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MINISTRY OF THE ENVIRONMENT

Estonia's Eighth National Communication

Under the United Nations Framework Convention on Climate Change

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Table of Contents

Glossary

A	Afforestation
AEA	Annual Emission Allocation
AKTA	Estonian Development Co-operation Database
AR	Assessment Report
ARIB	Agricultural Registers and Information Board
AWMS	Animal waste management systems
BACC	BALTEX Assessment of Climate Change for the Baltic Sea Basin
Baltadapt	Baltic Sea Region Climate Change Adaptation Strategy
BAT	Best available technologies
boe	Barrels of oil equvalent
BREFs	Reference documents for BATs
BSN	Baltic Science Network
BSRN	Baseline Surface Radiation Network
CAP	Common Agricultural Policy
CCS	Carbon capture with permanent storage
CCU	Utilization of the captured CO_2
CF	Cohesion Fund
CH_4	Methane
CHP	Combined heat and power
CMIP5	Coupled Model Intercomparison Project Phase 5
CNG	Compressed natural gas
CO_2	Carbon dioxide
COP	Conference of the Parties to the United Nations Framework Convention on Climate Change
COPERT	EU standard vehicle emissions calculator
CRF	Common Reporting Format
CSEUR	The Consolidated System of EU Registries
D	Deforestation
DES	Data Exchange Standard
EB	Environmental Board
EC	European Commission
EEA	European Environment Agency
EEIC	Estonian Environment Information Centre
EERC	Estonian Environmental Research Centre
EFDP 2030	Estonian Forestry Development Programme until 2030
EFN	Estonian Fund for Nature
EGM	Estonian Green Movement

EIC	Environmental Investment Centre
EMEP	European Monitoring and Evaluation Programme
EMHI	Estonian Meteorological and Hydrological Institute
EMÜ	Estonian University of Life Sciences
ENMAK	Estonian Energy Development Plan until 2030
EPBD	Energy performance of buildings
eq.	Equivalent
ERDP 2014-2020	Estonian Rural Development Plan 2014-2020
ERR	Estonian Public Broadcasting
ESD	Effort Sharing Decision
ESR	Effort Sharing Regulation
ESTEA	Estonian Environment Agency
ETCB	Estonian Tax and Customs Board
EU ETS	European Union Emissions Trading System
EU	European Union
EUR	European Euro
FM	Forest management
GCF	Green Climate Fund
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEO	Group on Earth observations
GHG	Greenhouse gas
GIS	Green Investment Scheme
GLOBE	Global Learning and Observations to Benefit the Environment
GPCP 2050	General Principles of Climate Policy until 2050
GSN	GCOS Surface Network
GWP	Global warming potential
HELCOM	Baltic Marine Environment Protection Commission – Helsinki Commission
HFC	Hydrofluorocarbon
HOS	Emercency Act
HWP	Harvested wood products
ICTU	Information to facilitate clarity, transparency and understanding
IE	Included elsewhere
IEA	Industrial Emissions Act
IET	International Emissions Trading
IMO	International Maritime Organization
IPCC 2006 GL	Guidelines for National Greenhouse Gas Inventories

IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial processes and product use
ITF	International Transport Forum
ITL	Independent Transaction Log
JQ	Joint Questionnaire
KEVAD	Environmental Development Plan 2030
KP	Kyoto Protocol
LULUCF	Land use, land-use change and forestry
MAC	Mobile air conditioners
MFA	Ministry of Foreign Affairs
MoE	Ministry of the Environment
MoEAC	Ministry of Economic Affairs and Communications
MoER	Ministry of Education and Research
MoF	Ministry of Finance
MoRA	Ministry of Rural Affairs
MSW	Municipal solid waste
N_2O	Nitrous oxide
NA	Not applicable
NC	National Communication
NDC	Nationally determined contributions
NE	Not estimated
NEC	National Emissions Reduction Commitments
NF_3	Nitrogen trifluoride
NFI	National Forest Inventory
NGO	Nongovernmental Organisation
NIR	National Inventory Report
NMVOC	Non-methane volatile organic compounds
NO	Not occurring
NREAP	National Renewable Energy Action Plan
NWP	Estonian National Waste Plan
ODA	Official Development Assistance
ODS	Ozone-depleting substances
OECD DAC CRS	OECD Development Assistance Committee's Creditor Reporting System
OECD	Organisation for Economic Co-operation and Development
PaM	Policies and Measures
PFCs	Perfluorocarbons
QA	Quality assurance
QC	Quality control

R	Reforestation
R&D	Research and Development
RCP	Representative Concentration Pathway
RES	Renewable energy sources
RMK	State Forest Management Centre
SEN scenario	Alternative scenario
SF_6	Sulphur hexafluoride
SHC	Solid heat carrier
SMEAR	Station for Measuring Ecosystem-Atmosphere Relations
SRES	Special Report on Emissions Scenarios
SREX	Intergovernmental Panel on Climate Change, Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
SSSC	The State Shared Service Center
SWD	Solid waste disposal
TalTech	Tallinn University of Technology
TU	University of Tartu
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WAM	With Additional Measures
WEM	With Excisting Measures
WMO	World Meteorological Organization

1 Executive summary

1.1. National circumstances relevant to greenhouse gas emissions and removals

This sub-chapter provides an overview of different topics that describe Estonia's national circumstances and historical trends which are covered in Chapter 2, incl., among other topics, government structure, energy, transport, population, geographical, climate and economic profile of Estonia.

The total area of Estonia is 45,339 km^2 and, on 1 January 2022, the population of Estonia was 1.33 million, so it follows that population density is 30.6 inhabitants per km^2. In 2022, 69% of the population lived in urban areas. With regard to the developments of the urban system in the last decade, urban expansion is occurring in Estonia, which is resulting in the weakening of the position of most of the county towns and small towns in the settlement system. The growing model of urban areas, especially in Tallinn and Tartu, is characterised by suburbanisation, as well as remote urbanisation in the form of increasing commuting related to employment, education, and services from further-away areas.

In terms of its biological diversity, the nature of Estonia is quite outstanding. More than half of Estonian land is forested and bogs cover 4.9% of the territory. The area of agricultural land in Estonia has dropped from 1,458,400 hectares in 1990 to 986,627 hectares in 2021. There are 586 species under national protection in Estonia and protected areas cover more than 19% of the dry land. In addition, the country is illustrated by a very flat coastline and there are a number of islets (ca 2,222). In addition, a large number of lakes and rivers can be found in Estonia.

Estonia's biodiversity is caused by differences in climatic conditions. Country's climate, in turn, is mostly influenced by its geographical position. Local climatic differences are due to, above all, the neighbouring Baltic Sea, which warms up the coastal zone in winter, and later, especially in spring, has a cooling effect. The increase in the average annual temperature in Estonia since the middle of the twentieth century has been slightly faster than the global increase. The warming trend of the winter, especially January, is the clearest. The increase in the average annual precipitation in the second half of the 20th century has been significant in Estonia. The ice and snow cover period has shortened.

The Estonian economy is small, but open and flexible to external changes. The internal market of a country of 1.3 million residents is too small for many companies, which is why they have set their sights abroad. The export volume of Estonian goods and services forms over 90% of GDP. The most important economic partners are Finland, Sweden and Latvia. In 2020, Estonian GDP dropped by 2.9% compared to the year before due to the global COVID-19 pandemic, but remained at around half of the EU average and lower than expected, as was the case in other countries. The economic growth has amounted to almost 5% higher than the average of the last three years before the decline in 2020 (2017–2019). The GDP of Estonia has been growing successfully in the past twenty years in spite of the fact that the GHG emissions of Estonia (without the Land use, land use change, and forestry sector) have remained at roughly 20,000 kt CO_2 eq in the past decade and the emissions have shown a declining trend at the end of the decade.

In 2020, the added value of the industrial sector formed 14.7% of the Estonian economy, which is close to the EU average (15%). Compared to 2015, the volume of the industrial sector has increased by approx. 10% and, compared to 2008, it has grown 1.7 times in current prices. Wood is one of the most important natural resources in Estonia and the timber industry is, in turn, one of the most important sectors of the Estonian economy. The Estonian economy is export-oriented and the share of the manufacturing industry in the export has increased after 2013. In 2020, around 67% of the production of the manufacturing industry was exported, with the majority sold in the internal market of the EU, primarily in the Nordic countries.

Estonia is among the EU countries that are least dependent on energy imports. Thanks to the use of oil shale and increasing use of renewable fuels, Estonia can largely meet the energy requirements of the country. In 2020, the export was higher than the import, increasing by 27% compared to 2019. The change was mostly caused by an increase in the EU ETS allowance price, which made the price of oil-shale-based electricity non-competitive, as well as the low electricity exchange price. Estonia is one of the largest primary energy producers per capita in the EU. In 2020, the amount of electricity generated in Estonia was 5,956 GWh, which is 22% lower than in 2019. The electricity from renewable sources formed 17% of the entire electricity production in 2020. Historically, Estonia has almost always been a net energy exporter. In total, 66.1% of the electricity generated was exported to Latvia and Finland in 2020. The main fuels imported to Estonia are natural gas, liquid fuels, coal, and coke. In 2020, the Balticconnector gas pipe was opened between Estonia and Finland, which connects the gas systems between the two countries for the first time and enables the two-directional transport of gas. Taking the new gas pipe into use also opened a gas market connecting Estonia, Latvia, and Finland, which is the first market region involving three countries in Europe.

The Estonian transport network consists of the infrastructure required for road, rail, water, and air traffic. The total length of the road network as of 1 January 2022 was 58,946 km and, in addition to this, 87.6 km of temporary ice roads in the case of suitable weather conditions. Buses are mainly used for public transport in Estonia. The number of train users has been increasing year-by-year. Compared to 2016, the freight transport volumes decreased by 21.6% in total in 2021, incl. freight transport by rail by 8.3%. This is also one of the reasons why the Estonian GHG emissions in the sub-category of rail transport decreased by 32.9% in this period.

Any consumption assumes the producing of waste on some level. In order to keep the environment decent and save natural resources, the producing of waste must be avoided as much as possible; also, the existing waste must be collected and managed in an environmentally friendly way. There are five non-hazardous waste landfills operating in Estonia, which are fully conformed to environmental and technical requirements and standards and are capable of serving more than one service area. In total, roughly 16.8 million tonnes of waste was generated in 2020, including 0.5 million tonnes of municipal waste. The share of the waste from the oil shale industry formed more than 67% of the total waste generation in 2020. The waste rock from oil shale extraction which is directed to reuse can be put back in the circulation as raw material almost in the extent of 100% (mainly as crushed stone). Thus, the share of the reuse and recycling of waste rock has once again started to increase in the past few years thanks to the road construction and construction projects which require filling material. In 2014, roughly 3.3 million tonnes or less than 42% of the waste rock generated was recycled; in 2018, however, the respective indicators were approximately 4 million tonnes and 57%. The projects planned for the upcoming years, such as the construction of the Rail Baltica railway and a new solar power station in the territory of the Estonia mine, also encourage that the reusing will increase further.

1.2. Greenhouse Gas Inventory information

Estonia's total GHG emissions in 2020 were 11,555.81 kt CO_2 equivalent (eq.) (with indirect CO_2), excluding net emissions from Land use, land-use change and forestry (LULUCF). Emissions decreased by 71.2% in 1990–2020 (see Table 1.1) due to transition from a planned economy to a market economy in the early 1990s and due to recent efforts made to transition to renewable energy sources and due to high CO_2 quota price in emission trading system (ETS).

CO_2 emissions (with indirect CO_2) decreased by 74.7% from 36,922.21 kt in 1990 to 9,343.01 kt in 2020, particularly large decreases in the Energy sub-sector Public electricity and heat production, which is the major source of CO_2 in Estonia.

Methane is the second most significant contributor to greenhouse gas emissions in Estonia after CO_2. Emissions of CH_4 decreased by 42.7% from 1,912.52 kt CO_2 eq. in 1990 to 1,095.46 kt CO_2 eq. in 2020, the downturn was especially noticeable in the Agriculture sub-sector Enteric fermentation, which is a leading source of CH_4 in Estonia.

Table 1.1. GHG emissions and removals by sector in 1990, 1995, 2000, 2005, 2010 and 2018–2020, kt CO_2 eq.

	1990	1995	2000	2005	2010	2018	2019	2020
Energy	36,213.16	17,697.15	15,098.87	16,742.41	18,899.50	17,770.83	12,210.92	9,461.45
Industrial processes and product use (incl. indirect CO_2)	963.74	635.29	695.97	727.83	539.51	628.54	621.35	295.47
…Indirect CO_2 (from NMVOCs reported under IPPU 2.D.3 Solvent use and road paving with asphalt)[1]	18.45	17.39	16.52	18.50	11.32	18.41	20.76	24.74
Agriculture	2,628.34	1,350.11	1,122.23	1,172.06	1,253.80	1,417.62	1,501.48	1,508.38
Waste	369.93	397.97	562.45	515.18	488.00	308.74	302.38	290.51
Total (excl. LULUCF incl. indirect CO_2)	**40,175.17**	**20,080.53**	**17,479.52**	**19,157.48**	**21,180.81**	**20,125.74**	**14,636.12**	**11,555.81**
Land use, land-use change and forestry	-3,159.90	-2,799.39	-4,204.98	-1,275.73	-4,835.38	-1,438.30	-334.56	1,297.27
Total (incl. LULUCF and indirect CO_2)	**37,015.28**	**17,281.14**	**13,274.54**	**17,881.75**	**16,345.42**	**18,687.44**	**14,301.56**	**12,853.08**

[1] Indirect CO_2 emissions are calculated from NMVOCs reported under Industrial processes and product use (IPPU) 2.D.3 (CRF) Solvent use and road paving with asphalt.

Emissions of N_2O decreased by 29.3% from 1,340.45 kt CO_2 eq. in 1990 to 929.68 kt CO_2 eq. in 2020, especially N_2O emissions from Agriculture sub-sector Agricultural soils, which is the main contributor of N_2O emissions in Estonia.

The total GHG emissions reported from F-gases (HFCS, PFCS and SF_6) were 187.66 kt CO_2 eq. in 2020.

A single national entity with the overall responsibility for the Estonian greenhouse gas inventory is the Ministry of the Environment (MoE). In 2018, a change in the national inventory system was made when the 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 the MoE. The inventory will continue to be produced in collaboration between the MoE, EERC and ESTEA.

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

The UNFCCC, the KP and the EU greenhouse gas monitoring mechanism require Estonia to annually submit a NIR and CRF table. The annual submission contains emission estimates for the years between 1990 and the year before last year. The methodologies, activity data collection and emission factors are consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The quality requirements set for annual inventories are continuous improvement, transparency, consistency, comparability, completeness, accuracy and timeliness.

1.3. Policies and measures

Estonia is transposing the EU law (accessible in EUR-Lex, http://eur-lex.europa.eu) into several national legislative acts which can be accessed from a web-based outlet of Riigiteataja (https://www.riigiteataja.ee/) that also includes official announcements.

The Parliament of Estonia has adopted (5 April 2017) **General Principles of Climate Policy until 2050 (GPCP 2050)** for moving towards the long-term emission reduction target, which is set to reduce the emission of greenhouse gases by around 70% by 2030 and by 80% by 2050 in comparison with the emission levels of 1990. GPCP 2050 is a vision document that sets a long-term GHG emissions reduction target and policy guidelines for adapting to the impact of climate change or ensuring the preparedness and resilience to react to the impact of climate change. A proposal to amend the long-term target of Estonia to reduce the emission of greenhouse gases by 2050 by 80% set in the GPCP 2050 according to the 2050 climate neutrality goal set in Estonia's long-term strategy Estonia 2035 has been sent to the Parliament in March 2022.

Sectoral policies and measures used for calculating GHG emission projections (Chapter 5) are presented in Chapter 4.4 and summaries of policies and measures are included in Chapter 4.7.

The energy sector is the largest producer of GHG emissions and therefore the strategies regulating the sector are under closer attention. The Government of Estonia approved the Estonian Energy Development Plan until 2030 (ENMAK 2030) in 2017 and is currently in the process of updating the document. The Renewed Energy Development Plan until 2035 aims to update the trends, goals and activities of the energy economy included in the ENMAK 2030.

1.4. Projections and total effect of policies and measures

Projections are given for all greenhouse gases considered in the United Nations Framework Convention on Climate Change (UNFCCC), presented in the following sectors (CRF categories): Energy (incl. transport); Industrial processes and product use (IPPU); Agriculture; Land use, land use change and forestry (LULUCF); and Waste.

Projections of GHG emissions have been calculated for the period of 2021–2050. 2020 has been used as a reference year. Activity data for the base year of 2020 are in accordance with the latest, 2022, National GHG Inventory (submitted to the UNFCCC on 15 April 2022). Projections have been calculated using AR4 GWPs.

The methodology used for GHG projections under each sector can be found in Chapter 5.3. Two projection scenarios are presented. The With Measures (WEM) scenario evaluates future GHG emission trends under the current policies and measures. In the second scenario, a number of additional measures and their impact are taken into consideration in forming the basis for the With Additional Measures (WAM) scenario.

Sector-specific projections can be found in Chapter 5.1. Estonia's GHG emissions are expected to decrease by around 64.61% in the WEM scenario (without LULUCF) and about 66.55% in the WAM scenario (without LULUCF) by 2050 compared to the base year of 2020. GHG emissions in the WEM scenario (with LULUCF) are expected to decrease by around 46.48% and in the WAM scenario (with LULUCF) about 64.69% by 2050 compared to the base year of 2020.

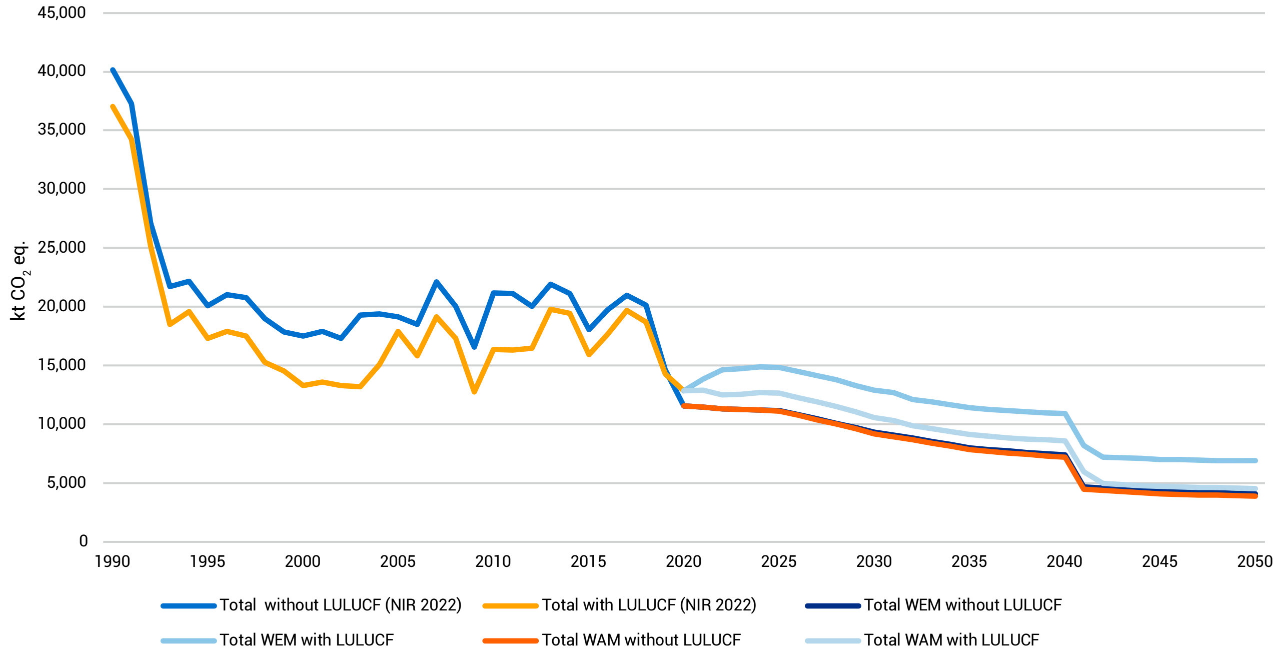

Figure 1.1. Historical GHG emissions (1990–2020) and projected emissions (2021–2050) for the WEM and WAM scenarios, kt CO_2 eq.

1.5. Vulnerability assessment, climate change impacts and adaptation measures

Amidst rapid environmental changes, it is no longer rational to rely on the spontaneous adjustment of the society and economy to the changes in the environment. While in the case of natural development, climate change is relatively slow and adaptation to the changed conditions can occur in the course of a natural, spontaneous development, human-induced climate change, including more frequent and intense extreme weather events, is increasingly causing widespread damage to both nature and people beyond natural climate change.

Chapter 6 provides an overview of the possible impacts of climate change in the 21st century in the following areas: health and rescue capability; land use and planning; natural environment; bioeconomy; economy; society, awareness, and cooperation; infrastructure and buildings; energy and security of supply.

In Estonia, climate change primarily causes the following problems:

- the spread of new pathogens and increasing health disorders;
- increased flooding risk and pressure for building relocation;
- changes in the hydrological cycle and vegetation and the spread of alien species;
- unfrozen and waterlogged forest land in the winter and new plant pests;
- transient effects of global trends on the economy;
- immigration from global migration;
- additional requirements on infrastructure and building durability;
- changes in seasonal energy consumption.

In 2017, the Government of the Republic of Estonia adopted the Climate Change Adaptation Development Plan until 2030 (KOHAK). The general purpose of the document is to reduce Estonia's vulnerability to climate change with the help of a unified action framework and to achieve the readiness and ability to cope with the impact of climate change at the local, regional and national level. In 2022, a report on the implementation of the Climate Change Adaptation Development Plan until 2030 for the period of 2017–2020 was presented to the Government of the Republic. The report provides a good overview of the achievement of the goals and effectiveness of the development plan. KOHAK's performance report pointed out that a total of 198 million euros was allocated for adaptation measures in the period of 2017–2020. In financial terms, the most adaptation measures and activities during this period were carried out in the fields of natural environment and the bioeconomy. In 2021, KOHAK's action plan for the period of 2021–2025 was completed. The implementation of the mentioned action plan is planned through sectoral action programmes, and its purpose is to ensure that climate change adaptation activities are consistent, meet the goals set in the development plan, and contribute to climate change adaptation at both the local and national level. The estimate of the cost of implementing the development plan for adapting to the effects of climate change for the years 2021–2025 is 296 million euros.

KOHAK will be included in the newly prepared environmental strategy document Environmental Development Plan until 2030 (KEVAD). According to the action programme of the Government of the Republic planned, the entry into force for KEVAD is the second half of 2023. The implementation of KEVAD's goals will take place through programmes in the performance areas, e.g. in the environmental result area, through the Environmental Protection and Use Programme and through the relevant programmes of other ministries. With the entry into force of KEVAD, KOHAK will lose its validity as an independent document.

Successful adaptation to climate change requires close cross-sectoral cooperation at the central government, regional and local government levels, while communities must not be forgotten. The success of adapting to climate change depends on the actions of the state and the structure of the governance system, as well as the pressure from the non-governmental interest groups and the interests of businesses. Adaptation is also influenced by the level of education and science in the country, which determines how prepared the people are for climate change and how they assess the accompanying changes.

Climate change has already been included as a horizontal topic in several sectoral development documents and development plans, as well as in the Estonia's long-term strategy Estonia 2035. With the New Environmental Development Plan until 2030 (KEVAD), the national aim is set to integrate the impact of climate change and its adaptation into national strategic documents and sectoral development plans. In addition, local governments have begun to assess and also take into account the risks arising from climate change in their local development plans, and nearly 50 out of 79 local governments already have or are still preparing local energy and climate plans.

1.6. Financial, technological and capacity-building support

Estonia is not one of the Parties listed in Annex II to the Climate Convention; consequently, Estonia is not obliged to fulfil the commitments under Articles 4.3, 4.4 and 4.5 of the Convention. Despite this, Estonia has contributed to climate finance voluntarily.

The Government of Estonia is committed to fighting against global climate change, focusing in particular on the situation in countries which are most affected by climate change, such as the Least Developed Countries and the Small Island Developing States.

Estonia recognises that the need for financing to reach the climate policy objectives is one of many important elements that need to be tackled continuously. Both public and private funding should support investments into programmes and policies aimed at reducing emissions and increasing resilience to climate change.

Estonia has decided to proceed with funding the needs of developing countries when supporting climate action and wants to continue with this principle in the future as well. Estonia aims to support all actions related to climate change mitigation and adaptation in developing countries, for example by supporting the development of renewable energy sources, energy- and resource-efficiency projects in the transport sector and industry, as well as by strengthening administrative capacity regarding climate action or supporting solutions climate change adaptation.

During the reporting period for the National Communication, in 2018 the MoE adopted a regulation aiming to support developing-country cooperation and stipulating specific rules for international climate cooperation. This regulation was developed in cooperation with various ministries to ensure that the use of resources will be conducted in a coordinated manner. Support will be provided in two ways: firstly, through international cooperation, and, secondly, through open project calls. The main aim of the regulation is to support both mitigation- and adaptation-related actions in developing countries through annual project calls.

During the period of 2019–2020 Estonia has had two open project calls to support climate cooperation projects in developing countries. Through the project calls Estonia aims to support different mitigation- and adaptation-oriented projects and consider the needs of the destination countries. During this period Estonia has supported climate action in the following countries: Algeria, Bangladesh, Burkina Faso, Costa Rica, Georgia, Grenada, Kenya, Myanmar, Republic of South Africa, and Uzbekistan.

The most recent announcement was made at COP26, where Estonia announced a voluntary contribution of EUR 1 million to the Least Developed Countries Fund (operated by the Global Environment Facility (GEF)).

In Chapter 7 detailed information related to Estonia's contribution to financing international climate cooperation, technology development and transfer and capacity-building can be found.

1.7. Research and systematic observation

Research and development (R&D) includes activities which may be related to entrepreneurial or governmental innovation. Decisions related to Estonia's R&D policies are made by the Riigikogu (Parliament) on the basis of regulations and legal acts drafted by the Government of the Republic. The basis for the organisation of R&D is established with the Organisation of Research and Development Act. The Ministry of Education and Research (MoER) is responsible for the planning, coordination, execution and monitoring of education and research policies; it also organises the evaluation of R&D institutions.

Currently, R&D in Estonia is based on the Estonian Research and Development, Innovation and Entrepreneurship Strategy 2021-2035, adopted in July 2021. The focus of the strategy is to ensure synergies between the research system, the business environment and other systems in society, keeping in mind society's overall resilience and ability to adapt to crisis situations and global changes.

R&D is financed within the system of the MoER of the Republic of Estonia from the state budget and EU support. The share of R&D activities in GDP has been increasing since 2018, whereas funding from the private sector is increasing more rapidly than from the public sector and exceeding it in recent years. The public investments into R&D sector are above the average of EU (8th position among EU countries), but private investments are roughly 1.5 times smaller.

Estonia participates in several European and world-wide research and environmental monitoring programmes, which are important for fulfilling the commitments made in international treaties and for the development of open science. Since the 1990s international R&D cooperation has developed and multiplied rapidly. There are several factors for the success of Estonian researchers in the framework programmes, mainly their strong level of expertise and high reliability in the eyes of foreign partners, readiness to write competitive projects, desire to cooperate with foreign partners and a well-functioning support system for framework programmes.

Research related to climate change is carried out in Estonia by a number of universities, governmental and non-governmental institutions. In recent years various research institutions have carried out numerous and increasing amounts of R&D projects. In chapter 8 the most important projects are listed by aspects of climate relevance.

Research is also carried out to perform different parts of the national environmental monitoring programme. The national environmental monitoring programme is the responsibility of the ESTEA. Estonia contributes to international cooperation in making systematic observations as well. Among others, Estonia is a member of the international Group on Earth Observations (GEO). The objective of the GEO is to create a Global Earth Observation System of System (GEOSS) for ensuring the sustainable development of humankind to improve the health and safety of humankind and to protect the global environment. The weather service of the ESTEA fulfils the obligations of the Estonian national meteorological service in accordance with its statutes and the recommendations of the World Meteorological Organisation (WMO). The ESTEA's weather service participates in the work of many international organisations, has been a cooperating member of the European Centre for Medium-Range Weather Forecasts (ECMWF) since 2005 and is full member since 2020.

1.8. Education, training and public awareness

The general environmental awareness of people of Estonia was summarised by the Eurobarometer survey on the attitudes of European citizens towards climate change in 2021. In general, the awareness and readiness to take action of Estonian respondents is below the average of European Union, but gradually improving in comparison with previous surveys (2019, 2017). About one in seven respondents in Estonia (14%, compared with the EU average of 18%) consider climate change to be the single most serious problem facing the world. More than six in ten respondents (63%, below the EU average of 78%) consider climate change to be a very serious problem.

The Estonian education system supports the teaching of sustainable development. Topics of climate change are included in the content of teaching and learning outcomes of nature subjects included in the national curricula at various levels of education in Estonia. Even the national curriculum of preschool institutions includes a field, The environment and I, in which changes occurring in the natural world is one of the topics. The national curriculum for basic schools and upper secondary schools establishes the framework for implementation of all recurrent topics, incl. the compulsory cross-curricular topic of Environment and sustainable development. At the level of higher education, it is possible to study at different climate- and climate-change-related courses.

The MoER also supports the participation of schoolchildren in various extracurricular environmental programmes and environmental research work competitions, as well as various environmental education projects for schoolchildren by targeted financing. The MoER supports the participation of schools in international sustainable development promoting educational programmes within the framework of the general education programme of the Estonian lifelong learning strategy.

More than 160 organisations in Estonia are providing informal environmental education study programmes for schoolchildren as well as others who are interested. In 2018–2022 the Environmental Investment Centre (EIC) has financed 2,822 projects on environmental awareness 11.2 million euros in total. Most of projects are carried out at certain municipalities or certain educational institutions, including for visiting the nature trails and environmentally important objects.

There are several climate-related environmental campaigns organised in Estonia, which are aimed at the public. Most of those campaigns are directly focused on energy efficiency. The campaigns are often also related to healthy ways of mobility. Conferences and lecture series related to the environment are organised in various places all over Estonia, which are open to anyone interested. The Environmental Board continues to organise the nature evenings or learning days for the public, which were focused on climate change.

Official national climate information is shared on the website of the MoE. However, the wider public are mainly informed on climate-related issues through the media.

In addition to participation in the international projects for schoolchildren and taking part in the activities of the International environment days, climate-change-related environmental topics are also discussed at a more general international level. Since 2018, the World Cleanup Days – Let's Do It! – take place in the autumn of every year on the initiative of Estonians. Tallinn was elected the European Green Capital for 2023. The aim of the initiative is to improve the living environment in European cities and, above all, to acknowledge and reward the efforts made by cities to improve the environment and the quality of life.

The situation on public access to information and public participation in Estonia, including advances and drawbacks in information delivery by governmental organisations and municipalities, is described in detail in the reports on implementation of Arhus Convention delivered most recently in 2021, whereas the previous one was released in 2016. As stated in the report, the measures to enable citizens access to environmental information on request and publish the most important information regularly, to grant the rights to participate in decision-making process, and to appeal to court, are incorporated in national legislation and followed in general. However, some drawbacks are mentioned. The NGOs draw attention to the cases of formal inclusion and sometimes dismissive attitude of local authorities, too short deadlines for NGOs to respond in the process of inclusion, isolated cases of no answer by authorities to their requests and high costs of court cases.

2 National circumstances relevant to greenhouse gas emissions and removals

Key developments:

- The Estonian economy is export-oriented and 67% of the production of the manufacturing industry was exported in 2020.
- The share of renewable energy in the final energy consumption amounted to 30.1% in 2020 and has nearly doubled in the past five years.
- The construction of new dwellings is showing a growing trend and the demand remains high. The majority of the dwellings built are in the major cities (Tallinn, Tartu) or in the vicinity thereof.
- The number of agricultural holdings has decreased by 32% in the past five years.
- The development of birth rates is characterised by leaving first pregnancies to an older age. While the average age of mothers at the birth of their first child was 27.2 in 2015, it had risen to 31 by 2021.
- The life expectancy of Estonians is somewhat lower compared to the EU average – in 2021, it was 72.8 years for men and 81.4 years for women.

2.1. Government structure

Estonia is a democratic parliamentary republic, the institutional structure of which was laid down by the Constitution adopted in 1992. Pursuant to the Constitution, the supreme power of the state is vested in the people, who exercise their power through the legislative representative body, the Riigikogu (the Parliament of the Republic of Estonia), the head of the state is the President of the Republic of Estonia, and the executive is vested in the Government of the Republic. The Riigikogu is the unicameral parliament of Estonia, the main duties of which include developing legislative acts, appointing high officials, incl. the Prime Minister and the Chief Justice of the Supreme Court, exercising parliamentary supervision, and developing foreign communication. (Riigikogu, 2022)

The head of state of Estonia is the President of the Republic, who is elected by the Riigikogu. If none of the candidates receive two thirds of the votes of the members of the Riigikogu, the President is elected by an electoral body comprised of the members of the Riigikogu and representatives of the municipal councils. Presidential elections are held in Estonia once in five years. The President declares the laws adopted by the Riigikogu and signs instruments of ratification or denunciation of international treaties. The President represents Estonia in international relations, appoints the diplomatic agents of Estonia, and receives the credentials of the diplomatic agents accredited to Estonia. Their scope of competence also includes appointing the Prime Minister, other ministers, the President of the Bank of Estonia, and several other high state officials. Several advisory bodies, such as the Academic Council, operate within the institution of the President. (Constitution of the Republic of Estonia, 1992)

The Government of the Republic consists of the Prime Minister and ministers. The Government may include up to fifteen members, including the Prime Minister. The Prime Minister determines the competence of the ministers in leading the ministries and the fields of responsibility of the ministries. Based on proposals of the Prime Minister, ministers who are not in charge of a specific ministry may also be appointed. The Government holds executive power. The definition of executive state power also includes legislative drafting to a limited extent. For the implementation of laws, they often require further specification. This is done with the regulations of the Government of the Republic and the ministers. (Constitution of the Republic of Estonia, 1992) In 2021, the Government of the Republic of Estonia formed a green policy steering committee with the aim of coordinating the implementation of the green transition in Estonia to promote sustainable economic growth. This committee will be shaping political opinions and charting cross-sectoral solutions; the committee will also approve the action plan for the implementation of the green transition, assess the results of the implementation and the actions required for the implementation of the green transition, and make suggestions for funding those actions. (Government of the Republic, 2021)

Based on the Constitution, all issues concerning local life are organised by the local governments, which operate independently based on legislation. The territory of Estonia is divided into counties, and the counties into rural municipalities and cities. The rural municipalities and cities are local governments. There are 15 counties and 79 local governments in Estonia – 15 cities and 64 rural municipalities. Pursuant to the law, all local governments share the same functions and are mainly responsible for education, national construction works, housing, local road maintenance, waste management, and healthcare at the primary level. The local governments are financially largely dependent on the central government. (Ministry of Finance, 2022; Constitution of the Republic of Estonia, 1992)

2.1.1. Implementation of climate policy within the government structure

Three ministries are primarily in charge of and supporting activities related to climate change in Estonia: the Ministry of the Environment, the Ministry of Economic Affairs and Communications, and the Ministry of Rural Affairs (Ministry of the Environment, 2022a; Ministry of Economic Affairs and Communications, 2022a; Ministry of Rural Affairs, 2022a).

The Government Office is also involved in the coordination and is tasked with supporting the Government of the Republic and the Prime Minister in drawing up and implementing the policy. Two of the structural units of the Government Office are involved in the field of climate policy. The Strategy Unit coordinates the drawing up and implementation of the action programmes of the Government of the Republic and the strategic development plans for increasing the competitiveness of the state and for sustainable development. The Strategy Unit also organises the work of expert groups. An expert group is formed in a field which concerns several ministries, in which more efficient cross-cutting cooperation is needed and solutions are sought for problems which are not clearly in the field of responsibility of one specific ministry. Among others, a green transition expert group was launched in the beginning of 2022 with the aim of submitting proposals to the government committee for drawing up a comprehensive action plan for the successful implementation of the green transition in Estonia. The other unit, the European Union (EU) Secretariat, coordinates the formation of the opinions of Estonia in EU-related matters and the transposition of the EU legislation. The European Union Secretariat also advises and supports the Prime Minister in EU-related matters and in preparing for the European Council meetings. (Government Office, 2022)

Pursuant to section 143 of the Atmospheric Air Protection Act (2017), activities to reduce climate change shall be arranged by the Ministry of the Environment on the basis of the requirements for limitation of greenhouse gas emissions arising from the Framework Convention on Climate Change, the Kyoto Protocol, the Paris Agreement, and the European Union legislation. The Ministry of the Environment implements the national climate policy and draws up development plans in the waste sector and in the land use, land use change, and forestry (LULUCF) sector, as well as in the fields of industrial processes and the use of products (incl. F-gases). The Ministry of the Environment also supervises the drawing up of the annual greenhouse gas inventory, the National Communications, the Biennial reports, and the reports on policies, measures and projections; the ministry also reports on the implementation of the European Union Emissions Trading System (EU ETS) and on the sectors included under the Effort Sharing Regulation, the sectors not included in the EU ETS, and the fulfilling of the obligation to reduce GHG emissions. (Ministry of the Environment, 2022a)

The Ministry of Economic Affairs and Communications develops and implements the national economic policy and draws up economic development plans in the fields which have a direct impact on climate change: industry, trade, energy, housing, construction, transport, and traffic management (e.g. the Estonian Energy Development Plan until 2030, the Estonian National Energy and Climate Plan until 2030, the Transport and Mobility Development Plan 2021–2035, etc.) (Ministry of Economic Affairs and Communications, 2022a).

In addition to the two aforementioned ministries, the Ministry of Rural Affairs is also involved in the various aspects of climate issues at the national level, developing and implementing national agricultural and rural life policies and the development plans of the sectors, which chart, among other things, the impact of climate change on various different agricultural sectors and highlight the possibilities for alleviating and adapting to climate change (Ministry of Rural Affairs, 2022a). The Ministry of Rural Affairs also actively participates in coordinating several international research networks and joint initiatives for studying the impacts of climate change (Ministry of Rural Affairs, 2022b). The European Union Common Agricultural Policy (CAP) includes several different support schemes, such as climate and environmental support, for supporting the development of agriculture and rural life (Ministry of Rural Affairs, 2021a).

In addition to the aforementioned ministries, the Ministry of the Interior, the Ministry of Finance, the Ministry of Education and Research, the Ministry of Social Affairs, and the Ministry of Foreign Affairs also deal with different aspects of climate issues at the national level. The Ministry of the Interior is in charge of crisis management and organising rescue operations. The Ministry of the Interior is also responsible for drawing up emergency situation risk analyses (incl. for storms, floods, and extreme weather conditions) and the respective response plans. (Ministry of the Interior, 2021) If one of the ministries has a leading role in the strategy or development plan related to a certain climate aspect, the remaining ministries involved take part in the working groups assembled for the development of those strategies.

Local governments have also started to integrate aspects related to climate change more actively into spatial planning and transport management. Several of the local governments at a risk of floods have developed detailed adaptation and action plans for coping in the case of a flood. In the last few years, local governments have become more active in setting climate goals for themselves, adding climate- and energy-related issues to the development documents, and drawing up climate and energy plans (Environmental Investment Centre, 2022).

The national system for organising environmental monitoring has been restructured with the aim of accumulating high-quality source information required for organising the entire environmental sector at the domestic and international level. In 2013, the Estonian Meteorological and Hydrological Institute and the Environment Information Centre merged to create the Estonian Environment Agency, which took over the duties, rights, and obligations of the merged authorities. The weather service of the Estonian Environment Agency is most important from the perspective of the climate, conducting meteorological and hydrological observations, distributing weather forecasts, drawing up Estonian climatological studies, etc. (Statutes of the Environmental Agency, 2015)

2.2. Population profile

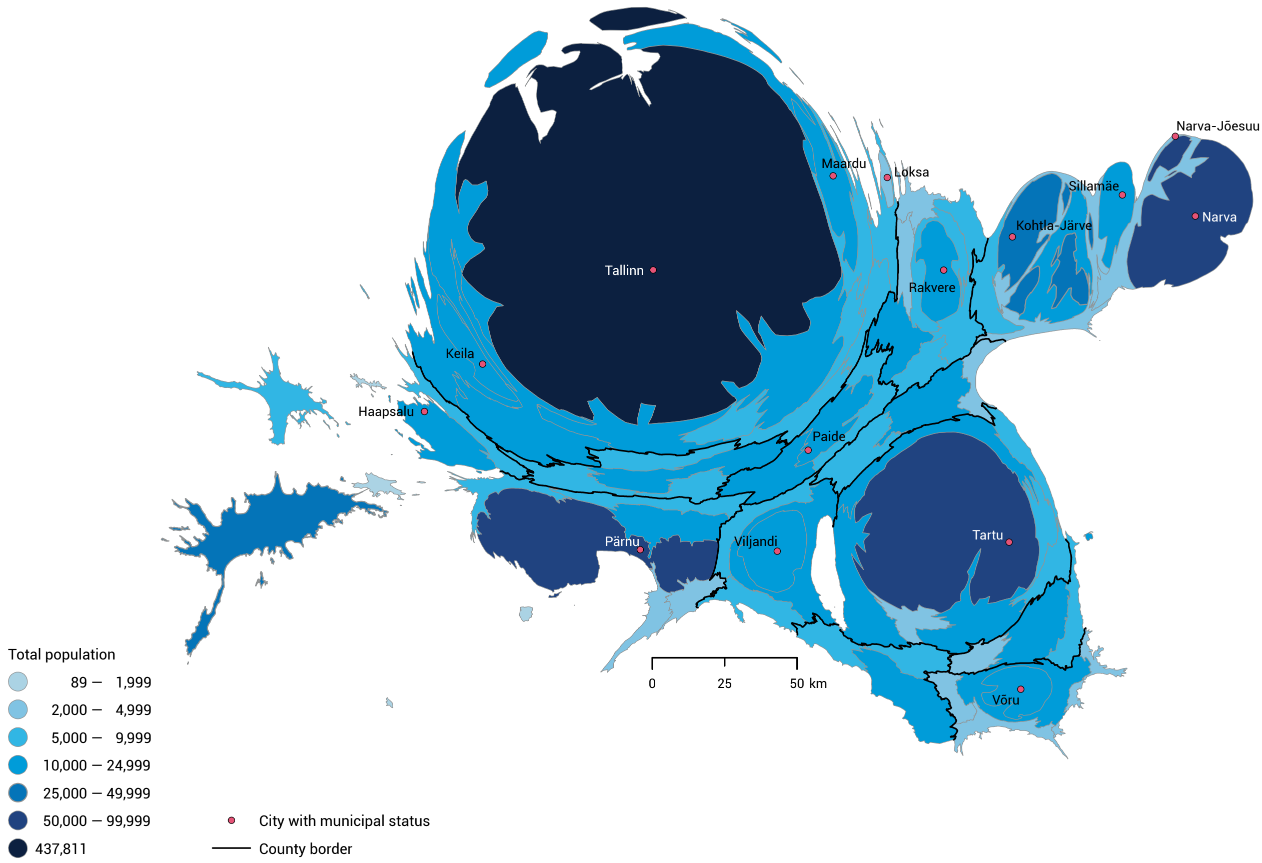

Figure 2.1. The distribution of the Estonian population as at 1 January 2022, person (Statistics Estonia, 2022b)

As at 2022, the Estonian population is 1,328,439 (Statistics Estonia, 2022a). In total, 69% of the Estonian population lives in an urban environment, including more than 47% in Tallinn (**Figure 2.1**).

The Estonian population has been constantly decreasing since the 1990s. Since the beginning of the twenty-first century, the shrinking of the population has been slowing down thanks to the modest increase in the birth rate and the decrease in the mortality rate. Based on the main population scenario of Statistics Estonia (2022c), there will be 1,179,667 people living in Estonia by 2080.

From the perspective of the development of birth rates, Estonia is characterised by leaving first pregnancies to an older age. The timing of the first birth has shifted by more than three years within the past five years. While the average age of mothers at the birth of their first child was 27.2 in 2015, it had risen to 31 by 2021. The fertility rate or the average number of children per woman was 1.61 in 2021 (Statistics Estonia, 2022d).

The main long-term factor influencing the development of the Estonian population has been the geopolitical position of the country. Therefore, Estonia has experienced a number of societal transformations, such as occupations before and after World War II, the collapse of the Soviet Union, and regaining independence in 1991. From the perspective of the development of the population, the composition and structure of the Estonian population was changed by immigration after the war. Since the 1990s, migration has shrunk the Estonian population and we are second after Luxembourg with 33% in terms of the percentage of the population of foreign origin in the European Union (Estonian Cooperation Assembly, 2017).

The post-war development has also had an impact on the long-term standstill in the mortality rate until the middle of the 1990s, which was followed by a rapid increase in the average life expectancy. The life expectancy of Estonians is somewhat lower compared to the average of the European Union. In 2021, the life expectancy of men in Estonia was 72.8 years and the life expectancy of women, 81.4 years. The number of healthy life years is very low in Estonia, however, and the percentage of the population with activity limitations is high. (Eurostat, 2021a; Statistics Estonia, 2020)

2.3. Economic profile

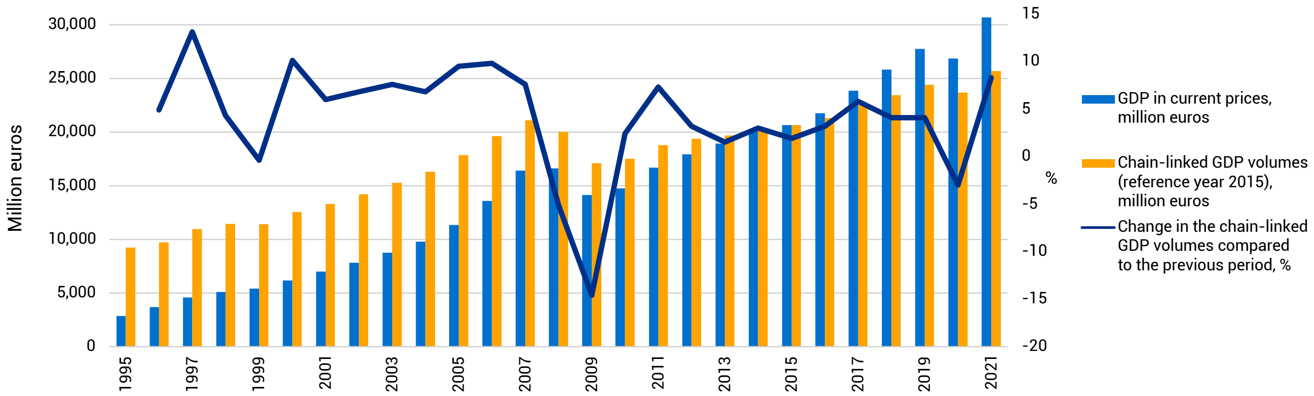

Figure 2.2. Estonian GDP growth in 1995–2021, million euros (Statistics Estonia, 2022e)

The Estonian economy is small, but open to external changes and flexible. The internal market of the country of 1.3 million residents is too small for many companies, which is why they have set their sights abroad. The Estonian economy is tightly connected to other EU Member States. The share of the EU in the total export of Estonia is 66% (Ministry of Finance, Ministry of Economic Affairs and Communications, 2020). Based on the economic development, Estonia has been relatively rapidly approaching the more developed EU counties, but the gap remains quite considerable: according to Eurostat, the GDP per capita adjusted by purchase power was 37% of the EU average in 2000 and 84% in 2020 (Eurostat, 2021b). Estonian productivity is relatively similar. The GDP of Estonia has been growing successfully in the past twenty years in spite of the fact that the GHG emissions of Estonia (without the land use, land use change, and forestry sector) have remained at roughly 20,000 kt CO_2 eq in the past decade and the emissions have shown a declining trend at the end of the decade.

In 2020, the Estonian GDP dropped by 2.9% compared to the year before due to the global COVID-19 pandemic, but remained at around half of the EU average and lower than expected, as was the case in other countries (Figure 2.2). The economic decline was caused by cross-border restrictions on movement, weak foreign demand, and a decrease in private consumption and investments. In spite of the wage support measures, unemployment doubled in 2020 and is only expected to decrease starting from 2022. The employment rate decreased, the prices dropped most in the areas of activity related to tourism and services, a certain decline also hit the consumption activity, and the real growth of wage income continued. The economy grew by 8.3% in 2021. The growth was powered by the manufacturing industry, which reached the pre-COVID level. The economic growth was also accelerated by information and communication, transport and warehousing, and professional, scientific, and technological activities. A very rapid growth continued in the accommodation and catering sectors. The main fields of activity which were slowing down the economy due to the increase in prices were the trade and agriculture sectors, however. (Ministry of Finance, Ministry of the Economic Affairs and Communications, 2020).

Due to the small size of Estonia, it is not possible to manufacture all products and provide all services needed by the local people and business undertakings here, for example engine fuels, household appliances, or metals. The export volume of Estonian goods and services forms over 90% of the GDP, with about a third of this volume formed by the export of services. The most important services, the export of which is generating income for Estonian companies, are various transport-related services, but also tourism. More than three quarters of the Estonian industrial production is exported; many companies sell all their production outside of Estonia (Ernst & Young Baltic AS, Policy Lab OÜ, 2021).

Estonian export is diverse – electrical machinery and appliances, mineral products, various wood and timber products, metal products, and various services. The availability of natural resources also makes all forest-related fields of activity important for the Estonian economy. The export and import volumes are characterised by Figure 2.3. The biggest export partners of Estonian goods are Finland, Sweden, and Latvia. While the export of goods to those and other nearby Bal-

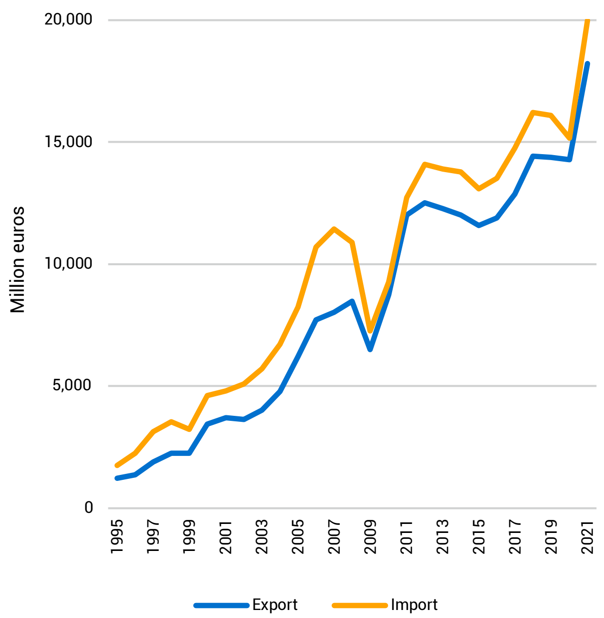

Figure 2.3. Foreign trade 1995-2021 (Statistics Estonia, 2022f; 2022g)

tic Sea region countries decreased, the export to the United States, China, India, Canada, Japan, the Republic of Korea, as well as several Western European countries showed a strong growth (Ernst & Young Baltic AS, Policy Lab OÜ, 2021).

The growth in the average wage has outpaced the forecasts in the recent years and has been accompanied by a quicker growth of the wage costs compared to the growth in added value. So far, this has not resulted in a significant loss of competitiveness in the foreign markets and the expanding of the export has continued. While the current account has been in surplus in the past few years, it showed a small deficit in 2020, but this will be temporary. The growth in the export of goods accelerated, thereby compensating for the stronger domestic demand, and resulting in a decrease of the trade deficit. The economic growth has also surprised positively, amounting to almost 5% as the average of the last three years before the decline in 2020 (2017–2019). Despite the rapid growth, there should not be any unbalanced internal changes in the Estonian economy (Ministry of Finance, Ministry of Economic Affairs and Communications, 2020; 2021).

2.4. Geographical profile

The Republic of Estonia on the eastern coast of the Baltic Sea is the northernmost of the Baltic States and the smallest by surface area (45,339 km^2) (NFI, 2022). Along with the Western Estonian archipelago and the numerous individual islands in the coastal sea, Estonia lies between Finland and the Gulf of Riga as an extensive peninsula, the borders of which are hard to define. The natural geographical factors which influence the climate characterising Estonia include the long coastline, the high number of small islands (approx. 2,222) (Association of Estonian Islands, 2022), the multitude of lakes and rivers, and a very level relief. The highest peak is the Suur Munamägi, which reaches 318 m above the sea level (Vandel, 2017). There are bedrock outcrops – limestone cliffs – stretching all over the mainland part of the northern coast and the coastline of the larger islands.

The neighbouring countries of Estonia are Russia in the east, Latvia in the south, Sweden in the west (across the Baltic Sea), and Finland in the north (across the Gulf of Finland). Estonia is located between the latitudes of 57°30′ N and 59°49′ N and longitudes of 21°46′ E and 28°13′ E, i.e. the northern part of the temperate zone, on the northern border of boreal broad-leaved forests, and in the transition zone between the oceanic and continental climates (Vandel, 2017). Due to the strong impact of the Baltic Sea, the conditions in one half of the country are boreonemoral and in the other half, continental boreal. Compared to other areas at the same latitude in Western Europe, the winters in Estonia are colder and the summers warmer, there are less precipitation and clouds, and the winds are weaker. Compared to the regions in the inland part of the Eurasian continent, however, our winters are warmer, summers cooler, there is more precipitation and clouds, and the wind is stronger. (Enno, 2012)

Approximately half of the dry land is covered with forests (approx. 51.3%) (NFI, 2022). There are 2,804 natural and artificial lakes in Estonia, in total (Tamre, 2006), and the percentage of bogs is 4.9%, stretching over 223,400 hectares (NFI, 2022). Estonia boasts one of the richest biodiversities among territories of a similar size north from the 57th latitude. This is thanks to the varying climate conditions, the presence of island and mainland areas, the length of the coastline and the multitude of inland water bodies, and the variations in the bedrock and soil conditions which have all created a good basis for the formation and development of a diverse ecosystem. Estonia is believed to be the home of roughly 40,000 species, of which over 30,000 or more than 75% have been found (Loodusveeb, 2022).

Even though Estonia is a small country in terms of the surface area, the share of untouched protected nature in the country is quite high. This is mainly thanks to the low population density – 30.6 residents per 1 km^2 – which is also highly polarised, as almost two thirds of the population live in cities and just one third in rural areas (Statistics Estonia, 2022i). There are 586 species under national protection in Estonia and protected areas cover more than 19% of the dry land (Loodusveeb, 2022).

The most significant climate change-based phenomena in Estonia include the rise in temperature, which is above the global average, the decreased snow and ice cover, the higher frequency of winter storms, the changes in the habitats of species, and increased precipitation. This will result in more flooding and erosion in the coastal areas. An increased frequency of the aforementioned phenomena will probably increase the extent of catastrophes, resulting in remarkable economic damage, health issues, and deaths. (Ministry of the Environment, 2016)

2.5. Climate profile

The main factor impacting the climate in Estonia is its geographical position. Estonia is in the mixed-forest subregion of the continental Atlantic region of the moderate zone and in the transition zone between the oceanic and continental climates (Kallis et al., 2019). Based on the Köppen climate classification, the majority of Estonia is of the Dfb climate type (cold winter humid continental climate) and only the outermost western parts of Saaremaa and Hiiumaa are of the Cfb climate type (temperate oceanic climate). The local differences in the climate are mainly caused by the Baltic Sea bordering the mainland, which warms the coastal areas and the islands in winter and cools them in spring. (Environment Agency, 2020a)

The summers in Estonia are moderately warm (the average temperature in July is 16–17 °C) and the winters moderately cold (the average temperature in February ranges from –3 to –4 °C). The highest temperature ever measured is +35,6 °C (1992, Võru); the lowest, however, –43,5 °C (1940, Jõgeva). (Environment Agency, 2022a)

The Estonian climate is characterised well by the timeline of the average annual temperatures of the Tartu-Tõravere station (**Figure 2.4**). The timeline shows a rapid increase in the temperature in the end of the twentieth century and a certain stabilisation which has occurred in the last few decades. It should be highlighted that the current situation of a relatively high average temperature also occurred in the end of the 1930s as a shorter period. (Environment Agency, 2021)

According to the report 'Estonian future climate scenarios until 2100' (Luhamaa et al., 2015), the increase in the average annual temperature in Estonia since the middle of the twentieth century has been a bit faster than the global increase. The warming trend in winter, especially in January, can clearly be seen by month.

As the annual precipitation is almost twice as high as the evaporation, the climate is very humid. The average annual precipitation is approximately 550–700 mm, ranging from 520 mm on some islands to up to 740 mm on highlands. The seasonal fluctuation of the precipitation is similar all over the country. The driest months are February and March, with the precipitation gradually increasing in the following months. The wettest months are July and August, after which the precipitation decreases towards winter and autumn. The lowest annual precipitation in the coastal area may remain below 350 mm, but the highest in the inland region sometimes exceeds 1,000 mm. The highest measured daily precipitation was 148 mm (1972, Tooma) and the highest annual precipitation 1,157 mm (1990, Nääri). (Kallis et al., 2019)

The duration, thickness, and water capacity of snow cover vary significantly by year. While the periods in the middle of the 1970s and in the end of the 1980s were dominated by mild winters with almost no snow cover, the winters in 1920–1933 were long and with a thick layer of snow. On average, there are 109 days with snow cover in Estonia per year, ranging from 61 to 155 days. A negative trend in the duration of snow cover has been detected for the period of 1961–2002: over the forty years, the average duration of snow cover decreased by 25.9 days. (Kallis et al., 2019)

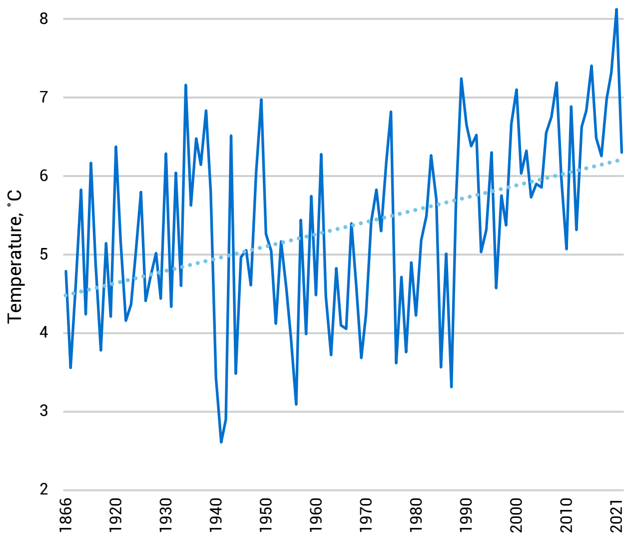

Figure 2.4. Average annual temperature values of Tartu-Tõravere and the trend thereof in the period 1866–2021, °C (Environment Agency, 2021)

Snow cover develops first on the uplands of Haanja, Pandivere, and Otepää, on average in the beginning of December, and remains until the end of March. In Saaremaa and Hiiumaa, permanent snow cover usually develops in the middle of January. Some years, snow cover does not develop at all. (Kallis et al., 2019)

South-western, southern, and western winds prevail in Estonia. Northern winds are more frequent in spring and early summer. The average wind speed is 5–7 m/s in coastal areas and 3–5 m/s inland. The wind is strongest in the autumn and winter months, especially in November, December, and January (average wind speed of 4.3 m/s). The wind is weakest in summer (the average wind speed from July to August is 3.1 m/s). The strongest gust of wind measured by Estonian meteorological stations was 48 m/s measured in Ruhnu in November 1969. (Kallis et al., 2019)

The average Estonian total amounts of solar radiation range from 3,300–3,600 MJ/m^2, with the hours of sunshine varying from 1,650 hours in inland regions to 1,950 hours on the islands. June and July are the sunniest and December is the least sunny. The multi-year mean duration of sunshine in the period of 1981–2010 was 1,766 hours. (Kallis et al., 2019)

2.6. Energy

The Estonian energy and fuel sector, the aim of which is to supply the state with electricity and thermal energy and high-quality fuels and ensure the optimum development of the sector affects almost all fields of life. For example, heating and housing sectors have an effect on the regional development of Estonia and on public health. The choices which are related to the production of biofuels have an impact on land use, rural life, and the foreign trade balance. The

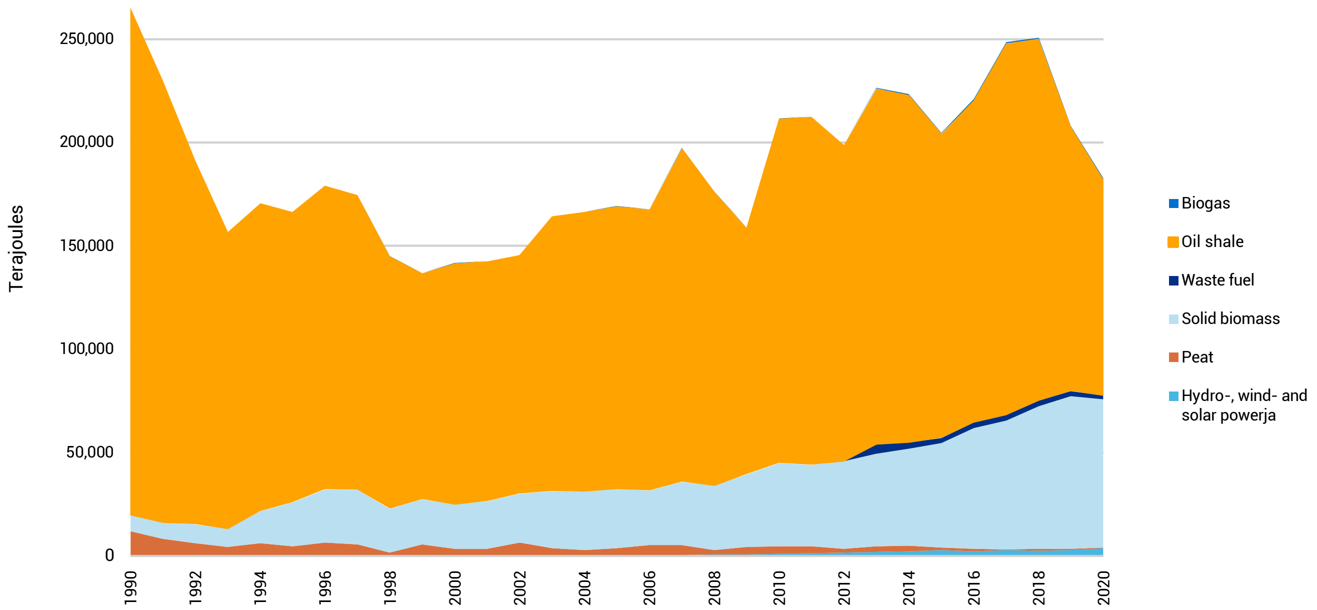

Figure 2.5. Primary energy generation in Estonia 1990–2020, terajoules (JQ, 2022)

fuels selected for electricity generation have an impact on the Estonian environmental condition and on the efficiency of business activities. The main source of energy of Estonia is oil shale, which ensures the energy independence of the state and invigorates the economy, but has a negative impact on the environment and on public health (Tammiksaar, 2015).

Estonia is one of the largest primary energy producers per capita in the EU. The primary energy production in Estonia (**Figure 2.5**) peaked in 2018 due to an increase in oil shale production volumes. In 2020, the primary energy production dropped below the level of 2016, mainly due to a decrease in the oil shale production volumes. Oil shale extraction dropped by 24% compared to the year before in 2020 and the extraction volume was the lowest of the last thirty years. The lower extraction volumes were mainly caused by an increase in the CO_2 quota price and the work load of the oil shale-based power plants was reduced due to the low market prices of electricity (Statistics Estonia, 2022j; Joint Questionnaire (JQ), 2022).

In addition to generating electricity, oil shale is also used for producing shale oil, the production of which has increased throughout the years in connection with the construction of new plants. In 2020, the amount of electricity generated in Estonia was 5,956 GWh, which is 22% lower than in 2019. The electricity from renewable sources formed 17% of the entire electricity production in 2020 (JQ, 2022).

The majority of electricity and heat produced in Estonia comes from oil shale, biomass, and natural gas; thereat, electricity is mainly generated from oil shale and various wood fuels are used in heat generation. Cogeneration of heat and electricity is the most efficient method of energy production from the perspective of environmental protection. The number of cogeneration plants has been consistently increasing. While there were 42 different cogeneration plants in Estonia in 2015, the figure had risen to 51 by 2020, with 16 of those using back-pressure steam turbines, 17 condensing turbines, and 18 internal combustion engines (Statistics Estonia, 2022k).

2.6.1. Energy taxes and subsidies

The state earns a significant revenue from energy taxation, mainly from fuel and electricity excise duties, which form approximately 6% of the tax revenues in the state budget. In addition to being a source of revenue to the budget, the aim of the energy taxes is to reduce energy consumption and greenhouse gas emissions. The most significant excise duties applicable in the first half of 2020 were the electricity excise of 4.47 euros per MWh and the petrol and diesel fuel excise duties of 563 and 493 euros per 1,000 litres, respectively. To alleviate the consequences of declaring an emergency situation due to the global COVID-19 pandemic in 2020, the government reduced the excise rates applied to electricity and certain fuels temporarily from 1 May 2020 to 30 April 2022. The electricity excise was reduced to 1 euro per MWh and the diesel fuel excise to 372 euros per 1,000 litres (Alcohol, Tobacco, Fuel and Electricity Excise Duty Act, 2003).

Electricity generation from renewable sources is supported in Estonia. In July 2018, the Electricity Market Act was amended, and the state switched to an auction system in supporting renewable energy sources. In certain cases, however, the right for direct aid which was applicable so far remains in force. The support rates remain the same in the new supporting scheme, but the supporting scheme itself changed. The support rates paid for production machinery based on the old subsidy scheme are specified in **Table 2.1**.

Table 2.1. The support rates applicable to producing electricity from renewable energy, €/kWh (Electricity Market Act §59)

Level of subsidy €/kWh	Conditions for receiving the subsidy
0.0537	Electricity generated from a renewable energy source except biomass if the net capacity of the production machinery does not exceed 125 MW
0.0537	Electricity generated from biomass by using the cogeneration regime
0.032	In efficient CHP mode from waste as defined in the Waste Act, peat or oil shale retort gas.
0.032	In efficient CHP mode using generating equipment with a capacity of not more than 10 MW

Based on the new scheme, the producers who wish to receive the support must take part in an auction, as a result of which the support is allocated to those undertakings which generate the cheapest renewable energy. Only offers for generating electricity by using production machinery which will begin production after the winner of the auction has been found and which have not received investment aid from the state can be submitted to the auction. The support is only allocated to the winner of a respective auction. An upper threshold based on the exchange price has also been established – 0.093 EUR/kWh (Electricity Market Act, 2003).

The point of the simultaneous application of the old and new renewable energy support schemes is to ensure the legal certainty to those undertakings which have invested in the production and of renewable energy, knowing and taking into consideration that the current support scheme will remain in force and guarantee the respective support for them for up to twelve years. On the other hand, the aim of the renewable energy support is to increase the exploitation of renewable energy sources and the efficiency of the energy sector (Põld, 2020).

2.6.2. Trade

Historically, Estonia has almost always been a net energy exporter. While the amount of electricity exported in 2018 was 4.9 TWh, 2.7 TWh was exported a year later, and the import of electricity exceeded the export. The export dropped by 45% in 2019, showing the largest decline in the past ten years, and the import of electricity increased by 37%. In 2020, the export was again higher than the import, increasing by 27% compared to 2019 (JQ, 2022). The change was mostly caused by an increase in the CO_2 quota price, which made the price of oil shale-based electricity non-competitive, as well as the low electricity exchange price.

In total, 66.1% of the electricity generated was exported to Latvia and Finland in 2020. The main import partner of Estonia is Finland, through whom electricity is imported via the EstLink 1 and EstLink 2 connections. The combined transmission capacity of the two links is 1,000 MW (Elering, 2013). The electricity import has increased, as cheap hydroenergy can be imported from Scandinavia in certain periods via the electricity links between Estonia and Finland. The construction of a third electricity link between Estonia and Latvia was completed in the end of 2020, which will provide an additional 600 MW of transmission capacity between the two countries and improve the electricity links in the north-south direction (Elering, 2020a).

The consumption of natural gas has gradually decreased (**Table 2.2**), primarily due to the fluctuating gas price and the

Table 2.2. Fuel consumption based on fuel type, TJ (JQ, 2022)

Fuel type, TJ	1990	1995	2000	2005	2010	2015	2020
Coal	10,311	2,576	2,401	1,521	1,630	706	306
Oil shale	242,064	140,860	119,376	134,468	165,061	148,996	104,185
Peat	11,293	6,305	3,375	2,884	3,796	1,482	1,196
Solid biomass	10,044	20,538	21,378	24,220	34,192	34,557	47,515
Biogas	0	85	76	149	155	550	832
Semi-coke gas	700	905	1,043	1,600	3,064	9,450	11,096
Natural gas	43,642	19,481	23,923	28,833	24,032	16,559	14,649
Fuel oils (incl. shale oil, domestic and heavy fuel oil)	75 080	22,076	10,925	11,549	8,384	8,606	5,547
Diesel oil	19,050	11,305	10,941	16,101	17,615	22,013	23,016
Gasoline	22,968	10,912	12,452	12,760	12,115	10,180	9,092
Aviation fuel	78	46	34	66	39	58	50
LPG	1,306	425	350	335	455	819	1,115
CNG	0	0	0	0	2	116	365

increased use of biomass. Biomass consumption has increased by 28% in the past ten years, while the use of natural gas has declined by 38% over the same period. Of solid fuels, the use of coal and coke has also decreased. The liquid fuel consumption has remained relatively stable throughout the years, but the use of fuel oils for heating has dropped. LPG is mainly used as automotive fuel and in public buildings and households. While the use of LPG has increased by 18% over the past ten years, its consumption in the transport sector has grown by 75% over the same period due to increased use of LPG cars. The use of CNG has been increasing since 2010 with CNG-fuel based cars being taken into use (JQ, 2022).

The main fuels imported to Estonia are natural gas, liquid fuels, coal, and coke. In 2020, the Balticconnector gas pipe was opened between Estonia and Finland, which connects the gas systems between the two countries for the first time and enables the two-directional transport of gas. Taking the new gas pipe into use also opened a gas market connecting Estonia, Latvia, and Finland, which is the first market region involving three countries in Europe (Elering, 2020b).

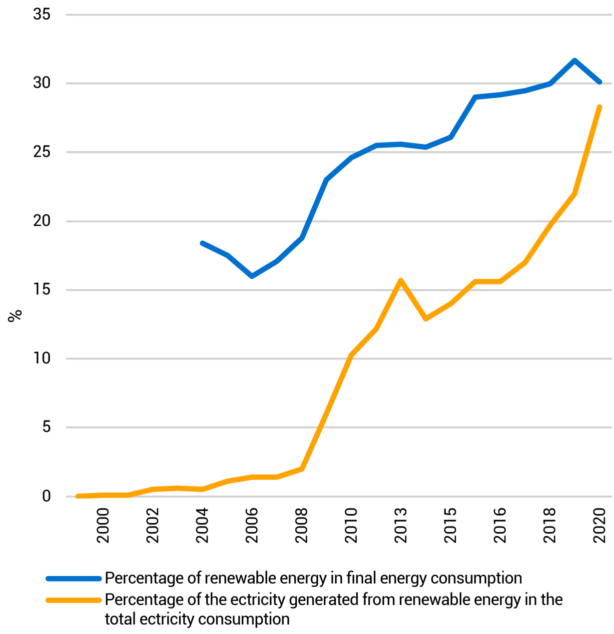

Figure 2.6. Energy from renewable sources, % (Statistics Estonia, 2022l)

2.6.3. Renewable energy

The share of renewable energy has been gradually growing in Estonia throughout the years (**Figure 2.6**). In 2020, the share of renewable energy in electricity production grew to 28.3% of the total electricity production, which means a 12.7% growth compared to 2015. Renewable energy formed 30.1% of the final energy consumption in 2020, which is 1.1% more than in 2015. In total, 69% of the renewable sources used in electricity generation was formed by biomass, followed by wind energy (29%) and waste fuel (5%) (Statistics Estonia, 2022l).

2.7. Transport

The Estonian transport network consists of the infrastructure required for road, rail, water, and air traffic. In 2020, the emissions from the transport sector formed 19.3% of the total greenhouse gas emissions of Estonia. As of 1 January 2022, the total length of the road network is 58,946 km, of which 16,993 km is formed by state roads. This is complemented by 87.6 km of temporary ice roads, depending on the weather. Paved roads form 74% of all state roads; in 2016, the same figure was 69.3%. The density of the state roads is 373 km per 1,000 km^2 and the density of the entire road network is 1,298 km per 1,000 km^2. (Estonian Transport Administration, 2020; 2022a)

The total length of the railways in Estonia is 2,164 km, of which 71.2% is in public use and 28.8% in non-public use. An electric railway of 132 km is part of the public railway. This is complemented by private railway sections at ports and the railway built for transporting oil shale. The majority of the railway is owned by AS Eesti Raudtee and Edelaraudtee Infrastruktuuri AS. The Ministry of Economic Affairs and Communications and the institutions in its area of administration coordinate the development of the railway infrastructure, logistics, passenger and freight transport, the rolling stock, and traffic and environmental safety in Estonia (Ministry of Economic Affairs and Communications, 2022b).

The length of the Estonian coastline is 4,015 km and there is a dense network of ports on the coast. Including the ports of the internal water bodies, there are 232 ports registered in the Estonian State Port Register, with the largest reaching the depth of over 17 m (State Port Register, 2022). The Port of Tallinn is the largest complex of freight and passenger ports, the number of passengers of which was increasing until 2019 (10.64 million passengers) but shrunk sharply in 2020 due to the global COVID-19 pandemic. In 2020, the Port of Tallinn served over 4.3 million passengers. In 2021, the number of passengers dropped to 3.5 million. Taking into consideration the number of passengers, as well as the freight flows, the Port of Tallinn is also the largest port complex of the Baltic Sea (The Port of Tallinn, 2022).

There are ten airports in Estonia (five visual and five instrumental airports), in total, in Estonia, which served 897,000 passengers in 2020, that is more than two thirds less than in 2019, when approximately 3.3 million passengers were served. In 2021, the number of passengers increased by half compared to 2020, amounting to 1.3 million passengers. The Tallinn Airport, which is the biggest airport in Estonia, was used by approximately 1.3 million passengers in 2021 (Tallinn Airport, 2022; Transport Administration, 2022b).

2.7.1. Passenger transport

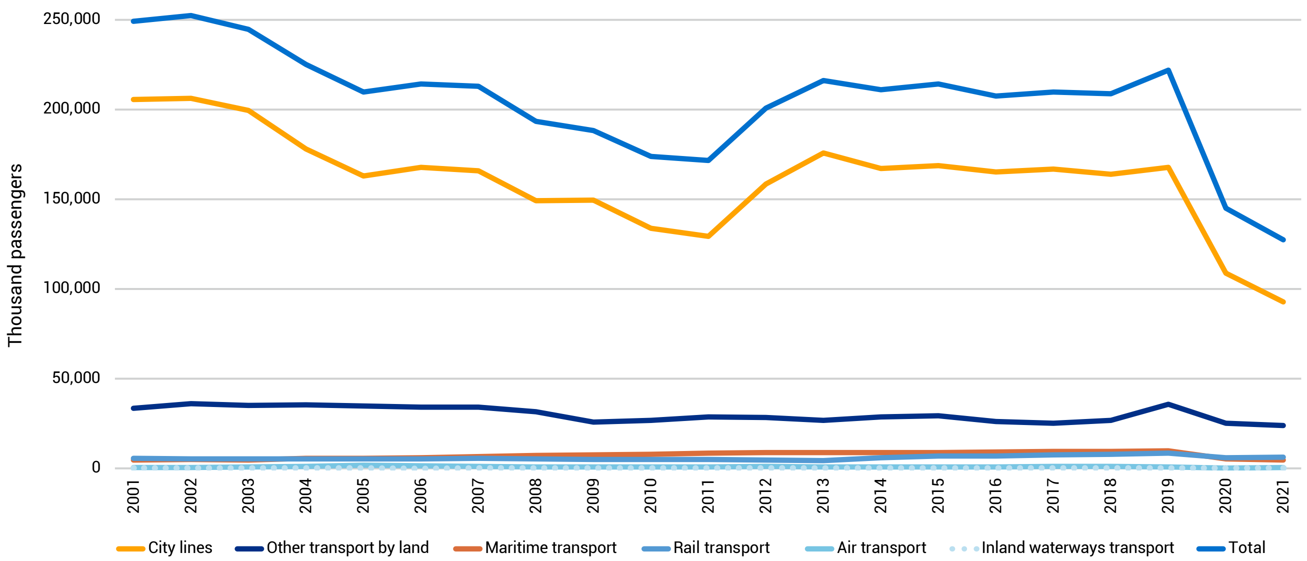

Figure 2.7. Passenger transport of transport companies, thousand passengers (Statistics Estonia, 2022m).

Estonian transport companies served the total of 127 million passengers in 2021. This figure dropped by 12% compared to the year before, when 145 million people were served (**Figure 2.7**). The decline may be deemed to have arisen from the domestic and international restrictions of movement enforced in the spring of 2020 due to the emergency situation which was caused by the global COVID-19 pandemic (Statistics Estonia, 2022m).

Buses are mainly used for public transport in Estonia. On city lines, bus transport was used by 73 million passengers in 2021, which formed more than half of domestic passenger transport. Buses, trams, and trolley buses were used by approximately 116 million passengers, in total, which is 13% less compared to 2020 (Statistics Estonia, 2022m). The number of train users has been increasing year-by-year – the number of rail transport users exceeded the threshold of 8 million in 2019 but dropped by 29% in 2020 due to the restrictions on movement. In 2021, train services were used by 6 million passengers (Ministry of Economic Affairs and Communications, 2021).

2.7.2. Freight transport

The freight transport volumes decreased significantly in 2008 and 2009 due to the recession. Then, the freight transport started to gradually recover, reaching the highest post-crisis level in 2011 (**Figure 2.8**). The following years have shown a constant decreasing trend of the freight transport volumes, which mainly arises from the drop in the freight transport by rail in the transit between Estonia and Russia since 2011, as well as the fact that Russia is increasingly using their ports

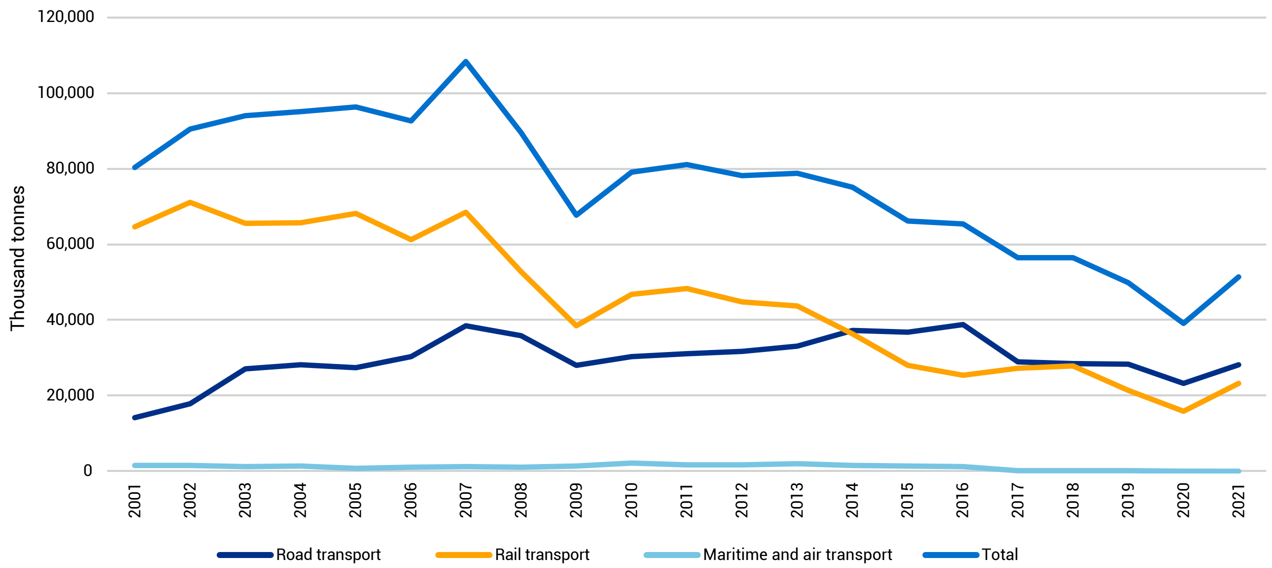

Figure 2.8. Freight transport by transport companies, thousand tonnes (Statistics Estonia, 2022n)

instead of the railway for dispatching goods to foreign countries (Ministry of Finance, Ministry of the Economic Affairs and Communications, 2020).

