobic treatments	Total %
1990	11.4	25.8	62.8	100
2005	5.7	20.3	74	100
2021	3.2	14.8	82	100
2022	3.2	14.8	82	100
2023	3.0	14.0	83	100
2024	2.9	14.1	83	100

Data on population is obtained from the dataset of the SE.

The calculations of CH₄ emissions from Industrial wastewater are based on 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 centralised aerobic treatment plants (well-managed with MCF 0) or they have their own well-managed aerobic treatment systems (MCF 0).

The generated CH₄ was flared in 2000–2009 and starting from 2010 CH₄ was recovered for energy. Degradable Organic Carbon (DOC) used in the calculations is calculated based on the cleaning efficiency. COD concentration in 2000–2004 was calculated based on the BOD concentration because there is no plant-specific COD data on that period. In addition, industrial wastewater quantity interpolation for years 2000 and 2001 was necessary due to the reporting accuracy of that period as cooling water was reported together with industrial wastewater. Starting from 2005 plant-specific COD concentrations were included in the calculations. In 2022 the company applied for a new environmental permit due to the changed production technology. According to the revised permit, starting from 2010, not all wastewater goes directly to the wastewater treatment plant, but part of it is produced as a co-product – vinasse, therefore the COD concentrations became lower.

For calculating N₂O emissions, the Estonian population data obtained from the dataset of the SE and the annual protein consumption per capita from FAO statistical database³⁹⁰ were used as activity data. Nitrogen in sludge was calculated based on the data obtained from the dataset of EstEA. As industrial and commercial wastewater in Estonia is co-discharged into the domestic sewer system, the default F_{IND-COM} fraction of 1.25 is applied to Equation 7.9 for calculating total nitrogen in the effluent.

Emission factors

The IPCC 2006 Guidelines default emission factors used in calculations are presented in Table 7.17.

Table 7.17. Emission factors and parameters used in the calculations of Wastewater treatment and discharge

	Value
CH₄ from domestic wastewater	
Bo (kg CH ₄ /kg BOD) ³⁹¹	0.6
Degradable organic component (g BOD/person/day) ³⁹²	60
MCF anaerobic lagoon ³⁹³	0.2
MCF septic system ³⁹³	0.5
MCF latrines ³⁹³	0.7
MCF centralised wastewater treatment ³⁹³	0
CH₄ from industrial wastewater	
Bo (kg CH ₄ /kg COD) ³⁹⁴	0.25
MCF ³⁹⁵	0.8
N₂O from wastewater ³⁹⁶	
F _{NRP} (kg N/year)	0.16
F _{NON-CON}	1.4
F _{IND-COM}	1.25
EF _{EFFLUENT} (kg N ₂ O-N/kg-N)	0.005

The 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 collecting system. It is necessary to consider this possibility. In 1990's it was popular for households to have a garbage disposal unit to shred food waste and lead it into the wastewater system. Nowadays this type of technology is not so popular, and some local governments prohibit the activity with the public water supply and sewerage regulation. Nevertheless, the possibility of washing food down the collecting system has to be considered when calculating N₂O emissions.

7.5.3. Uncertainty assessment and time-series consistency

For uncertainty assessment of Wastewater treatment and discharge subcategory, please see Annex A.II.5 Waste, Wastewater treatment and discharge (5.D) chapter.

³⁹⁰ FAOSTAT New food Balances database [www] <http://www.fao.org/faostat/en/#data/FBS> (30.11.2025)

³⁹¹ IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.12, table 6.2.

³⁹² IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.14, table 6.4.

³⁹³ IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.13, table 6.3

³⁹⁴ IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.21.

³⁹⁵ IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.21, table 6.8

³⁹⁶ IPCC 2006 Guidelines, Volume 5, Chapter 6: Wastewater Treatment and Discharge, page 6.27, table 6.11.

7.5.4. Category-specific QA/QC and verification, if applicable

Complete QA and QC were carried out pursuant to the procedures described in IPCC 2006 Guidelines³⁹⁷. In addition, fundamental QA/QC procedures regarding 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 the Estonian GHG inventory at the national level are presented in Chapter 1.5.

7.5.5. Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process

Due to the updated protein consumption information from FAOSTAT, N₂O emissions from domestic wastewater were recalculated (Table 7.18).

Table 7.18. Protein consumption per capita and recalculated N₂O emissions

	2025 submission		2026 submission	
	Protein consumption, kg/person/year	N ₂ O emissions, kt	Protein consumption, kg/person/year	N ₂ O emissions, kt
2010	37.672	0.10970	37.679	0.10972
2011	37.705	0.10901	37.715	0.10905
2012	36.573	0.10647	36.566	0.10645
2013	39.143	0.11361	39.132	0.11358
2014	38.705	0.11181	38.712	0.11183
2015	39.274	0.11323	39.263	0.11320
2016	39.515	0.11412	39.508	0.11409
2017	38.891	0.11128	38.887	0.11127
2019	40.329	0.11543	40.325	0.11542
2020	39.387	0.11235	39.373	0.11231
2021	40.486	0.11554	40.387	0.11525
2022	40.373	0.11530	40.475	0.11560
2023	40.373	0.11864	40.927	0.12031

7.5.6. Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors), including those in response to the review process

The activity data is kept under consideration and will be updated as necessary.

8. OTHER (CRT SECTOR 6)

Estonia does not report any emissions under the Other sector.

³⁹⁷ IPCC 2006 Guidelines, Volume 1, Chapter 6: Quality Assurance / Quality Control and Verification.

9. INDIRECT CARBON DIOXIDE AND NITROUS OXIDE EMISSIONS

9.1. Description of sources of indirect emissions in the GHG inventory

Estonia has chosen to report indirect CO₂ emissions calculated from NMVOC emissions from the CRT subcategory 2.D.3. This subcategory consists of

- Solvent use;
- Road paving with asphalt.

The indirect CO₂ emissions are reported under the aforementioned subcategory on CO₂ emission rows.

Information on how the indirect CO₂ emissions were calculated is provided in Chapters 4.5.1. Solvent use and 4.5.1. Road paving with asphalt.

Information regarding indirect N₂O emissions in the agriculture and LULUCF sectors are reported under Agriculture and LULUCF sectoral chapters.

10. RECALCULATIONS AND IMPROVEMENTS

10.1. Explanations and justifications for recalculations, including in response to the review process

Explanations and justifications for the recalculations performed for this submission are given in Table 10.1.

Table 10.1. Recalculations made for the 2026 inventory submission by the CRT category and their implications

SECTOR	IPCC CATEGORY	RECALCULATION
Energy	1.A.3.b Road Transport	Road transport emissions were recalculated to reflect updated activity data, methodological improvements and to ensure time-series consistency. The recalculation was mainly due to revised vehicle stock data provided by the Estonian Transport Administration for 2014–2023. In addition, the results were affected by a COPERT version upgrade, including updates to model checks and emission factors for selected vehicle categories.
Agriculture	3.B.1 Manure management, CH ₄ emissions; 3.B.2 Manure management, N ₂ O emissions	Layers' population numbers whose manure was sent to biogas plants in 2023 was corrected for emission calculations for the 2026 submission due to a calculation error in previous submission. Nitrogen excretion rates for Layers and Pullets were corrected for emission calculations for the years 1990-2023 due

SECTOR	IPCC CATEGORY	RECALCULATION
		to a misuse of IPCC 2006 Default Nex values in previous submissions.
	3.D Agricultural soils, direct N ₂ O emissions	Emissions from Animal manure applied to soils (CRT 3.D.1.b.i) were recalculated for the whole time-series due to recalculations and corrections made in 3.B Manure management category. Emissions from Crop Residues (3.D.1.d) were recalculated for the years 2021-2023 due to a correction in temporary grassland production area. The N₂O emissions from Mineralization/Immobilization Associated with the Loss/Gain of Soil Organic Matter (CRT 3.D.1.e), and from Cultivation of organic soils (CRT 3.D.1.g) for the whole timeseries were updated in the framework of updating the land area activity data in the NFI (see Chapter 6 LULUCF). This impacts also the direct N₂O emissions from managed soils for the whole time series. Indirect N₂O emissions from Agricultural Soils (3.D.2) were recalculated for the whole timeseries due to corrections and recalculations mentioned above.
	3.H Urea application	Due to a corrected amount of urea fertilizers used in 2023 in the emission calculations, the emissions from Urea application to fields were recalculated for the 2026 submission, although the change in emissions was minor.
LULUCF	4.A Forest land	Recalculations in the LULUCF sector compared to the previous submission result mainly from the new methodology and additional data for estimating annual land use changes. Also, the entire time series of activity data from NFI, such as C stocks in living biomass and dead wood in Forest land and Grassland, are updated annually. EF for mineral soils in Forest land remaining forest land has been updated. Changes in methodology for estimating C stock changes in litter and mineral soils on conversion areas. New EFs for estimating CH ₄ and N ₂ O emissions from drained organic forest soils and more precise assessment of drained organic soils for Land converted to Forest land subcategories.
	4.B Cropland	Recalculated activity data (land areas and average living biomass and dead wood C stocks). Revised methodology for estimating C stock changes in perennial cropland biomass. On deforested areas, changes in litter pool were considered as part of SOC change. New methodology for estimating C stock changes in mineral

SECTOR	IPCC CATEGORY	RECALCULATION
		soils on Settlements converted to Cropland areas.
	4.C Grassland	Recalculated activity data (land areas and average living biomass and dead wood C stocks). New methodology for estimating changes in living biomass and dead wood on Grassland remaining grassland areas. On deforested land, changes in litter pool were considered as part of SOC change. CSCs in mineral soil for Settlements and Other land converted to grasslands were reported. The area of drained organic soils and related CO ₂ emissions were specified for Land converted to Grassland subcategories.
	4.D Wetlands	Recalculated areas of land-use categories. Since the current submission, the area of peat extraction sites is obtained from the Mineral Resources Register. Updated data about living biomass and DOM losses due to land use changes.
	4.E Settlements	Recalculated areas of land-use categories. Updated average C stock losses in living biomass and DOM were applied for land conversions from Forest land, Cropland and Grassland to Settlements. CSCs in mineral soil for Wetlands converted to Settlements were estimated for the first time.
	4.F Other land	Recalculated areas of land-use categories. Updated average C stock losses in living biomass and DOM were applied for land conversions from Forest land, Cropland and Grassland to Other land. CSCs in mineral soil for Wetlands converted to other land were estimated for the first time.
	4.G Harvested wood products	Updated activity data.
Waste	5.A Solid Waste Disposal	As recommended by the EEA/EC review (finding EE-5A-2024-0001), Estonia has separated the emissions from managed and uncategorized landfills previously reported together. Additionally, as recommended during capacity building, Estonia started using the 2019 refinement of the waste model. These changes affect the CH ₄ emissions for 1990-2023.
	5.A Solid Waste Disposal	The percentages of the various waste fractions in the MSW composition for the period 2008-2011 were corrected because earlier the values had been mistakenly rounded. This correction affects the emissions for years 2009-2023.
	5.D Wastewater treatment and discharge	Due to the updated protein consumption information from FAOSTAT, N ₂ O emissions from domestic wastewater were recalculated for years 2010-2017 and 2019-2023.

10.2. Implications for emission and removal levels

As a result of the continuous improvement of Estonia's GHG inventory, emissions of some sub-categories have been recalculated based on updated data or revised methodologies. For the national total CO₂ equivalent emissions (with indirect CO₂ and without LULUCF), the general impact of the improvements and recalculations performed depend on the year. The changes for the whole time-series are shown in Table 10.2.

The entire time series of LULUCF sector's activity data has been recalculated, mainly due to the new methodology for estimating annual land use changes and updated data from the National Forest Inventory. In addition, number of methodological changes and previous error corrections in the current submission have resulted in recalculations of emissions/removals (Table 10.3).

Table 10.2. Recalculation performed in 2026 submission for years 1990–2023 in kt CO₂ eq. Differences in % between 2025 April submission and 2026 submission.

	National Total GHG emissions without LULUCF			
	Submission 2025	Submission 2026	Recalculation difference	Recalculation difference,
	kt CO ₂ eq.			%
1990	40 277.58	40 342.40	64.83	0.16%
1991	37 402.96	37 463.46	60.51	0.16%
1992	27 221.59	27 278.90	57.30	0.21%
1993	21 758.73	21 799.27	40.54	0.19%
1994	22 232.88	22 274.63	41.75	0.19%
1995	20 069.53	20 113.74	44.22	0.22%
1996	21 012.96	21 064.09	51.13	0.24%
1997	20 711.36	20 774.35	62.99	0.30%
1998	18 981.97	19 051.56	69.59	0.37%
1999	17 811.74	17 884.39	72.64	0.41%
2000	17 436.38	17 514.23	77.85	0.45%
2001	17 872.41	17 951.89	79.48	0.44%
2002	17 286.47	17 360.69	74.22	0.43%
2003	19 221.00	19 290.59	69.59	0.36%
2004	19 358.95	19 422.01	63.06	0.33%
2005	19 136.76	19 194.29	57.53	0.30%
2006	18 483.22	18 537.37	54.15	0.29%
2007	22 034.11	22 081.78	47.67	0.22%
2008	19 935.63	19 977.82	42.19	0.21%
2009	16 498.90	16 536.47	37.57	0.23%
2010	21 100.20	21 128.63	28.43	0.13%
2011	21 058.64	21 076.89	18.25	0.09%
2012	19 947.29	19 960.57	13.28	0.07%
2013	21 824.85	21 828.30	3.45	0.02%
2014	20 987.27	20 985.72	-1.56	-0.01%
2015	17 920.95	17 910.50	-10.45	-0.06%
2016	19 539.23	19 517.74	-21.49	-0.11%
2017	20 767.06	20 750.37	-16.70	-0.08%

	National Total GHG emissions without LULUCF			
	Submission 2025	Submission 2026	Recalculation difference	Recalculation difference,
	kt CO ₂ eq.			%
2018	19 955.58	19 943.59	-11.98	-0.06%
2019	14 512.46	14 498.58	-13.87	-0.10%
2020	11 337.32	11 320.17	-17.15	-0.15%
2021	12 568.18	12 568.00	-0.18	0.00%
2022	14 149.11	14 163.02	13.91	0.10%
2023	10 862.46	10 887.97	25.51	0.23%

Table 10.3. Recalculation difference of Estonia's 2026 GHG emissions compared to the 2025 April submission by sector, kt CO₂ eq.