Compared to 2016, the freight transport volumes decreased by 21.6% in total in 2021, incl. freight transport by rail by 8.3%. This is also one of the reasons why the Estonian GHG emissions in the sub-category of rail transport decreased by 32.9% in this period. At the same time, road transport has been increasing steadily since the end of the recession, reaching the pre-crisis level in 2016, but has been continuously dropping since then due to a lower number of haulage operations (Statistics Estonia, 2022n).

As the amounts of cargo transported by the Estonian transport companies by sea or air are very small, the figures of the maritime and air freight transport have been summarised in the figure.

2.8. Industry

In 2020, the added value of the industrial sector formed 14.7% of the Estonian economy (Statistics Estonia, 2022o), which is close to the EU average (15%). Compared to 2015, the volume of the industrial sector has increased by approx. 10% and, compared to 2008, it has grown 1.7 times in current prices (**Figure 2.9**).

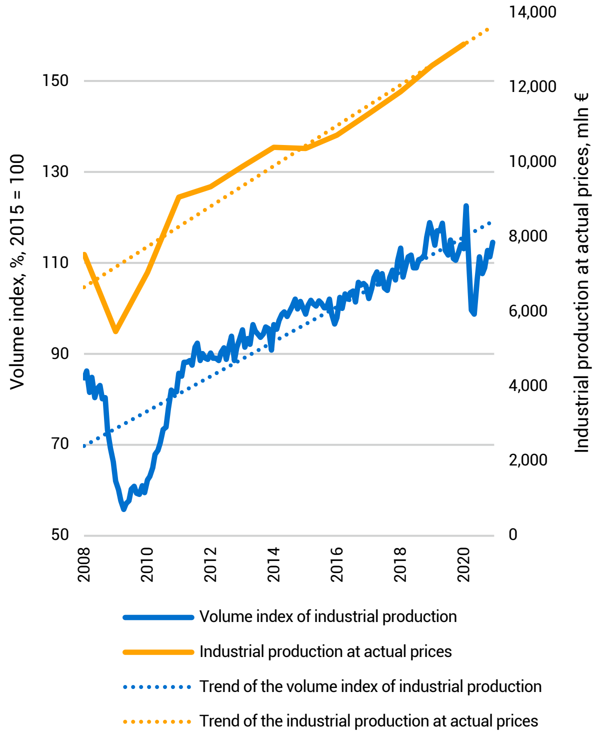

Figure 2.9. Estonian industrial production 2008–2020 (Statistics Estonia, 2022p)

The general structure of the economy underwent large-scale changes in the beginning of the 1990s, as the service sector had not yet developed and the majority of the factories were oriented to the Soviet Union market. The decrease in the industrial production in the course of the transfer from a planned economy to a market economy also brought along a significant drop in the GHG emissions. In the 2000s, the emissions fluctuated extensively, achieving the maximum level in 2007 due to the rapid economic growth (National Greenhouse Gas Inventory Report 1990–2020, 2022). In 2020, the industrial production decreased by 4%, which was exceptional and caused by the impact of the global COVID-19 pandemic on export (Nestor, 2021).

Over the past decade, the general distribution between the procurement, processing, and service sectors has remained constant and the increase in the GHG emissions has been slow. Changes have occurred within sectors with the share of high-technology and knowledge-intensive industry (e.g. the appliance industry) gradually increasing (Statistics Estonia, 2022o).

The timber industry has been the main frontrunner of the branches of manufacturing industry for years. In the last few years, the increase in the production volumes has been the most rapid in the appliance and food industries (Statistics Estonia, 2022o). The timber, appliance, metal, and food industries create the most added value (**Figure 2.10**).

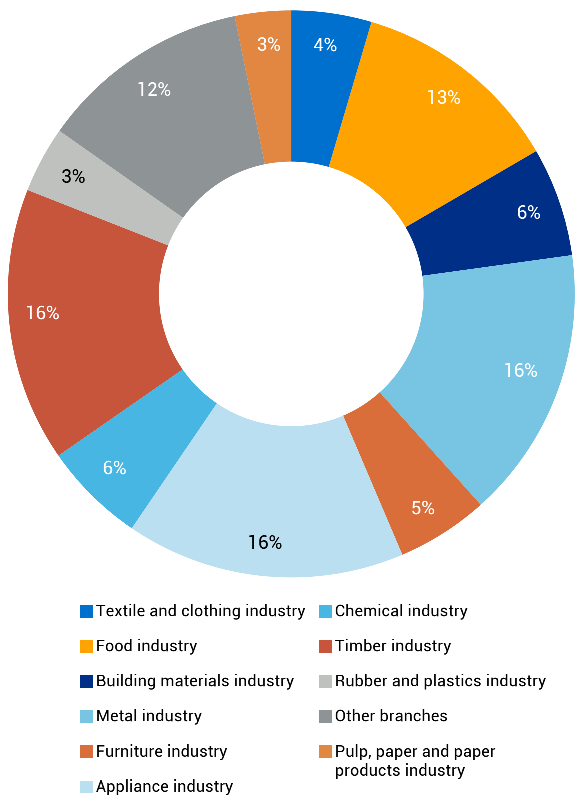

Figure 2.10. The structure of the manufacturing industry in Estonia based on added value, 2019 (Statistics Estonia, 2022o)

Wood is one of the most important natural resources in Estonia and the timber industry is, in turn, one of the most important sectors of the Estonian economy. The importance of the timber industry has been gradually increasing and is about to reach about a fifth of the entire manufacturing industry production and 7.9% of the Estonian GDP. (Statistics Estonia, 2022q, 2022r). The timber industry is a net exporter which is important from the perspective of balancing the foreign trade balance (Estonian Forest and Wood Industries Association, 2021). Estonia has a competitive advantage thanks to the easy availability of high-quality raw material and the long experience; on the other hand, though, there is an increasing pressure to limit the felling volumes (Environmental Agency, Estonian University of Life Sciences, 2021).

The Estonian economy is export-oriented and the share of the manufacture ng industry in the export has increased after 2013. In 2020, about 67% of the production of the manufacturing industry was exported, with the majority sold in the internal market of the EU, primarily in the Nordic countries (Statistics Estonia, 2022o).

There are over 7,500 companies operating in the Estonian industrial sector, of which the majority are small or medium-sized companies. There are more than 200 companies with over 200 employees, but a half of all employees of the industrial sector are employed at those companies. In total, 25% of the labour force was employed in the manufacturing industry in 1991 and 18% in 2020 (Statistics Estonia, 2022s), which is above the EU average (14%) (Geomedia OÜ, 2018) and shows that other countries create more added value with the same number of employees. The number of people employed in the manufacturing industry is very likely to continue to decrease in the future, supported by an increase in productivity and a decrease in the difference in the share of employment, especially in the more labour-intensive fields.

2.9. Waste

The development and goals of waste management in Estonia are based on the EU and national legislation (the Waste Act) and the current Waste Management Plan 2014–2020 (extended until the end of 2022). The Waste Management Plan was drawn up based on the Seventh Environmental Action Plan, which is aimed at directing the European environmental policy until 2020 and beyond. In 2008, the 2008/98/EC waste framework directive of the European Parliament and of the Council entered into force, establishing the quantitative targets for the recycling and reuse of municipal waste, construction and demolition waste. Those targets are also established by the Waste Act and the current Waste Management Plan. Pursuant to the Estonian Waste Act, as of 2020, the percentage of biodegradable waste in the total quantity of municipal waste deposited in a landfill may not exceed 20 per cent by weight (The Waste Act, 2004). Furthermore, an amendment of the EU framework directive 2018/851 on waste also sets a target level of 55% of the total mass for the recycling of municipal waste for 2025 (Directive of the European Parliament and of the Council, 2018). As a result of all of the above, the greenhouse gas emissions in the waste sector have decreased by 21.2% by 2020 (compared to 1990) (National Greenhouse Gas Inventory Report 1990-2020, 2022).

The sorting surveys of mixed municipal waste have shown that the percentage of biodegradable waste in the total mass of mixed municipal waste amounted to 53% in Estonia in 2020. The percentage of biowaste (kitchen, garden, and park waste) in the mixed municipal waste is roughly 32%. The current Waste Management Plan foresees, among other things, a more extensive implementation of biodegradable waste composting and anaerobic digestion technologies and processing products, which should also help to achieve the recycling targets. (Stockholm Environment Institute Tallinn Centre, 2020)

The collection of municipal waste by type is organised by local governments which have been continuously expanding this activity and developed the construction of a network of waste stations. Local residents, for their part, must follow the municipal waste management regulations of the local government, which state where different types of waste can be disposed of within the territory of the local government. (Ministry of the Environment, 2022b)

There are five non-hazardous waste landfills operating in Estonia: the Tallinn Waste Recycling Centre, Uikala, Väätsa, Torma, and Paikre (Ministry of the Environment, 2022c). Those landfills are fully compliant with the environmental and technical requirements and standards and are able to serve more than one service area. In total, roughly 16.8 million tonnes of waste was generated in 2020, including 0.5 million tonnes of municipal waste. The total waste generation has remained at over 20 million tonnes over the past ten years, except in 2020, when the amount of waste generated was lower due to the crisis. (Environment Agency, 2022)

The share of the waste from the oil shale industry formed more than 67% of the total waste generation in 2020. The total amounts of the oil shale sector waste generated continued to increase until 2015, primarily in connection with an increase in the shale oil production and export volumes, and remained stable until 2017. Since 2018, however, the production volumes of the oil shale-based electricity have been decreasing, largely due to the cheaper electricity produced in Russia, which has arrived in the single market of the Nordic and Baltic countries, as well as due to a drop in the oil price at the end of 2018. The increased productivity of the oil shale extraction and processing processes due to the investments made by oil shale undertakings has also contributed to the lower waste generation. (Environment Agency, 2020; Environment Agency, 2022)

The waste rock from oil shale extraction which is directed to reuse can be put back in the circulation as raw material almost in the extent of one hundred per cent (mainly as crushed stone). Thus, the share of the reuse and recycling of waste rock has once again started to increase in the past few years thanks to the road construction and construction projects which require filling material. In 2014, roughly 3.3 million tonnes or less than 42% of the waste rock generated was recycled; in 2018, however, the respective indicators were approximately 4 million tonnes and 57%. The projects planned for the upcoming years, such as the construction of the Rail Baltica railway and a new solar power station in the territory of the Estonia mine, also give hope that the reusing will increase further. The increase in reuse is accompanied by a drop in the amount of the waste rock deposited in spoil tips. (Environment Agency, 2020)

2.10. Building stock and urban structure

In 2021, there were 737,837 dwellings in Estonia, in total, of which almost 76% or 557,146, in total, were populated. In total, 99% of the populated dwellings were conventional living spaces and other residential units and the remaining were collective dwellings. The average living space per resident in Estonia is 30.1 m², which is about a third lower than the EU average (43 m²). In 2021, more than a half of the population or 61% lived in apartment buildings, 34% in single-family dwellings, and the remaining 5% in row and semi-detached houses (Eurostat, 2022c). Based on the share of people living in apartments, Estonia was in third place among the EU countries. In total, 81% owned their homes and about a fifth of the population were living in rented dwellings (Statistics Estonia, 2022t; Eurostat, 2021c).

The construction of new residential premises has increased considerably in the past ten years. In 2021, 6,735 new dwellings (612,600 m²) were approved for use, which is 60% more compared to the year before. The overall ageing of the housing stock continues, however, as the renewal rate remains modest (0.8%, 2018) and more than half of the housing stock still originates from the mass housing construction period of the Soviet Union in 1961–1990. Geographically, 38% of the new dwellings were built in the urban area of Tallinn, 19% in Tartu, and 5% in Pärnu in 2020 (Statistics Estonia, 2022t; 2022u).

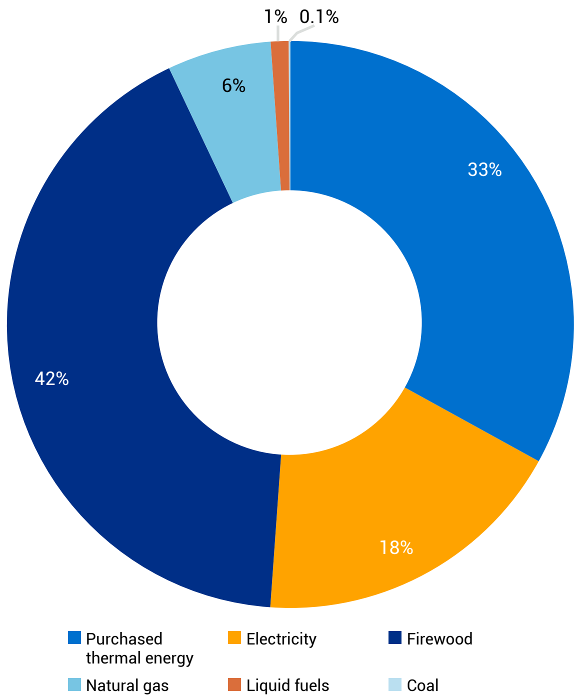

Figure 2.11. Household energy consumption by type, 2020 (JQ, 2022)

The total energy consumption of households was 39.7 PJ in 2020, which forms 34% of the final energy consumption and is a third higher than the EU average (26%). The figure below (**Figure 2.11**) shows that the energy consumption of households is divided as follows based on the type of energy and fuel: firewood 42%, purchased thermal energy 33%, electric energy 18%, and natural gas 6%. Between 2015 and 2020, the thermal energy consumption of households increased by 9% and the increase in the consumption of electric power was even higher (14%). Private residences still use firewood quite extensively; the use thereof increased by 9% in the same period. The use of liquid fuels has decreased by 27%. In the same period, the use of natural gas increased by 12% (JQ, 2022).

The greatest issue of the housing sector is the low energy efficiency and quality of the dwellings compared to other European Union member states and the renewal of the infrastructure calls for the implementation of further energy and climate policy measures. Social factors are also problematic in the field of the housing stock: the low solvency of the weakest population groups, the weak cooperation between the local governments, the state and civil organisations, abandoning of certain regions and apartment buildings (Energiatalgud, 2019). Based on the long-term strategy for the reconstruction of buildings published in 2020, approximately 100,000 detached houses with a total surface area of 14 million m², 14,000 apartment buildings with a surface area of 18 million m², and 27,000 non-residential buildings with total surface area of 22 million m² require reconstruction. The target is the cost-efficient reconstruction of the current housing stock by 2050. Regulation "Minimum energy performance requirements for buildings" set out in the Building Code establishes the cost-optimum energy efficiency level of significant reconstruction works which is equivalent to the energy label class C. Reconstruction of buildings will reduce the use and import of fossil fuels and the sales volumes of district heating undertakings. The need to invest in new energy production capacities will decrease. The lower energy demand of buildings will also enable to use the potential of renewable energy solutions and distributed energy technologies and increase energy independence and the security of the energy supply. Support and other stimulating measures are required to eliminate the problem, as large-scale investments are needed for the comprehensive reconstruction of buildings (TalTech, 2020).

Based on the developments of the urban system, it may be stated that Estonia is undergoing urbanisation which favours bigger cities. In total, 69% of the residents of Estonia live in cities – including 40% in and around Tallinn – and 31% in rural settlements. The largest urban areas are Tallinn, Tartu, Pärnu, Jõhvi, Kohtla-Järve, and Narva. Estonian cities with less than 500,000 residents are among the medium and small cities in Europe. (Estonian Cooperation Assembly, 2020)

The main migration directions are related to the life cycles of people: young people are mainly moving to big cities, families with children to suburbs, and older working-age people and retired people to rural areas. The attraction of Tallinn and Tartu, as well as Pärnu and the urban agglomeration in Ida-Viru County, is ensured by higher education institutions and the number of jobs which are related to the knowledge-based economy. Changes are ongoing in rural areas as well. The region of Western Estonia (Saare County, Hiiu County, Lääne County) is increasingly becoming a holiday home region for the people of Tallinn. The number of permanent residents of the region is also increasing, as people are moving there from elsewhere in Estonia. Similar changes can also be observed in Southern Estonia, where the balance of domestic migration has turned positive in Põlva County, Valga County, and Viljandi County. The nature-friendliness of the rural areas may also prove attractive to a certain number of people from other countries. Taking small renewable energy technology into use will improve the possibilities to live in peripheral villages and on small islands (Ministry of the Interior, 2012; Tammaru, 2021).

Based on daily commuting, thirty-seven areas of action have been defined which have been built in wider regional (Tallinn and Tartu), county (13), smaller regional (21), and local centres based on the centre/hinterland system. The growth model of urban areas, especially in Tallinn and Tartu, is characterised by urbanisation, but also remote urbanisation in the form of an increasing work-, education-, and service-related commuting from further away. The current areas of action cover the majority of Estonia, but not the entire territory (Ministry of the Interior, 2012).

County plans have introduced a new principle of settlement development areas, which aims to make the settlements more compact, increase the density of the urban space, and place new settlements cohesively with respect to the existing ones to create a higher-quality and more energy-efficient urban environment. In regard to dispersed settlement, the preservation of local centres and traditional rural settlement are prioritised. The national regional policy measures co-funded from the EU funds have attempted to reinforce the development of urban regions and develop county centres and other local centres of gravity, but it has not stopped the metropolisation or the weakening of the lower levels of settlement. A further concentration in the Estonian settlement system was caused by the administrative reform of 2017, as a result of which the number of local governments decreased from 213 to 79 (Ministry of the Interior, 2012).

2.11. Agriculture

The emissions of the agricultural sector have decreased by 42.6% compared to the base year (1990). This mainly arises from the decrease in the number of grazing livestock and the reduced use of synthetic (nitrogen) fertilisers and manure on the fields after the collapse of the markets of the Soviet Union. (National Greenhouse Gas Inventory Report 1990–2020, 2022) The climate situation is very important for the horticulture in Estonia. Due to the long rainy periods and cold winters, only the summer period is usually favourable for horticulture.

The surface area of agricultural land has dropped from 1,458,400 hectares in 1990 to 986,627 hectares in 2021. Thereat, the agricultural land area has increased by 40,680 hectares in the past decade. In 2021, the growing area of arable crops was 699,632 ha, of which cereals formed more than half (52.5%, 367,117 ha), fodder crops 178,225 ha (25.5%), industrial crops 85,313 ha (12.2%), and potatoes, legumes, and vegetables 54,160 ha (7,7%), in total. (Statistics Estonia, 2021v; 2021z)

In 2020, on average, 35% of the agricultural land in use was owned and 65% was rented or taken into use under other conditions. There were 127 hectares of agricultural land, on average, at the disposal of the Estonian agricultural producers in 2020. (Agricultural Research Centre, 2021)

The number of farm animals has decreased by 67.1% since 1990. Based on the data of 2021, there were 250,700 cattle (incl. 83,600 dairy cows), 308,000 pigs, 75,323 sheep, 4,977 goats, and 2,105,100 poultry in Estonia. The drop has mainly been caused by the transfer from a planned economy to a market economy in the beginning of 1990s. The dairy industry has had to face changes in the market conditions since 2014, mainly due to the economic sanctions imposed by Russia against the European Union. This was followed by a decrease in the purchase price of milk. As a result of this, the number of dairy cows decreased by 12.5% by 2021 compared to 2014. The number of pigs decreased by 13.9% in the same period. The main reason for this is the African Swine Fever (ASF) outbreak in Estonia in 2015. For a while, the number of pigs increased due to the better economic situation of the country and the growing demand for pork as the most popular meat; in 2021, however, the number of pigs dropped again by 2.8% compared to 2020. (Statistics Estonia, 2022w)

When appropriated land was returned to owners after the independence of Estonia was restored, the number of agricultural households increased from 7,400 to 55,700 between 1991 and 2001. (Statistics Estonia, 2022x). After this, the number of agricultural households begun to decline and in 2020 there were 11,396 agricultural households with at least one hectare of agricultural land or households producing primarily for sales, of which 7,428 were keeping farm animals, poultry, or bee colonies. (Statistics Estonia, 2022x; 2022y)

2021 was relatively favourable for grain production. The total grain yield was 1.29 million tonnes and the grain growing area only decreased by 0.8% compared to 2020. Legumes, mainly peas and beans, were cultivated on 48,972 hectares, in total, which is 538 hectares less compared to the year before. The legume yield dropped considerably compared to the year before – by 34% or to 79,189 tonnes (Statistics Estonia, 2022v; 2022z).

In 2021, the total production of the agricultural sector amounted to 1.073 billion euros, which is 8% more than a year earlier. Of this, 432.6 million (40%) was formed by animal output and 548 million (51%) by crop output, which is the highest of the past twenty years. The biggest industries were cultivation of cereal and oilseed, with the value of the total production of those industries being 11% higher compared to the year before, and dairy production with a 5% increase in the total production. (Estonian Chamber of Agriculture and Commerce, 2021; Ministry of Rural Affairs, 2021b)

Organic farming has expanded rapidly in Estonia – the area under organic farming has increased almost three times in the past decade. In 2020, 22% (223,813 ha) of all agricultural land in Estonia was used for organic farming, which places Estonia in the top three among the EU Member States. Compared to 2010, the percentage of organic farming has increased by 45%. On the other hand, 2020 was the first year in the history of Estonian organic farming when the area used for organic farming shrunk instead of increasing. The decline was small, however – just 348 ha. The number of organic processors and marketers and the share of the organic food sold has been increasing year-by-year, however in 2020 there were 2,050 agricultural undertakings involved with organic farming, which is about a dozen less than a year before. In total, 1,133 of those undertakings were involved in organic animal husbandry. Cattle (in 2020, 52,062 animals, incl. 19,380 suckler cows) and sheep (39,318 animals) are most widespread. The average size of organic undertakings remained at the level of the year before – in 2020, they had 109 hectares of agricultural land at their disposal, on average. (Estonian Organic Farming Foundation, 2020)

In order to facilitate the development of the agriculture, food industry, and rural life, subsidies are paid based on the Common Agricultural Policy of the European Union. Since Estonia's ascension to the European Union, such support measures have been funded from the budgets of four financial periods: agriculture, the food industry, and rural life were supported in the amount of 346 million euros in 2004–2006; in the amount of 1,705 million euros in 2007–2013; in the amount of 722 million euros in 2014–2016; and in the amount of 1,248 million euros, in 2017–2020 within the framework of the Common Agricultural Policy. 2021 was the first transition year of the new financial period (2021–2027), in which the budget of the new period can be used for implementing the measures of the previous period. The rules of the temporary state aid framework can also be used to support undertakings in the pandemic conditions. The budget of the subsidies paid to support the development of the agriculture, fishery, and rural life amounted to approximately 402 million euros in 2021, of which 3.8 million euros was paid as emergency support to agricultural producers via the Rural Development Foundation. (Ministry of Rural Affairs, 2019; 2021)

2.12. Forest

Forests are the main greenhouse gas sequesters in Estonia and play an important part in the national carbon cycle. The age structure of the forests managed is dominated by mature forest stands. Approximately 39% of the forest stands are more than 60 years old; thus, in the last few years, the increment has been lower than previously. 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 capacity of carbon sequestration in biomass has decreased in recent years. In addition, the annual increase in conversion from other land categories to Forest land (afforestation and reforestation) has been slowing and the total forest land area has stabilized. (National Greenhouse Gas Inventory Report 1990–2020, 2022)

Based on the Statistical Forest Inventory (NFI, 2022) more than half of the Estonian land is forested, with the surface area of forests amounting to 2,324,904 hectares (ha). According to the definition of forest in the Kyoto Protocol, the forest area in Estonia is even more extensive – 2,394,332 ha (National Greenhouse Gas Inventory Report 1990–2020, 2022). The share of forest land has been growing continuously since the end of the 1950s and reached 51.3% of the total land area by the end of 2020, according to the NFI (2022). Since joining the EU, the area of forest land has stabilised as EU agricultural subsidies were implemented in Estonia, therefore decreasing afforestation of agricultural land. The growth in the forest land area has decelerated in the past decade and the forest land area has decreased somewhat since 2017 (National Greenhouse Gas Inventory Report 1990–2020, 2022). This has been caused by lower afforestation (both anthropogenic and natural) and by increased clearing of forests.

In the period of 2012–2016, a lot of forest land without an owner which had mainly been left unmanaged were handed over to the State Forest Management Centre. This increased the surface area of the forest land owned by the State Forest Management Centre by 119,000 ha. Today, the centre owns 1,096,200 hectares or 45 per cent of the entire forest land in Estonia. This has also increased the surface area of managed forests. On the other hand, the share of strictly protected non-managed forests has increased to almost 15% by 2020, mainly due to the forests owned by the State Forest Management Centre. (NFI, 2022)

The total growing stock of Estonian forests is 472,415,000 m^3, i.e. 203.2 m^3 per one hectare of forest land. The annual increment of the forests is 16,167,500 m^3. In order to increase natural diversity, more standing trees and down timber are left untouched, amounting to 14.7 million and 21.6 million m^3 in total, respectively. On average, there is 15.6 m^3 of dead wood per hectare. (NFI, 2022)

In the area deemed forest land based on the definition provided in the Kyoto Protocol, there was 489.4 million m^3 of wood growing in 2020, in total. In addition to forest land, there is also 3 million m^3 of wood growing in grasslands (National Greenhouse Gas Inventory Report 1990–2020, 2022).

Estonia is located on the northern border of the hemiboreal climate. There are equal amounts of deciduous tree stands and coniferous tree stands, based on surface area (50% of both). The average stock by hectare is higher in the case of coniferous tree stands, which is why they dominate by volume – 55% of the growing stock. The three most commonly found species are pine, spruce, and birch, which cover 79% of the forest land and 81% of the growing stock as the dominant tree species. These are followed by grey alder, aspen, and common alder, which form 20% of forest land and 18% of the growing stock, in total. The share of the remaining trees remains below 2% both by the surface area as well as the growing stock. (NFI, 2022)

The age structure of the forests managed in Estonia is dominated by mature forest stands. Approximately 39% of the stands are more than 60 years old and a further 10% will reach this status within the next ten years. The share of strictly protected forests is a bit higher than 14% – those areas are not included in the regular forest management. (NFI, 2022)

The forest and timber industry have a significant effect on the Estonian economy. In 2019, the total of 25.6% of the total production of the manufacturing industry came from the timber, paper, and furniture industry. The forest and wood cluster contributed significantly to the Estonian foreign trade, in which the export of more than 2.1 billion euros formed 10.5% in 2019. (Valgepea et al., 2020)

The felling volume has been relatively volatile in the past fifteen years. The felling volume has been smaller than the increment throughout the period (**Figure 2.12**). In 2020, the total felling volume was 10.6 million cubic metres, of which 85% was felled in the course of regeneration cutting and 15% in the course of improvement cutting. The annual increment of wood was 16.17 million cubic metres. (NFI, 2022)

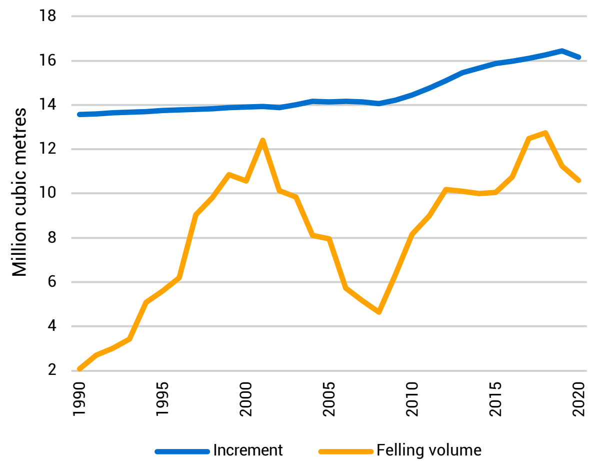

Figure 2.12. Felling volume and increment in 1990–2020, million m^3 (NFI, 2022)

Forest areas and use of wood form a significant part of the emissions/removals of the land use, land-use change, and forestry sector. Maintaining the intensity of the felling contributes to the decrease in the carbon stock of the forests, but also increases the amount of felled wood products.

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3. Greenhouse gas inventory information, including information on national systems and national registries

Key developments:

- Estonia's total greenhouse gas emissions in 2020 were 11,555.81 kt CO_2 equivalent (with indirect CO_2), excluding net emissions from Land use, land-use change and forestry.
- In 2020, the total emissions (including LULUCF) of GHGs (with indirect CO_2), measured as CO_2 eq., were 12,853.08 kt. In 2020, the LULUCF sector acted as a CO_2 source, totalling 1,297.3 kt CO_2 eq. with emissions. Since 1990, net removals have decreased by 141.1%.
- Total emissions decreased by 71.2% due to transition from a planned economy to a market economy in the early 1990s and due to recent efforts made to transition to renewable energy sources and due to high EU ETS allowance price.
- The accuracy of emissions estimates in Estonia has been improved since the 7th National Communication by improving data collection methods.

3.1. Introduction and summary tables

This chapter sets out Estonia's greenhouse gas (GHG) emissions and their trends for the period 1990–2020. It also provides information on Estonia's national system for GHG inventory and the national registry. The GHG data presented in the chapter is consistent with Estonia's 2022 submission to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat (National Greenhouse Gas Inventory Report 1990–2020, 2022). Common Reporting Format (CRF) tables were resubmitted in September 2022 (UNFCCC, 2022). Summary tables of GHG emissions in the CRF are presented in Annex I. The chapter presents data on direct GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6).

3.2. Descriptive summary of emission trends

3.2.1. Overall greenhouse gas emission trends

Estonia's total GHG emissions in 2020 were 11,555.81 kt CO_2 equivalent (eq.) (with indirect CO_2), excluding net emissions from LULUCF (Land use, land-use change and forestry). Emissions decreased by 71.2% in 1990–2020 (see **Table 3.1**). Emissions decreased by 71.2% due to transition from a planned economy to a market economy in the early 1990s and due to recent efforts made to transition to renewable energy sources and due to a high due to high European Union Emission Trading System (EU ETS) allowance price.

Emission trends by sector are given in **Figure 3.1**.

The Energy sector is by far the largest producer of GHG emissions in Estonia. In 2020, the sector accounted for 81.9% of Estonia's total GHG emissions (**Figure 3.2**).

The second largest sector that contributes to the GHG emissions is Agriculture, which accounted for 13.1% of total emissions in 2020. Emissions from the Industrial processes and product use (IPPU) and the Waste sector accounted for 2.6% and 2.5% of total emissions, respectively.

The LULUCF sector, acting until 2020 as the only possible sink of GHG emissions in Estonia, plays an important role in the national carbon cycle. In 2020, net emissions from the LULUCF sector equalled 1,297.27 kt CO_2 equivalent (**Table 3.1**).

Table 3.1. GHG emissions and removals by sector in 1990, 1995, 2000, 2005, 2010 and 2018–2020, kt CO_2 eq.

	1990	1995	2000	2005	2010	2018	2019	2020
Energy	36,213.16	17,697.15	15,098.87	16,742.41	18,899.50	17,770.83	12,210.92	9,461.45
Industrial processes and product use (incl. indirect CO_2)	963.74	635.29	695.97	727.83	539.51	628.54	621.35	295.47
Indirect CO_2 (from NMVOCs reported under IPPU 2.D.3 Solvent use and road paving with asphalt)[1]	18.45	17.39	16.52	18.50	11.32	18.41	20.76	24.74
Agriculture	2,628.34	1,350.11	1,122.23	1,172.06	1,253.80	1,417.62	1,501.48	1,508.38
Waste	369.93	397.97	562.45	515.18	488.00	308.74	302.38	290.51
Total (excl. LULUCF incl. indirect CO_2)	**40,175.17**	**20,080.53**	**17,479.52**	**19,157.48**	**21,180.81**	**20,125.74**	**14,636.12**	**11,555.81**
Land use, land-use change and forestry	−3,159.90	−2,799.39	−4,204.98	−1,275.73	−4,835.38	−1,438.30	−334.56	1,297.27
Total (incl. LULUCF and indirect CO_2)	**37,015.28**	**17,281.14**	**13,274.54**	**17,881.75**	**16,345.42**	**18,687.44**	**14,301.56**	**12,853.08**

In 2020, as in previous years, the main GHG in Estonia was CO_2, accounting for 80.9% of the total GHG emissions (with indirect CO_2 and without LULUCF) expressed in CO_2 eq., followed by CH_4 with 9.5% and N_2O with 8.0%. Fluorinated gases (the so-called F-gases) collectively accounted for about 1.6% of overall GHG emissions (Figure 3.3).

CO_2 emissions (with indirect CO_2) decreased by 74.7% from 36,922.21 kt in 1990 to 9,343.01 kt in 2020 (Table 3.2), with particularly large decreases in the Energy sub-sector Public electricity and heat production, which is the major source of CO_2 in Estonia.

Methane is the second most significant contributor to greenhouse gas emissions in Estonia after CO_2. Emissions of CH_4 decreased by 42.7% from 1,912.52 kt CO_2 eq. in 1990 to 1,095.46 kt CO_2 eq. in 2020. The downturn was especially noticeable in the Agriculture sub-sector Enteric fermentation, which is a leading source of CH_4 in Estonia.

Emissions of N_2O decreased by 29.3% from 1,340.45 kt CO_2 eq. in 1990 to 929.68 kt CO_2 eq. in 2020, especially N_2O emissions from the Agriculture sub-sector Agricultural soils, which is the main contributor of N_2O emissions in Estonia.

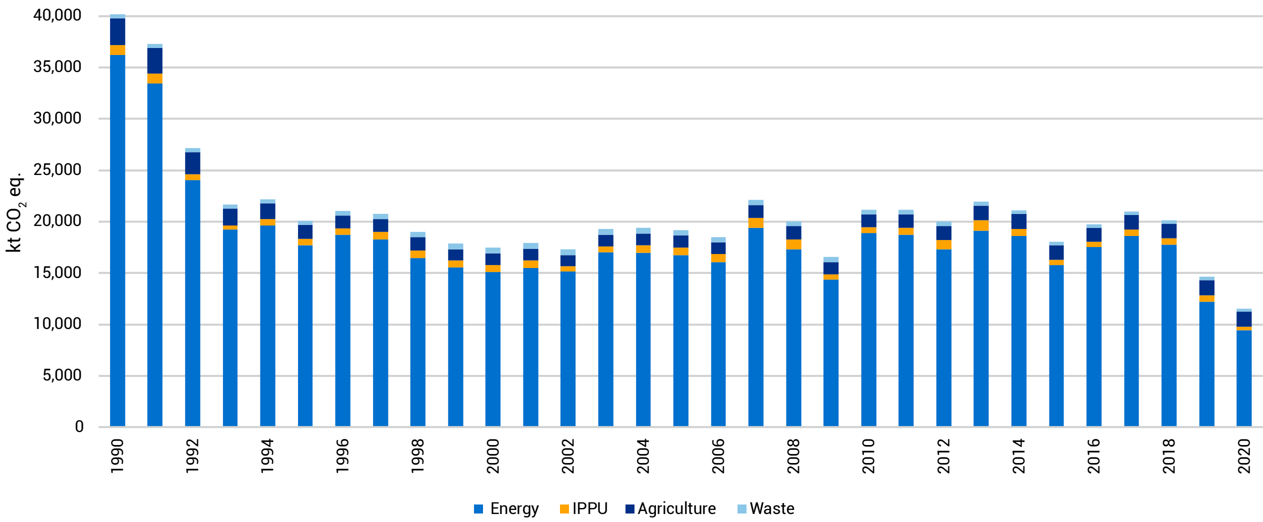

Figure 3.1. Estonia's GHG emissions by sector 1990–2020, excluding LULUCF, kt CO_2 eq.

[1] Indirect CO_2 emissions are calculated from NMVOCs reported under Industrial processes and product use (IPPU) 2.D.3 (CRF) Solvent use and road paving with asphalt.

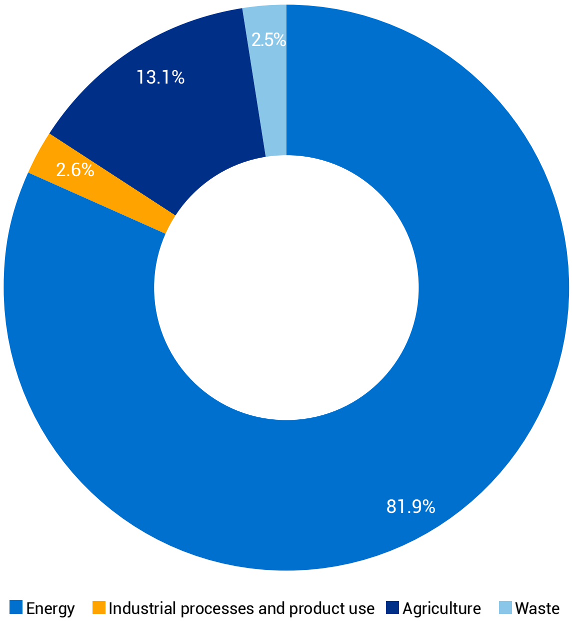

Figure 3.2. GHG emissions by sector in 2020, %

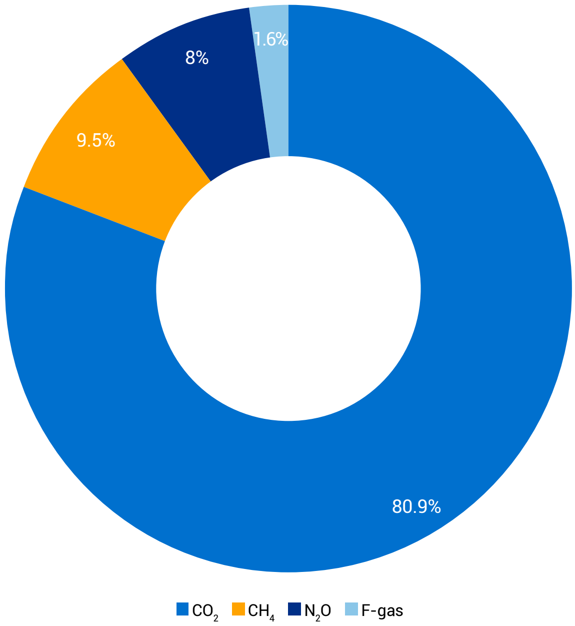

Figure 3.3. Greenhouse gas emissions by gas in 2020, %

The total GHG emissions reported from F-gases (HFCs, PFCs, and SF_6) were 187.66 kt CO_2 eq. in 2020.

The total emissions of HFCs have increased rapidly since 1993, especially HFC emissions from refrigeration and air-conditioning equipment, which is a major source of halocarbons in Estonia. Until 2016, emissions from the Refrigeration and air conditioning subsector grew rapidly because of the substitution of ozone-depleting substances with HFCs. In 2017–2020, the emission-curbing effects of EU Regulation No. 517/2014 (restrictions on placing on the market certain commercial refrigeration systems with high-GWP HFCs (GWP 2,500 and more) and the ban on refilling existing equipment with virgin HFCs with a GWP of 2,500 and more) on this subsector can be seen. 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. The second largest source is Foam blowing agents, which showed a relatively steady increase of emissions until 2007.

Table 3.2. GHG emissions by gas in 1990, 1995, 2000, 2005, 2010 and 2018–2020, kt CO_2 eq.

	1990	1995	2000	2005	2010	2018	2019	2020
CO_2 emissions incl. indirect CO_2 (excl. net CO_2 from LULUCF)	36,922.21	18,066.41	15,500.38	17,109.78	19,002.52	17,935.07	12,380.19	9,343.01
Indirect CO_2 (from NMVOCs reported under IPPU 2.D.3 Solvent use and road paving with asphalt)	18.45	17.39	16.52	18.50	11.32	18.41	20.76	24.74
CH_4 emissions (excl. CH_4 from LULUCF)	1,912.52	1,284.38	1,259.91	1,239.50	1,253.87	1,093.14	1,098.30	1,095.46
N_2O emissions (excl. N_2O from LULUCF)	1,340.45	698.21	637.47	672.16	746.47	862.50	928.46	929.68
HFCs*	NO	28.45	79.15	134.96	176.11	232.36	226.33	184.74
PFCs*	NO	NO	NO	NO, NA	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	NO	3.07	2.61	1.08	1.83	2.67	2.84	2.92
NF_3	NO	NO	NO	NO	NO	NO	NO	NO
Total (excl. LULUCF)	40,175.17	20,080.53	17,479.52	19,157.48	21,180.81	20,125.74	14,636.12	11,555.81
Total (incl. LULUCF)	37,015.28	17,281.14	13,274.54	17,881.75	16,345.42	18,687.44	14,301.56	12,853.08

* NO – not occured / NA - not applicable

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 the much lower GWP of HFC-152a, the emissions decreased suddenly in the corresponding years.

3.2.2. Greenhouse gas emissions by sector

Energy

Estonia's emissions from the Energy sector are divided into the following categories (**Figure 3.4**):

- Fuel combustion, including Energy industries;
- Manufacturing industries and construction;
- Transport;
- Other sectors;
- Fugitive emissions.

Until 2020 submissions fuel consumption and emissions from military vehicles were included separately in the sector 1.A.5 Other, but from 2021 submission fuel consumption and emissions from military vehicles are included in category 1.A.4.a Commercial/institutional, because of the Joint Questionnaire dataset.

The Energy sector is the major source of GHG emissions in Estonia, contributing 81.9% of all emissions in 2020, totalling 9,461.45 kt CO_2 eq. 99.8% of emissions originate from fuel combustion, and only 0.2% from fugitive emissions. Energy-related CO_2 emissions varied mainly in relation to the economic trend, the energy supply structure, and weather conditions. The decrease of GHG emissions between 1990 and 1993 is related to major structural changes in the economy after Estonia regained its independence from the Soviet Union. A small increase 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 and 2007 is related to the overall economic upturn and the decrease of emissions between 2007 and 2009 to the overall economic downfall. Since 2009, the GHG emissions are strongly related to exported electricity, which is mainly produced from oil shale. The decrease in GHG emissions in 2019 and 2020 compared to the previous years was mainly in the energy industries, because of the EU ETS emission allowance price increase and lower electricity prices.

Emissions from the Energy sector have decreased by 73.9% since 1990 (incl. Energy industries – 79.3%; Manufacturing industries and construction – 85.3%; Transport – 10.0%; Other sectors – 55.3%; and Fugitive emissions – 70.9%). There has been a drastic decrease in the consumption of fuels and energy in energy industries (closing 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 after 1991, when Estonia regained independence. The overall progression of GHG emissions in the Energy sector is presented in **Figure 3.4**. Since 2009, the GHG emissions are strongly related to exported electricity, which is mainly produced from oil shale. The GHG emissions from the energy sector in 2019 and 2020 have decreased significantly due to a significant reduction in oil shale electricity production, the main reason for which is the high emission allowance price of the EU ETS.

Industrial processes and product use

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);

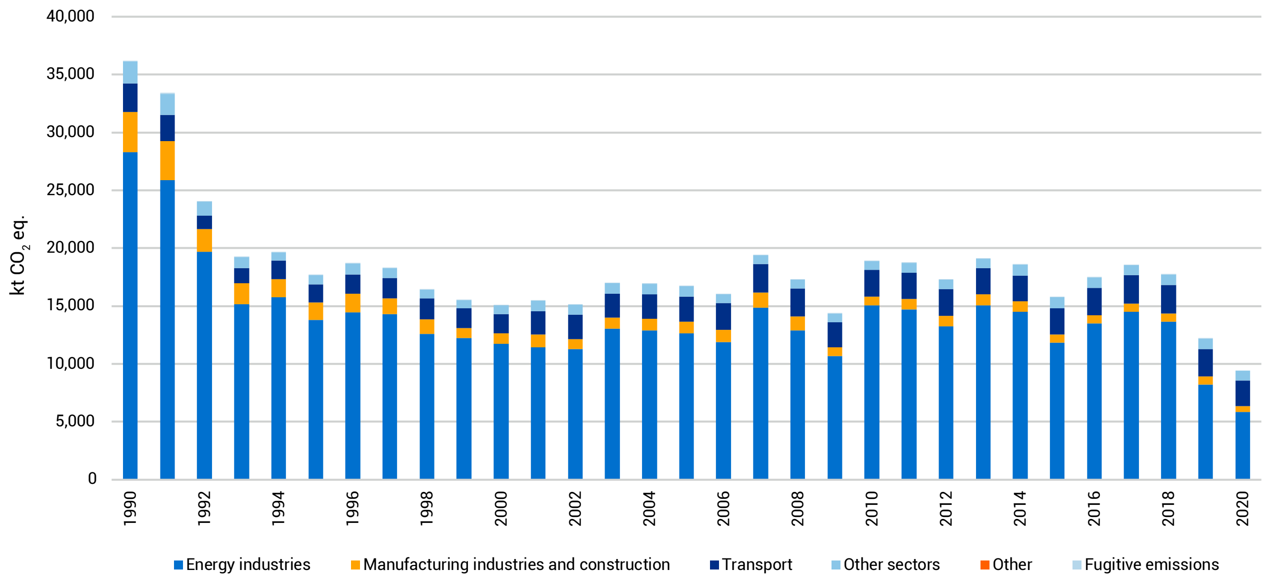

Figure 3.4. Trend in emissions from the Energy sector 1990–2020, kt CO_2 eq.

- Non-energy products from fuels and solvent use (CO_2 emissions from lubricant and paraffin wax use and urea-based catalysts for motor vehicles, as well as NMVOC emissions from solvent use and road paving with asphalt) and indirect CO_2 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 (SF_6 emissions from electrical equipment, SF_6 and PFC emissions from other product use, and N_2O emissions from product use).

In addition, NOx, CO, and SO_2 emissions from Pulp and paper are reported under the category 2.H (Other production). The non-fuel-based CO_2 emissions from the pulp and paper industry are estimated to be negligible in Estonia. All N_2O emissions from the pulp and paper and food industry are reported as fuel-based emissions under the Energy sector.

In 2020, the Industrial processes and product use sector contributed 2.6% of all GHG emissions in Estonia, totalling 295.47 kt CO_2 eq. with indirect CO_2 and 270.73 kt CO_2 eq. without indirect CO_2. The most significant emission sources in the IPPU sector were HFC emissions from refrigeration and air conditioning, emitting 60.1% of the total emissions from the sector (with indirect CO_2). Compared to 2019, the emissions from Industrial processes and product use (with indirect CO_2) decreased by 52.5% in 2020. This is because of the closure of clinker production in the cement plant in March 2020 and decreased F-gas emissions. The F-gas emissions decreased because of the bans imposed by Regulation (EU) No. 517/2014 that were implemented in 2020.

Industrial CO_2 emissions have fluctuated strongly during years 1990–2020. 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 halocarbons 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. CO_2 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 in cement production. A decrease in the output of the mineral (and cement) industry was the main driver in the overall decrease of industrial CO_2 emissions from 2014 to 2016. Emissions of F-gases have been halted since 2017 because of the effect of restrictions of the Regulation (EU) No. 517/2014. Emissions of HFCs halted in 2017–2018 and significantly decreased in 2019–2020 because of the bans and quota restrictions of EU Regulation No. 517/2014 (the strictest ones started from 2020).

The share of emissions by category and overall progression of GHG emissions in the Industrial processes and product use sector in CO_2 eq. is presented in **Figure 3.5**.

Agriculture

Estonia's emissions from the Agriculture sector are divided into the following categories:

- Enteric fermentation of domestic livestock;
- N_2O and CH_4 emissions from Manure management systems;
- direct and indirect N_2O emissions from Agricultural soils;
- CO_2 emissions from Liming;
- Urea application to agricultural soils.

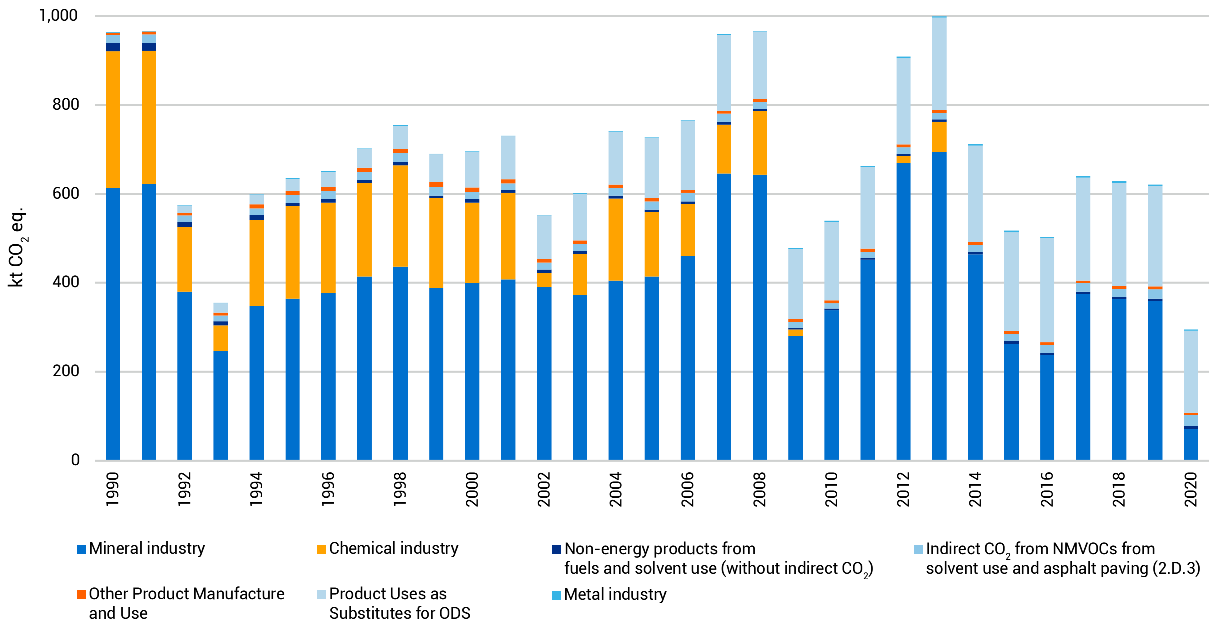

Figure 3.5. Trend in emissions from Industrial processes and product use sector 1990–2020, kt CO_2 eq.

Direct N_2O emissions include emissions from synthetic fertilisers, emissions from animal manure, compost, and sludge applied to agricultural soil, emissions from crop residues and cultivation of organic soils, mineralisation associated with the loss or gain of soil organic matter, and emissions from urine and dung deposited by grazing animals. Indirect N_2O emissions include emissions due to atmospheric deposition and nitrogen leaching and run-off from manure management. The trend in emissions in CO_2 eq. by category is presented in **Figure 3.6**. The positive impact on agricultural production manifested itself in the years preceding the accession to the EU and is reflected in the turnover of a downward GHG emissions trend that began in the 1990s. Emissions from Agricultural soils and Enteric fermentation of livestock were the major contributors to the total emissions recorded in the sector – 49% and 35%, respectively.

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 produce. Western markets remained closed to Estonian agricultural products, mostly for two reasons – high customs barriers and non-compliance of our products with the requirements and practices abroad. Producer prices in Estonia fell to a level up to 50% lower than the prices on world markets and became insufficient to cover production costs (Laansalu, 2002). This led to a rapid decline of agricultural production in Estonia and explains why the GHG emissions from the Agricultural sector have declined by 42.5% by 2020 compared with the base year (1990). In 2002–2008, the most important driving force for Estonian agriculture was the accession to the EU and implementation of the accompanying common agricultural policy of the EU, the significant effect of which appeared a few years before joining (Estonian University of Life Sciences, 2011). The dairy industry has suffered a decline in production due to economic sanctions imposed by Russia on the EU starting from August 2014. Consequently, the number of dairy cattle in 2020 fell by 11.8% in comparison with 2014. The number of swine has fallen by 11.5% in 2020 compared to 2014 in Estonia because of the outbreak of African swine fever in the region in 2015. However, compared to 2018, the number of swine increased by 8.3% by 2020. The increase in the number of livestock is caused by the improved economic situation. In addition, high demand for pork in both inland and foreign markets due to pork being the most popular meat in Estonia has helped, to some extent, to recover the number of swine after the low point that started after the African swine fever in 2015.

The total GHG emissions reported in the Agricultural sector for Estonia were 1,508.38 kt CO_2 eq. in 2020. The sector contributed about 13% to the total CO_2 eq. emissions in Estonia. In 2020, the emissions from Enteric fermentation decreased by 0.6% compared to the previous year, while the emissions from Manure management increased by 4.2%.

Land use, land-use change and forestry

The LULUCF sector, being 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;
- Harvested wood products (HWP).

Each category, except HWP, is further divided into 'land remaining' and 'land converted to' subcategories. The share of LULUCF sector emissions and removals by each land use

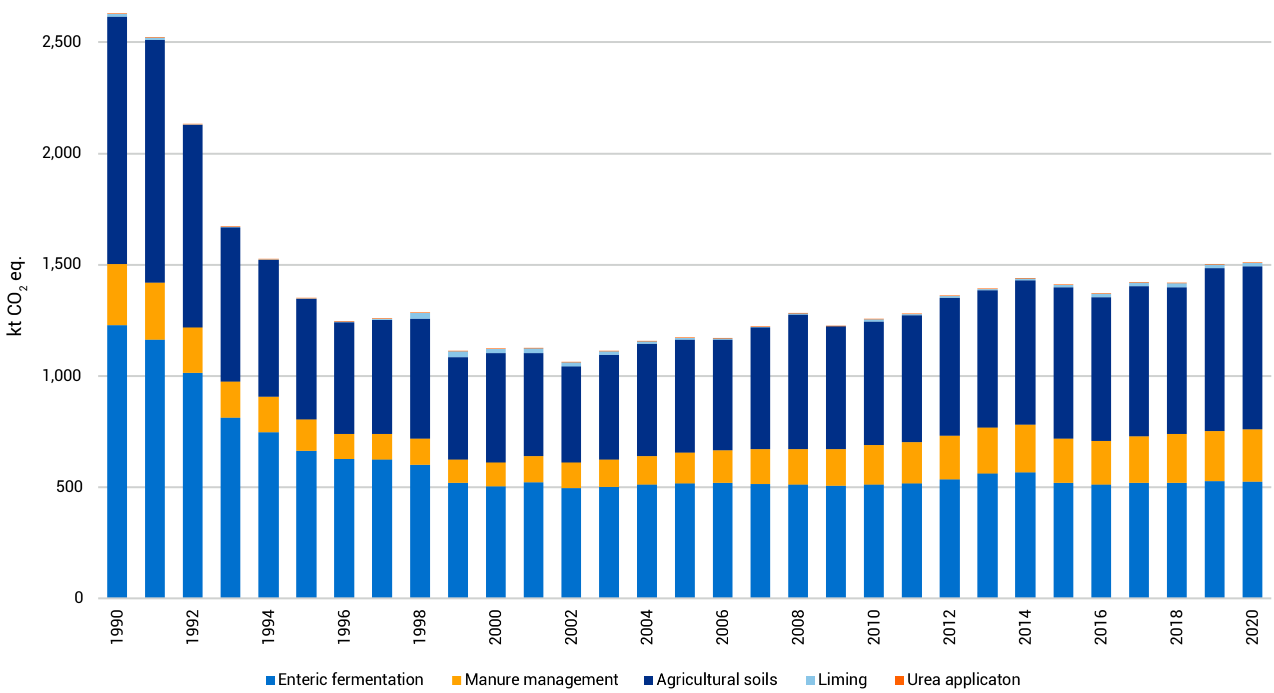

Figure 3.6. GHG emissions from Agriculture sector 1990–2020, kt CO_2 eq.

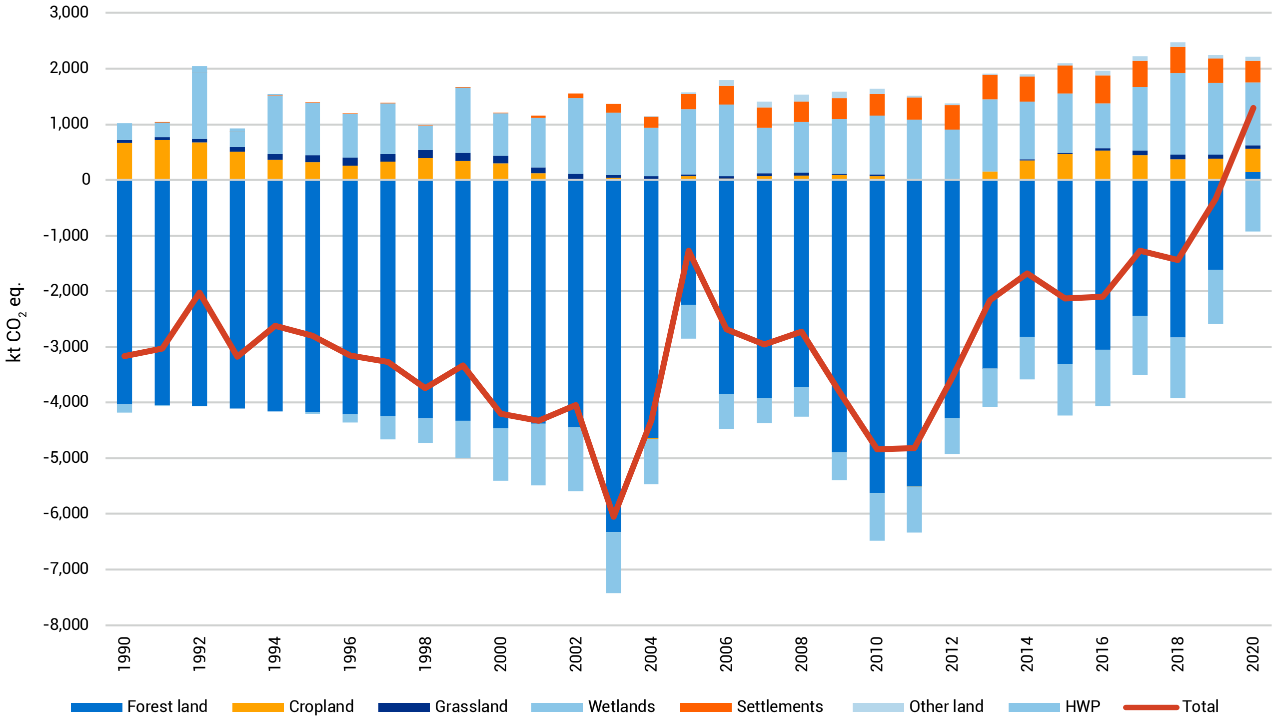

Figure 3.7. GHG emissions and removals from the Land use, land-use change and forestry sector 1990–2020, kt CO_2 eq.

category during the time period 1990–2020 is presented in Figure 3.7. In 2020, net emissions from the LULUCF sector equalled 1,297.27 kt CO_2 eq. Compared to the base year (1990), uptake of CO_2 in the LULUCF sector has decreased by 141.1%.

Due to the high proportion of mature and near-mature forest stands and an increasing proportion of forest area belonging to the first development classes (treeless area, area under regeneration, and young stands), the capacity of carbon sequestration in biomass has decreased in recent years. In addition, the annual increase in conversion from other land categories to Forest land (afforestation and reforestation) has been slowing – particularly in Cropland and Grassland conversion to Forest land, and the total forest area has stabilised. The annual estimate of average growing stock per hectare is also influenced by variability caused by the sampling design of the National Forest Inventory (NFI), which is based on the systematic random sampling.

In the period 1990–2002, the area of Forest land remaining forest land category decreased due to the 20-year transition period (the total forest land area increased). However, carbon sequestration increased due to the rapid increase in forest growing stock. In 2004–2008, carbon sequestration decreased as the felling volume increased strongly in the previous few years. Felling volumes in 2004–2011 were lower compared to the previous period. The LULUCF sector sink is mainly affected by the age structure of managed forests, management practices in forestry and agriculture, usage of peat soils and horticultural peat, and C sequestration in HWP.

Waste

Estonia's GHG emissions from Waste sector covers:

- Solid waste disposal sites including solid municipal and industrial waste;
- CH_4 and N_2O emissions from waste incineration without energy recovery and open burning of waste;
- Biological treatment of solid waste;
- Wastewater treatment and discharge from domestic and industrial sector.

CO_2 emissions are reported from non-biogenic incineration without energy recovery. The share of emissions by each category is presented in Figure 3.8. CO_2 eq. emissions from the Waste sector were 290.51 kt in 2020, i.e. 2.5% of total GHG emissions in 2020. Total CO_2 eq. emissions from the Waste sector in 2020 decreased by 3.9% compared to 2019. In recent years, total emissions have followed a declining trend. Compared to the base year of 1990, the amount of CO_2 eq. emissions in 2020 was 21.5% smaller. Compared to the base year, CO_2 eq. emissions from Solid waste disposal (SWD) have decreased by 18.6%, CO_2 eq. emissions from Waste incineration and Open burning of waste by 78.9%, and from Wastewater treatment and discharge by 44.1%. On the other hand, CO_2 eq. emissions from Biological treatment of solid waste have, compared to the base year of 1990, increased by 2,586.3%.

The lowest CO_2 eq. emissions occurred in 2020, which was mainly connected to the decreasing amount of waste deposited in landfills. Low CO_2 eq. emissions in 1995 are related to decreasing CH_4 emissions from paper and sludge disposal. The highest CO_2 equivalent emission in 2000–2001 is related to significant increase in emissions mainly from Solid waste disposal. The increasing trend of emission until 2001 is linked to the high amount of deposited organics and food, which were deposited due to a low rate of waste sorting. The decrease of CO_2 eq. in the waste sector after 2004 is connected with the increasing amount of methane recovery from landfills. The decrease of CO_2 emissions starting from 2009 is connected with the financial crisis during 2007–2008. The financial crisis did not affect the waste sector im-

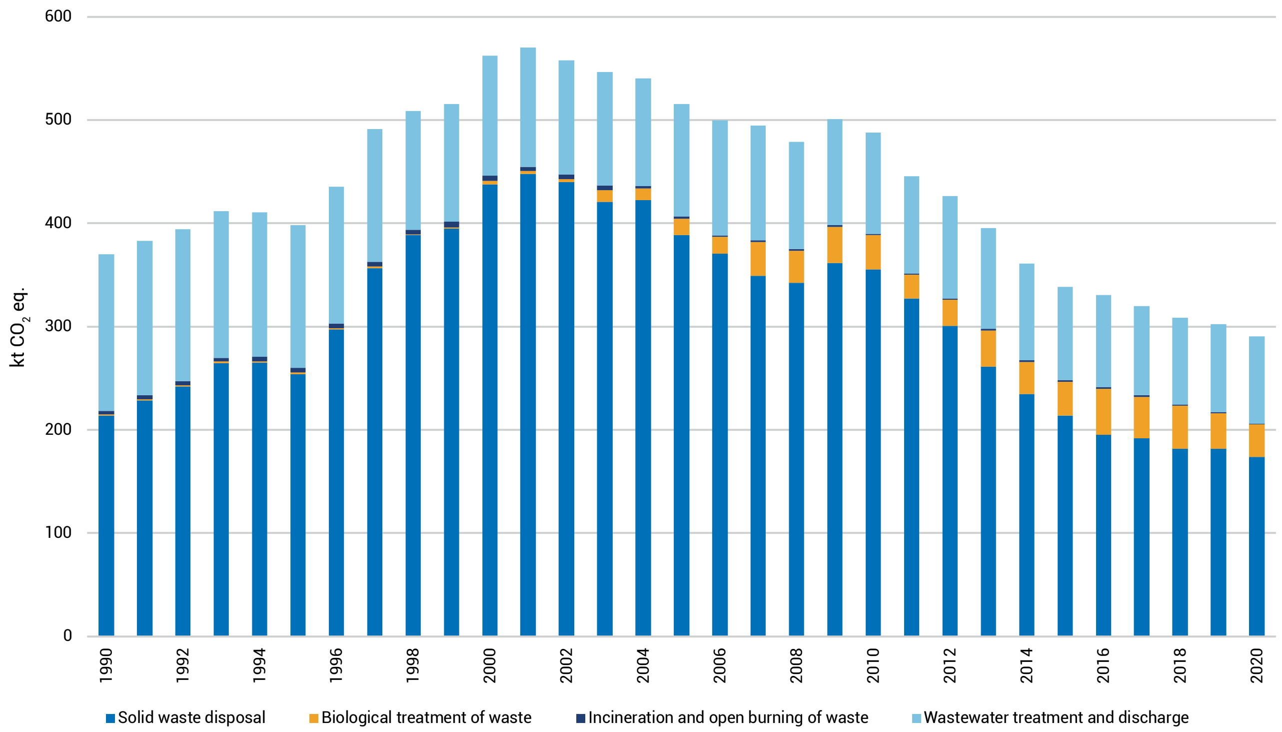

Figure 3.8. GHG emissions from the Waste sector 1990–2020, kt CO_2 eq.

mediately, because companies had a prepared raw material reserve. The total CO_2 equivalent in 2011 has decreased significantly compared to the previous years, mainly because of the change in national currency, which uplifted the prices in the country and therefore lessened the consumption habits and waste generation. In addition, the opening of the Iru waste incineration plant in 2013 had a decreasing effect on the trend of the amount of deposited waste since 2010.

Reporting under paragraphs 3 and 4 of Article 3 of the Kyoto Protocol

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

Under paragraph 3 of Article 3 of the KP, Estonia reports emissions and removals from afforestation (A), reforestation (R) and deforestation (D). Under paragraph 4 of Article 3, Forest management (FM) is reported.

In 2020, Article 3.3 activities were a net source in Estonia. The total net emissions were estimated at 295.27 kt CO_2 eq. Uptake from Afforestation and reforestation activities, including non-CO_2 emissions from drained forest and emissions from wildfires, were estimated at –172.90 kt CO_2 eq. Net emissions from Deforestation were 468.17 kt CO_2 eq. Areas subject to A, R, and D were 56.70 kha and 34.11 kha, respectively, by the end of 2020. Forest management, under Article 3.4, was a net sink with total uptake of –22.98 kt CO_2 eq. (with HWP).

3.3. Greenhouse gas inventory system, under Article 5, paragraph 1 of the Kyoto Protocol

3.3.1. Institutional arrangements

Single national entity with overall responsibility for the Estonian greenhouse gas inventory is Ministry of the Environment (MoE). 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 the MoE. The inventory will continue to be produced in collaboration between the MoE, EERC and ESTEA as until now.

The contacts in the MoE are:

Ms Kristiina Joon
Inventory focal point
Advisor of the Climate Department
Tel. +372 626 3107
Fax +372 626 2801
kristiina.joon@envir.ee

The MoE is responsible for:
- entering into formal agreements with the inventory co-ordinator (EERC);
- 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 implementation of the QA/QC plan and final QA/QC of the inventory;
- sending the final inventory to the MoE and approving the inventory before the official submissions;
- reporting the greenhouse gas inventory to the EC and to the UNFCCC, including the National Inventory Report and CRF tables on behalf of MoE;
- 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, IPPU, Agriculture, and Waste sectors. The Forest Department of the Estonian Environment Agency is responsible for LULUCF and KP LULUCF estimates. Sectoral experts collect activity data, estimate emissions and/or removals, implement quality control (QC) procedures, and record the results, fill in sectoral data to the CRF Reporter, and prepare the sectoral parts of the NIR. These experts are also responsible for archiving activity data, estimates, and all other relevant information according to the archiving system.

The three core institutions – MoE, EERC, and ESTEA – work together to fulfil the requirements for the national system. The overview of the allocation of responsibilities is shown in **Figure 3.9**.

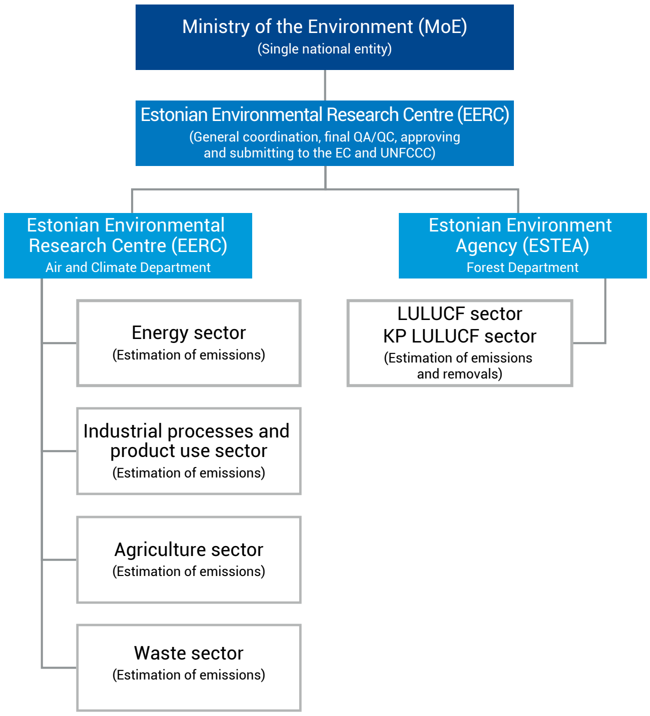

Figure 3.9. Overview of institutional arrangements for the compilation of Estonia's 2020 GHG inventory

Legal arrangements

In accordance with § 143 of the Atmospheric Air Protection Act (RT I, 05.07.2016, 1), activities to reduce climate change shall be arranged by the MoE. The basis of the requirements for the restriction of the limit values of GHG emissions are provided by the UNFCCC, the KP, and the European Union legislation.

In accordance with § 6 of the Statutes of the MoE (RT I 2009, 63, 412), the MoE is responsible for climate change-related tasks and pursuant to § 23 section 8, the Climate Department task is to organise, develop, and implement climate change mitigation and adaptation policies. In accordance with the Statutes of the Climate Department of the MoE, the department is responsible for organising and coordinating GHG emission reporting activities under the UNFCCC, the KP, and the EU legislation. In the beginning of 2018 with an aim to improve/optimize the inventory compiling process in Estonia, MoE 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 organization established for general interest, all of the shares in which are held by the Republic of Estonia. EERC belongs to the government area of the Ministry of the Environment. Any changes to and the approval of the statutes of the EERC are the responsibility of the Ministry of Environment.

The Estonian Environment Agency (ESTEA), institution that is responsible for the LULUCF estimates, is a state authority administered by MoE, which was formed as a result of the merger of the Estonian Meteorological and Hydrological Institute (EMHI) and the Estonian Environment Information Centre (EEIC) in 2013. In accordance with §9 section 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.

3.3.2. Inventory process

The UNFCCC, the KP, and the EU greenhouse gas monitoring mechanism require Estonia to submit NIR and CRF tables annually. The annual submission contains emission estimates for the years between 1990 and the year before the previous year.

Estonia's national GHG inventory system is designed and operated according to the guidelines for national systems under article 5, paragraph 1 of the KP to ensure the transparency, consistency, comparability, completeness, and accuracy of inventories. Inventory activities include the planning, preparation, and management of inventories.

The EERC and the MoE have developed an inventory production plan that sets out the schedule for inventory preparation. The schedule, which is annually reviewed, forms part of Estonia's QA/QC plan and must be followed by all core institutions (MoE, EERC and ESTEA).

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

The methodologies, activity data collection, and emission factors are consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006 GL).

The inventory process for the next inventory cycle starts with an examination of previous years and an analysis of the available datasets to improve the inventory through new knowledge and the activity data developed. Activity data is mainly based on official statistics and data from companies and the National Forest Inventory. The emission factors are national values, values recommended in the IPCC GL, or values taken from other countries' GHG inventories.

Sectoral experts collect activity data, estimate emissions and/or removals, implement QC procedures and record the results, fill in sectoral data to the CRF Reporter, and prepare the sectoral parts of the NIR. These experts are also responsible for archiving activity data, estimates, and all other relevant information according to the archiving system. The EERC compiles the NIR according to the parts submitted by the inventory experts, evaluates the overall uncertainty of the inventory totals, and performs key category analysis.

The uncertainty estimate of the 2020 inventory has been done according to the Tier 1 method presented by the IPCC 2006 GL. The Tier 1 method combines the uncertainty in activity rates and emission factors, for each source category and GHG, and then aggregates these uncertainties, for all source categories and GHGs, to obtain the total uncertainty for the inventory. In many cases, uncertainty values have been assigned based on default uncertainty estimates according to the IPCC guidelines or expert judgement, because there is a lack of information. For each source, uncertainties are quantified for emission factors and activity data.

Key categories are those of emissions/removals, which have a significant influence on the total inventory in terms of the absolute level of emissions or trends in emissions (or both). Estonia uses the Tier 2 method to identify key categories, and emission categories are sorted according to their contribution to emission levels or trends. The key categories are those that together represent 90% of the inventory level or trend.

The results of key category analysis are important because they guide decisions on methodological choice. The goal is to screen the long list of contributions by category and gas and find those that are most important in terms of the emissions level or trend. The list of key categories forms the basis of discussions with the sectoral experts on the quality of the estimates and possible need for improvement.

Recalculations are made if errors, overlaps, or inconsistencies in the time series are identified, when a new source or sink is considered, or if more accurate knowledge becomes available. The driving forces in applying recalculations to Estonia's GHG inventory are the implementation of the guidance given in IPCC 2006 GL and the recommendations from the UNFCCC inventory reviews. In order to ensure the consistency of the emission inventory, recalculations are carried out on the whole time series, as far as possible.

All institutions involved in compiling the GHG inventory keep 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.

Estonia has undertaken several projects to improve the quality of the country-specific emission factors and other parameters used in the GHG inventory (see Chapter 8).

3.3.3. Quality management

The starting point in accomplishing a high-quality GHG inventory is the 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. The next step is the development of the QA/QC plan and implementing the appropriate quality control measures (e.g. routine checks and documentation) focused on meeting the quality objectives set and fulfilling the requirements. In addition, quality assurance (QA) procedures are planned and implemented. In the improvement phase of the inventory, conclusions are made on the basis of the realised QA/QC process and its results.

The MoE as the national entity has overall responsibility for the GHG inventory in Estonia, incl. the responsibility for assuring that the appropriate QA/QC procedures are implemented annually. The EERC as the inventory coordinator is responsible for coordinating the implementation of the QA/QC plan.

Estonia's QA/QC plan consists of seven parts: (1) production plan; (2) annual meetings; (3) QA/QC checks; (4) QA results documentation form; (5) archiving structure; (6) response table to review process; and (7) list of planned activities and improvements.

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

QC procedures

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

EERC checks the QC checklists completed by EERC and ESTEA. If it disagrees with a report, the errors are discussed and changes are made, where necessary. In addition to the general inventory QC procedures, Estonia applied category-specific QC procedures on some source/sink categories in the 2020 submission, focusing on key categories and on those categories in which significant methodological changes and/or data revisions occurred.

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

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

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

QA procedures

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

Estonia's GHG inventory is checked annually by one or more independent experts. From the 2009 submission to the 2012 submission, all data collected by institutions involved in the inventory process was checked by an independent expert from the Tallinn University of Technology. In the 2013–2016 submission, the inventory was reviewed in parts by the EERC, Tallinn University of Technology (TalTech), University of Tartu (UT), Estonian University of Life Sciences (EMÜ), and other national experts. The 2020 submission was checked by experts from TalTech, EMÜ, and other national experts. The findings of the independent experts are looked through by experts (in collaboration with the EERC) and adjustments carried out as a result, if necessary.

UNFCCC reviews are part of QA. The reviews are performed by a team of experts from other countries. They examine the data and methods that Estonia is using and check the documentation, archiving system, and national system. In conclusion, they report on whether Estonia's overall performance is in accordance with current guidelines. The review report indicates the specific areas in which the inventory is in need of improvement.

The draft NIR is uploaded to the MoE website www.envir.ee, where all interested parties have the opportunity to comment on it. The inventory is also checked by different ministries and institutions.

For a more detailed description of the QA/QC system, please see Estonia's National Inventory Report.

3.4. National registry

Directive 2009/29/EC adopted in 2009, provides for the centralization of the EU ETS operations into a single European Union registry operated by the European Commission as well as for the inclusion of the aviation sector. At the same time, and with a view to increasing efficiency in the operations of their respective national registries, the EU Member States who are also Parties to the Kyoto Protocol (25) plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and decision 24/CP.8.

With a view to complying with the new requirements of Commission Regulation 389/2013 and Commission Regulation 1193/2011, in addition to implementing the platform shared by the consolidating Parties, the registry of EU has undergone a major re-development. The consolidated platform which implements the national registries in a consolidated manner (including the registry of EU) is called Consolidated System of EU registries (CSEUR) and was developed together with the new EU registry on the basis the following modalities:

- Each Party retains its organization designated as its registry administrator to maintain the national registry of that Party and remains responsible for all the obligations of Parties that are to be fulfilled through registries;
- Each Kyoto unit issued by the Parties in such a consolidated system is issued by one of the constituent Parties and continues to carry the Party of origin identifier in its unique serial number;
- Each Party retains its own set of national accounts as required by paragraph 21 of the Annex to Decision 15/CMP.1. Each account within a national registry keeps a unique account number comprising the identifier of the Party and a unique number within the Party where the account is maintained;
- Kyoto transactions continue to be forwarded to and checked by the UNFCCC Independent Transaction Log (ITL), which remains responsible for verifying the accuracy and validity of those transactions;
- The transaction log and registries continue to reconcile their data with each other in order to ensure data consistency and facilitate the automated checks of the ITL;
- The requirements of paragraphs 44–48 of the Annex to Decision 13/CMP.1 concerning making non-confidential information accessible to the public is fulfilled by each Party through a publicly available web page hosted by the Union registry;
- All registries reside on a consolidated IT platform sharing the same infrastructure technologies. The chosen architecture implements modalities to ensure that the consolidated national registries are uniquely identifiable, protected and distinguishable from each other, notably:
    a. With regards to the data exchange, each national registry connects to the ITL directly and establishes a distinct and secure communication link through a consolidated communication channel (VPN tunnel);
    b. The ITL remains responsible for authenticating the national registries and takes the full and final record of all transactions involving Kyoto units and other administrative processes such that those actions cannot be disputed or repudiated;
    c. With regards to the data storage, the consolidated platform continues to guarantee that data is kept confidential and protected against unauthorized manipulation;
    d. The data storage architecture also ensures that the data pertaining to a national registry are distinguishable and uniquely identifiable from the data pertaining to other consolidated national registries;
    e. In addition, each consolidated national registry keeps a distinct user access entry point (URL) and a distinct set of authorisation and configuration rules.

Following the successful implementation of the CSEUR platform, the 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20 June 2012. During the go-live process, all relevant transaction and holdings data were migrated to the CSEUR platform and the individual connections to and from the ITL were re-established for each Party.

Table 3.3. Changes to the Union Registry compared to NC7.

Information on registry administrator	Change of contact occurred during the reporting period. In 2017, the registry administrator was Piret Väinsalu. As of January 2018, registry administrator was changed from Piret Väinsalu to Annika Konovalov. National administrator is: Ms Annika Konovalov khgregister@keskkonnaamet.ee tel. +372 5694 4935
Cooperation with other countries concerning operation of the registry	There was a change in the cooperation arrangement during the reported period as the United Kingdom of Great Britain and Northern Ireland no longer operate their registry in a consolidated manner within the Consolidated System of EU registries, CSEUR.

Database structure and capacity of national registry	There has been 9 new EUCR releases during the reporting period, version 13.5.2 is the latest. New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality and other minor changes in the structure of the database were made. These changes were limited and only affected EU ETS functionality. No change was required to the application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.
Conformity with DES	The changes that have occurred in different versions are listed in Annex B. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production. Annex H testing was completed in January 2017 and the test report was attached with SIAR submitted in 2017. No other change in the registry's conformance to the technical standards occurred for the reported period.
Procedures employed to minimise discrepancies in the issuance, transfer, acquisition, cancellation, and retirement of registry units	No change of discrepancies procedures occurred during the reported period.
Overview of security measures to prevent unauthorised manipulations and operator errors	During the reported period the mandatory use of hard tokens for authentication and signature was introduced for registry administrators and the use of soft tokens for authentication and signature was introduced for the registry end users.
Information available to the public	No change to the list of publicly available information occurred during the reported period.
Internet address for the national registry	The registry internet address changed during the reported period. The new URL is: https://unionregistry.ec.europa.eu/euregistry/EE/index.xhtml
Measures taken to safeguard, maintain and, recover data to ensure the integrity of data storage and recovery of registry services in the event of a disaster	No change of data integrity measures occurred during the reported period.
Results of any test procedures that might be available or developed with the aim of testing the performance, procedures and security measures of national registry	Both regression testing and tests on the new functionality were successfully carried out before each version was released to production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission.

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4

Policies and Measures

Key developments:

- The Parliament of Estonia has adopted the strategy for moving towards a long-term emission reduction target, which is set to reduce the emission of greenhouse gases by 80% by 2050 in comparison with the emission levels of 1990. A proposal to amend the long-term target to the 2050 climate neutrality goal set in Estonia's long term strategy Estonia 2035 has been sent to the Parliament.
- The Energy sector is the largest producer of GHG emissions in Estonia and therefore the strategies regulating the sector are under closer attention.
- According to strategy Estonia 2035, the target level of the share of renewable energy in the total final energy consumption set in the strategy is >55%.
- In accordance with Directive 2018/2001, Estonia must ensure that the share of energy from renewable sources amounts to 25% of the gross final consumption of energy by 2020. The share of renewable resources in final energy consumption was already reached in 2015 (29.0%) and reached 30.1% in 2020. Therefore, Estonia has reached its 2020 target.

4.1. Introduction

This chapter describes policies and measures implemented or planned to be implemented in Estonia in order to achieve the emission reduction commitments agreed on in the national and international level.

4.2. Climate policymaking process

4.2.1. Domestic programmes and legislative arrangements

The strategy documents and action plans are generally available on the websites of the responsible ministries, which are also liable for the implementation procedures. During their compilation, interested parties are able to provide input to the process.

The monitoring and regular evaluation of policies and measures (PaMs) adopted is usually performed by the institution that is implementing the relevant strategy document or action plan.

Legislation
Estonia is transposing the EU law (accessible in EUR-Lex, http://eur-lex.europa.eu) into several national legislative acts which can be accessed from a web-based outlet of Riigiteataja (https://www.riigiteataja.ee/) that also includes official announcements.

According to §5 of the **Constitution of the Republic of Estonia** (1992) the natural wealth and resources of Estonia must be used economically, and §53 prescribes that everyone has a duty to preserve the human and natural environment and the procedure for compensation shall be provided by law. It is important to emphasise that §123 of the Constitution stipulates that if the laws or other legislation of Estonia are in conflict with international treaties ratified by the Parliament, the provisions of the international treaty shall prevail.

According to the **Public Information Act** (2001) holders of information are required to grant access to information in their possession pursuant to the procedure provided by law. Holders of information are also required to clearly explain the procedure for and the conditions and methods of access to information to persons making requests for information. Also, the Constitution of the Republic of Estonia (1992) stipulates that everyone has the right to address informational letters and petitions to government agencies, local authorities, and their officials.

The Sustainable Development Act (1995), last amended on 1 January 2017, prescribes the principles of sustainable development, thus serving as a basis for all environment-related legislation and relevant national programmes. Therefore, the legal acts regulating the energy, industrial and transport sectors (i.e. the sectors that are the largest emitters of GHGs) usually take into account major environmental issues.

The Atmospheric Air Protection Act (2017), provides for:

- the requirements set for affecting ambient air by chemical and physical pollutants;
- the measures for maintaining and improving the quality of ambient air;
- the requirements for protection of the ozone layer;
- the measures for the mitigation of climate changes and reduction of greenhouse gas emissions;
- the organisation of state supervision over compliance with the requirements provided for in this Act;
- the liability for failure to comply with the requirements provided for in this Act.

The Act stipulates that activities for a reduction in climate change must be organised by the MoE on the basis of the requirements for limitation of GHG emissions arising from the UNFCCC, KP, Paris Agreement and the EU legislation. The Act also provides that the possessors of pollution sources must take additional measures to reduce the emission levels of CO_2 and other GHGs.

The Environmental Monitoring Act (2017) establishes the organisation of national, local government and voluntary environmental monitoring, the completion of national environmental monitoring programme and its sub-programmes, the establishment, use, protection and liquidation of national environmental monitoring stations and areas, the procedure for the storage, use and dissemination of data obtained during the course of environmental monitoring, and the organisation of state supervision and the responsibility for failure to meet the requirements provided in the Act.

The Environmental Impact Assessment and Environmental Management System Act (2005) provides legal grounds and procedure for the assessment of likely environmental impact, organisation of the environmental management and audit scheme and legal grounds for awarding the eco-label in order to prevent environmental damage along with establishing liability for violation of the requirements of the Act.

The General Part of the Environmental Code Act (2017) aims to ensure the reduction of environmental nuisances to the maximum extent possible in order to protect the environment, human health, well-being, property and cultural heritage. It also stipulates the promotion of sustainable development in order to secure an environment that meets the human health and well-being needs of the present generation and future generations, incl. the prevention of damage to the environment and the remedying of damage caused to the environment.

The Environmental Liability Act (2007) is targeted at the more effective implementation of the 'polluter pays' principle and more efficient reaction to environmental damage. The act specifies the procedures for the prevention and rectification of environmental damage, which ensures the restoration of the environment by those who cause the damage.

General strategy documents and national GHG targets

On 12 May 2021 the Parliament adopted Estonia's long term strategy Estonia 2035. The Estonia 2035 strategy sets out five long-term strategic goals that are value-based goals which are the basis for making the country's strategic choices and to the implementation of which all Estonian strategic development documents contribute. They are also taken into account in the state budget strategy and in the preparation of the government's action programme. In order to reach the goals, it is necessary to take into account Estonia's development needs, global trends, the policy framework of the European Union, and the global objectives of sustainable development.

According to the strategy, by 2050, Estonia will be a competitive, climate-neutral country with a knowledge-based society and economy and a high-quality and species-rich living environment, willing and able to reduce the adverse effects of climate change and make the best use of its positive aspects. Coordinated development of the cultural, social, environmental and economic fields is a prerequisite for achieving the goals of sustainable development. In Estonia, knowledge-based decisions are made, with effective and innovative approaches being preferred when choosing solutions.

The Estonia 2035 action plan is updated annually, if necessary, by the government based on domestic events affecting the development of Estonia and changes in the foreign environment. The Estonia 2035 action plan is also the Estonian reform plan submitted within the framework of the European Semester for the coordination of economic policies. The current action plan was approved by the government on April 28, 2022. The action plan sets a target level for net emissions of greenhouse gases (incl. the LULUCF sector) of 8 million tons of CO_2 eq. by 2035. There is also a target level for net emissions of greenhouse gases in the Transport sector of 1700 kt CO_2 eq.

The Parliament of Estonia has adopted (5 April 2017) the **General Principles of Climate Policy until 2050 (GPCP 2050)** (MoE, 2016) for moving towards a long-term emission reduction target which is set to reduce the emission of greenhouse gases by around 70% by 2030 and by 80% by 2050 in comparison with the emission levels of 1990.

A proposal to amend the long-term target of Estonia to reduce the emission of greenhouse gases by 2050 by 80% set in the GPCP 2050 according to the 2050 climate neutrality goal set in Estonia's long-term strategy Estonia 2035 has been sent to the Parliament in March 2022.

The GPCP 2050 is a vision document that sets a long-term GHG emissions reduction target and policy guidelines for adapting to the impact of climate change or ensuring the preparedness and resilience to react to the impact of climate change.

Principles and guidelines in the document have to be taken into account when renewing and implementing the cross-sectoral and sectoral strategies and national development plans. Estonia will be transformed into an attractive environment primarily intended for the development of innovative technologies, products and services reducing the emission of GHGs. In addition, the export and global implementation of such technologies, products and services shall be facilitated for the resolution of global problems. The general sectoral policy guidelines and principles of GPCP 2050 include:

- Efficient interaction of the system as a whole when planning energy consumption centres and new production capacities.
- Facilitating the implementation of technologies with a low emission factor of CO_2 and the efficient use of resources in manufacturing processes.
- Considering the economy and energy efficiency of the system as a whole when renovating the existing building stock and planning and constructing new buildings.
- Considering the economy and energy efficiency when planning, building, managing and reconstructing grids within energy systems with the aim of achieving maximum energy and resource efficiency.
- Moving towards enhancing energetic value and the production of products with higher additional value to minimise GHG emissions in the oil shale treatment process in a way that does not entail an increase in other negative environmental impacts.
- Directing major participants in the energy and industry sectors towards a successful and cost-efficient reduction of GHG emissions while continuing the use of market-based mechanisms.
- Ensuring energy security and security of supply with a gradual wider exploitation of domestic renewable energy sources in all sectors of final consumption with a view to increasing the welfare of the society.
- Facilitating a well-functioning transportation system and reducing forced traffic through the integration of the planning of settlements and transportation and the design and implementation of mobility plans.
- Influencing the purchase of economical vehicles and sustainable alternative fuels through investments and tax policies of the public sector.
- Prioritising the development of public transportation, non-motorised traffic and energy-efficient carriage of goods.
- Increasing and maintaining the soil's carbon stock incl. developing and maintaining significant carbon stock of land areas.
- Encouraging the efficient and ecological use of agricultural land while avoiding the falling out of the agricultural use of such land.
- Enhancing the use of plant nutrients and replacement of mineral fertilisers with organic fertilisers and eco-friendly soil conditioners.
- Enhancing the production of bioenergy and using it in energy-intensive manufacturing processes.
- Increasing the productivity of agriculture, with a focus on eco-friendlier manure management for limiting ammonia emissions.
- Increasing forest increment and the ability to sequestrate carbon through the timely regeneration of forests.
- Promoting the use of wooden products and increasing carbon storage in wooden products and buildings will help replace non-renewable natural resources and develop domestic wood production.
- Promoting the preservation of the existing forest area and increasing carbon sequestration and emission reduction in other land-use categories.
- Preserving and increasing carbon stocks in wetlands. Avoiding further wetland drainage and already drained wetlands will be rewetted if possible to avoid further degradation.
- Preferring the development of research studies in the Land use and forestry sector that will help to increase carbon sequestration and to find alternative uses for wood.
- Continuing the reduction of waste generation and making the separate collection of waste more efficient.
- Facilitating research, development and innovation that will help to increase the development of efficient energy technologies, renewable energy production technologies, sustainable transportation and mobility, sustainable agriculture, carbon sequestration in forestry and finding alternative uses for timber will be preferred.

The Action Plan for 2021–2023 of the Government (2021), has set the following goals:

- the reuse amount of the total mass of municipal solid waste (MSW) is 48%;
- felling of timber does not exceed the yearly regrowth of wood;
- the share of renewables in final energy consumption is 27% (17% in final consumption of electricity and 53% in heat generation in district heating systems).

The Climate Change Adaptation Development Plan until 2030 (adopted by the Government on 2 March 2017) was prepared in cooperation between the MoE, EERC and other institutions with support from the European Economic Association Financial Mechanism. The main objective of the Development Plan is to increase the readiness and capacity of the state, the regional, and the local level to adapt to the effects of climate change. The Development Plan is further described under Chapter 6 – Climate change impacts, vulnerability assessment and adaptation measures.

The Ministry of the Environment started the preparation of the strategic **Environmental Development Plan 2030** (KEVAD) (MoE, 2022a). The aim is to integrate various subfields of the environment into one development document, which includes information on the current situation and trends, analysis of the main problems and most effective policy instruments and the goals and metrics. KEVAD is covering the circular economy; climate, ambient air and radiation; sea and water environment; biodiversity (and forestry management); environmental awareness and spatial data. The approval of the development plan is planned for February 2023.

In 2021 a framework for estimating the ex-ante and ex-post mitigation impacts of measures to reduce greenhouse gas emissions was established, the so-called MHR. The main goal of the MHR is to ensure a unified approach in designing and assessing the expected (ex-ante) and realised (ex-post) impact of planned and existing climate measures, and the applicability of these impact assessments in international GHG reporting. With the support of the MHR, implementing agencies (relevant policy-making ministries) and their implementing units should be able to independently assess the climate impact of the measures developed in their area of responsibility, regardless of the funding sources of the measures. Integrating the MHR in the wider climate measure design system is currently under way. (MoE, 2021)

4.3. International agreements and conventions, EU legislation

Since regaining its independence in 1991, Estonia has entered into a number of bilateral or trilateral environmental agreements and has become a party to many environmental conventions and protocols. The conventions to which Estonia has acceded include New York (1992), Arhus (1998), Espoo (1991), Helsinki (1992), Geneva (1979), Rio de Janeiro (1992) and Vienna (1985).

The United Nations Framework Convention on Climate Change (UNFCCC) was opened for signature on 9 May 1992, after an Intergovernmental Negotiating Committee produced the text of the Framework Convention as a report following its meeting in New York from 30 April to 9 May 1992. It entered into force on 21 March 1994. As of December 2015, UNFCCC has 197 parties. Estonia ratified the Convention on 27 July 1994. Estonia signed the Kyoto Protocol (KP) to the UNFCCC on 3 December 1998. The Protocol was ratified by the Estonian Parliament in September 2002.

Parties to the KP adopted an amendment to the KP by decision 1/CMP.8 in accordance with Articles 20 and 21 of the KP held in Doha, Qatar, in December 2012. As of 15 June 2022, 148 parties deposited their instrument of acceptance, therefore the threshold for entry into force of the Doha Amendment was achieved. The amendment entered into force on 31 December 2020. In accordance with Article 4, paragraph 2, of the KP, Estonia as a party to the European Union, and the Republic of Iceland, notified of fulfilling their commitments of not exceeding the average annual GHG emissions between 2013 and 2020 80% jointly. (UNFCCC, 2022)

The Paris Agreement

In December 2015, the 2015 United Nations Climate Change Conference was held in Paris, during which 195 countries agreed to a legally binding treaty to combat global climate change. The agreement sets forth a global long-term goal of holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. The countries agreed to enforce measures to reduce GHG emissions substantially. Estonia deposited the instruments of ratification on the 31 October 2016.

The Paris Agreement requires all parties to contribute to reaching the long-term goals through nationally determined contributions (NDC). The EU's NDC was set out in the conclusions by the European Council of October 2014 as an EU-wide binding target of at least 40% domestic reduction in GHG emissions by 2030 compared to 1990, also including the Land use, land-use change and forestry (LULUCF) sector that needs to contribute to meeting the GHG reduction target of the EU. A further target has been pledged to the Convention through the EU's Nationally Determined Contribution submitted under the Paris Agreement. In December 2020, the EU submitted its updated and enhanced NDC target to reduce emissions by at least 55% by 2030 from 1990 levels, and information to facilitate clarity, transparency and understanding (ICTU) of the NDC. The EU and its Member States, acting jointly, are committed to a binding target of a net domestic reduction of at least 55% in greenhouse gas emissions by 2030 compared to 1990.

Climate policy of the European Union

The EU has jointly committed to its UNFCCC target and implemented it internally through EU legislation in the 2020 EU Climate and Energy Package. In this package, the EU introduced a clear approach to achieving the 20% reduction in total GHG emissions from 1990 levels, by dividing the effort between the sectors covered by the EU Emissions Trading System (EU ETS) and the sectors under the Effort Sharing Decision (ESD). Binding national targets were set for Member States under the Effort Sharing Decision. The achievement of EU internal compliance under the 2020 Climate and Energy Package including the national targets under the ESD is not subject to the UNFCCC assessment of the EU's joint commitment under the Convention.

The EU 2020 Climate and Energy Package aims at a 21% reduction target compared to 2005 for emissions covered by the EU ETS, and a 10% reduction target compared to 2005 for non-ETS sectors. Whilst LULUCF is not counted towards the EU commitment or Member State targets, it does count towards the achievement of the Kyoto Protocol target (the LULUCF Decision, NO 529/2013, translates the Kyoto Protocol accounting rules for this sector into EU law).

Under the EU ETS Directive for the trading period of 2013–2020, a single ETS cap covers EU Member States and three participating non-EU countries (Norway, Iceland and Liechtenstein), there were no further individual caps by country. Allowances allocated in the EU ETS from 2013 to 2020 decreased by 1.74% annually, starting from the average level of allowances issued by Member States for the second trading period (2008–2012).

The vast majority of emissions within the EU, which fall outside the scope of the EU ETS, are addressed under the Effort Sharing Decision (ESD) (Decision 406/2009/EC). The ESD covers emissions from all sources outside the EU ETS, except for de minimis aviation emissions, international maritime emissions, and emissions and removals from Land use, land use change and forestry (LULUCF). It thus includes a diverse range of small-scale emitters in a wide range of sectors: transport (cars, lorries), buildings (in particular heating), services, small industrial installations, fugitive emissions from the energy sector, emissions of fluorinated gases from appliances and other sources, agriculture and waste.

The ESD establishes GHG emission limits for MS to be achieved by 2020 through binding annual targets between 2013 and 2020 (Annual Emission Allocations – AEA), in 2017 the allocations for the period of 2017 to 2020 have been revised, to take into account changes introduced by the implementation of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

According to the ESD, each MS must define and implement national policies and measures to limit the GHG emissions covered by the ESD. The inclusion of the ESD within the EU's 2020 climate and energy package ensures that the abatement potential from ESD sectors contributes to the delivery of the EU-wide target of reducing GHG emissions by 20% below 1990 levels by 2020. For Estonia, the GHG emission growth from ESD sectors has to be limited at least by 11% by the end of the period of 2013–2020 compared to 2005.

The European Commission has put forward a series of legislative proposals to make its policies fit for delivering the updated 2030 greenhouse gas emissions net reduction target of 55% below 1990 levels, as set out in the 2030 Climate Target Plan and written into the European Climate Law. Legislative proposals under the Fit for 55 package are currently in different stages of negotiations in the EU Council and with the EU Parliament.

The European Commission submitted a proposal on 14 July 2021, to review the collective and national targets set up in the Effort-sharing Regulation (ESR). In order to contribute to the -55% GHG emission reduction target, sectors covered by the ESR should achieve a collective reduction of 40 % in their emissions by 2030 compared to 2005. In November 2022 the Council and the European Parliament have reached a provisional political agreement on the proposal to amend the Effort sharing Regulation, where Estonia's new target by 2030 for reducing emissions in sectors covered under the ESR is -24% compared to 2005.

Beyond this period and beyond this goal, the first European Climate Law to enshrine the 2050 climate-neutrality target into law, entered into force on 29 July 2021. The EU submitted its long-term strategy to the United Nations Framework Convention on Climate Change (UNFCCC) in March 2020.

The revised **Renewable Energy Directive** (2018/2001) and the amended Energy Efficiency Directive (2018/2002) set separate EU-level targets on renewable energy and energy efficiency in 2018. For renewable energy, a binding target of at least 32% of final energy consumption by 2030 was set. Concerning energy efficiency, it is a headline target of at least 32.5%. Both the renewable energy target and the energy efficiency target include a review clause by 2023 for an upward revision.

Emissions trading under the EU Emissions Trading System

The European Union Emissions Trading System (EU ETS) is the cornerstone of the EU's policy to combat climate change and its key tool for reducing GHG emissions cost-effectively. It was established by Directive 2003/87/EC (the EU ETS Directive) and entered into force on 1 January 2005. The EU ETS covers energy production and energy-intensive industry sectors. From 2012, it is also covering intra-EEA aviation.

Since 2013, a single ETS cap covers installations in the EU Member States and three participating non-EU countries (Norway, Iceland and Liechtenstein). There were no longer individual caps by country. The cap in the EU ETS decreased from 2013 to 2020 by 1.74% annually, starting from the average level of allowances issued by Member States for the second trading period (2008–2012). For the fourth trading period (2021–2030) the cap decreases by 2.2% annually.

The overall quantity of allowances in the EU ETS is auctioned by Member States. Some allowances are also allocated free to installations, following the harmonised free allocation rules and Article 10a of the EU ETS Directive. Additionally, 300 million allowances were set aside in the New Entrants Reserve to fund the deployment of innovative renewable energy technologies and carbon capture and storage through the NER 300 programme.

Articles 10c of the EU Emissions Trading Directive (Directive 2003/87/EC as amended by Directive 2009/29/EC) allowed several Member States (incl. Estonia) to allocate over the period of 2013–2020 a limited number of emission allowances free of charge to installations. These Articles are covering district heating and high efficiency cogeneration for economically justifiable demand in respect to the production of heating or cooling and existing power plants, provided that the funds are used to modernise the energy system. In June 2012 the EC concluded that the provisions of Estonia's development plan for the Electricity sector allocating free allowances are in line with EU state aid rules. During the transition period (2013–2019) Estonia was permitted to allocate 18 million of free allowances to electricity producers included in the EU ETS. While Article 10c is also applicable in the fourth trading period, Estonia decided not to implement it.

The share of Estonia's EU ETS emissions from all sectors is high, comprising around 48.6% from total emissions in 2020. As of 2020, Estonia had 47 installations. Between 2013 and 2020, emissions in the sectors covered by the EU ETS in Estonia decreased by 64.7% (EEA, 2022).

July 14, 2021 the European Commission published its proposal Fit for 55, which included a set of legislative proposals for the EU to reach its 2030 greenhouse gas reduction target, -55% over 1990 levels, that was agreed by the Council and the European Parliament earlier that year. At the end of June 2022 the Council reached general approaches on important legislative proposals in the Fit for 55 package, including a common position on EU ETS.

The Council agreed to increase the emission reduction to 61% by 2030 in the sectors covered by the EU ETS compared to 2005 levels. To increase the pace of emissions cuts in phase 4, the overall number of emission allowances was increased to decline at an annual rate of 4.2% from 2021 onwards, compared to 2.2% from the existing legal act.

4.4. Sectoral policies and measures and their effects

4.4.1. Cross-cutting policies and measures

Excise duties

Excise duties (Table 4.1) are one of the fiscal measures in Estonia with an impact on GHG emissions. The excise duty rate has been temporarily reduced in the period of 01.06–31.12.2022.

Table 4.1. Excise tax on fuels and electricity (as of April 2022, ETCB)

Fuel/energy type	Unit	EUR/unit
Unleaded petrol	1,000 l	563
Leaded petrol	1,000 l	563
Aviation spirit	1,000 l	563
Kerosene	1,000 l	330.1
Diesel oil	1,000 l	372
Diesel oil for specific purposes	1,000 l	21[1]
Light heating oil	t	372
Heavy fuel oil	t	422
Heavy fuel oil[2]	t	58
Shale-derived fuel oil	t	414
Shale-derived fuel oil[3]	t	57
LPG (used as heating fuel)	t	55
LPG (used as motor fuel)	t	193
Natural gas (used as heating fuel)	1,000 m^3	40
Natural gas (to a gas-intensive undertaking with a permit for exemption from excise duty)	1,000 m^3	11.30
Motor natural gas (which is used as motor fuel, including in stationary engines)	1,000 m^3	40
Motor natural gas in liquefied form (which is used as used as motor fuel, including in stationary engines)	1,000 kg	55.79
Solid fuels (coal, brown coal, coke, oil shale; heat production	GJ (GCV)	0.93
Electricity	MWh	1
Electricity (to an electro-intensive undertaking with a permit for exemption from excise duty)	MWh	0.5

Pollution charges

Pollution charges are a second fiscal measure in Estonia with an impact on GHG emissions. The government's tax policy is based on objectives aimed at reducing environmental impact by increasing the rates of charges on pollution and resource use.

The Environmental Charges Act (2006)

This Act provides the grounds for determining the natural resource charges, the rates of the pollution charge, the procedure for calculation and payment thereof, and the grounds and specific purposes for using state budget revenue obtained from environmental use. Environmental charges are established and imposed based on the need for environmental protection, the economic and social situation of the state and, in the events specified in this Act, also based on the value created by natural resources subject to the charge as well as the purpose and manner of use of the environment. A mineral resource extraction charge that exceeds the minimum rates provided for in this Act is established based on the state's goal of earning revenue. In the case of an energy mineral resource, the added value generated by the energy mineral resource is relied upon in addition to the goal of earning revenue.

In Estonia a pollution charge for releasing CO_2 into the ambient air was introduced in 2000. Currently, the Environmental Charges Act obliges the owners of combustion equipment to pay pollution charges for several pollutants emitted into the air. The pollution charge in the case of emissions into ambient air must be paid by all enterprises that are required to have an air pollution permit. The air pollution permit is obligatory for all enterprises which own and operate combustion equipment (utilising solid, liquid or gas fuel) with a rated capacity equal to or higher than 1 MWth in one location. Thermal power producers pay a pollution charge for the CO_2 emissions into the ambient air based on the quantity of CO_2 emitted into the environment upon the amount of CO_2 emitted. The CO_2 charge has been 2 EUR/t. Installations that emit sulphur oxide, carbon monoxide, particles, except heavy metals and compounds of heavy metals, nitrogen oxides, volatile organic compounds, heavy metals and compounds of heavy metals into the ambient air also pay a pollution charge. CH_4 and fluorinated gases (HFC – hydrofluorocarbons, PFC and SF_6) are not subject to pollution charges.

As an exception, the Environmental Charges Act provides the option of replacing the pollution charge (incl. the CO_2 charge) with environmental investment by enterprises. The obligation to pay the pollution charge is substituted by the obligation to finance environmental protection measures for pollutants or types of waste whose quantity is reduced by at least 15% by the planned environmental protection measures.

[1] The excise duty rate has been temporarily reduced in the period of 01.06–31.12.2022.
[2] Heavy fuel oil, which density is >900 kg/m^3 at 15 °C, viscosity is >5 mm^2/s at 40 °C, contains >0.5% sulphur.
[3] Shale-derived fuel oil, which density is >900 kg/m^3 at 15 °C, viscosity is >5 mm^2/s at 40 °C, contains >0.5% sulphur.

Policies and measures

Cross-cutting measures with a potential for GHG reduction in both LULUCF and Agriculture sector in the WEM scenario include the **Agri-environment-climate measures with three sub-measures.**

1. Support for environment-friendly horticulture – The general objective is to promote the use of environment-friendly practices in gardening. One of the more specific aims is to decrease leaching.
2. Regional soil protection support – The general objective is to ensure the sustainable use of eroded and peat soils and to minimise soil degradation by improving the management of soils and using other activities improving cropland management. The measure includes bringing agricultural lands with erosion and peat soils under grassland.
3. Support for maintaining semi-natural habitats – The general objective is to ameliorate the conditions of semi-natural habitats and its species by improving grazing land or grassland management.

This measure is from the Estonian rural development plan 2014–2020 (ERDP 2014–2020) and is still applying as the funding for the implementation of the measures is in place until 2023 and/or 2024.

In addition, the Common Agricultural Policy (CAP) Strategic Plan 2023–2027 (MoRA, 2022) includes an **environmentally friendly management** measure with the sub-measures cultivation of catch crops and neutralisation of acid soils measures. The aim of the neutralisation of acid soils measure is to neutralise the acid soils to achieve the optimal conditions for the plant growth. As a result, the loss of agricultural land in use can be avoided and the soil carbon pool will be increased. The neutralisation of acid soils measure was first proposed as a GHG reduction measure in the Analysis of the opportunities to increase climate ambition in Estonia (SEI, 2019).

Cross-cutting measures with a potential for GHG reduction in both the Energy and Agriculture sector in the WAM scenario include:

Investments into improved performance of agricultural holdings. The aims are to support the reconstruction or construction of new livestock facilities (including manure and silage storage facilities) and provide investments into renewable energy through investments in bioenergy and promote its production. The objective of the measure is to increase the competitiveness of agricultural producers, so that the producers would receive support for their agricultural work. For instance, the bioenergy produced with the support is used for the farm activities.

In addition, the Common Agricultural Policy (CAP) Strategic Plan 2023–2027 (approved 11.11.2022) includes **Material and intangible investments by farmers** includes six sub-actions:

1. Investments in the establishment of environmentally friendly renewable energy solutions and energy savings on the farm.
2. Purchase of precision fertilisation sensor systems.
3. The acquisition of clean refrigeration units or the replacement of items of refrigeration equipment for more environmentally sustainable ones.
4. Construction of manure storage facilities and silos, covering of manure storage facilities and construction of leak-proof substrates for deep litter housing.
5. Investments in manure spreading equipment.
6. Purchase of filters that capture ammonia.

In addition, CAP Strategic Plan 2023–2027 (approved 11.11.2022) includes a measure that is not yet implemented and therefore not part of the projection scenarios.

Investment support for the enhancement of bio-resources – is aimed at contributing to providing higher economic added value to bio-resources, increasing R&D and innovation capacity and reducing GHG emissions. Giving higher added value to bioresources increases the profitability of companies, helps reduce dependence on domestic and foreign non-renewable resources, and accelerates the replacement of non-renewable resources in line with the EU's climate goals. The new jobs created will promote the regional economy, including in peripheral areas. The intervention also promotes (inter-sectoral) cooperation, the formation of co-operatives and clusters, and introduces the possibilities of the bioeconomy to a wider target group. Enhancement of bio-resources is financed from the Recovery and Resilience Facility and the CAP Strategic Plan 2023–2027 (approved 11.11.2022).

The following measures mainly affect the Transport sector in the WEM and WAM scenarios, but will also have a small effect on the IPPU sector WEM and WAM scenarios through a reduction of final energy demand for road transport and diesel fuel exhaust fluid (usage of Ad Blue is reported under the IPPU sector. Additional information on the measures is provided under Chapter 4.4.3.

WEM measures:

1. Promoting the use of electricity in passenger cars
2. Promoting the use of biomethane in buses
3. Promoting the use of electricity in buses
4. Promoting the use of biomethane in heavy-duty vehicles
5. Promotion of economical driving
6. Reduction of forced movement by passenger car
7. Reorganisation of city streets
8. Development of convenient and modern public transport
9. Road usage fees for heavy-duty vehicles based on time
10. Electric car purchase support
11. Promotion of clean and energy-efficient road transport vehicles in public procurement
12. Developing the railroad infrastructure (includes the building of Rail Baltic)
13. Pilot project for hydrogen
14. New tram lines in Tallinn

WAM measures:
1. Additional spatial and land-use measures for urban transport energy savings to increase and improve the efficiency of the transport system
2. Additional promotion of economical driving
3. Road usage fees for heavy-duty vehicles based on mileage
4. Vehicle tyre pressure and tyre energy label

4.4.2. Energy sector

Policies and measures for electricity supply, heat supply, energy consumption – commercial/institutional and residential sectors and energy consumption – and manufacturing industries are included in Chapter 4.4.2. Cross-sectoral measures are included in Chapter 4.4.1.

The Government of Estonia approved the **Estonian Energy Development Plan until 2030** (ENMAK 2030) in 2017 and has planned to update the document. The renewed **Energy Development Plan until 2035** aims to update the trends, goals and activities of the energy economy included in the ENMAK 2030. It will also include the development vision, goals, bottlenecks and policy instruments of the Estonian energy economy in moving towards climate-neutral energy production and consumption and ensuring energy security. The deadline for approving the renewed Energy Development Plan until 2035 is set for 2025.

According to the strategy Estonia 2035, the target level of the share of renewable energy in the total final energy consumption set is >55%.

In accordance with Directive 2018/2001, Estonia must ensure that the share of energy from renewable sources amounts to 25% of the gross final consumption of energy by 2020. The share of renewable resources in final energy consumption was already reached in 2015 (29.0%) and reached 30.1% in 2020. Therefore, Estonia has reached its 2020 target.

Electricity supply

The Electricity Market Act (2005) governs the generation, transmission, sale, export, import and transit of electricity and the economic and technical management of the power system. This Act prescribes the principles of the operation of the electricity market, based on the need to ensure an effective supply of electricity which is provided at a reasonable price and which meets environmental requirements and the needs of consumers, and the utilisation of energy sources in a balanced manner, in an environmentally clean way and with a long-term perspective. It states that electricity undertakings shall always facilitate activities performed by consumers for the purpose of conserving electricity.

Electricity supply WEM scenario measures include:
1. **Renewable energy support through underbidding auctions (technology neutral)** – The aim of this measure is to increase energy production from renewable energy sources. Support for renewable energy production is regulated by the Electricity Market Act (technology neutral auction).

Table 4.2. Support for renewable and efficient CHP-based electricity production (Electricity Market Act §59)

Level of subsidy	Conditions for receiving the subsidy
	Subsidies are paid for electricity that is produced:
0.0537 €/kWh	Electricity generated from a renewable energy source except biomass if the net capacity of the production machinery does not exceed 125 MW
0.0537 €/kWh	From biomass in CHP mode. From 1 July 2010, producers who have started generating electricity from biomass can only get the subsidy for electricity generated in efficient CHP mode
0.032 €/kWh	In efficient CHP mode from waste as defined in the Waste Act, peat or oil shale retort gas
0.032 €/kWh	In efficient CHP mode using generating equipment with a capacity of not more than 10 MW

2. **Support for renewable and efficient CHP-based electricity production** – The aim of this measure is to increase energy production from renewable energy sources and promote cogeneration. (Table 4.2)
3. **Investment support for wind parks** – The aim of this measure is to increase electricity production from renewable energy sources.
4. **Increasing the share of solar energy in electricity generation** – The aim of this measure is to increase electricity production by increasing the proportion of solar energy.
5. **Introduction of renewable energy in maritime surveillance radar stations on small islands** – Increase energy production from renewable energy sources. Many small islands in Estonia do not have a permanent connection to the electricity grid. However, small islands have various state-owned facilities or buildings and permanent residents.
6. **Renewable energy support through underbidding auctions (technology specific)** – Support for renewable energy production through technology-specific auction. Increase energy production from renewable energy sources.

In addition to the planned measures, there are additional electricity-supply-related measures that have either a direct effect on GHG emissions or support the implementation of WEM/WAM measures. The following additional measures are under discussion and therefore not part of the projection scenarios.
1. **Energy storage pilot programme** – supports measures to increase the deployment of renewable energy by enabling the deployment of heat storage devices to reduce the demand for fossil fuels during peak loads.
2. **Government actions for the construction of small modular reactors** – A small modular reactor could be built in 2030 if the preparatory activities are started in the 2020s. There are no small reactors suitable for Estonia (so-called "modular reactors") in the world as

yet. As a result, the construction of a nuclear power plant in Estonia will not affect the fulfilment of the GHG emission reduction target set for 2030.

3. **Government actions to capture and store carbon or to promote its use** – Tallinn University of Technology's 2019–2021 project "Climate change mitigation through CCS and CCU technologies", aims to evaluate the suitability of various carbon capture technologies and develop scenarios for the application of these technologies in the Estonian oil shale industry. The environmental impact of the most effective solutions and the technological and economic capacity of the Estonian industrial sector to use captured CO_2 are also analysed. The economic analysis focuses on the differences in unit costs of the most suitable capture technologies, the sensitivity to EU ETS allowance price and electricity prices, and the need for investment subsidies, as well as the export potential of the captured CO_2.
4. **The acquisition of air surveillance radars for the development of wind farms** – Supporting the development of wind energy through the construction of radars and other compensation measures in order to promote the development of renewable energy in Estonia, freeing the areas of onshore and offshore wind farms from height and national defence restrictions, which enables the construction of wind farms.
5. **Research and development programme for the National Development Plan of the Energy Sector** – Supporting the implementation of the development plan through research and development activities.
6. **Moving the municipal waste incineration sector to the EU ETS**
7. **Electricity grid reinforcement programme to increase renewable energy production capacity and adaptation to climate change** – Implementation of this measure would increase the capacity of the Estonian electricity system while introducing renewable energy increases and new renewable energy production capacities are added to the electricity system.

Heat supply

The District Heating Act (2003) governs activities related to the production, distribution and sale of heat by way of district heating networks and connection to district heating networks.

Due to the large share of buildings in the total energy use, the improvement of energy efficiency in the residential and tertiary sectors also has an important role from the emissions reduction aspect. Here, the impact of EU Directive 2002/91/EC and its recast 2010/31/EU on the energy performance of buildings (EPBD) should be highlighted. In Estonia, the implementation of the EPBD is the responsibility of the MoEAC. The provisions of the EPBD have been transposed into the Building Code. Several detailed requirements were enforced using secondary legislation. The most important secondary-level act is the regulation (No 55 of 3 June 2015) for **Minimum requirements for energy performance regulation** that establishes minimum requirements for the energy performance of buildings, including low energy buildings and nearly zero-energy buildings. The regulation applies to new as well as existing ones undergoing major renovations.

Heat supply WEM scenario measures include:

1. **Construction of local heating solutions instead of district heating solution** – The aim of the measure is to reduce the final consumption of energy. As part of the measure, inefficient district heating will be replaced with local heating, provided that the district heating company continues to provide the service through the local heating solution.
2. **Renovation of depreciated and inefficient heat pipelines** – Renovation of depreciated and inefficient heat pipelines and/or construction of new heat pipelines.
3. **Renovation of district heating boilers and fuel change** – Renovation and/or construction of district heating boilers and fuel exchange.
4. **Oil boiler replacement programme** – The aim of the measure is to replace local inefficient fossil fuel heating systems with efficient modern systems.

Heat supply WAM scenario measures include:

1. **Additional renovation of depreciated and inefficient heat pipelines** – Additional renovation of depreciated and inefficient heat pipelines and/or construction of new heat pipelines.
2. **Additional renovation of district heating boilers and fuel change** – Additional renovation and/or construction of district heating boilers and fuel exchange.
3. **Additional construction of local heating solutions instead of district heating solution** – Additional replacement of inefficient district heating with local heating, provided that the district heating company continues to provide the service through the local heating solution.

In addition to the planned measures, there are additional heat-supply-related measures that have either a direct effect on GHG emissions or support the implementation of WEM/WAM measures. The following additional measures are under discussion and therefore not part of the projection scenarios.

1. **Preparation of a heat economy development plan** – Support of preparation of the heat management development plan in local governments.
2. **Use of residual heat in the server park** – The aim of the measure is to raise the efficiency of energy use.

Energy consumption – Manufacturing industries and construction

WEM scenario measures in energy consumption in manufacturing industries include:

1. **Support for energy- and resource audits in industries** – Raising awareness in energy and resource usage efficiency in the manufacturing industries.
2. **Energy and resource efficiency in industries** – Supporting investment in energy and resource usage efficiency in the manufacturing industries.

Energy consumption – Other sectors (Commercial/Institutional and Residential sectors)

The Product Conformity Act (2010) sets out the competence of authorities participating in market surveillance and stipulates that the Technical Surveillance Authority must exercise state surveillance over compliance of household appliances, heating appliances and devices with energy efficiency, energy performance labels and ecological design requirements.

Energy Sector Organisation Act (2017) provides the measures for achieving the national target of energy efficiency, the principles for promoting renewable energy and the requirements for improving energy efficiency and the parties on whom obligations are imposed in the public as well as in the private sector.

WEM scenario measures in energy consumption in other sectors include:

1. **Support for making the processing of fishery and aquaculture products more energy and resource efficient** – The aim of the measure is to increase the energy saving and resource productivity of companies through the introduction of more sustainable technologies and solutions, while reducing the impact on the environment. The implementation of an energy- or resource-saving solution based on an energy or resource audit is supported.
2. **Energy efficiency in local government buildings** – The purpose of the measure is to increase the energy efficiency of local government buildings, reduce greenhouse gas emissions, support the use of renewable energy and reduce general heating costs.
3. **Energy efficiency in central government buildings** – The purpose of the measure is to increase the energy efficiency of central government buildings, reduce greenhouse gas emissions, support the use of renewable energy and reduce general heating costs.
4. **Arrangement of the basic school network** – The aim of the measure is to support the construction of new schools to replace old ones or the complete renovation of old school buildings.
5. **Arrangement of the gymnasium network** – The aim of the measure is to support the construction of new gymnasiums to replace old ones or the complete renovation of old gymnasium buildings.
6. **Reorganisation of special care institutions** – The aim of the measure is to support the construction of new care institutions to replace old ones or the complete renovation of old care institution buildings.
7. **Institutional development programme for R&D institutions and higher education institutions** – The measure supports the construction and reconstruction of new buildings for research and development institutions and schools.
8. **Modernisation of health centres** – The aim of the measure is to support the construction of new health centres to replace old ones or the complete renovation of old health centres.
9. **New childcare and pre-primary education infrastructure** – The aim of the measure is to support the renovation of childcare and pre-primary school buildings.
10. **Kindergarten renovation** – The aim of the measure is to support the renovation of kindergarten buildings.
11. **Supporting the reconstruction of apartment buildings** – The aim of the measure is to increase the energy efficiency of apartment buildings and improve the indoor climate. Across all investments, the goal is to reconstruct an estimated net area of 3.2 million m^2 of apartment buildings.
12. **Supporting the reconstruction of small houses** - The aim is to support the complete reconstruction of small houses and to reduce the energy consumption of small houses. The goal is to reconstruct 80 small houses. The investment in small houses will support the energy efficiency and reconstruction of an estimated 13,000 m^2 of net space.
13. **Street lighting reconstruction programme investments** – The purpose of the programme is to improve the use of electricity in street lighting through the renovation of the street lighting infrastructure.

WAM scenario measures in energy consumption in other sectors include:

1. **Supporting the reconstruction of non-residential buildings in the private sector** – The aim is to support the complete reconstruction of the non-residential buildings by 2050.
2. **Reconstruction of municipal buildings** – The aim is to support the complete reconstruction of the municipal buildings by 2050.
3. **Reconstruction of central government buildings** – The aim is to support the complete reconstruction of the central government buildings by 2050.
4. **Additional reconstruction of apartment buildings** – The aim is additional support for the complete reconstruction of the apartment buildings by 2050.
5. **Additional reconstruction of small houses** – The aim is additional support for the complete reconstruction of the small houses by 2050.
6. **Investments into energy saving of greenhouses and vegetable warehouses and dissemination of renewable energy** – Supporting investment in energy and resource usage efficiency in agriculture.

In addition to the planned measures, there are additional energy-consumption-related measures in other sectors that have either a direct effect on GHG emissions or support the implementation of WEM/WAM measures. The following additional measures are under discussion and therefore not part of the projection scenarios.

1. **Training and events promoting the more sustainable use of energy and resources** – The aim of the environmental awareness programme is to create an understanding that a human is a part of nature, nature is the basis of economy and culture, and there must be a balance between protecting and using the environment. The programme supports activities in learning about the principles of sustainable environmental use, the relationship between nature and human society, natural processes and biodiversity. One of the results of the project is the development of an energy-saving way of thinking.
2. **Support for energy and resource audits of fishery and aquaculture products establishments** – The aim is to support the conducting of an energy and resource audit. The energy and resource audit identifies those investments in the processing of fishery and aquaculture products that help save energy or reduce the

impact on the environment, including investments in waste processing. The measure directs companies to a more economical way of thinking and promotes cost-effective measures.

3. **Residential Investment Fund** – The housing investment fund allows the possibility to ensure consistent financing (loans, loan guarantees) in regions where the real estate value is low and the residents' opportunities to carry out reconstruction under market conditions are limited. The fund brings together resources from the public sector, including European Union structural funds, and resources from the private sector.
4. **Alternative fuels in forest and agricultural machinery** – The aim of the measure is to replace 25% of the total diesel consumption of tractors, harvesters and forestry machines with biofuels or other alternative fuels that meet sustainability criteria, and 50% by 2030.

4.4.3. Transport

The Liquid Fuel Act (2003) provides the bases and procedure for handling liquid fuel, the liability for violations of this Act and the arrangements for exercising state supervision, with a view to ensuring the payment of taxes and guaranteeing the quality of the more widely used motor fuels.

The main focus of the **Transport and Mobility Development Plan 2021–2035** (MoEAC, 2021) is to reduce the environmental footprint of the transport means and system to contribute to the achievement of climate goals by 2050. In order to manage people's behavioural changes in the future, emphasis is placed on the 'polluter pays' principle and, among other things, to taxation of fuels according to their emission factors and energy content. Also, according to the development plan, it is necessary to introduce low-carbon fuels in all modes of transport.

For this development plan, the Ministry of Economic Affairs and Communications also commissioned a report from the International Transport Forum (ITF) The Future of Passenger Mobility and Goods (ITF, 2020), the goal of which was to assess Estonia´s transport sector and give recommendations for future improvements from an external observer's perspective.

Reducing GHG emissions in the Transport sector is one of the key questions for Estonia in meeting the ESR targets in the future as the energy consumption has been growing in the same trend as the gross domestic product (GDP). The main goals for the measures implemented or planned in the Transport sector are directed at increasing the efficiency of vehicles and reducing the demand in domestic transport.

In the transport sector, the WEM measures having an effect on GHG emissions that are already in place include:

1. **Increasing the share of biofuels in transport** – 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, must include a total energy content of biofuels, or of biomethane or electricity supplied for final consumption, at the value, as a weighted average for the calendar year, of at least 7.5% by the end of that year.
2. **Promoting the use of electricity in passenger cars** – The aim of the measure is to develop a support system for expanding infrastructure that is needed for switching to electric cars.
3. **Promoting the use of biomethane in buses** – The aim of the measure is to increase the supply of biomethane in the market, creating demand for fuels produced from renewable energy sources and supporting the construction of filling stations.
4. **Promoting the use of electricity in buses** – This measure includes the development of a support system for the infrastructure to switch to electric buses (including the use of trolleybuses).
5. **Promoting the use of biomethane in heavy-duty vehicles** – The aim of the support is to offer the market an alternative fuel source (biomethane or bio-LNG) to replace diesel-fuelled heavy-duty trucks.
6. **Promotion of economical driving** – This measure includes promoting eco-driving, which helps to save fuel, and reduce noise level, emissions, accidents and vehicle repair costs.
7. **Reduction of forced movement by passenger car** – Implementing the measure helps to plan land use to reduce urbanisation and car dependency (forced mobility). It includes the development of telecommunications and also the development of a short-term rental car network. The measure requires stronger spatial planning at the regional level, because the activities of the measure go beyond the borders of one municipality. The aim of the measure is also to ease the transport burden during peak hours.
8. **Reorganisation of city streets** – The measure includes updating parking policies in cities, planning land use to reduce the use of private cars, restructuring city streets, etc. The measure also requires stronger spatial planning at the regional level, because the activities of the measure go beyond the borders of one municipality. The aim of the measure is also to ease the transport burden during peak hours.
9. **Development of convenient and modern public transport** – This measure includes improving the availability of public transport, along with the development of ticket systems and new services. The measure also requires stronger spatial planning at the regional level, because the activities of the measure go beyond the borders of one municipality.
10. **Road usage fees for heavy-duty vehicles based on time** – This measure includes the establishment of road user charges based on time, location, environmental aspects, etc. for vehicles with a gross weight greater than 3,500 kg (heavy trucks).
11. **Electric car purchase support** – The purchase subsidy for electric cars is aimed at companies and individuals with high transport needs. The condition for receiving the subsidy is that the vehicle is driven 80,000 kilometres within four years from the payment of the subsidy. This means that an average of 20,000 km is covered per year. At least 80% of this, or 16,000 km, must be travelled in Estonia.

12. **Promotion of clean and energy-efficient road transport vehicles in public procurement** – The government must implement the system provided in the Clean Vehicles Directive within 24 months, i.e., from August 2021. The aim is to promote the procurement of clean and energy-efficient vehicles in the public sector.
13. **The railroad electrification** – Electrification of existing railway and extension of its use.
14. **Acquisition of additional passenger trains** – Additional acquisition of comfortable new passenger trains.
15. **Developing the railroad infrastructure (includes the building of Rail Baltic)** – This measure includes building Rail Baltic, additional stops and raising speed limits. In addition to transport, the measure also concerns emissions from the Industry and solvent sector (IPPU). The impact of Rail Baltic on the fuel consumption of heavy trucks is evaluated, which in turn means reducing the consumption of AdBlue (exhaust gas catalyst liquid) and the CO_2 released from it.
16. **Pilot project for hydrogen** – A project covering the entire hydrogen use chain, i.e., from production, transport, storage to consumption in public transport (hydrogen taxi).
17. **New tram lines in Tallinn** – Includes the development of two new tram lines.
18. **Making a domestic ferry climate neutral** – Includes the electrification of one ferry.

The following measures are still in discussion and henceforth are reported as planned in the WAM scenario:

1. **Additional spatial and land-use measures for urban transport energy savings to increase and improve the efficiency of the transport system** – This measure includes additional investments for the *Reduction of forced movement by passenger car, Reconstruction of city streets and Development of convenient and modern public transport* measures. This means that additional resources are planned to achieve additional energy efficiency and additional GHG emission savings. As this is a proposed measure, it is not yet clear when it will be implemented.
2. **Making an additional domestic ferry climate neutral** – Includes the transfer of one additional ferry sailing between the Estonian mainland and the islands to electricity or biofuel that meets the sustainability criteria.
3. **Additional promotion of economical driving** – This measure includes additional implementation of the measure "Promotion of economical driving", which means planning additional resources to achieve additional energy efficiency and additional GHG emission savings. As this is a proposed measure, it is not yet clear when it will be implemented.
4. **Road usage fees for heavy-duty vehicles based on mileage** – This measure includes the establishment of road user charges based on mileage, location, environmental aspects, etc.
5. **Vehicle tyre pressure and tyre energy label** – The measure introduces tyres with better rolling resistance which also improves the aerodynamics of vehicles. Training materials for truck drivers are being updated to emphasise the importance of checking tyres and tyre pressure.

In addition to the planned measures, there are additional transport related measures that have either a direct effect on GHG emissions or support the implementation of WEM/WAM measures. The following additional measures are under discussion and therefore not part of the projection scenarios.

1. **Annual vehicle tax**– Registration and/or annual tax for passenger cars depending on the energy class (fuel consumption) of cars is one way to design a more fuel-efficient car fleet. The purpose of the tax is not to tax the car as such and to increase the state's tax revenues, but rather to influence consumer choices and design a more economical vehicle fleet.
2. **Congestion charge** – Congestion charge is the flexible taxation of road use, with the aim of reducing motor vehicle traffic during peak hours and covering costs related to congestion in cities and/or their immediate surroundings. Depending on the scope of the toll system and the size of the tolls, Tallinn's congestion charge can operate in parallel with kilometre-based tolls on highways or as a separate measure before the implementation of road user tolls.
3. **Taxation of company vehicles based on CO_2** – Taxation of company vehicles according to the CO_2 indicator of the vehicle.
4. **Restrictions on imports of second-hand vehicles** – Import ban on used cars from a certain EURO class, CO_2 indicator or other environmental indicator.
5. **Subsidising biofuels that meet sustainability criteria or imposing a sales obligation on service stations** – Setting a 50% obligation to sell biofuel that meets sustainability criteria to gas stations.
6. **Additional new tram lines in Tallinn** – Expanding the tram network (including acquiring trams) and improving it in such a way that the movement of trams is not obstructed by cars, both within the city and across borders. In doing so, the goal must be to increase the average speed of trams, i.e. to gain time for passengers. Tallinn projects (indicative list: Viimsi, Rae (Peetri), Kesklinn–Endla, Mustamäe (Sõpruse), Stroomi, Tondi–Tammsaare road, Lasnamäe, Tondi–Järve, Vana–Sadama, approximately 50 km in total).
7. **Tallinn taxis using electricity** – Companies offering the Tallinn taxi service are obliged to use electric cars.
8. **Making additional domestic ferries climate neutral** – Includes the transfer of all ferries (an additional 10) plying between the Estonian mainland and the islands to electricity or biofuel that meets the economic criteria.

Cross-sectoral measures are included in Chapter 4.4.1.

4.4.4. Industrial processes and product use

Emissions from the IPPU sector are regulated by the duty for manufacturing industries to implement the best available technologies (BAT) (stipulated in the Industrial Emissions Act (IEA) (2013) and Industrial Emissions Directive 2010/75/EU). The purpose of the Industrial Emissions Act is to achieve a high level of protection of the environment taken as a whole by minimising emissions into the air, water and soil and the generation of waste in order to prevent adverse environmental impacts. In addition, the IEA determines industrial activities of high environmental hazard, provides the requirements for operation therein and liability for failure to comply with the requirements, and the organisation of state supervision.

A production plant has to comply with the BAT. The requirements of the IEA include emission limit values, and monitoring and emission reduction measures through the implementation of BATs if an environmental permit is issued. This does not result in an additional reduction of emissions because all production plants have to comply with BATs as they operate.

In the IPPU sector, the main measure having an effect on GHG emissions is the Bans and duties from the **Regulation (EU) No 517/2014** on fluorinated greenhouse gases and **Directive 2006/40/EC** related to emissions from mobile air conditioners (MACs), consisting of two policies:

Regulation (EU) No. 517/2014 on fluorinated greenhouse gases. This regulation only affects GHG emissions, similarly in the WEM and WAM scenarios. The effect is ongoing until at least 2030. The objectives are to significantly reduce fluorinated greenhouse gas emissions and replace fluorinated greenhouse gases with refrigerants with low GWP, limiting the total amount of the most important F-gases that can be sold in the EU from 2015 onwards and phasing them down in steps to one-fifth of 2014 sales in 2030. To achieve this, a phase-down scheme of F-gases brought onto the EU market is stipulated, bans on placing on the market and servicing of certain equipment, (certification) duties for operators and servicing personnel, duty of collecting the gases from decommissioned equipment.

Directive 2006/40/EC related to emissions from mobile air conditioners (MACs) only affects GHG emissions, similarly in the WEM and WAM scenarios. The objective of MACs Directive 2006/40/EC is to reduce F-gas emissions from passenger cars and vans by prohibiting the use of F-gases with a GWP of more than 150 times greater than carbon dioxide (CO_2) in new types of cars and vans introduced from 2011, and in all new cars and vans introduced to the market from 2017.

Cross-sectoral measures are included in Chapter 4.4.1.

4.4.5. Agriculture

Development of the Agriculture sector and the implementation of various targeted measures are mostly governed by the **Common Agricultural Policy (CAP) Strategic Plan 2023–2027** (approved 11.11.2022) and **Agriculture and fisheries development plan until 2030** (AFDP 2030) (MoRA, 2021). In addition, there are some measures from the **Estonian rural development plan 2014–2020** (ERDP 2014–2020) that are still applying as the funding for the implementation of the measures is in place until 2023 and/or 2024.

The CAP Strategic Plan 2023–2027 includes four specific objectives, that also contain climate-related actions:

1. Contribute to climate change mitigation and adaptation, including by reducing GHG emissions and enhancing carbon sequestration, as well as promoting sustainable energy. This specific objective includes the following identified needs:
   - To prefer environmentally sustainable production, investments, solutions based on the circular bioeconomy;
   - To increase carbon sequestration in soils and protect soil organic carbon stocks.
2. Foster sustainable development and efficient management of natural resources such as water, soil and air. This specific objective includes the following identified needs:
   - Continued support for land improvement investments;
   - Contribute to the use of agricultural practices that conserve surface and groundwater;
   - Neutralisation of acidic soils;
   - Encouraging the development and introduction of environmentally friendly technologies;
   - Development of environmental consulting;
   - Implementation of the requirements and measures resulting from the air pollutant emission reduction programme;
   - Maintenance of soil fertility.
3. Contribute to the protection of biodiversity, enhance ecosystem services and preserve habitats and landscapes
4. Improve the response of EU agriculture to societal demands on food and health, including safe, nutritious and sustainable food, food waste, as well as animal welfare. This specific objective includes the following identified needs:
   - Increasing organic production in organic agriculture by reducing the processing of organic products as conventional products;
   - Diversity of agricultural and garden (horticultural) crops, availability of varieties suitable for local conditions;
   - Increase livestock keepers' knowledge of livestock health and well-being in general.

As regards impact on the environment, the **Organic Farming Act** (2007) is important among the legislation regulating the agricultural sector, as it provides for the requirements for operating in the area of organic farming to the extent not regulated by the regulations of the EU, as well as for the grounds and extent of supervision exercised over persons operating in the area of organic farming, and for the liability for violation of the requirements established by such legislation. In addition, a number of secondary legislative acts have been issued on the basis of this act to regulate aspects of organic farming.

Actions to reduce nitrogen losses from agriculture, for example, based on the requirements of the *Nitrates Directive*, have led to reduced nitrogen emissions to the aquatic environment with indirect positive effects for the mitigation of climate gas emissions. The legislation which is relevant for the implementation of the *Nitrates Directive* is the *Water Act*, which was enacted in 1994 and has been revised since, especially in connection with the accession into the European Union. An updated *Code of Good Agricultural Practices* and a Government decree on water protection requirements for fertiliser, manure and silage (revised several times) were introduced. The **Water Act** (2019) is one of the principal legal acts that the prime measures in the *Estonian Water Management Plan measure programme 2015–2021* are grounded upon. Additional measures to promote water protection in agriculture are mainly based on the *ERDP* and its measures.

ERDP 2014–2020 measures that continue to contribute to WEM scenario GHG emission reduction include:

Agri-environment-climate measures with three sub-measures:

1. Regional water protection support – The objectives are to prevent and reduce water nitrogen pollution to preserve the water quality by decreasing agricultural soil leaching.
2. Support for growing local plant varieties – The objective is to ensure the preservation of the local plant varieties valuable for cultural heritage and genetic diversity. The measure helps to preserve crop varieties more suitable for local conditions (more resistant to locally spread diseases and climate conditions) and therefore gives a good basis for developing new breeds and supports organic farming.
3. Support for keeping animals of local endangered breeds – The objective is to ensure the preservation of animal breeds that are endangered and considered important for cultural heritage and genetic diversity.

Organic production – The objectives of the measure are to develop organic production, increase the competitiveness of organic production, preserve and improve biodiversity and landscape diversity, preserve and enhance soil fertility and water quality, and develop animal welfare. The measure helps to reduce GHG emissions by using organic fertilisers instead of mineral fertilisers. Additionally, emission per one hectare is lower compared to the conventional production.

Knowledge transfer and information actions – The general objective of the measure is to develop and enhance the technical, economic and environmental knowledge of the enterprisers and their employees in the Agriculture, food and forest sector to improve the bioeconomy and adapt new challenges to use resources sustainably. The measure aims to promote the organisation of educational training, presentations, awareness-raising activities, organising workshops or visits to enterprises and long-term programmes.

Advisory services, farm management and farm relief services – The general objective of the measure is to enhance the sustainable management or effectiveness of agricultural holdings or enterprises by providing high-quality advisory services to people working in the agriculture sector. Advisory services include inter alia environmental and climatic topics by providing high-quality advisory services to the people working in the agriculture sector. Advisory services include inter alia environmental and climatic topics.

There are additional agriculture-related measures WEM measures from the CAP Strategic Plan 2023–2027 (approved 11.11.2022).These measures are similar to the measures implemented under ERDP 2014–2020. The CAP Strategic Plan contains important support activities and sectoral interventions affecting GHG emissions which include:

Eco-scheme for organic farming – The support is granted to farmers who start conversion to organic farming and engage in organic farming. Support is granted on the basis of the area of their agricultural land under organic farming.

Eco-scheme for ecological focus areas – The support promotes the creation of non-productive areas and landscape features on arable land in order to contribute to biodiversity and mosaic landscapes.

Support for maintenance of ecosystem services on agricultural land – Intervention will support a diversified agricultural landscape, the preservation of landscape features and natural areas, with the aim of ensuring the natural enemies of arable land pests in providing natural pest management ecosystem services.

Soil and water protection support – In terms of soil protection, the aim of this intervention is to reduce carbon emissions and protect soil organic carbon stocks and peat soils. The highest organic carbon emissions in agriculture occur from peat soils and cultivated peat soils have the highest organic carbon content and these soils are vulnerable to mineralisation. The aim of the intervention is to reduce the cultivation of peat soils and to promote the transfer of arable land under long-term grassland and vice versa, avoiding cultivation of arable crops instead of grassland.

Support for the maintenance of valuable permanent grassland – The aim of the intervention is to preserve permanent grasslands of a high biological value, where natural vegetation has been developed or preserved and thus the conditions for species richness are guaranteed. Support for the maintenance of valuable permanent grassland is intended for semi-natural grasslands located outside protected areas and permanent grassland intended by experts as valuable permanent grassland.

Support for maintaining semi-natural grassland – The aim of the intervention is to preserve semi-natural grasslands in Natura 2000 areas and thereby the richness of species on agricultural land. Semi-natural grasslands also play an important role in adapting to climate change and the sequestration of organic carbon into soils.

Animal welfare support – The overall objective of the intervention is to raise animal welfare awareness among livestock farmers and to support farmers who meet higher animal welfare standards and thereby improve animal welfare and health. In addition, the support helps to reduce the negative environmental impact of livestock farming on air and soil and to increase the number of animals grazed extensively in order to maintain grassland biodiversity without encouraging an increase in the total number of animals and stocking densities. The intervention shall support:

- Environmentally friendly grazing of dairy cattle and horses;
- Increased housing area per pig, feeding plans approved by a veterinarian, feed containing mycotoxin binders and/or acidifiers and the use of anaesthesia and analgesia in the case of castration of piglets;
- Implementation of alternative systems in poultry farming, larger housing area per laying hen and quail.

Support for the development of knowledge transfer and advisory services (AKIS) – Coherent AKIS is important for the sustainable development of the Agriculture and food sector and helps to increase the competitiveness of companies in the sector, creating additional opportunities for the modernisation of agriculture and rural life, promoting and sharing knowledge, supporting innovation and digital transition, and encouraging their adoption.

Support for Advisory Services – This measure helps to increase awareness of the mutual impact of climate, climate changes and agriculture.

The **Cover crops** requirement is targeting arable land and land under permanent crops that shall be at least 50% under winter vegetation cover. 'Winter vegetation cover' means crops on arable land from 1 November to 31 March, including catch crops, stubble and plant remnants. By way of exception, the requirement for winter vegetation cover is 30% for horticultural producers. This measure was proposed by a study to find cost-effective mitigation measures.

The WAM scenario includes one measure contributing to reducing GHG emissions **– Improvement of manure management**. CO_2 reduction potential of this measure is reflected by significantly lower CH_4 emissions from covered storages compared to uncovered storages with a natural crust. Furthermore, more accurate reductions in GHG emissions need to be explored through research and pilot projects.

In addition to the WEM and WAM measures, there are additional agriculture-related measures that either have a direct effect on GHG emissions or support the implementation of WEM/WAM measures. These are however not included in the GHG projection scenarios:

Audits in large agricultural holdings – The measure includes methodology development, training of the audit team and conducting the audits. As part of the audits, the current situation of companies is assessed and the main measures to improve the situation are proposed.

Studies and pilot projects – The studies and pilot projects would enable the possibility to evaluate the effect of different agricultural practices and technologies on climate more precisely and to develop country-specific emission factors. This is a prerequisite for the effective development and implementation of several agricultural and the EU Common Agricultural Policy´s measures, as the impact of these measures will only contribute to meeting Estonian climate policy objectives in the case that the impact of these measures can be reflected in the GHG inventory.

Increase the proportion of grazing on grassland measure from the Analysis of possibilities raising Estonia´s climate ambition includes the objective of increasing grazing by 15% by 2050, which is considered to be a limiting factor in the growth of GHG emissions. Primarily, non-dairy cattle, sheep and goats are grazed. As a result, the nitrogen compounds found in the manure are fixed in the grassland. Animal welfare support somewhat contributes to this.

Another study to find the most cost-effective measures to achieve the goals of climate policy and the shared responsibility regulation in Estonia includes a **replacement of mineral fertilisers by organic fertilisers** measure. Replacement of mineral fertilisers by organic fertilisers aims to reduce N_2O emissions from the arable soils measure.

National emission control programme for air pollutants (MoE, 2019) submitted under National Emissions reduction Commitments (NEC) Directive (2016/2284/EU) includes two activities also reducing GHG emissions in Agriculture sector:

1. **Low-emission manure spreading techniques** – The measure supports the purchase of equipment for site-specific fertilisation to enable the possibility to reduce the use of nitrogen fertilisers. The objective is to enhance the efficiency of fertiliser use by using site-specific fertilisation equipment (e.g., GPS, equipment for incorporating manure and mineral fertilisers).
2. **Limiting ammonia emissions from the use of mineral fertilisers** – Limitation of ammonia emissions caused by the use of mineral fertilisers by using rapid application of fertilisers to the soil.

The Agriculture, food and rural life programme 2022–2025 includes activities contributing GHG emission reduction. The purpose of **agri-environment** activities include the reduction of negative environmental impact related to the use of fertilisers, plant protection products and GHG emissions and ensuring the preservation of the biodiversity of agricultural land and the diversity of landscapes. In addition, the aim of the programme's activities is to ensure the wider use of environmentally friendly practices in agriculture. In order to further ensure environmental protection, the adoption and continued use of environmentally sustainable management methods in agriculture is encouraged, among other things, with the help of subsidies. The purpose of the **land improvement** activities is to ensure the targeted use of drained agricultural and forest land.

These include the reduction of negative environmental impact related to the use of fertilisers, plant protection products and GHG emissions and ensuring the preservation of the biodiversity of agricultural land and the diversity of landscapes. In addition, the aim of the programme's activities is to ensure the wider use of environmentally friendly practices in agriculture. In order to further ensure environmental protection, the adoption and continued use of environmentally sustainable management methods in agriculture is encouraged, among other things, with the help of subsidies. The purpose of the **land improvement** activities is to ensure the targeted use of drained agricultural and forest land.

Cross-sectoral measures are included in Chapter 4.4.1.

4.4.6. Land use, land-use change and forestry

The Forest Act (2007) provides the legal framework for managing the Estonian forests to ensure protection and sustainable management of the forest as an ecosystem. The Forest Act encompasses the reforestation measure aiming at the recovery of the forest after logging or natural disaster. According to the Forest Act, the forest owner is obliged to ensure reforestation at the latest within five years after the logging or natural disaster. Supporting the fast reforestation after logging favours consistent carbon capture on the woodland and hence preservation of the GHG capture level of Estonian forests. The state also supports private forestry by the training of private forest owners and agricultural advisers, and investments aimed at increasing the economic, ecological, social and cultural value of the forest. Voluntary protection of key habitats in forests is encouraged through compensation for private forest owners.

The **Estonian Forestry Development Plan until 2020** (EFDP 2020) (MoE, 2011) determined the forestry targets for 2011–2020 and described the measures and resources to achieve these targets. The main objective of the EFDP 2020 was to ensure forest productivity and vitality, and the diverse and efficient use of this resource. The EFDP 2020 also included measures for the protection of natural processes and threatened species. Financing of the EFDP 2020 measures that are considered in the projections continues and they are also likely to be included in the next Forestry Development Plan.

The MoE has prepared the draft Forestry Development Plan until 2030 (EFDP 2030) (MoE, 2022). Currently, the EFDP 2030 programme, or implementation plan, is being prepared. The aim of the development plan is to achieve a social agreement on the sustainable management of forests, taking into account social, economic, environmental and cultural aspects. Sustainable forestry means the management of forests in a way that ensures their current biological diversity, productivity, capability for regeneration, vitality and potential and enables the possibility to also perform all functions in the future, without causing harm to other ecosystems. The following planned policy directions have an impact on the LULUCF sector:

- Adaptation of forestry to climate change – The aim is to increase the carbon sequestration and storage in forests in order to alleviate climate change and raise the resilience of forests to the effects of climate change;
- Improving the state of biodiversity in forest ecosystems – Forest management takes into account biodiversity, environmental and climate objectives;
- Enhancing the competitiveness of the Forest sector – One aim of this policy is to ensure greater productivity, quality and good health status of forests;
- Better valorisation of wood – More efficient and resource-efficient wood use is encouraged and supported in the forest and timber industries.

According to the **Earth's Crust Act** (2017), the owner of the extraction permit is obliged to restore the land disturbed by mining. The objective of the restoration is to adjust the land degraded by extraction to forest land, water body, land with recognised value or to any other kind of land that can be used for beneficial purposes.

The main objectives of the **Nature Conservation Act** (2004) are the promotion and preservation of biodiversity, the preservation of the natural environments of cultural or aesthetic value, as well as the promotion of the sustainable use of natural resources. The Act also stipulates the application of compensatory measures for the Natura 2000 areas.

The **Estonian Action Plan for Protected Mires** (2016– 2023) (MoE, 2015) has been prepared to preserve and restore the biodiversity and ecosystem services of Estonia's protected mires. One of the objectives of the plan is to develop methodologies for the restoration of mires and to restore a near-natural water regime in the most prioritised of the degraded mires.

In order to contribute to the preservation of Estonian semi-natural communities, an **action plan for semi-natural grasslands (2021–2027)** (Environmental Board, 2021) has been drawn up. By 2027, the goal is to maintain heritage meadows on at least 50,000 hectares. Planned activities include continued funding for the maintenance of semi-natural communities and the restoration of new habitats, taking into account the coherence and species protection aspects.

European structural and investment funds and LIFE programme have supported several projects to preserve and restore Estonian protected habitats and semi-natural grasslands, and to restore the water level in abandoned cut-away peatlands and degraded wet habitats.

Several activities for supporting the private forestry, and maintaining semi-natural habitats and Natura 2000 sites are (co-)financed through the CAP. Specific objectives set in Estonian CAP Strategic Plan 2023–2027 include contribution to climate change mitigation and adaptation by reducing GHG emissions and enhancing carbon sequestration, and promoting the sustainable and efficient management of natural resources.

LULUCF WEM scenario measures include:

Supporting the reforestation in private forests with native tree species of best possible hereditary characteristics suitable for the site – The overall objective of the measure is to support activities related to the timely regeneration of forests in order to improve the quality of forest resources and ensure the efficient use of forest land production potential. The measure has a positive effect on the growth of new forest which helps to increase carbon uptake.

Reduction of environmental impacts related to the use of fossil fuels and non-renewable natural resources by increasing the Estonian timber production and use – The measure helps to reduce the GHG emissions of fossil fuels and deposit carbon in harvested wood products. Specific activities include information campaigns to promote the use of wood and encouraging the use of wood through green public procurement (public buildings, energy, etc.). The construction of a wooden reference building is planned with the aim of creating experience in the construction of large wooden buildings and thereby increasing the export potential of the Estonian wood sector and promoting the valorisation of local raw materials.

Compensation for nature conservation restrictions on private forest areas outside the Natura 2000 network – Subsidies are paid to the owners of private forests outside Natura 2000 areas in limited management zones, limited-conservation areas and in areas where protection proceedings have been initiated. Protected areas on forest land help to preserve the forest carbon stock.

Protection of woodland key habitats – In state forests, conservation of key habitats is organised by the State Forest Service. Private forest owners may conclude a contract for the protection of a key habitat for 20 years, and the state pays the owner remuneration.

Prevention of bark beetle damage – The aim of the aid is to prevent damage to private forests. Supported activities include the use of trapping trees, the acquisition and installation of pheromone traps and the elimination of fresh storm damage.

Ensuring the protection of biodiversity – The objective of this measure is to ensure the favourable condition of species and habitats, and the diversity of landscape so that the habitats function as a single ecological network and the ecosystem services provided by biodiversity are sustainable. The measure also includes restoration of habitats (mires, semi-natural communities) to achieve their favourable status.

The CAP Strategic Plan 2023–2027 includes the following LULUCF WEM measures:

Investments to support forest adaptation to climate change – Forest investments contribute to mitigating and adapting to climate change, as a growing forest, in particular, accumulates carbon. Maintenance felling in stands up to 30 years old is supported and investments are made for the development of nurseries. The measure also provides support for preventing and eliminating damage caused by fire, pests and storms.

Promoting biodiversity in Natura 2000 private forests – The measure aims to maintain biological and landscape diversity in Natura 2000 areas and outside the Natura 2000 protected areas in the conservation zone, covered with forests.

Cross-sectoral measures are included in Chapter 4.4.1.

4.4.7. Waste

The **Waste Act** (2004) provides waste management requirements for preventing waste generation and the health and environmental hazards arising from waste, including measures for improving the efficiency of the use of natural resources and reducing the adverse impacts of such use and progressive reduction of landfilling of waste that is suitable for recycling or other recovery. The act also includes organisation of waste management including bases and extent of state supervision.

In the beginning of 2021, the Minister of the Environment initiated the preparation of the **National Waste Plan 2022–2028** (NWP 2022-2028) (MoE, 2022b) which will be finalised in the first quarter of 2023. The vision for the NWP 2022–2028 is avoiding waste generation. Products are reused and repaired, generated waste is collected separately which is part of everyday behaviour. The vision is supported by a user-friendly, efficient, transparent and functioning innovative waste management system based on the waste hierarchy. Also, new value is created from waste as raw material.

NWP 2022–2028 is based on three strategic goals:

1. sustainable, conscious production and consumption promotion of waste prevention and re-use;
2. increasing safe material circulation;
3. consideration of the effects of waste management on both the human and natural environment as a whole.

The Circular Economy White Paper (MoE, 2022c) brings together the vision of the ministries and interest groups, the principles of the circular economy and the directions of circular economy development, which are the basis for future activities. The document supports various parties to make the circular economy an overarching framework in planning, consumption, production, politics, lifestyle, culture and values. In the future, the circular economy activity plan includes the activities and metrics of various fields which are highlighted.

In the waste sector, the main measures having an effect on GHG emissions that are already in place include:

Limiting the percentage of biodegradable waste going to landfill and increasing the reuse and recycling of waste materials – The focus of the measure is to increase the volume of recycling of municipal waste, including increasing the recycling of biodegradable waste and reducing the share of biodegradable waste in landfilling, also developing a nationwide waste collection network with a more efficient reporting information system. Consistent guidance on recycling and preparation for re-use of waste and an expanding and simple waste management system will help to increase the amount of waste collected separately and reduce the proportion of biodegradable waste in landfills. The establishment of a national biodegradable waste collection and treatment network is particularly important for reducing GHG emissions from solid waste disposal.

Promoting the prevention and reduction of waste generated, including the environmentally sound management of waste – The general objective of the measure is to improve the resource efficiency of the Estonian economy and to promote waste prevention in order to reduce the negative effects on the environment and human health. The state supports waste prevention by disseminating information. Various initiatives will be used to implement the measure, environmental management measures will be implemented, additional studies will be carried out, investments will be made and the necessary legislation will be supplemented.

Reducing environmental risks arising from waste, improvement of monitoring and supervision – The general objective of the measure is to supplement the range of methods used for the management of hazardous waste and to reduce the environmental risks associated with waste disposal. Closed landfills must be properly managed. Strengthening the monitoring of waste management will help reduce illegal dumping.

Enhancing safe circular material use rate – In order to increase the recycling of different materials and the use of secondary raw materials, we promote the adoption of sustainable production and consumption models. Resource efficiency, including energy efficiency, must be improved in companies, for example by supporting industrial symbiosis, digitalisation and more resource-efficient technologies. Waste management is reorganised based on the waste hierarchy, adopting innovative solutions to reduce waste generation, increase material recycling and ensure the separate collection of waste.

In addition to WEM measures, there are additional waste-related measures that have either a direct effect on GHG emissions or support the implementation of WEM measures. The following additional measures are under discussion and therefore not part of the projection scenarios.

Reduction of food waste – This measure originates from the Estonian food waste prevention plan which is enforced through other action plans. The aim of the measure is to reduce the generation of food waste and food loss in the entire food supply chain, i.e. primary production, food processing and preparation, food retailing and wholesale and other means of delivery, as well as catering and households. This ensures savings in natural resources, economic resources and the burden on the social system.

4.4.8. International bunkers

CO_2 emissions from aviation have been included in the EU ETS since 2012. Under the EU ETS, all airlines operating in Europe, European and non-European alike, are required to monitor, report and verify their emissions, and to surrender allowances against those emissions. They receive emission allowances for free covering a certain level of emissions from their flights per year. In October 2022, the International Civil Aviation Organization (ICAO) Assembly adopted a long-term global aspirational goal (LTAG) for international aviation of net-zero carbon emissions by 2050 in support of the UNFCCC Paris Agreement's temperature goal. The LTAG does not attribute specific obligations or commitments in the form of emissions reduction goals to individual States. Instead, it recognizes that each State's special circumstances and respective capabilities (e.g., the level of development, maturity of aviation markets, sustainable growth of its international aviation, just transition, and national priorities of air transport development) will inform the ability of each State to contribute to the LTAG within its own national timeframe. Each State will contribute to achieving the goal in a socially, economically and environmentally sustainable manner and in accordance with its national circumstances. (ICAO, 2022)

The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) was agreed on by the ICAO in 2018 with the aim of stabilising GHG emissions from international aviation at their pre-COVID 2019-2020 levels. It complements a broader basket of measures, including aircraft technology improvements, operational improvements and sustainable aviation fuels. (Council of the EU, 2022) Airlines are required to monitor emissions on all international routes, offset emissions from routes included in the scheme by purchasing eligible emission units generated by projects that reduce emissions in other sectors (e.g. renewable energy). A regular review of the scheme is required under the terms of the agreement. This should allow for continuous improvement, incl. in how the scheme contributes to the goals of the Paris Agreement. Work is ongoing at ICAO to develop the necessary implementation rules and tools to make the scheme operational. Effective and concrete implementation and operationalization of CORSIA will ultimately depend on national measures to be developed and enforced at domestic level. Estonia, as all other EU Member States, will participate in the voluntary Phase I (2021–2026). Participation of states in the will become mandatory in Phase II (as of 2027) and exemptions will then apply for some states.

International Maritime Organization's (IMO) Marine Environment Protection Committee (MEPC) continues to address GHG emissions from international shipping, with work on track for the adoption of an initial IMO strategy on the reduction of GHG emissions from ships in 2018. Considerable efforts to agree such an approach have been made over recent years within both the IMO and the UNFCCC also with a view to ensure a fair contribution of the sector to the objective of the Paris agreement to limit the average increase of the temperatures to +1.5 °C. In 2016 the IMO in its MEPC 70 meeting reached an agreement on a global data collection system as the next step in their action to tackle CO_2 emissions. Also MEPC 70 agreed to develop a Roadmap for addressing CO_2 emissions from international shipping, with initial CO_2 reduction commitments to be agreed in MEPC 72 by April 2018. In 2017 MEPC 71 adopted guidelines for administration verification of ship fuel oil consumption data (Resolution MEPC.292(71)) and guidelines for the development and management of the IMO ship fuel oil consumption database (Resolution MEPC.293(71)). In October 2018 (MEPC 73), IMO approved a follow-up programme, intended to be used as a planning tool in meeting the timelines identified in the initial IMO strategy and follow-up actions towards the development of the revised Strategy – set to be adopted in 2023. (IMO,2022) At MEPC 79 in December 2022, Parties continued the negotiations for revising the Initial IMO GHG Strategy with the aim to adopt the Revised IMO GHG Strategy at MEPC 80 in 2023.

In June 2013, the EC set out a strategy to progressively integrate maritime emissions into the EU's policy for reducing its domestic GHG emissions consisting 3 consecutive steps: 1. monitoring, reporting and verification of CO_2 emissions from large ships using EU ports; 2. GHG reduction targets for the maritime transport sector; 3. further measures, incl. market-based measures, in the medium to long term. EU has already taken the first step: monitoring, reporting and verification of CO_2 emissions from large ships using EU ports. Large ships over 5000 gross tonnes loading/unloading cargo/passengers from 1 January 2018 at EU maritime ports are to monitor and later report their related CO_2 emissions and other relevant information in accordance with their monitoring plan. Monitoring, reporting and verification of information shall be done in conformity with Regulation 2015/757 (as amended by Delegated Regulation 2016/2071). In July 2021, the EC proposed amendments to the EU Emissions Trading System (EU ETS) Directive (Directive 2003/87/EC). Part of the amendment involved expanding the scope of the EU ETS to include shipping emissions from ships starting from 5000 GT to the system. In December 2022, council and parliament came to a preliminary agreement on all amendments of the EU ETS directive, including expanding it to include shipping starting from 2024.

According to the EU's Marine Strategy Framework Directive (MSFD, 2008/56/EC), all Member States must establish and implement the programme of measures to achieve or maintain good environmental status of the marine areas by 2020. One of the measures under the Programme of measures of the Estonian marine strategy 2016-2020 included creating the readiness to use liquefied natural gas (LNG) as ship fuel that helps to maintain good environmental status of the marine areas, which was fulfilled in 2017. (Ristikivi, 2017)

International bunkers cover International aviation and Navigation. Historically, the emissions from Aviation bunkering form around 10% of all bunkering emissions. The emissions of Aviation bunkering are projected to increase 4 times by 2050 compared to 2020. The reason for the big difference is due to COVID-19, which halted most of the international aviation in 2020 and Tallinn Airport's expansion plans to increase the number of passengers to 6 million by 2035. The total GHG emissions of Marine bunkering are expected to increase by 29.8% by 2050 compared to 2020, as to the current trend. Overall, the GHG emissions from International bunkering are expected to increase by 57.0% in 2050 compared to 2020.