	Submission 2025		Submission 2026		Recalculation difference, %	
	1990	2023	1990	2023	1990	2023
Energy	36 182.03	8762.44	36 181.97	8783.47	0.00%	0.24%
IPPU	952.36	265.16	952.36	265.27	0.00%	0.04%
Agriculture	2734.62	1534.73	2765.12	1545.47	1.12%	0.70%
LULUCF	-4970.05	2130.79	-4043.28	2493.42	-18.65%	17.02%
Waste	408.57	300.13	442.96	293.76	8.42%	-2.12%

10.3. Implications for emission and removal trends, including time-series consistency

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. Therefore, 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 sources 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.

10.4. Areas of improvement and/or capacity-building in response to the review process

Table 10.4 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 10.5 summarises Estonia's responses to the 2015/2016/2018 and 2020 inventory review report (FCCC/ARR/2022/EST) and observations from the 2022 review report.

Table 10.6 summarises Estonia's responses to the 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 Article 4(3) of Regulation (EU) No 2018/842 and Article 4(4) of Regulation (EU) No 2018/841.

Table 10.4. Sector-specific improvement needs of Estonia’s national greenhouse gas inventory

SECTOR	IPCC CATEGORY	IMPROVEMENTS
Energy	1.A.1 Energy industries	Verification measurements of specific CH ₄ and N ₂ O emission factors (e.g. for solid biomass) for large combustion plants (over 50 MW) in the energy sector are planned for 2026.
Energy	All Energy sub-categories	Statistics Estonia and the inventory compiler will review fuel quantities in the energy balance and the underlying methodology. If needed, revised fuel time series will be implemented in the 2027 submission.
Energy	1.A.3.b Road Transport	Planned improvements include: review and correction of historical vehicle stock data for 2013 and earlier, and review of transport fuel quantities in the energy balance. Revised data and methodological improvements will be implemented in the 2027 submission.
Agriculture	3.A Enteric fermentation	Estonia is conducting an inventory development project to measure CH ₄ emissions for the most represented ruminants in Estonia and thus develop county-specific emission factors.
	3. B Manure management	Estonia is working on developing country-specific methane conversion factors for animal manure sent to biogas digesters.
	3.D Agricultural Soils	Estonia is conducting an inventory development project to develop county-specific emission factors for emission calculations from Crop residues and Grazing.
		Estonia is conducting an inventory development project to develop country-specific emission factors for emission calculations from Cultivation of organic soils.
LULUCF		Estonia has implemented a research project to specify the activity data and emissions from drainage ditches in all land use categories.
		Estonia has launched a project for developing a governance system for land and soil management. The project aims to update and consolidate land use-related datasets and to develop higher tier methodologies for estimating SOC changes in all land-use categories.
	4.A Forest land	Various remote sensing projects for forest resources have been launched with the purpose of annually calculating country-wide tree cover maps. Several completed, ongoing and planned NFI developments support more accurate estimates of annual biomass C stock changes.
		Project “Demonstration of climate change mitigation potential of nutrients rich organic soils in Baltic States and Finland” aims to improve the GHG accounting methods and activity data for nutrient-rich organic soils in the temperate cool & moist climate region. GHG emissions from nutrient-poor drained organic forest soils are specified during the project “Assessment of emissions and carbon stock dynamics in Estonian drained organic forest soils in the national greenhouse gas inventory”.
	4.B Cropland	Project “Demonstration of climate change mitigation potential of nutrients rich organic soils in Baltic States and Finland” aims to improve the GHG accounting methods and activity data for nutrient-rich organic soils in the temperate cool & moist climate region.
	4.C Grassland	
	4.D Wetlands	Research projects have been launched to improve GHG accounting methods for peatlands managed for peat extraction and for restored extraction sites, and to obtain more accurate activity data for reporting under the Wetlands category.

Table 10.5. Response to the UNFCCC review of the 2015/2016/2018 and 2020 inventory submissions

CRT category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NID
Uncertainty analysis (G.4, 2020) Convention reporting adherence	Report in the NIR on methods and underlying assumptions used for the uncertainty assessment for the purpose of helping to prioritize efforts to improve the accuracy of the national inventory in the future and to guide decisions on methodological choice in accordance with paragraph 42 of the UNFCCC Annex I inventory reporting guidelines. Addressing. The Party documented in its NIR (section 1.6, pp.44–45) the general method used for the uncertainty analysis. In section 1.2.1, under “Procedural arrangements”, Estonia stated that sectoral uncertainty estimates, among other inputs (e.g. recommendations from previous review reports), are used to prioritize its efforts to improve the accuracy of the inventory. On the basis of the sectoral method used, the share in total emissions and the uncertainty (in per cent), Estonia evaluates on a case- by-case basis whether a higher-tier method can be applied. Estonia uses the IPCC tier 1 methodology to estimate the total uncertainty of the inventory by aggregating the uncertainty of AD and EFs for each source category and GHG. During the review, the Party clarified that experts provide information on potential improvements to methods and underlying assumptions used in the uncertainty assessment. This information is discussed in an annual inventory meeting of the experts with the inventory coordinators, who evaluate the possibilities for improvement and forward the evaluation to the Ministry of the Environment to initiate a discussion on funding. The NIR serves as the main means of documentation for the methods and assumptions used in the uncertainty assessment and all sectors follow the same structure in the report except energy, for which information on uncertainty is included in section 3.2.4.3. To enhance transparency, Estonia indicated that it will harmonize the reporting on uncertainty for the energy sector with that of other sectors in its next annual submission. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet reported on methods and underlying assumptions used in the uncertainty assessment consistently for all sectors.	ARR2022/G.2	To enhance transparency, the structure on reporting on uncertainty analysis was harmonized, since 2024 submission Estonia has reported sectoral uncertainty assessment and relevant information regarding this in one chapter in the NID Annex document in Annex II.		NID Annex II

Uncertainty analysis (G.5, 2020) Convention reporting adherence	Perform the quantitative uncertainty assessment for the base year including and excluding LULUCF, following approach 1 from the 2006 IPCC Guidelines (vol. 1, chap. 3), and report the results in the NIR (e.g. using the structure provided in the 2006 IPCC Guidelines (vol. 1, table 3.3)). Addressing. The Party reported in its NIR (sections 1.6 and 10) that lack of AD is the reason for not being able to estimate specific uncertainty percentages for the base year. During the review, the Party clarified that the availability of base-year information has been affected by the institutional changes that have taken place since the country regained independence in 1991. The Party's next steps to resolve this issue are through GHG inventory development projects currently ongoing in different categories, after which the sectoral experts will update inventory AD and EF values, including associated uncertainty values for the base year. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet reported base-year uncertainty for the inventory with and without LULUCF.	ARR2022/G.3	Estonia has included uncertainty analysis for the inventory with LULUCF in Annex II Table Annex II. 2.		NID Annex II, Table Annex II. 2.
1. General (energy sector) – other fossil fuels – CO₂ (E.4, 2020) (E.7, 2018) (E.11, 2016) (E.10, 2015) Transparency	Report which categories' non-biogenic waste is included under which fuel types in the reference approach in a more transparent manner. Addressing. The Party reported in its NIR (table 3.9, p.80) a list of non-biogenic waste types. For the sectoral approach, waste oils are allocated to category 1.A.2.f (non- metallic minerals) and MSW to category 1.A.1.a (public electricity and heat production). However, the ERT noted that the NIR (section 3.2.1) does not include information on which categories' non-biogenic waste is included under which fuel types for the reference approach, which will explain the differences in the carbon EF reported in NIR table 3.9 and CRF table 1.A(b). During the review, the Party clarified that MSW is included in the reference approach under non-biogenic waste used in the production of heat and electricity. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet reported in its NIR (section 3.2.1) which categories' non-biogenic waste is included under which fuel types for the reference approach, for example whether the fossil part of waste that is reported under categories 1.A.1.a and 1.A.2.f in the sectoral approach is all reported under non-biogenic waste in the reference approach or reported under other fuel categories, as explained during the 2015 review. Such an explanation would help to improve the understanding of the carbon EF reported in CRF table 1.A(b).	ARR2022/E.1	Since 2023 submission NID includes detailed information on non-biogenic waste and under which fuel types in the reference approach it is included		Chapter 3.2.1

1.A.3.b Road transportation – liquid fuels – CO₂, CH₄ and N₂O (E.7, 2020) (E.15, 2018) (E.18, 2016) (E.17, 2015) Transparency	Explain how data from different sources (Statistics Estonia and the Estonian Transport 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 COPERT). Addressing. The Party reported in its NIR the number of vehicles in the country (table 3.25, p.99) and road traffic mileage (table 3.26, p.100). However, the ERT noted that the Party did not include in the NIR a transparent explanation of how data from different sources are rearranged to ensure consistency across the three data sets (number of vehicles, annual road traffic mileage and the division used in COPERT). During the review, the Party clarified that emissions from road transport are estimated, using COPERT V, by the Estonian Environment Agency. The Agency collects data on the number of vehicles and annual mileage per vehicle from the Estonian Transport Administration and data on fuel consumption from Statistics Estonia. The statistics on fuel consumption are inputted into COPERT V by distributing them between vehicle categories on the basis of annual mileage per vehicle category from odometer readings taken during annual technical inspections to maintain a balance between calculated and statistical fuel consumption. The Party indicated that this explanation will be included in the next annual submission. The ERT considers that the recommendation has not yet been fully addressed because the Party, while it provided the required explanation during the review, has not yet included it in the NIR.	ARR2022/E.8	Since 2023 submission NID includes the explanation on how the number of vehicles, annual road mileage and the division used in COPERT model is used to ensure data consistency across these three datasets		Chapter 3.2.6.2

1.A.3.b.iv Motorcycles – gasoline – CO₂, CH₄ and N₂O (E.23, 2020) Consistency	Work with the national vehicle registry to report the correct number of motorcycles for 1990–2012 by including mopeds under the motorcycles category (e.g. by using a data gap filling technique in accordance with the 2006 IPCC Guidelines (vol. 1, chap. 5, p.5.14)); and revise the estimated emissions under motorcycles (subcategory 1.A.3.b.iv) using the updated AD for 1990–2012, ensuring time-series consistency and documenting the estimates in the NIR. Addressing. The Party corrected in its NIR the AD for 1990–2012 for the number of motorcycles (table 3.25, p.99) and their mileage (table 3.26, p.100). The estimated emissions for subcategory 1.A.3.b.iv (motorcycles) were revised using the corrected AD. However, the ERT noted that the NIR does not include an explanation of the data gap filling technique that was used to correct the number of motorcycles reported. During the review, the Party explained that an analysis of the high statistical number of motorcycles in use during 1990–1994 was carried out, and as a result, the number of vehicles was corrected to ensure that the data no longer include vehicles that are not in use. The number of mopeds for 1995–2012 was adjusted on the basis of the corrections to the number of motorcycles for 1990–1994. The Party indicated that more	ARR2022/E.10	Since 2023 submission NID includes a detailed explanation that the number of motorcycles was adjusted for 1995-2012 based on the corrections for 1990-1994 period		Chapter 3.2.6.2
1.A.3.b.iv Motorcycles – gasoline – CO₂ (E.11, 2020) (E.26, 2018) Transparency	Report in the NIR the differences between the number of motorcycles reported by the national vehicle registry and the number of motorcycles used for estimating emissions in COPERT, and explain the underlying reasons for the differences, when applicable. Addressing. The Party reported in its NIR (table 3.25, p.99) the number of motorcycles and mopeds used in COPERT and explained in its NIR (table 10.8, p.430) the method used for calculating the number of motorcycles. During the review, the Party clarified that the number of motorcycles in the national vehicle registry includes motorcycles that have been disposed of, while data used in COPERT have been corrected to exclude such motorcycles. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet included in the NIR (section 3.2.5.3) the differences between the number of motorcycles reported by the national vehicle registry and the number of motorcycles used in COPERT or the reasons for these differences.	ARR2022/E.11	Since 2023 submission NID includes a detailed explanation about the number of motorcycles used in COPERT and in national registry		Chapter 3.2.6.2