4.5. Assessment of economic and social consequences of response measures

To ensure that European Union's new policy initiatives' potential adverse social, environmental, and economic impacts on various stakeholders, including developing-country parties, are identified and minimised, an impact assessment of new policy initiatives has been established. Specific guidelines for the impact assessment have been adopted in 2009, called Impact Assessment Guidelines. The Impact Assessment guidelines were revised in May 2015, since then called Better Regulation Guidelines. For details please refer to EU BR 1, BR 2 and Section 4.5.2 of the BR 3 (European Union 2014, 2015 and 2017) as well as Chapter 15 of the EU National Inventory Report 2022 (European Union, 2022).

In Estonia, impact assessments (which include the environmental impacts) are carried out in the early stages of the policy-making process.

Estonia also takes measures aiming to reduce GHG emissions through energy savings and aiming at the promotion of renewable energy sources to other parties, including developing-country parties. Estonia is supporting the achievement of climate policy goals in developing countries. The objective of the application round is to bring knowledge and solutions in the field of green technology developed in Estonia to developing countries. Also being supported are activities needed for increasing the capacity and capabilities of developing countries. The connection between the expected results of the project and climate change must be definable in connection with OECD methodology (so-called Rio markers).

4.6. Policies and measures no longer in place

During the reporting period most of the PaMs reported in the previous national communication expired due to the arrival of target dates (2020) of the development plans. As a rule, these policy documents were replaced with the new versions, which in some cases apply similar measures, albeit with some differences in the descriptions of the measures.

4.7. Summaries of policies and measures

A summary of policies and measures in all sectors is included in **Table 4.3.** Brief descriptions of the policies and measures are included in Chapter 4.4 under each sector.

Table 4.3. Summary of policies and measures.

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implementation year	Implementing entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2] 2020 base year	2030	2040	2050
Cross-sectoral – Transport and IPPU										
1. *The GHG reduction from the usage of AdBlue in the Transport sector´s WEM scenario	CO_2	The decrease of Adblue consumption	Economic; Information; Regulatory	Implemented	For individual years, please see the measures under transport section	MoEAC, EIC	-1.13	-1.25	-0.73	-0.22
2. The GHG reduction from the usage of AdBlue in the Transport sector´s WAM scenario	CO_2	The decrease of Adblue consumption	Economic; Information; Regulatory	Planned		MoEAC, EIC		-1.19	-0.67	-0.20
Cross-sectoral – Energy and Agriculture										
1. *Investments into improved performance of agricultural holdings	CH_4, N_2O	The objective is to support the reconstruction or construction of new livestock facilities and provide investments into renewable energy through investments in bioenergy and promote its production.	Economic	Implemented	2015	MoRa	NE	NE	NE	NE
2. *Material and intangible investments by farmers	CH_4, N_2O	The objective is to promote resource efficiency in agricultural production, to prevent the generation of waste and emissions, to reduce the environmental impact of production and greenhouse gas emissions, and to improve biosecurity through tangible investments which may also lead to intangible investments.	Economic	Planned	2024	MoRa	NE	NE	NE	NE
Cross-sectoral – LULUCF and Agriculture										
1. *Agri-environment-climate measures (including three sub-measures)	CO_2, CH_4, N_2O	This measure includes: • Support for environment-friendly horticulture – Promoting the use of environment-friendly practices in gardening. • Regional soil protection support – Ensuring the sustainable use of eroded and peat soils and to minimise soil degradation by improving management of soils and using other activities improving cropland management. • Support for maintaining semi-natural habitats –Ameliorating the conditions of semi-natural habitats and its species by improving grazing land or grassland management.	Economic; Education; Information; Regulatory	Implemented	2015	MoRa	NE	NE	NE	NE

[1] All PaMs marked with an asterisk (*) are included in the WEM scenario projections.

[2] NE – not estimated – Some policies and measures are either not yet quantifiable or do not have an impact in the whole time series. Not quantifiable but implemented measures are impacting the projections through the base year or base period and therefore their impact is included in the projections, although not quantified.

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implementation year	Implementing entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2]			
							2020 base year	2030	2040	2050
2. *Environmentally friendly management	CO_2, CH_4, N_2O	The objective is to support practices that help reduce pressure on surface water, groundwater and human health and contribute to the preservation and enhancement of biodiversity.	Economic; Education; Information; Regulatory	Planned	2023	MoRA	NE	NE	NE	NE
Electricity supply										
1. *The Electricity Market Act	CO_2, CH_4, N_2O	The act regulates the production, storage, transmission, sale, export, import and transit of electricity, as well as the economic and technical management of the electricity system.	Regulatory	Adopted	2003	MoEAC	NE	NE	NE	NE
2. *Renewable energy support through underbidding auctions (technology neutral)	CO_2, CH_4, N_2O	Increase in renewable energy	Economic	Implemented	2019	Elering	-2.95	-268.21	-268.21	-268.21
3. *Support for renewable and efficient CHP-based electricity production	CO_2, CH_4, N_2O	Increase in renewable energy	Economic	Implemented	2007	Elering	-769.16	-471.57	-471.57	-471.57
4. *Investment support for wind parks	CO_2, CH_4, N_2O	Increase in renewable energy	Economic	Implemented	2010	EIC	-412.63	-3864.76	-5927.89	-5927.89
5. *Increasing the share of solar energy in electricity generation	CO_2, CH_4, N_2O	Increase in renewable energy	Economic	Implemented	2019	EIC	-141.47	-383.15	-383.15	-383.15
6. *Introduction of renewable energy in maritime surveillance radar stations on small islands	CO_2, CH_4, N_2O	Increase in renewable energy	Economic	Adopted	2021	MoEAC	NE	-0.01	-0.01	-0.01
7. *Renewable energy support through underbidding auctions (technology specific)	CO_2, CH_4, N_2O	Increase in renewable energy	Economic	Adopted	2025	Elering	NE	-383.15	-383.15	-383.15

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implementation year	Implementing entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2]			
							2020 base year	2030	2040	2050
Heat supply										
1. *The District Heating Act	CO_2, CH_4, N_2O	Governs activities related to the production, distribution and sale of heat by way of district heating networks, and connection to district heating networks.	Regulatory	Adopted	2003	MoEAC	NE	NE	NE	NE
2. *Construction of local heating solutions instead of district heating solution	CO_2, CH_4, N_2O	Efficiency improvement in the Energy and Transformation sector	Economic	Implemented	2017	MoEAC	-0.21	-2.40	-2.40	-2.40
3. *Renovation of depreciated and inefficient heat pipelines	CO_2, CH_4, N_2O	Reduction of losses	Economic	Implemented	2016	MoEAC	-1.41	-14.07	-17.47	-17.47
4. *Renovation of district heating boilers and fuel change	CO_2, CH_4, N_2O	Increase in renewable energy; switch to less carbon-intensive fuels; efficiency improvement in the Energy and Transformation sector	Economic	Implemented	2016	MoEAC	-2.42	-35.03	-57.88	-57.88
5. *Oil boiler replacement programme	CO_2, CH_4, N_2O	Increase in renewable energy; switch to less carbon-intensive fuels; efficiency improvement in the Energy and Transformation sector	Economic	Implemented	2014	EIC	NE	-0.33	-0.33	-0.33
6. Additional renovation of depreciated and inefficient heat pipelines	CO_2, CH_4, N_2O	Reduction of losses	Economic	Planned	2025	MoEAC	NE	-15.16	-15.16	-15.16
7. Additional renovation of district heating boilers and fuel change	CO_2, CH_4, N_2O	Increase in renewable energy; switch to less carbon-intensive fuels; efficiency improvement in the Energy and Transformation sector	Economic	Planned	2025	MoEAC	NE	-37.75	-37.75	-37.75
8. Additional construction of local heating solutions instead of district heating solution	CO_2, CH_4, N_2O	Efficiency improvement in the Energy and Transformation sector	Economic	Planned	2025	MoEAC	NE	-2.58	-2.58	-2.58
Energy consumption – Manufacturing industries and construction										
1. *Support for energy- and resource audits in industries	CO_2, CH_4, N_2O	Increase in renewable energy; switch to less carbon-intensive fuels; energy usage efficiency improvement	Economic	Implemented	2016	EIC	NE	NE	NE	NE

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implementation year	Implementing entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2]			
							2020 base year	2030	2040	2050
2. *Energy and resource efficiency in industries	CO_2, CH_4, N_2O	Increase in renewable energy; switch to less carbon-intensive fuels; energy usage efficiency improvement	Economic	Implemented	2016	EIC	NE	-6.77	-6.77	-6.77
Energy consumption – Other Sectors (Commercial/Institutional and Residential sectors)										
1. *The Product Conformity Act	CO_2, CH_4, N_2O	The purpose of the act is ensure state surveillance over compliance of household appliances, heating appliances and devices with energy efficiency, energy performance labels and ecological design requirements.	Regulatory	Adopted	2010	MoEAC	NE	NE	NE	NE
2. *Energy Sector Organisation Act	CO_2, CH_4, N_2O	The act provides measures for achieving the national target of energy efficiency and promoting renewable energy	Regulatory	Adopted	2016	MoEAC, MoF	NE	NE	NE	NE
3. *Minimum requirements for energy performance regulation	CO_2, CH_4, N_2O	The regulation establishes minimum requirements for the energy performance of buildings, including low energy buildings and nearly zero-energy buildings	Regulatory	Adopted	2019	MoEAC	NE	NE	NE	NE
4. *Support for making the processing of fishery and aquaculture products more energy and resource efficient	CO_2, CH_4, N_2O	Increase in renewable energy; switch to less carbon-intensive fuels; energy usage efficiency improvement	Economic	Implemented	2016	Agricultural Registers and Information Board (ARIB)	NE	-3.64	-3.64	-3.64
5. *Energy efficiency in local government buildings	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Implemented	2020	The State Shared Service Center (SSSC)	-0.05	-0.05	-0.05	-0.05
6. *Energy efficiency in central government buildings	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/Tertiary sector; demand management/reduction	Economic	Implemented	2019	SSSC	-0.05	-0.05	-0.05	-0.05
7. *Arrangement of the basic school network	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Implemented	2018	SSSC	-0.46	-0.72	-0.72	-0.72
8. *Arrangement of the gymnasium network	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Implemented	2018	SSSC	-0.46	-0.72	-0.72	-0.72
9. *Reorganisation of special care institutions	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Implemented	2017	SSSC	-0.15	-0.21	-0.21	-0.21

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implementation year	Implementing entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2]			
							2020 base year	2030	2040	2050
10. *Institutional development programme for R&D institutions and higher education institutions	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Implemented	2016	SSSC	-0.02	-0.02	-0.02	-0.02
11. *Modernisation of health centres	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Implemented	2016	SSSC	-0.19	-0.44	-0.44	-0.44
12. *New childcare and pre-primary education infrastructure	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Implemented	2016	SSSC	-0.10	-0.10	-0.10	-0.10
13. *Kindergarten renovation	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Implemented	2017	EIC	-0.10	-0.10	-0.10	-0.10
14. *Supporting the reconstruction of apartment buildings	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Implemented	2015	KredEx	-9.13	-37.93	-37.93	-37.93
15. *Supporting the reconstruction of small houses.	CO_2, CH_4, N_2O, CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Implemented	2015	KredEx	-0.85	-0.97	-0.97	-0.97
16. *Street lighting reconstruction programme investments	CO_2, CH_4, N_2O	Demand management/reduction	Economic	Implemented	2007	EIC	-4.89	-63.79	-63.79	-63.79
17. Supporting the reconstruction of non-residential buildings in the private sector	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Planned	2025	KredEx, EIC	NE	-2.2	-12.96	-36.36
18. Reconstruction of municipal building	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Planned	2025	SSSC	NE	-18.15	-29.85	-34.17
19. Reconstruction of central government buildings	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Planned	2025	SSSC	NE	-3.70	-5.77	-7.12

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implemen-ting entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2]			
							2020 base year	2030	2040	2050
20. Additional reconstruction of apartment building	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Planned	2025	KredEx	NE	-35.32	-75.49	-110.59
21. Additional reconstruction of small houses	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Planned	2025	KredEx	NE	-9.27	-24.93	-51.39
22. Investments into energy saving of greenhouses and vegetable warehouses and dissemination of renewable energy	CO_2, CH_4, N_2O	Efficiency improvements of buildings; efficiency improvement in Services/ Tertiary sector; demand management/reduction	Economic	Planned	2025	ARIB	NE	-0.13	-0.13	-0.13
Energy consumption – Transport										
1. *Liquid Fuel Act	CO_2, CH_4, N_2O	Grounds and the rules for handling liquid fuel	Regulatory	Adopted	2003	MoEAC	NE	NE	NE	NE
2. *Increasing the share of biofuels in transport	CO_2, CH_4, N_2O	Low carbon fuels	Regulatory	Implemented	2010	MoEAC	-112.62	NE	NE	NE
3. *Promoting the use of electricity in passenger cars	CO_2, CH_4, N_2O	Electric cars	Economic	Implemented	2015	MoEAC	-4.33	-74.31	-519.89	-676.20
4. *Promoting the use of biomethane in buses	CO_2, CH_4, N_2O	Low carbon fuels	Economic	Implemented	2015	EIC	-21.93	-90.96	-44.11	NE
5. *Promoting the use of electricity in buses	CO_2, CH_4, N_2O	Electric buses	Economic	Implemented	2020	EIC	NE	-18.80	-63.39	-97.84
6. *Promoting the use of biomethane in heavy-duty vehicles	CO_2, CH_4, N_2O	Low carbon fuels	Economic	Planned	2036	MoEAC	NE	NE	-46.85	-91.55
7. *Promotion of economical driving	CO_2, CH_4, N_2O	Modal shift to public transport or non-motorised transport; demand management/reduction; improved behaviour	Information	Adopted	2002	MoEAC	-14.06	-14.86	-10.89	-7.47
8. *Reduction of forced movement by passenger car	CO_2, CH_4, N_2O	Demand management/reduction	Planning	Adopted	2015	MoEAC	NE	-18.58	-13.61	-9.34

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implementation year	Implementing entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2]			
							2020 base year	2030	2040	2050
9. *Reorganisation of city streets	CO_2, CH_4, N_2O	Modal shift to public transport or non-motorised transport; demand management/reduction; improved transport infrastructure	Regulatory, Planning	Adopted	2015	MoEAC	NE	-18.58	-13.61	-9.34
10. *Development of convenient and modern public transport	CO_2, CH_4, N_2O	Improved behaviour; improved transport infrastructure	Economic	Implemented	2015	MoEAC	NE	NE	NE	NE
11. *Road usage fees for heavy-duty vehicles based on time	CO_2, CH_4, N_2O	Demand management/reduction; improved behaviour	Fiscal	Implemented	2018	MoEAC	NE	-2.00	-2.00	-2.00
12. *Electric car purchase support	CO_2, CH_4, N_2O	Electric cars	Economic	Implemented	2020	EIC	NE	-14.32	NE	NE
13. *Promotion of clean and energy-efficient road transport vehicles in public procurement	CO_2, CH_4, N_2O	Efficiency improvements of vehicles	Regulatory	Adopted	2021	MoEAC	NE	-15.01	NE	NE
14. *The railroad electrification	CO_2, CH_4, N_2O	Efficiency improvements	Economic	Adopted	2021	MoEAC	NE	-29.43	-29.43	-29.43
15. *Acquisition of additional passenger trains	CO_2, CH_4, N_2O	Electric trains	Economic	Adopted	2020	MoEAC	NE	NE	NE	NE
16. *Developing the railroad infrastructure (includes the building of Rail Baltic)	CO_2, CH_4, N_2O	Modal shift to public transport or non-motorised transport; demand management/reduction	Economic	Adopted	2021	MoEAC	NE	-20.76	-61.16	-61.16
17. *Pilot project for hydrogen	CO_2, CH_4, N_2O	Hydrogen vehicles	Economic	Adopted	2021	EIC	NE	-1.00	-1.00	-1.00
18. *New tram lines in Tallinn	CO_2, CH_4, N_2O	Modal shift to public transport or non-motorised transport; demand management/reduction	Economic	Implemented	2021	MoEAC	-0.11	-0.11	-0.11	-0.11
19. *Making a domestic ferry climate neutral	CO_2, CH_4, N_2O	Efficiency improvements; electric ferry	Economic	Planned	2027	MoEAC	NE	-8.13	-8.13	-8.13

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implementation year	Implementing entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2]			
							2020 base year	2030	2040	2050
20. Additional spatial and land-use measures for urban transport energy savings to increase and improve the efficiency of the transport system	CO_2, CH_4, N_2O	Modal shift to public transport or non-motorised transport; demand management/reduction	Regulatory, Planning	Planned	2023	MoEAC	NE	-29.72	-21.78	-14.94
21. Making an additional domestic ferry climate neutral	CO_2, CH_4, N_2O	Efficiency improvements; electric ferries	Economic	Planned	2035	MoEAC	NE	NE	-8.13	-8.13
22. Additional promotion of economical driving	CO_2, CH_4, N_2O	Modal shift to public transport or non-motorised transport; demand management/reduction; improved behaviour	Information	Planned	2025	MoEAC	NE	-14.86	-10.89	-7.47
23. Road usage fees for heavy-duty vehicles based on mileage	CO_2, CH_4, N_2O	Demand management/reduction; improved behaviour	Fiscal	Planned	2031	MoEAC	NE	-2.00	-2.00	-2.00
24. Vehicle tyre pressure and tyre energy label	CO_2, CH_4, N_2O	Efficiency improvements	Information	Planned	2021	MoEAC	NE	-17.52	-15.38	-10.14
Industrial processes and product use										
1. *Industrial Emissions Act	CO_2	Determines the industrial activities of high environmental hazard, provides the requirements for operation therein and liability for failure to comply with the requirements, and the organisation of state supervision.	Regulatory	Adopted	2013	MoE	NE	NE	NE	NE
2. *Bans and duties from the Regulation (EU) No 517/2014 on fluorinated greenhouse gases and Directive 2006/40/EC related to emissions from mobile air conditioners (MACs)*	HFC	Reduction of emissions of fluorinated gases; replacement of fluorinated gases by other substances	Regulatory	Implemented	2015	MoE	NE	-137.39	-196.45	-208.58

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implementation year	Implementing entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2]			
							2020 base year	2030	2040	2050
3. *Implement best available technologies (BAT)	CO_2	The emission limit values, equivalent parameters or technical measures provided for in integrated permits are based on best available techniques.	Regulatory	Implemented	2013	MoE	NE	-0.065	-0.062	-0.023
Agriculture										
1. *Organic Farming Act	CO_2, CH_4, N_2O	The grounds and extent of supervision exercised over persons operating in the area of organic farming, and for the liability for violation of the requirements established by such legislation	Regulatory	Adopted	2007	MoRa	NE	NE	NE	NE
2. *Water Act	N_2O	Grounds for planning and organising the use and protection of water, the implementation of which will promote sustainable water use	Regulatory	Adopted	2019	MoE	NE	NE	NE	NE
3. *Agri-environment-climate measures (including three sub-measures)	CO_2, CH_4, N_2O	This measure includes: • Regional water protection support: The objectives are to prevent and reduce water nitrogen pollution to preserve the water quality by decreasing agricultural soil leaching. • Support for growing local plant varieties: The objective is to ensure the preservation of the local plant varieties valuable for cultural heritage and genetic diversity. • Support for keeping animals of local endangered breeds- The objective is to ensure the preservation of animal breeds that are endangered and considered important for cultural heritage and genetic diversity.	Economic; Education; Information; Regulatory	Implemented	2015	MoRa	NE	NE	NE	NE
4. *Organic production	CO_2, CH_4, N_2O	The measure helps to reduce GHG emissions by using organic fertilisers instead of mineral fertilisers.	Regulatory; Economic	Implemented	2015	MoRa	NE	NE	NE	NE
5. *Knowledge transfer and information actions	CO_2, CH_4, N_2O	The general objective of the measure is to develop and enhance the technical, economic and environmental knowledge of the enterprisers and their employees in the Agriculture, food and forest sector to improve the bioeconomy and adapt new challenges to use resources sustainably.	Information; Education	Implemented	2015	MoRa	NE	NE	NE	NE
6. *Advisory services, farm management and farm relief services	CO_2, CH_4, N_2O	The general objective of the measure is to enhance the sustainable management or effectiveness of agricultural holdings or enterprisers by providing high-quality advisory services to the people working for agriculture sector.	Information; Education	Implemented	2015	MoRa	NE	NE	NE	NE
7. *Eco-scheme for organic farming	CO_2, CH_4, N_2O	The support is granted to farmers who start conversion to organic farming and engage in organic farming.	Economic, Regulatory	Planned	2023	MoRa	NE	NE	NE	NE
8. *Eco-scheme for ecological focus areas	CO_2, N_2O	Promoting the creation of non-productive areas and landscape features on arable land in order to contribute to biodiversity and mosaic landscapes.	Economic	Planned	2023	MoRa	NE	NE	NE	NE
9. *Support for maintenance of ecosystem services on agricultural land	CO_2, N_2O	The preservation of landscape features and natural areas, with the aim of ensuring the natural enemies of arable land pests providing natural pest management ecosystem services.	Economic	Planned	2023	MoRa	NE	NE	NE	NE

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implementation year	Implementing entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2]			
							2020 base year	2030	2040	2050
10. *Soil and water protection support	CO_2, CH_4, N_2O	In terms of soil protection, the aim is to reduce carbon emissions and protect soil organic carbon stocks and peat soils.	Economic	Planned	2023	MoRa	NE	NE	NE	NE
11. *Support for the maintenance of valuable permanent grassland	CO_2, N_2O	The aim is to preserve permanent grasslands of high biological value, where natural vegetation has been developed or preserved and thus the conditions for species richness are guaranteed.	Economic	Planned	2024	MoRa	NE	NE	NE	NE
12. *Support for maintaining semi-natural grassland	CO_2, N_2O	Semi-natural grasslands plays an important role in adapting to climate change and the sequestration of organic carbon into soils.	Economic	Planned	2023	MoRa	NE	NE	NE	NE
13. *Animal welfare support	CH_4	The objective is to help to reduce the negative environmental impact of livestock farming on air and soil and to increase the number of animals grazed extensively in order to maintain grassland biodiversity without encouraging an increase in the total number of animals and stocking densities.	Economic	Planned	2023	MoRa	NE	NE	NE	NE
14. *Support for the development of knowledge transfer and advisory services (AKIS)	CO_2, CH_4, N_2O	Creating additional opportunities for the modernisation of agriculture and rural life, promoting and sharing knowledge, supporting innovation and digital transition, and encouraging their adoption.	Information, Education	Planned	2023	MoRa	NE	NE	NE	NE
15. *Support for Advisory Services	CO_2, CH_4, N_2O	The objective is to increase awareness of the mutual impact of climate, climate changes and agriculture.	Information, Education	Planned	2024	MoRa	NE	NE	NE	NE
16. *Cover crops	N_2O	The objective of this measure is aimed that arable land and land under permanent crops shall be at least 50% under winter vegetation cover.	Regulatory	Planned	2023	MoRa	NE	NE	NE	NE
17. Improvement of manure management	CH_4	CO_2 reduction potential of this measure is reflected by significantly lower CH_4 emissions from covered storages compared to uncovered storages with a natural crust.	Economic	Planned	2023	MoRa	NE	0.22	0.29	0.36
LULUCF										
1. *The Forest Act	CO_2, CH_4, N_2O	Regulates the directing of forestry, forest survey and management in order to ensure the protection and sustainable management of the forest as an ecosystem.	Regulatory	Adopted	2007	MoE	NE	NE	NE	NE
2. *Earth's Crust Act	CO_2, CH_4, N_2O	To ensure sustainable and economically efficient use of the earth's crust.	Regulatory	Adopted	2017	MoE	NE	NE	NE	NE
3. *Nature Conservation Act	CO_2, CH_4, N_2O	To promote the preservation of biodiversity, natural environments and sustainable use of natural resources.	Regulatory	Adopted	2004	MoE	NE	NE	NE	NE

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implemen-ting entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2]			
							2020 base year	2030	2040	2050
4. *Supporting the reforestation in private forests with native tree species of best possible hereditary characteristics suitable for the site	CO_2	The aim is to support activities related to the timely regeneration of forests in order to improve the quality of forest resources and ensure the efficient use of forest land production potential.	Economic	Implemented	2012	MoE	NE	NE	NE	NE
5. *Reduction of environmental impacts related to the use of fossil fuels and non-renewable natural resources by increasing the Estonian timber production and use	CO_2	The measure helps to reduce GHG emissions of fossil fuels and deposit carbon in harvested wood products. Specific activities include information campaigns to promote the use of wood and encouraging the use of wood through green public procurement.	Economic; Infor-mation	Implemented	2012	MoE	NE	NE	NE	NE
6. *Compensation for nature conservation restrictions on private forest areas outside the Natura 2000 network	CO_2, CH_4, N_2O	Subsidies are paid to owners of private forests outside Natura 2000 areas in limited management zones, limited-conservation areas and in areas where protection proceedings have been initiated.	Economic	Implemented	2022	MoE	NE	NE	NE	NE
7. *Protection of woodland key habitats	CO_2, CH_4, N_2O	In state forests, the conservation of key habitats is organised by the State Forest Service. Private forest owners may conclude a contract for the protection of a key habitat for 20 years.	Regulatory; Voluntary; Economic	Implemented	2009	MoE	NE	NE	NE	NE
8. *Prevention of bark beetle damage	CO_2	Supported activities include the use of trapping trees, the acquisition and installation of pheromone traps and elimination of fresh storm damage.	Economic	Implemented	2021	MoE	NE	NE	NE	NE
9. *Ensuring the protection of biodiversity	CO_2, CH_4, N_2O	The objective of this measure is to ensure favourable condition of species and habitats, and the diversity of landscape. The measure also includes restoration of habitats (mires, semi-natural communities) to achieve their favourable status.	Economic, Regulatory, Information, Research	Implemented	2020	MoE	NE	NE	NE	NE
10. *Investments to support forest adaptation to climate change	CO_2, CH_4, N_2O	Maintenance felling in stands up to 30 years old is supported and in-vestments are made for the development of nurseries. The measure also provides support for preventing and eliminating damage caused by fire, pests and storms.	Economic	Planned	2023	MoRA	NE	NE	NE	NE
11. *Promoting biodiversity in Natura 2000 private forests	CO_2, CH_4, N_2O	The measure aims to maintain biological and landscape diversity in Natura 2000 areas and outside the Natura 2000 protected areas in the conserva-tion zone, covered with forests.	Economic	Planned	2023	MoRA	NE	NE	NE	NE

Name of policy or measure[1]	GHG affected	Objective and/or activity affected	Type of instrument	Status	Implementation year	Implementing entity	Total GHG estimate of mitigation impact, kt CO_2 eq.[2]			
							2020 base year	2030	2040	2050
Waste										
1. *Waste Act	CO_2, CH_4, N_2O	Includes requirements for preventing waste generation and the health and environmental impact arising from waste.	Regulatory	Adopted	2004	MoE	NE	NE	NE	NE
2. *Limiting the percentage of biodegradable waste going to landfill and increasing the reuse and recycling of waste materials	CH_4, N_2O	The objective is to increase the volume of recycling of municipal waste, including increasing recycling of biodegradable waste and reducing the share of biodegradable waste in landfilling.	Regulatory; Planning	Implemented	2014	MoE	NE	NE	NE	NE
3. *Promoting the prevention and reduction of waste generated, including the environmentally sound management of waste	CH_4, N_2O	The objective is to improve the resource efficiency of the Estonian economy and to promote waste prevention in order to reduce the negative effects on the environment and human health.	Regulatory; Information	Implemented	2014	MoE	NE	NE	NE	NE
4. *Reducing environmental risks arising from waste, improvement of monitoring and supervision	CH_4	The objective is to supplement methods used for the management of hazardous waste and to reduce the environmental risks associated from waste disposal.	Information	Implemented	2014	MoE	NE	NE	NE	NE
5. *Enhancing safe circular material use rate	CH_4	The objective is to promote the adoption of sustainable production and consumption models and improving material circularity	Regulatory	Implemented	2021	MoE	NE	NE	NE	NE

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5. Projections and the total effect of policies and measures

Key developments:

- Estonia has compiled two projection scenarios. First, there is the With Existing Measures (WEM) scenario (evaluates future GHG emission trends under the current policies and measures). In the second scenario, a number of additional measures and their impact are taken into consideration, forming the basis for the With Additional Measures (WAM) scenario.
- Projections of greenhouse gas emissions have been calculated for the period of 2021–2050 and 2020 has been used as a reference year (NIR, 2022).
- Estonia's greenhouse gas emissions are expected to decrease by around 64.61% in the WEM scenario (without LULUCF) and about 66.55% in the WAM scenario (without LULUCF) by 2050 compared to the base year of 2020. GHG emissions in the WEM scenario (with LULUCF) are expected to decrease by around 46.48% and in the WAM scenario (with LULUCF) by about 64.69% by 2050 compared to the base year of 2020.
- GHG emission reduction in the Energy sector is driven by the Energy industries. This is due to the phasing out of oil shale pulverised combustion in these plants and the building of a more effective oil shale combustion plant, along with the introduction of new shale oil production plants (fluidised bed combustion).
- According to the projections, the LULUCF sector is expected to remain a source of GHGs in both scenarios, meaning that total emissions arising from the sector will exceed the total removals. The WEM scenario assumes the continuation of current forest management practices and intensity, whereas the WAM scenario is based on the assumption of uniform final felling which is proposed in the draft Forestry Development Plan until 2030.

Introduction

The main objective of this chapter is to give an indication of future trends of greenhouse gas (GHG) emissions in Estonia, given the policies and measures implemented and adopted. Projections are given for all greenhouse gases considered in the United Nations Framework Convention on Climate Change (UNFCCC), presented in the following sectors (CRF categories): Energy (incl. transport); Industrial processes and product use (IPPU); Agriculture; Land use, land use change and forestry (LULUCF); and Waste. Projections of GHG emissions have been calculated for the period of 2021–2050. 2020 has been used as a reference year. Activity data for the base year of 2020 is in accordance with the latest, 2022 National GHG Inventory (submitted to the UNFCCC on 15 April 2022). Projections have been calculated using AR4 GWP-s.

For indirect emissions, activity data for the base year 2020 and trends are in accordance with the Estonian Informative Inventory Report (Estonian Environmental Agency, 2022) submitted under the Convention on Long-Range Transboundary Air Pollution.

Two projection scenarios are presented. The With Existing Measures (WEM) scenario evaluates future GHG emission trends under the current policies and measures. In the second scenario, a number of additional measures and their impact are taken into consideration in forming the basis for the With Additional Measures (WAM) scenario.

The projections in the current National Communication (NC) are updated, compared to the previous National Communication (NC7). The projections are updated because pursuant to Regulation No. 2018/1999 of the European Parliament and Council, EU Member States must update their GHG projections every two years. Key assumptions and differences in assumptions between the current NC and the previous NC are presented in Chapter 5.5.

5.1. Projections

Projections of GHG emissions have been calculated for the period of 2021–2050 and 2020 from the NIR 2022 has been used as a reference year. Two scenarios are presented. The WEM scenario evaluates future GHG emission trends under the current policies and measures. In the second scenario, a number of additional measures and their impact are taken into consideration, forming the basis for the WAM scenario.

5.1.1. Energy (excluding transport)

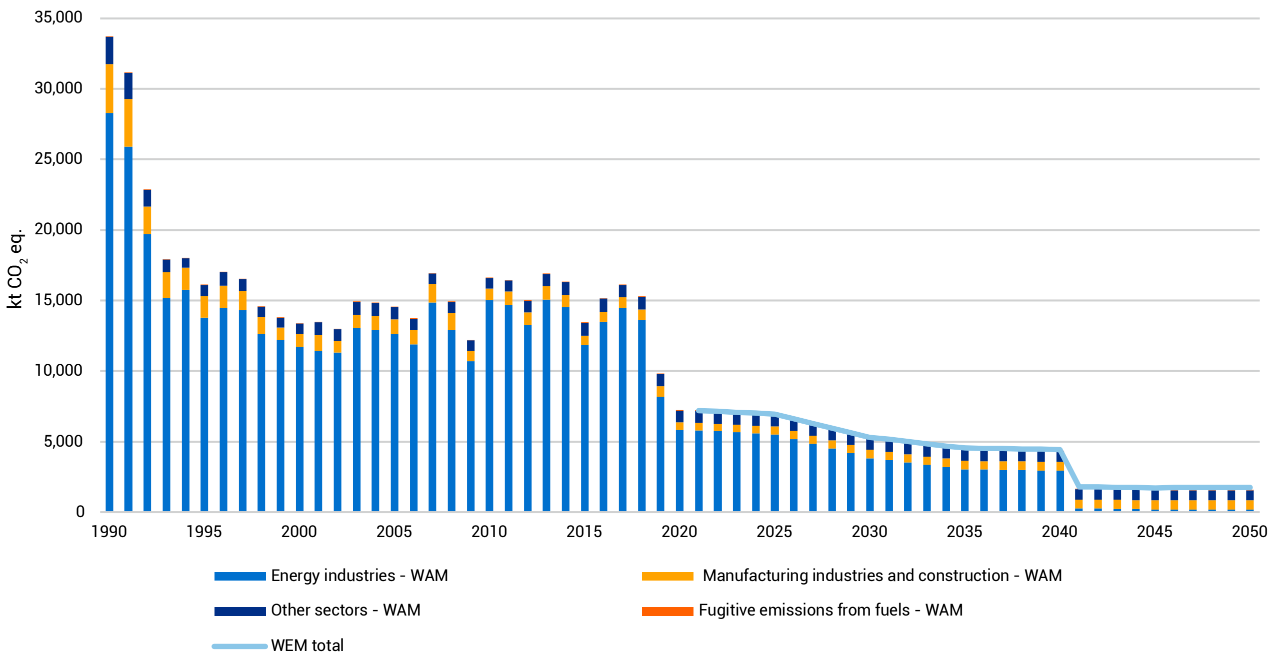

Figure 5.1. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) from the Energy sector according to the WEM and WAM scenarios, kt CO^2 eq.

The Energy sector (excluding transport) includes GHG emissions from the consumption and production of fuels and energy (electricity and heat). The main sub-sectors in this sector are: Energy industries; Manufacturing industries and construction; Other sectors (incl. Commercial/institutional, Residential, Agriculture/Forestry/ Fishing/Fish farms and Military) and Fugitive emissions from natural gas distribution. The GHG emission decrease in 2020 compared to the previous two years was primarily in the Energy industries, because of the EU ETS emission allowance price increase and lower electricity prices.

The Energy sector's projected emissions in the WEM scenario are presented in **Figure 5.1**. In the WEM scenario, the emissions are projected to decrease by 75.7% from 2020 to 2050. The largest absolute decrease occurs in the Energy industries.

The main electricity producer in Estonia is Enefit Power AS incl. the Eesti Power Plant and the Balti Power Plant. Both plants mainly use oil shale for electricity production. Enefit power plants are also the largest producers of GHG emissions in Estonia. This is due to the phasing out of oil shale pulverised combustion in these plants, the building of a more effective Auvere oil shale combustion plant, and the introduction of new shale oil production plants (fluidised bed combustion). It is planned by the companies to phase-out shale oil in solid heat carrier technology based shale oil plants, which causes a larger decrease in GHG emissions between 2040 and 2041 (**Figure 5.1**). The GHG emissions are projected to decrease by 95.4% by 2050 compared to 2020 in the Energy industries sector.

GHG emissions in the Manufacturing and construction sector (divided into iron and steel; non-ferrous metals; chemicals; pulp, paper and print; food processing, beverages and tobacco; non-metallic minerals; and other industries) are projected to increase by 28.3% by 2050 compared to 2020. In this sector, only the scenario is projected, as there are no additional planned policies or measures.

The emissions in Other sectors (Commercial/institutional, Residential and Agriculture/Forestry/Fishing/Fish farms) are expected to decrease by 4.7% in 2050 compared to 2020.

The projected emissions together with the 2022 NIR information of the Energy sector in the WAM scenario are presented in **Figure 5.1**. In the WAM scenario, the emissions are projected to decrease by 78.3% in the period of 2020 – 2050. The increased reduction of GHGs in the WAM scenario results from higher energy efficiency requirements for buildings (entails additional funding for renovation purposes) and district heating networks, which help to decrease energy consumption for heat production. Decreased GHG emissions also result from an increased amount of energy unions that help to produce energy more efficiently for certain locations or interest groups. The largest absolute decrease occurs in the Energy industries sector. The decrease is projected to be 96.6% in the period of 2020 – 2050.

5.1.2. Transport

The main share of GHG emissions in the Transport sector originate from road transport. In 2020, the share of GHG emissions from road transport was around 97.4% of total GHG emissions of the Transport sector.

The emissions in the Transport sector in the WEM scenario are expected to decrease by around80.2% in 2050 compared to 2020. The emissions in Road transport are projected to

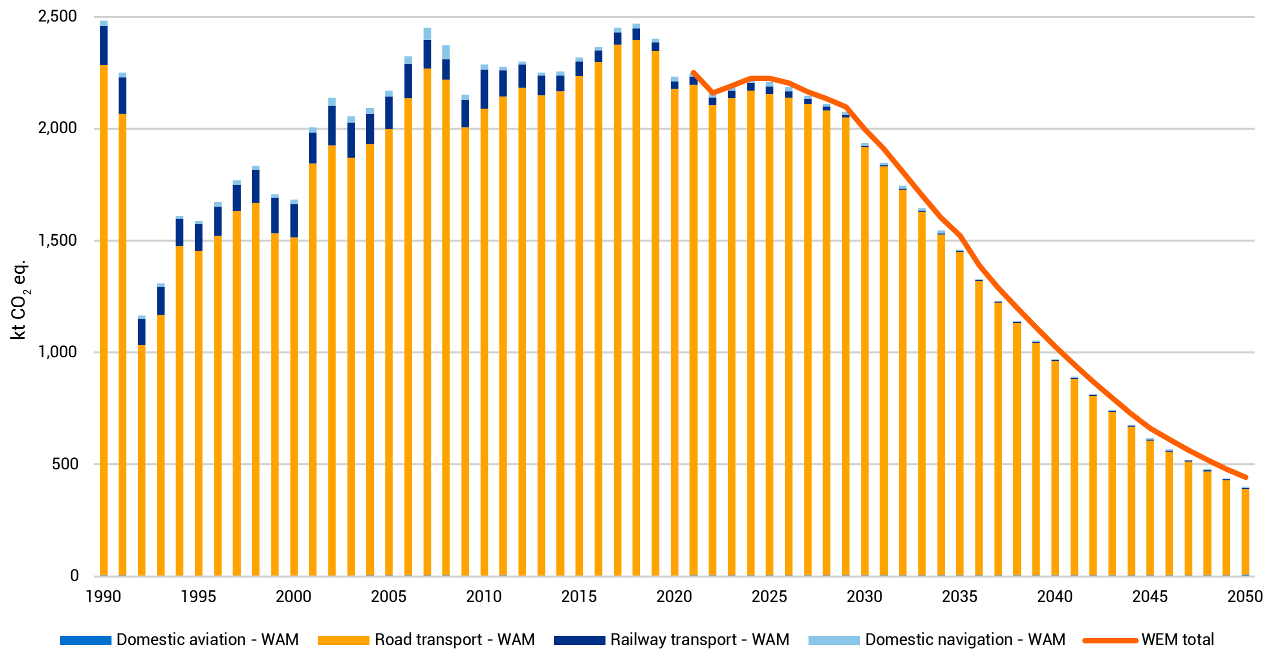

Figure 5.2. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) from the Transport sector in the WEM and WAM scenarios, kt CO_2 eq.

decrease in both the WEM and WAM scenario. The total projected GHG emissions in the WEM and WAM scenarios are presented in the Figure 5.2.

The emissions in the Transport sector in the WAM scenario are expected to decrease by 82.0% in 2050 compared to 2020. Domestic aviation and Railway emissions are expected to stay at approximately the same level (as in the WEM scenario) during the period of 2018–2050. Domestic navigation and Road transport emissions are projected to decrease compared to the base year. The largest emission reductions occur in the Road transport sector – emissions are projected to decrease by 82.3% in 2050 compared to 2020 to a total of 384.90 kt CO_2 eq in the WAM scenario, which is the result of implementing additional measures that will help lower demand for private transport even more. However, the biggest driver for the steep decrement of GHG emissions in the WEM and WAM scenarios is the uptake of electric vehicles. This is reinforced by measures which support the promotion of electric vehicles and the notion that from 2035 all new passenger cars have to meet the criteria of 0 gCO_2/km (in accordance with the Regulation (EC) No 2019/631 of the European Parliament and of the Council).

5.1.3. IPPU

Emissions from the IPPU sector are projected according to the WEM and WAM scenarios whereby WAM only affects the emissions from urea-based catalysts for motor vehicles.

The WAM scenario for IPPU is projected because additional measures in the transport sector– additional promotion of economical driving, road usage fees for heavy-duty vehicles, vehicle tyres and aerodynamics – have an effect on subsector 2.D.3 Other – Urea-based catalysts for motor vehicles. In the WAM scenario diesel fuel consumption decreases, as does the consumption of urea-based diesel exhaust fluid. The GHG emission impact is included in Chapter 4.7.

The overall emissions from the IPPU sector are projected to decrease by 45.17% from 2020 until 2050 in the WEM scenario and 45.18% in the WAM scenario.The main decrease comes from the mineral industry (because a large plant has ceased its clinker production) and product uses as substitutes for ODS (F-gases).

Emissions from the mineral industry already decreased in 2020 when the cement industry ceased burning clinker in wet process kilns because it was not economically feasible anymore (production only took place in the first 3 months of 2020). The plant does not foresee starting production again. Other mineral industries estimated future production volumes in 2025 either as the same as in 2020 or up to 50% higher. After 2025 the production volumes will stabilise. Nevertheless, total emissions from the mineral industry sector remain ca 5 times lower than before the shutdown of clinker production.

Estonia's chemical industry sector emissions originate from the ammonia industry. The plant operator has announced that it has sold all of 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.

In the metal industry production volumes will rise by around 10% from 2020 to 2022, as will the emissions from this category, and then stay the same until 2050. The metal industry made up 0.47% of the emissions in the year 2020 (2.9 kt CO_2 eq.), therefore the rise will not strongly influence the overall emissions.

Emissions (both direct and indirect CO_2) from non-energy products from the Fuels and solvent subsector use (2.D.3) are projected to decrease in both the WEM and WAM scenarios –19.8% from 2020 until 2050. Emissions from most subcategories (Use of diesel exhaust fluid AdBlue and Use of paraffin wax and solvents) are projected to decrease and emissions from the subcategory lubricant use are projected to increase. A smaller part of these emissions are the CO_2 emissions from urea containing diesel exhaust fluid use which decrease by 80.2% from 2020 until 2050 in WEM scenario and 82.3% in the WAM scenario. This difference in WAM scenario is mainly caused by curbing diesel fuel consumption and urea containing diesel exhaust fluid consumption as a result of additional measures in the transport sector.

Emissions from lubricants are projected to increase by 20% (up to 0.6 kt CO_2 eq.) from 2020 until 2050. Consumption of these products depends on the economic situation of many small industries (linked to real GDP growth rate). Given the economic growth (the Ministry of the Finance) these emissions are projected to increase.

Emission of NMVOCs from the solvents sector and indirect CO_2 from NMVOCs is projected to decrease. Although the consumption of solvent containing products has an upward trend because of its correlation with GDP growth, the emission factors have a declining trend. Concerning paints (2.D.3.d Coating applications) probably the Directive 2004/42/CE on the limitation of emissions of VOCs from paints and varnishes and vehicle refinishing products has contributed to declining emission factors. The same declining trend of emission factors can be seen in the Domestic use of solvents (2.D.3.a) and it results from the restrictions of the regulations (EC) No 648/2004 on detergents, (EC) No 1223/2009 on cosmetic products and (EU) No 528/2012 on biocidal products. In some subcategories NMVOCs decrease because of the declining population. In comparison to 2020 the emissions are projected to decrease by 24% by 2030 and stay around the same level until 2050.

Emissions of HFC-s (substitutes for ozone-depleting substances (ODS) are projected to be the same in the WEM and WAM scenarios. HFC emissions projections will decrease by 68% from 2020 to 2050. The majority of R-404A containing equipment (to which installation and servicing bans are applying from 2020) should be decommissioned until 2035 and also most old split-type air conditioners and heat pumps.

Directive 2006/40/EC has a gradual effect on HFC emissions until 2030 when most old vehicles equipped with HFC-134a based air conditioners should have been replaced.

Emissions of SF_6 reported under the CRF subcategory Other product manufacture and use are projected to rise steadily until 2050 when they are projected to be 65% larger than today (according to the WEM and WAM scenarios). SF_6 insulated electrical equipment is not directly affected by Regulation (EU) No. 517/2014. Until 2030 new equipment is installed instead of old air insulated switchgear. After 2030 emissions continue to rise because many items of SF_6 insulated equipment exceeding their service life will be decommissioned. After 2040 it is assumed that no more medium-voltage switchgear with SF_6 will be installed.

N_2O emissions from the subcategory Other product manufacture and use are projected to decline from 2020 to 2050 by 76% as the use of N_2O is connected to declining population numbers.

The historical and projected emissions in 1990–2050 according to WEM and WAM scenarios are depicted in Figure 5.3.

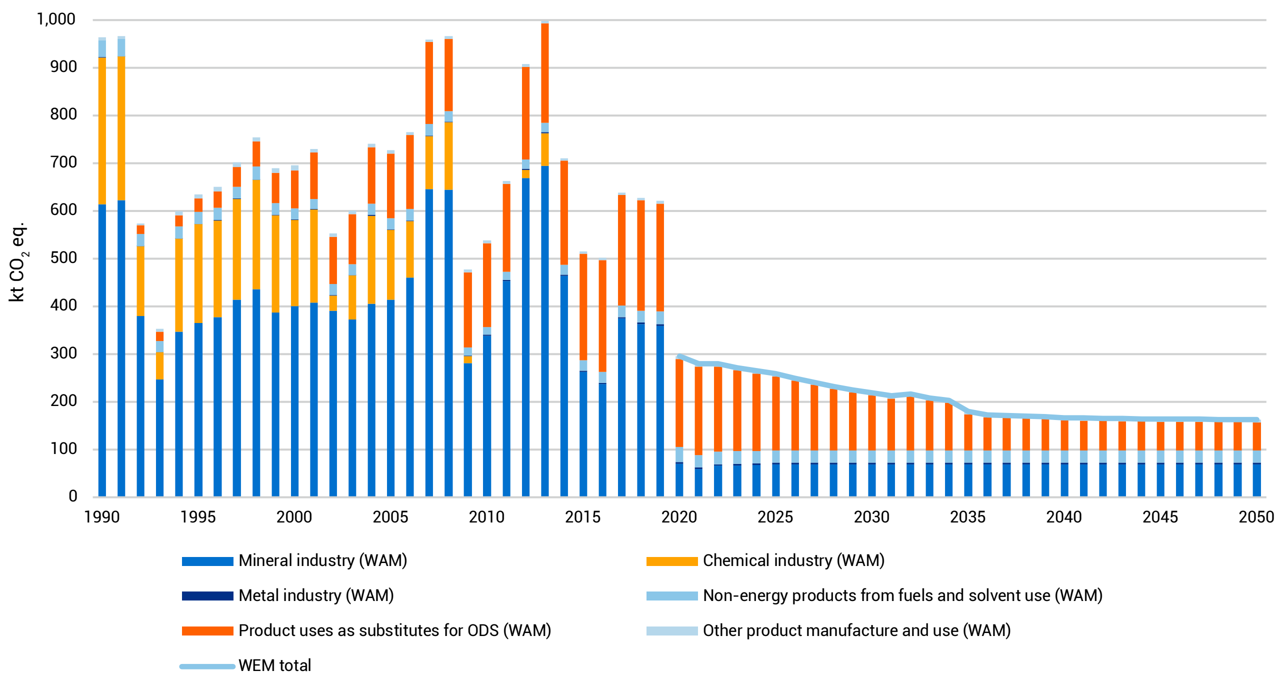

Figure 5.3. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) from the IPPU sector (with Solvent use) according to the WEM and WAM scenarios, kt CO_2 eq.

5.1.4. Agriculture

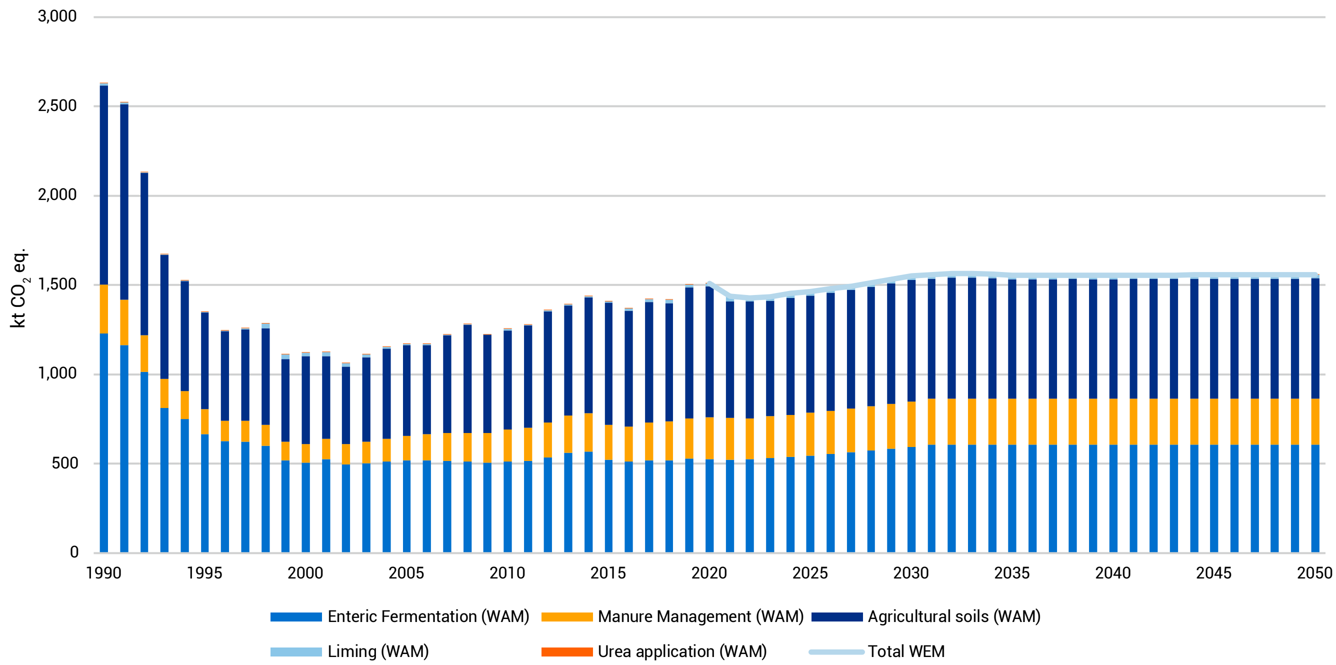

Figure 5.4. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) from the Agriculture sector in the WEM and WAM scenarios, kt CO_2 eq.

According to the WEM scenario, emissions from the Agriculture sector will increase from 1,508.38 kt CO_2 eq. in 2020 to 1,558.08 kt CO_2 eq. (3.30%) by 2050 (**Figure 5.4**). Increase in the Enteric fermentation sub-sector is projected to be 81.64 kt CO_2 eq., in Manure management 23.63 kt CO_2 eq., in Agricultural soils the emissions are projected to decrease by 61.88 kt CO_2 eq., in Liming to increase 6.31 kt CO_2 eq. and in Urea application to stay at the same level, at 0.13 kt CO_2 eq. in 2050 compared to 2020. According to the WAM scenario, emissions will increase from 1,508.38 kt CO_2 eq. to 1,558.44 kt CO_2 eq. (3.32%) by 2050.

Differences in WEM and WAM scenarios' results were caused by implementing the measure Improvement of manure management. The WAM measure only affected the Manure management and Agricultural soils sub-sectors due to the projected changes in the shares of types and covers of the manure stores. As the measure aims to increase the share the covering of manure storages, it decreases NH_3 emissions due to the decrease of direct sunlight (temperature impacts) and wind effects on the storage surface. On the contrary, covering the manure storages increases N_2O emissions as more N_2O is emitted in anaerobic conditions. This caused the increase of WAM scenario´s total GHG emissions from the Agriculture sector compared to WEM scenario.

5.1.5. LULUCF

GHG emissions from the LULUCF sector are projected according to the 'With Existing Measures' (WEM) and 'With Additional Measures' (WAM) scenarios. The WAM scenario only concerns the Forest land and HWP categories: the WEM scenario assumes the continuation of current forest management practices and intensity, whereas the WAM scenario is based on the assumption of uniform final felling which is proposed in the draft Forestry Development Plan until 2030 (Ministry of the Environment, 2022).

The projected area of land use by classes is the same for both the WEM and WAM scenarios and is presented in **Table 5.1**.

Table 5.1. Projected land use in the LULUCF sector, thousand hectares

Land use class	2020 (2022 inventory)	2025	2030	2040	2050
Forest land	2,443.5	2,443.5	2,443.5	2,443.5	2,443.5
Cropland	985.6	985.6	985.6	985.6	985.6
Grassland	274.7	268.0	260.9	250.5	240.4
Wetlands	428.4	427.4	426.4	424.5	422.6
Settlements	359.8	366.9	374.3	385.4	396.2
Other Land	42.0	42.5	43.1	44.4	45.6
LULUCF Total	**4,533.9**	**4,533.9**	**4,533.9**	**4,533.9**	**4,533.9**

Total Forest land and Cropland areas were expected to remain equal to the area in 2020. The projected areas of Wetlands and Other land categories are also relatively stable. Grassland area will decrease when the current land-use trends continue, even considering the planned deforestation due to restoration of semi-natural communities (heritage meadows). The area under Settlements will increase, as a result of the continuation of current trends and several planned large infrastructure projects.

According to the projections, the LULUCF sector is expected to remain a source of GHGs in both scenarios (**Figure 5.5** and **Figure 5.6**), meaning that total emissions arising from the sector will exceed total removals. The projected overall emissions from the LULUCF sector were 2,788.74 and 672.94 kt CO_2 eq. in 2050 according to the WEM and WAM scenarios, respectively.

In the WEM scenario (total felling volume is 11.5 mln m^3 year-1), Forest land will act as a net source. Projected changes in forest growing stock primarily depend on the age distribution of forests, growing stock changes were projected as ten-year averages. Due to the high proportion of mature and premature forest stands and increasing proportion of forest area belonging to the first development classes (treeless area, area under regeneration and young stands), the capacity of carbon sequestration in tree biomass has decreased in recent years and the decline is expected to continue during the next decades. According to the WEM scenario, total forest growing stock will be approximately 11% lower in 2050 than it is now. In addition, conversion from other land categories to Forest land has been slowing in recent years, and in the future, cumulative areas of Land converted to forest land categories will decrease further. Net emissions from the Forest land category are projected to increase from 139.28 kt CO_2 eq. in 2020 up to 1,502.29 kt CO_2 eq. in 2041. After that, net emissions will decrease to 668.11 kt CO_2 eq. in 2050 as the decline of the forest growing stock is expected to slow down.

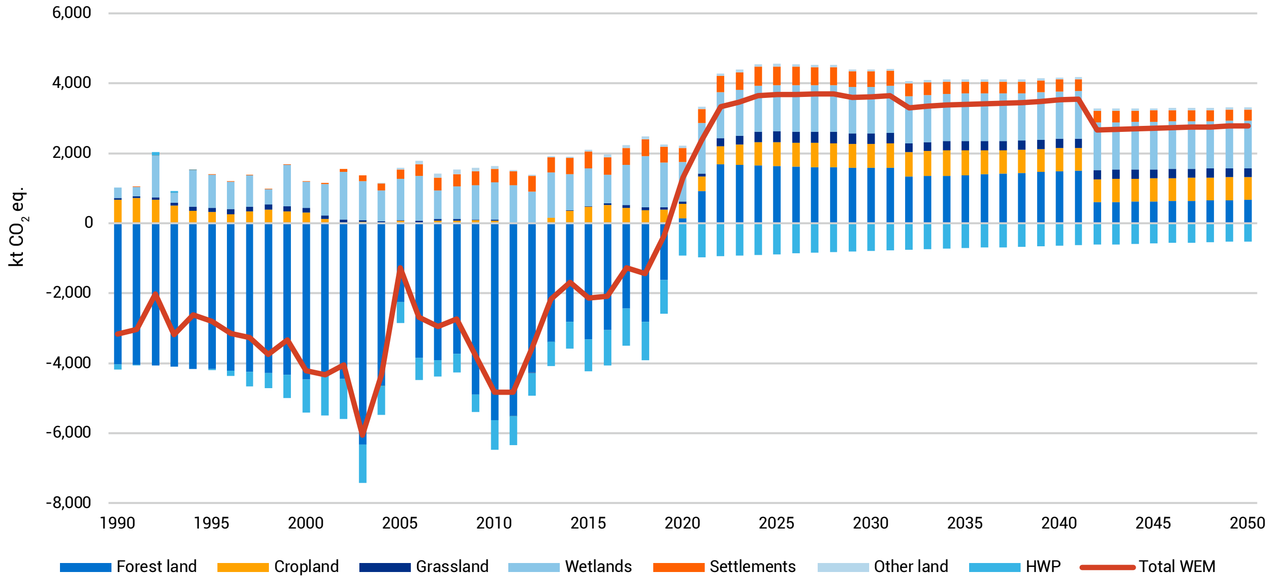

Figure 5.5. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) from the LULUCF sector by land use class according to the WEM scenario

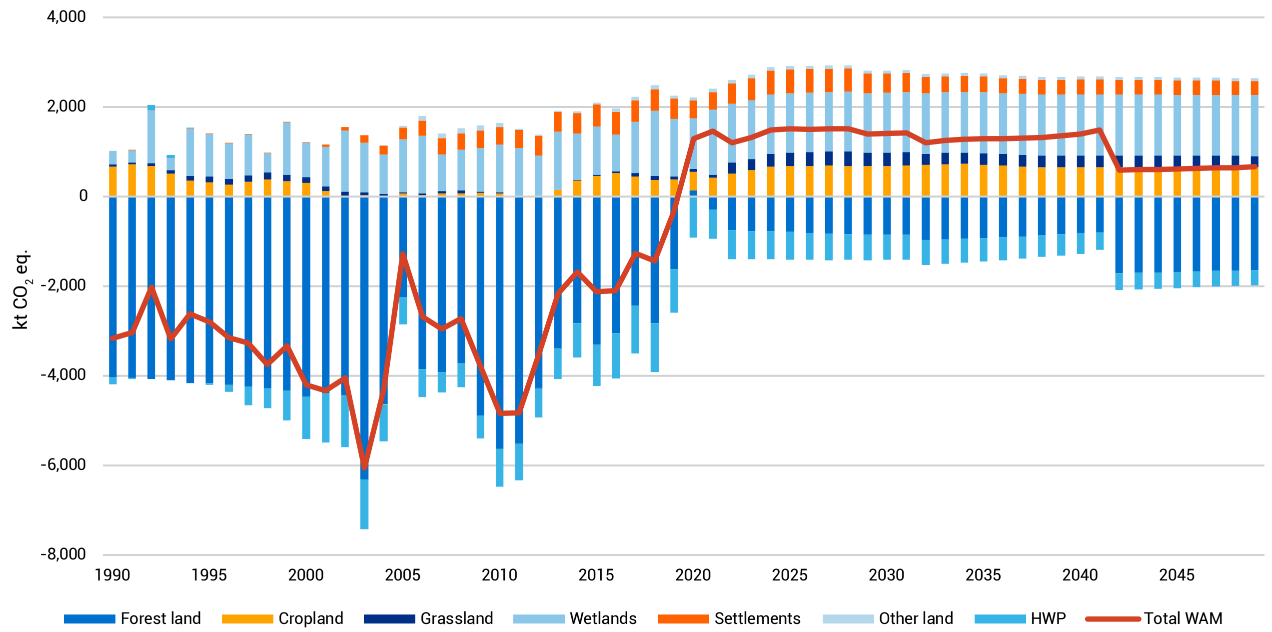

Figure 5.6. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) from the LULUCF sector by land use class according to the WAM scenario

In the WAM scenario (total felling volume is 9.4–9.8 mln m^3 year-1), Forest land and HWP will sequester carbon. It is expected that in 2022–2041 the forest growing stock will remain stable and CO_2 sequestration from Forest land will increase slightly over the period to -805.33 kt CO_2 eq. by 2041. Net removal from Forest land will increase due to increasing growing stock in 2042–2050 and net removal reaches -1,640.85 kt CO_2 eq.

C sequestration in HWP will decrease in the WEM and WAM scenarios. According to the WEM scenario, removals from HWP will decrease from -922.24 kt CO_2 in 2020 to -520.35 kt CO_2 by 2050. In the WAM scenario, the removals are projected to decrease to -327.18 kt CO_2 in 2050. It is likely that the production of wood products will become more efficient and thus it can be assumed that production volumes and consequently carbon sequestration has been considered rather conservatively. Estonia is also planning to build a pulp mill, which will have a bigger impact in the first ten years, during which the HWP category would sequester an additional 200 kt CO_2 per year.

Emissions from the Cropland category are expected to increase compared to the current level (417.73 kt CO_2 eq. in 2020), although the total cropland area, land use and management practices are expected to remain the same. This is because Estonia uses the default method with aggregated activity data for calculating C stock changes in cropland mineral soils. According to this methodology, soil organic C reaches a stable value over 20 years given that land use and management practices do not change during that period. In 2050, the projected emissions from the Cropland category are 651.65 kt CO_2 eq. Emissions mainly originate from the cultivation of organic soils, and smaller part also from land conversion to croplands.

Net emissions from the Grassland category are projected to increase from 64.14 kt CO_2 eq. in 2020 up to 255.61 kt CO_2 eq. in 2050. Currently, emissions mostly result from the drainage of organic soils; these emissions are expected to remain stable, but C losses from deforestation due to the restoration of heritage meadows will increase significantly in the future.

In total, estimated emissions from the Wetlands category are expected to increase by 20.2% in the 2020–2050 period, reaching up to 1,359.49 kt CO_2 eq. in 2050. Of this, 1,189.95 kt CO_2 results from the production and use of horticultural peat and 149.10 kt CO_2 eq. are emitted by active and rewetted peat extraction sites.

Under the Settlements and Other land categories, only emissions arising from the land conversions have been reported. Several planned infrastructure projects will increase land conversion to Settlements significantly in the period of 2022–2031. Projected emissions will reach the maximum value (538.49 kt CO_2 eq.) in 2024 and then decline to 309.93 kt CO_2 eq. in 2050. There are no quantitative estimates of land use changes for a number of proposed projects, such as military training grounds and onshore wind farms and due to this they are not included in the projections.

It was assumed that annual land conversions to Other land will continue to occur at the same level as the average of 2016–2020. The total cumulative area of Land converted to other land category and related emissions are expected to decrease slightly, to the level of 64.29 kt CO_2 eq. in 2050.

5.1.6. Waste

Since there are no additional measures intended in the Waste sector then the WAM scenario emissions are equal to the WEM scenario emissions (Figure 5.7).

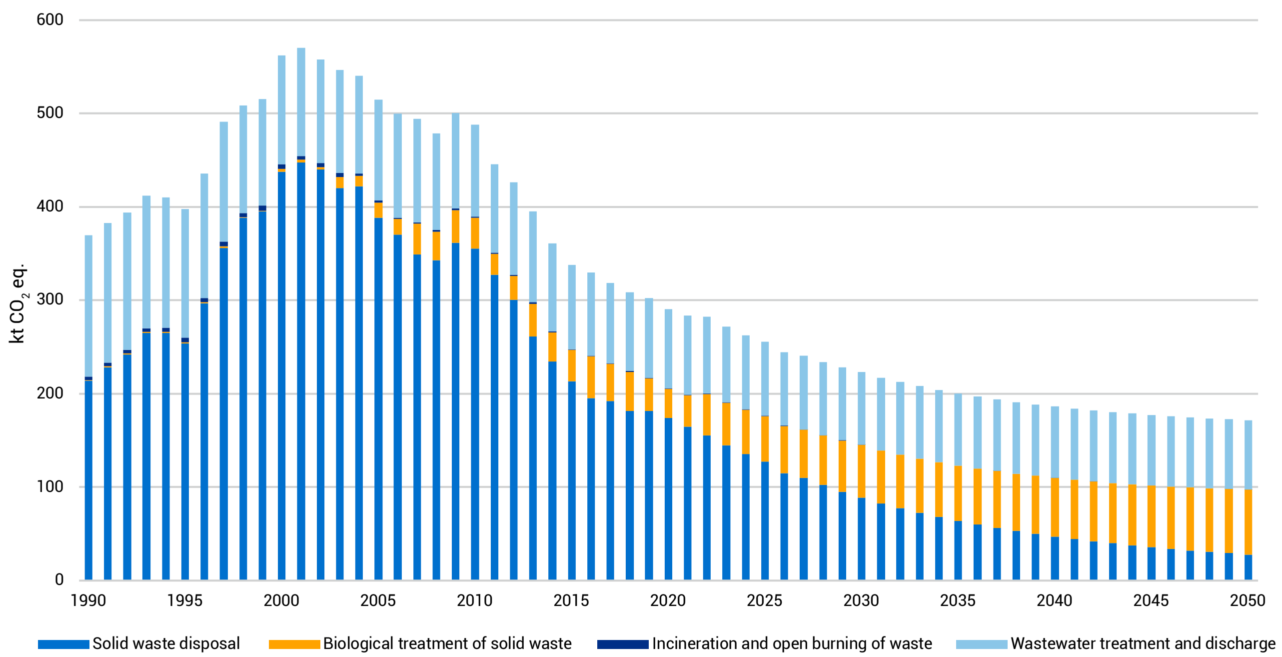

Figure 5.7. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) from the Waste sector according to the WEM=WAM scenario, kt CO_2 eq.

Compared to 2020, the 2050 WEM scenario CO_2 eq. projections from the Waste sector are projected to decrease by 40.8%. Emission decrease is mainly related to the increase of reusing and recycling waste materials, decreasing amount of biodegradable waste deposited in landfills and to waste incineration in the Iru CHP plant. The decrease of 2050 emissions from the Solid waste disposal subcategory are projected to decrease by 83.9% compared to base year emissions.

Increase in GHG emissions from biological treatment of solid waste (121% increase in 2050 compared to 2020) is correlated to the decreased amount of biodegradable waste in the total amount of solid waste disposed in landfills.

Open burning of waste will end by 2030 and a marginal amount of waste will be incinerated without energy recovery, the emissions will decrease by 99.9%.

The emission decrease from wastewater treatment and discharge (11.8% in 2050 compared to 2020) is connected to the expanding sewerage network and upgrading wastewater treatment systems in low-density settlements.

5.1.7. Total projected GHG emissions of Estonia

Estonia's total projected GHG emissions are presented in **Figure 5.8** – **Figure 5.12**.

Estonia's GHG emissions are expected to decrease by around 64.61% in the WEM scenario (without LULUCF) and about 66.55% in the WAM scenario (without LULUCF) by 2050 compared to the base year of 2020. GHG emissions in the WEM scenario (with LULUCF) are expected to decrease by around 46.48% and in the WAM scenario (with LULUCF) about 64.69% by 2050 compared to the base year of 2020.

While the Energy sector´s subcategory Energy industries dominated total emissions in 1990, its emissions decreased sharply in the beginning of the time series and fluctuate but are projected to continue on a decreasing pathway, reaching a reduction of 99.1% by 2050 compared to 1990.

Emissions from the Transport sector, are driven by the Road transport category, as its share of the total transport sector was approximately 97.4% in 2020. Therefore, it will also be the biggest driver for the decrease of GHG emissions in the road transport sector due to the uptake of electric vehicles. The total decrease of emissions by 2050 compared to 1990 is projected to be 82% in the WEM scenario and 84% in the WAM scenario.

Historically, the IPPU sector emissions were driven by the Mineral industries subcategory, however the cement industry ceased burning clinker in wet process kilns and does not foresee future production, which will already decrease starting from 2020. HFC emissions projection will decrease by 68% from 2020 to 2050. It is projected that the majority of R-404A containing equipment and old split-type air conditioners and heat pumps are gradually decommissioned. The total decrease of emissions by 2050 compared to 1990 is projected to be 74% in the WEM scenario and 83% in the WAM scenario.

Agriculture emissions are projected to decrease by 40.7% compared to 1990 in the 2050 WEM scenario, however the projections foresee a slight increase of 3.30% compared to 2020 by 2050 (in the WAM scenario the emissions are projected to increase by 3.32% by 2050 compared to 2020). Estonia´s agriculture sector is driven by the Enteric Fermentation and Agricultural soils subcategories that are an important food source.

According to the projections, the LULUCF sector is expected to remain a source of GHGs in the WEM and WAM scenarios from –3,159.9 kt CO_2 eq. total sequestration in 1990 2,788.74 and 672.94 kt CO_2 eq. in 2050 according to the WEM and WAM scenarios, respectively. In the WEM scenario (total felling volume is 11.5 mln m^3 year-1), Forest land will act as a net source. Due to the high proportion of mature and premature forest stands and the increasing proportion of forest area belonging to the first development classes (treeless area, area under regeneration and young stands), the capacity of carbon sequestration in tree biomass has decreased in recent years and the decline is expected to continue during the next decades. In the WAM scenario (total felling volume is 9.4–9.8 mln m^3 year-1), Forest land and HWP will sequester carbon.

The increasing trend of waste sector emissions in 1990–2001 is linked to low rate of waste sorting. However, the emission decrease until 2050 is mainly related to the increase of reusing and recycling waste materials, the decreasing amount of biodegradable waste deposited in landfills and to waste incineration in the Iru CHP plant in 2013. The decrease of emissions by 2050 is reaching 53.4% compared to 1990 in WEM=WAM scenarios.

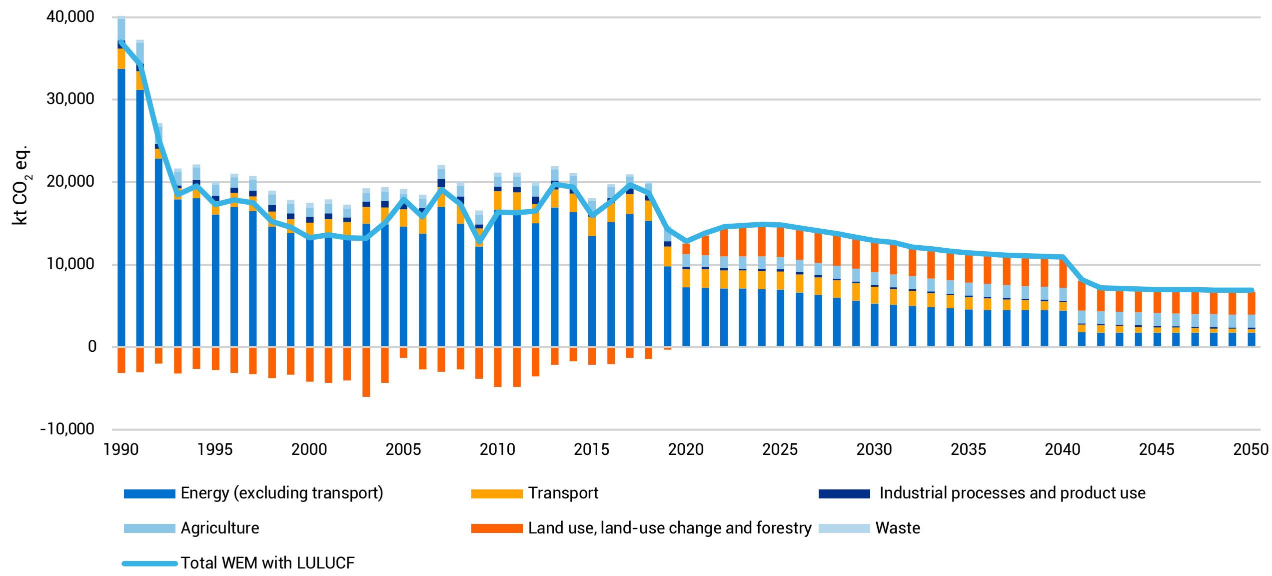

Figure 5.8. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) for the WEM scenario, kt CO_2 eq.

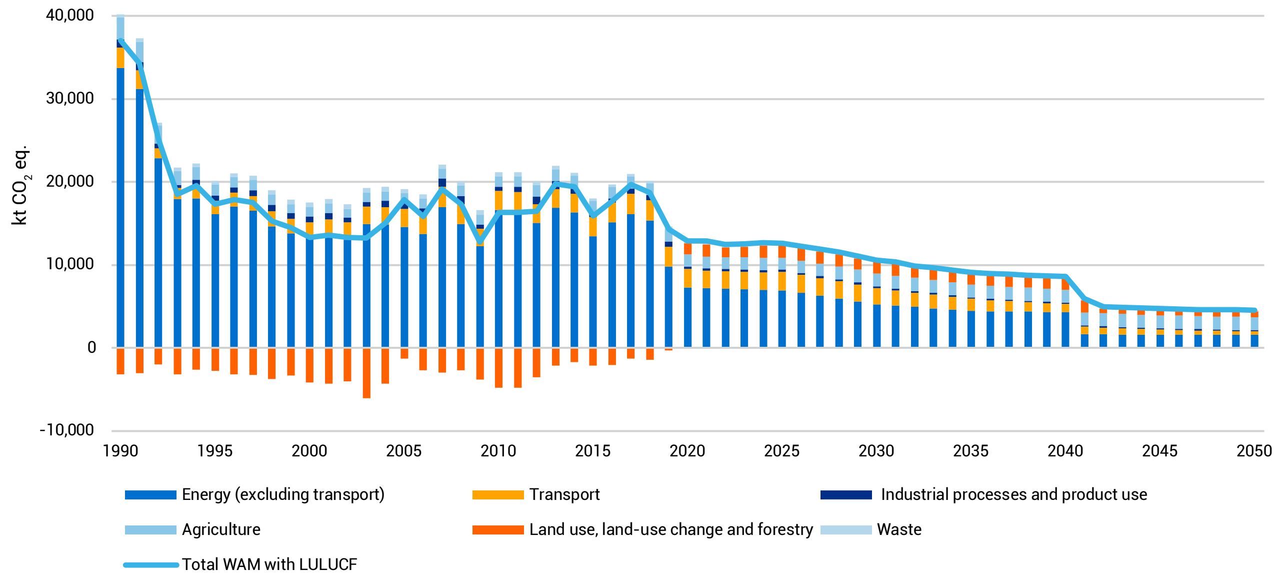

Figure 5.9. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) for the WAM scenario, kt CO_2 eq.

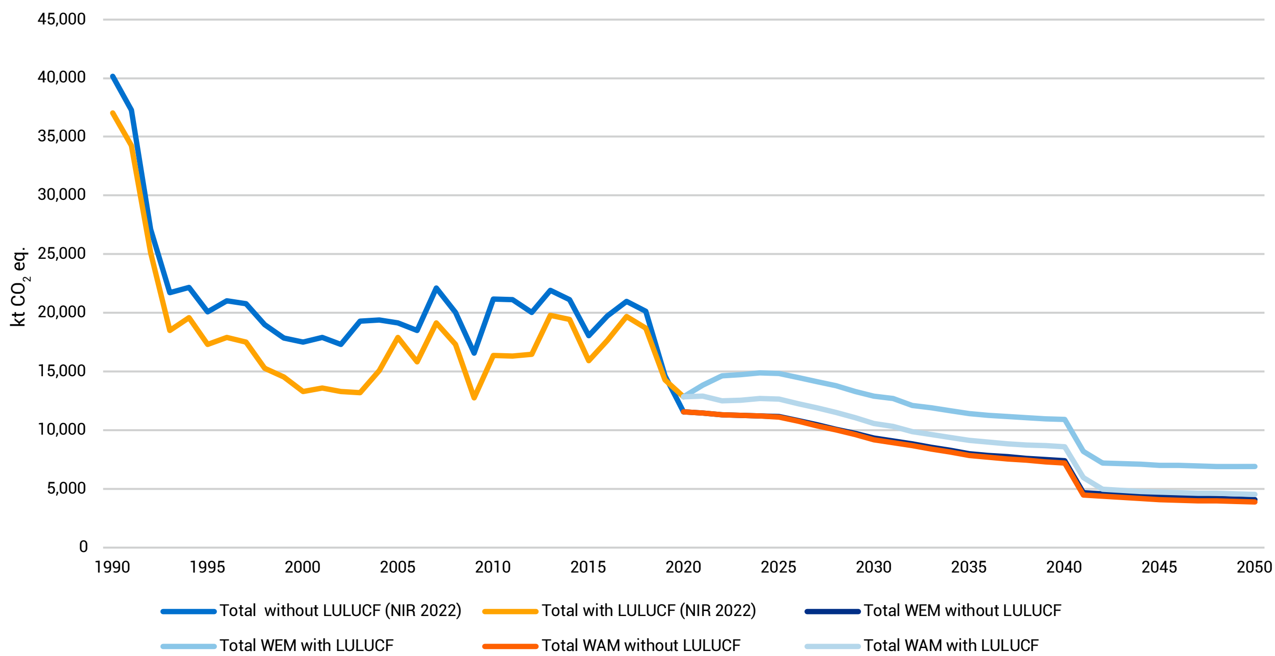

Figure 5.10. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) for the WEM and WAM scenarios, kt CO_2 eq.

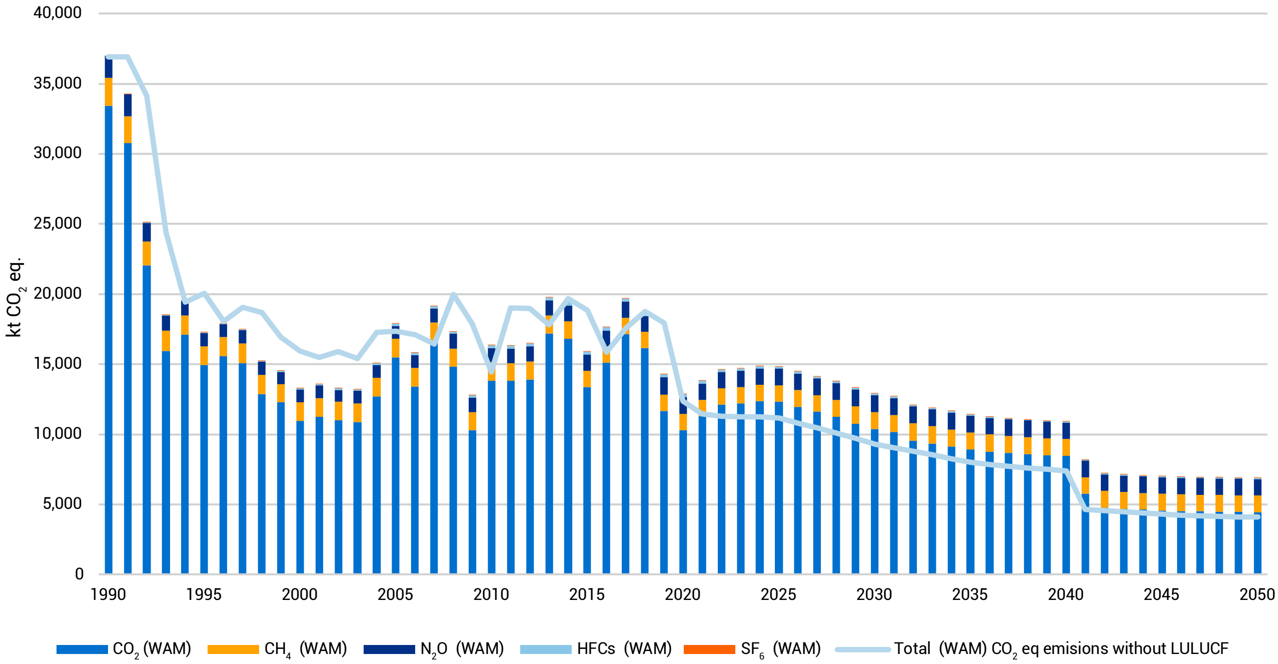

Figure 5.11. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) for the WEM scenario by gas, kt CO_2 eq.