1.A.4 Other sectors – liquid fuels – CO₂, CH₄ and N₂O (E.25, 2020) Accuracy	Work with Statistics Estonia to collect AD on total liquid fuel consumption for the subcategories commercial/institutional (1.A.4.a), residential (1.A.4.b) and agriculture/forestry/fishing (1.A.4.c), ensure the accuracy of the AD and recalculate emissions for all years (1990–2018). Not resolved. The Party reported in its NIR (section 3.2.6.2, p.117) that Statistics Estonia collects AD on total liquid fuel consumption for the subcategories 1.A.4.a, 1.A.4.b and 1.A.4.c by sending questionnaires to all companies with at least 50 employees and by sending questionnaires to a random selection of smaller companies. The ERT noted that this may lead to an overestimation or underestimation of the AD and emissions if only the smallest or largest fuel users are covered by each questionnaire. During the review, the Party clarified that Statistics Estonia has been notified of the issue and is looking into improving the accuracy of the data.	ARR2022/E.14		Statistics Estonia is using Eurostat methodology for a survey sampling for energy consumers and a random selection procedure for smaller companies (https://www.stat.ee/en/find-statistics/methodology-and-quality/esms-metadata/20206#18-Statistical-processing-17). For this reason, the methodology used covers a significant part of this sector and is the best possible method for data gathering.	
1.B.2.a Oil – CH₄ (E.16, 2020) (E.19, 2018) (E.21, 2016) (E.20, 2015) Transparency	Fill in AD in the columns “Unit” and “Value” of the row “Distribution of oil products” in CRF table 1.B.2 instead of reporting these values as “NA”, and change the notation keys in the other cells to “NA”.	ARR2022/E.15	The issue has been fixed for 2023 submission in CRF tables. The “kt” under the column “unit” has been fixed for "NE"		CRF 1.B.2.a.Oil Distribution for oil products
International navigation – liquid fuels – CO₂, CH₄ and N₂O (E.1, 2020) (E.20, 2018) Consistency	Revise fuel consumption estimates for international navigation and ensure their time- series consistency. Not resolved. The Party reported recalculations for 1990–2019 in NIR table 3.4 (p.65), which were made owing to the use of the updated Joint Questionnaire data set from Statistics Estonia. However, the Party continued to report in its NIR (section 3.2.2, p.64) that the almost 200 per cent increase in emissions between 2011 and 2012 was caused by an AD-related change in the methodology used by Statistics Estonia. During the review, the Party clarified that Statistics Estonia has been notified of the issue and is looking into improving the time-series consistency of the data on fuel consumption for international navigation. The ERT considers that the recommendation has not yet been addressed because the AD-related change in methodology results in a time series that is not consistent, as described in section 3.2.2 of the NIR and as shown by the reported sharp increase in emissions between 2011 and 2012.	ARR2022/E.16		The Statistics Estonia is aware of the large variations in liquid fuels reported under International navigation and have been notified to look into the matter. The Statistics Estonia is correcting the data when they carry out the revision, but the timeline for the revision is not set.	

Fuel combustion – reference approach – all fuels – CO₂ Transparency	The Party reported in its NIR (section 3.2.1, p.64) that the difference in total CO₂ emissions between the reference approach and the sectoral approach is 29.6 per cent. However, CRF table 1.A(c) lists this difference as 41.99 per cent. The ERT noted that the difference in CO₂ emissions between the two approaches is largest for solid fuels (72.08 per cent for 2020) and other fuels (56.12 per cent for 2020). In the NIR (section 3.2.1, p.64), the Party explained that in the case of solid fuels, the amount of emitted CO₂ is different, as the sectoral approach considers that some of the oil shale is turned into shale oil, and this process has a smaller CEF than the combustion of oil shale (some of the carbon is transferred into shale oil), while in the reference approach calculations all the carbon in oil shale is combusted. The ERT noted that a quantitative analysis of the differences is not included in the NIR. The ERT noted that these differences are due to an overestimation in the reference approach and no issues related to the sectoral approach were identified. During the review, the Party clarified there is an error in the NIR (section 3.2.1, p.64) and that the difference in emissions between the approaches is 41.99 per cent, as reported in CRF table 1.A(c). The ERT recommends that the Party report in the NIR the correct difference in total CO₂ emissions from fuel combustion (per cent) between the reference approach and the sectoral approach and expand the explanation for the difference between the two approaches by including a quantitative explanation of the CO₂ calculations of oil shale and shale oil in the reference approach and the sectoral approach, as described in NIR section 3.2.1.	ARR2022/E.17	The difference in total CO ₂ emissions between SA and RA approach was corrected for the 2024 submission.		NID 2024 Chapter 3.2.1. Comparison of the sectoral approach with the reference approach
Comparison with international data – liquid fuels – CO₂, CH₄ and N₂O Transparency	The Party reported in CRF table 1.A(b) a total liquid fuel consumption of 44,790 TJ for 2019 and 43,970 TJ for 2020. However, the IEA values for consumption of the same fuels are –526 TJ for 2019 and –1,663 TJ for 2020. The ERT noted that the Party did not provide the energy balance for the most recent year in the NIR as annex 4 as required by the UNFCCC Annex I inventory reporting guidelines. The ERT also noted that the Estonian energy balance is available online (https://andmed.stat.ee/en/stat/majandus_energeetika_energia-tarbimine-ja-tootmine_aastastatistika/KE0240). There is a large difference between the stock change of shale oil for 2019 and 2020 reported in these statistics and in CRF table 1.A(b): the energy statistics include a stock change for oil shale of 0 TJ for 2019 and 2020, while CRF table 1.A(b) contains a stock change for shale oil of –1,132.00 kt (–44,464.96 TJ) for 2019 and –1,114.48 kt (–44,121.56 TJ) for 2020. During the review, the Party clarified that the fuel consumption data reported in CRF table 1.A(b) are provided by Statistics Estonia, which also provides data to IEA. The Party indicated that Statistics Estonia has confirmed that the data used for the inventory and the data provided to IEA are the same. The ERT recommends that the Party (1) include the national energy balance for the most recent year in the NIR as annex 4 and (2) compare the national energy statistics with the AD reported in CRF table 1.A(b) and either correct the AD so that the values are consistent or describe transparently in the NIR any differences between them. The ERT	ARR2022/E.18	Shale oil is reported under Liquid fuels Shale Oil in 1.A(b) in CRF tables and under Other hydrocarbons in the energy balance. The production of secondary fuels (which shale oil is) is not accounted for in the energy balance and in 1.A.(b) and Estonia exports most of its produced shale oil and this causes a negative apparent consumption of shale oil in the energy balance. This is the reason there is a negative value reported in the stock change in 1.A.(b) as there is no consumption reported and the calculated consumption in CRF has to be zero. The explanation was added into Chapter 3.2.1. Estonia is using Joint Questionnaire (JQ) dataset made by Statistics Estonia instead of national energy balance since NIR 2021 submission as JQ allowed for a more accurate redistribution of fuels between sectors. Joint Questionnaires data data can		Chapter 3.2.1 Comparison of the sectoral approach with the reference approach

	encourages the Party to explore the differences between the data used for the annual inventory submission and the data submitted to IEA and report on them in the NIR.		be accessed via Statistics Estonia website (https://www.stat.ee/) or can be shared as Excel files upon request.		
1.A.1.a Public electricity and heat production – other fossil fuels – CO₂, CH₄ and N₂O Transparency	The Party reported, as an information item in CRF table 1.A(a)s4, the total emissions from waste incineration, with energy recovery divided into biogenic and fossil fuel emissions (with the same value of 1,198.37 TJ and the same emissions for both portions). However, no further explanation of which fuel types these emissions are included under was provided in the documentation box of CRF table 1.A(a)s4 or in the NIR. Additionally, the Party reported in its NIR (section 3.2.4.1, p.67) that emissions from the Iru waste-to-energy plant are included under “Other fossil fuels” under category 1.A.1.a in CRF table 1.A(a)s1. The ERT noted, upon comparing the consumption of “Other fossil fuels” under category 1.A.1.a in CRF table 1.A(a)s1 with the information item in CRF table 1.A(a)s4 (total emissions from waste incineration with energy recovery), that the Party included the biogenic portion of the waste under “Other fossil fuels” under category 1.A.1.a in CRF table 1.A(a)s1. The ERT also noted that the plant-specific CEF for MSW, as reported in NIR table 3.9, is 17.94 GJ/t, but it is not clear from the NIR whether this value includes only the fossil portion of the MSW or both the fossil and the biogenic portions. During the review, the Party clarified that the emissions from waste incineration with energy recovery reported in CRF table 1.A(a)s4 are included under category 1.A.1.a (public electricity and heat production) in CRF table 1.A(a)s1. The ERT recommends that the Party allocate the biogenic portion of the waste incinerated with energy recovery to “Biomass” under category 1.A.1.a (public electricity and heat production) in CRF table 1.A(a)s1 and transparently report in the NIR on the derivation of the EFs for MSW for “Other fossil fuels” and “Biomass” of the same category.	ARR2022/E.19	Since 2023 submission NID includes more detailed explanation on the fossil and biogenic part of waste reported under 1.A.1.a Public heat and power production		Chapter 3.2.4.2 Methodological issues
1.A.2.g Other (manufacturing industries and construction) – biomass – CO₂, CH₄ and N₂O Transparency	The ERT noted a significant decrease in biomass consumption, from 4,022 TJ for 2015 to 341 TJ for 2016, was reported in CRF table 1.A(a)s2 for category 1.A.2.g (other (manufacturing industries and construction)). During the review, the Party clarified that Statistics Estonia explained that this decrease results from the introduction of new technologies and the switch to a different fuel in the wood and wood products industry. The ERT recommends that the Party explain in the NIR the drivers of the trend in biomass consumption by manufacturing industries and construction and the reasons for any significant inter-annual variation.	ARR2022/E.20	The reason provided by Statistics Estonia for the significant inter-annual variation is that 2016 CHP plants using wood were completed in the sector and this means that any wood burned in these CHP plants were no longer reported under 1.A.2.g, but in the transformation sector (1.A.1.a) instead. This explanation was also added to the NID Chapter 3.2.5.2.		Chapter 3.2.5.2 Methodological issues

2.F.1 Refrigeration and air conditioning – HFCs (I.7, 2020) (I.7, 2018) (I.10, 2016) (I.9, 2015) Accuracy	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 report on progress. Addressing. The Party reported in its NIR (p.173) the issue with the completeness of AD and EFs for commercial and industrial refrigeration, which leads to high uncertainties. Inventory compilers and environmental inspectors collect AD in the commercial and industrial refrigeration sectors. The uncertainty of AD has decreased since the 2020 submission, while the uncertainty of EFs has not improved. The database for fluorinated gas equipment and servicing was overhauled in 2021, but still needs further improvement because the use of the database by service companies is low. During the review, the Party clarified that discussions on and development of the method to calculate emissions for the commercial and industrial refrigeration sectors are ongoing. The ERT does not have any data that might lead to lower uncertainties in the AD and EFs used to calculate emissions and that would allow it to evaluate potential underestimations thereof, but it compared the per capita emissions of Estonia with those of neighbouring countries with similar climatic, economic and urban planning conditions and found that Estonia's were not significantly lower. The ERT concludes that any possible underestimation would be below the threshold for application of an adjustment in accordance with decision 22/CMP.1, annex, paragraph 80(b), in conjunction with decision 4/CMP.11 (5.78–10.97 kt CO₂ eq for 2013–2020) and therefore the issue is not included in the list of potential problems and further questions raised. The ERT considers that the recommendation has not yet been fully addressed because, while the Party has improved the uncertainty of the AD, it has not yet improved the uncertainty of the EFs in comparison with those used for the previous annual submissions.	ARR2022/I.3		Continuous work in progress improving AD through HFC database (FOKA). Renewed FOKA database has now less errors and is functioning better. Currently different institutions work on the subject how to remind owners of the equipment and maintenance companies most efficiently about continuous obligation to add their maintenance data to the database: information letters are sent and it is considered to add automatic reminders to the database functionality. Throughout these actions AD should be more complete.	
2.F.1 Refrigeration and air conditioning – HFC- 143a (I.8, 2020) Transparency	Ensure that CRF table 2(II)B-Hs2 includes the correct AD for HFC-143a filled into new manufactured products for industrial refrigeration for 2016 and include an explanation of significant inter-annual changes in AD in the next annual submission. Addressing. The Party reported in the NIR (pp.176–178) of its 2021 submission recalculations of HFC-143a for industrial refrigeration for 2016, but the inter-annual change between 2010 and 2011 noted by the previous ERT is still reported in the 2022 submission. During the review, the Party clarified that the AD for HFC-143a filled into new manufactured products for 2016 were corrected and that an explanation of these recalculations is included in the 2021 NIR (section 4.6.1.3.5). The ERT considers that the recommendation has not yet been fully addressed because the Party did not include in the NIR an explanation of the significant inter-annual changes for HFC-143a filled into new manufactured products for industrial refrigeration (e.g. a 261.3 per cent increase between 2010 and 2011).	ARR2022/I.4	Explanation has been included about significant inter-annual changes in AD (HFC-143a filled into new manufactured products) for industrial refrigeration for 2010-2011 because these years were not under discussion during review week and were not addressed as ERT recommendation in ARR2020 where this issue was raised initially and were also not under discussion during the 2022 centralized review.		NID 2024 Chapter 4.6.1. Category description (2.F.1.c Industrial refrigeration)