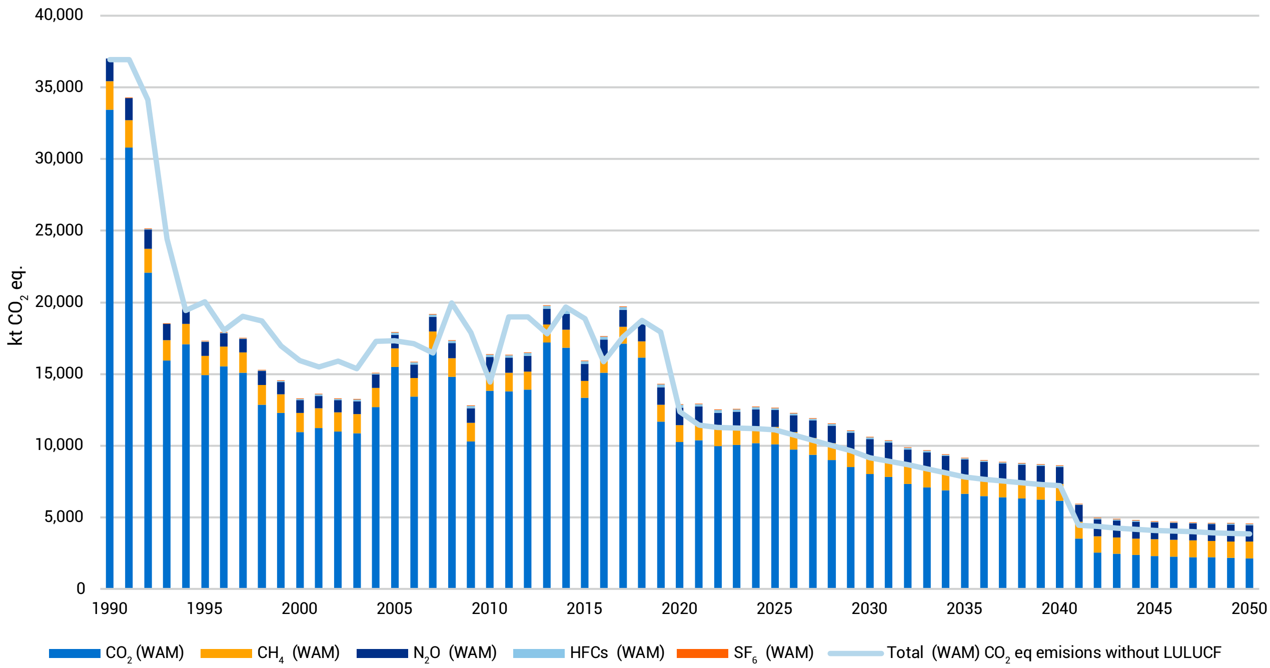

Figure 5.12. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021–2050) for the WAM scenario by gas, kt CO_2 eq.

Table 5.2. Historical GHG emissions in 1990–2020 (NIR, 2022) and projected emissions for 2025–2050 for the WEM and WAM scenarios kt CO_2 eq.

	GHG emissions and removals (kt CO_2 eq) (2022 NIR)							GHG projections (kt CO_2 eq)					
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2050
By sector:													
Energy (excluding transport) WEM	33,731.25	16,110.33	13,414.02	14,573.18	16,611.11	13,454.95	7,228.91	6,966.79	5,308.79	4,548.08	4,453.24	1,756.48
Energy (excluding transport) WAM								6,940.43	5,249.14	4,441.52	4,320.35	1,572.05
Transport WEM	2,481.91	1,586.83	1,684.86	2,169.22	2,288.39	2,318.49	2,232.54	2,225.90	1,997.20	1,522.52	1,027.69	441.73
Transport WAM								2,209.05	1,935.10	1,458.82	971.52	401.04
Industrial processes and product use WEM	963.74	635.29	695.97	727.83	539.51	517.03	295.47	258.56	218.37	179.24	166.60	161.96
Industrial processes and product use WAM								258.53	218.30	179.05	166.54	161.94
Agriculture WEM	2,628.34	1,350.11	1,122.23	1,172.06	1,253.80	1,408.52	1,508.38	1,461.21	1,551.44	1,552.92	1,554.29	1,558.08
Agriculture WAM								1,461.34	1,551.67	1,553.18	1,554.59	1,558.44
Land use, land-use change and forestry WEM	-3,159.90	-2,799.39	-4,204.98	-1,275.73	-4,835.38	-2,128.02	1,297.27	3,672.52	3,607.67	3,403.91	3,525.24	2,788.74
Land use, land-use change and forestry WAM								1,507.47	1,407.83	1,292.22	1,392.25	672.94
Waste WEM=WAM	369.93	397.97	562.45	515.18	488.00	337.69	290.51	255.73	223.25	200.50	186.37	171.84
Total WEM (without LULUCF)	40,175.17	20,080.53	17,479.52	19,157.48	21,180.81	18,036.69	11,555.81	11,168.19	9,299.05	8,003.27	7,388.19	4,090.09
Total WAM (without LULUCF)								11,125.09	9,177.46	7,833.08	7,199.38	3,865.31
Total WEM (with LULUCF)	37,015.28	17,281.14	13,274.54	17,881.75	16,345.42	15,908.67	12,853.08	14,840.71	12,906.72	11,407.18	10,913.43	6,878.83
Total WAM (with LULUCF)								12,632.56	10,585.29	9,125.30	8,591.62	4,538.26
By gas, CO_2:													
Energy (excluding transport) WEM	33,527.13	15,914.55	13,232.02	14,390.63	16,388.24	13,261.52	7,016.80	6,719.34	5,040.12	4,263.34	4,178.47	1,482.31
Energy (excluding transport) WAM								6,695.24	4,987.56	4,172.58	4,072.08	1,345.45
Transport WEM	2,421.43	1,546.91	1,639.59	2,124.05	2,247.60	2,288.34	2,205.13	2,195.84	1,974.54	1,506.97	1,019.67	438.41
Transport WAM								2,179.19	1,913.14	1,443.98	964.13	398.17
Industrial processes and product use WEM	958.29	597.73	606.11	585.02	356.46	287.46	104.72	98.33	98.13	98.01	97.56	97.55
Industrial processes and product use WAM								98.31	98.07	97.81	97.50	97.53
Agriculture WEM	13.11	4.23	19.85	8.63	9.37	9.07	15.86	21.64	22.23	22.17	22.17	22.17
Agriculture WAM								21.64	22.23	22.17	22.17	22.17
Land use, land-use change and forestry WEM	-3,486.97	-3,127.98	-4,537.44	-1,612.85	-5,184.38	-2,487.19	932.20	3,288.36	3,224.12	3,023.01	3,144.97	2,408.45
Land use, land-use change and forestry WAM								1,123.32	1,024.28	911.32	1011.97	292.66
Waste WEM=WAM	2.25	2.99	2.82	1.46	0.84	0.51	0.49	0.35	0.00006	0.00005	0.00005	0.00004
CO_2 WEM emissions without net CO_2 from LULUCF	36,922.21	18,066.41	15,500.38	17,109.78	19,002.52	15,846.90	9,343.01	9,035.50	7,135.02	5,890.49	5,317.88	2,040.44
CO_2 WAM emissions without net CO_2 from LULUCF								8,994.73	7,020.99	5,736.54	5,155.88	1,863.32
CO_2 WEM emissions with net CO_2 from LULUCF	33,435.24	14,938.43	10,962.94	15,496.94	13,818.14	13,359.71	10,275.21	12,323.86	10,359.14	8,913.50	8,462.84	4,448.89
CO_2 WAM emissions with net CO_2 from LULUCF								10,118.05	8,045.27	6,647.86	6,167.85	2,155.98

	GHG emissions and removals (kt CO_2 eq) (2022 NIR)							GHG projections (kt CO_2 eq)				
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2050
By gas, CH_4:												
Energy (excluding transport) WEM	169.99	165.40	155.16	150.41	177.79	148.76	160.61	177.05	188.06	195.16	192.18	193.05
Energy (excluding transport) WAM								175.78	183.82	185.04	174.28	158.86
Transport WEM	21.91	12.37	11.51	9.67	6.31	4.00	3.03	5.79	5.34	4.19	2.84	1.70
Transport WAM								5.77	5.27	4.10	2.76	1.64
Industrial processes and product use WEM	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Industrial processes and product use WAM								NO	NO	NO	NO	NO
Agriculture WEM	1,392.30	746.47	564.83	602.69	628.01	651.90	686.50	709.01	768.20	781.76	781.41	781.41
Agriculture WAM								709.01	768.20	781.76	781.41	781.41
Land use, land-use change and forestry WEM	64.14	64.47	65.85	65.25	65.49	66.23	66.26	83.95	88.63	89.58	90.52	92.40
Land use, land-use change and forestry WAM								83.95	88.63	89.58	90.52	92.40
Waste WEM=WAM	328.31	360.14	528.40	476.74	441.76	291.21	245.31	203.53	168.42	144.52	129.28	112.46
CH_4 WEM emissions without CH_4 from LULUCF	1912.52	1284.38	1259.91	1,239.50	1,253.87	1,095.87	1,095.46	1,095.38	1,130.02	1,125.64	1,105.72	1,088.62
CH_4 WAM emissions without CH_4 from LULUCF								1,094.09	1,125.70	1,115.42	1,087.74	1,054.37
CH_4 WEM emissions with CH_4 from LULUCF	1976.66	1348.85	1325.76	1,304.74	1,319.36	1,162.10	1,161.72	1,179.34	1,218.65	1,215.21	1,196.24	1,181.02
CH_4 WAM emissions with CH_4 from LULUCF								1,178.05	1,214.33	1,205.00	1,178.26	1,146.77
By gas, N_2O:												
Energy (excluding transport) WEM	34.14	30.37	26.84	32.14	45.09	44.67	51.50	70.39	80.61	89.58	82.59	81.12
Energy (excluding transport) WAM								69.40	77.76	83.91	73.99	67.74
Transport WEM	38.56	27.54	33.76	35.51	34.48	26.16	24.38	24.27	17.32	11.36	5.18	1.62
Transport WAM								24.09	16.70	10.74	4.63	1.23
Industrial processes and product use WEM	5.45	6.04	8.10	6.78	5.11	3.87	3.09	1.47	0.49	0.38	0.38	0.38
Industrial processes and product use WAM								1.47	0.49	0.38	0.38	0.38
Agriculture WEM	1,222.93	599.41	537.54	560.75	616.41	747.56	806.01	730.56	761.01	748.99	750.71	754.49
Agriculture WAM								730.69	761.24	749.25	751.00	754.86
Land use, land-use change and forestry WEM	262.93	264.11	266.61	271.87	283.51	292.95	298.80	300.20	294.91	291.33	289.76	287.89
Land use, land-use change and forestry WAM								300.20	294.91	291.33	289.76	287.89
Waste WEM=WAM	39.37	34.85	31.23	36.99	45.39	45.97	44.70	51.85	54.83	55.99	57.09	59.38
N_2O WEM emissions without N_2O from LULUCF	1,340.45	698.21	637.47	672.16	746.47	868.22	929.68	878.55	914.27	906.29	895.94	896.99
N_2O WAM emissions without N_2O from LULUCF								877.51	911.03	900.26	887.09	883.58
N_2O WEM emissions with N_2O from LULUCF	1,603.37	962.32	904.09	944.03	1,029.98	1,161.16	1,228.48	1,178.76	1,209.18	1,197.62	1,185.69	1,184.88
N_2O WAM emissions with N_2O from LULUCF								1,177.71	1,205.94	1,191.58	1,176.85	1,171.47
By gas, F-gases:												
HFCs	NO	28.45	79.15	134.96	176.11	223.35	184.74	154.77	115.40	76.15	63.81	59.29
PFCs	NO	NO	NO	NO,NA	NO	NO	NO	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	NO	3.07	2.61	1.08	1.83	2.35	2.92	3.86	4.21	4.56	4.71	4.60
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

5.1.8. Total projected indirect emissions of Estonia

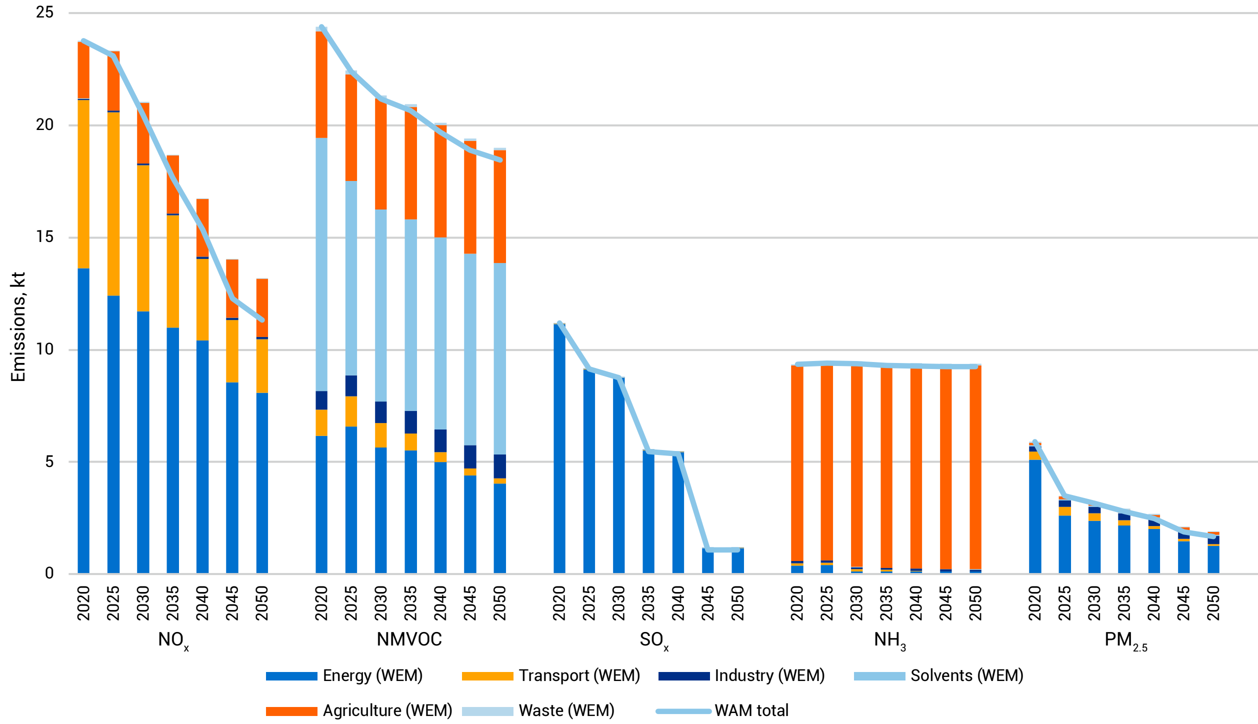

Figure 5.13. Total projected indirect emissions, kt

Estonia's total projected indirect projections in the WEM and WAM scenarios are presented in **Figure 5.13**. The overall main driver for decreasing air pollutant projections is the Energy industries subsector, due to the phasing out of oil shale pulverised combustion and use of more renewable energy (wind and sun) by electricity producers. For NH_3, the main driver is the Agriculture sector and the increasing number of livestock.

- NO_x – in 2020–2050, emissions are projected to decrease by 44% in the WEM scenario and 52% in the WAM scenario. This estimate takes into account NO_x emissions from the Agriculture sector both in 2020 and in projections.
- NMVOC – in 2020–2050, emissions are projected to decrease by 22% in the WEM scenario and 24% in the WAM scenario. This estimate takes into account NMVOC emissions from the Agriculture sector both in 2020 and in projections.
- SO_2 – in 2018–2050, emissions are projected to decrease by 89% in the WEM scenario and 90% in the WAM scenario.
- NH_3 – in 2018–2050, emissions are projected to increase by 0% in the WEM scenario and decrease by 1% in the WAM scenario.
- $PM_{2.5}$ – in 2018–2050, emissions are projected to decrease by 67% in the WEM scenario and 72% in the WAM scenario.

5.1.9. Sensitivity analysis

During every projection compilation period, trajectories for parameters for reporting on national GHG projections in 2023 are provided by the European Commission (EC) for all the EU Member States. These include harmonised values to be considered for the 2023 national GHG projections on the international oil, gas and coal import prices, the EU ETS carbon prices and GDP.

For the projection compilation, it was possible to use Estonia's Ministry of Finance´s updated the long term real GDP growth rate from September 2022 and population projection by Statistics Estonia which were considered more up to date.

The EC parameters were used for sensitivity analysis to validate national data used in the projections.

Energy

Manufacturing industries' and construction (1.A.2) and Agriculture/Forestry/Fishing/Fish farms (1.A.4.c) GHG projections are based on the future GDP growth of Estonia. The GDP projections until 2050 by the Ministry of Finance were used. However, a GDP scenario was also provided by the European Commission. Therefore, an alternative scenario has been modelled (SEN scenario).

Comparing the GDP projections from the Ministry of Finance with GDP projections from the European Commission, it was seen that the Commissions GPD projections were somewhat more optimistic in the future growth of Estonia, which also reflects in the GHG projections. When comparing GHG emissions between the WEM and SEN scenarios, the emissions are projected to increase by 3.3% by 2050 in the SEN scenario. The results of the SEN scenario are presented in Figure 5.14. A sharp drop in the emissions in 2040–2041 is due to the companies phasing out shale oil in solid heat carrier technology based shale oil plants.

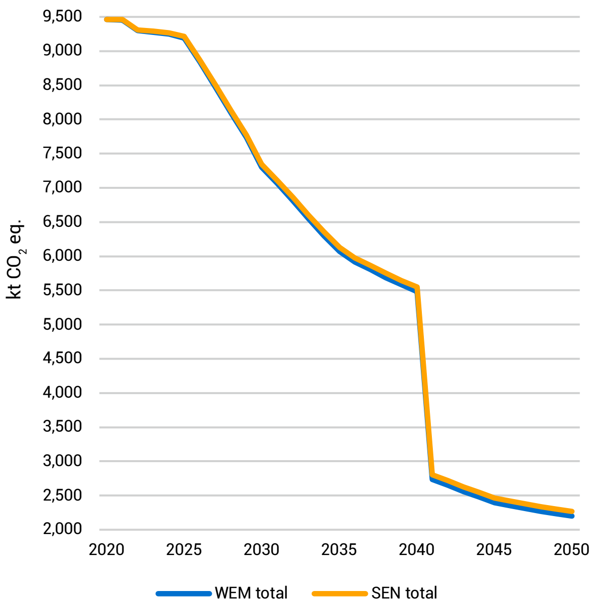

Figure 5.14. Comparison of GHG emissions of the WEM and SEN scenarios in energy sector, kt CO_2 eq.

IPPU

Sensitivity analysis for IPPU sector emissions is based on the population and annual real GDP growth rate harmonised values Table 5.2) given by the European Commission (*Trajectories for parameters for reporting on national GHG projections in 2023*).

Table 5.3. Harmonised parameters given by the European Commission

Indicator	2025	2030	2035	2040	2050
GDP (in market prices), million euros	2.68	2.48	2.14	1.61	1.26
Population in Estonia, million	1.322	1.308	1.294	1.282	1.256

The results of the SEN analysis show that IPPU sector emissions in general are dependent on the population projections and changes in GDP estimations.

When comparing GHG emissions between the WEM and SEN scenarios, the emissions are projected to decrease by 0.68% (1.13 kt CO_2 ekv) in 2040 and by 0.69% (1.12 kt CO_2 ekv) in 2050 in the SEN scenario compared to the WEM scenario. The results of the SEN scenario are presented in Figure 5.15.

Under the SEN scenario population and/or GDP growth rate values from Table 5.3 were used in the calculations of IPPU categories 2.D Non-energy products from fuels and solvent use (GDP and population), 2.F Product uses as substitutes for ODS according (GDP and population) and 2.G Other product manufacture and use (GDP and population) according to the methodology of the WEM scenario. The methodology for calculating the WEM scenario is provided in Chapter 5.4.3. Categories 2.A (mineral industry) and 2.C (metal industry) are not affected by the change of population or GDP growth rate.

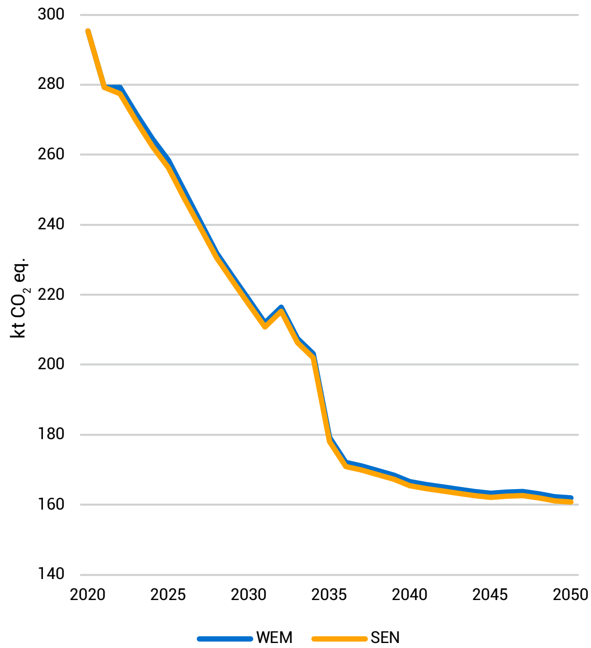

Figure 5.15. Comparison of GHG emissions of the WEM and SEN scenarios in IPPU sector, kt CO_2 eq.

Waste

Sensitivity analysis for Waste sector emissions is based on the scenarios, where population and annual real GDP growth rate (Table 5.3) are based on the harmonised values given by the European Commission (Recommended parameters for reporting on GHG projections in 2021 30 June 2020).

Under the SEN scenario (Figure 5.16), population and GDP growth rate from Table 5.3 were both used in projection calculations. The methodology for calculating the SEN (and WEM) scenario is provided in Chapter . All subcategories in the Waste sector are affected by the change of population projections and fluctuations in GDP.

The results of the SEN analysis show that Waste sector emissions in general are dependent on the population projections and changes in GDP estimations. The Incineration and open burning of waste and Wastewater treatment and discharge categories are not highly affected when using SEN parameters. Incineration and open burning subcategory have a marginal share in the total share of emissions and the Wastewater treatment and discharge subcategory would be more affected by the change of different wastewater treatment methodologies. However, population and GDP growth are affecting the Solid waste disposal and Biological treatment of solid waste subcategories. When comparing 2050 emissions, total emissions are projected to decrease by 5.2% in the WEM scenario compared to the SEN scenario.

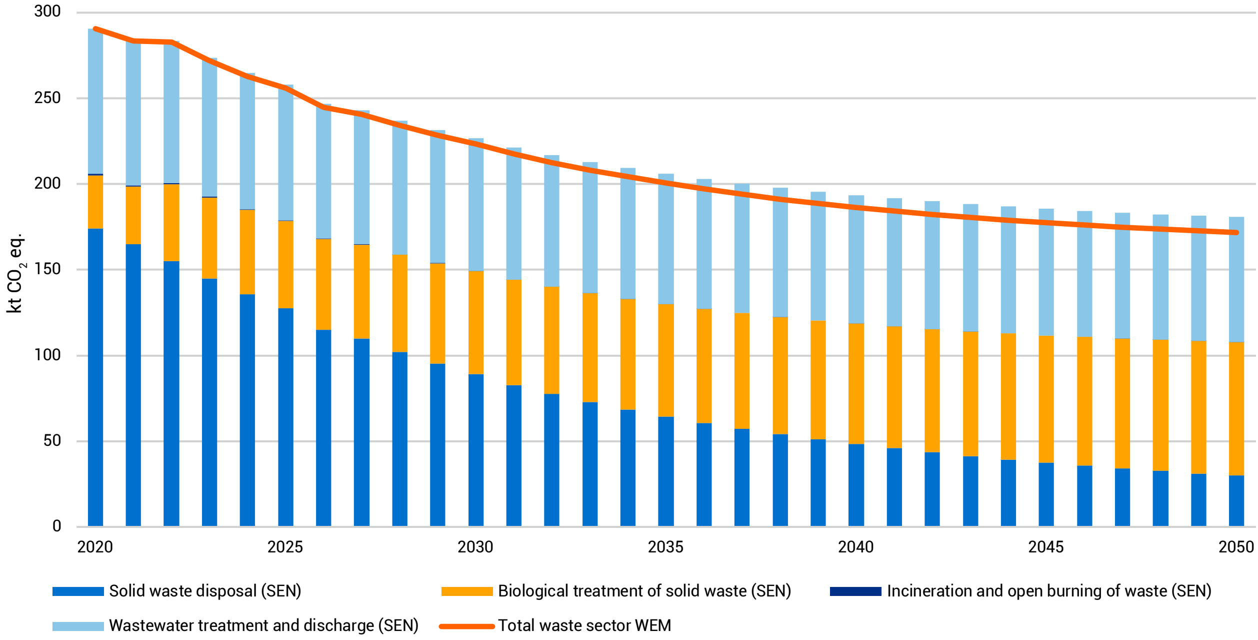

Figure 5.16. Comparison of GHG emissions of the SEN and WEM scenarios waste sector total emissions, kt CO_2 eq.

5.1.10. International bunker fuels

International bunkers cover International aviation and navigation.

Eurocontrol forecasts an annual 1.9% increase (Eurocontrol, 2018) in European aviation flights until at least 2040, which is taken into account in the Aviation bunkering projections. In the Marine bunkering projections, the International Maritime Organization forecast is taken into account, which states an increase in international shipping of 40% (ICCT, 2021).

Historically, the emissions from Aviation bunkering formed about 10% of all bunkering emissions. Due to the methodology change in activity data by Statistics Estonia, the emissions increased by around two times in 2012 compared to 2011 (**Figure 5.17**).

The emissions from Aviation bunkering are projected to increase 4 times by 2050 compared to 2020. The reason for the big difference is COVID-19, which halted most of the international aviation in 2020 and Tallinn Airports expansion plans to increase the number of passengers to 6 million by 2035. The total GHG emissions of Marine bunkering are expected to increase by 29.8% by 2050 compared to 2020, as regards the current trend (**Figure 5.17** and **Table 5.4**). Overall, the GHG emissions from International bunkering are expected to increase by 57.0% in 2050 compared to 2020.

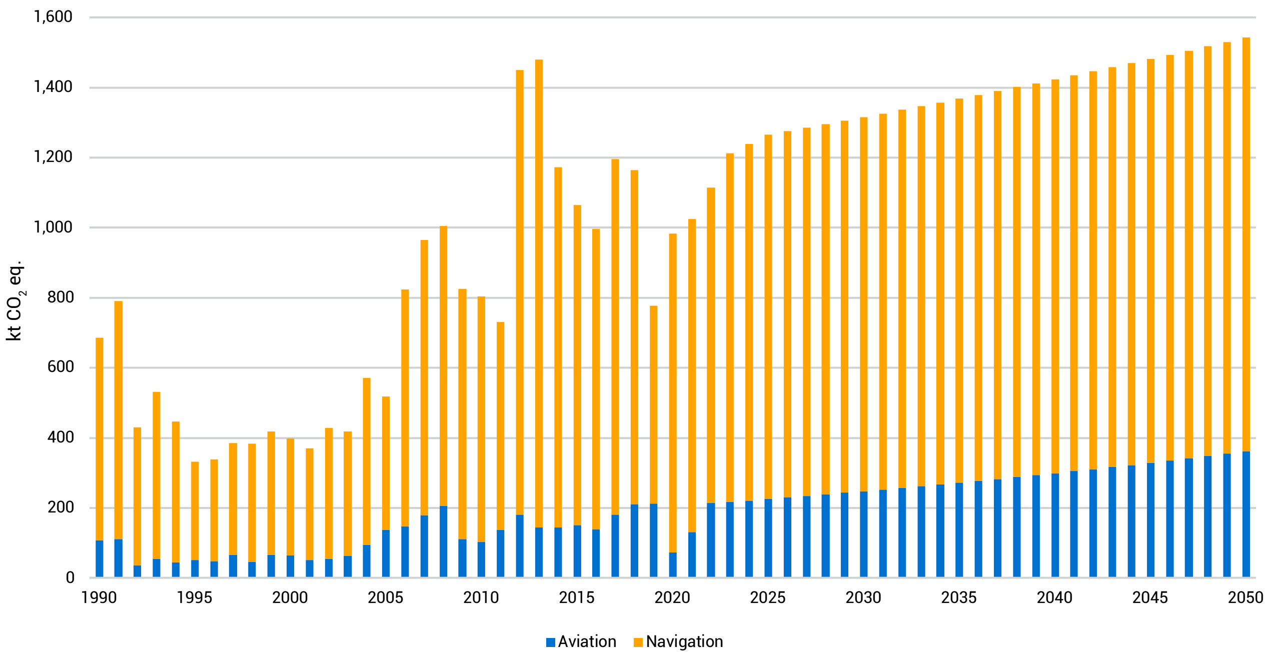

Figure 5.17. Historical GHG emissions (1990–2020) (NIR, 2022) and projected emissions (2021-2050) from International bunkering according to the WEM=WAM scenario, kt CO_2 eq.

Table 5.4. GHG projections of International bunkering, kt

	GHG	2020	2025	2030	2035	2040	2050
Aviation bunkering	CO_2	72.11	223.35	245.39	269.60	296.20	357.55
	CH_4	0.001	0.016	0.017	0.019	0.021	0.025
	N_2O	0.002	0.006	0.007	0.008	0.008	0.010
	Total CO_2 eq.	72.72	225.59	247.85	272.31	299.18	361.14
Marine bunkering	CO_2	900.99	1,029.99	1,058.10	1,086.21	1,114.32	1,170.82
	CH_4	0.084	0.098	0.100	0.103	0.106	0.111
	N_2O	0.023	0.023	0.024	0.024	0.025	0.025
	Total CO_2 eq.	909.90	1,039.42	1,067.70	1,095.98	1,124.26	1,181.11
International bunkering total	CO_2	973.09	1,253.34	1,303.49	1,355.81	1,410.52	1,528.36
	CH_4	0.085	0.113	0.117	0.122	0.126	0.136
	N_2O	0.025	0.030	0.031	0.032	0.033	0.035
	Total CO_2 eq.	982.62	1,265.01	1,315.55	1,368.29	1,423.44	1,542.25

5.2. Assessment of aggregate effects of policies and measures

Individual effects of single PaMs are included in Chapter 4 and total GHG emission impact is included in **Table 5.5**. As many policies and measures are either not yet quantifiable or do not have an impact in the whole time series, then the impact in **Table 5.5** is not giving the total impact of the measures. Not quantifiable but implemented measures are impacting the projections through the base year or base period and therefore their impact is included in the projections, however this is not quantified.

Table 5.5. Total effect of implemented and adopted PaMs, kt CO_2 eq.

	2020	2030	2040	2050
WEM measures	-1,500.88	-6,409.94	-9,045.18	-9,236.15
WAM measures	-1.13	-189.33	-263.18	-337.77

The the difference between the WEM and WAM scenarios (**Table 5.6**) gives an overview of the impact of additional measures compared to the WEM scenario.

Table 5.6. Total effect of implemented and adopted PaMs based on the projections, kt CO_2 eq.

	2020	2025	2030	2035	2040	2050
CO_2	0	2,206	2,314	2,266	2,295	2,293
CH_4	0	0.05	0.17	0.41	0.72	1.37
N_2O	0	0.004	0.01	0.02	0.03	0.04
Total CO_2 eq.	0	2,208	2,321	2,282	2,322	2,341

5.3. Methodology used for the presented GHG emission projections

5.3.1. Energy sector

Two projections scenarios of GHG emissions have been calculated for the period 2021–2050. The reference year 2020 used in projections is consistent with Estonia's 2022 submission to the UNFCCC on 15th of April 2022 (National Greenhouse Gas Inventory Report 1990–2020, 2022). The 'With Existing Measures' (WEM) scenario evaluates future GHG trends under current policies and measures. In the second scenario a number of additional measures and their impact are taken into consideration, forming the basis of the 'With Additional Measures' (WAM) scenario.

The scenarios projecting GHG emissions in the Energy sector are mainly based on the measures of the Ministry of the

Environment and Ministry of Economic Affairs and Communications, which are funded through the Recovery and Resilience Facility, Environmental Investment Centre and the State Shared Service Center. In addition, the scenarios were updated based on the input received from the Ministry of Economic Affairs and Communication, the Ministry of Environment and input from the meeting points of the Government´s Climate and Energy Committee (2020).

The Balmorel model was used for the electricity generation projections in the Electricity generation sector. It is a model for analysing the Electricity and Combined heat and power sectors from an international perspective while minimising the total costs of the system. The Balmorel model combines the approach of bottom-up modelling in a classic technical modelling tradition with top-down economic analysis, projections and forecasts. Some of the key strengths of the Balmorel model include the flexible handling of the time and space dimensions and the combination of operation and investment optimisation. The existing functionality and structural suitability for extensions make it a useful tool for assessing challenges in the ongoing energy transitions. However, the downsides of the Balmorel model are complex user interface, the speed of the model and adding additional sectors to make the energy model more complete. The Balmorel model can differentiate, for example, the fuel consumption between the electricity and heat production, which is useful on order to avoid double counting. Furthermore, the Balmorel model makes estimated projections for both heat and power, to what extent it is reasonable to use a type of fuel (like biomass) to meet energy demand.

The main assumption for the projection was that step-by-step, the use of oil shale shall decrease for the production of electricity and increase for the production of shale oil. The retort gas that occurs as a side product during the production of shale oil is used for electricity production. The projected future usage of fuel based on the model was applied while using the emission calculations of the 2006 IPCC Guidelines.

The projections for heat generation in the Public heat and electricity generation sector are primarily based on the reconstruction rate of the Shared Service Center, Analysis of the opportunities to increase climate ambition in Estonia measuresand Long-term strategy (SEI-Tallinn, 2019) for building reconstruction scenarios (TalTech, 2020). The projections in the heat production are based on measures funded through the Environmental Investment Centre and measures highlighted in the Analysis of the opportunities to increase the climate ambitions in Estonia.

The projections of the GHG emissions of shale oil production in the Manufacturing of solid fuels and other energy industries were calculated based on input from the industry. The amounts of oil shale used and the construction of a new shale oil production plant were used for the GHG projections.

The GHG projections in the Manufacturing industries and construction sector and in Other sectors are also based on historical trends, long term real GDP growth rate (the Ministry of Finance), Shared Service Center measures and Long-term strategy for building reconstruction scenarios (TalTech, 2020). The emissions are calculated based on the methodology of the 2006 IPCC and EMEP/EEA 2019 Guidebook.

5.3.2. Transport sector

Two projections scenarios of GHG emissions have been calculated for the period 2021–2050. The reference year 2020 used in projections is consistent with Estonia's 2022 submission to the UNFCCC on 15th of April 2022 (National Greenhouse Gas Inventory Report 1990–2020, 2022). The 'With Existing Measures' (WEM) scenario evaluates future GHG trends under current policies and measures. In the second scenario a number of additional measures and their impact are taken into consideration forming the basis of the 'With Additional Measures' (WAM) scenario.

Sybil baseline model was used for the GHG projections in the road transport sector. The model uses a bottom-up approach requiring data about the vehicle fleet, technology (EURO class) and road activity. The biggest strength of the model is compatibility with COPERT, which is used for the compilation of road transport in the national inventory report and kept up to date by EMISIA, the same team as for COPERT. On the other hand, its weakness is the high time consumption of calculating the effect of each individual measure. For that reason, it is easier to calculate separately the effects of the measure and insert the sum effect into the model.

The projections in the Transport sector are based on the information from the ITF report "The Future of Passenger Mobility and Goods", the TalTech report "Traffic survey manual and the business as usual forecast", the Ministry of Economic Affairs and Communication, the Ministry of Environment and input from the meeting points of the Government´s Climate and Energy Committee (2020). To estimate GHG emissions emission factor data from the 2006 IPCC and EMEP/EEA 2019 Guidebook along with country-specific emission factors were used.

The projections for the WEM scenario are also in line with Regulation (EC) No 2019/631 of the European Parliament and of the Council. In addition, it is also taken to account that by 2035, the average emissions target for a new passenger car is 0 gCO_2/km and 130 gCO_2/km for light duty vehicles.

5.3.3. IPPU sector

Two projection scenarios for GHG emissions have been calculated for the period 2021–2050. The reference year 2020 used in projections is consistent with Estonia's 2022 submission to the UNFCCC on 15th of April 2022 (National Greenhouse Gas Inventory Report 1990–2020, 2022). Emissions from the IPPU sector are projected according to the 'With Existing Measures' (WEM) scenario, which evaluates future GHG trends under current policies and measures and the 'With Additional Measures' (WAM) scenario, whereby WAM only affects the emission from urea-based catalysts for motor vehicles.

The Estonian industry sector is relatively small. The majority of emissions from subcategories, such as the Mineral industry, Non-energy products from fuels and solvents, and Other product manufacture, as well as their respective subcategories, comprise emissions from the activity of only a few companies who also influence the emissions' trend. In most subsectors bottom-up data gathering, companies' production forecasts, population projection (Statistics Estonia), the long-term real GDP growth rate (the Ministry of Finance) and expert judgements are combined and used. This approach ensures the most proximate projections that reflect the actual situation in subcategories with a limited number of emitting agents.

The Mineral industry's projected emissions are based on industries' operator projections taking into account planned production capacities and and/or maximal production capacities according to companies' environmental permits. The Chemical (ammonia) industry is no longer active in Estonia and emissions from that sector are 0. The Metal industry´s projected emissions are based on industries' operator production forecasts. Consumption of lubricants is based on 2014–2021 (as the data for the year 2021 were known while compiling the projections' consumption trend and projection of GDP growth rate and is slightly increasing. Consumption of paraffin waxes (candles and other paraffin waxes) is based on the average consumption of the years 2017–2021 (as the data for the year 2021 were known while compiling the projections) and will decrease compared to 2020 in the years 2021–2022 and then stabilise.

Indirect CO_2 emissions from the Solvent use sector, affected by both GDP growth and population decline, are projected to decrease a little because of decreasing emission factors in the Domestic solvent use and Coating (paint use) categories.

Emissions from urea-based catalyst AdBlue are projected taking into account:

1. broadening of NO_x emission standards to light vehicles (Euro 6 standards);
2. the forecast of the number of vehicles and their average fuel consumption is consistent with the projections of the Transport sector (see Chapter 3.2.2.1).

Emissions of fluorinated gases are projected according to the GHG inventory's calculation methods. Emissions from each group of HFC-containing equipment are projected separately. Bans and restrictions stipulated in the Regulation (EU) No. 517/2014 and Directive 2006/40/EC were taken into account. Trends in the domestic market of refrigeration and air-conditioning could be seen from the national database for F-gases (according Article 6 paragraph 2 of Regulation (EU) No. 517/2014). Some companies who service large commercial refrigeration systems were interviewed about their intentions towards restrictions of Regulation (EU) No. 517/2014. Trends in the import of pre-charged air conditioning equipment could be seen from import reports of companies.

Emissions were calculated from large and small commercial refrigeration equipment, industrial refrigeration and cooling, stationary air conditioning/cooling, mobile refrigeration, mobile air conditioning, fire protection equipment and foam producing by taking the following bans into account:

1. Bans on placing on the market, e.g.:
    - stationary refrigeration equipment that contains HFCs with GWP of 2500 or more (from 2020);
    - commercial refrigeration equipment (hermetic equipment with HFCs, multipack systems (40 kW or more) with HFCs except multilevel cascade systems partly with HFC-134a (from 2020);
    - single split stationary air conditioners and heat pumps that contain HFCs with GWP of 750 or more (from 2025);
    - fire protection equipment with HFC-23 (additionally, HFC-227ea containing fire protection systems have a sharply decreasing trend);
    - one-component foams that contain HFCs with GWP 150 or higher;
    - ban of the sale of new vehicles with EU-type approval having refrigerant with GWP over 150 in the air conditioner since 01.01.2017 is taken into account (according to the Directive 2006/40/EC);
2. Ban of refilling equipment that contains HFCs with GWP of 2500 or more (from 2020).

It is assumed that an effect of a completed project of the promotion of alternative and low-GWP refrigerants is that the majority of commercial and industrial refrigeration is switching to alternative refrigerants (CO_2 and NH_3 based systems respectively). In categories where the use of banned, high-GWP HFCs was subtracted but there is no information about alternatives, substitutions with lower GWP HFC-s were taken into account.

It was assumed that HFC refrigerants are properly collected from discharged equipment.

Projection of emissions from subsector 2.F.2 Foam blowing agents is based on forecasts of foam producers, real GDP growth rate and population size. Projection of emissions from 2.F.3 Fire protection is based on expert opinion from service companies concerning new equipment and a method of calculating the stock based on the GHG inventory. Projection of emissions from 2.F.4 Aerosols is based on the trend of medical aerosol use in 2014–2020, population size and real GDP growth rate.

SF_6 emissions (from 2.G Other product manufacture and use) are not regulated by the Regulation (EU) No. 517/2014. SF_6 emissions were calculated according to the methods of GHG inventory while taking into account plans on equipment replacement by the electrical network operators in Estonia.

Regarding N_2O – consumption of medical N_2O was provided by wholesalers who explained that sales will decline and consumption of N_2O in aerosols was calculated with the projection of population size and average emissions of N_2O per population in 2020–2021 (as the data for the year 2021 were known while compiling the projections).

5.3.4. Agriculture sector

Two projections scenarios of GHG emissions have been calculated for the period 2021–2050. Reference year 2020 used in projections is consistent with Estonia's 2020 submission to the UNFCCC on 15th of April 2022 (National Greenhouse Gas Inventory Report 1990–2020, 2022). The 'With Existing Measures' (WEM) scenario evaluates future GHG trends under current policies and measures. In the second scenario one additional measure is taken into consideration forming the basis of the 'With Additional Measures' (WAM) scenario.

Estonia's agricultural GHG emissions are projected to increase due to global demand for meat- and dairy products along with suitable climatic conditions favouring cattle production in Estonia to expand. Therefore, the highest impact on CH_4 emissions comes from Enteric fermentation due to the projected increase of domestic livestock. Aricultural soils is the second largest GHG emission source in Estonia, of which emissions are mostly driven by synthetic N-containing fertilisers applied to soils, however also organic soils cultivation, crop production, other organic fertilisers applied to soils, data about mineralisation, and sewage sludge applied to soils are affecting the total projections. Other categories, e.g. Manure management (driven by the livestock numbers), CO_2 emissions from Liming and Urea fertilization do not have a significant impact on the GHG emission trend.

Projections of emissions are calculated based on the 2006 IPCC methodology applied in the Estonian Greenhouse Gas Inventory. The projected numbers of animals, crop productions and the amounts of mineral fertilisers used are based on the results of the Agriculture Projection Model (APM), developed in 2021 by Agricultural Research Centre. This model considers the characteristics common to Estonia and provides opportunities to analyse different policy scenarios and changing market and macroeconomic conditions. All animal numbers from the APM results were rounded to an integer. . Also, average sheep, goat and poultry annual numbers were calculated for keeping consistency with the GHG inventory methodology. The quarterly sheep and goat numbers were divided with the last five-year average ratio of sheep and goats used in the inventory. The total number of broilers was projected based on the last five years in the 2022 NIR. The number of other hens and roosters was calculated based on the average ratio of the animal group used in the 2022 NIR. Poultry, layers and other poultry projections are based on the APM result.

Main activity data for calculating CH_4 emissions from Enteric fermentation and CH_4 and N_2O emissions from Manure management are livestock population, distribution of animal waste management systems (AWMS) and milk yield and pregnancy rate for dairy cows. Estonia-specific volatile solids (VS) and N excretion rates (kg/head/year) of dairy cattle have been calculated on the basis of projected milk yields. With the supporting mechanisms of the Common Agricultural Policy (CAP) Strategic Plan 2023-2027, the practise of raising sheep and goats may be presumed to grow moderately. Demand for lamb and goat meat, wool and milk will grow. The number of horses is projected to rise steadily until 2022 and then stay at that level. The population of rabbits is expected to grow steadily until 2031 and then stay at the same level until 2050. The population of fur animals will decrease steadily to zero in 2026, when fur farms will be banned in Estonia. The number of pigs is anticipated to decrease moderately until 2022, then start rising again until 2031 and then remain at that level until 2050. The level of poultry production is expected to fluctuate until 2031 and then remain at that level until 2050. Feed intake parameters and the methane conversion rate are harmonised with the national GHG inventory. Gross energy intake of dairy cows was calculated on the basis of projected milk yields. Average milk yield per cow is projected to increase until 2031. Projected values are in accordance with the projections in GPCP 2050. Fat content in milk (%) for the projected period is assumed to remain at the same level as in 2021 (3.9%) until 2050.

Projected N_2O emissions from the Agricultural soils subsector are based on the amounts of organic and synthetic N-containing fertilisers applied to soil, quantities of harvested crops, carbon stock change in mineral soils, and area of cultivated organic soils. Direct N_2O emissions include emissions from synthetic and organic fertilisers applied to agricultural soils, emissions from animal waste, emissions from crop residues, emissions from the cultivation of organic soils and emissions from mineralisation associated with loss of soil organic matter. Indirect N_2O emissions include emissions from atmospheric deposition and from leaching and run-off. The quantities of sewage sludge and composted organic waste applied to soils are harmonised with the Waste sector projections (see Waste sector GHG projections chapter), data for calculating carbon stock change in mineral soils and organic soils cultivation are provided by the LULUCF sector expert. The use of synthetic fertilisers increased in 2021 compared to 2020. From 2022, it is projected to drop back to around the same level as in 2020 and remain there until 2030, in 2031 it is projected to drop even more and then remain at that level until 2050. Estonia's crop production is projected to decrease in 2021 compared to 2020. From 2022, it is projected to fluctuate steadily until 2031 and then remain at that level until 2050.

The amount of lime applied to soil is calculated using the moving average of the last three years until 2031. Then it will remain at that level until 2050. Therefore, emissions from liming are projected to increase in 2021, then they are projected to decrease slightly and start steadily fluctuating until 2031, from then on they will remain at that year's level. Emissions from the Agriculture sector are projected according to the WEM and WAM scenarios. According to the WAM scenario, the use of low-emission manure storage technologies (storage of liquid manure in tented roof or concrete roof storage facilities, as well as in closed steel or plastic tanks) will increase by 2030 compared to 2020. The WAM scenario uses reduced NH_3 emission amounts from the Estonian Atmospheric pollutant emissions projections until 2050, as input data for GHG projections.

5.3.5. LULUCF sector

LULUCF sector 'With Existing Measures' (WEM) scenario and 'With Additional Measures' (WAM) scenario GHG projections have been calculated for the period from 2021–2050. The reference year 2020 used in projections is consistent with Estonia's 2022 submission to the European Commission on the 15th of March (National Greenhouse Gas Inventory Report 1990–2020, 2022). The WEM scenario evaluates future

GHG emission trends under the current policies and measures. In the second scenario one alternative policy direction, uniform final felling, is taken into consideration forming the basis of the WAM scenario. It is based on the draft Forestry Development Plan until 2030.

The LULUCF sector includes emissions and removals of GHGs from Forest land, Cropland, Grassland, Wetlands, Settlements, Other land and Harvested wood products.

The projections of land use categories are based on the following assumptions and planned activities:

- Annual land conversions will generally continue to occur at the same level as the average of 2016–2020, except for the conversions described below;
- Forest land and Cropland total areas will remain equal to the area in 2020, annual land use changes to/from Forest land and Cropland are balanced by the Grassland category;
- Deforestation of 22 000 ha of Forest land due to the restoration of heritage meadows (Grassland category) was divided equally between 2022–2050 (MoE);
- The following changes in land use were expected due to the construction of Rail Baltic (Steiger, 2021) in the period of 2023–2028:
  - FL-SL 722.3 ha
  - CL-SL 157.5 ha
  - GL-SL 29.8 ha
  - WL-SL 38.8 ha
  - OL-SL 1 065 ha
- Deforested area due to the establishment of training grounds for the Defence Forces was assumed to be split in half between categories FL-GL and FL-SL. Total projected deforested areas were:
  - development of the central polygon of Defence Forces – deforested area 4275 ha (Skepast & Puhkim, 2022) in the period 2022–2031
  - Sirgala training ground – deforested area 1500 ha (Estonian Centre for Defence Investment), in the period 2023–2028
- Shares of drained organic soils from the total area of organic soils for Forest land remaining forest land and Grassland remaining Grassland were estimated as an average of 2016–2020.

Projected areas of land use categories

Table 5.1 and methods described in the NIR 2022 chapter 6 were used for estimating GHG emissions and removals. Additional assumptions for specific categories are stated below.

Future harvesting rates in Estonia depend on adopted and planned policies. WEM projections for Forest land are based on the business as usual scenario and WAM projections on the uniform final felling scenario, both composed by the Estonian Environment Agency. The following assumptions and methods were applied in WEM scenario projections for Forest land category:

- Total final felling volume was expected to be 11.5 mln m^3 year-1, which is the average of years 2017–2021 (NFI, 2021). Felling rates was projected as a ten-year average;
- In modelling the final fellings, actual harvesting distribution between dominant tree species in recent years was used. The calculation of the final felling area is only applied in the case of forest available for wood supply. Strictly protected forests are modelled without fellings;
- Final fellings are projected by dominant tree species and site quality classes depending on the age, diameter and stocking of the stand;
- The improvement of forest growth (site quality class) was only projected in the areas that are regenerating during the period. Site quality class indicates the productivity of the habitat. However, the growing stock of young forests is small, and therefore the effect is insignificant (on average less than 1 mln m^3 additional growing stock by 2050);
- The growing stock volume in Forest land was projected by decade and was obtained by multiplying the area in age class with the average growing stock per hectare in the relevant age class;
- Distribution of forest area by dominant tree species remains the same during the entire period;
- The share of the forest not available for wood supply is 17.5% (NFI, 2021). It is projected to remain at the same level;
- In the case of forest available for wood supply with additional protective measures (excluding water protection forests on banks, 8.5% from total Forest land), half of the uniform final felling coupe intensity was applied;
- Growing stock in Forest land remaining forest land was calculated as the difference between projected total forest land and estimated Land converted to forest land growing stocks;
- Changes in dead wood C stock in Forest land remaining forest land were estimated by multiplying the 5-year average carbon stock change content per hectare by the projected area;
- Non-CO_2 emissions from drained organic forest soils were estimated as the average of the 2016–2020 period.

According to the WAM scenario, the uniform annual final felling area is assumed during the whole rotation period. The final felling volume is expected to be 9.4–9.8 mln year-1. The distribution of felling areas by dominant tree species is optimal and does not consider the actual harvesting distribution (as in WEM).

Estimations for the HWP pool are based on the projected harvest levels; therefore, both WEM and WAM scenarios have been projected. The fraction of harvest for the HWP commodity production and the share of HWP commodities were assumed to remain at the current level.

For calculating C stock changes in the mineral soils of the Cropland remaining cropland category, it was assumed that the present land use (shares of long-term cultivated, perennial and set-aside areas, as well as the shares of crops with different C inputs) and management practices (shares of areas under full tillage, reduced tillage and no-till) will continue; therefore average mineral soil SOC stock for the period 2016–2020 was used in calculations. Estimated annual SOC change values were smoothed using a moving average in order to reduce inter-annual variations.

The majority of emissions from the Wetlands category derive from the horticultural use of peat. The amount of peat removed for horticultural use is calculated as the difference between total peat production and the primary production of energy peat, and is assumed to be oxidised in the year of extraction. The long-term average total peat extraction was calculated as the average of the 2017–2021 period. The use of energy peat has had a declining trend which was expected to continue, and, after 2035, all extracted peat was projected to be used in horticulture. The area of active and unrestored peat extraction sites will decrease linearly from 25.55 kha in 2020 to 19 kha in the period 2026–2050. Land area by which the area of active extraction sites is smaller than the total peat extraction area as assumed to be rewetted. GHG emissions from rewetted sites were estimated according to the IPCC Wetlands Supplement (IPCC, 2014), Chapter 3. Default emission factors for the temperate zone nutrient-poor sites were applied.

CH_4 and N_2O emissions from wildfires were estimated as the average of the 2016–2020 period. Similarly, reported and projected CH_4 and N_2O emissions from biomass burning in the Grassland remaining grassland category also include emissions from Land converted to grassland and Wetlands categories. GHG emissions from wildfires were not estimated for Croplands and Settlements as they were considered insignificant in terms of the overall level and trend in national emission.

5.3.6. Waste sector

Waste sector 'With Existing Measures' (WEM) scenario GHG projections have been calculated for the period of 2020–2050. The reference year 2020 used in projections is consistent with Estonia's 2022 submission to the UNFCCC on 15th of April 2022 (National Greenhouse Gas Inventory Report 1990–2020, 2022). The WEM scenario evaluates future GHG emission trends under the current policies and measures.

GHG emissions emitted from the Waste sector include CO_2, CH_4 and N_2O. CO_2 is emitted from the Waste incineration category. The main share of CH_4 from the Waste sector comes from Solid waste disposal on land. CH_4 and N_2O emitted from Wastewater treatment and discharge, Biological treatment and Waste incineration.

CH_4 emission projections in the Solid waste disposal on land (SWD) subcategory are done using the 2006 IPCC Waste Model, which has been developed by the IPCC for estimating CH_4 emissions from solid waste disposal sites, for projections, additional sheets have been interlinked with the existing Waste model template sheets which are easy to adjust the to reflect the country specific needs. Also it is possible to interlink cells making the calculations easy. It is difficult to point out the weakness of the model as the calculations difficulties depend on the adjustments and activity data. In the IPCC 2006 Waste Model, synergies of waste decomposition over time period is taken into account in the calculation. There are no overlaps, because the input data is clearly divided to different waste groups.

The MSW generation projections take into account population projection (Statistics Estonia) and the long-term real GDP growth rate (the Ministry of Finance). The composition and the amount of generated MSW is taking into account, that from 2035 at least 65% of the municipal waste shall be prepared for re-use and recycled. In addition, starting from 2030 it is prohibited to deposit waste suitable for recycling or other recovery, in particular municipal waste. Also, from 2030 the quantity of municipal waste deposited in a landfill shall not exceed 10 % by weight of the total quantity of municipal waste generated in the same year. For textile waste, local governments will start separate collection of textile waste no later than 2025 and implement separate collection or recycling at source no later than 2023, which decrease the amount of degradable waste at landfills. Projections also take into account the amount of waste incinerated MSW in Iru CHP plant (emissions from this activity is included in the Energy sector projections).

Mixed Municipal Solid Waste Composition Study carried out in 2020 (SEI-Tallinn, 2020) was used for a MSW composition projection. Real GDP growth rate was also used for projecting industrial waste generation.

Projections in the subcategory Biological treatment of solid waste are based on the long-term real GDP growth rate projections by the Ministry of Finance applied to the previous year's biologically treated solid waste amount. While calculating, it is considered, that more biological waste is separated from the municipal solid waste and that there will be additional biodegradable waste from industrial sources (calculated under Solid waste disposal subcategory).

Only a small amount of waste gets incinerated without energy recovery. Projections in the subcategory Waste incineration and open burning were done using the assumptions of no open burning taking place after 2030 and that a small amount of waste will be incinerated without energy recovery (for burning contraband, utilising hazardous waste, etc.). Open burning of municipal solid waste is prohibited, nevertheless an expert judgment is used to evaluate the amount of waste that might be open-burned based on the amount MSW generated. The MSW generation is in accordance with the subsector Solid waste disposal on land. Activity data about generated MSW is projected under the SWD subcategory.

Projections of GHG emissions in Wastewater treatment and discharge subcategory account for population projection (Statistics Estonia) and an expert judgement given by the MoE on the usage of different wastewater treatment types and the coverage of centralised wastewater system. Different wastewater treatment systems are covering both high and low density settlements. GHG emissions from Industrial wastewater was conducted using stable production throughout the time series of 2021–2050.

5.3.7. Key assumptions

The key underlying assumptions used in the projections are presented in **Table 5.7** and **Table 5.8**.

Table 5.7. Key assumptions used in WEM projections

PARAMETER USED ('WITH EXISTING MEASURES' SCENARIO)		unit	2000	2005	2010	2015	2020	2025	2030	2035	2040	2050
General parameters and variables												
Population		Count	1,401,250	1,358,850	1,333,290	1,313,271	1,328,889	1 ,320 ,618	1,313,906	1,304,849	1,296,836	1,278,110
Gross domestic product (GDP)	Real growth rate	%	10.1	9.5	2.4	1.9	-0.6	2.5	1.6	1.5	1.4	1.3
	Constant prices	EUR million (2015)	12,541	17,866	17,504	20,631	24,107	27,926	30,512	33,056	35,459	40,558
International (wholesale) fuel import prices	Coal	EUR(2020)/GJ	-	-	-	-	1.6	3.1	3.1	3.1	3.3	3.7
	Crude Oil	EUR(2020)/GJ	-	-	-	-	6.4	15.4	15.4	15.4	16.3	19.7
	Natural gas	EUR(2020)/GJ	-	-	-	-	3.1	13.2	11.3	11.3	11.3	11.8
EU ETS carbon price		EUR (2020)/EUA	-	-	-	-	24	80	80	120	250	410
Energy supply												
Gross inland consumption by fuel type source (total)	Solid fossil fuels	TJ	124,991	140,906	173,066	162,508	118,198	127,107	111,209	102,893	102,630	-
	Crude oil and petroleum products	TJ	36,817	42,926	41,063	42,734	39,529	39,288	36,345	29,879	22,951	15,341
	Natural gas	TJ	23,923	28,833	24,032	16,559	14,649	12,955	12,017	11,859	10,795	10,951
	Renewables	TJ	21,472	24,692	36,066	38,093	54,267	52,370	67,499	76,557	74,086	74,489
	Other	TJ	3,383	3,494	4,263	5,192	4,432	4,272	3,420	3,087	3,316	2,620
Energy consumption												
Final energy consumption	Total	TJ	58,857	71,158	71,513	71,940	69,565	70,488	68,775	64,318	60,917	58,070
Final energy consumption split	Solids	TJ	4,267	3,970	3,226	1,282	350	-	-	-	-	-
	Oil	TJ	28,803	36,403	35,316	39,376	37,341	38,287	35,358	28,910	22,109	14,500
	Gas	TJ	7,422	11,022	8,670	9,312	9,976	9,894	9,738	9,831	9,908	10,064
	Electricity	TJ	-	-	-	-	52	578	681	2,199	4,934	9,076
	Renewable energy	TJ	17,788	18,778	23,675	20,520	21,007	20,174	21,444	21,822	22,411	22,876
	Other	TJ	577	984	627	1,450	840	1,555	1,555	1,555	1,555	1,555
Industry	Total	TJ	15,475	19,835	15,401	13,957	9,409	10,485	10,791	11,175	11,524	12,227
Industry split	Solids	TJ	3,253	2,884	2,927	1,174	260	-	-	-	-	-
	Oil	TJ	3,714	3,751	2,547	2,896	2,699	2,907	3,040	3,164	3,278	3,506
	Gas	TJ	5,099	6,934	4,783	3,948	3,962	4,247	4,340	4,523	4,690	5,025
	Renewable energy	TJ	3,318	5,509	4,678	4,626	1,648	1,775	1,856	1,932	2,001	2,141
	Other	TJ	91	758	467	1,313	840	1,555	1,555	1,555	1,555	1,555
Residential	Total	TJ	17,911	15,749	20,903	17,980	19,426	19,337	19,259	19,259	19,259	19,259
Residential split	Solids	TJ	800	788	217	109	40	-	-	-	-	-
	Oil	TJ	1,013	544	515	568	434	387	385	347	308	193
	Gas	TJ	1,769	1,883	2,299	2,065	2,352	2,224	2,119	2,022	1,926	1,733
	Renewable energy	TJ	13,888	12,342	17,728	15,133	16,600	16,726	16,756	16,890	17,025	17,333
	Other	TJ	442	192	144	106	-	-	-	-	-	-
Tertiary	Total	TJ	3,247	4,804	3,333	4,836	4,893	4,862	4,860	4,860	4,860	4,860

PARAMETER USED ('WITH EXISTING MEASURES' SCENARIO)		unit	2000	2005	2010	2015	2020	2025	2030	2035	2040	2050
Tertiary split	Solids	TJ	187	272	81	-	43	-	-	-	-	-
	Oil	TJ	2,203	1,851	1,224	1,392	1,059	827	535	292	-	-
	Gas	TJ	446	1,936	1,245	2,930	3,147	3,112	3,110	3,110	3,110	3,110
	Renewable energy	TJ	366	711	767	484	643	924	1,215	1,458	1,750	1,750
	Other	TJ	45	35	16	30	-	-	-	-	-	-
Agriculture/ Forestry	Total	TJ	1,573	3,470	3,244	4,747	4,071	4,380	4,579	4,767	4,938	5,282
Agriculture/ Forestry split	Solids	TJ	27	27	-	-	6	-	-	-	-	-
	Oil	TJ	1,223	2,963	2,720	4,324	3,715	4,002	4,184	4,356	4,512	4,827
	Gas	TJ	107	270	342	253	150	162	169	176	182	195
	Renewable energy	TJ	216	210	182	170	201	216	226	235	244	260
Transport	Total	TJ	20,650	27,300	28,632	30,419	31,766	31,425	29,286	24,257	20,337	16,441
Transport split	Oil	TJ	20,650	27,294	28,310	30,196	29,434	30,164	27,214	20,752	14,012	5,974
	Gas	TJ	-	-	2	116	364	150	-	-	-	-
	Electricity	TJ	-	-	-	-	52	578	681	2,199	4,934	9,076
	Renewable energy	TJ	-	7	320	107	1,916	533	1,392	1,306	1,392	1,392
Agriculture												
Livestock	Dairy cattle	1000 heads	131	112.8	96.5	90.6	84.3	84.2	87.9	88.8	88.8	88.8
	Non-dairy cattle	1000 heads	121.8	136.7	139.8	165.6	169	172.7	189.7	194.4	194.4	194.4
	Sheep	1000 heads	33.3	55.5	95.8	88.1	75.3	96.8	113.6	116.3	116.3	116.3
	Pigs	1000 heads	300.2	346.5	371.7	304.5	316.8	299.4	304.3	303.9	303.9	303.9
	Poultry	1000 heads	2,366.4	1,878.7	2,046.4	2,161.8	2,148.8	2,164.1	2,141.7	2,131.7	2,131.7	2,131.7
Nitrogen input from application of synthetic fertilisers		kt nitrogen	22.4	20.08	28.63	36.28	41.49	41.83	42.06	38.42	38.42	38.42
Nitrogen input from application of manure		kt nitrogen	12,132	13,604	15,297	16,290	17,016	17,534	18,930	19,319	19,413	19,619
Nitrogen in crop residues returned to soils		kt nitrogen	16,086	18,802	17,932	29,146	33,497	28,884	30,216	30,520	30,520	30,520
Area of cultivated organic soils		1000 hectares	27.8	27.3	26.88	27.62	27.75	27.75	27.75	27.75	27.75	27.75
The share of lagoons with natural crust from cattle´s liquid manure storages		%	-	-	-	-	62.2	62.2	62.2	62.2	62.2	62.2
The share of ring storage tanks with natural crust from cattle´s liquid manure storages		%	-	-	-	-	37.2	37.2	37.2	37.2	37.2	37.2
The share of closed storage tanks from cattle´s liquid manure storages		%	-	-	-	-	0.6	0.6	0.6	0.6	0.6	0.6
The share of lagoons with floating cover from swine´s liquid manure storages		%	-	-	-	-	19.2	19.2	19.2	19.2	19.2	19.2
The share of ring storage tanks with floating cover from swine´s liquid manure storages		%	-	-	-	-	77.9	77.9	77.9	77.9	77.9	77.9
The share of closed storage tanks from swine´s liquid manure storages		%	-	-	-	-	2.9	2.9	2.9	2.9	2.9	2.9
Waste												
Municipal solid waste (MSW) generation (including biodegradable industrial waste)		t	1,416,442	2,302,511	1,322,199	924,058	615,056	601,502	576,652	556,598	540,281	525,096

PARAMETER USED ('WITH EXISTING MEASURES' SCENARIO)		unit	2000	2005	2010	2015	2020	2025	2030	2035	2040	2050
Municipal solid waste (MSW) going to landfills (including biodegradable industrial waste)		kt	440,811	377,805	237,639	31,243	65,130	13,327	14,570	15,766	16,893	18,061
Fraction of recovered methane		%	8	16	10	21	16	17	23	30	36	49
Biodegradable waste composted		tonnes / dry matter	3,042	37,431	78,001	77,254	181,994	284,047	328,018	347,220	365,360	403,857
Amount of municipal solid waste open burned		%	2.0	1.0	1.0	0.5	0.5	0.25	0	0	0	0
LULUCF												
Forest land remaining forest land	Mineral soils	1000 hectares	1,785.03	1,781.18	1,774.57	1,788.91	1,811.32	1,822.72	1,829.14	1,832.58	1,831.04	1,835.07
Forest land remaining forest land	Organic soils	1000 hectares	572.91	572.45	570.59	571.28	573.17	574.61	575.86	577.43	577.65	579.25
Cropland converted to forest land	Mineral soils	1000 hectares	24.49	32.02	35.82	28.65	14.05	6.85	3.03	1.36	1.36	1.36
Grassland converted to forest land	Mineral soils	1000 hectares	17.17	24.05	32.55	31.99	27.21	27.30	26.04	24.59	26.10	22.06
Grassland converted to forest land	Organic soils	1000 hectares	1.13	1.54	2.00	2.81	2.49	2.92	3.43	2.48	2.26	0.66
Wetlands converted to forest land	Mineral soils	1000 hectares	NO	NO	NO	0.14	0.18	0.24	0.31	0.24	0.27	0.27
Wetlands converted to forest land	Organic soils	1000 hectares	2.85	5.53	7.84	8.22	7.38	5.63	4.21	3.76	3.76	3.76
Settlements converted to forest land	Mineral soils	1000 hectares	4.01	5.51	5.71	4.20	2.44	1.05	0.61	0.47	0.47	0.47
Settlements converted to forest land	Organic soils	1000 hectares	0.69	0.82	1.11	0.80	0.63	0.50	0.17	NO	NO	NO
Other land converted to forest land	Mineral soils	1000 hectares	6.47	9.60	10.53	8.23	4.68	1.70	0.74	0.63	0.63	0.63
Cropland remaining cropland	Mineral soils	1000 hectares	978.69	960.59	944.99	937.48	934.51	933.20	938.96	942.95	946.18	946.29
Cropland remaining cropland	Organic soils	1000 hectares	27.56	27.09	26.13	26.03	26.16	26.14	26.66	27.58	27.71	27.75
Forest land converted to cropland	Mineral soils	1000 hectares	NO	NO	0.36	1.09	1.70	1.70	1.34	0.61	NO	NO
Grassland converted to cropland	Mineral soils	1000 hectares	1.64	1.64	9.98	16.13	21.64	22.95	17.55	14.29	11.67	11.55
Grassland converted to cropland	Organic soils	1000 hectares	NO	NO	0.54	1.46	1.60	1.61	1.09	0.17	0.04	NO
Grassland remaining grassland	Mineral soils	1000 hectares	222.44	212.93	192.30	185.17	192.95	193.43	191.95	186.17	178.93	169.61
Grassland remaining grassland	Organic soils	1000 hectares	52.06	51.57	50.40	49.78	50.73	50.40	50.21	50.21	50.36	51.74
Forest land converted to grassland	Mineral soils	1000 hectares	3.42	5.12	6.52	6.50	5.28	7.17	10.05	12.50	14.30	12.74
Forest land converted to grassland	Organic soils	1000 hectares	0.21	0.21	0.21	0.19	0.22	0.85	1.60	1.95	2.16	1.48
Cropland converted to grassland	Mineral soils	1000 hectares	21.49	30.79	39.10	35.81	21.72	13.49	6.18	4.30	4.30	4.30
Cropland converted to grassland	Organic soils	1000 hectares	2.42	2.85	3.63	2.32	1.47	1.04	0.18	NO	NO	NO
Wetlands converted to grassland	Mineral soils	1000 hectares	0.00	0.00	0.00	0.17	0.17	0.17	0.17	NO	NO	NO
Wetlands converted to grassland	Organic soils	1000 hectares	0.54	0.63	0.63	0.57	0.24	0.28	0.40	0.50	0.50	0.50
Settlements converted to grassland	Mineral soils	1000 hectares	1.06	1.50	1.71	1.51	0.69	0.25	NO	NO	NO	NO
Other land converted to grassland	Mineral soils	1000 hectares	NO	0.30	1.04	1.24	1.24	0.94	0.20	NO	NO	NO
Peat extraction remaining peat extraction	Active and abandoned unreclaimed sites	1000 hectares	24.71	23.74	23.37	24.28	25.02	20.22	19.00	19.00	19.00	19.00
Peat extraction remaining peat extraction	Rewetted sites	1000 hectares	NO	NO	NO	NO	NO	5.64	7.16	7.47	7.78	8.39
Forest land converted to peat extraction		1000 hectares	NO	NO	1.41	0.56	NO	NO	NO	NO	NO	NO
Wetlands converted to peat extraction		1000 hectares	0.17	NO	NO	0.25	0.53	0.38	0.38	0.38	0.38	0.38
Forest land converted to other wetlands	Mineral soils	1000 hectares	NO	NO	NO	0.28	0.56	0.56	0.56	0.29	NO	NO
Forest land converted to other wetlands	Organic soils	1000 hectares	0.17	0.21	0.41	0.62	0.82	1.11	1.20	1.20	1.34	1.34

PARAMETER USED ('WITH EXISTING MEASURES' SCENARIO)		unit	2000	2005	2010	2015	2020	2025	2030	2035	2040	2050
Cropland converted to other wetlands	Mineral soils	1000 hectares	NO	NO	NO	0.02	0.10	0.10	0.10	0.08	NO	NO
Grassland converted to other wetlands	Organic soils	1000 hectares	0.20	0.28	0.48	0.48	0.41	0.32	0.12	NO	NO	NO
Settlements converted to other wetlands	Organic soils	1000 hectares	NO	0.21	1.20	1.45	1.45	1.24	0.25	NO	NO	NO
Forest land converted to settle-ments	Mineral soils	1000 hectares	0.07	2.05	5.89	11.58	15.25	16.67	15.66	13.25	11.85	9.38
Forest land converted to settle-ments	Organic soils	1000 hectares	NO	0.42	0.68	1.02	1.41	1.41	1.79	2.33	2.53	2.52
Cropland converted to settlements	Mineral soils	1000 hectares	0.41	1.59	3.85	6.80	7.75	7.97	6.67	5.52	5.52	5.40
Cropland converted to settlements	Organic soils	1000 hectares	0.00	0.03	0.13	0.13	0.13	0.13	0.12	0.04	0.04	NO
Grassland converted to settlements	Mineral soils	1000 hectares	0.60	1.55	4.07	5.24	6.36	6.75	5.11	5.34	5.34	5.32
Wetlands converted to settlements	Mineral soils	1000 hectares	NO	NO	NO	NO	0.03	0.03	0.05	0.08	0.10	0.10
Wetlands converted to settlements	Organic soils	1000 hectares	NO	NO	NO	NO	0.12	0.27	0.41	0.53	0.53	0.50
Other land converted to settlements	Mineral soils	1000 hectares	0.21	0.42	0.75	0.67	0.69	0.69	0.54	0.23	0.15	0.15
Forest land converted to other land	Mineral soils	1000 hectares	NO	0.17	1.96	2.17	3.05	3.55	2.43	2.89	2.68	2.68
Cropland converted to other land	Mineral soils	1000 hectares	NO	0.08	0.42	0.45	0.57	0.61	0.40	0.50	0.50	0.50
Grassland converted to other land	Mineral soils	1000 hectares	NO	0.04	0.26	0.26	0.26	0.21	NO	NO	NO	NO
Wetlands converted to other land	Mineral soils	1000 hectares	NO	NO	0.12	0.12	0.12	0.12	NO	NO	NO	NO
Forest not available for wood supply and forest available for wood supply with additional protective measures (excluding water protection forests on banks)		%	-	-	-	-	-	26	26	26	26	26
Felling volume		million m^2	10.6	8.0	8.2	10.1	10.6	11.5	11.5	11.5	11.5	11.5
Share of drained organic soils	Forest land remaining forest land	%	47.8	47.9	48.0	48.1	48.3	48.2	48.2	48.2	48.2	48.2
Share of drained organic soils	Grassland remaining grassland	%	14.9	14.3	14.1	15.2	16.6	16.6	16.6	16.6	16.6	16.6
Average SOC stock	Cropland remaining cropland	t C/ha	74.04	75.52	75.81	75.66	75.63	75.69	75.69	75.69	75.69	75.69
Production of horticultural peat		1000 tonnes	406.70	695.60	562.50	598.20	644.10	783.60	797.64	811.26	811.26	811.26
Index of produced sawnwood volume to felling volume		Index	-	-	-	-	-	0.2252	0.2252	0.2252	0.2252	0.2252
Index of produced wood–based panels volume to felling volume		Index	-	-	-	-	-	0.0635	0.0635	0.0635	0.0635	0.0635
Index of produced paper and paperboard volume to felling volume		Index	-	-	-	-	-	0.0097	0.0097	0.0097	0.0097	0.0097
Index of produced semi-chemical wood pulp volume to felling volume		Index	-	-	-	-	-	0.0216	0.0216	0.0216	0.0216	0.0216
Other parameters and variables												
Enefit280 oil shale plants		Count	0	0	0	1	1	2	2	2	2	2
Petroter oil shale plants		Count	0	0	1	3	3	3	3	3	3	3

Table 5.8. Additional key parameters used in WAM projections

PARAMETER USED ('WITH ADDITIONAL MEASURES' SCENARIO)		unit	2020	2025	2030	2035	2040	2050
Energy supply								
Gross inland consumption by fuel type source (total)	Solid fossil fuels	TJ	118,198	127,054	111,134	102,753	102,444	0
	Crude oil and petroleum products	TJ	39,529	39,003	35,360	28,784	21,966	14,494
	Natural gas	TJ	14,649	12,760	11,517	10,922	9,699	9,278
	Renewables	TJ	54,267	51,552	65,092	71,704	66,672	62,944
	Other	TJ	4,432	4,211	3,289	2,891	3,055	2,268
Energy consumption								
Final energy consumption	Total	TJ	69,565	70,032	67,160	61,664	57,016	51,655
Final energy consumption split	Solids	TJ	350					
	Oil	TJ	37,341	37,668	34,476	27,995	21,327	13,920
	Gas	TJ	9,976	9,805	9,459	9,266	9,030	8,684
	Electricity	TJ	52	945	659	2,156	4,829	8,861
	Renewable energy	TJ	21,007	20,060	21,011	20,692	20,275	18,634
	Other	TJ	840	1,555	1,555	1,555	1,555	1,555
Industry	Total	TJ	9,409	10,485	10,791	11,175	11,524	12,227
Industry split	Solids	TJ	260					
	Oil	TJ	2,699	2,907	3,040	3,164	3,278	3,506
	Gas	TJ	3,962	4,247	4,340	4,523	4,690	5,025
	Renewable energy	TJ	1,648	1,775	1,856	1,932	2,001	2,141
	Other	TJ	840	1,555	1,555	1,555	1,555	1,555
Residential	Total	TJ	19,426	19,231	18,868	18,214	17,275	15,179
Residential split	Solids	TJ	40					
	Oil	TJ	434	385	377	328	276	152
	Gas	TJ	2,352	2,212	2,075	1,912	1,728	1,366
	Renewable energy	TJ	16,600	16,635	16,415	15,974	15,271	13,661
Tertiary	Total	TJ	4,893	4,742	4,492	4,148	3,798	3,278
Tertiary split	Solids	TJ	43					
	Oil	TJ	1,059	806	494	249		
	Gas	TJ	3,147	3,035	2,875	2,655	2,431	2,098
	Renewable energy	TJ	643	901	1,123	1,245	1,367	1,180
Agriculture/ Forestry	Total	TJ	4,071	4,380	4,579	4,767	4,938	5,282
Agriculture/ Forestry split	Solids	TJ	6					
	Oil	TJ	3,715	4,002	4,184	4,356	4,512	4,827
	Gas	TJ	150	162	169	176	182	195
	Renewable energy	TJ	201	216	226	235	244	260
Transport	Total	TJ	31,766	31,195	28,431	23,360	19,481	15,688
Transport split	Oil	TJ	29,434	29,567	26,381	19,898	13,261	5,435
	Gas	TJ	364	150				
	Electricity	TJ	52	945	659	2,156	4,829	8,861
	Renewable energy	TJ	1,916	533	1,392	1,306	1,392	1,392
Agriculture								
The share of lagoons with natural crust from cattle´s liquid manure storages		%	62.2	61.0	59.0	59.0	59.0	59.0
The share of ring storage tanks with natural crust from cattle´s liquid manure storages		%	37.2	38.0	39.0	39.0	39.0	39.0
The share of closed storage tanks from cattle´s liquid manure storages		%	0.6	1.0	2.0	2.0	2.0	2.0
The share of lagoons with floating cover from swine´s liquid manure storages		%	19.2	15.0	12.0	12.0	12.0	12.0
The share of ring storage tanks with floating cover from swine´s liquid manure storages		%	77.9	81.5	83.0	83.0	83.0	83.0
The share of closed storage tanks from swine´s liquid manure storages		%	2.9	3.5	5.0	5.0	5.0	5.0
LULUCF								
Felling volume		million m^3	10.6	9.7	9.7	9.8	9.8	9.4

5.4. Comparison of projections of previous and current NC

NC7 as well as NC8 have been compiled by the EERC. The NC7 projections had 2014 as the base year with projections up to 2035, however current NC includes 2020 as a base year with projections up to 2050. In general, the main differences between the two projections include improved projection estimations, revised fossil fuel prices and economic growth assumptions. The renewed sectoral development plans with updated parameters and targets described under Chapter 4 allow for making projections that are more precise. For agriculture projection compilation, Agriculture Projection Model (APM) was used in NC8.

In the Energy sector there has been an update in historic trends (taking into account data until 2018), the update of EU ETS emission allowance price, new modelling with the Balmorel model, new input from the companies about their future plans, update of emission factors and changes in sources for the measures.

In the Transport sector there has been a recalculation of the measures´ impact on GHG decrement, update in the road transport mileage of the vehicle fleet, activity data update of the domestic aviation and update in the railway electrification measure. Long Range Energy Alternatives Planning System (LEAP) modelling tool used for NC7 projections is no longer in use and replaced by Sibyl baseline.

Some of the main assumptions and results of the previous and current NC projections are presented in Table 5.9.

Table 5.9. Comparison of projections of previous and current NC

	2020	2025	2030	2035
NC7 Annual GDP growth rates, %	3.0	2.5	2.5	2.1
NC8 Annual GDP growth rates, %	-0.6	2.5	1.6	1.5
NC7 Population, thousand people	1,297.4	1,276.0	1,250.7	1,222.9
NC8 Population, thousand people	1,328.9	1 ,320 .6	1,314.0	1,304.9
NC7 EU ETS carbon price EUR/EUA	15	20	26.5	36.5
NC8 EU ETS carbon price EUR/EUA	24	80	80	120
NC7 International (wholesale) fuel import prices -Electricity coal €/GJ	2.58	2.61	2.64	2.67
NC8 International (wholesale) fuel import prices – coal € (2020)/GJ	1.6	3.1	3.1	3.1
NC7 International (wholesale) fuel import prices – Natural gas €/GJ	6.69	8.01	9.36	9.83
NC8 International (wholesale) fuel import prices – Natural gas € (2020)/GJ	3.1	13.2	11.3	11.3
NC7 Area of cultivated organic soils, 1000 hectares	24	24	24	24
NC8 Area of cultivated organic soils, 1000 hectares	27.75	27.75	27.75	27.75
NC7 Number of total cattle, thousand heads	270	281	292	304
NC8 Number of total cattle, thousand heads	253.3	256.8	277.6	283.2
NC7 Municipal solid waste (MSW) generation, kt MSW	342.8	360.6	376.2	389.3
NC8 Municipal solid waste (MSW) generation, kt MSW	615.1	601.5	576.7	556.6
NC7 WEM total emissions, kt CO_2 eq. (with LULUCF)	17,192.2	17,061.5	15,329.8	14,945.0
NC8 WEM total emissions, kt CO_2 eq. (with LULUCF)	12,852.98	14,840.71	12,906.72	11,407.18
NC7 WAM total emissions, kt CO_2 eq. (with LULUCF)	16,620.3	15,980.2	13,494.1	12,763.6
NC8 WAM total emissions, kt CO_2 eq. (with LULUCF)	12,852.98	12,632.56	10,585.29	9,125.30

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6. Vulnerability assessment, climate change impacts and adaptation measures

Key developments:

- With the New Environmental Development Plan until 2030 (KEVAD), the national aim is set to integrate the impact of climate change and its adaptation into national strategic documents and sectoral development plans.
- Local governments have begun to assess and also take into account the risks arising from climate change in their local development plans, and nearly 50 out of 79 local governments already have or are still preparing local energy and climate plans. Improved readiness of municipalities for climate change is supported by the better availability of climate data, including the continuous development of environmental- and weather monitoring information systems, along with knowledge and skills on the implementation of adaptation measures. It is also very important to continue informing the population about climate and energy goals. State authorities have prepared and supplemented several important analyses, as well as spatial data and maps, for better planning of land use and for monitoring various climate change effects.
- In 2021, the Climate Change Adaptation Development Plan until 2030 action plan for the period of 2021–2025 was completed. The implementation of the action plan is planned through sectoral action programmes, and its purpose is to ensure that climate change adaptation activities are consistent, meet the goals set in the development plan, and contribute to climate change adaptation at both the local and national level. The estimated cost of implementing the development plan for adapting to the effects of climate change for the years 2021–2025 is 296 million euros.
- In 2022, a report on the implementation of the Climate Change Adaptation Development Plan until 2030 for the period of 2017–2020 was presented to the Government of the Republic. The report provides a good overview of the achievement of the goals and effectiveness of the development plan.