2.A.2 Lime production – CO₂ Transparency	The Party reported in its NIR (p.134) that EFs based on actual CaO and MgO content measured by one of the bigger lime plants in the country have been available since 2005. As the EFs from that lime plant differ significantly from the default EFs available in the 2006 IPCC Guidelines (vol. 3, table 2.4), EFs for 1990– 2004 were established as mean values from the EFs for 2005–2008. The ERT noted that the significant differences between country- or plant-specific EFs and default EFs from the 2006 IPCC Guidelines should be explained in line with the 2006 IPCC Guidelines (vol. 1, chap. 6, p.6.13). During the review, the Party clarified that the percentage of CaO and MgO in lime differs from year to year because of differences in the quality of the raw material. The EFs for CaO and MgO were calculated on the basis of the ratio of the molecular weight of CO₂ to CaO or MgO. The Party explained that the recalculations made for the 2010 submission (2010 NIR section 4.2.2.5, on source-specific recalculations) following a recommendation in a previous review report (FCCC/ARR/2009/EST, para. 93) showed differences in the emissions estimated using plant-specific EFs and those estimated using default EFs.	ARR2022/I.6	Explanation of differences on the emission factors for different years and comparison with the 2006 IPCC Guidelines default emission factors have been included in the NID since 2024 submission.		Chapter 4.2.2 Methodological issues (under Emission factors section 2.A.1 Lime production, Table 4.9)
2.A.2 Lime production – CO₂ Transparency	The Party reported in its NIR (p.134) that its method for calculating emissions from lime production is consistent with the tier 2 methodology and that four different EFs were used in the calculations. The ERT noted that in the NIR (section 4.2.2.3, on uncertainties and time-series consistency), no description is included of how the use of different EFs affects time-series consistency. During the review, the Party clarified that for 1990–1996, production data from Statistics Estonia and the IPCC default EF were used to calculate emissions for those plants for which it did not receive company- specific information and that emissions for 1990–1996 were recalculated by applying plant-specific EFs from two production plants. Emissions for 1997–2007 were recalculated owing to better AD and plant-specific EFs becoming available. The ERT noted that the 1990–1996 plant-specific EFs from the two production plants could be used to calculate an implied EF for those plants for which company-specific information was not received. The ERT recommends that the Party improve the justification in the NIR for using IPCC default EFs for some plants for 1990–1996 and for why it considers them more appropriate than a country-specific implied EF for 1990–1996.	ARR2022/I.7	According to the ERT finding Estonia performed recalculation for the 2025 march submission (NID 2025) by replacing default EF-s with country-specific implied EF-s for the years 1990-1996 for the plants for which country-specific information was not received.		NID 2025, Chapter 4.2.5 Chapter 4.2.5. Category-specific recalculations, Table 4.12

2.B.1 NH3 production – CO2 Comparability	The Party reported in its NIR (p.147) that it used plant-specific EFs for calculating CO2 emissions from NH3 production throughout the time series and that these NH3 production EFs varied between 1.276 and 1.516 t CO2/t NH3 produced. The ERT noted that the EFs reported by Estonia are outside the range of default EF values in the 2006 IPCC Guidelines (vol. 3, table 3.1); that is, 1.694–3.273 t CO2/t NH3. During the review, the Party clarified that the difference is attributable to the fact that the default EFs in table 3.1 of the 2006 IPCC Guidelines take into account natural gas used as both fuel and feedstock. The Party noted that it explained in the NIR (section 4.3.1.2) that under the IPPU sector, Estonia accounts only for emissions from the natural gas used as feedstock for primary steam reforming. The amount of natural gas combusted is reported under the energy sector (category 1.A.2.c) as it is possible to obtain separate data on natural gas that is used for non-fuel and fuel purposes from Statistics Estonia. Thus, the plant-specific EFs are lower than the default EFs in table 3.1 of the 2006 IPCC Guidelines. The ERT noted that this is not in line with the 2006 IPCC Guidelines (vol. 3, chap. 3.2.2, p.3.11), which state that “in the case of NH3 production no distinction is made between fuel and feedstock emissions with all emissions accounted for in the IPPU Sector”. The ERT recommends that the Party report all CO2 emissions from NH3 production (category 2.B.1) under the IPPU sector in accordance with the 2006 IPCC Guidelines (vol. 3, chap. 3.2.2, p.3.11) and ensure that the related fuel consumption is excluded from the emissions reported under the energy sector in order to avoid double counting	ARR2022/I.8	The explanation how double accounting is avoided currently and why natural gas used is accounted separately as feedstock and for process is added to NID chapter 4.3.2 since 2024 submission: Estonia was 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 was 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 the Joint Questionnaire dataset. In the Joint Questionnaire dataset provided by Statistics Estonia, it is not possible to split by single plants.		Chapter 4.3.2. (Methodological issues, Choice of methods, 2.B.1 Ammonia production)
2.D.1 Lubricant use – CO2 Transparency	The Party reported in NIR figure 4.4 (p.155) the emissions from lubricant use. The ERT noted that the emissions decreased from about 16 kt CO2 eq for 1990 to about 3 kt CO2 eq for 2020 and no explanation for this decrease was provided. During the review, the Party clarified that AD on lubricants are obtained from Statistics Estonia and Eurostat; both data sources have similar information on imports and exports. Import numbers declined steadily from 1990 to 2006, which has made the biggest impact on the overall trend. The ERT recommends that the Party include the description of the trend in lubricant use and associated emissions in the NIR (section 4.5.1.4). The ERT encourages the Party to conduct category-specific QA/QC and verification for this category and to explain the significant decrease in lubricant imports over the time series.	ARR2022/I.9	Additional information is added to the NID Chapter 4.5.4. under 'Lubricant use' since 2024 submission: <i>Activity data on lubricants are obtained from Statistics Estonia and Eurostat and both data sources have similar information on imports and exports. Import numbers declined steadily from 1990 to 2006, which has made the biggest impact on the overall trend. The amount of lubricants used shows that less lubricants are needed on the market. 2020 -2022 data shows an increase in usage of lubricants and therefore rise in CO2 emissions.</i>		Chapter 4.5.4. Category-specific QA/QC, 2.D.1 Lubricant use)

2.F.1 Refrigeration and air conditioning – HFC-134a Transparency	The Party reported in NIR table 4.17 (under section 4.6.1.3.5, on category-specific recalculations) that the HFC-134a filled into new equipment for industrial refrigeration amounts to 1.2 kt and the quantity in stock is 4.98 kt for 2019. However, the ERT noted that in CRF table 2(II)B-Hs2, HFC-134a filled into new equipment for industrial refrigeration is reported as 1.31 t and the average annual stock as 10.66 t for the same year. During the review, the Party clarified that the data in NIR table 4.17 are on recalculations of HFC-134a that were not in different blends of HFCs but in a pure form. The amount of HFC-134a in different blends stayed the same. In contrast, the amounts reported in the CRF table are calculated as the sum of HFC-134a in pure form and in blends. The ERT recommends that the Party provide in the NIR, in the AD section for category 2.F.1, in tabular format, if appropriate, information on how the values for HFC-134a filled into new equipment and in stock for industrial refrigeration reported in CRF table 2(II)B-Hs2 were calculated, including an indication of whether they are based on individual HFCs or blends thereof that are used in the country.	ARR2022/I.10	Estonia has added the information on how the R-134a values were calculated in pure form and in blends that summed up in CRF table 2(II)B-Hs2 in NID.		Chapter 4.6.2 (Methodological issues), Table 4.29
3.B.4 Other livestock – CH₄ and N₂O (A.5, 2020) (A.7, 2018) Accuracy	Correct the allocation of poultry manure, taking into account the findings from the new study by the Estonian University of Life Sciences or, if the study does not provide the necessary information, change the allocation from pasture/range/paddock to dry lot. Addressing. The Party reported in NIR table 5.33 (p.258) that the allocation of poultry manure is 99.41 per cent solid waste and 0.59 per cent pasture, range and paddock. In CRF table 3.B(a)s2, 100 per cent solid storage and dry lot is reported. The ERT considers that the recommendation has not yet been addressed because the Party has not yet reported N₂O emissions in CRF table 3.B(b) that are consistent with NIR table 5.33 and that the allocation of poultry manure is 99.41 per cent solid waste and 0.51 per cent pasture, range and paddock.	ARR2022/A.2	In accordance with the 2022 ERT review's Recommendation ARR2022/A.2, since 2022 submission, the issue has been fixed in the Inventory report. Data reported in CRT 3.B.4.g section is consistent with what is reported in the inventory document, Chapter 5.3.2. Methodological issues, Activity data section, under "3.B.2 and 3.B.4 Manure management of sheep and other livestock".		Chapter 5.3.2.
3.B Manure management – CH₄ Transparency	The Party reported in its NIR (pp.219 and 250, table 5.26 and figure 5.12) that the total CH₄ emissions from livestock manure management were 5.97 kt for 2014, decreasing to 5.25 kt for 2016 and increasing to 6.52 kt for 2020. The Party indicated that the main reason for this trend is “the recovering pork production in Estonia during the recent years after the outbreak of African swine fever in 2015” (NIR p.250). The ERT noted that no supporting documentation was provided to justify the reasons for the trend in the swine and dairy cattle annual population. During the review, the Party clarified that the dairy cattle and swine populations started to decrease from 2014 owing to the economic sanctions imposed by the Russian Federation on the EU and because of the African swine fever outbreak in the country in 2015, which reiterated the explanation included in the NIR (p.219): “Economic sanctions imposed by Russia on the EU starting from August 2014 have had an impact on the dairy industry resulting with a decline in production. Consequently, the number of dairy cattle in 2020 had fallen by 11.8% in comparison with 2014. The number of swine has fallen by 11.5% in 2020 compared to 2014 because of African swine fever outbreak in the region in 2015”.	ARR2022/A.6	In accordance with the 2022 ERT review's Recommendation ARR2022/A.6, since 2024 submission, the Inventory Document includes more detailed information about the decline in swine and cattle population over the years. More information on the impact of African swine fever outbreak and economic sanctions imposed by Russia on the EU is included.		Chapter 5.1.

	The ERT recommends that the Party include in the NIR the reasons for the trend in livestock populations between 2014 and 2020, which led to a reduction and then increase in CH₄ emissions from manure management, for example by providing more information on the impacts of and recovery from the 2015 outbreak of African swine fever in the country (in the case of swine) and on the economic sanctions imposed by the Russian Federation on the EU from 2014 onward (in the case of dairy cattle).				
3.D.a.2.b Sewage sludge applied to soils – N₂O Transparency	The Party reported in its NIR (p.283, including table 5.56) that the methodology for treating sewage sludge according to the R10 category (which is one of the country-specific categories under which sludge is treated) for 1990–1998 was developed by the Tallinn University of Technology, which compiled the GHG inventory until 2012. During 1990–1998, limited waste-related data were gathered by the predecessor of the Estonian Environment Agency (the Estonian Environment Information Centre) and, therefore, an assumption was made that 50 per cent of the total amount of sewage sludge generated was applied to agricultural land. The ERT noted that no justification for the assumption that 50 per cent of the total amount of sewage sludge generated was applied to agricultural land is included in the NIR. During the review, the Party clarified that the assumption is based on historical data on the use of sewage sludge and was originally made by the Tallinn University of Technology. The ERT recommends that the Party include in the NIR supporting documentation to justify the assumption that, for 1990–1998, 50 per cent of the total amount of sewage sludge generated was applied to agricultural land.	ARR2022/A.7	In accordance with the 2022 ERT review's Recommendation ARR2022/A.7, Estonia has been developing an expert judgement for the evaluation that 50% of the total amount of generated sewage sludge was used for improving the environmental situation and 50% was composted in the years 1990-1998. The previous evaluation was originally provided by the Tallinn University of Technology. An authorized engineer in water supply and sewerage, Aare Kuusik (PhD) conducted the evaluation, by using all available preserved materials from archives to compile an expert opinion on the usage of sewage sludge in the years 1990-98 and conducted an evaluation on the amounts of sludge being used on agricultural lands and the amounts composted during these years. New, corrected amounts of sewage sludge and compost applied to agricultural lands during the years 1990-98 are used for the emission calculations in the 2025 Inventory. The complete expert judgement, including the references to supporting documents, are stored in the Inventory archive (in Estonian).		Chapter 5.4.2

3.F Field burning of agricultural residues – CH₄ and N₂O Transparency	The Party reported in its NIR (p.298) that CH₄ and N₂O emissions from the field burning of agricultural residues were reported as “NO” for the whole time series. It also reported that it is feasible that it has been overestimating emissions for 1990–2006 by applying the IPCC default value for the fraction of residues burned in the field for previous submissions. During the review, the Party acknowledged that the text in the NIR may be confusing and indicated that it will improve the description for this category in the next NIR. Since the 2015 submission, Estonia has applied the notation key “NO” for the entire time series for this category because in 2004 the burning of crop residues was prohibited by Estonian law and, prior to this, the Estonian Ministry of Rural Affairs does not consider that there was widespread burning of crop residues. The ERT recommends that the Party investigate the probability that some field burning of agricultural residues does occur (because there may not be 100 per cent compliance with the law prohibiting the burning of crop residues) and include in the NIR the findings, which may take the form of expert judgment or a relevant document, in order to justify the reporting of CH₄ and N₂O emissions for this category as “NO”.	ARR2022/A.8	In accordance with the 2022 ERT review's Recommendation ARR2022/A.8, Estonia has investigated the probability of potential field burning of agricultural residues and has found out that no burning of agricultural residues has been performed as it is prohibited by the law in the country. Since 2023 submission, the inventory report includes a renewed expert judgement of the issue.		Chapter 5.5.
3.G Liming – CO₂ Transparency	The Party reported in its NIR (p.299) that the emissions from limestone application were calculated using sales records for clinker dust, chalk and powdered limestone. The fraction of calcium carbonate in cement clinker dust (49.48 per cent) was obtained from the only cement plant operating in Estonia. The ERT noted that the method used to calculate this fraction was not clearly reported in the NIR. During the review, the Party clarified that it received a calculation sheet from the cement plant in which different components of clinker dust and their proportions were shown. Therefore, using the burning residue percentage (80.92 per cent) and the CaO percentage in burning residue (51.92 per cent), which were both calculated by the cement plant, it was possible to calculate the fraction of calcium carbonate in the cement clinker dust. The Party indicated that it will add this clarification to the next NIR. The ERT recommends that the Party include in the NIR an explanation of how the value of the calcium carbonate content of cement clinker dust used in estimating CO₂ emissions from liming was derived, along with supporting documentation to justify the value used.	ARR2022/A.9	In accordance with the 2022 ERT review's Recommendation ARR2022/A.9, since 2023 submission, the inventory report now includes an expert judgement of the assumption for CaCO₃ content in cement clinker dust used in estimating CO₂ emissions from liming (documented in the archive).		Chapter 5.6.2.

3.H Urea application – CO₂ Accuracy	The Party reported in its NIR (p.302) that as the Agriculture and Food Board has not collected data on the amounts of marketed urea fertilizers since 2019, the CO₂ emissions from urea application for 2018 were also used as the 2019 and 2020 values. During the review, the Party clarified that the study referred to in the NIR included conducting a comparison of the data on urea fertilizers used in Estonia from IFASTAT and the data used in the inventory from Statistics Estonia and Nitrofert (a urea fertilizer producer). The Party noted that, unfortunately, highly significant discrepancies were found in the historical time series of data from IFASTAT that were not explained by the manager of IFASTAT. Therefore, using IFASTAT data to update Estonia's fertilizer time series was considered not possible. Estonia has contacted mineral fertilizer manufacturers and resellers to obtain data on the amount of urea fertilizers sold in Estonian markets each year. The Party will evaluate the possibility of using the manufacturers' data for reporting urea fertilizer use in the 2023 submission. The ERT noted that based on the AD time series, there is no underestimation of emissions in 2019 and 2020. The ERT recommends that the Party ensure reliable and consistent AD across the time series, include information on its activities to obtain urea fertilizer use data and report on the results of its evaluation of the manufacturers' data in the next annual submission.	ARR2022/A.10	Estonia has been working on finding a new data source for estimating CO₂ emissions from Urea application for the years 2019-2021. Different databases have been investigated, but no institution in Estonia that collects national data on urea consumption have been identified. In accordance with the 2022 ERT review's Recommendation ARR2022/A.10, urea resellers and manufacturers have been contacted and their sales data have been validated. Additionally, Estonian inventory team had capacity building consultations with external experts facilitated by Umweltbundesamt (UBA) within the Effort Sharing Regulation sectors capacity-building support, on the proposed approach to implement the manufacturers' sales data to Estonia's emission estimates. The external experts concluded that the switch to a new database can be done directly, without any modeling. Data on urea fertilizers sold to Estonian markets can be used from 2016 (the year that the data is available) and assumed that all urea sold on Estonian markets is used on Estonian agricultural lands. Therefore, since 2024 submission, the emissions from urea application starting from 2016 have been calculated using the manufacturers' and resellers' data on sold fertilizers to Estonian markets.		Chapter 5.7.2.
4. General (LULUCF) – CO₂, CH₄ and N₂O (L.2, 2020) (L.3, 2018) Accuracy	Acquire land-use change data for 1970–1990 and recalculate N₂O emissions for the entire reporting period. Addressing. Land-use change assumptions or data for 1970–1990 are not documented in the NIR (see also ID# L.12 in table 5). The N₂O emissions have been recalculated for the entire reporting period, but on the basis of updated and corrected land-use change data for 1991–2020 rather than by acquiring data for 1970–1990. During the review, the Party clarified that the Estonian Land Board has started digitalizing old orthophotos and that as these data become available Estonia will use them to report on 1970–1990 land-use changes in NFI plots. The ERT, while noting that the information provided during the review demonstrates that the Party has made progress in addressing this recommendation, considers that it should	ARR2022/L.1	Estonia has acquired land-use change data for 1970–1990. The areas of land-use categories and related GHG emissions have been recalculated in the current submission.		Chapter 6.3.1

	describe its progress in future NIRs. The ERT also notes that this recommendation is relevant to all GHGs, not only N ₂ O.				
4.A Forest land – CO₂ (L.15, 2020) Transparency	Provide additional information in the NIR on time-series management of NFI data to allocate AD to individual years with a view to ensuring that estimates remain accurate and reliable as recalculations occur. Addressing. The ERT noted that NIR figure 6.11 still shows large inter-annual CSC for living biomass in forest land remaining forest land. As noted by the previous ERT, this seems to be in contradiction with a stock difference method, which usually smooths inter-annual variation as it gives only one value for an entire inventory cycle for any given plot. The NIR (p.439) points to sections 6.1.3 and 6.2 as addressing this issue by clarifying how plot data are aggregated to determine the national total. The ERT considers that these sections are not yet fully transparent. On p.321 (section 6.2), the Party mentions summing estimates for “each given area” but does not specify what these areas are. On p.314 (section 6.1.3), it states that “the average standing volume is calculated for every year based on the 15-year trend”. During the review, the Party clarified that the procedure applied for estimating CSC in living biomass involves (1) estimating the standing volume on each plot; (2) summing all plots to obtain the total national standing volume for each year; (3) regressing the standing volume against time over a 15-year window centred on each year; (4) estimating a “smoothed standing volume” for each year as 75 per cent of the regressed value for the year plus 25 per cent of the actual value for the year; and (5) computing the difference with the standing volume in year $y - 1$ to obtain the reported CSC in living biomass for year y. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet provided in its NIR a fully transparent explanation of how it estimates CSC for living biomass in forest land remaining forest land. The ERT considers that the issue could be resolved by detailing in the NIR the procedure outlined during the review, including, ideally, providing equations that allow the ERT to track how Estonia goes from standing stock in each NFI plot to reported CSC in living biomass for a specific year.	ARR2022/L.5	Estonia has implemented the gain-loss method for estimating C stock changes in living biomass since the 2024 submission and no longer applies the smoothing. This will eliminate the need for recalculations in case the trend changes. New methodology has been described in the NID.		Chapter 6.4.2
4. General (LULUCF) – CO₂, CH₄ and N₂O Accuracy	The Party reported in its NIR (pp.318–319) and showed in NIR figures 6.9 and 6.10 that the area of land converted to forest land is very small for the 1990s and is associated with a decreasing area in forest land remaining forest land. The ERT noted that this pattern could be the result of an implicit assumption that there was no conversion to forest land prior to 1990; however, this assumption is neither stated nor justified in the NIR. More generally, assumptions made on land-use changes between 1970 and 1990 are not explicitly described in the NIR. During the review, Estonia declared that it was still in the process of collecting data on pre-1990 areas and practices. Because Estonia has chosen the default transition period of 20 years for conversions between land categories, data or assumptions on land-use changes necessarily start in 1970 to estimate areas of land categories in 1990 (in line with the 2006 IPCC Guidelines, vol. 4, p.4.33), even if Estonia has not yet acquired data for 1970–1990 (see also ID# L.1 in table 3).	ARR2022/L.12	Estonia has acquired land-use change data for 1970–1990. The areas of land-use categories and related GHG emissions have been recalculated in the current submission.		Chapter 6.3.1

	The ERT recommends that the Party transparently describe in the NIR the assumptions made on land-use changes between 1970 and 1990, possibly by including a representative land-transition matrix for that period, and, if the area subject to land-use changes is not nil, recalculate all estimates accordingly for 1990–2009.				
4. General (LULUCF) – CO₂ Accuracy	The Party reported in its NIR (p.326) that it uses EFs from the 2020 Swedish NIR for estimating CO₂ emissions from the drainage of organic soils. The ERT noted that the Swedish EFs are weighted averages of IPCC default EFs from the Wetlands Supplement (p.2.11); for forest land, they are weighted by the shares of boreal/poor, boreal/rich and temperate forest soils in Sweden. Similar weightings are applied for other land uses. The ERT considers that the application of these Swedish EFs by Estonia is not justified as Estonia lies entirely in the temperate zone according to the maps in the 2006 IPCC Guidelines (p.3.47). During the review, the Party clarified that its experts considered that using the default EFs from the 2006 IPCC Guidelines (vol. 4, chap. 4, p.4.53) for the temperate zone would be appropriate. The ERT agrees that this is in line with the UNFCCC Annex I inventory reporting guidelines, noting that using the more recent and more detailed default EFs from the Wetlands Supplement would likely improve the accuracy of the emission estimates. The ERT recommends that the Party use EFs that are better suited to Estonia’s national soils and climate than the EFs currently in use (from the Swedish NIR) for estimating CO₂ emissions from the drainage of organic soils; for example, the ERT considers that the IPCC default EFs from the Wetlands Supplement (p.2.11) would be appropriate.	ARR2022/L.13	The default EFs from the 2006 IPCC Guidelines were applied for drained organic soils since the 2023 submission. Estonia has ongoing research projects to develop country-specific EFs.		Chapter 6.4, Chapter 6.5, Chapter 6.6, Chapter 6.8
4.A Forest land – CO₂ Transparency	The Party reported in its NIR (p.321) country-specific values for BCEFs. The ERT noted that these BCEFs present a counter-intuitive pattern because they are approximately stable per growing stock level, whereas BCEFs normally tend to decrease substantially with increasing growing stock level. For example, the changes in the BCEFs from the <20 m³ class to the 21–50 m³ class are very small (the <20 m³ value is even lower than the 21–50 m³ value for pine), whereas this change is commonly around –50 per cent (e.g. default values from the 2006 IPCC Guidelines (vol. 4, pp.4.50–4.51)). During the review, the Party clarified that the stable trend is the result of a fitted regression (BCEF as a function of stand volume) based on 165 pine, 127 spruce and 117 birch sample trees. The ERT recommends that the Party demonstrate in its NIR that the regression performed (BCEF as a function of stand volume) is accurate by providing the equation and parameters used together with graphical or numerical evidence that residuals are evenly distributed around zero along a representative range of growing stock levels. The ERT notes that, for example, a graph showing the regression curve for each tree type (i.e. pine, spruce and birch) together with points for each measured tree and an indicator of the fit (e.g. adjusted R-squared) would address the issue.	ARR2022/L.14	Estonia has updated the models for estimating BCEF values. More information is provided in Annex A.V.4.		Annex A. V. 4.1

4.A Forest land – CO₂ Accuracy	The Party reported in its NIR (p.321) weighted averages for BCEFs for each subcategory of forest land, as well as BCEF values per tree species and growing stock level. However, the NIR does not clearly state which of these two sets of values are used in the calculations. During the review, the Party clarified that it applied each weighted average to all the plots for a subcategory rather than applying different BCEFs corresponding to the growing stock level of each plot. The ERT notes that by doing so, the Party risks overestimating emissions from harvest, as the average is higher than the value for plots with a high growing stock level. The ERT recommends that the Party either demonstrate that the risk of overestimating emissions from harvest is negligible when using a weighted average BCEF value for each subcategory of forest land or apply a set of BCEFs adapted to the variation in BCEF values per growing stock level.	ARR2022/L.15	Estonia has improved the method for calculating C stock changes in living biomass since the 2024 submission. According to the new methodology, tree biomass is calculated for each NFI plot, using the BCEFs applicable for specific growing stock level. The same approach is also applied to estimate biomass losses from harvests, using information on pre-harvest growing stocks on NFI plots.		Chapter 6.4.2
4.A.1 Forest land remaining forest land – CO₂ Accuracy	The Party reported in its NIR (p.319) that annual felling is generally the first-order driver of CSCs in forest land remaining forest land in the short to medium term (one to five years). The ERT noted that the time series for harvesting was not provided in the NIR. Comparing a time series of harvest values downloaded from FAOSTAT with overall removals in forest land (NIR figure 6.10 (p.119)), the ERT noted three major concerns: (a) Consistently with the narrative in the NIR (p.312), the comparison indicates that the end of the planned economy led to a substantial increase in harvested amounts in the 1990s (500 per cent between 1992 and 2001). One would therefore expect removals to have fallen steadily over that period, which is, however, not the case in the reported time series; (b) The maximum in removals occurred in 2003 and corresponded to a local maximum in harvest statistics. In general, a peak in harvest corresponds to lower removals. A similar feature, although less pronounced, occurred in 2018, when removals increased whereas harvest reached its all-time maximum. Usually, local maximums in removals correspond to local minimums in harvest and vice versa; (c) Since 2010, harvest statistics and removals have been broadly correlated at the 10-year timescale by an overall increasing trend in harvest and an overall decreasing trend in removals. However, at the five-year timescale, this is not the case: harvest rose sharply between 2008 and 2012, whereas removals also increased over that period, and, after a short plateau, harvest rose again sharply between 2014 and 2018, whereas removals were broadly stable. During the review, the Party offered three explanations for these concerns: (1) harvest is not the only factor affecting CSC in forest biomass, which depends also on the forest age structure and change in forest land area, as well as on the relative impact of changes in these factors over time; (2) the smoothing procedure cuts off the peaks in 2003 and 2018; and (3) the unfinished NFI cycles generate uncertainties in the most recent years of the time series. The ERT understands that because the NFI cycle is five years long, unfinished NFI cycles can blur the estimates for the last four reported years (2017–2020 in the case of the 2022 submission). However, a harvest lower than the increment justifies net removals, not a	ARR2022/L.16	Estonia has improved the method for calculating C stock changes in living biomass and switched to the gain-loss methodology, which directly takes into account harvest rates. Annual losses of biomass from clear felling are shown in Figure 6.12 and felling volumes in Figure 6.13.		Chapter 6.4.2