6.1. Introduction

Climate change, whether anthropogenic or the result of other factors, is an eternal and natural component of nature. In the case of natural development, however, climate change is relatively slow and adaptation to the changed conditions can occur in the course of a natural, spontaneous development. However, the exponential industrial development in the 20th century has resulted in very high pollution loads and a decrease in nature´s buffering capability, which in turn have made the changes in the climate very rapid. Amidst rapid environmental changes, it is no longer rational to rely on the spontaneous adjustment of the society and economy to the changes in the environment.

Human-induced climate change, including more frequent and intense extreme weather events, is increasingly causing widespread damage to both nature and people beyond natural climate change. According to the latest models, a temperature increase of 1.5 °C over a century will cause irreversible effects on low-resilience ecosystems (e.g. polar, mountain and coastal ecosystems). With a temperature increase greater than 1.5 °C, the risk of serious and irreversible effects increases.

The impacts of climate change on different regions differ: the impacts vary by location (e.g. floods in coastal areas or lower areas). If, for example, in the agriculture sector, the effects climate change have an effect on most of the world (in the middle and low latitudes) are negative, some positive effects can be expected in the higher latitudes. In terms of energy demand and tourism, there are both 'winners and losers' depending on the geographical location. Also, climate change does not affect different social groups equally (e.g. the elderly and young children are more vulnerable to extreme cold and heat). The risks are highest for disadvantaged people – those in a poorer socio-economic situation, with less social capital or people with chronic illnesses.

Thus, extreme weather conditions may deepen the inequality in society and put the cohesion of society at risk. The economies which are able to adjust to the changed conditions more rapidly and effectively achieve a significant competitive advantage.

The efficiency of adaptation to the impacts of climate change in society depends, on the one hand, on the actions of the state, the fragmentation of the decision-making structures, and the political and administrative culture, and, on the other, on the activities of non-governmental stakeholders, incl. the research community, on the pressure from the public and non-governmental organisations, and on the interests of commercial enterprises. It is the duty of the state and authorities to create favourable social structures for institutions and the population for adaptation: the legal frameworks, information and mentorship, technical support.

In addition, the European Union (EU) has clearly expressed the importance of national adaptation strategies and plans and has set the obligation to its Member States to prepare them, with the aim of reducing vulnerability and increasing the ability to adapt to the effects of climate change.

The development of measures for adaptation to climate change is based on the determination of the negative and in some cases positive impacts that accompany climate change. This is best executed by different sectors: health and rescue capability, land use, natural environment, economy, society, infrastructure, energy, etc. Adaptation to climate change and the respective measures are slowly, but surely, becoming a cross-cutting horizontal policy topic that concerns all sectors in Estonia. In recent years, more emphasis has been placed on the awareness of the authorities and citizens about the impact of climate change. Thus, the impact of climate change and possible adaptation measures have been taken into account in several policy documents and development plans.

6.2. Climate change and climate change scenarios in Estonia

The aim of this chapter is to provide an overview of the climatic changes which occurred in Estonia in the course of the last century, as well as of the projections and assessments of the future climate in Estonia up to 2100. The scientific basis used here is the report Future climate change scenarios in Estonia until 2100, drawn up by the Estonian Environment Agency (ESTEA) (ESTEA, 2015). This report forms the basis for the assessment of the sectors that are influenced by atmosphere and ground conditions. A climate scenario provides information on the spatio-temporal variability of the climate, taking into account both the relationships between the physical processes of the entire atmospheric, terrestrial and aquatic system, as well as emission scenarios.

Where possible, the report was drawn up on the basis of the CMIP5 (CMIP – Coupled Model Intercomparison Project) regional fine-scaling compiled for the latest report of the Intergovernmental Panel on Climate Change (IPCC), AR5. The period of 1971–2000 was used as the base climate period (reference period), if possible, and the periods of 2041–2070 and 2071–2100 as future comparison periods. The climate forecasts were drawn up based on the global climate change scenarios RCP4.51 and RCP8.5. (Both also form the basis for the CMIP5 experiment). RCP (Representative Concentration Pathway) is used to describe possible concentrations of GHGs caused by human activities and the resulting increase in radiative forcing on the earth (e.g. for RCP4.5 the radiative forcing increase is +4.5 W/m[2]. (ESTEA, 2015)

The respective results were assembled and published within the framework of the EUROCORDEX project. Where it was not possible or reasonable to use the results of EURO-CORDEX directly, summaries of published scientific literary works were used, incl. the IPCC reports AR5 (2013) and AR4 (2007), the IPCC special report on extreme climate events and disaster management, SREX (2012), overview of the scientific literature on climate change in the Baltic Sea basin, BACC (2008), and the climate change adaptation strategy, Baltadapt (2013). (ESTEA, 2015)

With the help of the LIFE project AdaptEst, new climate projections will be prepared for Estonia based on the 6th IPCC assessment report (AR6). Compiling Estonian climate projections and updating the future climate scenarios is one of the activities of the LIFE programme SIP (Strategic Integrated Project) in AdaptEst. In cooperation with the ESTEA, the University of Tartu and Tallinn University of Technology it is planned to prepare high-resolution climate models for Estonia until the end of this century. The cost of preparing climate scenarios is around 1 million euros. Preparation of Estonian climate projections is planned for the project period of 2023–2026. Climate projections are also impacting the development of other areas (e.g. creating a model of the water bodies that are most affected by climate change, developing construction standards taking extreme weather events into account, etc.). The climate projections are an important input for the new period Environmental Development Plan 2031+, but also for the planning of climate change adaptation activities in other sectoral development plans.

6.2.1. The most significant climatic changes observed in Estonia

The main factor influencing Estonia's climate is the country's geographical position. Local climatic differences are mainly caused by the neighbouring Baltic Sea, which warms up the coastal zone in winter and has a cooling effect in spring. Estonia lies in the transition zone between maritime and continental climates. Topography plays an important role in the distribution and duration of snow cover, especially in the highlands of south-eastern Estonia. (ESTEA 2015)

The average annual temperature has increased slightly faster in Estonia compared to the world as a whole since the middle of the last century (Jaagus, 2006; BACC 2008). The global increase in the ground level temperature since 1951 has been 0.12 °C per decade, for Estonia it has been 0.2–0.3 °C per decade (Jaagus, 2006). In the last 60 years, the average temperature in Estonia has risen by 1.2 °C. Climate warming has not occurred evenly throughout the year. The temperature has risen the most in winter (from December to February) and spring (from March to May). The climate warming is also reflected in changes in nature's seasonality. As a general tendency, spring climatic seasons have started to arrive earlier and the autumn ones later, as a result of which the warmer half-year has become longer and the winter has become shorter. (Nõges et al., 2012)

The increase in the average annual precipitation in the second half of the 20th century has been significant in Estonia, remaining between 5% and 15%, taking into consideration a correction for wetting. A higher trend can be observed in the period from October to March (Jaagus, 2006). In 1866–1995, only a weak and statistically insignificant growth trend has been observed in the case of Estonia, which is stronger in autumn and winter and weaker in spring and summer. Regular cycles have also been observed in the total amount of precipitation, which are of the lengths 50–60, 25–33, and 5–7 years. The average annual precipitation in a specific region may differ by more than twice, for example, 400 mm in 1965 and 850 mm in 1990. (Jaagus, 1992; Jaagus, 1998; Jaagus and Tarand, 1998)

A periodicity similar to that of precipitation is generally also characteristic of the runoff of Estonian rivers. Short-term variability can most often be observed in periods of 3–4 years and long-term variability in periods of 26–27 years, which reflect the regularity of the water-rich and water-hungry periods in the 20th century. No one-way increases or decreases in runoff have been observed in Estonia in the last 150 years and the impacts of climate change on runoff are not as clear or clearly targeted as the observed long-term increase in precipitation (Nõges et al., 2012). The data on the water temperature of Lake Peipus and Lake Võrtsjärv show an increasing trend (Nõges, 2009; Nõges and Järvet, 2005) similarly to other lakes in the Baltic Sea basin (BACC, 2008). The end of winter in the Estonian inland waterbodies moved to a month earlier in the period of 1946–1998 (Nõges et al., 2012). The ice cover period of Estonian rivers and lakes has shortened. Järvedes (Jaagus, 1997). The runoff maximum of the rivers has moved to an earlier time and the peak runoffs are less steep (Reihan et al., 2012). The likelihood of high runoffs in spring (≤ 10%, i.e. runoff, which occurs once in ten years) decreased in the period of 1922–2010. (Sarauskiene et al., 2015)

Sea water surface temperature is one of the main parameters characterising the climate of the surface layer of the Baltic Sea and its variability. The research, based on the analysis of infrared channel data from satellites, found a warming of the average annual surface temperature of the Baltic Sea. Around the coast of Estonia, the temperature change has been 0.6 to 1.0 °C per decade in the period of 1990–2008 (Lehmann et al., 2011). The time series of the Baltic Sea ice cover shows that, during the last 50 years, the maximum ice cover extent of the Baltic Sea has fluctuated between 50,000 km^2 and 400,000 km^2. In previous years, it has reached up to 420,000 km^2. A sharp decrease in the maximum extent of ice cover after 1990 is preceded by predominantly ice-rich years and followed by ice-poor years (Nõges et al., 2012). Decreasing sea ice cover has also been accompanied by a shorter duration of ice cover in the coastal areas of Estonia – ice formation is taking place later and the melting earlier. (Jaagus, 2003)

6.2.2. Future climate change scenarios in Estonia

Air temperature

The average annual increases in air temperature provided in **Table 6.1** and **Figure 6.1** are higher than the global average values forecasted in AR5. This matches the distribution of the increase in the average temperature in the CMIP5 forecasts, which shows that the increase in temperature is high in the northern hemisphere, especially at higher latitudes. (ESTEA, 2015)

Table 6.1. Absolute seasonal change in air temperature based on the EURO-CORDEX ensemble at the height of 2 m at the end of the 21st century compared to the control period of 1971–2000, °C (ESTEA, 2015)

Period	2041–2070		2071–2100	
Scenario	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Winter (DJV)	2,3	2,9	3,1	4,9
Spring (MAM)	2,4	3,1	3,4	4,9
Summer (JJA)	1,6	2,2	2,2	3,8
Autumn (SON)	1,7	2,2	2,2	3,6
Annual average	2,0	2,6	2,7	4,3

The highest average increase in the temperature by month is observed in March in the case of both scenarios. This may be explained by the faster warming of the ground due to springs with less snow. Higher increases in the temperature are also observed in other winter (December, January, February, i.e. DJF) and spring (March, April, May, i.e. MAM) months. The absolute seasonal changes in air temperature are provided in **Table 6.1** and **Figure 6.1**. In the period of 2041–2070, the increase in the temperature will be lowest

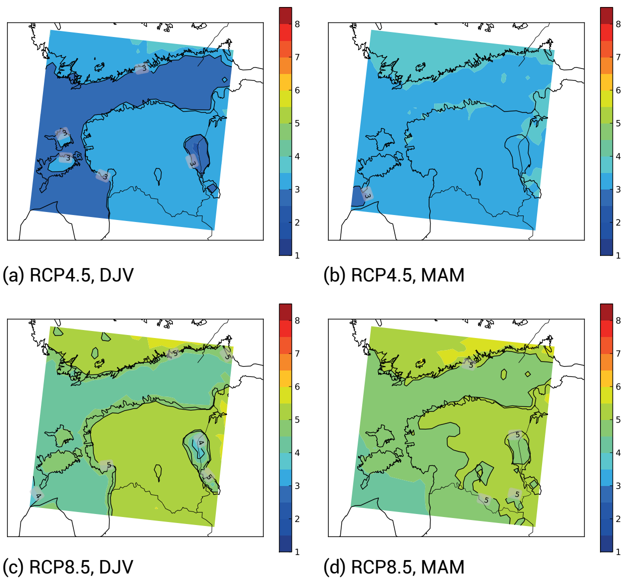


Figure 6.1. Absolute seasonal change in the average temperature by the end of the 21st century compared to the control period of 1971–2000; top row (a, b): scenario RCP4.5, bottom row (c, d): scenario RCP8.5; left to right: winter (DJF), spring (MAM), °C (ESTEA, 2015)

in the summer months (June, July, August, i.e. JJA), and, in the period of 2071–2100, in the autumn months (September, October, November, i.e. SON). (ESTEA, 2015)

Shortwave radiative forcing of the Sun affecting the surface of the Earth

Table 6.2 presents an overview of the relative change in the shortwave radiative forcing affecting the surface of the Earth found by the EURO-CORDEX high-resolution model. The main outcome of the calculations performed by using the model ensemble was a decrease in the shortwave radiative forcing affecting the surface of the Earth. The decrease is more obvious in the colder part of the year with the change in the radiative forcing remaining insignificant in the summer months. This result matches the expected strengthening of the western flow, which will result in cloudier weather in the colder half of the year. (ESTEA, 2015)

Table 6.2. Relative seasonal change in the average shortwave radiative forcing affecting the surface of the Earth by the end of the 21st century compared to the control period of 1971–2000, % (ESTEA, 2015)

Period	2071–2100	
Scenario	RCP4.5	RCP8.5
Winter (DJV)	-6	-11
Spring (MAM)	-3	-6
Summer (JJA)	0	-1
Autumn (SON)	-4	-3
Annual average	-3	-5

Wind

The majority of the sources are referring to an increase in the average wind velocity in winter and partly in spring. The increase is likely to range between 3% and 18% and is related to the increase in the number of cyclones moving to our territories from the Atlantic Ocean. The average wind velocity in the summer season will increase less or will not increase at all. The forecasts concerning extreme wind velocities are not deemed reliable enough to be used. (ESTEA, 2015)

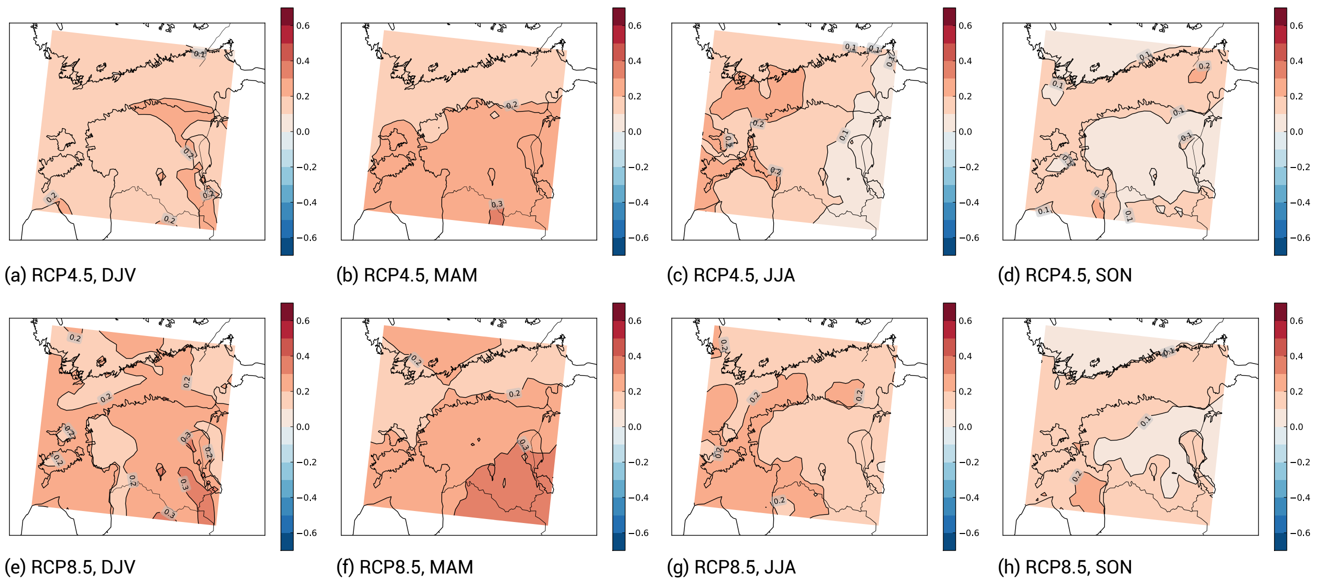
Precipitation

Table 6.3 and Figure 6.2 summarise the modelled relative change in average precipitation. By the end of the century, higher precipitation will be experienced in the spring months; however, in the period of 2041–2070, primarily in the summer months. The change in the precipitation is lowest in the autumn months. The geographical distribution presented in Figure 6.2 clearly shows that, irrespective of the scenario, an increase in the precipitation in the winter and spring months can be expected on land and in the summer and autumn months over the sea. (ESTEA, 2015)

The average annual increase in precipitation of 19% in the RCP8.5 scenario accurately matches the precipitation forecast provided in AR5, based on which the changes in the territory of Estonia will remain between 10% and 20%. Examining the forecasted increases in precipitation for all seasons in the case of both scenarios and combinations of the period, the highest increase in precipitation in the RCP8.5 scenario can be observed in spring, and in the RCP4.5 scenario however, in summer. (ESTEA, 2015)

Table 6.3. Average seasonal change in precipitation in the periods of 2041–2070 and 2071–2100 compared to the control period of 1971–2000, % (ESTEA, 2015)

Period	2041–2070		2071–2100	
Scenario	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Winter (DJV)	9	15	16	22
Spring (MAM)	10	16	21	24
Summer (JJA)	11	18	15	19
Autumn (SON)	10	8	11	12
Annual average	10	14	16	19



(a) RCP4.5, DJV (b) RCP4.5, MAM (c) RCP4.5, JJA (d) RCP4.5, SON

(e) RCP8.5, DJV (f) RCP8.5, MAM (g) RCP8.5, JJA (h) RCP8.5, SON

Figure 6.2. Relative seasonal change in the average precipitation by the end of the 21st century compared to the control period of 1971–2000; top row (a, b, c, d): scenario RCP4.5, bottom row (e, f, g, h): scenario RCP8.5; left to right: winter (DJF), spring (MAM), summer (JJA), autumn (SON), the scale division value 0.1 = 10, % (ESTEA, 2015)

Extreme values of precipitation

Table 6.4 presents the likelihood of the occurrence of more than 30 mm of precipitation over 24 hours by seasons and scenarios as analysed with the EURO-CORDEX model. The last column of the table provides the likelihood of the occurrence of more than 30 mm of precipitation at a certain point on a certain day as an average of the entire area included in the model ensemble. Based on the models, an increase in the number of occurrences of extreme precipitation is forecast, but taking into consideration the very low likelihood thereof in the majority of the year, these occurrences are only significant in summer. (ESTEA, 2015)

Table 6.4. Relative changes in the occurrences of more than 30 mm of precipitation over 24 hours by seasons, scenarios, and periods compared to the likelihood of the event at a certain point in a certain day in the control period of 1971–2000, % (ESTEA, 2015)

Period	2041–2070		2071–2100		1971–2000
Scenario	RCP4.5	RCP8.5	RCP4.5	RCP8.5	Control
Autumn (SON)	188	174	184	245	16
Winter (DJV)	201	231	141	435	1
Spring (MAM)	158	209	207	244	8
Summer (JJA)	124	139	137	165	54

Snow cover

Projections show a significant decrease in snow cover by the end of the 21st century. In the control period of 1971–2000, there were 1–6 days of snow, on average, in April. Based on both scenarios, RCP4.5 and RCP8.5, the likelihood of snow in April is very low. According to the RCP4.5 scenario, the number of days of snow in March will decrease by more than 10 days compared to the control period and, according to the RCP8.5 scenario, by up to 15 days, rarely exceeding 5 days. In January-February, according to the RCP4.5 scenario, snow cover will also decrease by at least 10 days, reaching the average of 15 days, which means that permanent snow cover will not form. In more than half of the days, snow can only be found in rare areas in North-Eastern Estonia. According to RCP8.5, the duration of snow cover in January and February remains under 10 days as a rule. (ESTEA, 2015)

Sea level

The local change in the sea level of the Baltic Sea is the highest in the Gulf of Finland and in the Gulf of Riga, with the relative increases of 6–8 cm (Meier et al., 2011). This study disregards the land uplift, which equals approximately 1 mm in Pärnu, over 2 mm in Hiiu County, and even more towards the northwest, reaching the maximum level of approximately 9 mm at the bottom of the Gulf of Bothnia near the coast of Sweden (Ekman, 1996). In Estonia, studies of the time series of the sea level in the period of 1924–2004 have shown that the slight rising of the sea level in summer is balanced by the land uplift in Pärnu. In the winter period, however, an average increase of 15 cm in the sea level has been observed. In Ristna, where the land uplift is higher, lowering of the average sea level in summer has been observed, while there are no changes in winter. As the relative local change and the land uplift have a balancing effect with respect to one another on the western coast of Estonia, it is mostly necessary to consider the average global rising of the sea level here, which may mean an average rise of the sea level on the coasts of Estonia by 20–40 cm based on the RCP4.5 future scenario and by approximately 40–60 cm based on the RCP8.5 future scenario by the end of the 21st century. (Meier et al., 2011)

Seawater surface temperature

According to the estimations of BACC (2008), the seawater surface temperature will rise by 2.9 °C as an average of the model ensemble by 2071–2100 compared to the period of 1961–1990. The increase in the seawater surface temperature will be the highest in May and June and will be expressed most in the southern and central areas of the Baltic Sea. Meier et al. (2011) observed the largest sea surface temperature increase in the Gulf of Bothnia and the Gulf of Finland for the SRES-A1B scenario (similar to the RCP6 scenario, which lies between the RCP4.5 and RCP8.5 scenarios). Based on the same modelling results, the seawater surface temperatures in the Estonian coastal waters will be 2.1–2.8 °C higher in winter and spring and 1.0–2.0 °C higher in summer and autumn in the period of 2061–2090 compared to the period of 1970–1999. (Meier et al., 2011)

Sea ice

Modelling based on the AR5 scenarios shows that according to the RCP4.5 scenario, the coverage of the Baltic Sea with ice in a typical winter in the 2040s has decreased. The coastal areas of the Gulf of Finland, the Väinameri Sea, and the Gulf of Riga are still covered with ice, but the thickness of the ice layer has decreased by half or up to three times. By the 2080s, the ice cover of the Baltic Sea will have decreased further – the Väinameri Sea and the Gulf of Riga are almost completely ice-free, but the coastal areas of the Gulf of Finland are still covered with ice. In the RCP8.5 scenario, the ice cover in the 2040s will be slightly less extensive than in the RCP4.5 scenario, but still quite similar to the more optimistic scenario. In a typical winter of the 2080s, however, most of the Baltic Sea is ice-free. Only a 30–40 cm ice layer forms on the Gulf of Bothnia and a 0–10 cm ice layer in the north-eastern part of the Gulf of Finland. The estimated extent of the ice cover on the Baltic Sea by 2085 is 75,000 km^2 (30,000 km^2 to 140,000 km^2) in the case of the RCP4.5 and 45,000 km^2 (23,000 km^2 to 70,000 km^2) in the case of the RCP8.5 compared to the current average of 115,000 km^2. (Luomaranta et al., 2014)

Inland water

According to the IPCC SRES-A2 emission model scenario (similar to the RCP8.5, but with a slightly lower radiative forcing), the water temperature of the lakes in Europe, incl. in Estonia, will rise by 2–7 °C by 2100. (ESTEA, 2015)

Due to the increasing winter temperatures, the ice cover period of Estonian rivers is shortening, or no ice cover will form on most of the rivers (BACC, 2008; Nõges et al., 2012). This will result in runoff in the winter period, as the precipitation will no longer accumulate in the form of snow. (Bates et al., 2008)

Due to the forecasted decreasing of the snow cover, the maximum runoffs modelled for the future are smaller than the current runoffs and distributed more evenly over the year, thus the maximum water levels are also lower. The significant decrease in the runoff in the maximum period (typically in April and May) will result in the lengthening of the minimum period in the summer towards spring, which will cause the decreasing of the water supply during the first half of the vegetation period and the risk of small streams and rivers becoming vulnerable to decreasing runoff during the first half of the summer. The seasonal distribution of the runoff of the rivers in Southern and Eastern Estonia will remain relatively unchanged compared to the base period. In Northern Estonia, where the rivers are influenced by karst, the autumn runoff will increase significantly. The impact of climate change on the seasonality of runoff is the greatest in Western Estonia and on the islands, where the autumn runoff will increase and even exceed the spring runoff. There will be two main hydrological seasons instead of the current four. Thus, the increase of precipitation in autumn will increase the autumn runoff and autumn may become the most water-rich period in Northern and Western Estonia and on the islands. (ESTEA, 2015)

6.3. Climate change impact and vulnerability assessment

From the implementation aspect, the correct interpretation of the forecasted parameters of the future scenarios has an important role in climate change impacts and vulnerability assessment. It is important to deduct the so-called secondary weather data from the monthly average data. In this case, two approaches may be applied.

First, we can presume that the weather structure and pattern will remain similar to those in the control period (1971–2000). This means that, for example, the number of arrivals of arctic air masses or summer heat waves in the periods of 2041–2070 or 2071–2100 will be the same as in the control period, but due to the overall warming of the climate, the air temperature in Estonia during a heat wave will not be +27 °C, but +30 °C. (Sepp, 2015)

Thus, the respective coefficient provided in a future scenario may be added to the data of the control period. This enables the possibility to find various air temperature indexes required for the implementation tasks, the average beginning and end dates of seasons of a 30-year period, the durations of vegetation and other similar periods. At the level of the average values of a 30-year period, the results are relatively reliable and the potential errors small. (Sepp, 2015)

This solution is, however, not universal. The problem is that there is a very high peak of around 0 °C in the distribution of the frequencies of daily temperatures in the cold half of the year (in Estonian climatology, traditionally in November, December, January, February, and March, when precipitation occurs in solid form), for example. This means that in the control period, in almost a fourth of the days of the cold half of the year the air temperature ranged from -1 to +1 °C. Summation shifts this peak to approximately +4 °C and we can come to a rough, but incorrect, conclusion – e.g. that the glaze hazard on Estonian roads will reduce or even disappear completely in the future. The glaze hazard is highest when the minimum temperature over 24 hours ranges from 0 to -3 °C and the maximum temperature from 0 to +3 °C. (Sepp, 2015)

Thus, future scenarios can be interpreted by following another approach, based on the tendencies, which are already climatologically observable and have expressed themselves today, will strengthen in the future.

For example, comparing the changes in the temperature in the cold half of the year in Türi in the periods of 1952–1981 and 1981–2010, the average of the first period is -7 °C and the average of the second -5.4 °C. Relating this warming to the changes in the distribution of air temperature over 24 hours, we must admit that the warming does not arise as much from the number of warmer days with temperatures over 0 °C as it does from the significant increase in the number of days with the temperature around 0 °C. While in the first period, the share of the days with the air temperature between -1 and +1°C was 23%, the share was considerably higher in the second period, i.e. 29%. Assuming that, based on the RCP8.5 scenario, the average temperature in the cold half of the year in the period of 2071–2100 is -0.9 °C, it is possible to draw up a mathematical model based on the changes that have occurred so far and estimate the number of the 0 °C days in the future (ca 50%). (Sepp, 2015)

However, it should be kept in mind that such mathematical models are only of theoretical value and strengthening the tendencies based on these models comes with a very high level of uncertainty. Still, the issue of distribution frequencies must be taken more seriously than it has been so far (especially in the case of precipitation), as a large percentage of climate change impacts are determined by changes in the frequency of certain particularly extraordinary events, not average events. (Sepp, 2015)

The climate change impacts and vulnerability assessment in the basic research of the national development plan for adaptation to the impacts of climate change described below are primarily based on the risk assessment methods of the IPCC and on the relevant scientific sources, which connect climate change, exceptional weather conditions, and extremities of the climate with the developments of society. The assessment methods connect factors based on climate, the environment, and human activity/existence, which are expressed in the impacts of climate change. The assessment and management of risks is also covered, with several non-climatological factors having a relatively important role. Therefore, equal attention should be paid to natural and anthropogenic climate changes, as well as socio-economic processes. Vulnerability depends on exposure, sensitivity, and the ability to adapt; therefore, exposure means the manner, extent, and frequency of the system coming into contact with climate factors; sensitivity means the extent to which climate stressors have an impact on the observed system; and ability to adapt means the potential of the system to adapt to climate change. Sensitivity comprises people, the assets created by people, such as buildings and infrastructure, biological species and ecosystems. The contact, or also exposure and sensitivity, together determine the potential impacts of climate change on the system. The ability to adapt describes the potential of a region or a country to cope with the impacts of climate change. All of the above-mentioned factors together determine the vulnerability to climate change. (Roose, 2015)

The potential impacts of climate change and the vulnerability vary greatly by region, but adaptation must be based on the location and on territorial risk assessments. An assessment of vulnerability and climate change impacts is drawn up based on the assumption that exposure, sensitivity, and ability to adapt are phenomena that vary spatially. In addition to climatic changes moving in different directions in different regions and due to the fact that some regions are more exposed than others, all regions have their own clearly distinguishable environmental, social, and economic features, which are sensitive to climate change to a larger or smaller extent. In order to assess vulnerability, the impacts of change and the regional ability to adapt are integrated. This is based on the principle that a region with high impacts of climate change may still be moderately vulnerable if it is well-adapted to the presumed climate change. On the other hand, high impacts may be expected to result in higher vulnerability if the ability of the region to adapt is low. (Roose, 2015)

6.4. Sectoral impacts of climate change and vulnerability in Estonia

In 2014, the Republic of Estonia commenced drafting of the Climate Change Adaptation Development Plan until 2030 (Kliimamuutustega kohanemise arengukava – KOHAK). KOHAK is based on the EC Guidelines on developing adaptation strategies, the EU strategy on adaptation to climate change, the methodology of other EU countries, the 5th IPCC assessment report, the analyses of climate change scenarios drawn up by the ESTEA, the knowledge base of Estonia, other national cohesion policies (see Chapter 6.5), and the measures and practices being implemented. KOHAK and the accompanying implementation plan for the period of 2017–2020 were adopted by the Government of the Republic on March 2, 2017.

Drafting of the KOHAK was coordinated by the Ministry of the Environment (MoE) and the Estonian Environmental Research Centre (EERC) in cooperation with the ESTEA, the University of Tartu, the Estonian University of Life Sciences, the Stockholm Environment Institute Tallinn Centre, and the Norwegian Directorate for Civil Protection. KOHAK describes the most important problems in the area of adaptation to climate change and analysed vulnerability (see Chapter 6.3), the impacts of climate change until 2100, and the potential adaptation measures (see Chapter 6.5) based on the future climate change scenarios in Estonia in eight priority areas (MoE, 2017a):

1. health and rescue capability;
2. land use and planning;
3. natural environment;
4. bioeconomy;
5. economy;
6. society, awareness, and cooperation;
7. infrastructure and buildings;
8. energy and security of supply.

The first stage included the collection and analysis of the available information on key sectors listed above, for this sectoral studies were commissioned by experts and researchers. If possible, the information was collected and presented in the form of spatial data. Forecasts and analyses of the society were primarily based on national statistics. In the sectoral vulnerability analysis, climate-related factors were discussed in the context of regional variability, which formed the basis for thorough sectoral analyses of the impacts of climate change. (MoE, 2017a)

Vulnerability assessment, climate change impacts and adaptation measures described for priority areas are based on results outlined in the KOHAK. (MoE, 2017a)

A synopsis of important climate change impacts in Estonia until 2100 includes (MoE, 2017a):

- the spread of new pathogens and increasing health disorders;
- increasing flooding risk and pressure for building relocation;
- changes in the hydrological cycle and vegetation and the spread of alien species;
- unfrozen and waterlogged forest land in the winter and new plant pests;
- transient effects of global trends on the economy;
- immigration from global migration;
- additional requirements on infrastructure and building durability;
- changes in seasonal energy consumption.

6.4.1. Health and rescue capability

Health

The most serious impact on people's health is the increase in air temperature and the increasing rate of heat waves, together with the impact of the heat island effect. The impact of higher temperatures on hot days and the increased number of heat waves have been already manifested, as mortality was quite high during hot weather periods (with the maximum temperature of the day exceeding 27 °C) in the period of 1996–2013. (MoE, 2017a)

The summer of 2021 was the warmest in the 155-year history of Estonian weather observations. In June 2021, 15 absolute air temperature records were recorded at 25 stations of the National Weather Service. On average, they exceeded the absolute air temperature norms calculated for the period of 1991–2020 by 2–3 °C (Estonian Weather Service, 2022). Although the number of deaths in July 2021 was 7% higher than in 2020 (by almost 80 people) (Euromomo, 2022), unfortunately the statistics collected in Estonia do not reflect deaths caused by heat waves, because it is not a medical diagnosis. It is possible to make a correlation with the occurrence of a heat wave, but in recent years, due to COVID-19, it is difficult to draw firm conclusions about specific causes. (Health Board, 2022)

Before that, an extremely warm summer affecting the health of the population of Estonia was seen in 2010, when the mortality in the summer months apparently increased by almost 30%. As heat waves are becoming more frequent due to climate change, depending on the climate change scenario used (RCP4.5 or RCP8.5), 506 or 679, or almost 655 or 1,068 excessive deaths per year, on average, can be expected in the periods of 2030–2050 and 2050–2100, respectively. In spite of the general warming of the climate, the health risks arising from very low temperatures or formation of glare ice on roads should also not be underestimated in Estonia in the future. Further extreme weather conditions, which may endanger human health, include storms and heavy rain (the resulting floods), which may also make vital medical assistance less accessible or even completely inaccessible. (MoE, 2017a)

Air quality also has an important effect on health. Poor air quality is considered one of the biggest environmental health risks, as air pollution has a significant impact on public health. The most important primary pollutants that degrade air quality are particulate matter (PM10), fine particles (PM2.5) and nitrogen dioxide (NO2). The main sources of fine particle air pollution are car traffic (both exhaust gases and particles from road surface and tire wear), local heating (mainly stove heating) and industrial enterprises. In addition to local pollution, there is also the long-range transmission of air pollutants, which is especially important in rural areas. Fine particles can also have natural sources such as forest fires. (Orru, H., et al. 2022)

In 2020, air pollution fine particles and nitrogen dioxide in the ambient air caused an average of 1,179 early deaths in Estonia. Among the various sources of air pollution, local heating had the highest negative health impact (a total of 571 early deaths in 2020), followed by traffic (433 early deaths, of which 87% are caused by exhaust gases and 13% by health effects resulting from road dust). Life expectancy is reduced by almost 10 months on average due to air pollution. The highest drop in life expectancy was seen in bigger cities such as Tallinn, Tartu, Narva, Pärnu, Viljandi and Kohtla-Järve, and was somewhat higher in Ida-Virumaa. (Orru, H., et al. 2022)

Although the pollutant content of the air may increase (formation of ground-level ozone intensifies during heat waves, the conditions for the diffusion of fine particles may deteriorate in certain periods, and forest fires may become more frequent), the most direct impact of climate change related to air quality is the increased spread of pollen. In the RCP8.5 scenario, the duration of the pollen season will increase by the end of the century and new allergenic plant species will spread to the territory of Estonia, which will increase the health risk. (MoE, 2017a)

Changing climate impacts the spread of vector-borne diseases of animals and plants (e.g. spread by fleas, ticks, mosquitos), which may pass on dangerous infections. Changes in the spreading areas of vector-borne diseases will result in more frequent occurrences of both the diseases already prevalent in Estonia, such as tick-borne encephalitis and Lyme disease, as well as diseases that are currently relatively rare in Estonia, such as leishmaniasis, hantavirus, tularaemia, dengue fever, etc. Therefore, the impacts of various climate components are conflicting – milder winters and periods of higher humidity (but not heavy rain) generally support, while drought periods prevent, the spread of diseases. Heavy rain may cause the carrying of hazardous substances or excessive nutrients (the former of which may present a direct hazard to human health and the latter may cause more intensive eutrophication) and many parasites (which may end up in drinking water in the case of insufficient treatment processes) from the environment into the water. Long drought periods, however, may leave shallow drinking water wells dry. A higher frequency of hot summers may also increase the frequency of algal blooming, which deteriorates the quality of bathing water. The wider spread of plant diseases and mycotoxins presents a hazard related to food safety, which, according to the RCP8.5 scenario, may increase in the period of 2050–2100. (MoE, 2017a)

Rescue capability

The main factors to be taken into consideration from the aspect of rescue capability are floods in densely populated areas and extensive forest and landscape fires. As 60% of forest fires occur in May and June, the higher frequency of drought periods in spring and summer also increases the forest fire hazard. These emergencies do not present a very high risk to human life and health in Estonian conditions, but may cause huge proprietary damage and interruptions in operative rescue works or the processing of emergency calls. Forest fires are also generally accompanied by extensive damage to the natural environment.

It is remarkable that human activity may still be deemed to be the main cause of forest fires, but climate change increases the risk of fire outbreaks (heat and dryness). Sharpening of the impacts of climate change calls for a need for more extensive involvement of volunteers as well as defence structures and the private sector in responding to emergencies, while the amount of human assets and money spent will also increase. (MoE, 2017a)

6.4.2. Land use and planning

Coastal areas

Due to changes in the trajectories of cyclones and the resulting higher frequency of western storms, Estonian coastal areas may be at a risk of increasingly frequent rises in the water level and floods, the extent of which in the future will probably exceed what has been experienced so far. Rising of the global sea level, more frequent western storms, and the decreasing extent of ice cover in winter together will probably bring forth more intensive erosion processes in the Estonian coastal areas in the next few decades, which may also endanger objects in the direct vicinity of the coastal zone, incl. cultural heritage, and coastal tourism may suffer. It should also be taken into account that, in the future, the isolines of the area with a risk of flooding will be located further inland due to the rise of the sea level. For a more accurate and operative assessment of the floods caused by storm surges, management of risks, and operative responding to the consequences, methods and systems for monitoring coastal areas must be applied, significant endangered objects must be identified and the protection of such objects planned, which will be accompanied by higher financial costs. (MoE, 2017a)

Other areas affected by flood risk

There are 15 areas exposed to floods in densely populated areas in the Western Estonian hydrographic basin and 5 in the Eastern Estonian hydrographic basin. Floods, which are likely to occur once every 10 years, endanger approximately 1,000 people in coastal settlements, those likely to occur once in 100 years approximately 6,600, and those likely to occur once in 1,000 years approximately 15,000 people. Floods which are likely to occur once in 10 years, endanger 843 residential buildings, those likely to occur once in 100 years, approximately 3,200, and those likely to occur once in 1,000 years, approximately 6,400 residential buildings. The flood risk in inland waters is assessed as considerably lower compared to that in coastal areas. (MoE, 2017a)

Land improvement

The forecasted increase in the ground water level as a result of climate change is not high, but may cause significant changes in the quality of the ground water as well as in the hydrography of the ground level water table. The latter determines the water regime of the soils and the use of drained land. In low, level areas, especially in the case of heavy-textured soils and organic soils, the level of the ground level ground water table may rise so much that the total area of wetlands will expand. Climate change together with deterioration (amortisation) of the condition of drainage systems will in turn bring forth changes in land use – excessively wet areas will expand and may be left out of use as the yield or harvestability of the areas decrease. The selection of the cultivated cultures will depend on the resistance of the cultures to excessively wet conditions or droughts. The decreasing of the amount of agricultural land available for crops, which provide higher added value, may, for example, result in less land for cultivating potatoes, rapeseed, and cereals, and thus in the expansion of the areas of grasslands. (MoE, 2017a)

High-intensity rain with a high amount of precipitation may start to cause local floods. An increase in the amount of precipitation will increase the risk of the flushing out of nutrients from the soil into the surface or ground water. Milder winters will decrease the water supply in the soil in the first half of the vegetation period, which will in turn bring forth a need for more irrigation. (MoE, 2017a)

Renovation of many land improvement objects established in previous decades is highly resource-exhaustive, the need for renovation, however, is several times higher than the investment capability. Thus, in order to ensure the operability of the land improvement systems in the near future, decisions must be made on which drainage systems are important for the Estonian economy and which should be abandoned. (MoE, 2017a)

Cities

Both direct as well as indirect impacts of climate change above all affect the larger cities, Tallinn, Tartu and Pärnu, where the majority of the population, economic activity, assets, capital, and cultural objects have accumulated. The technogenic city environment of a high population density and complex city planning interdependencies is unable to buffer the impacts quickly enough – new structures often even amplify the risks. (MoE, 2017a)

Taking into consideration the geographical location of Estonia and the sparse settlement system, the risks related to climate change here are relatively low and, as a rule, the area of influence is local (specific streets or districts). On the other hand, however, the planning practice used here does not consider climate change. The main risks which Estonian towns face according to the future climate forecasts arise from a higher frequency of exceptional weather conditions, incl. storms, floods, and heat waves. Of the above, the negative impact of the flooding of the coastal sea is the highest and endangers the cities of Kuressaare, Haapsalu, Pärnu, and Tallinn as well as eight small towns. The impact is the most extensive in Virtsu, Nasva, Uuemõisa, Võiste, and Paralepa. The flooding risk of Estonian rivers is the likeliest and potentially most extensive on the shores of River Emajõgi in Tartu and the flooding risk of the lakes is the highest on the shores of Lake Tamula in Võru. The risks of storm damage affecting settlements are higher in Western Estonia, islands and coastal areas, where winds blowing over 21 m/s occur more often. (MoE, 2017a)

Heat waves, which have already presented themselves as climate-related risks in the summers of the last few decades in Estonia, are amplified in the cities due to the heat island effect, which most significantly affects the chronically ill, small children, and the elderly. The abovementioned population groups are more vulnerable to the risks of morbidity and mortality. A study of the heat wave of July 2014 revealed that all densely populated areas are affected by the heat island effect, not only larger cities. The negative impact of heat waves is amplified by the ageing of the population and urbanisation, which can already be observed in Estonia today and will accelerate in the future. (MoE, 2017a)

6.4.3. Natural environment

Biological diversity

Based on the current knowledge, the species that have adapted to specific environmental conditions and those in the peripheral areas of their habitats are the most vulnerable to climate change. Climate change may exacerbate the spread of invasive foreign species and reduce the efficiency of the control measures applied so far. Invasive foreign species anchor themselves outside of their natural habitats and endanger ecosystems, habitats, and ingenious species, thereby causing economic losses. (MoE, 2017a)

Terrestrial ecosystems

Warmer winters prevent the freezing of the soil, which, above all, increases the extent of storm damage in excessively wet forest areas with a superficial root system and makes the performance of forestry works more difficult, thereby increasing the risk of damaging the soil. Higher frequency of spring and summer drought periods increases the prevalence of forest fires and facilitates the reproduction and spread of forest pests. Climate change impacts the spread and coherence of forest habitats, biological diversity, interspecies relationships, and forest habitat types. (MoE, 2017a)

Climate change increases the frequency of droughts in wetland areas and causes a higher risk of floods and fires. Increasing air temperature and a higher amount of precipitation causes a rise in the greenhouse gas (GHG) emissions from natural and drained peat areas, consequently the areas which are affected by human activity can be expected to generate significantly (up to two times) higher GHG emissions. Climate warming and changes in the precipitation regime also cause long-term shifts in the species composition of the vegetation of wetlands, changing the ratios of peat moss species and increasing the competitive advantage of shrubs compared to peat mosses. (MoE, 2017a)

Higher temperatures accelerate the decomposition of the organic matter in agricultural land and grasslands, which in turn impacts the fertility of the soil. Higher precipitation increases the production of grasslands and may also somewhat accelerate the decomposition of organic matter. It is very difficult to distinguish the changes in the grasslands which have occurred as a result of climate change so far from those arising from human activity. It is clear that more frequent, deeper, and more extensive cultivation of the soil increases the carbon dioxide (CO_2) emission from the soils of agricultural land and grasslands, thereby reducing the fertility of the soil, and extensive tillage helps to preserve the humus content and fertility of the soils. (MoE, 2017a)

Ecosystem services

Until 2030, ecosystem services will be most heavily impacted by the increasing frequency of extreme weather phenomena. Although various climate risks will manifest to a significant extent in the case of both climate change scenarios by 2050 and 2100, bringing along changes in provision of the supply and adjustment as well as cultural services, the higher frequency of extreme weather phenomena is likely to be the main force behind the changes in the quantities and qualities of ecosystem services. The impacts of climate change on ecosystem services may differ, i.e. may be simultaneously positive as well as negative. The effect of the negative impacts will presumably be highest in the case of the ecosystem services for sea and freshwater communities and somewhat lower in the case of services for terrestrial ecosystems; urban ecosystems, on the other hand, will show most positive effects. (MoE, 2017a)

6.4.4. Bioeconomy

Agriculture

In agriculture, climate change mainly impacts the selection of cultures and species, the yield thereof, the efficiency and productivity of animal husbandry, and the spread of plant pests and infectious animal diseases. The conditions for growing the traditional cultures, e.g. for the wintering of winter crops, may deteriorate. Nutrients are flushed out of unfrozen soil in winter and may be washed into the ground water or waterbodies. Earlier spring has enabled the earlier sowing of cultures while later autumn allows for later harvesting. Later harvesting may however be complicated due to excessive water content of the soil in some areas. Extreme weather phenomena increase the risk of crop failures and may result in the deaths of agricultural animals due to power cuts or floods. Heat waves and drought periods in the summer endanger the welfare, productivity, and feed supplies of animals. Longer cultivation periods increase the mass of forage plants, while longer grazing periods reduce the animal upkeep costs in winter. Higher temperatures allow for the growing of frost-sensitive cultures. In gardening, the increase in the outside temperature will bring forth significant changes in the profitability of glasshouse agriculture and in the selection of open area plants. (MoE, 2017a)

Forestry

The higher frequency and longer duration of drought periods in spring and summer will facilitate the development of root rot and the reproduction of bark beetles and increase the fire hazard in the forests. The increase in summer temperature and milder winters will potentially create favourable living conditions for various pests, which can usually be found in masses south from the territory of Estonia, in addition to our local pests. (MoE, 2017a)

In the excessively wet habitat types in Estonia, forests have been traditionally cut when the ground is frozen. Due to the reduced number of winter periods of lower temperatures the soils in Estonian forests fail to freeze deeply, which may result in more extensive damage to the soils during felling work. (MoE, 2017a)

Pine and fir trees are also growing well in habitats where the temperature is 5 °C higher than in Estonia, if there are no drought periods. Thus, the potential increase in temperature will not be accompanied by considerable changes in the species composition of Estonian forests; changes in the percentage of certain species are, however, possible. Due to changes in the natural conditions, the conditions will improve for the forest species which have been rarely found in Estonia so far and are on the northern border of their habitat, while the conditions will deteriorate or become unsuitable for the species on the southern borders of their habitats. (MoE, 2017a)

Fisheries

The forecasted climatic changes could mainly impact the size and species composition of the fisheries resources, which directly influence the opportunities for industrial and hobby fishing. The signs of climate change (changes in the water level and temperature, extreme weather phenomena, unstable ice cover or no ice cover, inflow of saline water into the Baltic Sea or the lack thereof) may directly impact the abundance of fisheries resources, which are important from a fisheries management perspective and are less resistant (more vulnerable) to climate change, and the amount of fisheries resources in the Baltic Sea as well as in Estonian inland waters. The increasing temperature should increase the general productivity of these water ecosystems and accelerate the growth of the fish, but this is also dependent on many other factors (e.g. the eutrophication, pollution arising from human activity, overfishing). There are fish species of quite different ecological needs living side-by-side in Estonian waterbodies and the forecasted climatic changes may have conflicting impacts on the size of the resources of these species: the numbers of freshwater and cold-water fish (e.g. the Salmonidae, European whitefish, Peipsi whitefish, burbot, smelt) may decrease further in the future and their habitat may become narrower compared to warm-water fish species (e.g. Cyprinidae, pike perch), which prefer more nutrient-rich habitats. Gradual changes in the water temperature may have a smaller impact on the fisheries resources than sudden changes in the regime (e.g. heat waves, inflow of saline water into the Baltic Sea), which may cause drastic changes in the living environment of the fish within a short period of time (even hours). (MoE, 2017a)

The status of the fisheries resources may be strongly impacted by the ice conditions and changes in the water temperature within one year (seasonal changes), which determine the successful reproduction of the fish, the strength of the generation, and the size of the progeny. For example, shortening of the ice cover period may have conflicting effects on the fisheries resources: 1) it may decrease the mortality risk of fish in shallow lakes in winter due to a lack of oxygen; 2) it may negatively affect the success of the reproduction of the fish, which spawn in late autumn or in winter, such as the European whitefish, powan, and burbot; 3) it may damage the opportunities for hobby fishing in winter. Climate change also facilitates the spread of invasive foreign species and new fish parasites and diseases, which have a negative impact on the fisheries resources. (MoE, 2017a)

Peat production

Peatlands cover 1.2 million ha of the territory of Estonia, or more than a fifth of the land (MoE, 2022a). Currently, the annual rate of peat extraction is 2.85 million tons (Annual rate of peat extraction and size of critical and usable reserves, 2017). The increase in the average air temperature arising from climate change will presumably bring forth more extensive mineralisation of the peat in the extraction areas and thereby up to twice as high CO_2 emissions. Furthermore, it may be significantly impacted by the amount of precipitation and the humidity of the soil. (MoE, 2017a)

6.4.5. Economy

Estonia as a small country with open economy is more vulnerable to the impacts of climate change to the global economy than to the local processes related to climate change. The global need for technological progress, more sustainable management, and environmentally friendlier manufacturing arising from climate change have above all placed the issues of climate change in the sector of opportunities for entrepreneurship in Estonia. The success of the sector of technology companies is showing a growing trend in Estonia, and the availability of natural resources (timber and other natural materials), which enable sustainable production, and the traditions of using such materials provide a developmental advantage. (MoE, 2017a)

Estonian companies must take into consideration the environmental safety requirements and restrictions applicable to the use of the environment which have formed in time. For example, the impacts of climate change on the industrial sector mainly manifest through alleviation measures – adjustment of the building, availability and prices of raw material, changes in the supply chain and transportation. The pressure from consumers arising from the threats of climate change has, however, remained rather modest in Estonia so far. (MoE, 2017a)

6.4.6. Society, awareness, and cooperation

More frequent extreme weather phenomena are accompanied by a need for the assistance of social workers, especially for servicing vulnerable groups, who are in danger of social isolation. The need for cooperation between the (civil and military) institutions, organisations, and individuals who are involved in rescue work also increases. (MoE, 2017a)

An increase in extreme weather events can increase unforeseen property damage. The hazards accompanying extreme weather phenomena impact different groups of society differently – the impacts vary locally (e.g. floods in seaside or lowland areas) and by members of society (e.g. the elderly are more vulnerable to extreme cold and heat). Climate change endangers the most disadvantaged people, i.e., those in a poorer socio-economic situation and those with less social capital, who may not have the resources or networks for buffering the impacts of climate change that affect them directly, or for the management of climate-related risks. The impacts on health are mainly prevalent in children, the elderly, and in chronically ill people or those affected by multiple health conditions. Thus, extreme weather phenomena may further deepen inequality in society. (MoE, 2017a)

From the aspect of climate change, Estonia is most influenced by EU climate policies in international communication. Estonia is also one of the parties of main international treaties and participates in the developmental cooperation oriented to third countries as a member of the EU and the Organisation for Economic Co-operation and Development (OECD). At the global level, Estonia is principally a party that provides assistance and thus global agreements as well as any agreements in the area of adaptation to climate change, which are reached within the EU, primarily impacting the Estonian policies of cooperation for development. Increased immigration pressure arising from climate change is also possible. (MoE, 2017a)

6.4.7. Infrastructure and buildings

Transport system

In this century, significant changes can be seen in the need for upkeep and maintenance of the transport infrastructure (both road and street network, railway network, bridges, ports and airports). For example, there is a need for more frequent removal of storm or flood debris from roads, ports, and airports. Overhead transmission lines must be maintained due to the increased number of days of glaze. Some circumstances arising from the climate, which may damage the transport infrastructure, can also be foreseen, such as the softening of road surfaces, deformation of railroads, or destruction of roads or bridges as a result of floods. For example, in 2021 and 2022, high temperatures caused technical problems for several trains; the trains' cooling and hydraulic systems overheated, causing the temperature of the engines to rise. For this reason, the trains had to reduce their speed, and there were delays in train traffic both for departures and arrivals. (Raudmäe, 2021; Koch, 2022)

In comparing various types of transport, the most vulnerable are the entire means of transport on the roads and streets as well as the safety of people related to the infrastructure arising from changes due to interruptions in traffic, slipping hazards, reduced load-bearing capability of unpaved side roads, and safety of cycle and pedestrian tracks. Small Estonian ports are also vulnerable due to the rising sea level and more frequent storms. (MoE, 2017a)

In order to ensure climate resilience, the European Commission came up with technical guidelines in the autumn of 2021 regarding the methodology for assessing the climate resilience of infrastructure. When using European Union Cohesion Policy funds for the period of 2021–2027, it is a condition to ensure climate resilience in the case of infrastructure investments based on the Common Provisions Regulation (EU) 2021/1060. The infrastructure object can be new or the renewal or expansion of an existing one. Ensuring climate resilience includes both mitigating and adapting to climate change, and, among other things, it requires that a climate change adaptation risk assessment has been carried out for infrastructure projects and possible climate impacts and mitigation solutions have been taken into account. (European Commission, 2021a) The MoE, in cooperation with the State Support Center and implementing agencies, ensures that when applying for infrastructure investments, various climate risks affecting the infrastructure are assessed and, if necessary, mitigated.

Water and sewerage infrastructure

Increased average amount of precipitation, less extensive snow cover and decreased amount of flooding in spring due to a rise in temperature as well as more frequent climate events, such as droughts or heavy rains, all have a direct impact on the functioning of the water and sewerage system. Shorter snow cover periods and faster vaporisation of the water supplies from the soil due to higher temperatures in summer will result in reduced productivity of the upper ground water layer over a longer period of time, which may cause drying of the wells in sparsely populated or karst areas. On the other hand, isolated and very intensive rain periods accompanying southern cyclones may be expected in the conditions of higher temperature in summer, which may produce local floods in lower parts of cities due to the limited capacities of the storm drains. (MoE, 2017a)

The causes of water shortages and droughts can be the result of global warming and the decrease in the amount of precipitation during certain seasons. If the snow cover and the ice period of the rivers decrease, it will lead to a significant change in the hydrological regime. Autumn and winter runoff increase, springtime high water remains smaller and shifts to an earlier time, which is directly accompanied by a decrease in spring floods, but also lengthens the summer minimum runoff period. In the big picture, the issue of water shortage in Estonia is not yet serious, but there is a high probability that it will worsen in certain areas over time. (Nõges et al., 2012)

Initially, groundwater is available for drinking in Estonia, but this valuable resource is unfortunately used for many other purposes: irrigation, industrial water, firefighting – groundwater is also lowered to enable mining, and if there are several dry summers in a row, the security of water supply is already at risk. A common example is also the use of groundwater table level water in sparsely populated areas or in former summerhouse areas near bigger cities, where wells have traditionally not been built very deep to meet only seasonal needs. Thus, in such regions, during the drought period, it may be the case that the existing borehole is no longer able to provide a sufficient amount of water, or the water obtained from it is polluted. However, it can become especially difficult in the so-called former polluted groundwater areas (Tapa) or in the Ida-Viru region, where there is often no alternative option when quality water decreases as available water may be polluted. Estonia's islands and densely populated areas by the sea are also risk areas for water shortages and droughts, where a lower groundwater level can be accompanied by seawater seeping into the aquifers and deterioration of water quality. Fortunately, there have been no cases of water shortage or droughts with serious consequences in Estonia as yet. (MoE, 2017a)

Buildings and energy efficiency

The higher the efficiency of buildings and the equipment in the buildings, the lower the vulnerability thereof to the impacts of climate change. Estonian buildings, however, are characterised by low energy efficiency and quality compared to other EU Member States and the Estonian building stock is old and the construction quality of the new developments unstable. The thermal insulation of the poorly built building structures is low and higher springtime wind velocity increases the heat losses of the buildings. On the other hand, the need for air conditioning in the indoor premises increases as the summer temperatures grow. The steeply increasing power consumption due to heating or cooling in the case of very cold or very hot weather may overload the system and cause power cuts. (MoE, 2017a)

6.4.8. Energy and security of supply

Energy resources

The largest non-renewable energy resource used in Estonia is oil shale, which will also serve as the largest energy resource available in 2030, based on currently known resources. The largest renewable energy source is timber, which will also remain the largest source of renewable energy in the future, based on the information available today. The changes in the climate factors forecasted have relatively little impact on the availability of energy resources up to 2100. In 2020, the largest primary energy consumption energy resource in Estonia was oil shale, while renewable energy resources, such as biomass, wind and solar energy, are of the highest consumption potential. The forecasted changes will have positive as well as negative impacts on the availability and quality of energy resources. The compliance of the technology used, the timing, and the infrastructure with the weather conditions is of increasing importance in the collection of bioenergy resources. For example, the collection of timber, herbaceous biomass, or peat is a highly seasonal activity. These fuels require interim storage, which increases vulnerability if the storage conditions are not protected from the weather conditions. By 2100, the ongoing climatic changes can be expected to bring a positive total impact on the wind energy resource, while a small negative impact can be presumed in the case of solar energy (due to an increase in the number of cloudy days), and on the consumption of timber as an energy resource. The impact of weather conditions and the changes thereof are the lowest on using the energy source of oil shale. The changes forecasted have no impact on the extent of the oil shale resource to be used. (MoE, 2017a)

Heat production and cooling

Centralised heat production is more susceptible to climate change than local heating, as the lower heat consumption as a result of climate change may turn the operating of district heating networks unfeasible from an economic perspective. Shortening of the heating period will increase the percentage of the losses in the transmission of the heat, which is used for heating centralised domestic water outside of the heating period. (MoE, 2017a)

In Estonia, the remaining of the maximum air temperature during 24 hours at ≥ 30 °C for at least five days is deemed especially hazardous to human health. Currently, the air conditioning systems of buildings are not designed to take into consideration the heating solar radiation permeating through the windows which makes it difficult to maintain a specific temperature (e.g. the estimated temperature range in offices during a cooling period is 22–27 °C). Climate change has a dual impact on the energy sector. On the one hand, increasing the temperature in winter will decrease the thermal energy consumption in the cold half of the year. On the other hand, the increase in the average temperature, the higher temperature in summer and more frequent short heat waves (7–10 days, on average) increase the need for cooling buildings, which is mainly fuelled by electricity. Therefore, the decrease in the demand for thermal energy is not proportional to the increase in the winter temperatures, as the higher winter temperatures are primarily related to windy weather and the inflow of a warmer, humid air mass over Estonia. Due to the higher humidity and wind velocity, additional energy is needed to maintain a comfortable temperature. The higher amount of precipitation raises the level of the upper level of ground water. The higher level of ground water and higher humidity of the soil cause large heat losses, especially in old, uninsulated heating pipelines, as the heat conductivity of the soil increases. (MoE, 2017a)

A warmer climate in our region leads to a decrease in the energy consumption required for heat production, which is however replaced by cooling demand. This is why it is important to plan economical cooling solutions such as district- and exhaust cooling and smart planning of buildings (shading, etc.) to proactively ensure the most economical use of energy.

6.5. Progress of adaptation to climate change

Successful adaptation to climate change requires close cross-sectoral cooperation at the central government, regional and local government levels, while communities must not be forgotten. The success of adapting to climate change depends on the actions of the state and the structure of the governance system, as well as the pressure from non-governmental interest groups and the interests of businesses. Adaptation is also influenced by the level of education and science in the country, which determines how prepared the people are for climate change and how they assess the accompanying changes.

The ability to adapt is high in the case of known or experienced risks, but low in the case of indirect or complex impact chains. Adaptation activities can be continuously planned and implemented in Estonia, mainly on the basis of the experience and lessons from recent climate events. As the knowledge (but partly also awareness) of adaptation to the climate increases, it will be possible to focus research more accurately and conduct targeted studies. Cohesive cross-sector studies are required above all (global transient effects of climate change on Estonian economy and society).

Increase in the ability to adapt will certainly be supported by the new climate projections prepared under the leadership of the ESTEA with the help of universities, and the updated climate scenarios based on the projections, which should be completed by the end of 2026.

Estonia is in the 83rd position among all countries in the world in the Global Climate Risk Index. This index takes into account extreme weather events (e.g. storms, floods, heat waves) but not slow changes (e.g. sea level rise, melting of glaciers, acidification). The ranking is based on the number of deaths and the amount of economic damage, and the countries that rank higher are the most affected by extreme weather events (Eckstein et al., 2021). In recent years, Estonia has increased its position in the Global Climate Risk Index (Eckstein et al., 2019, 2020, 2021), i.e. Estonia's situation has worsened based on this index, taking into account the consequences of the occurrence of more extreme weather events.

Compared to European countries, Estonia's adaptability is below average (ESPON, 2011). On the one hand, a low level of risk should prevent overreaction to risks and their overestimation, and in turn, enable a pragmatic approach to problems. However, it prevents more decisive progress in adaptation policy and does not promote climate adaptation among other topics important to Estonian society.

A large part of climate change adaptation measures can be implemented through public awareness, as the decisive and often primary factor is human behaviour. One of the strongest influencing factors in the development of environmental awareness is education – the views of people with higher education are more environmentally friendly than average, the understanding of the functioning of ecosystems is more comprehensive, and the self-esteem behaviour is more environmentally sustainable than people with lower education. Also, people with higher education express a more responsible attitude and more active attitudes in terms of preventing and solving environmental problems than people with lower education. Climate change mitigation is also considered a higher priority by people with higher education. (MoE, 2020a)

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According to the environmental awareness survey of Estonian residents commissioned by the MoE in 2020, the majority of people are aware of the harmful consequences of climate change, and 88% consider climate change to be a serious problem in the world as a whole (MoE, 2020a). This is also supported by the Eurobarometer survey conducted in the spring of 2021, according to which Estonians considered climate change to be the second most important problem facing the world at the moment (the spread of infectious diseases was in first place) (European Commission, 2021b). Compared to the survey conducted in 2019, climate change has risen two places in the list of the most important problems in the world for Estonians (being in fourth place in 2019). 63% of respondents in 2021 considered climate change a very serious problem, which was a lower result than the EU average (79%), but a better result than in 2019 (59%). Compared to the 2019 Eurobarometer survey, the percentage of people who think they are personally responsible for fighting climate change has fallen, from 33% in 2019 to 26% in 2021. (European Commission, 2019, 2021b)

Although assessments of Estonia's environmental condition as a whole have become slightly more critical compared to 2018, satisfaction with the situation in various environmental areas has generally remained at the same level or slightly improved compared to 2018 (MoE 2018a, 2020a). The effects of climate change can already be seen in Estonia, which gives grounds for concluding that people are unable to connect local changes in the environment to changes taking place on a global level. (MoE, 2020a)

According to the environmental awareness survey of Estonian residents, the majority of Estonian residents understand the danger of an ecological crisis resulting from human activities – nearly three-quarters of those surveyed agree that if human activities continue on their current course, we will soon face a major ecological disaster. However, almost a third think that the talk about the so-called ecological crisis threatening humanity is greatly exaggerated. 41% of the respondents are, in their estimation, well informed and 50% poorly informed about the effects of climate change. (MoE, 2020a)

The consequences of climate change are mostly considered to be storms and floods, an increase in forest fires, heat waves, rising ocean levels and a lack of clean drinking water. Almost three-quarters of respondents understand that the climate is changing due to both natural causes and human activities. The consequences of climate change are not so widely perceived at the local level – only slightly more than half (56%) of those surveyed consider the consequences of climate change to be a problem for Estonia (MoE, 2020a). However, the share of the last indicator has increased over the years, being only 41% in the 2016 survey (MoE, 2016). A little over a third (38%) of those surveyed believe that climate change will affect their lives in the coming years, while half of the respondents believe that it will affect them little or not at all. The most likely danger was felt in strong storms, heat waves or reduced snow cover. A third of the respondents thought that mitigation of climate change is not sufficiently addressed in Estonia. (MoE, 2020a)

6.5.1. Adaptation measures at the national level

The strategic development documents of Estonia include direct and indirect measures, which may help society in adapting to the impacts of climate change.

Climate change has already been included as a horizontal topic in several sectoral development documents and development plans, as well as in the long-term strategy Estonia 2035. The goal is the comprehensive introduction of solutions that contribute to the green transition and in order to achieve this the following activities are planned: supporting planning in cooperation with local governments to mitigate climate change, reducing the impact of climate change and adapting to it, increasing and preserving biodiversity, diversifying the living environment, and promoting environmentally friendly living and visiting environments. (Government of the Republic, 2022)

To achieve this, the implementation of green transition solutions is aimed for and the supporting the local governments design process to mitigate climate change, reduce climate change impacts through local governments activities, diminish and mitigate the destruction of biodiversity, diversify the biodiversity, and promote environmentally friendly living arrangements and the visitor environment (Government of the Republic, 2022).

Adaptation to climate change is also integrated into the climate policy vision document General Principles of Climate Policy until 2050 (GPCP) where the long-term vision of Estonian climate policy, along with sectoral and economy-wide policy directions, will set a clear path towards 2050 for mitigating climate change, i.e. reducing GHG emissions and also adapting to climate change effects. (MoE, 2017b)

In the Development Plan for Internal Security 2020–2030, climate change is considered as one of the important trends affecting the field of internal security. According to this, it is more necessary than before to pay attention to the prevention of widespread fires, monitoring their occurrence, and extinguishing fires that have broken out as economically and quickly as possible. As climate change causes an increase in extreme weather conditions (including floods and storms) and can also lead to widespread crises, then preparing for such crises becomes more important than before for both residents and the country. (Ministry of the Interior, 2021)

One of the sub-goals of the Population Health Development Plan 2020–2030 is a health-supporting environment and the readiness and flexibility to consider the impact of climate change on health is stated as one of the prerequisites for achieving it. According to the development plan, it must be taken into account that poor people are most vulnerable to climate change (e.g. more frequent storms and floods in winter and hot periods in summer), as they may lack the means and network to buffer against the impact of climate change or to mitigate climate risks. Therefore, extreme weather events can increase inequality in society. The health effects caused by climate change are primarily seen in children, the elderly and the chronically ill, as well as people with multiple health problems at the same time. (Ministry of Social Affairs, 2020)

The goals and directions in the Agriculture and Fisheries Strategy 2030 take into account the needs for sustainable development as well as for the mitigation of climate change and adaptation. The development plan states that, according to climate projections, our region may be one of the few where production conditions tend to improve over time, although it is assumed that the weather may become more extreme and unpredictable than before. At the same time, the globalisation of trade and climate change encourage the spread of new plant pests and animal diseases. (Ministry of Agriculture, 2021)

The main focus of the Transport and Mobility Development Plan 2030 is the reduction of the environmental footprint of the transport means and system and the development of climate-resistant infrastructure, with the aim of helping to achieve the climate goals for 2030 and 2050. (Ministry of Economic Affairs and Communications, 2021)

The Youth Sector Development Plan 2021–2035 considers raising the awareness and readiness of young people to solve future challenges, including problems associated with climate change, as an important challenge in the period of 2021–2025. It is proven that climate and environmental topics are important for young people all over the world, including in Estonia, where there are already civic youth movements on climate change. The topic of climate change is dealt with in various forms of education, including non-formal education and youth work activities. (Ministry of Education and Research, 2021)

The Emergency Act governs the drawing up of risk analyses of emergencies and plans for responding in emergency situations, emergency-related training, notification of emergencies, management of responding to emergencies, as well as the declaring of emergency situations and the measures applied during emergency situations. This includes the obligation to work for third parties, expropriation of movables, prohibition on staying and other restrictions on the freedom of movement. (Emergency Act, 2017)

In the case of a rescue event, the leading authority for the preparation of the emergency risk analysis is the Estonian Rescue Board, and in the case of a healthcare event, the Health Board. Risk analyses make it possible to systematically assess which events may develop into an emergency and which may not. During the evaluation, the readiness and capabilities of the institution leading the preparation and its cooperation partners to deal with emergency situations, as well as to prepare for them and to prevent them, are analysed (List of events that can cause an emergency, for which a risk analysis is prepared, requirements and procedure for preparing the analysis, and the institution leading its preparation, 2021). In the health sector, infectious diseases and poisoning are the main risks that can develop into an emergency, in the rescue sector, floods caused by storms and accidents with a domino effect in a company with the risk of a major accident are considered to be the main risks. (Estonian Rescue Board, 2022; Health Board, 2022)

Although the risk analyses do not highlight the impacts of climate change or the importance of adaptation to climate change, the existing measures help to manage climate risks and are, by nature, works which should be performed by the administrator of the systems anyway or which should be ordered by the state from enterprises. This includes modernisation of storm drains, maintenance of dams, drawing up of detailed maps of at-risk areas and risk management plans, and the training of local governments on emergency-related issues. The timeliness of risk analyses is assessed every year, which ensures their correctness and reliance on the latest knowledge and data when assessing, solving and mitigating situations. (List of events that can cause an emergency, for which a risk analysis is prepared, requirements and procedure for preparing the analysis, and the institution leading its preparation, 2021)

The Emergency Act also stipulates the organisation of the continuity of vital services (e.g. electricity and natural gas supply, organisation of the continuity of emergency care for the purposes of the Health Services Organisation Act (water supply and sewerage, etc.), which may also be affected by climate change (in the case of an increase in extreme weather events). Risk analyses of continuous operation and continuous operation plans must be drawn up to ensure the continuous operation of vital services. The measures related to the Emergency Act are primarily focused on increasing the awareness of the population and those providing vital services, notification of at-risk groups, and cooperation, as well as on increasing the efficiency of weather forecasts and weatherproof infrastructure. (Emergency Act, 2017; Health Services Organisation Act, 2002)

The impact of climate change is also included in the Water Act, with goals to prevent the deterioration of the condition of water ecosystems, terrestrial ecosystems and wetlands that depend on them and to improve their condition, to promote the sustainable use of water and to ensure the long-term protection of surface and groundwater resources and adequate water supply, to contribute to mitigating the effects of floods and droughts and achieve good environmental conditions in the marine area. The Water Act stipulates the obligation to prepare maps of areas with a flood risk (updated and published in 2019 (MoE, 2019b)), to assess flood risks and to prepare flood risk mitigation plans. (Water Act, 2019)

The aim of these activities and plans is to manage the potential damaging consequences arising from floods to human health, property, the environment, cultural heritage, and economic activities and decrease the likelihood of such damage in the future, primarily by increasing awareness, as well as by identifying and assessing new, increasing risks. During the risk assessment, previous similar events are mapped, and their scope, course and damage are described. (Content requirements of the flood risk assessment report, mitigation plan and updated mitigation plan and data marked on the map of the flood hazard area and flood-related risk area, 2019)

Risk mitigation must include flood protection, flood preparedness, flood forecasting and early warning systems. Implementation of the measures will commence at the national level, at the level of the local government of the area at risk, or at the level of companies, organisations, or residents. In the summer of 2022, the mitigation plans for the risks related to the flood threat in the East-Estonia, West-Estonia and Koiva river basins were approved. Plans are necessary to prevent and mitigate the damage caused by natural floods to human health, property and to the environment. Measures and guidelines of mitigation plans must be taken into account in general plans, development plans and crisis management plans of national and local governments. (MoE, 2022)

The European Commission's climate change adaptation strategy Forging a climate-resilient Europe – the new EU Strategy on Adaptation to Climate Change is part of the initiatives under the European Green Deal. This strategy is a continuation of the climate change adaptation strategy adopted in 2013 Climate change adaptation: European action framework. (European Commission, 2009; European Commission, 2021c)

The strategy presents a long-term vision of how to transform the European Union into a society that is resilient to climate change and fully adapted to the inevitable effects of climate change by 2050. This includes improving the adaptability of the Union and minimise vulnerability to the effects of climate change in accordance with the Paris Agreement and the proposal for a European climate law. (European Commission, 2021c)

The adaptation strategy has four main objectives (European Commission, 2021c):

1. **smarter adaptation** – improving knowledge and data availability while addressing climate change uncertainty; ensuring more high-quality and up-to-date data on climate-related risks and damage and make the Climate-ADAPT platform a reliable European information platform on adaptation and enhance its functioning;
2. **more systematic adaptation** – to support policy making at all levels of government, society, economy and other sectors; enhance the preparation of adaptation strategies and plans; integrate climate change resilience into macroeconomic policies and promote nature-based adaptation solutions;
3. **faster adaptation** – accelerate adaptation solutions and measure development and implementation; reduce the economic damage resulting from climate-related risks, extreme weather conditions and ensure the availability of freshwater resources and their sustainable use;
4. **more systematic adaptation to climate change at the international level and strengthening of resilience to ongoing climate change.**

According to the first EU strategy on adaption to climate change (approved by the European Commission in April 2013) guidelines for the development of national strategies and the distribution of prioritised sectors – the overall goal of KOHAK is to decrease the vulnerability of Estonia to climate change and achieve the preparedness and capability to cope with the impacts of climate change at the local, regional, and national level with the help of a framework of activities. Furthermore, the development plan includes eight sub-goals, which are directly based on the vulnerability of prioritised areas. The implementation of the development plan is supported by measures and activities for adaptation in the action plan including the descriptions, outcomes, supervisors, costs and funding. **Table 6.5** provides an overview of KOHAK sectoral sub-goals and adaptation measures. (MoE, 2022a)

The Regulation (EU) 2021/1119 of the European Parliament and of the Council (European Climate Regulation), adopted in the summer of 2021, sets out the requirement for EU Member States to have national adaptation strategies and action plans, the implementation of which is periodically reported and regularly updated.

KOHAK unites the goals, measures and activities related to adaptation to climate change and will be included in the newly prepared environmental strategy document Environmental Development Plan until 2030 (KEVAD). According to the action programme of the Government of the Republic, the entry into force for KEVAD is the second half of 2023. With the entry into force of KEVAD, KOHAK will lose its validity as an independent document. The implementation of KEVAD's goals will take place through programs in the performance areas, e.g. in the environmental result area, through the Environmental Protection and Use Program and through relevant programmes of other ministries.

Table 6.5. Summary of information on vulnerability and adaptation to climate change

Sector and goal	Vulnerability	Adaptation measures applied in the sector
1. Health and rescue capability Improved rescue capability and the ability of people to protect their health and property has decreased the negative impacts of climate change on health and living environment.	The main vulnerability of the health sector arises from the capability and preparedness of healthcare systems to adapt to the changing climate and extreme weather phenomena (availability of medical care may be interrupted), from the sensitivity and inequality of the population, from the share of more vulnerable people (the elderly, children, chronically ill), and from the existence and functioning of warning systems. In the case of rescue capability, vulnerability depends on processing large amounts of emergency calls (in the case of floods, forest or landscape fires), on the learnt helplessness of people, and on interruptions in rescue work and in ensuring public order.	1.1. Development of information, monitoring, and support systems and drawing up of action plans to increase the efficiency of the management of the health risks arising from climate change and the management of the health risks
		1.2. Increasing of rescue capability
2. Land use and planning The risk of storms, floods, and erosion has been managed, the heat island effect has been managed, the climate resistance of settlements has been increased by selecting the best land use and planning solutions.	Realisation of climate risks in land use depends on the maintenance of or a failure to maintain drainage systems, as well as the natural depreciation thereof. The main risks related to climate change manifest and are amplified in the cities, which are exposed to extreme weather phenomena, where the activities of people are restricted to certain areas, where there is specific land use, constructed environment, and urban landscape. The vulnerability of Estonian cities to climate change primarily depends on population processes, which include shrinking and ageing of the population and the declining birth rate, but also increasing spatial polarisation, the population in Harju County becoming denser, suburbanisation, fading away of small towns, moving to peripheral locations, and extensive emigration.	2.1. Increasing awareness of the impacts and risks of climate change on land use, urban organisation and planning, development of planning methods for areas at risk, and adjustment of the legal framework
		2.2. Management of the flood hazard and development of green areas and green areas in cities to manage climate risks

Sector and goal	Vulnerability	Adaptation measures applied in the sector
3. Natural environment Variety of certain species, habitats, and landscapes, the favourable condition and completeness of terrestrial and aquatic ecosystems, and provision of socio-economically significant ecosystem services in a sufficient extent and with a sufficient quality have been ensured in the changing climate conditions.	The highest vulnerability in the sector of the natural environment is the susceptibility of the favourable condition and completeness of all ecosystems (terrestrial ecosystems, freshwater ecosystems, marine environment) and the volume and quality of ecosystem services to changes in the hydrologic (incl. ice and snow cover) regime and, from the perspective of biodiversity, the species, which have adapted to special environmental conditions, are most vulnerable.	3.1. Preservation of biodiversity
		3.2. Prevention of the entry of invasive foreign species into nature, and the eradication and control of such species in the changing climate
		3.3. Ensuring the favourable condition of biotas and the variety of landscapes, and organising nature conservation in the changing climate
		3.4. Ensuring the stability, favourable condition, functions, resources, and variety of terrestrial ecosystems and habitats in the changing climate
		3.5. Monitoring the condition of surface water, structure of the composition of biota, the external and internal loads of substances arising from changes in temperature and the hydrologic regime and minimising climate risks
		3.6. Minimising the negative impacts of climate change to achieve a good condition of the marine environment and the preservation of biological diversity
		3.7. Ensuring the sufficient extent and sufficient quality of the ecosystem services, which are important from the socio-economic perspective, taking into consideration climate-related risks
4. Bioeconomy Sustainability of the bioeconomic sectors, which are important to Estonia, is ensured through planning the agriculture, forestry, water management, fisheries and the leisure industry as well as peat extraction by taking into consideration the climate.	Planning the agriculture, forestry, water management, fisheries, and the leisure industry without considering the climate (failure to take into consideration changes in the hydrologic regime and increase in the average temperature) endangers the sustainability of the bioeconomic sectors, which are important to Estonia.	4.1. Ensuring food supplies in the changing climate through the development of land improvement systems, increasing the competitiveness of agriculture, and through the creation and transfer of knowledge
		4.2. Ensuring the productivity and viability of forests, and the diverse and efficient use of forests in the changing climate
		4.3. Ensuring the sustainability of the fisheries resources and the welfare of the people who earn their living from the fisheries sector in the changing climate
		4.4. Diversification of tourism and increasing the satisfaction of visitors
5. Economy Participants in the economy are using the opportunities which accompany climate change, in the best possible manner and manage the risks related thereto.	The relatively slow pace of climate change and the response speed of Estonian companies to external changes and their adaption capability ensure low vulnerability of the economy even if the adaption consists of the cessation of activities in regions significantly impacted by climate change or of the considerable changing of such activities. The vulnerability increases when the economy as a whole is unable to take advantage of the new opportunities presenting themselves as a result of climate change.	5.1. Management of household risks accompanying climate change
		5.2. Supporting the entrepreneurship, which takes the impacts of climate change into consideration

Sector and goal	Vulnerability	Adaptation measures applied in the sector
6. Society, awareness, and cooperation People understand the hazards and opportunities accompanying climate change.	The vulnerability of the society and the ability of the society to adapt to climate change are significantly impacted by the level of understanding of the accompanying hazards and opportunities and the level of research and education in the country. People who are less informed, disadvantaged, in a poor socio-economic condition and have a lower social capital are most vulnerable to climate change.	6.1. Increasing the efficiency of risk management and ensuring the ability of the employees of state and local government authorities to manage the risks accompanying climate change
		6.2. Supporting the adaptation to climate change of preschool education institutions, general educational institutions and hobby schools, environmental education centres and vocational educational institutions to the impacts of climate change
		6.3. Ensuring the availability of up-to-date and thorough information about the impacts of climate change, incl. the transferred impacts of global climate change on Estonia
		6.4. Participation in international cooperation for management of the impacts of climate change and adaptation to the impacts as well as in the development of a strong international climate policy
7. Infrastructure and buildings The impacts of climate change will not result in decreased availability of vital services or decreased energy-efficiency of buildings.	Increasing frequency of extreme weather phenomena will put to the test the entire transport system, with the concurrence of several circumstances potentially resulting in unpredictable risks or hazardous situations. In comparing various types of transport, the most vulnerable are the entire means of transport on the roads and streets as well as the safety of people related to the infrastructure arising from changes due to interruptions in traffic, slipping hazard, reduced load-bearing capability of unpaved side roads, and safety of cycle and pedestrian tracks. The direction of the development of the vulnerability of transport technologies and fuels in the second half of the century is unknown. The vulnerability of buildings is higher due to the ageing building stock compared to the average of the EU, which is of low quality and highly energy-consuming.	7.1. Ensuring safe traffic, delivery of goods, and access to vital services in changing weather conditions
		7.2. Ensuring the durability and energy-efficiency of buildings and a comfortable indoor climate for people in changing weather conditions
8. Energy and security of supply Climate change will not result in decreased energy independence, energy security, security of supply or usability of renewable energy resources or in the increase of the volume of the final consumption of primary energy.	The energy independence and security of supply, which are largely built on the oil shale industry and above all depend on the existence and availability of domestic energy resources and the sufficiency of the production capacities required for generation of energy (electricity, heating, and fuels), are generally not very vulnerable to the climatic changes forecast for the end of the century. The use of renewable energy sources, such as timber, biomass, or peat, is more vulnerable than the oil shale energy industry due to the seasonality of collection and the need for interim storage.	8.1. Ensuring the availability of renewable energy resources and energy and heating supply to the consumers in changing climate conditions

The measures included in KOHAK are focused on increasing awareness and resilience and on the following leading principles based on the implementation of the principle of caution:

- Awareness – increasing the awareness of the public (the society as a whole, people, officials) and decreasing the gaps in knowledge related to climate change and the uncertainties arising therefrom (measures related to knowledge).
- Preparedness and resilience – ensuring the capability to manage climate-related risks and increasing strategic and operational readiness.
- Caution – acknowledging long-term changes and preventive operation in the long-term perspective.