	flat trend in removals, and smoothing justifies lower peaks than expected, but not opposite local extremes in harvest and CSCs. In addition, the Party clarified that it was using both permanent and temporary plots to estimate CSCs via the stock difference method. The ERT notes that using temporary plots together with the stock difference method could introduce a substantial random component in the estimates of CSCs. Indeed, when the stock difference method is applied to permanent plots, the estimate only reflects the change in stock, whereas when it is applied to temporary plots, the estimate also reflects the random change in sampled plots. Therefore, the ERT notes that the inconsistencies between the reported CSCs and the harvested volumes might be the result of an inaccurate smoothing procedure (see also ID# L.5 in table 3). The ERT recommends that the Party (1) provide in the NIR a transparent description of the counteracting forces that prevail over harvest as the main drivers of inter-annual (or short-term) changes in harvest levels or reconsider its smoothing procedure so that it better reflects short-term (at least on a five-year timescale) changes in harvest levels and (2) report in the NIR harvest statistics for the entire reporting period, possibly in the same figure (graph) as the one displaying total emissions/removals for the category (figure 6.10 (p.319) in the 2022 NIR).				
4.A.2 Land converted to forest land – CO₂ Accuracy	The Party reported in its NIR (p.325) that its EFs for CSCs in mineral soils in cropland converted to forest land and grassland converted to forest land were derived from a published article (Kölli et al., 2010). During the review, the Party provided the ERT with the article together with the calculation sheet describing how the figures from the articles were combined into the reported EFs. The ERT noted that the calculation method is in line with the 2006 IPCC Guidelines (vol. 4, chap. 2, p.2.38). However, the ERT also noted that the soil types for which no data were available were misrepresented as “no change in soil carbon” rather than being noted as “no data” and that the shares of forest per soil type did not add up to 100 per cent. The ERT recommends that the Party correct the estimates for CSCs in mineral soils in cropland converted to forest land and grassland converted to forest land by correcting the errors in the calculation sheet used to estimate the EFs for CSCs in mineral soils in cropland converted to forest land and grassland converted to forest land (by noting “no data” rather than “0” for soil types for which no data are available and ensuring that the shares of forest per soil type add up to 100 per cent) and report on the associated recalculations of emissions in the NIR.	ARR2022/L.17	Country-specific factors for mineral soils in conversion areas were corrected and calculations have been updated since the 2023 submission.		Chapter 6.4.2, Chapter 6.5.2, Chapter 6.6.2, Annex A. V. 4.2
4.E.2 Land converted to settlements – CO₂ Accuracy	The Party reported in its NIR (p.357) that it uses EFs from the 2020 Swedish NIR for CSCs in mineral soils for all subcategories of land converted to settlements, with the exception of forest land converted to settlements. The ERT noted that this is in principle reasonable, provided that Estonia has assessed that (1) the neighbouring country (in this case Sweden) is likely to be comparable for the given EFs and (2) the neighbouring country’s EFs were obtained in line with the 2006 IPCC Guidelines. In this case, at least the first condition might not apply, as reported soil carbon stocks in Estonia and Sweden are very different in several categories (e.g. cropland and forest land). The ERT also noted that the reported EFs are very counter- intuitive: the EF for cropland converted to	ARR2022/L.18	Estonia no longer uses Swedish EFs to estimate CSC in mineral soils for Land converted to settlements subcategories. Instead, it is assumed that 20% of the initial country-specific average SOC stock is lost after land use change, which is the default value from the 2006 IPCC Guidelines for the settlement area that is paved over.		Chapter 6.8.2

	settlements is substantially lower than those for forest land converted to settlements and grassland converted to settlements despite soil carbon stocks being substantially higher in forest land and grassland compared with cropland. Similarly, the EF for forest land converted to settlements is three times lower than the EF for grassland converted to settlements despite the fact that Estonia considers that the transition from forest land to grassland results in negligible soil carbon changes in mineral soils. During the review, the Party noted that it has not validated the assumptions that the proportions of land-use groups within the different subcategories and the effects of land-use changes on soil carbon stocks in Estonia and Sweden are similar. The ERT recommends that the Party verify that the Swedish and Estonian situations are similar for the EFs in the land converted to settlements categories and that the Swedish EFs were obtained in line with the 2006 IPCC Guidelines, and if either of these conditions is violated, use a different set of EFs, possibly in conjunction with a tier 1 method for estimating emissions until an accurate higher-tier method can be properly justified.				
4.G HWP – CO₂ Transparency	The Party reported in its NIR (p.370) several sources of data used in equations 2.8.1–2.8.6 from the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol, but did not provide the numerical values of a few key variables (e.g. total stock in HWP, share of industrial roundwood for the domestic production of HWP originating from domestic forests and share of domestically produced pulp for the domestic production of paper and paperboard). During the review, the Party clarified the description in the NIR by providing the source of data for each variable in the IPCC equations as well as the numerical values of a few key variables (e.g. total stock in HWP, share of industrial roundwood for the domestic production of HWP originating from domestic forests and share of domestically produced pulp for the domestic production of paper and paperboard) for a selection of years, including 1990. The ERT recommends that the Party provide in the NIR the source of the data as well as numerical values for each key variable in the equations used for estimating CO₂ emissions for this category (equations 2.8.1–2.8.6 from the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol).	ARR2022/L.19	Since 2023 submission Estonia has added in the NID a table providing numerical values for key variables as well as relevant data sources.		Chapter 6.12, Table 6.37
5. General (waste) – CO₂ (W.7, 2020) Convention reporting adherence	Improve QC procedures and report consistent information in the NIR and the CRF tables. Addressing. The Party reported in CRF table 5.C and NIR annex 4 (p.92) consistent information for subcategories 5.C.1.1 (waste incineration – biogenic) and 5.C.2.1 (open burning of waste – biogenic). However, for subcategory 5.A.1.a (managed waste disposal sites – anaerobic), the Party reported the CO₂ emissions as “NA” in annex 4 (p.92) to the NIR but as “NO” in CRF table 5.A. The ERT considers that the recommendation has not yet been fully addressed.	ARR2022/W.2	Correction has been made in the 2021 submission		CRT 5.A.1.a, 5.C.1.a, 5.C.2.a

5.A Solid waste disposal on land – CH₄ Transparency	The Party reported in its NIR (pp.380 and 397) that its waste stream includes imported and exported waste and clarified that all waste data have been considered in the emission calculations. However, no details on the two streams are provided in the NIR. During the review, the Party clarified that when preparing the inventory, the entire waste stream, including waste that is generated, imported, exported, recycled and landfilled, is checked. The majority of the imported waste types (e.g. different metals) are reported by Estonian recycling companies. Historically, only a small part of the imported waste has been landfilled; this waste, while it is included in the waste model calculation, is inert waste for which CH₄ emissions are not calculated. The ERT recommends that the Party provide in the NIR a thorough description of imported waste, including its amount, characteristics and how it is accounted for in the calculations of CH₄ emissions for this category.	ARR2022/W.4	Explanation has been added since 2023 submission.		Chapter 7.2.2
5.A Solid waste disposal on land – CH₄ Convention reporting adherence	The Party reported in NIR table 7.7 that the IPCC default value of DOCf was used and in CRF table 5.A the DOCf for anaerobic managed waste disposal sites was reported as 13.84. The ERT noted that this is not in accordance with the 2006 IPCC Guidelines (vol. 5, chap. 3, p.3.13), which provide a default value of 0.5 for DOCf. During the review, the Party clarified that an error occurred in reporting, namely that the MSW DOC was reported as DOCf in CRF table 5.A. The default fraction of 0.5 from the 2006 IPCC Guidelines was, however, used in the calculations. The ERT recommends that the Party correct the DOCf value for anaerobic managed waste disposal sites reported in CRF table 5.A (i.e. to the default value from the 2006 IPCC Guidelines) in the next annual submission.	ARR2022/W.5	Correction has been made in CRF/CRT.		CRT 5.A.1.a
5.A Solid waste disposal on land – CH₄ Transparency	The Party reported in NIR table 7.7 (p.385) that k values are 0.06, 0.03, 0.1, 0.185 and 0.09 for paper/textile, wood, organic/garden and park, food and sewage, and industrial waste respectively. However, the NIR provides no justification on the choice of the values used from table 3.3 of the 2006 IPCC Guidelines (vol. 5, chap. 3, p.3.17). The ERT noted that the k values are those from the boreal and temperate climate zone for wet waste. During the review, the Party clarified that it plans to include climate zone information in the methodological section of the waste sector chapter in the next NIR and noted that according to the Estonian Environment Agency, the mean annual temperature in Estonia (1991–2020) was 6.4 °C and precipitation is almost twice as much as evaporation, so the climate is wet. The ERT recommends that the Party provide in its NIR an explanation of the reason for its choice of climate zone when selecting k values for waste.	ARR2022/W.6	Climate zone information has been added since 2023 submission.		Chapter 7.2.2

5.A Solid waste disposal on land – CH₄ Transparency	The Party reported in its NIR (p.385) that default DOC content factors from the 2006 IPCC Guidelines were used in emission calculations. The ERT noted that NIR table 7.11 (p.386) includes country-specific DOC content factors for mixed MSW divided into five periods. The ERT also noted that NIR table 7.1 (p.373) states that default EFs were used. During the review, the Party clarified that NIR table 7.1 should include both country-specific and default EFs for estimating CH₄ emissions because the DOC values are calculated using data from national MSW studies that take place periodically. The ERT recommends that the Party include in NIR table 7.1 that country-specific EFs are used for estimating CH₄ emissions from MSW disposal on land and provide in the NIR information about the way in which these country-specific DOC content factors in MSW have been calculated.	ARR2022/W.7	It is correct, that IPCC 2006 Guidelines waste DOC content is used for GHG emission calculation, therefore Table 7.1 is correct. Unfortunately there was miscommunication during the review week. Municipal waste DOC values were calculated and included to reflect how carbon content has changed over time in MSW waste as a group of different waste materials. This estimation is based on the mixed municipal waste sorting studies and no waste content measurements have been made. The GHG calculations are done separately for all waste groups (e.g. food waste, garden, paper, textile etc) and therefore MSW is also divided to different waste groups.		Chapter 7.1
5.B.1 Composting – CH₄ Transparency	The Party reported in NIR table 7.15 (p.391) the quantities of MSW composted in 2003, 2014 and 2017. For the other years of the time series, the notation key NO was used for composted MSW. During the review, the Party clarified that for 2003, 2014 and 2017, a waste management company reported composted waste with an MSW code, which is not common practice, and therefore switched to reporting the quantities of waste under the respective waste groups in future years. The ERT recommends that the Party include information on the composting of MSW across the time series. The ERT encourages the Party to provide a description of composted waste practices in its next annual submission.	ARR2022/W.8	Description of composted waste practices has been added in NID since 2023 submission. Full timeline of the quantities of composted MSW can be seen in CRT 5.B.1.a		Chapter 7.3.2, CRT 5.B.1.a

Table 10.6. Responses to the 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 Article 4(3) of Regulation (EU) No 2018/842 and Article 4(4) of Regulation (EU) No 2018/841

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
EE-1A1a-2025-0001-1A1a Public electricity and heat production, CO₂, 2023	For 1A1a Public Electricity and Heat Production, the TERT noted that the implied emission factor for CO ₂ for natural gas is low and outside of the 2006 IPCC's Guidelines default emission factor range (54,300 - 58,300 Kg/TJ) (Table 1.4 of V2_1_Ch1_Introduction of the 2006 IPCC Guidelines) for this fuel. In response to a question raised during the review, Estonia explained that the reason for the low emission factor was that a large proportion of their natural gas in 2023 came from the USA which has a low carbon factor for natural gas. The TERT recommends that Estonia look into this issue further (as it is unusual for an emission factor to be outside of the IPCC Guidelines default range) and provide information in the next NID on the calorific value and carbon content used to derive the emission factor.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(3) of Regulation (EU) No 2018/842, Table 4	Almost all natural gas consumed in Estonia originated from Russia until 2023, when sanctions against Russian natural gas were enforced. Natural gas consumed in 2024 originated from different countries and a similar methodology to liquid fuels was implemented to determine the CO ₂ IEF of natural gas. The methodology is to calculate weighted average IEF of natural gas consumed in Estonia using natural gas import quantities by country and CO ₂ IEF-s of natural gas reported by these countries (from the latest submitted CRT fail). The reason why the average CO ₂ IEF is so low is because the US CEF for natural gas is very low (13.68 tC/TJ or 50.16 tCO ₂ /TJ) and as US was the first largest source of natural gas in 2024 this resulted in the lower average result.		1.A.1.c Manufacture of solid fuels and other energy industries, Activity Data, Table 3.6
EE-3-2025-0001 - 3 Agriculture, N₂O, 1990-2023	For category 3 Agriculture N ₂ O 1990-2023 the TERT noted that in response to a question raised during the review Estonia explained that they did not include N ₂ emissions in the current reporting for Total N volatilized in table 3B(b). Estonia did not provide a revised estimate. The TERT noted that the issue does not affect the emission calculation. The TERT recommends that Estonia keep on working on the issue and include the revised estimates for Total N volatilised in the next submission.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(3) of Regulation (EU) No 2018/842, Table 4	Since 2026 submission, the Party has reported also N ₂ emissions for Total N volatilized in table 3B(b).		5.1 Overview of the sector

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
EE-3B-2025-0003 - 3B Manure Management, N₂O, 1990-2023	For category 3B1 Cattle, 3B3 Swine and 3B4.g Poultry for N ₂ O 1990-2023 the TERT noted that there is a lack of transparency regarding the emission factors (EF) used because no information is provided in NID for EF for anaerobic digester, poultry manure and the share of liquid manure with and without natural crust cover for cattle and swine. The TERT notes that this issue does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Estonia explained which EFs were used. The TERT recommends that Estonia include information on the EFs used in the emission calculations for all relevant manure management systems in the NID.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(3) of Regulation (EU) No 2018/842, Table 4	Since 2026 submission, the Party reported in its NID, Chapter 5.3.2 Methodological issues, Activity data section, Table 5.33 the full information on the EFs used in the emission calculations for all relevant manure management systems.		5.3.2 Methodological issues, Activity data section, Table 5.33

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
EE-4-2025-0006 - 4 Land use, land-use change and forestry, CO₂, N₂O, 1990-2023	The TERT noted inconsistencies in the calculation of mineral soil carbon stock changes across land-use conversions. For example, the reported emission factor (EF) for Grassland converted to Forest Land is -0.12 t C ha⁻¹ yr⁻¹ (Table 6.10), while for Forest Land converted to Grassland it is 0.159 t ha⁻¹ yr⁻¹ (Table 6.21). Furthermore, these values are not consistent with the national soil carbon stock values provided: Forest Land – 108.0 t C ha⁻¹, Grassland – 107.3 t C ha⁻¹, and Cropland – 88.2 t C ha⁻¹. Applying a 20-year transition period, the expected average annual carbon stock change between Forest Land and Grassland would be 0.035 t C ha⁻¹ yr⁻¹. The issue persists in all land-use changes. The current approach can theoretically result in a drift toward negative soil carbon stock values if land continuously transitions between two land-use categories. Considering the assumption that both EFs and average C stocks provided by Estonia are based on the same weighted average soil type distribution and applied 20-year conversion period and that the actual annual distribution of converted soil types is not tracked, the applied EFs should be equal to the difference in average C stocks divided by 20, however, such consistency is not ensured. In addition, The TERT noted an incompleteness in the reporting of carbon stock changes (CSCs) in mineral soils in land conversions involving Grassland and Settlements. CSC in mineral soils is reported for Grassland converted to Settlements; however, no mineral soil CSC is reported for the reverse transition, i.e., Settlements converted to Grassland. For consistency and completeness, CSC should be reported in both directions of land-use conversion in accordance with the 2006 IPCC Guidelines (Vol. 4, Ch. 2). In response to a question raised during the review, Estonia explained that mineral soil C stock changes due to land conversion between Forest land, Cropland and Grassland were estimated based on the article (Kõlli et al. 2010) that compares SOC stocks under different land use separately for each soil type. Weighted average EFs were calculated based on the distribution of soil types in the original land use (from Kõlli et al. 2009). The Reference SOC value is not used in calculations. The assumed distribution of soil types is the same as that used for calculating the average SOC stock of the land-use categories. The approach that Estonia applies for land conversions of Settlements and Other land is the same as in the Swedish NIR. Responding to a potential technical correction, Estonia has submitted a revised calculation for	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	SOC changes in mineral soils and related N₂O emissions have been recalculated for the entire time-series, as recommended by the TERT. Additional chapter including the methodology and data, as well as the matrix of calculated CSC values for mineral soils under land-use change was added to the Annex of the NID. CSCFs for Cropland and Grassland converted to Forest land have been verified using published articles. Estonia has several ongoing research projects to improve the accuracy of reporting for soils, including updating the soil map and moving to Tier 3 methodologies for the assessment of carbon stock changes in soils.		Chapter 6.4, Chapter 6.5, Chapter 6.6, Chapter 6.8, Chapter 6.9, Chapter 6.10, Annex A. V. 4.2

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
	lands converted from Wetlands, Settlements, and Other Land categories. Additionally, Estonia provided detailed calculations of CSCFs for land-use changes between Forest Land, Cropland, and Grassland. For these land categories, Estonia presented a matrix that transparently demonstrates the derivation of CSC values at the level of each soil type. The values were calculated as the difference in average carbon stocks measured for different soil types under various land uses and were subsequently aggregated at the land-use category level. Estonia also reported on the verification of these CSC values by referring to the NID, Chapter 6.4.4. The revised estimate included previously absent estimates of mineral soil carbon stock changes for Settlements converted to Grasslands. The TERT does not consider that the method applied causes systematic under- or over- estimates of emissions and removals, and it thus agrees with the recalculated estimates. Nevertheless, the TERT notes that the method applied assumes that the share among soil types of each kind of land use change remains constant across the entire time series based on information collected from a paper (Kolli et al, 2009), and that Other land includes also land with significant SOC stocks. Thus, the TERT recommends that Estonia report a complete time series of recalculated SOC changes in mineral soils, including carbon stock changes for Settlements converted to Grasslands, together with detailed data on SOC stocks of the different soil types under the different land uses, as well as the matrix of calculated CSCs in its next NID. To ensure transparency, the TERT recommends that Estonia report calculations of carbon stock changes in the NID split for the different types of other land, i.e. those without significant carbon stocks (see IPCC definition) and those with significant carbon stocks. Finally, the TERT recommends that Estonia collect information on the soil type of each detected land use change, through a spatially explicit system, and accordingly recalculate estimates of SOC changes, as well as that Estonia continue to verify the accuracy of CSC values in the matrix and report on the results of verification exercises in next submissions.				

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
EE-4A-2025-0002 - 4A Forest land, CH ₄ , CO ₂ , N ₂ O, 1990-2023	The TERT noted that Estonia does not consistently apply emission factors across gases for organic soils in the Forest Land category. Estonia uses Tier 1 temperate zone emission factors from the 2006 IPCC Guidelines for CO₂ emissions but applies boreal zone emission factors from the 2013 IPCC Wetlands Supplement for N₂O and CH₄ emissions. According to Figure 3A.5.1 of the 2006 IPCC Guidelines, Estonia lies within the temperate zone; therefore, temperate zone emission factors should be applied consistently across all gases. The TERT recommends that Estonia apply the updated 2013 IPCC Wetlands Supplement emission factors for CO₂, N₂O, and CH₄ for the temperate zone to ensure methodological consistency. In response to a question raised during the review, Estonia provided revised estimates. Estonia recalculated N₂O emissions from drained organic forest soils using default emission factors from the 2006 IPCC Guidelines (Ch. 11, Table 11.1, temperate and boreal zone) and calculated CH₄ emissions using EFs for temperate zone from the 2013 IPCC Wetlands supplement, as 2006 IPCC Guidelines do not provide a default value for the CH₄ EF. The TERT agreed with the revised estimate provided by Estonia. The TERT recommends that Estonia include revised estimate using temperate EFs in its next submission. Additionally, the TERT encourages Estonia to adopt the 2013 IPCC Wetlands Supplement emission factors for drained organic soil emissions for all gases, until country-specific methods become available.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	Estonia has recalculated N ₂ O emissions from drained organic forest soils using default emission factors from the 2006 IPCC Guidelines (Ch. 11, Table 11.1, temperate and boreal zone) and CH ₄ emissions using EFs for temperate zone from the 2013 IPCC Wetlands supplement, as 2006 IPCC Guidelines do not provide a default value for the CH ₄ EF. Estonia is working on developing the country-specific EFs for drained organic soils.		Chapter 6.4

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
EE-4B-2025-0004 - 4B Cropland, CO ₂ , 1990-2023	The TERT noted that Equation 6.7 to estimate biomass C stock changes in perennial cropland counts for C stock losses/gains associated with area changes only. Such an approach is inconsistent with the IPCC good practice that requires to estimate annual gains, associated with biomass growth, and annual losses, associated with final logging of the trees, across the entire area cultivated with perennial croplands, even when no changes in management, e.g. the type of trees occurs. The TERT asked if Estonia can provide revised estimates of biomass C stock changes from perennial cropland. In response to a question raised during the review, Estonia explained that it has data on the average biomass in orchards from a research project, as well as total annual area data from Statistics Estonia. However, there is no information available on harvested areas or land-use changes to or from perennial croplands. The biomass of perennial woody crops was measured in major market gardens and privately owned orchards in Estonia in 2012. Based on these results, Estonia considers the updated methodology provided in the 2019 Refinement (Chapter 5, Section 5.2.1) to be more suitable than the default values provided in the 2006 IPCC Guidelines. For example, the default value for mean aboveground biomass carbon stock of orchards in Table 5.3 of the 2019 Refinement is close to Estonia's measured value of 7.8 t/ha (assuming a carbon fraction of 0.47). Consequently, Estonia revised its estimate using the Tier 1 methodology from the 2019 Refinement. The TERT agreed with the methodological approach applied to calculate the revised estimate; although the TERT noted that, according to Table 5.5 of the 2019 Refinement, annual growth rate of 0.43 t C/ha should be used, while instead Estonia used a value of 0.28 t C/ha. Accordingly, the TERT informed Estonia of the error and Estonia agreed to correct the value to 0.43 t C/ha in the revised estimates. The TERT recommends that Estonia include a complete time series of the revised estimate in the next submission. Furthermore, given that it is good practice to seek national data on above-ground woody biomass growth rates, the TERT encourages Estonia to address existing knowledge gaps related to woody biomass growth rates, carbon stocks at the time of harvesting and land-use changes between annual and perennial crops, to improve the estimation of carbon stock changes in perennial crop living biomass for Cropland remaining Cropland and conversion to and from Cropland with perennial crops.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	Estonia has recalculated biomass C stock changes in orchards using the Tier 1 methodology from the IPCC 2019 Refinement.		Chapter 6.5.2

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
EE-4-2025-0007 - 4 Land use, land-use change and forestry, CO₂, 1990-2023	The TERT noted that in the previous UNFCCC review (ARR 2022), the ERT recommended (L.14) that Estonia demonstrate the accuracy of the regression used to estimate BCEFs as a function of stand volume, by providing the equation, parameters, and graphical or numerical evidence (e.g., residual plots, adjusted R²). In the 2025 submission, Estonia has provided a table of BCEF by stand volume class (Annex A.V.4) and mentioned in NID Table 1.5 the use of a regression approach. However, the regression equations and statistics on fitting are not presented, and no graphical or numerical evidence of the regression fit is included. Considering that BCEFs are a key component used within Estonia's Tier 3 method for estimating carbon stock changes in living biomass, the ERT recommended that Estonia report a completed description of the process to derivate the BCEF values, including the regression equations, parameter values, and evidence of the statistical fit (e.g., residuals plots or adjusted R²) or other empirical evidence that the BCEFs are accurate. In response to a question raised during the review, Estonia explained to the TERT that the development of BCEF coefficients can be found in a report of the Estonian University of Life Sciences (Sims, 2024) (https://keskkonnaportaal.ee/sites/default/files/2024-08/K%C3%A4sundusleping_aruanne.pdf). The report contains information on the development of BCEF coefficients, including the regression estimates and parameters for single tree biomass by species, from NFI data. The TERT recommends that Estonia include information on the regression equations used to develop the BCEF values, as well as information on the statistics on fitting and on the data used, in the NID or in its annex in the next submission, in addition to the literature references.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	In the current submission, a description of the development of the BCEF coefficients has been added to Annex of the NID, Chapter A. V. 4.1, including the single-tree biomass models that were used for constructing BCEFs		Annex A. V. 4.1

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
EE-4A-2025-0005 - 4A Forest land, CH ₄ , NO ₂ , 2012-2023	The TERT noted that for wildfires in Forest lands a constant combustion efficiency value of 0.15 was applied for the years 1990–2011 based on IPCC default values. The TERT further noted that Estonia's NID explains that, starting from 2012, the values of the 2 variables/parameters: "mass of available fuel (MB)" and "combustion efficiency (Cf)" for wildfire emissions are determined through field inventories conducted by the Estonian Environment Agency. However, the actual measured values of MB and Cf used since 2012 are not transparently reported in the NID. Thus, the TERT asked Estonia on MB and Cf values used in each year from 2012 onward and transparently justify their selection. In response, Estonia clarified that it no longer uses the "mass of available fuel (MB)" and "combustion efficiency (Cf)" to calculate emissions from wildfire. Instead, in-situ measurements are conducted at each burned area, where only the burned biomass is assessed. This approach ensures a direct and precise estimation of wildfire-related losses based on actual field observations. The TERT recommends that Estonia report complete information on the methodology applied to estimate the amount of biomass combusted for the year 2012 onward.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	The methodological description for estimating emissions from wildfires has been amended.		Chapter 6.11.2
EE-4A-2025-0004 - 4A Forest land, CO ₂ , 1990-2023	The TERT noted that in the previous UNFCCC review (ARR 2022, L. 16), the ERT recommended that Estonia provide a transparent description of the counteracting forces that prevail over harvest as drivers of inter-annual carbon stock changes in living biomass for forest land remaining forest land, and that harvest statistics be reported alongside removals over the entire reporting period. In the 2025 submission, Estonia has implemented a Gain-Loss method to estimate carbon stock changes, and harvest statistics are now reported together with removals (Figures 6.12 and 6.13 of the NID), so addressing part of the recommendation, and it is developing a more detailed gain-loss methodology, which is expected to be used no later than in the 2027 submission. During the review, Estonia had communicated to the ERT that factors such as forest age structure, increment, net of natural mortality, and land area changes counteract the effect of harvesting. However, a detailed description of these counteracting drivers is not included explicitly in the NID. The TERT recommends that Estonia include in future NIDs a transparent explanation of each of the components estimated in the	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	Estonia has an ongoing project to develop new forest growth and mortality models, thus gross increment and natural mortality will be included in the NID when new methodology is applied. Harvest losses have been presented in Figure 6.12.	Estonia is developing a more detailed gain-loss methodology.	