Measures and developments of the health and rescue capability sector

The measures of the health sector mainly stress increasing the awareness of the population of the health impacts of climate-related risks and improvement of the monitoring capability of the healthcare system. Increasing risks call for further studies to specify the nature of the risks in detail.

In order to get closer to the goals given in **Table 6.5**, ESTEA specialists participated in external training related to the further development of weather forecasts and forecast models HARMONIE (numerical weather prediction model) in 2019. In addition, in 2019–2020, as part of the health measure, probability scenarios and map layers of coastal flood areas were prepared by the ESTEA, and the beach monitoring methodology was updated. In the period of 2019–2020, the study 'Use and development of remote sensing data in the public services' was carried out within the research programme RITA. As part of the study, a flood mapping methodology suitable for Estonia was developed based on remote monitoring data, which enables operationally occurring floods to be mapped and the state's operational institutions to deliver the necessary warnings and evacuate residents. In addition, the information about the flood that occurred can be used for planning in the future. As a follow-up activity, the development of the ESTEA´s service based on this methodology started in 2021. (MoE, 2022b)

In addition, updating the sea level forecast model and introducing the new sea modelling environment, NEMO-Est, started in 2020. NEMO-Est can be used for operational forecasts of the Estonian sea area, climate studies and assessment of various marine processes. By updating the model, operational forecasts of sea level, water temperature, salinity, currents and ice conditions will become more accurate. To date, the NEMO-Est operational model has been implemented in the ESTEA. (MoE, 2022b)

The prerequisite for increasing the rescue capability is increasing the efficiency of risk management. The efficiency of risk management can be increased in emergency situations related to climate change in order to ensure better possibilities for the prevention and management of emergencies. Communication of the risks also requires development – notifying and warning of the public in time to bring vital information smoothly to the vulnerable population. It is also important to increase the awareness of the population of the hazards and to teach them about coping and assisting others in emergency situations. Organising cooperation must be focused upon more than before, both between the civil and military institutions and between authorities and the private sector. Acquiring and development of the rescue service equipment required for responding to emergencies related to climate change is also important, as even though the general level of forest and landscape fires is decreasing, the number of fires caused by climate factors is on the rise. (MoE, 2017a)

In order to increase the rescue capacity, the Rescue Board has developed the ability to monitor and extinguish forest fires from the air and has acquired and deployed 15 drones (including 7 with a thermal camera). In order to effectively respond to emergency situations arising from climate change (floods, wildfires, extreme weather conditions), the Rescue Board has acquired modern rescue equipment and technology (including rescue vehicles with increased cross-country ability, all-terrain vehicles (ATVs), utility terrain vehicles (UTVs) and crawler fire fighting vehicles) in 2017–2020. In the case of extraordinary weather phenomena, the Rescue Committee has the possibility of direct communication with the ESTEA weather forecaster (on call) to obtain information in addition to the transmitted warnings. The ability of volunteer rescue teams to extinguish forest fires has been improved by increasing the number of rescue vehicles. Personal protection and rescue equipment including fire hose stocks were also renewed. (MoE, 2022b)

Measures and developments of the land use and planning sector

In the case of land use and planning measures, spatial planning is the instrument which enables the prevention of adaptation-related risks affecting cities and coastal areas. Another important factor is the competence and ability of local governments and county governments in the field of planning, i.e. the existence of specialists competent in the area of adaptation to the impacts of climate change. Thus, integration of the knowledge of both the people as well as specialists into plans, strategic assessment of environmental impacts, as well as urban organisation is important. (MoE, 2017a)

It is also important to organise pilot projects of comprehensive and detailed plans and draw up guidelines for managing the risks related to climate change on the basis thereof, as well as recommendations for climate-proof implementation of design criteria (e.g. buildings and planting of greenery, storm water removal). The projects will determine the circumstances and problems that various levels of the plan must focus on. The experimental projects will also provide an efficient input into legislative drafting and the compilation of a spatial database. (MoE, 2017a)

Taking into consideration the demands of adaptation to the impacts of climate change also requires detailed information for expressing the extent of certain problems in the area at risk. Thus, it is important to study the microclimates of larger cities and draw up relevant analyses and maps. Risks related to climate change must be mapped and collected into a single nationwide spatial database. (MoE, 2017a)

The measures are focused on the prevention of the potential damage arising from heat waves and heat islands, floods and storms and on the management of risks by applying measures related to land use, the management of risks related to flooding and heat waves by creating and maintaining green areas, using the cooling effect of water and various construction technology solutions, such as reconstruction and construction of storm water systems, consideration of the heat-reflecting, heat-absorbing, and heat-retaining qualities of surfaces and air circulation in the design and construction of buildings. Implementation of the measures is primarily the landowners' duty. The state and local governments must guide the application of the implementation measures within the scope of their legal and administrative competences. (MoE, 2017a)

To ensure better land use, urban organisation and planning, the MoE has organised several information days and public discussions. For example, in 2017, an information day on 'Considering climate change and mitigating risks' was held for local governments and planners. In 2019, an information day 'Taking into account the effects of climate change and floods in planning' was held for the same target group. In 2018, recommendations and guidance materials for rainwater solutions in the planning process and an overview of engineering-technical solutions for rainwater were prepared in cooperation between MoE and the Ministry of Finance (MoE, 2022b). Also, in 2019, MoE, in cooperation with the Rescue Service, developed information brochures with guidelines for areas with a flood risk. (MoE, 2019a)

In order to prevent possible damage caused by heat islands and to mitigate risks, the ESTEA prepared a heat island analysis for the largest cities in Estonia in 2020 (Tallinn, Tartu, Pärnu, Kohtla-Järve, Narva, Rakvere and Viljandi) based on Landsat-8 satellite data. Developers of residential areas and urban planners can use the maps when making spatial planning decisions. Map layers are also available on the Geoportal of the Land Administration in the map application Heat Islands (ESTEA, 2020a). Estonia's largest city, Tallinn, also conducted a study on the location of its heat islands and changes in temporal and spatial dynamics. (Tallinn Strategy Centre, 2021)

In 2018, the MoE updated and made public the assessment of flood-related risks and determined risk areas in order to mitigate flood risks (MoE, 2018b). In 2019, maps of the flood hazard areas and the flood-related risk areas were updated and made public (MoE, 2019b). Maps are public and intended for use by the general public, as well as planning and environmental experts and local governments for spatial planning decisions. In addition, the ESTEA also mapped the probability scenarios of coastal floods outside the flood risk areas in 2020. (ESTEA, 2020b)

Several mitigation plans have been made to mitigate flood risks – technical solutions of the flood risk mitigation plan in the city of Tartu (MoE, 2021a); technical solutions of the flood risk mitigation plan in the city of Kärdla (MoE, 2021b); technical solutions of the flood risk mitigation plan in the city of Sindi city (MoE, 2021c); Calculation and mapping of flood probability scenarios of the Jõelähtme river in Raasiku township (MoE, 2018c). The above-mentioned works analyse the probability and possible extent of flooding in the areas in question and what measures would be necessary and practical to implement in order to prevent (or significantly reduce) the occurrence of flooding (MoE, 2018c, 2021a, 2021b, 2021c). The study 'Economic indicators and methodology for describing flood-related losses in risk areas' was also completed, outlining the damage assessment methodology that can be used for describing flood-related damage. (MoE, 2018d)

In addition, instructional materials for nature-based rainwater solutions have been prepared, and the preparation of urban greening plans will begin in 2023. Moreover, in the coming years, guidance material aimed at local governments for considering climate risks will be prepared - how to take climate change into account in spatial planning (e.g. building conditions in flood-prone areas, taking coastal erosion into account, mitigating the heat island effect, etc.). The methodologies for assessing the climate effects (carbon footprint) of various land uses need additional research and development, in order to take into account the location of buildings, technical infrastructure, the nature and richness of the life of pavements, and the climate impact of movement needs due to use on a scientific basis.

In the course of the Environment Agency's project 'Tools necessary for assessing, forecasting and ensuring the availability to assess the socio-economic and climate change-related environmental condition of biodiversity' a green network planning guide was prepared, in which special attention was placed on areas with urban institutions and the planning of green areas in the urban environment. It is a helpful guide material for local governments for green area planning (ESTEA, 2022). A legislative proposal was recently published by the European Commission on nature restoration, aiming for the greening of cities and the topic of natural ecosystems in cities. The regulation aims to set goals for increasing the greening of cities.

Measures and developments of the natural environment sector

The adaptation measures of the natural environment sector are based on the general nature conservation measures and activities, which also help to adapt to the impacts of climate change. The adaptation measures of the sector are focused on reducing the unfavourable impacts of climate change on the condition of species and biotas and on the integrity and functioning of ecosystems. The diverse biotas, sufficient protected areas, and healthy biological communities, which the measures aim to achieve, will ensure higher ecological resistance to the factors – both those arising from climate change as well as other human activities – which decrease biological diversity. (MoE, 2017a)

In the case of terrestrial ecosystems, the aim of the measures is to preserve the good condition of the ecosystems and the functions and resources in the changing climate. A significant share of the measures consists of scientific research on the impacts of climate change and monitoring of ecosystems, which provide the grounds for making more conscious decisions related to adaptation. In order to increase the adaptation capability of ecosystems, it is recommended to apply natural management (e.g. preservation of genotypes and the variety of habitats as well as the balance of the ecosystem matter cycles) and restore the natural state of the areas strongly affected by human activities. (MoE, 2017a)

In the case of freshwater ecosystems, both regulative and notifying measures are required as well as one-time studies and complementation of long-term monitoring. To increase the forecasting capability and accuracy, the changes related to climate change in the washing out of nutrients, internal loads, and water and stratification regimes in Estonia must be immediately modelled. These results would allow us to determine the need for further adaptation measures and switch the measures into the programmes of measures of water management plans or to implement them in the form of independent measure programmes. (MoE, 2017a)

To minimise the increase in the environmental impacts caused by climate change in the marine environment, it is first necessary to ensure the good condition of the marine environment. In connection with the changes in the environment arising from climate change and the management thereof, both regulative measures as well as plans and further studies are required to ensure this. (MoE, 2017a)

Almost half of the measures related to ecosystem services are oriented to the preservation of the volumes and quality of the water-related ecosystem services (e.g. preservation of the water regime, water purification, fish, seafood, drinking and irrigation water, fishing, water tourism opportunities, etc.). Regulative activities also play an important role and it is advised to increase the awareness of the population and target groups of climate risks and invest in the preservation of the volume and quality of ecosystem services. (MoE, 2017a)

The need for the development of a classification of ecosystem services and for finding the volumes, quality and the financial value must be highlighted. A freshwater and marine ecosystem classification based on the conditions prevalent in Estonia has been drawn up, but similar classifications are also required for other ecosystems (forest, wetlands, meadows, soil, cities). There is also a clear need for a study which would determine the functioning of the ecosystem matter cycles, based on which it would be possible to assess the climate risks of ecosystem services. Eventually, the climate sensitivity indicators of green zones, meadows, and grasslands as well as the soils should also be reflected in county and comprehensive plans. (MoE, 2017a)

In order to preserve biodiversity in changing weather conditions, species threatened by climate change, their adaptability and level of danger are determined, and action plans are drawn up for the protection of these species. It is important to monitor indicator and key species threatened by climate change. For this, in 2017–2020, conservation management works for rare and endangered species were ordered, inventories of habitats of protected plant species were carried out and protection management recommendations were given, alien species were mapped and a study of migratory movements was carried out. (MoE, 2022b)

In 2020, the Minister of the Environment's directive approved the National Action Plan on Invasive Alien Species 2020–2025 (MoE, 2019c), and in 2021, the ESTEA prepared a monitoring plan for alien species of EU-level importance to improve the monitoring of invasive alien species. In addition, as part of the coastal sea monitoring of the national environmental monitoring programme, already known alien species are monitored in the sea, and the presence of alien species is monitored at regular monitoring stations. In order to control the introduction of alien species in ballast water, studies were carried out in the water areas of major ports with the funding of the Environmental Investment Center (EIC). Within the framework of the RITA project 'Study of micro-organisms and viruses in ship ballast water' the species found in ship ballast water were studied (MoE, 2020b). Moreover, within the framework of the mereRITA project, monitoring methodologies were further developed to detect alien species early with the eDNA method (MoE, 2021d). In order to raise general awareness, the Environmental Board and the ESTEA have published several articles on alien species in recent years. (MoE, 2022b)

In order to ensure the favourable condition of communities and the diversity of landscapes, a green network planning guide was prepared, which is primarily intended for planning a green network at the level of general planning. The preparation of the guidance was preceded by an analysis of the functioning of the existing green network, and it can also be used at the level of detailed plans. (Ministry of Finance, 2018)

In order to ensure the stability, functions and diversity of terrestrial ecosystems and habitats, the 2014–2020 Cohesion Fund funds have been implemented by the EIC water protection programme project 'Adjustment of drained, exhausted and abandoned peatlands'. In the course of the project, up to 2,000 ha of residual bogs will be restored by 2023. As of the end of 2021, 871 ha of bogs with a water regime have been restored. In the years 2017–2020, the condition of around 5,000 ha of bogs has been improved, restoring the natural water regime. Within the framework of the financing climate change impacts and adaptation scientific and applied research and implementation of research results on the level of forest ecosystems, spruce and spruce-birch stands were included in the FAHM climate manipulation experiment, renewing the infrastructure was also led by the University of Tartu. In addition, the EULS studied the ecological-economic potential of birch plantations in climate change adaptation and mitigation. A study of the economic-ecological impact of logging ages was also conducted. (MoE, 2022b)

In 2019–2021, the EULS in cooperation with Tallinn University of Technology carried out modelling and forecasting of the impact of climate change on the external and internal load and stratification regime of lakes in order to minimise the climate risks on freshwater ecosystems. The RITA2 programme funded the 2020–2021 project 'Relationships and comparability between water standards for inland water bodies and the sea', in which the current nutrient standards in rivers and the sea were analysed and nutrient pollution loads from rivers to the sea and the possibilities of reducing them were assessed. (MoE, 2021e)

In order to minimise the negative impact of climate change on the achievement of a good state of the marine environment, the project 'Development and testing of innovative methods of analysis and assessment of the Estonian marine area in the pilot area' (mereRITA) was carried out through the RITA programme in 2019–2021. The objective of the project was to develop marine area monitoring, analysis and assessment methods that help assess the state of the marine area based on the requirements of the marine strategy and the EU Habitats Directive and assess the pressure factors affecting the marine environment (including the effects of pressure factors resulting from climate change, such as acidification, etc.). (MoE, 2022b)

In order to ensure socio-economically important ecosystem services, the RITA ForBee project 'Possibilities to reduce the death of pollinators, including honeybees' was implemented in 2019–2021 under the leadership of the EULS Institute of Agriculture and Environment. Selected ecosystem services have been mapped and evaluated as part of the ELME project 'Tools necessary for assessment, projecting and ensuring the availability of data of the socio-economic and environmental state of biodiversity associated with climate change' led by the ESTEA. (MoE, 2022b)

Measures and developments of the bioeconomy sector

Agricultural measures are above all focused on ensuring the companies' economic coping and competitiveness in order to create the prerequisites for adaptation to climate change. Due to the high level of uncertainty and the need to create the primary data required for decision-making, research measures must be used to designate a significant part of the Estonian scientific potential into basic and applied research analysing the changing conditions. The measures of information exchange help to communicate better knowledge to the target groups, which help to implement new, relevant technologies in practice and preserve a decent quality of life and a safe and clean living environment. A contribution by the state in the investment measures would help to develop systems for modelling the agroclimatic and agricultural environment and for issuing warnings of natural damage and emergencies in time to ensure food supply and food safety both in a shorter and longer perspective. (MoE, 2017a)

The main measure for preservation of the fisheries resources and thus also fishing opportunities in the changing climate conditions is, above all, changing the ratio of the fishing regime and the methods of use of the fisheries resources (hobby fishing and industrial fishing). The fisheries resources should be managed more accurately and skilfully, taking climate risks into account. Although the optimisation of minimum size limits, the creation of better spawning conditions, spatial and seasonal restrictions on fishing, and regulating fishing efforts is already a common practice in Estonia, these measures should be brought into compliance with changing climate and resources. One of the prioritised measures is reducing the factors which damage fish fauna (e.g. anthropogenic eutrophication, pollution). This helps to compensate for the negative impacts of climate change on the living environment of fish. In order to prevent significant damage, large investments must immediately be made in Lake Peipus and the Baltic Sea (cross-border, if possible) to implement measures which are of decisive importance for preserving the habitats of fish. A measure which can be implemented to increase the efficiency of the use of diminishing fisheries resources is the more extensive and efficient adding of value to the fish (incl. the fish of low value and foreign species) and restriction of illegal fishing. (MoE, 2017a)

If necessary and possible, alternative jobs should be created in a timely manner in the home regions of the population groups who are dependent on fisheries to provide an additional income source in coastal areas (e.g. development of tourism, incl. accommodation, catering establishments, car parks, transportation to the fishing sites on lakes or at sea) and fish farming should be developed. The lack of scientific information, which the adaptation measures could be based on, is of decisive importance here, incl. inaccurate assessment of the fisheries resources. Thus, complex studies of the pressure factors influencing fish fauna and communities (e.g. climate change and eutrophication) must be conducted in the coming years and hobby fishing should be monitored at the national level, allowing the state to gain a better overview of the use of the fisheries resources. In order to make knowledge-based decisions in the management of the fisheries resources, the results of the monitoring of the fisheries resources must be integrated better with other biota and environmental monitoring. The aim of such studies is to implement scientifically proven and thoroughly planned measures for adaptation to the climate in the fisheries sector all over Estonia. (MoE, 2017a)

The activities focused on increasing the awareness and ability in the sector have an important place in the tourism sector, incl. the required studies and notification activities. Implementation of the investment and support activities will commence, which will help to increase the estimated number of tourists due to the warmer weather conditions in summer and manage the impacts in the winter period, which is becoming less favourable. The most important of these includes the diversification of what is offered, increasing the satisfaction of the visitors, and reducing the load on the local community. (MoE, 2017a)

In 2019, in order to develop land improvement systems for ensuring Estonia's food supply and to increase the competitiveness of agriculture, the Ministry of Rural Affairs started drafting the legislation on the requirements of the land improvement conservation plan, in which the principles of the land improvement conservation plan were established. In 2021, the Agriculture and Food Board prepared land improvement conservation plans, which are planned to be established in 2027. The Estonian Crop Research Institute developed integrated plant protection guidelines. As part of the Rural Development Plan 2014–2020, support measures were developed for the development of land improvement systems for landowners and companies to improve sustainability and energy and resource efficiency, taking into account climate risks, land fund, soil and other regional and local conditions. In addition, support measures for product development were developed to encourage agricultural resource management and use the positive effects of climate change. (MoE, 2022b)

In 2019, the report Forest and Climate Change was prepared to ensure the productivity, vitality and diversity of forests. The work is based on existing and available scientific research, and it describes the role of Estonian forests in mitigating climate change (including energy and carbon storage) and adapting to it, keeping in mind European and global climate change policies. (MoE, 2020c) In 2019–2020, the EULS conducted a study on the nature and need of genetic reserve forests in Estonia. The paper outlines from which tree species it is possible to create a gene reserve forest, the number of areas and what size is optimal for Estonian conditions, and how to manage them. (MoE, 2022b)

In order to ensure the sustainability of fish stocks, in 2019–2020, on the order of MoE, the dynamics of the food spectrum of the growth period of young fish of the species were studied in fisheries important to Lake Kuremaa. In 2020, the Estonian University of Life Sciences (EMÜ) prepared a Study of the Impact of Climate Change on Estonian Small Lakes, which contains recommendations for maintaining and improving the ecological condition of the studied lakes (Estonian University of Life Sciences, 2020). The European Maritime and Fisheries Fund financed the projects carried out on behalf of the MoE in 2018–2020:

1. 'Preparation of regional aquaculture plans to manage possible environmental pressure', within the framework regional aquaculture plans were prepared for the Estonian coastal sea, containing recommendations based on the regional specificities of aquaculture species and forms and limitations, taking into account the possibilities of improving the state of the marine environment;
2. 'Adjustment of the fishing load to meet the conditions of a good environmental condition', the purpose was to reduce the impact of pressure resulting from fishing on commercially used fish populations in Estonian sea areas;
3. 'Modernization of regional fishing restrictions and limit sizes of fish', the purpose was to reduce the pressure from fishing and the impact of the impact of fishing on commercially used fish populations in Estonian marine areas. (MoE, 2022b)

In order to improve the ability of the tourism sector to adapt to the effects of climate change, the MoE has cooperated with the NGO Estonian Nature Tourism Association, which was founded in 2018 by Estonian nature tourism companies. The aim of the association is to raise awareness of the importance of Estonia's reputation and image as a high-value natural state and the need to preserve and improve it both in Estonia and internationally. One of the important goals of the association is the development, promotion and consolidation of the principles and standards of nature-friendly and nature-aware tourism. The Environmental Board and the EMÜ have continued to organise nature tourism conferences every year. In 2020, the tradition of celebrating the Estonian Wilderness Day was initiated. (MoE, 2022b)

Measures and developments of the economy sector

Insurance plays a very important role in the adaptation process. Insurance can be used to manage and direct the risks accompanying extreme weather conditions. However, it is very important from the perspective of insurance to collect information on the coverage of the risks and thus an additional study must be conducted in this sector. (MoE, 2017a)

The measures of the economy sector are primarily focused on companies to notify them of the risks and opportunities which accompany climate change, followed by supporting companies in the necessary restructuring. Thus, the main task is to make the information about climate change readily available, as well as to notify the companies operating in the at-risk areas of the risks accompanying climate change and make them prepare for hazardous situations. (MoE, 2017a)

In order to better ensure mitigation of household risks associated with climate change, the Ministry of Finance is conducting a study 'Analysis of insurance coverage of climate risks affecting Estonian households that can be mitigated with insurance services', which should be completed by 2025. (MoE, 2022b)

Although the main focus of businesses in the last two years has been on the COVID-19 crisis, in 2017–2020 several different climate-related information days, seminars and conferences were held, which were also aimed at private companies. Among them, the conference Biodiversity and Climate in a Changing World held at the end of 2021, where a discussion on the obligations, opportunities, and cooperation of various companies with the public sector in relation to environmental sustainability, climate change mitigation and adaptation took place. In 2021, the European Commission came up with a large-scale sustainable finance taxonomy framework aimed at business and financial markets, in which sustainability criteria are defined, including sustainability criteria developed specifically in the field of climate change mitigation and adaptation.

Based on this, investors can begin to evaluate and disclose whether their financing decisions and the financial products they offer are environmentally sustainable. Awareness needs to be raised on this topic in Estonia as well, and for this purpose a sustainable financing project has been initiated, during which the Estonian market will be analysed based on the context of sustainable financing, and awareness will be raised among various target groups and market participants (the project will finish at the end of 2022). (MoE, 2022b)

Measures and developments of the society, awareness, and cooperation sector

From the perspective of the equal and sustainable development of the society, it is important for the information on the impacts of climate change and the potential impacts of extreme weather phenomena to be equally and easily accessible for all. Based on this information, local governments and local communities can plan their activities and response in hazardous situations, and adaptation measures can support them in such planning (training, provision of equipment, etc.). It is essential to assess the awareness and knowledge of the population of the potential impacts of climate change and their ability to serve themselves. This information can be collected systematically via specific studies. (MoE, 2017a)

The success of adaptation to the impacts of climate change depends on the accuracy of the information available in Estonia on climate change. For the continuous updating of the information and increasing the accuracy of the forecasts, it is vital to support climate research and participate in international cooperation initiatives related to climate research (e.g. Copernicus, JPI Climate). The aim of notification and educational measures is to support schools and informal education institutions in adaptation to the impacts of climate change and to supply them with the required supporting materials, training, etc. for the integration of adaptation to the impacts of climate change in their curricula. (MoE, 2017a)

In the area of international relations and cooperation, it is necessary to increase the percentage of adaptation to the impacts of climate change in the Estonian development cooperation. This will help to increase the ability to adapt of all countries and to manage the international problems accompanying climate change, such as environmental migration, as well as provide the prerequisites for receiving assistance in the case of more extensive manifestation of the negative impacts of climate change in Estonia. (MoE, 2017a)

In order to make risk management more effective, a list of the emergency situations in which risk communication is organised and the authorities responsible for the organisation was prepared on the basis of § 10 of the Emergency Act. Behavioural guidelines for crisis situations (Ministry of the Interior, 2018) were prepared in 2018 together with the concept of population protection (updated in 2022). A website and an app Be prepared - Ole valmis (Be Prepared, 2022) are also available to residents. In relation to climate change, extraordinary weather situations (storms, excessively hot weather) and floods have been presented as crisis situations, and guidelines for behaviour in these situations have been provided. In the autumn of 2018, project plans for the implementation of a nationwide crisis hotline and the development of a location-based rapid threat notification system were prepared under the leadership of the Emergency Centre. In March 2020, in order to meet the information needs of the population in the emergency situation caused by COVID-19, the state helpline information number 1247 was opened, which also provides environmental information from the beginning of 2021. (MoE, 2022b)

In 2018–2019, the programme agreement of the European Economic Area was prepared, in which 'Climate change mitigation and adaptation' is one of the supported areas. The measure 'Climate awareness raising' is planned under this supported area, which will finance the preparation of teaching materials on climate change mitigation and adaptation through an open application round for pre-school institutions, for general education schools and interest schools, along with environmental education centres. This measure is also supported by the round of green technology aimed at general education schools, which was aimed to increase the awareness of green technology among students of general education schools (grades 1–9). The first round of this application round took place in 2021 and the second round of applications will be announced in 2022. The support is aimed at students of general education schools to raise awareness of the green technology projects that bring science closer to students and teach them to find smarter solutions. Students also gain knowledge about climate change mitigation and/or adaptation. This activity is financed by the proceeds from the auctioning of GHG emission allowances for aircraft operators in the EU ETS. In addition to the rounds, a climate-related activity and awareness round for kindergartens is being planned, which will support the teaching of environmental topics in the early childhood education curriculum. (MoE, 2022b)

In terms of international climate cooperation, in the period of 2015–2020, Estonia contributed 1 million euros annually to climate-change-related activities in developing countries on a voluntary basis, contributing in a cross-border fashion to mitigating climate change and adapting to its effects within the framework of development cooperation, involving Estonia's best know-how. From 2018, Estonian companies and NGOs started to transfer climate-related technologies and knowledge to developing countries. The sub-institution of the MoE involved is the EIC, which supports various activities within the framework of the state budget strategy measure 'Estonia's contribution to international climate cooperation' and the related regulation of the MoE, the purpose of which is to transfer solutions, knowledge, services and products developed in Estonia to developing countries that would help achieve climate goals. As part of the measure developed for this purpose, three open application rounds have been conducted. Projects have been started in different countries (Bangladesh, South Africa, Costa Rica, Kenya) and cooperation with international organisations (UNEP) is underway. Contributions to various international climate funds will also continue. From 2021, the allocation of funding for activities related to climate change will take place in pace with the planning of the state budget strategy. The allocation of support has currently been increased to 1.5 million euros per year. (MoE, 2022b)

Measures and developments of the infrastructure and building sector

In the sector of technical support systems, it is planned to increase the preparedness of the technical support systems in the case of any weather conditions designed for ensuring the dependability of the transport infrastructure (incl. roads, railways, and bridges) and operability of the infrastructure in extreme weather conditions. (MoE, 2017a)

Based on the current statistics, past weather conditions have been taken into consideration in the development of building standards, presuming that this information would also remain applicable in the future. However, changing weather conditions may have a significant impact on buildings and damage them. Thus, construction principles should be adjusted so that future climate conditions are primarily taken into consideration in the construction of buildings. Many problems related to the durability and indoor climate of the buildings arise from poor construction quality and, keeping in mind the future climate, poor construction quality may cause even more damage. It is equally important to increase the efficiency of heat supply and to minimise the climate risks in the area of supplying the consumers with heat and hot water. (MoE, 2017a)

Regulation No. 106 of the Minister of Economy and Infrastructure of 2015 Road Design Norms and the financing of national road maintenance plans are the basis for ensuring the passability and maintenance of the country's highways in changing weather conditions. In addition, the technical requirements for the construction of a new railway are established in directly applicable EU legislation. (MoE, 2022b) The resources of the European Union 2014–2020 Cohesion Fund have been invested in reducing the final consumption of energy by supporting the preparation of heat economy development plans for local governments. From 2015 to the beginning of 2022, 195 local governments (the large number of local governments is due to the administrative reform in 2017) have been supported in preparing the development plan for heat management. In 2020, the Government of the Republic approved the long-term reconstruction strategy by MoEAC, and by the autumn of the same year, MoEAC submitted a LIFE-IP BuildEst project application to implement the above-mentioned strategy, which received a positive funding decision in the summer of 2021. (MoE, 2022b)

The LIFE-IP BuildEst project deals with the development of technical solutions, pilot solutions for different building types and methods, activities related to climate risks and the circular economy, the development of digital tools and, more broadly, the raising of renovation-related awareness, in order to ultimately increase the ability of owners to renovate their buildings. During the project, among other things, climate risks are modelled and solutions for adapting to a changing climate are tested. These results are the basis for changes in design standards and regulations. The aim is to ensure better climate resistance of buildings in various extreme weather conditions throughout their life span, in order to avoid repeated renovation works. The project will last until 2028 and includes the activities of 18 institutions leading innovation in the construction field all over Estonia. Among them are municipalities, NGOs, ministries, universities, professional associations and state institutions. (Ministry of Economic Affairs and Communications, 2022)

Raising the problem awareness of the excess rainwater and sustainable rainwater solutions is being performed through the LIFE UrbanStorm project, which aims to develop sustainable urban rainwater systems that are resistant to climate change. The goal of the project is to increase the capacity of Estonian municipalities in adapting to climate change, especially in mitigating floods caused by torrential rains, thereby increasing the capacity of municipal water management specialists and engineers in local governments. In the course of the project, climate change adaptation strategies and action plans for Tallinn and Viimsi are prepared. (LIFE UrbanStorm, 2022) Reusing water is seen as a perspective of the future, and in the coming years there are plans to study reusing water and to develop a corresponding regulation in Estonia.

Measures and developments of the energy and security of supply sector

The activities of the measure of energy independence, security of supply, and energy security sector are tightly connected to the national development plan of the energy sector. Those activities increase energy independence, security of energy supply, and energy security today as well as in the case of less favourable weather conditions and more frequent extreme weather phenomena, at the national and regional level. (MoE, 2017a)

In the Estonian Recovery and resilience Plan (RRF), a programme to strengthen the electricity grid is planned to increase the production capacity of renewable energy and to continue with the construction of a weatherproof electricity grid necessary for adaptation to climate change. Making electricity networks weather-proof (mainly by replacing bare-wire overhead lines with weather-proof solutions in the distribution network, e.g. underground cables) helps to reduce breakdowns and ensure the supply of consumers even in extreme weather conditions (e.g. significant storms). The total investment until 2026 is nearly 68.5 million euros, of which the support part from the RRF is 30 million euros. (MoE, 2022b)

Funding and monitoring of the development plan for adaptation to the impacts of climate change

In 2017, the initial estimate of the cost of implementing the KOHAK for the period of 2017–2030 was 43.745 million euros (MoE, 2017a). KOHAK's performance report pointed out that a total of 198 million euros was allocated for adaptation measures in the period of 2017–2020. In financial terms, the majority of adaptation measures and activities during this period were carried out in the fields of natural environment and bioeconomy. The estimated cost of the KOHAK action plan for the period of 2021–2025 is 296 million euros. (MoE, 2022b)

The sources of funding for the activities of the implementation plan are the state budget (mainly the MoE budget), the EIC's environmental programme and external funds (EU structural funds, funds from the European Agricultural Fund for Rural Development, funds from the European Maritime and Fisheries Fund, Estonian recovery plan, support from the European Economic Area, but increasingly also support from the LIFE programme). Activities under the responsibility of other ministries are mostly financed through the action programmes of their sectoral development plans. (MoE, 2022ba)

The MoE had prepared an action plan for the period of 2021–2025 by the spring of 2021, in cooperation with other ministries and KOHAK steering committee members. The implementation of the activities of this action plan is planned through other sectoral action programmes, and the KOHAK action plan for the period of 2021–2025 does not need to be approved by the Government of the Republic (Moe, 2022). Almost half of the planned adaptation activities in this period are activities under the responsibility of the MoE (mainly in the fields of natural environment and bioeconomy). Greater emphasis is placed on more efficient use of primary energy and increasing the share of renewable energy in the final consumption in the field of energy and security of supply. (MoE, 2021f)

6.5.2. Adaptation at the local level

The role of the national level (incl. regional agencies of ministries – the Rescue Board, the Health Board, the Environmental Board) is to shape the common understanding with respect to the important adaptation goals (strategies and policies), to support (training, technical and financial support) and monitor the implementation of the policies (general and detailed spatial plans, inspection of the existence of evacuation and local crises management plans).

The role of local governments is to shape, plan, and undertake specific adaptation activities, as this level is best acquainted with the local conditions. The level of local governments is responsible for the application of measures, which would facilitate the local initiatives of different institutions and stakeholders. The community as well as the volunteer groups which will later be implementing the measures should be involved in shaping these measures.

A number of local governments have also taken the hazards arising from climate change into consideration in their development plans as well as in the renovation of water and sewerage or other lines, and in the drawing up of detailed and comprehensive plans. Water undertakings are regularly monitoring the conditions of water pipelines in order to ensure the quick outflow of storm water from the city in the case of heavy rain.

Local governments' awareness and ability to adapt to climate change is different. Local governments have an important role in adapting to climate change through spatial planning and design, through which they can either mitigate or amplify climate risks. The consistent activity of municipalities in planning for climate change and preparing for extreme weather conditions is supported by the development of information systems for environmental and weather monitoring and the existence of climate plans.

The preparation of energy and climate plans is financed from the funds of the Financial Mechanism of the European Economic Area 2014–2021 programme 'Climate change mitigation and adaptation'. The purpose of climate and energy plans is to help identify the areas related to climate change adaptation and mitigation in a specific region and to find the necessary developments and measures to deal with them. Possible risks and opportunities associated with the impact of climate change are thoroughly considered, thereby helping local governments to adopt knowledge-based long-term strategic decisions. By September 2022, 8 supported climate and energy plans will be ready. The energy and climate plans of Jõgeva County and Lääne County are still going through the last rounds of coordination. As of December 2022, local energy and climate plans exist in nearly 50 out of 79 local governments.

Local governments are preparing climate and energy plans in order for local governments to make long-term strategic decisions maintaining and improving their living environment and contributing to the fulfilment of GPCP, the Estonian National Energy and Climate Plan 2030 and KOHAK. In order to contribute to mapping, setting and achieving local climate and energy goals, the EIC supported the preparation of energy and climate plans in Tartu County (The Association of Municipalities of Tartu County, 2022), Pärnu County (Association of Municipalities of Pärnu county), Lääne County, Lääne-Viru County (Association of Municipalities in Lääne-Viru County, 2022), Jõgeva County and Võru County (Association of Municipalities in Võru County, 2022) municipality associations and Keila (Keila City Council, 2022), Narva (Narva City Government, 2022), Pärnu (Pärnu City Government, 2021) and Rakvere (Rakvere City Council, 2022) local governments. The preparation of energy and climate plans is financed from the funds of the Financial Mechanism of the European Economic Area 2014–2021 programme Climate Change Mitigation and Adaptation. The purpose of climate and energy plans is to help identify the areas related to climate change adaptation and mitigation in a specific region and to find the necessary developments and measures to deal with them. Possible risks and opportunities associated with the impact of climate change are thoroughly considered, thereby helping local governments to adopt knowledge-based long-term strategic decisions. By September 2022, 8 climate and energy plans were completed. The energy and climate plans of Jõgeva County and Lääne County are still going through the last rounds of coordination. As of December 2022, local energy and climate plans exist in nearly 50 out of 79 local governments.

In addition, the adaptation development plan for coping with climate change has been prepared, for example, by the Viimsi municipality (Viimsi Municipality Government, 2021). The energy and climate plans prepared by the Hiiumaa municipality (Hiiumaa Municipality Government, 2021). In 2021, the plans of two of Estonia's largest cities, Tallinn (Climate Neutral Tallinn. Sustainable Energy and Climate Action Plan 2030) and Tartu (Tartu Energy 2030) (Tartu City Council, 2021), were also approved. The plans focus on mitigating climate impacts and clearly outline the needs and actions to adapt to climate change.

In addition to the aforementioned, the development plan for coping with climate change has been prepared, for example, by the Viimsi municipality (Viimsi Municipality Government, 2021) and the energy and climate plan by the Hiiumaa municipality (Hiiumaa Municipality Government, 2021). In 2021, the plans of two of Estonia's largest cities, Tallinn (Climate Neutral Tallinn. Tallinn's Sustainable Energy Economy and Adaptation to Climate Change Plan 2030) and Tartu (Tartu Energy 2030) (Tartu City Council, 2021), were also approved, which focus on mitigating climate impacts and clearly outline the needs and actions to adapt to climate change.

Connected to the Emergency Act, four regional crisis committees have been formed to regulate crises at the regional level – the Eastern, Southern, Western and Northern Estonian Crisis Committees. These crisis committees are advised by the Rescue Board. It is also the duty of the Rescue Board to ensure cooperation between executive state authorities and local government units at the regional level in the organisation of crisis management. The municipality or city government forms the permanent crisis committee of the municipality operating in the territory of the local government. A municipality or city government can form a joint crisis committee with one or more local government units. The crisis committee unit coordinates crisis management in the local government unit, the duties and work procedures of the crisis committee are set out in the statute, which is established by the municipality or city government and which is coordinated by the Rescue Board. (Emergency Act, 2017)

The general goal of KOHAK emphasises that, in addition to the national level, the local and regional level play an important role in adapting to climate change. The MoE cooperates with the Association of Estonian Cities and Municipalities (AECM) to promote climate issues, e.g. cooperation in the local government's round tables and in environmental working groups of minuomavalitsus.ee. Various support measures have been initiated to promote climate and energy topics in local governments (for the preparation of local government climate and energy plans) with the aim of contributing to the conceptualisation, setting and achievement of climate and energy goals at the local level. (MoE, 2022b)

The Green Tiger, a multidisciplinary cooperation platform whose purpose is to create, teach and implement a balanced economic model, is also helpful in improving the cooperation between the state, local governments and local communities. Green Tiger's mission is to create and implement environmentally friendly practices in all sectors and develop a balanced economy. Green Tiger initiates and contributes to generating innovations inside companies and in society more broadly by involving entrepreneurs, individuals, the public sector and the civic sector. Green Tiger gathers knowledge and skills from companies and researchers and maps regulations that prevent companies, municipalities and organisations from operating in an environmentally friendly manner and offers input and suggestions for policy making. By the beginning of 2022, more than 60 companies have already joined Green Tiger. Companies and organisations (including local governments) had the opportunity to participate in the Green Tiger Academy, where companies map their current situation and, in cooperation with experts and mentors, develop a plan to reduce their organisation's environmental impact. (Green Tiger, 2022)

In 2021, with the help of Green Tiger, Estonia's first Climate Assembly for the youth of Ida-Virumaa was held. The format of the Climate Assembly, i.e. the people's assembly on environmental issues, is intended for making complex and long-term climate-related environmental decisions. The Climate Assembly is made up of participants summoned on the basis of a random sample, who form a so-called mini-public. After listening to experts and related interest groups, the Climate Assembly makes informed and considered decisions on a given topic. In 2022, a larger climate meeting was held in the city of Tartu. (Green Tiger, 2022)

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7 Financial, technological and capacity-building support

Key developments:

- During the period of 2019–2020, Estonia has channelled EUR 2 million from the revenues of the auctioning of EU ETS (Emissions Trading System) allowances for financing international climate cooperation by supporting the environmentally sustainable development of partner countries, through contributing to bilateral projects.
- From 2018 June, Estonia opened its first annual round of project calls to support climate cooperation projects in developing countries. Through the project calls different mitigation- and adaptation-oriented projects are supported while taking into account the needs of the destination country. Estonia is seeking to mobilise private finance through the annual project calls as applicants are required to contribute financially at least 10% of total eligible costs of the project.
- At COP26 Estonia announced a voluntary contribution of EUR 1 million to the Least Developed Countries Fund.

7.1. General overview of climate finance policy and transfer of technology and capacity-building

Estonia is not one of the Parties listed in Annex II to the Climate Convention; consequently, Estonia is not obliged to fulfil the commitments under Articles 4.3, 4.4 and 4.5 of the Convention. Despite this, Estonia has contributed to climate finance voluntarily.

The Government of Estonia is committed to fighting against global climate change, focusing especially on the situation in countries which are most affected by climate change, such as the Least Developed Countries and the Small Island Developing States.

Estonia recognises that the need for financing to reach the climate policy objectives is one of many important elements that need to be tackled continuously. Both public and private funding should support investments into programmes and policies aimed at reducing emissions and increasing resilience to climate change.

As stipulated by the Government of the Republic Act (Government of the Republic Act, 1995), the Ministry of Foreign Affairs (MFA) is responsible for administration of the provision of international development assistance. As a result of the development cooperation reform in 2021, the implementation and administration of development cooperation projects was transferred to the Estonian Centre for International Development on 1 January 2022, while the Ministry of Foreign Affairs continues to be responsible for planning the foreign policy for development cooperation (Terms and conditions of and procedure for the provision of development and humanitarian aid, 2021; MFA, 2022).

Estonia's foreign policy goal in development cooperation and humanitarian aid is to contribute to global security and sustainable development, in accordance with globally agreed Sustainable Development Goals and the priorities of the international partnership of the European Union (MFA, 2022). To achieve the Sustainable Development Goals, the sustainable use of the environment and natural resources is indispensable. Therefore, green transformation is one of the horizontal priorities of the development cooperation (MFA, 2022) to contribute to achieving Sustainable Development Goal 13 – Take urgent action to combat climate change and its impacts (UN General Assembly, 2015) that suggests strengthening resilience and adaptive capacity to climate-related hazards and natural disasters in all countries, integrating climate change measures into national strategies, improving awareness of climate change mitigation and adaptation, increasing relevant institutional capacity and support, and, above all, taking action in the Least Developed Countries by increasing climate change capacity. Cooperation on climate action is designed and implemented in cooperation with other relevant institutions, including the Ministry of the Environment (MoE) and others.

Estonia aims to develop environmentally sustainable solutions in partner countries as well as at the global level, through research and innovation projects which address energy issues (storage, efficiency) but also environmental awareness and forest management. In addition, Estonia's development cooperation addresses digitalisation issues which will also enable the partner countries to better address climate challenges. Estonia's development policy supports low-carbon and sustainable development.

Continuous efforts should be made to find more synergy with investments made in sectors with a high impact on climate change, such as energy, transport, and housing.

Estonia has decided to proceed with funding the needs of developing countries when supporting climate action and wants to continue with this principle in the future as well. Estonia aims to support all actions related to climate change mitigation and adaptation in developing countries, for example by supporting the development of renewable energy sources, energy- and resource-efficiency projects in the transport sector and industry, as well as by strengthening administrative capacity regarding climate action or supporting solutions climate change adaptation.

During the reporting period for the National Communication, in 2018 the MoE adopted a regulation (Terms and conditions of and procedure for providing support for achieving climate policy goals in developing countries, 2019) aiming to support developing country cooperation and stipulating specific rules for international climate cooperation. This regulation was developed in cooperation with various ministries to ensure that the use of resources will be conducted in a coordinated manner. Support will be provided in two ways: firstly, through international cooperation, and, secondly, through open project calls. The main aim of the regulation is to support both mitigation- and adaptation-related actions in developing countries through annual project calls. The regulation does not stipulate any preferences between adaptation and mitigation projects, but instead the needs of the destination country will be considered when choosing the projects for financing. For example, the needs of destination countries are identified from the countries of destination NDCs (Nationally Determined Contributions). During project evaluation, the description of the situation in the country of destination is reviewed, and the suitability of the project in the country of destination and compliance with the needs in the country of destination are assessed.

Gender equality is an important element when evaluating the project applications; there is a requirement in the evaluation of open round projects that no project should undermine gender equality.

7.1.1. Methodological approach for tracking the provision of financial, technological and capacity-building support to non-Annex I Parties

Estonia defines climate finance as finance provided for climate adaptation and mitigation purposes. Most of the multilateral and bilateral climate-related financial support provided to developing country Parties during the period of 2019–2020 was channelled through the Official Development Assistance (ODA) in accordance with the OECD DAC methodology. Estonia gathers all provided ODA in an Estonian Development Co-operation Database (AKTA). As the source of Estonian climate funding to developing countries is the ODA, all information on disbursed and committed climate finance through public interventions is gathered in the same database.

In addition, the Environmental Investment Centre (EIC) is contracted to carry out, monitor and supervise the annual round of project calls to support climate cooperation projects in developing countries. The EIC serves the same responsibility for most of the foreign and local funds dedicated to environmental projects in Estonia (Estonian Environmental Investment Centre, 2022a).

In Estonia all ODA is disbursed as grants. Estonia used Rio markers developed for the OECD Development Assistance Committee's Creditor Reporting System (OECD DAC CRS) to track adaptation- and mitigation-related finance based on the data provided in the CRS. The sector classification is performed based on OECD DAC.

The committed amount includes the funds allocated to certain activities ongoing in a year not necessarily signed in that year. The disbursed amount includes disbursements made (this means that all funds have been actually paid out to beneficiaries) that year. The OECD Imputed Multilateral Shares are used for determining climate-specific part of the core support.

7.2. Finance

The following section provides information on the total climate finance provided to developing countries via bi- or multilateral channels under bi- or multilateral agreements during 2019–2020.

At COP21 United Nations Climate Change Conference in Paris, a number of climate funding announcements were made by developed countries, including Estonia. Estonia pledged to contribute EUR 1 million annually until the year 2020 for financing international climate cooperation by supporting environmentally sustainable development in developing countries through contributing to bilateral projects, multilateral organisations and regional funds. (UNFCCC, 2015)

The climate-related measures designed to achieve different climate change-related objectives form a part of the State Budget Strategy, based on national objectives and the objectives of sectoral development plans. One of the measures in the State Budget Strategy 2022–2025 (State Budget Strategy 2022–2025, 2022) to be funded by the revenues from the greenhouse gas emissions allowance trading system in 2013–2020 is Estonia's contribution to international climate change cooperation. During the period of 2019–2020, Estonia has channelled EUR 2 million from the revenues of the auctioning of EU ETS (Emissions Trading System) allowances for financing international climate cooperation by supporting the environmentally sustainable development of partner countries, through contributing to bilateral projects.

Depending on specific decisions made in the context of the annual state budget process, it is possible that some additional amount might be committed to climate objective-related activities in the ODA target countries.

Please see **Table 7.1** for information on support provided in 2019–2020.

7.2.1. Financial contributions to multilateral institutions and programmes

According to the regulation aiming to support developing country cooperation and stipulating specific rules for international climate cooperation, international cooperation can also provide support to international climate funds, under a framework agreement or otherwise. Estonia supports different global programmes managed by multilateral organisations, including, among others, the UNCCD, UNEP, FAO, and IFAD. Estonia has also provided support to the operating entities of the financial mechanism of UNFCCC, and previously to the Green Climate Fund (GCF). The most recent announcement was made at COP26, where Estonia announced a voluntary contribution of EUR 1 million to the Least Developed Countries Fund (operated by the Global Environment Facility (GEF)) (Global Environment Facility, 2022).

7.2.2. Bilateral and Regional Financial Contributions

During the period of 2019–2020 Estonia has had two open project calls to support climate cooperation projects in developing countries. Through the project calls Estonia aims to support different mitigation- and adaptation-oriented projects and consider the needs of the destination countries. During this period Estonia has supported climate action in the following countries: Algeria, Bangladesh, Burkina Faso, Costa Rica, Georgia, Grenada, Kenya, Myanmar, Republic of South Africa, and Uzbekistan.

In the reporting period EUR 0.46 million was disbursed through the open project calls. Of the total bilateral climate finance provided during the period 2019–2020 EUR 84,232 was marked for mitigation, EUR 36,277 for adaptation, and EUR 691,696 as cross-cutting.

7.2.3. Private financial flows leveraged by bilateral climate finance towards mitigation and adaptation activities in non-Annex I Parties

As previously mentioned, Estonian MoE adopted a regulation (Terms and conditions of and procedure for providing support for achieving climate policy goals in developing countries, 2019) in June 2018 aiming to support developing country cooperation and stipulating specific rules for international climate cooperation. Through the open round project calls, applicants are required to contribute financially at least 10% of the total eligible costs of the project. In this way Estonia is seeking to mobilise private finance and plans to do so in the future.

Table 7.1. Provision of public financial support: summary information 2019–2020, EUR

Allocation channels	2019					2020				
	European euro – EUR					European euro – EUR				
	Core/general	Climate-specific				Core/general	Climate-specific			
		Mitigation	Adaptation	Cross-cutting	Other		Mitigation	Adaptation	Cross-cutting	Other
Total contributions through multilateral channels:	276,157.92	88,759.00	-	10,945.00	-	154,401.89	88,759.00	-	139,053.15	-
Multilateral climate change funds	-	-	-	-	-	-	-	-	-	-
Other multilateral climate change funds	-	88,759.00	-	-	-	-	88,759.00	-	-	-
Multilateral financial institutions, including regional development banks[a]	45,000.00	-	-	-	-	28,350.00	-	-	16,650.00	-
Specialised United Nations bodies[a]	208,171.79	-	-	10,945.00	-	107,581.27	-	-	122,403.15	-
Other[b]	22,986.13	-	-	-	-	18,470.62	-	-	-	-
Total contributions through bilateral, regional and other channels	-	84,232.00	20,154.00	327,673.03	-	-	-	16,123.00	364,022.57	-
Total climate-specific finance		531,763.03					607,957.72			

[a] In 2020 the latest OECD Imputed Multilateral Shares were used for determining the climate-specific part of the core support

[b] Under the section Other, contributions to those multilateral institutions are presented that do not fall under other categorisation, incl. contribution to IUCN, CITES, IRENA, IPBES.

7.3. Technology development and transfer and capacity-building

Technology transfer and/or capacity-building is always an essential component of any bilateral project. The contribution to the transfer of technologies is, for example, embedded in climate finance projects with a technology dimension.

The annual open project proposals consider, among other activities, support for example for renewable energy production, energy conservation, energy storage, and waste-handling technologies, but also increasing capacity and capability pursuant to Article 11 of the Paris Agreement (for example, in applying adaptation and alleviation activities, promoting the development, distribution and adoption of technology, simplifying access to climate financing, promoting relevant aspects relating to education, training and public awareness) (Estonian Environmental Investment Centre, 2022b). Therefore, capacity-building and technology development and transfer form a component of a larger project, and thus financial support provided for these activities is covered under the financial support paragraph.

Please see some examples of activities related to technology development and transfer in Table 7.2.

Table 7.2. Examples of activities related to Technology development and transfer

Project/programme title: Use of moisture and nutrient encapsulating igneous composites in crop production and restoration of ecosystems in arid areas			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Kenya	Agriculture	217,556.00[1]	2020–2023
Purpose and Description: The proposed methodology makes it possible to create new materials for plant cultivation improvement in semi-desert soil that retains the necessary moisture for the plant. Nutrients are tied up for up to a year, during which fast-growing plants (herbaceous, shrubby and woody plants) can develop a root system that is already capable of receiving water from a sufficiently deep depth. Such technology can be used to re-green or reforest desertified areas and create a sustainable self-regulating ecosystem for additional flora and fauna.			
Factors that led to project/programme's success: Project is still ongoing and therefore no information is yet available.			
Technology transferred: moisture and nutrient encapsulating igneous composites			
Impact on greenhouse gas emissions/removals (optional): Project is still ongoing and therefore no information is yet available.			
Project/programme title: Renewable energy closed-system hygiene module for use in areas with limited water resources			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Burkina Faso	Water and Sanitation	180,350.00[1]	2020–2022
Purpose and Description: ClearLife OÜ wants to alleviate the water shortage problem in Burkina Faso by developing a shower system with a closed system powered by renewable energy, where water is in constant circulation. The sustainable use of water resources is important in areas where droughts are a major problem.			
Factors that led to project/programme's success: Project is still ongoing and therefore no information is yet available.			
Technology transferred: renewable energy			
Impact on greenhouse gas emissions/removals (optional): Project is still ongoing and therefore no information is yet available.			

[1] Support allocated to the projects through the open call for proposals will be paid to the supported projects during the project, which can take place over several years.

Please see an example related to capacity-building in **Table 7.3**.

Table 7.3. Examples of activities related to capacity-building

Recipient country	Programme or project title	Description of project
Georgia	Reducing the impact of climate change through better prevention and response to forest fires in the Borjomi region of Georgia	The Rescue Association received a grant to share and implement the experiences of Estonian volunteer rescuers with its partner in the Borjom region of Georgia. The extreme weather conditions of recent years have caused extensive forest fires there, which in turn reduces the natural biodiversity and is a threat to the inhabitants and visitors of this beautiful place. The Rescue Association helps train local rescuers and equip them with the necessary equipment. In this way, forest fires on the ground can be brought to an end in good time and major natural disasters can be prevented.

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8. Research and systematic observation

Key developments:

- Percentage of research and development expenses from the gross domestic product increases again since 2017, following deep recession in 2013–2016.
- Share of foreign funding, which achieved its peak in recession years (2016–2017), has decreased again to the earlier level.
- In recent years the research funding from the private sector achieved 50% of the total.
- Systematic monitoring gets more versatile and more integrated with research.

8.1. General policy on research and systematic observation

Research and development (R&D) includes activities which may be related to entrepreneurial or governmental innovation. R&D is the first stage in the development of a new product or service. It includes fundamental and applied research as well as experimental and development activities which may partially coincide. R&D also includes innovative activities related to the production and marketing of the results. The basic structures of Estonian research have remained as reported in Estonia's Seventh National Communication (UNFCCC, 2017).

The organisational structure of Estonian R&D activities is represented in **Figure 8.1**. Decisions related to Estonia's R&D policies are made by the Riigikogu (parliament) on the basis of regulations and legal acts drafted by the Government of the Republic. The basis for the organisation of R&D is established with the Organisation of Research and Development Act (1997). The government is advised in its activities by the Research and Development Council that advises the government on the research and development strategy, thereby directing the development of the national R&D and innovation system. The Ministry of Education and Research (MoER) is responsible for the planning, coordination, execution and monitoring of education and research policies; it also organises the evaluation of R&D institutions (Ministry of Education and Research, 2022). In addition to R&D institutions and ministries, the MoER also cooperates with the Estonian Academy of Sciences and the Estonian Research Council (2022) in the field of R&D. The Minister of Education and Research is advised by the Research Policy Committee on matters of strategic development plans for Estonia's R&D and the development of Estonia's research policy (Ministry of Education and Research, 2022).

Currently, R&D in Estonia is based on the Estonian Research and Development, Innovation and Entrepreneurship Strategy 2021–2035 (RDIE strategy) adopted in July 2021. The focus of the strategy is to ensure synergies between the research system, the business environment and other systems in the society, keeping in mind society's overall resilience and ability to adapt to crisis situations and global changes. This focus addresses a certain problem stated in the RDIE Strategy: the connection between academic research institutions and the business sector has been relatively weak and Estonian enterprises' capability to adapt and adopt new business models, knowledge and technologies needs to grow. Business environment services lack sufficient automation and innovative solutions (artificial intelligence, real-time services). In response, the RDIE strategy states the goal of creating a business environment that would retain and attract capable entrepreneurs, investments and talents, would favour export of products and services with high added value, and support Estonian entrepreneurship, especially the growth of industrial competitiveness, including the increase in value chains, and the goals of sustainable development. On the other hand, uncertain, project-based funding of research teams results in uncertain career paths for researchers and hampers the emergence of new generations of researchers and engineers. To overcome this shortage, the RDIE strategy states maintaining the funding for R&D from national budget at a level of 1% of GDP since 2021. (Estonian Research and Development, Innovation and Entrepreneurship Strategy 2021-2035, 2021)

R&D is financed within the system of the MoER of the Republic of Estonia from the state budget and EU support, as shown in **Figure 8.2**. The strategy Eesti 2035 (2022) states the goals of the development of the R&D sector: supporting the development of a stable academic career model, completing the doctoral education reform to foster scientists and engineers in Estonian society, creating incentives for research institutions and researchers to take a leading role in international cooperation networks, widening the availability of scientific results, capacity building for knowledge transfer of research and higher education institutions, encouraging the mobility of researchers between universities, companies and the public sector and the implementation of research and development capacity in Estonia to solve the important development needs.

The share of R&D activities in GDP has been increasing since 2018, whereas funding from the private sector is increasing more rapidly than from the public sector and exceeding it in recent years (Figure 8.3). In the 2021 state budget the share of public R&D funding reached 1% of GDP for the first time after 2013. The peak in private funding in 2011–2012 occurred due to the construction of a new shale oil plant that started to operate in 2013 (UNFCCC, 2017). The public investments into the R&D sector are above the average of EU (8th position among EU countries), but private investments are roughly 1.5 times smaller (Eesti Teadusagentuur, 2022). Thus, for achieving the 3% goal, activation of the private sector is urgently needed. The share of foreign funding was 15% in 2017, when the funding in general was low. By 2020 the share decreased to 12%. The same percentage was usual before 2016, when the total funding of research was at nearly same level.

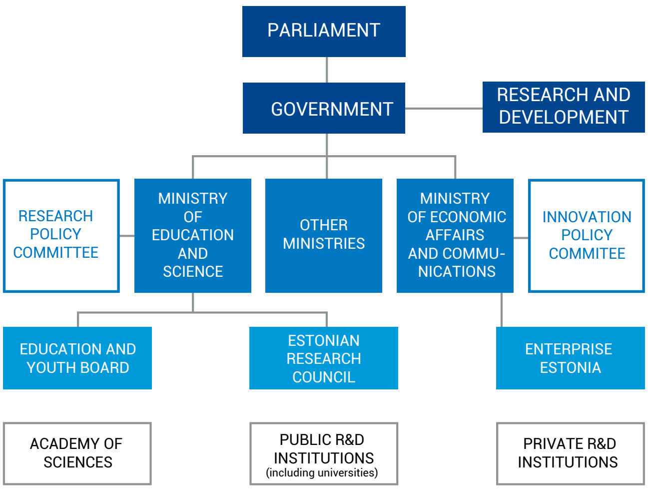

Figure 8.1. The organisational structure of Estonian R&D (Research in Estonia, 2022)

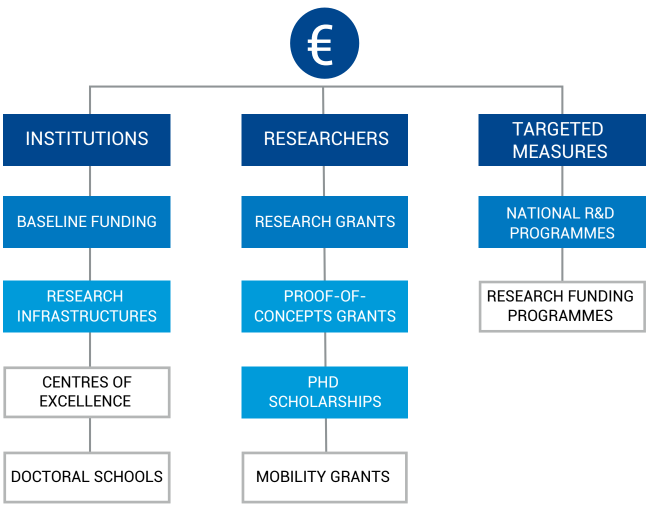

Figure 8.2. The structure of public funding of Estonian R&D (Research in Estonia, 2022)

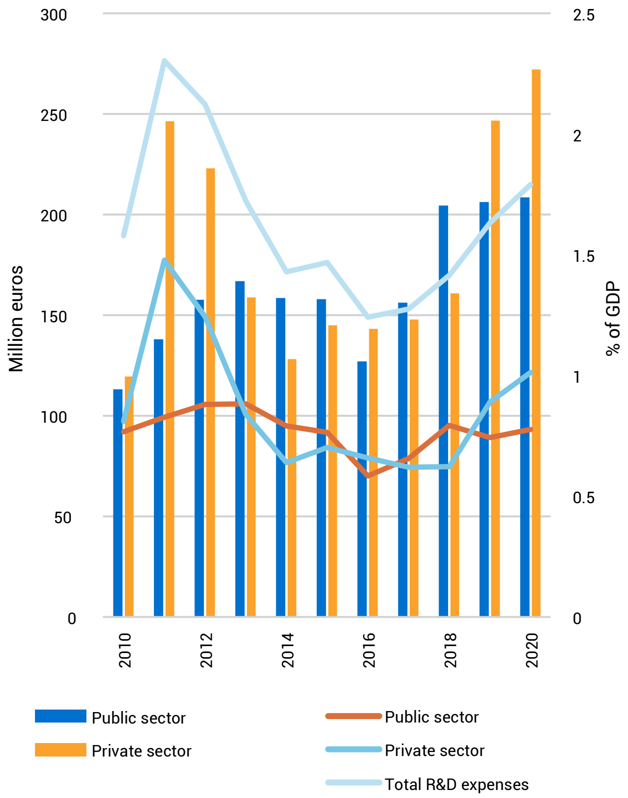

Figure 8.3. Research and Development Expenses (Eesti Teadusagentuur, 2022)

8.1.1. Research and Development programmes and funding of research and systematic observations

There are several factors for the success of Estonian researchers in the framework programmes, mainly their strong level of expertise and high reliability in the eyes of foreign partners, readiness to write competitive projects, desire to cooperate with foreign partners and a well-functioning support system for framework programmes. Although increasing foreign research funding is one of the objectives of the Estonian research policy, it is difficult to achieve fast growth, as our researchers are already extensively included in international cooperation.

The main instruments of the Estonian R&D funding system are baseline funding for research institutions, personal research grants (PRG) for a senior scientist with a work group and starting grants (SG) for an early career researcher to start his or her independent research and form a work group. The Mobilitas Pluss programme finances, among others, returning of researchers to Estonia after completing post-doctoral or comparable research abroad. The Dora Pluss programme finances Estonian master's and PhD students' studies and research abroad and foreign students' master's and doctoral studies and research in Estonia (ETAG, 2022).

Inter-sectoral mobility measure (SekMo, 2021–2023) is for temporary (3–48 months) employment of researchers with a Ph.D. or master's degree and a previous academic career in enterprises and the public sector for applied research and product development projects, with the aim of enhancing the research potential in private and public sector and mobility between sectors.

Interreg Baltic Sea Region is a joint research programme of the Baltic Sea Region. The objective of its project, the Baltic Science Network (BSN) is to provide ministries handling the research issues of the Baltic Sea region with a coordinating framework for developing research policies. This should enable the introduction of macro-regional interests to the wider public. In addition to strengthening macro-regional ties, the BSN project also helps to develop international strategies and action plans with the goal of facilitating the development of higher education, R&D and innovation as well as increasing top-level research in all countries and the Baltic Sea region in general. The project partners are Estonia, Latvia, Lithuania, Poland, Germany, Denmark, Sweden, Finland and several international organisations and associations of universities. The current project period is from 2021 to 2027.

RITA is a programme supported by the European Regional Development Fund with the goal of increasing the state's role in the strategic steering of research and the capability of R&D institutions in executing societally significant research. Through the programme, the Estonian

Research Council finances applied research projects with socio-economic objectives that fulfil state needs. The RITA programme is used to finance strategic R&D activities that help to execute interdisciplinary applied research with socio-economic objectives of state-level significance. One of the programme's objectives is the development of more efficient, environmentally friendly and sustainable usage options of the natural resources. RITA was started in 2015 and currently is planned to last until end of 2023.

ResTA resource valorisation programme supports business-oriented R&D in the valorisation of wood, food and minerals. The aim of the programme is to foster competence of research teams, growth of sectoral specialists and development cooperation between companies and research institutions. Research under the ResTA programme, with a budget of € 10.8 million, is due to end in August 2023, but a similar resource enhancement programme is planned to continue after that.

NUTIKAS support aims to contribute to growth in the research-intensity of the Estonian economy, supporting collaboration between R&D institutions and companies. The duration of supported projects is up to three years. Supported projects must be finished by August 31, 2022 at the latest.

The **Environmental Investment Centre** (EIC) is a public grant mediator, distributing state budget funds (revenues from environmental charges), EU Cohesion Fund, European Economic Area, European Regional Development Fund, EU emission trade system, LIFE programme, Recovery and Resilience Facility, as well as granting loans for the implementation of environmental projects. The EIC's main activity is the mediation of the following financial resources for financing environmental projects:

- revenues from Estonian environmental charges (the environmental programme);
- support from the EU's Cohesion Fund, the European Regional Development Fund and the European Social Fund;
- support for the EU emissions trading system (EU ETS);
- granting loans from the resources of received environmental charges or credit lines.

In 2017–2022, Estonia received around 759 million euros for the support of 12,164 different projects. Climate research and analysis is executed within the framework of the ambient air sub-programme. In 2017–2022, 110 projects for the protection of ambient air were financed in the amount of 7 million euros (EIC, 2022). A detailed overview of project funding in developing countries by EIC is given in Chapter 7.

8.1.2. International activity

Estonia participates in several European and worldwide research and environmental monitoring programmes, which are important for fulfilling the commitments made in international treaties and for the development of open science. Since the 1990s international R&D cooperation has developed and multiplied rapidly.

The weather service of the **Estonian Environmental Agency** (2022b) fulfils the obligations of an Estonian national meteorological service in accordance with its standard and the recommended practices of the World Meteorological Organisation (WMO). The ESTEA's weather service participates in the WMO's climate programme, incl. the Global Climate Observing System (GCOS). ESTEA is the Estonian contact of the Intergovernmental Panel of Climate Change (IPCC).

The **Tartu-Tõravere station** is included in the Baseline Surface Radiation Network (BSRN) from 1999. Through the BSRN network, the data from the station are used by the World Climate Research Programme (WCRP), the Global Energy and Water Exchange Project (GEWEX), the GCOS and the Global Atmospheric Watch (GAW). (WRMC, 2022)

The **Copernicus programme** is an extensive environmental and safety monitoring programme initiated by the EU in cooperation with the European Space Agency and other partners. Within the framework of the programme, six Sentinel-series mission satellites are put to work and the corresponding databases are created. To ensure the stable and seamless treatment of all data necessary for the creation of operative services, Estonia, in agreement between European Space Agency and Enterprise Estonia (2016), has created the ESTHub data centre in the area of administration of the Land Board. ESTHub gathers Sentinel and Landsat 8 data for the Estonian area of interest and provides a fast download service. (Land Board, 2022)

Estonia is a member of the international **Group on Earth Observations** (GEO, 2022). The objective of the GEO is to create a Global Earth Observation System of System (GEOSS) for ensuring the sustainable development of humankind to improve the health and safety of humanity and to protect the global environment. It is therefore necessary to systematically understand the changing nature of the Earth's climate, oceans, land and ecosystems as well as to know how to evaluate the effect of anthropogenic as well as natural factors on humankind. The collection and analysis of such data are however only possible through international cooperation, as the data need to be collected for the entire Earth, must comply with specific quality requirements, and must be comparable. Estonia's participation in the GEO's activities is coordinated by the MoER and the Ministry of the Environment.

Estonian Environmental Observatory (EEO, 2022) is an integrated network of experimental environment stations of Estonian research institutions, which covers three areas of environmental studies:

- atmosphere, climate and Earth studies;
- biodiversity studies;
- marine and lake studies.

8.2. Research

Research related to climate change is carried out in Estonia by a number of universities and governmental and non-governmental institutions, including Tallinn University Institute of Ecology, the Estonian Nature Fund, Institute of Ecology and Earth Sciences of University of Tartu, Institute of Physics of University of Tartu, Marine Institute of the University of Tartu, Institute of Agricultural and Environmental Sciences of Estonian University of Life Sciences, Department of Cybernetics of Tallinn University of Technology, Tartu Observatory of the University of Tartu, Department of Marine Systems of Tallinn University of Technology, Department of Energy Technology of Tallinn University of Technology, Department of Geology of Tallinn University of Technology, Institute of Ecology of Tallinn University, Estonian Environmental Research Centre (EERC) and ESTEA.

The main information source on research projects in this chapter is the Estonian Research Information System (ETIS) (2022b). Information about Estonian researchers and their articles (incl. the opportunity to order the articles) is available at the online catalogue ESTER of Estonian libraries (ESTER, 2022), and through the international ResearchGate (2022). The project descriptions in this chapter originate from project´s profile in ETIS, if not indicated otherwise.

In recent years various research institutions have carried out numerous and increasing amounts of R&D projects. In the next sub-chapters the most important projects are listed by aspects of climate relevance.

8.2.1. Climate process and climate system studies, including paleoclimate studies

The Institute of Ecology of the Tallinn University is an R&D institution with the objective of researching the impact of changes in climate conditions and the hydrodynamics of coastal waters on the development of different types of beaches; preparing forecasts for beach development models and for changes of coastal zones; analysing the condition and development of wetland ecosystems and the factors affecting them; above all researching the impact of disturbances on the structure, functioning and nutrient cycles of wetland ecosystems; developing research methods for and the scientific principles of the ecological restoration of wetlands; evaluating the temporal-spatial impact of natural and anthropogenic processes on the condition of ecosystems; developing paleoecological research methods; and modelling ecosystem development scenarios.

In 2014–2019 the institute carried out the project **Environmental Changes and Their Effects on the Coastal Landscape of Estonia: Past, Present and Future – ENCHANTED.** The main goal of the project was to identify temporal changes in the frequency of storms by using ecological, sedimentological and geomorphological data, and to evaluate the impact of such changes on the evolution, vegetation and land use of beaches in Estonia during the past millennia.

In 2021–2026 the Estonian Fund of Nature shall carry out the Horizon 2020 project **Water-based solutions for carbon storage, people and wilderness** – **WaterLANDS**. The aim of this project is to investigate the combination of factors which will permit the upscaling of wetland restoration across Europe. The project will be directed by the need to engage with multiple stakeholders to fully understand their needs and then to identify the governance structures and financing required to support these goals. To provide for this engagement, the project will examine the range of ecosystem services that wetlands currently provide, and what they could potentially provide, and the spatial and social distribution of these services. To understand the costs and practicalities of this, the project will also examine the combination of the ecological and hydrological conditions needed to upscale the restoration of a range of wetland types across Europe, drawing on existing experience to explore novel approaches that provide the capacity to sustain environmental conditions and maintain resilience in the context of climate change.

In 2021–2023 the Institute of Ecology and Earth Sciences of University of Tartu shall carry out the project **Assessment of emissions and carbon stock dynamics in Estonian drained organic forest soils in the national greenhouse gas inventory.** The aim of the study is to develop country-specific emission factors of greenhouse gases suitable for Estonian conditions for the assessment of greenhouse gas emissions from decomposed peat soils formed on the basis of drained transitional bog (coniferous: spruce, pine) and bog (pine).

In 2020–2024, an infrastructure development project, **Estonian Environmental Observatory**, will be carried out jointly by the University of Tartu (led by the Institute of Physics) and Institute of Agricultural and Environmental Sciences of Estonian University of Life Sciences, funded by the Core Infrastructure programme. New stage funding, following the respective Roadmap of Estonian Research Infrastructure project (2010–2015), includes infrastructure developments at the SMEAR station, geoinformatic laboratories in Tallinn and Tartu, water ecosystem research stations in Keri, Kõiguste and Võrtsjärv and the land ecosystem stations Jõhvi, Puhtu-Laelatu and Kilingi-Nõmme.

Station for Measuring Ecosystem-Atmosphere Relations (SMEAR) at Järvselja has been operated jointly since 2016 by the Estonian University of Life Sciences and University of Tartu and includes a 130-metre-tall mast for gas and energy flux measurements in and above the forest canopy. The measurement programme is harmonised with SMEAR stations in Finland. The SMEAR station belongs to the Estonian Environmental Observatory (EEO). Other atmosphere-biosphere interaction monitoring stations in EEO are Rõka experimental station (microclimate manipulation experiments with trees), Soontaga and Palojärve forest stations, operated by University of Tartu, Institute of Ecology and Earth Sciences.

In 2020–2024 the Institute of Physics, University of Tartu shall carry out the project **Molecular-level understanding on how atmosphere transforms the new-born air ions to climatically relevant aerosol particles in clean and polluted environments** (research team grant). It is investigated and measured how the corresponding processes, especially the oxidation of organic compounds, impact on ions and, in return, how ions and ionization impact on oxidation in the atmosphere. Through using these results an advanced evolution model of atmospheric ions and nanoparticles is developed that can progress our knowledge of ion-related processes. The research is supported by the corporately developed SMEAR station at **Järvselja, which is a part of Estonian Research Infrastructures Roadmap project "Estonian Environmental Observatory".**

8.2.2. Modelling and prediction, including general circulation models

In 2016–2018, the Department of Cybernetics of Tallinn University of Technology carried out the project **The impact of EXtreme events of future climates on the marine ecOSYSTEM in the Baltic and Barents Sea**. The goal is to examine the impact of climate change on the frequency and severity of marine extreme events such as algal blooms, floods, wind waves, currents, current-driven transport, upwellings and water levels. The focus regions are the Gulf of Finland and the Barents Sea. The estimates of the extreme events were provided using high-resolution models both in global and regional simulations.

In 2019–2022 the Institute of Physics of the University of Tartu has carried out the project **Pollution tracks in clouds help to understand anthropogenic impacts on Earth's climate** (personal research funding). To reduce the uncertainty in the aerosol forcing of Earth's climate, improved observational constraints on cloud responses to aerosols are derived using dedicated satellite observations. There is evidence that the common assumption that cloud water increases in response to aerosols in climate models is unrealistic and leads to overly negative aerosol forcing. To improve this, cloud perturbations induced by aerosols originating from various industrial sources, wildfires and volcanoes are analysed. Impacts of megacities and larger industrial regions on clouds are studied together with local-scale perturbations induced by isolated factories. The project's results will help to reduce uncertainty in anthropogenic climate forcing and increase the reliability of the projections of future climate.

8.2.3. Research on the impacts of climate change

The **EcolChange Centre of Excellence** (Estonian University of Life Sciences and Institute of Ecology and Earth Sciences of University of Tartu, 2016–2023) is a synergistic network of expertise for developing global and local scenarios for terrestrial ecosystems in the context of global change, from molecular to biome-level responses (EcolChange, 2022).

The main research areas are:
- integrated studies of ecosystem functions, biodiversity and adaptability;
- integration of macroecological big data with genetic research and experimental approaches;
- incorporation of ecological knowledge into the principles of adaptation to global change through sustainable ecosystem management;
- enhancement of ecologically sustainable economic growth via smart regional planning in forestry and agriculture: functionally diverse forests, cultivars for future climates, novel cereals and sustainable nutrient cycles.

In 2015–2018, the Tartu Observatory of the University of Tartu carried out the project **Aerosols and greenhouse gases' contribution to the climate change in the Baltic Sea region and in the Arctic**. This project targeted climate change in the Baltic Sea region and in the Arctic. The purpose of this project was to detect causation between the temporal variability of temperature, the atmosphere's energy budget components, aerosols and GHGs. For the analyses, atmospheric reanalysis models BaltAn65+ and ERA-Interim and aerosols model SILAM were applied. The modelled products were validated against measurement data (radiosondes, radiation meters, AERONET sunphotometer).

In 2013–2018, the Marine Institute of the University of Tartu carried out the project **Coastal ecosystems and rapid change: understanding and projecting effects of multiple stressors on marine biodiversity and functioning** with the purpose of developing models that can forecast the developments in ecosystems and consider long-term climate change and significant anthropogenic pressures, such as eutrophication.

In 2013–2018, the Institute of Ecology and Earth Sciences of University of Tartu carried out the project **Global Warming and Material Cycling in Landscapes. Global Warming- and Human-Induced Changes of Landscape Structure and Functions: Modelling and Ecotechnological Regulation of Material Fluxes in Landscapes**, focused on the spatio-temporal dynamics of the Estonian landscapes and related changes in material cycling caused by natural and anthropogenic factors.

In 2017–2020, the same institute carried out the project Future marine climate and ecological risks in the Baltic Sea with the aim of studying extratropical cyclones of future climates, the combined effect of sea level rise and its acceleration, and storm surges in the Baltic Sea during the 21st century and future manifestations of storm-induced oceanic climate-related and ecological risks in the Baltic Sea.

In 2014–2019, the Institute of Physics of the University of Tartu (the Laboratories of Environmental Physics and Atmospheric Physics) carried out the project **Airborne nanoparticles and their role in meteorological processes**. By developing the experimental basis and theory of nanoparticle formation and growth, advanced physical and optical models of aerosols and cloud particles were developed. The models were applied to compose new radiative transfer blocks for numerical weather and climate models and applied in national (KESTA) and international (MACC) weather and climate programmes. The research is supported by the Estonian Science Infrastructure Roadmap Project *Estonian Environmental Observatory*, which includes the implementation of the SMEAR measure.

In 2016–2019, the Department of Geography of the Institute of Ecology and Earth Sciences of the University of Tartu started the Water Joint Programming Initiative (JPI) Water project **Improving Drought and Flood Early Warning, Forecasting and Mitigation using real-time hydroclimatic indicators**. The main objective of the project was to apply the knowledge gained from the project (based on fundamental research) and develop information tools built on server-based technologies that are needed for the management of the flood and drought risk. This was done in close cooperation with stakeholders and end users to ensure the diligent commissioning of the new products. Spain, Portugal, South-Africa and Romania also took part in the project.

In 2020–2022, the Institute of Agricultural and Environmental Sciences of the Estonian University of Life Sciences carried out the project **Vulnerability by biotic stress and diagnostics of field crops under changing climate conditions for Northern Europe**.