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
	Gain and Loss estimate, including the counteracting forces influencing carbon stock changes. In particular, the TERT recommends that Estonia report in its next NID a complete time series of estimates of the gross increment, the natural mortality, and of the harvest losses contributing to the net carbon stock change over the whole time series. This would significantly improve the transparency and understanding of how different components influence the carbon dynamics of forest biomass over time.				
EE-4A-2025-0003 - 4A Forest land, CO₂, 1990-2023	The TERT noted that category 4A1. Forest Land Remaining Forest Land is a key category, with organic soil representing a significant source while Tier 1 EFs are applied. In accordance with Article 18(4) of Regulation (EU) 2018/841, at least a Tier 2 method should be applied for such pools. In Table 10.4 of the NID, it is indicated that an improved emission calculation method may be developed as an outcome of the project “Demonstration of climate change mitigation potential of nutrient-rich organic soils in the Baltic States and Finland.” The TERT noted that several studies conducted in Estonia (listed below) provide estimates of soil carbon losses or CO ₂ emissions from drained organic soils. Namely: Salm, J.-O., Maddison, M., Tammik, S., Soosaar, K., Truu, J., and Mander, Ü.: Emissions of CO ₂ , CH ₄ and N ₂ O from undisturbed, drained and mined peatlands in Estonia. <i>Hydrobiologia</i> , 692: 41–55, https://doi.org/10.1007/s10750-011-0934-7 , 2012. Uri, V., Kukumägi, M., Aosaar, J., Varik, M., Becker, H., Morozov, G., and Karoles, K.: Ecosystems 280 carbon budgets of differently aged downy birch stands growing on well-drained peatlands. <i>Forest Ecol. Manag.</i> , 399, 82–93, https://doi.org/10.1016/j.foreco.2017.05.023 , 2017. Minkinen, K., Laine, J., Shurpali, N. J., Mäkiranta, P., Alm, J., and Penttilä, T.: Heterotrophic soil respiration in forestry-drained peatlands. <i>Boreal Environ. Res.</i> , 12, 115–126, www.borenv.net/BER/pdfs/ber12/ber12-115.pdf , 2007b. In response to a question raised during the review, Estonia explained that it has launched a research project for developing country-specific GHG emission factors for drained organic forest soils (nutrient-poor sites) in 2021. During the project LIFE OrgBalt, emission factors have been developed for nutrient-rich organic soils in the temperate cool & moist (TCM) climate region. Both projects have been concluded, but the results will be implemented in the inventory after the publication of the emission factors in peer-	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	Estonia is working on developing country-specific emission factors for drained organic soils and plans to implement Tier 2 methodology in the 2027 submission.	Estonia is still working on the methodology for estimating emissions from drained organic soils.	Chapter 6.4.6

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
	reviewed journals. In 2025, Estonia also initiated a project for developing Tier 3 methodologies to estimate GHG emissions/removals in mineral and organic forest soils. Given that Forest Land Remaining Forest Land is a key category and organic soils represent a significant source, the TERT recommends that Estonia continue improvements as planned and implement a higher-tier method (Tier 2 or Tier 3) as soon as it is scientifically validated and available.				
EE-4A1-2025-0002 - 4A1 Forest land remaining forest land, CH₄, N₂O, 1990-2023	The TERT noted that for 4A1 Forest Land Remaining Forest Land, Estonia reports N₂O and CH₄ emissions from organic soils in Table 4(II) using a Tier 1 method with default emission factors from the 2013 IPCC Wetlands Supplement (the issue on choice of boreal EFs was raised by observation EE-4A-2025-0002). However, this is a key category, and organic soils represent a significant source. In line with the 2006 IPCC Guidelines and the LULUCF Regulation, higher-tier methods (Tier 2 or 3) are required for such significant pools of key categories. The TERT notes that in the NID, page 276 Estonia refers to recently concluded research projects expected to support methodological improvements in the estimation of emissions from organic soils. In response to a question raised during the review, Estonia explained it has launched a research project for developing country-specific GHG emission factors for drained organic forest soils (nutrient-poor sites) in 2021. During the project LIFE OrgBalt, emission factors have been developed for nutrient-rich organic soils in the temperate cool & moist (TCM) climate region. Both projects have been concluded, but the results will be implemented in the inventory after the publication of the emission factors in peer-reviewed journals. In addition, a research project to specify the activity data and emissions from drainage ditches in all land use categories has been recently concluded. Results will be evaluated and implemented in the GHG inventory. Currently the methodological changes concerning organic soils are planned to be implemented in the 2026 submission. The TERT recommends that Estonia introduce the methodological improvements concerning organic soils and move to higher tiers for this significant pool of a key category (Forest land remaining forest land, organic soils).	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	Estonia is working on developing country-specific emission factors for drained organic soils and plans to implement Tier 2 methodology in the 2027 submission.	Estonia is still working on the methodology for estimating emissions from drained organic soils.	Chapter 6.4.6

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
EE-4A1-2025-0001 - 4A1 Forest land remaining forest land, CO₂, 1990-2023	Estonia reports on page 261 of the NID that, although the extraction of stumps and roots is not practiced, the C stocks in the stumps and roots of harvested trees is not transferred to the DOM pools, as per Tier 1 approach, and thus counted in the NGHGI as emitted in the year in which the trees are harvested, although harvesting residues of belowground biomass likely represent a substantial transfer of living biomass to the dead organic matter pool making it a significant pool under the key category of Forest Land Remaining Forest Land. Moreover, given the high harvesting rates observed in the period 2010–2014, counting as an instantaneous emission in the year of harvest the entire C stock of the stumps and roots of harvested trees artificially concentrates carbon losses into earlier years, potentially affecting the accuracy of the time series for the period 2016–2023. The TERT recommends that Estonia count as a C stock gain in the DOM pool the C stocks in the stumps and large roots of harvested trees and then apply a decay function to estimate annual losses from DOM pool, using a Tier 2 or Tier 3 method in line with the 2006 IPCC Guidelines (Vol. 4, Ch. 4, Section 4.2.2.2). In response to a question raised during the review, Estonia explained that it is currently developing a decay function for stumps and roots. Analysis is based on NFI permanent plots. The results are planned to be implemented no later than in the 2027 inventory submission. The TERT recommends that Estonia implement a higher-tier method for estimating carbon stock changes in dead organic matter in the inventory as soon as the noted methodological work is concluded.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	Estonia is currently developing a decay function for stumps and roots and plans to implement the results in the next submission.	Estonia is still working on the methodology for estimating emissions from the stumps and roots after harvesting.	

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
EE-4A2-2025-0002 - 4A2 Land converted to forest land, CH4, 1990-2023	Estonia reports biomass gains for 4A2 Land converted to Grassland but does not report biomass losses for Grassland converted to Forest Land. Under typical land-use transformation practices, the establishment of forest cover is likely to result in the replacement or suppression of existing grassland vegetation and Estonia reports an annual living biomass carbon stock change of 0.11 t C ha⁻¹ yr⁻¹ for Grassland Remaining Grassland and Land converted to grassland (NID Table 6.20), which means that biomass C stocks are present on Grassland. In response to a question raised during the review, Estonia explained that grassland conversion to forest land takes place slowly during natural succession on areas that are no longer under agricultural use, and that thus there are no abrupt changes in the vegetation biomass stock (i.e. biomass losses) at the time of conversion. Instead, the existing vegetation continues to grow alongside the newly established trees. Since tree growth is slow, it is assumed that the grass persists throughout the entire 20-year transition period. Consequently, no biomass loss is reported during the conversion. The TERT partly agreed with the explanation provided by Estonia, indeed, although a constant rate of 0.11 t C ha⁻¹ yr⁻¹ is reported for the annual net gain in woody biomass on Grassland remaining Grassland and Land converted to Grassland, which thus justifies the presence of substantial woody biomass stocks, that constant rate may not accurately capture the long-term dynamics of biomass stocks in Grassland given it is derived by interpolating woody biomass stock data between two NFI cycles and the resulting figure is extrapolated across the entire time series. Further, the TERT notes that this may, in turn, affect assumptions related to carbon stock changes in living biomass due to afforestation of Grasslands. The TERT recommends that Estonia apply splicing techniques to extrapolate living biomass carbon stock changes in Grasslands, with the aim of producing dynamic and more accurate estimates and to assess the impact of these estimates on living biomass CSCs in Grassland Converted to Forest land, including potential biomass losses resulting from afforestation by forest planting following biomass removal.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	The methodology for estimating living biomass carbon stock changes in Grassland has been improved in the current submission. Grassland conversion to forest land does not result in significant biomass losses, as it generally takes place slowly during natural succession on areas that are no longer under agricultural use.		Chapter 6.4.2, Chapter 6.6.2

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
EE-4B-2025-0003 - 4B Cropland, CO ₂ , N ₂ O, 1990-2023	The TERT noted that Estonia applies updated FLU, FMG, and FI factors from the IPCC 2019 Refinement to estimate soil carbon stock change in mineral soils in cropland. On page 273 of the NID, it is reported that a national study (Putku and Penu, 2018) found no statistically significant differences in SOC stocks between conventional and no-till practices in Estonian soils (0–25 cm layer). The TERT thus noted that the use of IPCC default values of FMG may not be justified under the reported national circumstances of Estonia. In response to a question raised during the review, Estonia explained that the study by Putku and Penu (2018) included too few sites for developing country-specific FMG values. In addition, most fields representing conventional practices were actually tilled only 1-3 times across a 5-year period, and the effect was therefore more similar to the reduced tillage management. Thus, Estonia concluded that those results still supports the decision taken to apply FMG values from the 2019 Refinement, given those are lower compared to those provided in the 2006 IPCC Guidelines (as well as other published studies from the same region, e.g. Sheehy et al. 2015. Soil and Tillage Research 150, 107-113). In 2025, Estonia initiated a project that aims to implement RothC model for estimating SOC changes in Cropland mineral soils. The project will end in 2027. The TERT considers that the justification provided—namely that the study included too few sites and that the management practices did not clearly differentiate conventional from reduced tillage— to be sufficient for continuing the use of default FMG factors from the 2019 Refinement. Considering that mineral soils in Cropland Remaining Cropland represent a significant carbon pool, the TERT recommends Estonia to continue its methodological development efforts, including the planned implementation of the RothC model for cropland mineral soils, to improve the accuracy of future estimates of soil carbon stock changes in this category.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	Estonia has an ongoing project to apply Tier 3 methodologies for the assessment of carbon stock changes in cropland and grassland soils.	Ongoing research.	Chapter 6.5.6

CRT category / issue	Review recommendation, technical correction or revised estimate	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
EE-4C2-2025-0003 - 4C2 Land converted to grassland, CO₂, 1990-2023	The TERT noted that Estonia reports CO₂ emissions from organic soils in the category Land converted to Grassland using a Tier 1 method and emission factors from the 2006 IPCC Guidelines. However, this is a key category, and organic soils represent a significant carbon pool given that emissions account for more than 25% of total emissions in this category, consequently the application of a higher-tier method (Tier 2 or 3) is required, in line with IPCC good practice and with the Governance Regulation. The TERT notes that Estonia reported on page 276 of the NID a recently concluded research project, from which methodological improvements may be derived. In response to a question raised during the review, Estonia informed on the plan to implement a country-specific emission factor (Tier 2 method) that was developed during the LIFE OrgBalt project after it has been published in a peer-reviewed article. To ensure that the reporting of land converted to grassland, organic soils is compliant with the requirements in the Governance and LULUCF regulation, the TERT recommends Estonia to apply a higher tier method as soon as the needed information is published.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	Estonia is working on developing country-specific emission factors for drained organic soils and plans to implement Tier 2 methodology in the 2027 submission.	Ongoing research.	
EE-4G-2025-0002 - 4G Harvested wood	The TERT noted that on page 299 of the NID Estonia reported that the Production approach is applied. However, it is also reported that the HWP pool includes “all wood products in use in Estonia,” which raises a potential inconsistency. As outlined in the 2006 IPCC Guidelines (Vol. 4, Chapter 12, p.12.29), the Production is limited to wood products from domestically harvested wood only, and may include products made from domestic harvest that are exported and stored in uses in other countries. The TERT asked Estonia to clarify whether the current HWP methodology corresponds to the Production approach as required by the LULUCF Regulation and thus excludes the imported HWP in use as well as the HWP domestically produced with imported wood (if any). Estonia clarified that only domestically produced HWP with domestic wood is included in the HWP pool and that it will correct and clarify the description in the NID in the next submission. The TERT recommends that Estonia improve the clarity of the methodological description for harvested wood products in the NID in its next submission.	Final Review Report 2025 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(4) of Regulation (EU) No 2018/841, Table 3	Estonia has clarified the methodological description in the 2026 submission.		Chapter 6.12