8.2.4. Socio-economic analysis, including analysis of both the impacts of climate change and response options

The aim of the **SustainBaltic** project (Estonian University of Life Sciences & University of Turku, Finland, 2016–2018) was to prepare spatial development plans for coastal areas that would combine the preservation of the natural environment with the need to develop the social and economic environment based on human needs in a harmonious way, and to ensure a smooth and well-planned use of the space between coastal and marine areas.

In 2022–2023 the Tallinn University of Technology shall carry out the project Climate neutral district digital tool for energy and buildings solutions early stage planning. Its aim is to transform an industrial seaside neighbourhood in North Tallinn, known as Paljassaare Harbour, into a smart neighbourhood that is circular in design. It will be the first new major region built in the 21st century in Tallinn and the biggest climate-neutral district project in the Baltics planned for 16,000 inhabitants. The project will develop a digital tool intended for early stage district energy performance, CO_2 emissions and energy supply planning. The tool will enable the possibility to calculate hourly electricity and heat profiles of buildings which will serve as input for energy supply systems consisting of seawater heat pump plants for district heating and cooling, biogas fired cogeneration for electricity and district heat production, solar photovoltaic on-site and nearby electricity generation and an electricity storage system with batteries.

8.2.5. Research and development on mitigation and adaptation approaches, including technologies

In 2016–2021, Tallinn University carried out a joint project of five countries, **Life Peat Restore**, which is supported by the climate sub-programme of the EU's LIFE programme. Within the framework of the project, peatlands situated on the North European Plain that have been ruined by human activity are restored with the aim of reducing CO_2 emissions. The project partners included Germany's oldest nature protection organisation NABU, Poland's Ecological Club, Lithuanian Fund for Nature, the University of Latvia and Tallinn University. In addition to EU funds, the activities carried out in Estonia are also financed by the EIC and Tallinn University. During the project, a restoration plan was prepared and implemented. Comprehensive prior research of water, peat, vegetation, wild birds and carbon fluxes was conducted to ensure that correct decisions are made; follow-up monitoring will last for 20 years as of the end of the restoration works. Measuring carbon fluxes is important, as it proves whether peatlands capture carbon or not. The measuring methods used in different countries are calibrated for gaining more accurate results. Among the recent top achievements of Tallinn University of Technology, the new generation efficient solar panels, sustainable design of district heating and energy transition for climate-neutral construction industry are mentioned (TalTech, 2022a).

LIFE IP BuildEst (until 2028) is an R&D programme to support the energy-efficient renovation and climate-proofing of buildings. In this framework the Department of Marine Systems of Tallinn University of Technology shall carry out the project **Pursuing national climate ambition through renovation of Estonian building stock and developing its long-term resilience** in 2022–2023. Climate scenarios are analysed and the most suitable scenario for Estonia is selected and downscaled. Test years of standard environmental parameters are constructed according to climate scenarios.

In 2020 the LIFE-IP project **Comprehensive management of forest and farming landscapes to improve the conservation status of Natura 2000 habitats and species (ForEst&FarmLand)** was launched, involving all key players from universities, the forestry sector and nature conservation as well as NGOs to jointly protect and restore Estonian landscapes and ecosystems and to improve the condition of the species and habitats in Estonian forests and agricultural lands (ForEst&FarmLand, 2022). Key research partners of this project are the University of Tartu: the Landscape and Biodiversity Group and Centre of Applied Social Sciences (CASS). The project will continue until 2029.

In 2022, the Department of Energy Technology of Tallinn University of Technology carried out the project **Find more cost-effective solutions to use CO_2 captured from Enefit-280 plants as a raw material**, funded by Eesti Energia AS.

In 2017–2023, the Institute of Ecology and Earth Sciences of University of Tartu shall carry out the project **Water level restoration in cut-away peatlands: development of integrated monitoring methods and monitoring**, funded by State Forest Management Centre of Estonia. One of the aims is to find optimal solutions for restoring the carbon-binding capacity of cut-away bogs.

In 2020–2023, the Department of Geology of Tallinn University of Technology shall carry out the project **Evaluating Groundwater Resources and Groundwater-Surface-Water Interactions in the Context of Adapting to Climate Change**, funded by the International Atomic Energy Agency.

8.2.6. Research in support of the national greenhouse gas inventory

The MoE has initiated multi-year development contract with the EERC on the cross-sectoral project **Developing the reporting on greenhouse gases and ambient air pollutants**, to be carried out in 2020–2023 (Estonian Environmental Research Centre, 2022a). The progress in meeting GHG emission reduction targets is assessed based on the annual GHG inventory, which Estonia submits to both the European Commission and to the United Nations Framework Convention on Climate Change. When compiling GHG inventories, countries can use methodologies with different degrees of complexity (so-called Tier 1, Tier 2, Tier 3 methodologies) and specific emission factors used in calculations, which are either default values, country-specific, or company-specific. The activities of the abovementioned developments contribute to the further development of Estonian national GHG and air pollutant reporting as well as the development of country-specific methodologies in order to obtain as accurate as possible estimates of GHG and air pollutant emissions, based on which the ministries can design effective environmental and climate policies. The specific tasks of this project are listed in following sub-sections, referring to MoE-EERC developments.

Developments in the Waste sector
Tasks in the MoE-EERC project: **Control and analysis of the amounts of landfill gas burned in the landfill and reported in the Information System for Environmental Decisions (KOTKAS)** or in other sources (to be completed in 2023).

Developments in the Land use, land-use change and forestry (LULUCF) sector
Tasks in the MoE-EERC development work: **Analysis of changes in agricultural land use depending on future scenarios** (completed in 2022); A more accurate assessment of the dynamics of the carbon stock of Estonian agricultural soils in the national greenhouse gas inventory and; A more accurate assessment of the dynamics of emissions and carbon stocks of drained organic forest soils in Estonia in the national greenhouse gas inventory (to be completed in 2021–2023).

Also, a number of development projects are ongoing that contribute to LULUCF reporting.

Developments in the Energy sector
In 2017–2019, the Institute of Physics of the University of Tartu (the Laboratory of Atmospheric Physics) carried out a research project on the **geographic correlation of wind on AS Elering's power lines** with the purpose of determining the extent of the cooling effect of wind on high-voltage power lines to optimise the capacity of power lines in a situation where new wind turbines are continuously built in Western Estonia.

Tasks in MoE-EERC developments contract: Inventory of the spatial distribution of GHG and air pollutant emission sources of the energy sector, including the local heating sub-category, which also included inventory of the heating equipment used in the local heating sub-category (completed in 2020–2021); Control measurements of country-specific emission factors of households and large and medium combustion installations in the energy sector and update of databases for GHG and air pollutant reporting (to be completed in 2020–2023); Implementation of the Balmorel model in GHG emission projections (completed in 2020).

Developments in the Industrial Process sector
Tasks in the MoE-EERC developments contract: Update of specific emission factors for air pollutants in the industrial processes sector, specifically in asphalt paving subcategory (completed in 2020–2021); Reducing uncertainty in the

fluorinated greenhouse gas category of the industrial process sector (completed in 2020).

Developments in the Transport sector

Tasks in MoE-EERC developments contract: Update of specific emission factors for GHG and air pollutants in the transport sector for gas vehicles (completed in 2021); Integrated GHG and air pollutant transport projections model system, Review of road transport emission calculation principles and Review of road transport emission calculation principles (to be completed in 2020–2023); Review of calculation principles for emissions from other mobile emission sources (completed in 2020–2021).

Developments in the Agriculture sector

Tasks in MoE-EERC developments contract: Mapping Estonian manure management technologies and their impact (completed in 2020–2021); Survey of livestock feeding plans (completed in 2020–2022), Analysis for establishing the nitrogen balance system for Estonia (2021–2023) and GHG emissions assessment model for biogas production from agricultural resources (2021–2023). Development of a model for GHG emissions assessment of biogas production from agricultural resources, collection of initial data, development of country-specific emission factors (2020–2023): current options for calculating emissions from manure used for biogas production in Estonia are clarified.

8.3. Systematic observation

The national Environmental Monitoring Act which entered into force in 2017 establishes the organisation of environmental monitoring, the procedure for processing and keeping the retrieved data and the relationship between the executors of environmental monitoring and the owners or possessors of immovable property. Environmental monitoring is the continuous monitoring of the state of the environment and the factors affecting it, which includes environmental observations, collection, processing and storage of observation data, analysis of observation results and forecasting of changes. The prioritisation of the environment in society has increased the demand for environmental information, and the expectations on the quality and availability thereof. (Environmental Monitoring Act, 2017)

The area of activity of the **ESTEA** (Estonian Environmental Agency, 2022c) is the execution of the national environmental monitoring programme, the organisation of national and international environmental data exchange, the collection and analysis of data, provision of evaluations of environmental status and provision of weather forecasts, and warnings and necessary related monitoring data as a vital service. The ESTEA also ensures the working order of monitoring networks and the maintenance and renewal of monitoring stations, tools and devices.

In 2014–2022, the ESTEA (Estonian Environmental Agency, 2022a) carried out the project **Development of the monitoring of meteorological and hydrological indicators for evaluating or forecasting climate change** (SEME and SEME2). Within the framework of the project, hydrometeorological stations were improved and the necessary infrastructures were developed. In addition, the calibration laboratory of meteorological and hydrological sensors was renewed, and a new automatic radiosonde station was purchased for observations and research in the troposphere and higher atmospheres. Another project carried out by the ESTEA in partnership with the University of Tartu, Landscape Biodiversity Group in 2014–2020 was the **National Assessment and Mapping of Ecosystems and Ecosystem Services** (ELME), which included the topic area of ecosystem services, the application of new monitoring methods in the monitoring of biodiversity and developing the work tools to assess the socio-economic status of biodiversity and climate-change-related conditions, and to forecast and ensure the availability of data (University of Tartu, 2022).

The Air Quality and Climate Department of the **EERC** (2022b) is responsible for air quality monitoring in Estonia pursuant with European Directives and international conventions. The EERC is carrying out national ambient air quality monitoring in cities and rural areas. The regular monitoring network includes one street station, two urban background stations, three urban-industrial stations and four rural stations, one of them in cooperation with Institute of Physics, University of Tartu. Since 2016, the network includes five stations for allergenic pollen monitoring. An important task is the development and management of the Estonian Air Quality and Climate System. The system combines the continuous air quality monitoring (data collection from national monitoring stations and from industrial monitoring stations), air pollution modelling, emission databases, calculation of the air quality index and other data related to air. In addition to the ESTEA and the EERC, the Tartu Observatory of the University of Tartu, the Estonian Marine Institute and Institute of Physics of the University of Tartu and the Estonian Agricultural Research Centre also engaged in environmental monitoring.

International cooperation

The **ESTEA** fulfils the following international obligations: carrying out the duties of the national contact point for the European Environment Agency and the UNEP/Info-terra network, exchanging information with the European Environment Agency, the EUROSTAT (2022), the European Commission, the UN Environment Programme and other international and national institutions and compiling and delivering national and international reports to such institutions. The main goal of the ESTEA's environmental monitoring is to forecast (through the continuous monitoring and evaluation of environmental factors and environmental status) changes in environmental factors and statuses via a developed indicator system and forecasting models. There are a total of 12 sub-programmes of environmental monitoring: biodiversity and landscape monitoring, radiation monitoring, integrated monitoring, meteorological and hydrological monitoring, forest monitoring, soil monitoring, groundwater monitoring, marine monitoring, seismic monitoring, inland water bodies monitoring, the support programme and ambient air monitoring. Most monitoring programmes also research climate change (Estonian Environmental Agency, 2022c).

The **ESTEA's weather service** participates in the work of many international organisations, has been a cooperating member of the European Centre for Medium-Range Weather Forecasts (ECMWF) since 2005 and has been a full member since 2020, a cooperating member of the European Centre for the Exploitation of Meteorological Satellites (EUMETSAT) since 2006 and a full member since 2013. The ESTEA's weather service also participates in the work of the weather forecasting consortium HIRLAM (since 2007), which was joined with ACCORD (since 2021), the European Meteorological Services Network (EUMETNET) (since 2007), the Nordic Weather Radar Network (NORDRAD) (since 2010), the NORDIC cooperation on Numerical Weather Prediction (NORDNWP) (since 2016) and NORDMET/United Weather Centres (UWC)/MetCoop (since 2019). Estonian data are visible in the pan-European network for meteorological warnings (METEOALARM) since 2010. The ESTEA's weather service takes part in several climate-oriented programmes of the World Meteorological Organisation (WMO): the World Climate Programme (WCP), the GCOS, the Global Precipitation Climatology Centre (GPCC) and the work of the Baseline Surface Radiation Network (BSRN) of the World Climate Research Programme (WCRP) (Maves, Hendrikson&Co, 2022, WRMC, 2022).

The GCOS includes the meteorological networks GCOS Surface Network (GSN) and GCOS Upper Air Network (GUAN), which provide information necessary for researching climate change. The Tartu-Tõravere station, a member of the GSN network, carries out actinometric measurements for researching the spread of solar radiation in the Earth's atmosphere and its refraction in the subsoil. (Global Climate Observing System, 2022)

EMEP is the co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe. It is a scientifically based and policy driven programme under the UNECE Convention on Long-range Transboundary Air Pollution (LTRAP).

In Estonia, since 1994 background air monitoring is performed at three monitoring stations: on the island of Vilsandi, in Lahemaa National Park in northern Estonia and in Saarejärve, Jõgeva County.

8.3.1. Monitoring atmospheric climate

Atmospheric monitoring is carried out by the Tartu Observatory of University of Tartu (Tartu Observatory, 2022), which researches different links to climate change. Climate change research focuses on the causes of climate change in the Baltic Sea region and in the Arctic. The aim is to find causal relations between temperature, the components of the atmosphere's energy budget, aerosols and the temporary changes in GHGs; long-range relations between the Baltic Sea region and the Arctic climate are also researched. For the analyses, global atmospheric reanalysis models NCEP-CFSR and ERA-Interim, aerosols model SILAM and atmospheric radiative transfer model FUTBOLIN are applied. The model's data will be validated against measurement data (radiosondes, radiation meters, AERONET sunphotometer). One of the most important goals of the project is to evaluate the possible contribution of different climate parameters (water vapour, CO_2, aerosols) to climate change. The research project Aerosols and greenhouse gases' contribution to the climate change in the Baltic Sea region and in the Arctic was launched in 2015 and completed in 2018. One of the most important goals of the project was to evaluate the possible contribution of different climate parameters (water vapour, CO_2, aerosols) to climate change. In 2017–2022 the project EMPIR JRP. MetEOC3 Metrology for Earth observation and climate was carried out. The overall aim of this project was to contribute to the establishment of the necessary metrology infrastructure, tailored to climate needs in readiness for its use in climate observing systems.

The EERC (2022b) is responsible for ambient air quality monitoring on the national level. The development of a national air quality management system was financed by the Phare aid project EuropeAid/114968/D/S/EE Development of Estonian Air Quality Management System and the system was created with the help of the Swedish Meteorological and Hydrological Institute. Currently, the system is based on the Airviro platform (developed by Apertum IT AB, Sweden), which includes nine different air quality dispersion models, one odour model, one hydrological model and one noise model. A development project (2022–2023) to implement the SILAM chemical-transport model (developed by Finnish Meteorological Institute) on the Airviro platform, supported by the Estonian Research Council from Inter-sectoral mobility measure (SekMo), is ongoing (the State Shared Service Centre, 2022).

During hydrometeorological monitoring, data about air temperature, precipitation, wind direction and speed, water levels in water bodies and water temperatures are collected among other information. The data are collected, combined, processed and distributed by the Estonian Weather Service (Estonian Environmental Agency, 2022b) operating as part of the ESTEA. The ESTEA's network of permanent hydrometeorological monitoring stations covers the whole of continental Estonia, the coast, and major Western Estonian islands relatively well. In 2020 the network included 26 weather stations with a full observation programme and 64 weather stations with a reduced programme (only air temperature in most of them). Measurements are mostly automated, the manual measurements in parallel only continue in two weather stations: Tallinn-Harku and Tartu-Tõravere.

8.3.2. Ocean climate monitoring

Marine monitoring
Marine monitoring is carried out by the **Estonian Marine Institute of the University of Tartu** (2022). Within the framework of the national monitoring programme, the monitoring

of Estonian coastal waters started in 1993–1994 – initially only in accordance with the HELCOM (Baltic Marine Environment Protection Commission – Helsinki Commission) requirements and as of 2006, also in accordance with the requirement of the EU's directives.

To estimate the eutrophication, the winter maximal total amounts of biogens in basins are determined, and mass balances of basins are determined. Long-term changes in the spatial distribution of zoobenthos and the oxygen regime of the bottom layer are monitored. The seasonal cycle of phyto- and zooplankton communities is monitored, and exceptional phenomena are recorded. Based on the collected data, assessments are made about the state of the marine environment, its changes and their causes. Tools are developed to assess the socio-economic state of biodiversity and climate-change-related conditions, and to forecast and ensure the availability of data. Long-term changes in the content of dangerous substances are monitored and the state of pollution is assessed. Long-term and short-term changes in the species composition and structure of the benthic communities of the coastal sea are monitored. The changes found are related to the natural or anthropogenic dynamics of other environmental parameters. Changes in seacoasts are monitored in areas where the geological activity of the sea can cause significant damage (destruction of buildings, recreation areas, etc.). In the case of severe storm damage, the extent of the damage is assessed. (Estonian Marine Institute of the University of Tartu, 2022)

International cooperation in marine monitoring.

- To the extent provided by the HELCOM COMBINE programme, processing the information collected during the monitoring of the coastal sea.
- Participation in the North-West Atlantic Fisheries Organization NAFO (North-West Atlantic Fisheries Organization) cooperation programme for the protection and sustainable management of fish resources.
- Participation in the North-East Atlantic Fisheries Commission NEAFC (North-East Fisheries Commission) cooperation programme for the protection and sustainable management of fish resources.
- Participation in the cooperation programme of the members of the International Baltic Sea Fisheries Commission IBSFC (International Baltic Sea Fisheries Commission).
- Participation in the cooperation programme of the CCAMLR (Commission for the Conservation Antarctic Marine Living Resources).

The Marine Systems Institute of Tallinn University of Technology has contributed to marine monitoring with several projects on marine monitoring, including **Innovative approaches to monitoring and assessing marine environment and nature values in Estonian sea area** (2019–2022), **Marine monitoring** (2020–2021) **– open sea monitoring** (2020–2022) (Estonian Research Information System, 2022b), **Quantities and chemical composition of microplastics found in the benthic life of Estonian coastal seas** (2019), funded by EIC (TalTech, 2022).

Other hydrological monitoring

Hydrological monitoring is carried out by the Hydrology Department of the ESTEA (Estonian Environmental Agency, 2022b). Monitoring is the execution of hydrological observations, during which data about water levels and water temperatures of water bodies are collected from automated measuring stations placed on rivers. Additionally, water levels in Estonian coastal waters are measured in observation points. Data regarding river discharges are important for calculating water balance and pollution load, which allows the possibility to evaluate the capacity of pollutants carried from the rivers to the coastal waters and lakes. A network of permanent monitoring stations and observation points covers the entire continental Estonia area, the coastline and the major islands of Western Estonia relatively evenly. The network of monitoring stations, which includes 61 hydrological stations (2022), is mostly automated, which allows the continuous registration of measurement data and ensures the operative forwarding of data to the consumers. The outputs of this national monitoring programme are the operative availability of hydrological information for other sub-programmes of national monitoring; the preservation of an optimal amount of hydrological monitoring data series in electronic databases, incl. the retrospective entering of data (data series with length of up to 150 years); the general analysis of the hydrological monitoring data; and ensuring the availability of an optimal amount of data through the Internet.

8.3.3. Terrestrial monitoring

The Air Quality and Climate Department of the **EERC** is responsible for the management and execution of integrated monitoring within the framework of the national environmental monitoring programme (International Cooperation Programme on Integrated Monitoring). The EERC is Estonia's leading institution in international integrated monitoring (ICP IM – International Cooperation Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems), carried out on the basis of the Convention on Long-Range Transboundary Air Pollution (LRTAP). The purpose of monitoring is to collect data about the status of small complete terrestrial ecosystems (mainly ecosystems with the catchment area of a natural water body) and to forecast changes that may occur in the ecosystems over time, first and foremost, considering the environmental impact of nitrogen and sulphur pollution (acidification) on the environment, incl. the climate. The monitoring programme includes meteorology, atmospheric chemistry, chemical composition of precipitations, ground water and surface water, and several ecological and biochemical indicators of trees, mosses and soil. In Estonia, integrated monitoring has been carried out on Saare lake (Jõgeva County) and in Vilsandi (Saare County) since 1994. Vilsandi (in addition to the Lahemaa background monitoring station) also participates in the EMEP programme, meaning that the air monitoring results of these areas are used for the preparation of pan-European air pollution models, which serve as a basis for modelling pollution loads and air quality. The monitoring results in Europe are collected by Finnish Environment Institute (SYKE). (Estonian Environmental Research Centre, 2022c)

In Estonia, the forest monitoring programme is currently carried out by the **ESTEA**, in the framework of ICP Forests (International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests), which was created in 1985 to research the impact of air pollution on forest ecosystems, according to LRTAP. The purpose of monitoring forests and forest soil is to evaluate the status and increment of forests and to relate such data to the impact of biotic and abiotic factors. In areas of intense monitoring, comprehensive monitoring of the impact of air pollution and climate change on more representative habitats and forest stands growing in more typical forest communities is carried out. The monitoring work results in the evaluations of the status and increment of Estonian forests and overviews of the occurred changes and regional differences. The forest monitoring network currently includes 195 first-stage and 6 second-stage (more detailed monitoring) areas. (Estonian Environmental Agency, 2022c).

The agricultural soils monitoring is carried out by the **Estonian Agricultural Research Centre**. In Estonia, systematic monitoring of agricultural soils has been carried out from 1983 and within the framework of national environmental monitoring as of 2001 on 30 selected reference areas with a 5-year rotation (Agricultural Research Centre, 2022).

In 2020, there were 6 areas under agricultural soil monitoring, to which new monitoring areas were added to compare the results of agricultural soils with so-called natural areas and 1 leaching study area. The monitored areas in 2020 were Kogeri (Pärnu County), Pikareinu (Põlva County), Söödi (Järva County), Langi (Pärnu County), Risti (Pärnu County), Eametsa (Pärnu County) and the added areas Lahe, Lahe 2, Langi (Pärnumaa) forest analogue, Risti forest analogue and Aravete (Järva County) leaching monitoring area. In addition, a brief summary of the Environmental Investment Centre project was included, in which the abundance and biodiversity of soil fungi were mapped for the first time in Estonia (ESTEA, 2020). The decrease in organic carbon content compared to the previous monitoring round has occurred in practically all permanent monitoring areas monitored in 2020.

In 2021 the focus of agricultural soils monitoring was on pesticides in soils. In total 36 samples of agricultural soils in different parts of the country were analysed for pesticides. In addition, an experimental study on dynamics of residual glyphosate in soil was carried out.

8.3.4. Cryosphere monitoring

The wintertime sea ice and snow cover are monitored by the **Estonian Weather Service** operating as a part of the ESTEA (Estonian Environmental Agency, 2022c). The thickness and form of ice are monitored in 18 coastal and island stations. In addition, measurements from icebreakers and satellite (Sentinel) data are used. The snow depth is monitored in 23 meteorological observation stations on a daily basis. In 11 of the stations, the snow waster equivalent (SWE) is measured based on five-day time step. The results of sea ice and snow monitoring are published in near-real time at the webpage of Estonian Weather Service. The quasi-regular observations of snow water chemistry (basic anions and cations, suspended mater, pH) on a yearly basis (samples in late winter through naturally accumulated snow cover), focused on the oil-shale processing region in North-East Estonia, are made by the Laboratory of Atmospheric Physics in the Institute of Physics of the University of Tartu.

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9. Education, training and public awareness

Key developments:

- Awareness of Estonians about climate change is increasing gradually, getting closer to the EU average.
- Estonian people pay far more attention to the energy efficiency of households and transport than most EU nations.
- Tallinn was awarded the title of the European Green Capital of 2023.
- In recent years, several new grass-roots-level environmental and climate-concerned NGOs have emerged, marking a new level of public awareness in Estonia.

9.1. Introduction

This chapter provides an overview of activities that have been designed to increase climate awareness along with general trends of the Estonian public over the last five years. Estonia continues to contribute to the various climate education targets of the United Nations Framework Convention on Climate Change (UNFCCC), such as popularisation of climate education and increasing public awareness on climate change. Awareness of people about the environment, environmental protection, and climate change is increasing every year. This has become a general trend, which has in turn directed people's behavioural and consumption choices. Ecological lifestyles, organic farming, recycling, the use of environmentally friendly energy sources and technologies are gaining popularity, but these measures are quite often not related to the fight against climate change. Studies show that the Estonian awareness on climate change remains lower than the EU average, but continues to increase year-by-year, as shown in the latest Eurobarometer survey (Eurobarometer, 2021) in comparison with earlier ones.

In compilation of the national communication, the information was collected from different education-related institutions and organisations, e.g. the Estonian Research Council, NGOs, student associations for environmental protection, educational institutions, different ministries, national broadcasting, the Estonian Fund for Nature (2022), Fridays For Future (2022), Estonian Forest Aid (2022), and Save the Forest (2022). Various relevant parties, including professional associations, were involved in preparing the projections. The Estonian Research Information System (ETIS) was used extensively. Data on funding were acquired from the Environmental Investment Centre. The content of the section was confirmed by the Ministry of Education and Research and the Ministry of the Environment as well as other institutions that were contributing to the chapter.

Estonian general education policy supports the increasing of climate awareness. There have been numerous environmental and climate projects and training programmes implemented in Estonia over the last five years. Significant amounts have been invested in environmental education, which supports sustainable development. Targeted funding for the implementation of the Environmental Education and Awareness Action Plan 2019-2022 (2022) is almost 13 million Euros, which, however, does not cover all the expenditures of the public sector. In addition to educational institutions, most people receive information from the traditional media and increasingly from social media.

Reduction of air pollutants and GHG emissions is an important task all over Estonia. This is, for example, evident from the fact that energy efficiency is being taken into consideration in the design and use of all buildings, which will result in lower air and GHG emissions. The Capital city Tallinn, second largest city Tartu, and smaller municipalities Rakvere, Jõgeva, Rõuge, Valga, Saaremaa and Hiiumaa have joined the Covenant of Mayors for Climate & Energy. They thereby promised to reduce the GHG emissions resulting from their activities. Tallinn was awarded the title of European Green Capital of 2023 (Tallinn, 2021).

9.2. General policy on education, training and public awareness

9.2.1. Awareness of the public about the environment and climate change

The general environmental awareness of the people of Estonia was summarised by the Eurobarometer survey on the attitudes of European citizens towards climate change in 2021 (Eurobarometer, 2021). 1019 respondents in Estonia and 26,669 respondents in total in the EU were interviewed. In general, the awareness and readiness to take action of Estonian respondents is below the average of the European Union, but gradually improving in comparison with previous surveys (2019, 2017). However, the surveys reveal rather polarised opinions in some questions concerning climate change and the green transition.

About one in seven respondents in Estonia (14%, compared with the EU average of 18%) consider climate change to be the single most serious problem facing the world. Climate change ranks second, behind the spread of infectious diseases (29%, above the EU average of 17%). High awareness of infectious diseases was probably a result of the second, devastating wave of COVID-19, which coincided with the online interviewing of respondents in March and April 2021. Climate change has arisen two places, since it ranked the fourth most serious problem facing the world among respondents in Estonia in 2019.

More than six in ten respondents (63%, below the EU average of 78%) consider climate change to be a very serious problem. Only one Member State ranks lower (59%). However, this rate in Estonia has increased by 4 percentage points compared to the previous survey two years earlier, whereas in several EU countries it decreased remarkably and remained almost the same (78% vs. 79 %) as the EU average. Thus, climate awareness in Estonia is not only increasing in absolute, but also in relative, measures. The position of Estonia in perceiving climate change as the single most serious problem is much higher, 14th among the EU27.

Two thirds of respondents in Estonia (67%, compared with the EU average of 63%) believe that national governments are responsible for the tackling climate change, an increase of 16 percentage points since 2019 and largely ahead of any other actor. Around a quarter of respondents say they are personally responsible for tackling climate change (26%, below the EU average of 41%), a decrease of seven percentage

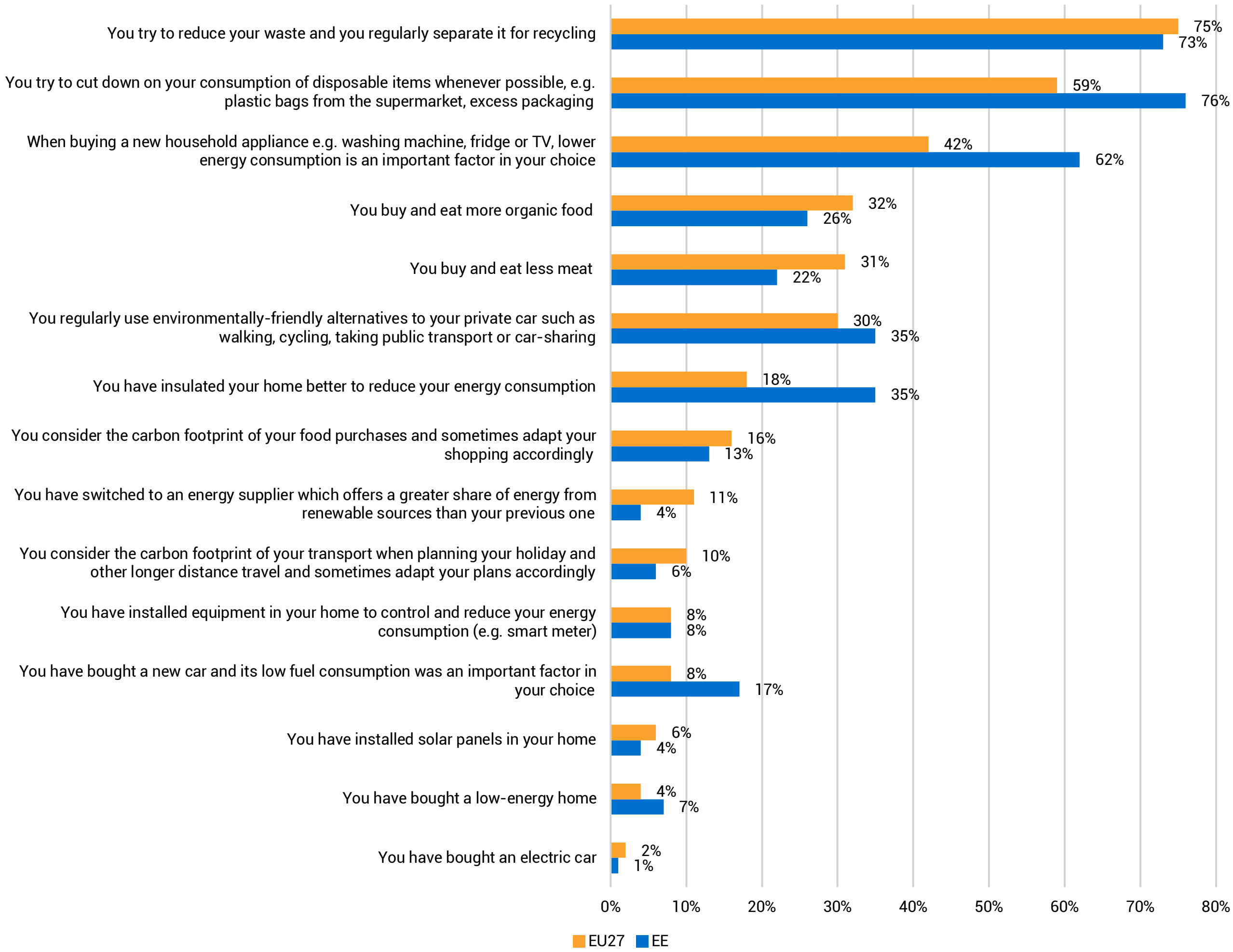

Figure 9.1. Responses of Estonian residents to the question *Which of the following actions, if any, apply to you?* (Eurobarometer, 2021)

points since 2019. A minority of respondents in Estonia say they have taken action to fight climate change in the past six months (47%, below the EU average of 64%), but this proportion rises to almost all respondents when asked to choose from a list of 15 possible actions to fight climate change (98%, compared with the EU average of 96%).

Actions to be taken by Estonian respondents to tackle climate change are presented in **Figure 9.1** Respondents in Estonia are much more likely to see lower energy consumption as an important factor when buying a new household appliance (62% vs the EU average of 42%) and to have better insulated their home to reduce their energy consumption (35% vs the EU average of 18%). As winters in Estonia are longer and colder than the EU average, saving energy for heating is a vital need for families from an economic point of view, which may be the reason for higher awareness on this point. In addition, Estonians are in favour of reducing their consumption of disposable items (e.g. plastic bags, excessive packing) whenever possible (76% vs the EU average of 59%).

Around three quarters of respondents in Estonia agree that tackling climate change and environmental issues should be a priority to improve public health (76%, below the EU average of 87%) and that the cost of the damage due to climate change is much higher than the investment needed for a green transition (75%, similar to the EU average of 74%).

More than eight in ten respondents in Estonia think it is important that both their national government (83% vs the EU average of 88%) and the European Union (85% vs the EU average of 87%) set ambitious targets to increase the amount of renewable energy used by 2030.

Close to nine in ten respondents in Estonia agree that greenhouse gas emissions should be reduced to a minimum while offsetting the remaining emissions in order to make the EU economy climate-neutral by 2050 (89%, similar to the EU average of 90%). Finally, more than three quarters of respondents (77%, compared with the EU average of 75%) think that the money from the economic recovery plan should primarily be invested in the green economy **(Figure 9.2)**. However, the views are more polarised than in the EU in general, as more than one fifth of respondents (21% in Estonia, only 15% as EU average) think that the fossil-fuel economy must be prioritised, and only an insignificant small number wish to invest in both or do not have an opinion on the matter (respectively 6% and 4% in EU).

The biggest survey ever carried out in Estonia, with nearly 13,904 respondents responding to the questionnaire online and in 150 libraries across the country, was carried out in April and May 2019 for the national umbrella strategy Eesti 2035 (Estonia 2035). The survey revealed that, in addition to safety, young people considered the conservation of nature and openness as important values for the development of Estonia, but over 40-year-olds clearly valued freedom and human-centeredness more. Safety, freedom, and environmentalism were the three most important keywords for Estonian-speaking people; Russian-speaking respondents, however, valued health and prosperity after safety. The survey also revealed gender differences – for women, in addition to being safe, Estonia should also be environmentally friendly and human-centred by 2035; for men, Estonia ought to be free and prosperous (Government Office, 2019).

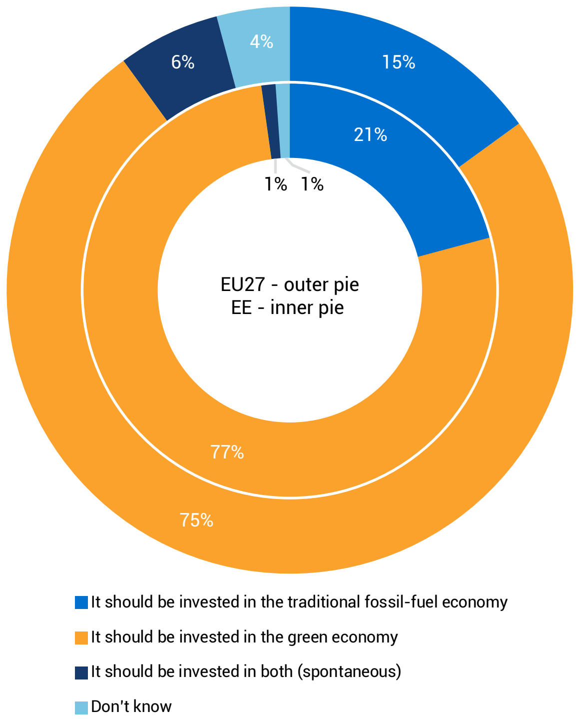

Figure 9.2. Responses of residents to the question *Do you think that the money from the economic recovery plan should be invested in the traditional fossil-fuelled economy or in the new green economy?* (Eurobarometer, 2021)

The questionnaire study (1001 respondents) Environmental awareness study of inhabitants of Estonia (2020) includes a block of questions on climate change and climate awareness. 42% of respondents consider their own awareness on the climate change impact to the Estonian environment good or very good and 50% bad or very bad. On the other hand, 50% think that climate change affects their life in the next year not at all or only slightly. 44% are concerned of a big or high impact on their life.

Remarkably, as many as 65% of respondents consider the forest cutting a reason for climate change, if the amount cut exceeds the increment of forest. The second largest reason, mentioned by 63% of respondents, is the use of gasoline or diesel cars. However, only 47% of respondents mention electricity production from oil shale, which is the main reason for the excessive carbon footprint of Estonia. Oil-shale energetics is fifth in the list, exceeded by use of synthetic herbicides and drying the wetlands (both 49%).

56% of respondents agree that general reduction of consumption contributes to the mitigation of climate change and 37% claim that they have reduced their consumption. 45% admit that it is necessary to reduce car transport and 32% answer they have done that. Remarkably, 31% consider that growing food for own consumption is climate-positive and nearly same number (32%) have done that themselves.

More than a half (56%) of respondents consider climate change a very serious or serious problem for Estonia, which is considerably more than in the previous study in 2016 (41%) – a clear indication of the rise of awareness. However, the overwhelming majority consider it a very serious (51%) or serious (37%) problem at world level.

9.2.2. General environmental education policy and education in Estonia

In Estonian environmental education, education supporting sustainable development is becoming more and more important, incl. the formation of environmentally friendly consumption habits, learning about nature in general, formation of values related to nature preservation, and understanding of ecosystem services. Promotion and shaping of education, which supports sustainable development, are some of the priorities for the Republic of Estonia. This approach to education is also highlighted in various international and domestic development documents: the UN Millennium Development Goals 2035 (Sustainable Development Goals, 2022), the UNESCO Global Action Programme on Education for Sustainable Development (2018) with the implementation guidelines, the national development plan Estonia 2035 (2021), and the national curricula for basic schools and upper secondary schools.

Environmental education in Estonia is promoted in cooperation with the Ministry of Education and Research (MoER) and the Ministry of the Environment (MoE). In 2017, the two ministers signed the still-operational third joint action memorandum. The memorandum sets the direction for future cooperation to promote education for sustainable development (Ministry of Education and Research & Ministry of the Environment, 2017). Therefore, the MoE is focused on the long-term environmental goal of sustainable development, which includes sustainable use of natural resources, pollution reduction, and preservation of biodiversity and natural areas. The role of the MoER includes popularisation and promotion of education for sustainable development, incl. more efficient implementation of the topic *Environment and sustainable development* in the national curricula and increasing of interest in the specialties and career choices, which are related to the areas of nature and exact sciences as well as technology. "The Action Plan for Environmental Education and Awareness 2019–2022" (2018) is the implementation plan of the memorandum, which forms the principles and directions set forth into goals and specific activities. The document consists of four parts. In the first, an overview of past developments is given to understand the context. The second part reflects on the strategy, including the vision and goals. The third part is the action plan corresponding to the objectives. The fourth part relates to implementation of the discussed action plan.

In 2018–2022 the Environmental Investment Centre (EIC) has financed 2822 projects on environmental awareness in a total amount of 11.2 million euros. Most projects are carried out at certain municipalities or certain educational institutions, including for visiting nature trails and environmentally important objects. 157 projects in a total amount of 2.7 million euros were spent on projects targeted at environmental awareness across the country, for developing the programmes and teaching practices, networking in education, awareness campaigns targeted at the entire society, and producing video clips and TV broadcasts. The seven biggest single projects exceed EIC funding of 100,000 euros each, including environmental education programmes for capital city Tallinn and second largest city Tartu, and country-wide "green school" programmes for 2020–2023. (Environmental Investment Centre, 2022)

9.3. Education

Topics concerning climate change are included in the content of teaching and learning outcomes of nature subjects included in the national curricula at various levels of education in Estonia. Even the national curriculum of preschool institutions includes a field: *The environment and I*, in which changes occurring in nature is one of the topics. The national curriculum for basic schools and upper secondary schools adopted by the Government of the Republic in 2011 and updated later on, establishes the framework for implementation of all recurrent topics, incl. the compulsory cross-curricular topic of *Environment and sustainable development*.

The environment-related topics dominating the curriculum of the first stage of basic school include natural resources, biodiversity, and the human being as a biological creature. At the second stage of basic school, changing of the environment as a result of human activity, energy consumption, and recycling of materials are covered. The geography curriculum of the third stage of basic school includes a separate block of topics dedicated to climate; climate is also discussed under the topics of hydrography and biomes. (Põhikooli riiklik õppekava, 2011)

Based on the national curriculum for upper secondary schools, climate, the factors that shape climate, climate change, global environmental problems and the impacts thereof are discussed in depth in geography lessons. The selection of topics of the optional human geography course *Globalising world* includes: climate change and regional impacts thereof, the reasons for decreasing biodiversity and the accompanying problems. The optional course *Natural sciences, technology, and society* offers the following module: *Climate change: what is the future of Estonia like?* (Gümnaasiumi riiklik õppekava, 2011)

The MoER also supports the participation of schoolchildren in various extracurricular environmental programmes and environmental research work competitions, as well as various environmental education projects for schoolchildren through targeted financing. The MoER supports the participation of schools in international sustainable development promoting educational programmes within the framework of the general education programme of the Estonian lifelong learning strategy. Such supported programmes are, for example, GLOBE (Global Learning and Observations to Benefit the Environment) and the Baltic Sea Project (2022). GLOBE is a global environmental education and research programme designed for primary, basic, and secondary school students, which offers learning through research and practical activities. By 2022, 61 Estonian schools had participated in the programme. The research programme of GLOBE (2022) includes atmosphere (weather observation and black carbon in air), biosphere (land cover and biometry), hydrology and soil studies. The Baltic Sea Project of UNESCO is focused on researching environmental problems in the Baltic Sea region and seeking solutions to the problems. Around 30 Estonian schools have taken part in the project. (Globe Eesti, 2022)

In the Report on implementation of "Climate Change Adaption Development Plan until 2030", time interval 2017-2020 (KOHAK, 2022), several educational activities are described.

Under the measure "Raising Climate Awareness" of programme agreement of the European Economic Area prepared in 2018–2019, an open application call for the preparation of learning materials on mitigating and adapting to the effects of climate change for students of pre-school educational institutions, general education and interest schools, and environmental education centres has been carried out. This measure is also supported by the application call on green technology for general education schools, aimed to increase the awareness of green technology among students (grades 1-9). The first round of this application call took place in 2021, and the second round of applications will be announced in 2022. The grant is aimed at students of general education schools for projects of increasing awareness on green technology, bringing science closer to the students and teaching them to find smart solutions. Students also gain knowledge about climate change mitigation and adaptation. This activity is financed from the revenues obtained from the auction of greenhouse gas emission units of aircraft operators of the EU Emissions Trading System. In addition to the aforementioned calls, a call on climate-related activities and awareness for kindergartens is being planned, which will support the teaching of environmental topics at early childhood education level.

The institutions of applied higher education teaching climate change include the Tallinn University of Applied Sciences and EuroAcademy. At the level of higher education, the topics of climate change are represented in the programmes of various specialities taught at various universities. The more general topics of sustainable development are, however, covered more frequently. The universities providing climate-related knowledge include the University of Tartu (Institute of Physics, Institute of Ecology and Earth Sciences, Marine Institute), Tallinn University of Technology (Department of Marine Systems, Department of Energy Technology, Department of Geology), Estonian University of Life Sciences (Institute of Agricultural and Environmental Sciences), and the University of Tallinn (Institute of Ecology). The Estonian University of Life Sciences has an international joint M.Sc.-study-level curriculum "Environmental governance and adaptation to climate change" Luua Forestry School and Räpina School of Horticulture are the vocational educational institutions which cover the topic of sustainable development in Estonia.

9.4. Public information campaigns

There are several climate-related environmental campaigns organised in Estonia which are aimed at the public. The majority of those campaigns are directly focused on energy efficiency. The campaigns are often also related to healthy ways of mobility.

In September every year, the **environmentally friendly mobility month** is organised in Tallinn. The general aim of the campaign is to increase the awareness of the residents of Tallinn about the environment and mobility. Various authorities, city district governments, and other cooperation partners are involved in creating a pleasant and safe environment in the city, in which it would be possible to travel sustainably, increase traffic safety on the streets, and promote the use of environmentally friendly and zero CO emission vehicles and the advantages of environmentally friendly means of mobility. During the campaign, more extensive use of public transport and less extensive use of private cars is promoted and the people are encouraged to choose environmentally friendly means of mobility, such as walking and cycling. (Tallinn, 2022)

In July and August, the **Car-free boulevard** (2022) was opened in Tartu in cooperation between the city government and NGOs. In 2020 and 2021 one of central streets at the riverside, Vabaduse puiestee (Boulevard of Freedom) was fully closed for car traffic for a month in summer and was made an outdoor meeting place for citizens. In 2022 the traffic was reduced (1+1 traffic lines, 30 km/h speed limit) for one and a half months and fully closed at weekends in this time interval. Concerts and various festival events took place in the temporary no-traffic area, to promote a healthy and carbon-neutral lifestyle.

The **European mobility week** (2022) promotes sustainable mobility on city streets and introduces environmentally friendlier methods of mobility. Four Estonian cities took part in the mobility week in 2022: Narva, Paide, Sillamäe and Tallinn.

The initiative **Cyclicious Estonia** (2022) was established with the aim of encouraging people to use bikes as their daily vehicles of choice. One can travel by car, by foot, or by public transport, but it is especially convenient to move around in the city by bicycle.

The aim of the **International Earth Day** (22 April) is to draw the attention of people to Earth-related environmental problems (climate warming, air pollution, excessive energy consumption, motorisation, etc.). Since 2014, the tradition of planting trees in the yards of Tallinn schools on the International Earth Day has been active. (Earth Day, 2022)

9.5. Trainings and study programmes

More than 160 organisations in Estonia are providing informal environmental education study programmes for schoolchildren as well as others who are interested. These organisations include public authorities, institutions managed by local municipality governments, foundations, non-governmental organisations, private companies, as well as subdivisions of universities. The portal Keskkonnaharidus (2022) includes information about more than 1500 study programmes, of which more than 20 have a main focus on climate and global warming. The many environmental issues discussed within the framework of the study programmes include climate change. The Environmental Board alone organised 168 study programmes in the period. The EIC is also funding numerous environmental awareness projects, which directly or indirectly cover the topics of climate change.

Estonian Environmental Education Association (2022) was founded in October 2017. It unites people working in the field of environmental education who want to develop a cooperation network and raise the quality of environmental education. The objectives of the association are promoting environmental education and awareness in society and ensuring the quality of environmental education, connecting persons engaged in environmental education and representing their interests, development of the professional skills of persons engaged in environmental education, development of an environmental education cooperation network and expansion of funding opportunities for environmental education. Anyone interested in environmental education who wishes to participate in the implementation of the association's goals and comply with the requirements of the statute can become a member of the association. The association has organised training events, *summer academies*, each summer during 2018–2022, for people active in the field of environmental education. These events are supported by the EIC.

The **Centre of Science Education** (2022) in the Institute of Ecology and Earth Sciences of University of Tartu is engaged in teaching and research in the field of science education. The Centre also offers in-service training courses for science teachers and coordinates the master's degree programme for gymnasium science teachers.

The **Green Tiger Academy** (2022) programme includes 9 months of intensive study and the application of the gained knowledge in the form of green projects. The programme has been prepared with the support of four universities and Green Tiger partners and is aimed at increasing the sustainability capacity of the entire organisation, whose members participate on courses. The purpose of the programme is to build capacity for the ambitious implementation of innovations in the business model, operating mechanisms and products and services, and to lay the foundation for self-sufficiency after the programme, for sustainable advancing.

9.5.1. Conferences

Conferences and lecture series related to the environment are organised in various locations all over Estonia, which are open to anyone interested. The Environmental Board continues to organise nature evenings or learning days for the public, which were focused on climate change.

The Sustainable Energy Forum organised by the Stockolm Environmental Institute, Tallinn Centre (SEI-Tallinn) is a discussion conference focused on the issues of the environment, economy, and society. In 2020 (Säästva Eesti Instituut, 2020), this forum focused on cities and climate change. The event was available as a live broadcast from the Estonian Parliament.

The Environment Agency organises annual conferences to celebrate the **global day of meteorology** (Estonian Environmental Agency, 2022). The conferences are open to specialists of relevant fields as well as to the wider public. The focus of the recent conferences was on clouds (2017), weather warnings (2018), and sunshine, in relation with environment, humankind and economy (2019), climate and water (2020), ocean, climate and weather (2021), and early warning and actions to reduce the risks of catastrophe (2022).

The **Green Tea Nights** (2022) are a series of environmental discussion evenings where the respective topics are introduced by experts in the field. Several topics, which are directly or indirectly related to climate, have been discussed in the lectures. These events are organised by the Estonian Green Movement (2022) and held in Tartu Nature House.

The **Opinion Festival** (2022) is an annual public meeting place for inspiring ideas, interesting thoughts, and new initiatives. The aim of the festival is to develop the opinion culture and citizen education. The climate change and GHG emission topics are increasingly in focus. In 2022 eight discussions were focused on the green transition, energy transition and climate change. A dedicated energy transition sector was present among the festival sites, but discussions on climate-related topics were held in the sectors of politics, future environment, green cooperation and digital knowledge too.

In May 2022, the international conference **On the green transition, by realistic means**, was held in Tallinn, organised by Postimees, the biggest media concern of Estonia (Postimees, 2022). The conference was intended to look for realities and choices beyond the slogan of the European Union's Green deal and climate goals.

In June 2022, the international research forum **10th** International Symposium on Ecosystem Behavior (BIOGEOMON,

2022) was held in Tartu, organised by the Institute of Ecology and Earth Sciences of University of Tartu. Many presentations and discussions during the five-day symposium were focused on the response of forest and different natural and agricultural ecosystems to climate change and their role in the global carbon balance.

The conference series **Talveakadeemia** (Winter Academy, since 2003), oriented at university students, includes themes of climate change and renewable energy resources. Video recordings of presentations and discussions are uploaded to YouTube channel Talveakadeemia (2022).

The Researchers' Night (2022), a scientific-popular event by the University of Tartu (in September each year), targeted at a wide public audience, includes classes on climate research. In 2022 the event included a class entitled "Climate is changing – so what?" and various scientific and technical aspects of the mitigation of climate change were presented by the researchers and professors of the University of Tartu.

The Centre of Renewable Energy of Estonian University of Life Sciences carries out annual renewable energy conferences on the **Research and application of renewable energy resources**, which include presentations and discussions by technology developers and experts from public institutions (TEUK, 2021).

9.6. Resource or information centres

9.6.1. Educational centres

An increasing number of centres exist in Estonia where children can take part in climate-related study programmes. Some of the centres also provide information on climate change for adults.

The **Särghaua earth science and environmental technology learning centre of the Tallinn University of Technology** (2022) organises climate-related learning days and educational programmes, which introduce how climate is researched, what the causes and impacts of climate change are, and what could the climate be like in the future.

The **Ice Age Centre** (2022) organises environmental educational activities and programmes, which are related to the exhibits of the centre. The topic of climate change is discussed within the framework of various study programmes. Overviews are provided about the development of the Earth as well as about climate change; additionally, various climate periods and the impacts of climate change in the Estonian territory are introduced.

The **Tallinn Botanic Garden** (2022) offers a weather- and climate-related study programme for secondary schools and the elder stages of basic school, which includes observations at a weather station, research activities, and discussions of global problems.

The climate change workshop at the **Energy Discovery Centre** (2022) seeks answers to the questions of why the average temperature on Earth is increasingly growing and what the consequences of this increase are. Experiments are conducted to study the connections between greenhouse gases and temperature changes in the atmosphere of the Earth.

The Museum of the University of Tartu includes the **Mad Scientist's office** (2022), a discovery room in which children as well as adults get to experiment. The *What is weather and what is climate?* programme introduces the work of weather and climate researchers and observes various weather phenomena.

The **Tallinn Zoo Environmental Education Centre** (2022) is primarily focused on promoting environmental education in and around Tallinn. The centre is in cooperation with other competent institutions and organisations in assuring that various different target groups have access to diverse environmental education, including the teaching of sustainable lifestyles.

The aim of the **Tartu Environmental Education Centre** (2022) based in Tartu Nature House is providing educational training, increasing the awareness of people, and creating a functioning model for environmentally aware behaviour. The study programmes offered by the Tartu Environmental Education Centre also complements the topic of climate change in the curricula of general education schools. An example of a recent new activity was the **H_2O visiting game** (2022) on climate change in August 2022, a joint event of 12 educational and visiting centres, led by Tartu Nature House. The participants have to visit at least 8 of these centres and solve different exercises specific for each of them. All the participants who collected at least eight stamps from visited centres participate in the lottery for various prizes. The three first participants who manage to do that receive special prizes.

9.6.2. Sources of information

Official national climate information is shared on the website Kliima of the **MoE**. The website explains the meanings of climate, climate change, the greenhouse effect, and greenhouse gases, as well as discusses adaption to climate change and the climate policy (Ministry of the Environment, 2022). The website also includes the development plan for adaption to climate change and information on the international battle against climate change. The detailed national plan to avoid and mitigate the climate change is provided (Kliimakava, 2022). The website Kliimamuutused of the Estonian Environmental Research Centre (2022) also introduces the possibilities for adapting to climate change and provides a list of which fields of life are affected by climate change in Estonia. Both websites include numerous references to various climate-related materials. The Estonian Fund for Nature, Estonian Green Movement and Estonian Environmental Law Centre are jointly running a climate change information website and a related Facebook blog.

The wider public are mainly informed on climate-related issues through the media. The MoE has launched a special webpage for information on COP and related activities, including LCDF, the Least Developed Countries Fund (COP27EE, 2022).

The **Estonian Public Broadcasting** (ERR) reports climate issues over the radio and television and online. The programme "Osoon" and news portal Novaator provide continuous information on climate-related topics. A science news channel produced in cooperation between the University of Tartu and the ERR is focused on introducing science and scientists (Novaator, 2022). The ETV2 channel of the ERR celebrates the environment month in May each year by showing various documentaries on the topic of the environment, including climate change. The Vikerraadio radio channel has covered topics related to climate change in several programmes.

The NGO **Mondo** administers a global education and training centre portal Maailmakool (2022). which includes global education materials for schools, teachers, and youth workers, which have been produced in Estonia or translated into Estonian. The website includes plenty of information on climate change, which can be used as teaching aids, such as clips, comics, and ideas, which facilitate teaching.

9.7. Involvement of the public and non-governmental organisations

The non-governmental organisations actively involved in the field of climate-related issues are to a large extent the same as the ones listed along with the aims of their activities in the previous climate report, such as the EGM and the EFN in the field of environmental protection; NGO Tervikring in field of the circular economy; Peipsi Cooperation Centre working on balanced regional development; the NGO Mondo working on global inequality and sustainability-related issues; the NGO Estonian Renewable Energy Association, Estonian Wind Power Association, and the Tartu Regional Energy Agency, which promote sustainable energy consumption; the Estonian Environmental Law Centre in the field of law, and the Baltic Environmental Forum and the Tallinn Centre of the Stockholm Environmental Institute, which take part in international programmes. In addition to those mentioned above, there are other and newer ones which are worthy of mention.

In April to May 2022, the first climate council was held in Tartu, the second largest city of Estonia. A total of 45 people from Tartu, chosen by random sampling, participated in the climate council – a cross-section of residents taking into account gender, age, place of residence, occupation and native language. The invitation to the climate meeting was sent to approximately 15,000 people from Tartu. The purpose of the Tartu climate council is to involve city residents in discussions on how to advance and make the Tartu's street space safer and more attractive. The climate council made suggestions to the city government on how to increase the safety and health of streets, reduce traffic-induced noise and air pollution in the urban space, and shape a more climate-friendly future (Tartu, 2022).

The NGO **Fridays for Future Eesti** (2022) (FFF Eesti) was established in 2019 as a youth grass roots activity, following the initiative of Greta Thunberg. The backbone of FFF Eesti is organising the regular climate strikes with manifestations mostly in Tallinn and Tartu, until September 2022, 185 strikes took place.

Vastuhakk Väljasuremisele (2022) is the Estonian organisation of Extinction Rebellion (XR), a branch of a decentralised, international and politically non-partisan movement using non-violent direct action and civil disobedience to persuade governments to act justly on the climate and ecological emergency, as climate change is one of threats to the biodiversity and reasons of the extinction of species. The Estonian organisation is largely focused on protests against excessive cutting of forest in the country.

Estonian Forest Aid (EMA, 2022) is an NGO established in 2016 and focused on the protection of Estonian forests, which are cut excessively, including for export in the form of pellets for industrial heat and electricity production. The aim of EMA is to bring logging activities within the boundaries of a safe living environment for forest biota and to strengthen the positions of nature-friendly stakeholders to a level comparable to that of industry. The work methods of EMA include direct action, negotiations with authorities and industries, publishing of opinions and analyses in media and networking with local environmental groups and abroad. A long-lasting action of EMA is participation in a working group for a national forest management plan, to promote sustainability in forestry.

Save the Forest (PEM, 2022) is another NGO focused on forest protection, a grass roots movement that started with the idea of organising a demonstration in support of Estonian forests on August 16, 2020. PEM has, along with direct action, published Estonian Forest Manifesto and a petition to the government, parliament and president of Estonia on the need to shift towards balanced forestry, which means the consistent regeneration of the ecological, cultural, financial and social value of forest.

University students' nature protection organisations, whose current activities include informal education and awareness on climate change and renewable energy, have a long history in Estonia. The **Tartu Student´s Nature Protection Circle**, established in 1958, is believed to be the oldest student nature protection organisation (TÜLKR, 2022). **Estonian Student´s Environmental Protection Society "Sorex"**, mostly based in Tallinn, was established in 1997 (Sorex, 2022).

9.8. Participation in international activities

In addition to participation in the international projects for schoolchildren discussed above (such as GLOBE, the Baltic Sea Project) and taking part in the activities of the international environment days, climate-change-related environmental topics are also discussed at a more general international level. Since 2018, the World Cleanup Day *Let's Do It!* has taken place in the autumn of every year on the initiative of Estonians. The most recent of them was held on September 17, 2022. The aim of the ***Let's Do It!* World Cleanup Day** (2022) is to achieve a clean world. The *Let's Do It World Cleanup* day is coordinated by the Let's Do It Foundation (Teeme Ära Sihtasutus, 2022).

Tallinn was elected the European Green Capital for 2023. This title is awarded by the European Commission. The aim of the initiative is to improve the living environment in European cities and, above all, to acknowledge and reward the efforts made by cities to improve the environment and the quality of life. The title is awarded to the city which has most improved the urban environment as a whole through various activities, such as introduction of sustainable ways of mobility, the creation and expansion of parks and other green and recreational areas, the modernisation of waste management, taking into use of renewable energy sources, noise reduction, implementation of innovative solutions, environmental management of the city government, cooperation between the authorities, residents, businesses, and other parties in the city with the aim to develop and improve the living conditions in the city. Tallinn is taking part in the Covenant of Mayor for Climate & Energy (2022) with the aim of decreasing greenhouse gas emissions by 40% by 2030. Eight more Estonian municipalities have joined the Covenant: Rakvere, Jõgeva, Tartu, Võru, Valga, Rõuge, Saaremaa and Hiiumaa.

The NGOs Fridays for Future Eesti and Vastuhakk Väljasuremisele (XR, Estonia) are deeply involved in Europe-wide and international cooperation, coordinating the protest actions to affect the political decisions on climate and environment more effectively. The Estonian Fund for Nature, Estonian Forest Aid and Save the Forest signed the petition **The EU must protect forests, not burn them for energy** (2022), to Executive Vice President of the European Commission, Frans Timmermans, and governments of EU Member States. Estonian Forest Aid is one of six organisations running this petition.

9.9. Monitoring, review and evaluation of the implementation of Article 6 of the Convention

In the following, the implementation of Article 6 is reviewed, based on its focuses relative to the specific case of Estonia.

Public awareness is monitored through regular nationwide questionnaire studies. The most recent of them is the **Environmental awareness study of inhabitants of Estonia 2020**. The overview of results in Chapter 10 on climate awareness includes a comparison with a similar study made in 2016. It was found that, in general, 56% of people are in some extent alerted on climate changes in the country, which is 15% more than in 2016. On the other hand, people appear rather confused when dealing with scientific truth on climate change. 74% of people agree that the knowledge of climate change is dynamic and can change somewhat in time, and 72% agree that there is no clear and unequivocal solution for the climate change problem. However, 63% of people think that theories on climate science are unreasonably sophisticated and 59% think that there is no way to approve the reliability of arguments on climate. Younger and more educated people tend to have more clarity and understanding on scientific facts about climate change.

The situation on **public access to information and public participation in Estonia**, including advances and drawbacks in information delivery by governmental organisations and municipalities, is described in detail in the reports on implementation of the Arhus Convention delivered most recently in 2021 (Ministry of the Environment, 2021), whereas the previous one was released in 2016. As stated in the report, the measures to enable citizens access to environmental information upon request and publish the most important information regularly, to grant the rights to participate in decision-making process, and to appeal to court, are incorporated in national legislation and followed in general. However, some drawbacks are mentioned. The NGOs draw attention to the cases of formal inclusion and sometimes irrespective attitude of local authorities, too-short deadlines for NGOs to respond in the process of inclusion, isolated cases of no answer by authorities to their requests and the high costs of court cases.

Training of scientific, technical and managerial personnel referred to in Section 9.5 is gradually growing, according to the number of training programmes and organisations providing it. A newly funded overarching organisation, the Estonian Environmental Education Association, promotes coordinated efforts in the raising of environmental awareness and attracts more funding for this purpose.

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Annexes

SUMMARY 1.A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Page 1 of 2)

NO – not occurring
NA – not applicable
NE – not estimated
IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/ emovals	CH_4	N_2O	HFCs[1]	PFCs[1]	Unspecified mix of HFCs and PFCs[1]	SF_6	NF_3	NO_x	CO	NMVOC	SO_2
	(kt)			(kt CO_2 equivalent)					(kt)			
Total national emissions and removals	10275.21	46.47	4.12	184.74	NO	NO	0.00	NO	31.55	134.18	29.28	16.11
1. Energy	**9221.94**	**6.55**	**0.25**						**29.05**	**134.02**	**12.54**	**16.10**
A. Fuel combustion Reference approach[2]	13094.44											
Sectoral approach[2]	9221.91	5.80	0.25						29.05	134.02	12.54	16.10
1. Energy industries	5808.56	0.52	0.09						13.34	32.06	5.21	14.13
2. Manufacturing industries and construction	508.51	0.03	0.01						1.18	1.80	0.14	0.83
3. Transport	2205.13	0.12	0.08						6.94	12.09	2.29	0.11
4. Other sectors	699.70	5.12	0.08						7.59	88.06	4.89	1.03
5. Other	NO	NO	NO						NO	NO	NO	NO
B. Fugitive emissions from fuels	0.03	0.75	NO						NO	NO	NO	NO
1. Solid fuels	NO	NO	NO						NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	0.03	0.75	NO						NO	NO	NO	NO
C. CO_2 Transport and storage	NO											
2. Industrial processes and product use	**104.72**	**NO**	**0.01**	**184.74**	**NO**	**NO**	**0.00**	**NO**	**0.00**	**0.10**	**11.99**	**0.01**
A. Mineral industry	70.31								NO	NO	NO	0.01
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	2.90	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
D. Non-energy products from fuels and solvent use	31.50	NO	NO						NO	0.07	11.25	NO
E. Electronic industry												
F. Product uses as substitutes for ODS				184.74								
G. Other product manufacture and use	NO	NO	0.01	NO	NO	NO	0.00	NO	NO	NO	NO	NO
H. Other[3]	NO	NO	NO	NO	NO	NO	NO	NO	0.00	0.03	0.73	0.00
3. Agriculture	**15.86**	**27.46**	**2.70**						**2.49**	**NO**	**4.57**	**NO**
A. Enteric fermentation		20.94										
B. Manure management		6.52	0.24								4.57	
C. Rice cultivation		NO									NO	
D. Agricultural soils		NO	2.46						2.49	NO	NE,NO	
E. Prescribed burning of savannas		NO	NO						NO	NO	NO	
F. Field burning of agricultural residues		NO	NO						NO	NO	NO	
G. Liming	15.73											
H. Urea application	0.13											
I. Other carbon-contining fertilizers	NO											
J. Other	NO	NO	NO						NO	NO	NO	NO

(Page 2 of 2)

NO – not occurring NE – not estimated
NA – not applicable IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/ emovals	CH_4	N_2O	HFCs[1]	PFCs[1]	Unspecified mix of HFCs and PFCs[1]	SF_6	NF_3	NO_x	CO	NMVOC	SO_2
	(kt)			(kt CO_2 equivalent)			(kt)					
4. Land use, land-use change and forestry [4]	**932.20**	**2.65**	**1.00**						**NO,NE**	**NO,NE**	**NO,NE**	**NO**
A. Forest land [4]	-193.38	2.64	0.89						NE	NE	NE	
B. Cropland [4]	413.74	NO,NE,NA	0.01						NE	NE	NE	
C. Grassland [4]	63.87	0.01	0.00						NE	NE	NE	
D. Wetlands [4]	1128.40	0.00	0.01						NE	NE	NE	
E. Settlements [4]	375.84	NO,NE	0.06						NE	NE	NE	
F. Other land [4]	65.98	NO	0.01						NE	NE	NE	
G. Harvested wood products	-922.24											
H. Other [4]	NO	NO	NO						NO	NO	NO	NO
5. Waste	**0.49**	**9.81**	**0.15**						**0.01**	**0.07**	**0.19**	**0.00**
A. Solid waste disposal [5]	NO	6.96							NO,NA	NO,NE	0.12	
B. Biological treatment of solid waste [5]		0.73	0.04						NO,NE	NO,NE	0.02	
C. Incineration and open burning of waste [5]	0.49	0.01	0.00						0.01	0.07	0.03	0.00
D. Wastewater treatment and discharge		2.12	0.11						0.00	NO,NA	0.02	
E. Other [5]	NO	NO	NO						NO	NO	NO	NO
6. Other (please specify)[6]	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

Memo items:[7]												
International bunkers	973.09	0.08	0.02						0.37	21.47	2.01	0.75
Aviation	72.11	0.00	0.00						0.29	0.09	0.02	0.02
Navigation	900.99	0.08	0.02						0.08	21.38	1.99	0.73
Multilateral operations	NO	NO	NO						NO	NO	NO	NO
CO_2 emissions from biomass	5567.02											
CO_2 captured	NO,NE											
Long-term storage of C in waste disposal sites	1643.24											
Indirect N_2O			NO,NE									
Indirect CO_2	NO,NE,IE											

(1) The emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), unspecified mix of HFCs and PFCs and other fluorinated gases are to be expressed as carbon dioxide (CO_2) equivalent emissions.

(2) For verification purposes, Parties are requested to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach in the documentation box to table 1.A(c). For estimating national total emissions, the results from the Sectoral approach should be used.

(3) 2.H. Other includes pulp and paper and food and beverages industry.

(4) For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(5) CO_2 from categories solid waste disposal on land and waste incineration should only be included if it stems from non-biogenic or inorganic waste streams. Only emissions from waste incineration without energy recovery are to be reported in the waste sector, whereas emissions from incineration with energy recovery are to be reported in the energy sector

(6) If reporting any country-specific category under sector "6. Other", detailed explanations should be provided in Chapter 8: Other (CRF sector 6) of the national inventory report (NIR).

(7) Parties are asked to report emissions from international aviation and international navigation and multilateral operations, as well as CO_2 emissions from biomass and CO_2 captured, under Memo Items. These emissions should not be included in the national total emissions from the energy sector. Amounts of biomass used as fuel are included in the national energy consumption but the corresponding CO_2 emissions are not included in the national total as it is assumed that the biomass is produced in a sustainable manner. If the biomass is harvested at an unsustainable rate, net CO_2 emissions are accounted for as a loss of biomass stocks in the Land Use, Land-use Change and Forestry sector.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS

(Page 1 of 2)

NO – not occurring
NE – not estimated
NA – not applicable
IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)(1)	**10275.21**	**1161.72**	**1228.48**	**184.74**	**NO**	**2.92**	**NO**	**NO**	**12853.08**
1. Energy	**9221.94**	**163.64**	**75.88**						**9461.45**
A. Fuel combustion (sectoral approach)	9221.91	144.96	75.88						9442.75
1. Energy industries	5808.56	12.99	26.15						5847.70
2. Manufacturing industries and construction	508.51	0.84	1.92						511.27
3. Transport	2205.13	3.03	24.38						2232.54
4. Other sectors	699.70	128.10	23.43						851.23
5. Other	NO	NO	NO						NO
B. Fugitive emissions from fuels	0.03	18.68	NO						18.70
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	0.03	18.68	NO						18.70
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**104.72**	**NO**	**3.09**	**184.74**	**NO**	**2.92**	**NO**	**NO**	**295.47**
A. Mineral industry	70.31								70.31
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	2.90	NO	NO	NO	NO	NO	NO	NO	2.90
D. Non-energy products from fuels and solvent use	31.50	NO	NO						31.50
E. Electronic Industry									
F. Product uses as ODS substitutes				184.74					184.74
G. Other product manufacture and use	NO	NO	3.09	NO	NO	2.92	NO	NO	6.01
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	**15.86**	**686.50**	**806.01**						**1508.38**
A. Enteric fermentation		523.46							523.46
B. Manure management		163.04	72.50						235.53
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	733.51						733.51
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	15.73								15.73
H. Urea application	0.13								0.13
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO

(Page 2 of 2)

NO – not occurring NE – not estimated
NA – not applicable IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
4. Land use, land-use change and forestry[1]	**932.20**	**66.26**	**298.80**						**1297.27**
A. Forest land	-193.38	66.03	266.52						139.17
B. Cropland	413.74	NO,NE,NA	3.26						417.00
C. Grassland	63.87	0.13	0.14						64.14
D. Wetlands	1128.40	0.10	2.27						1130.77
E. Settlements	375.84	NO,NE	18.73						394.58
F. Other land	65.98	NO	2.30						68.27
G. Harvested wood products	-922.24								-922.24
H. Other	NO	NO	NO						NO
5. Waste	**0.49**	**245.31**	**44.70**						**290.51**
A. Solid waste disposal	NO	173.91							173.91
B. Biological treatment of solid waste		18.20	13.02						31.22
C. Incineration and open burning of waste	0.49	0.24	0.05						0.78
D. Waste water treatment and discharge		52.96	31.64						84.60
E. Other	NO	NO	NO						NO
6. Other (as specified in summary 1.A)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

Memo items:[2]									
International bunkers	973.09	2.12	7.41						982.62
Aviation	72.11	0.02	0.60						72.72
Navigation	900.99	2.10	6.81						909.90
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	5567.02								5567.02
CO_2 captured	NO,NE								NO,NE
Long-term storage of C in waste disposal sites	1643.24								1643.24
Indirect N_2O			NO,NE						
Indirect CO_2 [3]	NO,NE,IE								
Total CO_2 equivalent emissions without land use, land-use change and forestry									**11555.81**
Total CO_2 equivalent emissions with land use, land-use change and forestry									**12853.08**
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									**NA**
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									**NA**

[1] For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).
[2] See footnote 7 to table Summary 1.A.
[3] In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

TABLE 10 EMISSION TRENDS (CO_2 eq emissions)

(Page 1 of 2)

Inventory 2020
Submission 2022 v4
ESTONIA

NO – not occurring
NA – not applicable
NE – not estimated
IE – included elsewhere

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(kt CO_2 eq)																
Total (net emissions)[2]	**37015.28**	**37015.28**	**34263.58**	**25110.71**	**18513.04**	**19560.12**	**17281.14**	**17877.33**	**17478.05**	**15257.86**	**14520.30**	**13274.54**	**13578.34**	**13270.32**	**13206.98**	**15071.46**	**17881.75**
1. Energy	**36213.16**	**36213.16**	**33424.21**	**24036.91**	**19251.80**	**19646.39**	**17697.15**	**18701.35**	**18297.74**	**16452.74**	**15534.89**	**15098.87**	**15484.70**	**15139.28**	**17002.73**	**16954.07**	**16742.41**
A. Fuel combustion (sectoral approach)	36148.99	36148.99	33359.72	23999.25	19233.12	19619.58	17666.58	18667.62	18264.95	16421.61	15504.28	15063.70	15447.03	15107.75	16966.65	16913.12	16700.15
1. Energy industries	28288.34	28288.34	25907.57	19717.30	15178.40	15772.62	13800.21	14466.63	14315.52	12619.23	12232.77	11727.31	11419.42	11305.70	13038.12	12921.53	12625.27
2. Manufacturing industries and construction	3475.23	3475.23	3359.61	1953.70	1815.28	1539.41	1507.55	1588.45	1345.59	1210.13	862.20	913.07	1113.61	814.71	951.57	996.67	1036.76
3. Transport	2481.91	2481.91	2249.57	1164.90	1308.45	1610.61	1586.83	1673.29	1768.52	1835.07	1707.18	1684.86	2006.02	2137.87	2055.29	2091.18	2169.22
4. Other sectors	1903.52	1903.52	1842.97	1163.34	930.98	696.95	772.00	939.25	835.31	757.18	702.13	738.47	907.97	849.47	921.66	903.74	868.90
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	64.17	64.17	64.49	37.66	18.68	26.82	30.58	33.73	32.79	31.13	30.61	35.17	37.68	31.53	36.08	40.95	42.26
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	64.17	64.17	64.49	37.66	18.68	26.82	30.58	33.73	32.79	31.13	30.61	35.17	37.68	31.53	36.08	40.95	42.26
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Industrial processes	**963.74**	**963.74**	**966.14**	**574.61**	**353.55**	**600.01**	**635.29**	**651.14**	**702.07**	**755.23**	**690.55**	**695.97**	**731.23**	**553.40**	**601.01**	**741.59**	**727.83**
A. Mineral industry	613.95	613.95	621.95	380.00	246.08	346.96	364.36	377.22	413.91	436.01	387.47	399.87	407.48	391.01	372.83	405.39	413.59
B. Chemical industry	307.73	307.73	301.22	145.43	57.88	194.24	207.83	202.81	211.40	228.44	203.12	180.78	195.35	31.33	92.17	184.47	146.36
C. Metal industry	0.76	0.76	0.65	0.34	0.23	0.67	0.65	0.71	1.02	1.46	1.32	1.55	1.45	1.39	0.68	1.65	1.52
D. Non-energy products from fuels and solvent use	35.84	35.84	36.49	26.04	22.64	26.51	24.89	26.17	24.97	27.30	24.86	23.90	20.91	23.00	22.68	23.10	23.55
E. Electronic industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes	NO	NO	NO	17.51	20.02	22.91	28.45	34.56	41.31	52.25	63.39	79.15	97.19	98.83	104.87	119.33	134.96
G. Other product manufacture and use	5.45	5.45	5.84	5.28	6.71	8.72	9.11	9.66	9.47	9.76	10.38	10.71	8.84	7.85	7.77	7.65	7.86
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	**2628.34**	**2628.34**	**2522.19**	**2130.93**	**1671.31**	**1524.38**	**1350.11**	**1245.41**	**1258.82**	**1283.51**	**1110.47**	**1122.23**	**1123.63**	**1062.48**	**1112.09**	**1154.70**	**1172.06**
A. Enteric fermentation	1227.77	1227.77	1162.86	1014.71	812.35	748.09	663.27	626.02	623.11	599.84	518.16	504.06	523.34	496.06	501.84	511.34	516.99
B. Manure management	274.92	274.92	255.78	203.20	163.29	157.37	141.53	114.27	116.63	117.21	104.84	106.27	115.63	114.32	121.56	127.20	138.38
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	1112.54	1112.54	1091.45	909.93	693.09	616.10	541.08	500.88	512.84	541.15	461.17	492.05	463.38	433.00	471.45	505.78	508.06
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Liming	12.11	12.11	11.17	2.60	2.38	2.16	3.59	3.65	5.76	24.95	25.84	19.41	20.83	18.83	16.85	9.73	7.22
H. Urea application	1.00	1.00	0.93	0.49	0.20	0.66	0.64	0.59	0.48	0.36	0.46	0.43	0.45	0.28	0.39	0.65	1.41
I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry [2]	**-3159.90**	**-3159.90**	**-3031.74**	**-2025.94**	**-3175.53**	**-2621.07**	**-2799.39**	**-3156.20**	**-3272.06**	**-3742.13**	**-3331.04**	**-4204.98**	**-4331.25**	**-4042.78**	**-6055.30**	**-4319.08**	**-1275.73**
A. Forest land	-4028.81	-4028.81	-4045.71	-4067.66	-4102.49	-4163.72	-4169.20	-4207.57	-4245.03	-4284.90	-4328.55	-4460.60	-4380.26	-4438.42	-6321.46	-4637.10	-2244.68
B. Cropland	667.40	667.40	718.41	675.48	507.91	361.96	316.75	259.26	334.85	388.32	342.98	301.86	117.20	9.11	37.81	-10.53	65.66
C. Grassland	46.76	46.76	46.26	64.09	80.50	103.98	127.94	142.42	135.34	155.10	141.27	134.40	110.00	97.37	56.53	63.67	31.97
D. Wetlands	311.03	311.03	270.10	1191.91	275.79	1050.91	947.00	791.75	906.64	424.38	1177.06	757.88	885.54	1368.72	1111.98	871.18	1178.69
E. Settlements	NO,NE,NA	NO,NE,NA	1.81	2.16	2.52	6.32	6.81	5.94	7.84	8.97	6.55	8.85	42.32	77.48	160.10	202.69	264.85
F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	11.01	35.22
G. Harvested wood products	-156.27	-156.27	-22.62	108.05	60.19	19.43	-28.75	-148.10	-411.81	-434.16	-670.54	-947.59	-1106.32	-1157.39	-1100.76	-820.65	-608.41
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Waste	**369.93**	**369.93**	**382.78**	**394.21**	**411.91**	**410.40**	**397.97**	**435.64**	**491.47**	**508.51**	**515.44**	**562.45**	**570.03**	**557.94**	**546.46**	**540.17**	**515.18**
A. Solid waste disposal	213.72	213.72	228.61	241.88	264.85	265.11	253.80	297.12	356.20	388.59	394.98	437.60	447.59	440.12	420.49	422.31	388.48
B. Biological treatment of solid waste	1.16	1.16	1.22	1.28	1.35	1.42	1.53	1.03	1.92	0.35	1.10	3.26	3.08	2.81	11.55	11.25	16.05
C. Incineration and open burning of waste	3.70	3.70	3.70	4.08	3.62	4.38	4.98	4.54	4.75	4.71	5.47	5.07	3.77	4.04	4.35	2.29	2.33
D. Waste water treatment and discharge	151.35	151.35	149.26	146.97	142.09	139.50	137.67	132.95	128.59	114.86	113.88	116.52	115.59	110.98	110.07	104.32	108.32
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Other (as specified in summary 1.A)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items:																	
International bunkers	684.98	684.98	790.46	429.52	531.70	447.09	332.09	337.92	384.61	384.11	419.06	398.22	369.72	428.68	418.65	570.72	518.09
Aviation	107.67	107.67	110.16	36.20	53.98	44.29	50.92	47.17	65.89	46.79	66.09	64.13	51.57	54.13	62.87	93.90	137.81
Navigation	577.32	577.32	680.30	393.32	477.72	402.80	281.18	290.75	318.72	337.32	352.96	334.09	318.15	374.55	355.78	476.82	380.28
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	1124.93	1124.93	1136.35	1014.50	963.09	1658.69	2304.90	2844.50	2823.55	2372.29	2430.47	2398.49	2527.16	2562.61	2693.50	2801.68	2726.16
CO_2 captured	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
Long-term storage of C in waste disposal sites	1751.44	1751.44	1761.65	1843.53	1871.01	2094.59	2259.90	2285.33	2384.17	2159.77	1849.46	2008.01	2053.53	2130.25	2633.60	2538.32	2540.89
Indirect N_2O	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
Indirect CO_2 [3]	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE
Total CO_2 equivalent emissions without land use, land-use change and forestry	**40175.17**	**40175.17**	**37295.32**	**27136.66**	**21688.57**	**22181.18**	**20080.53**	**21033.53**	**20750.10**	**19000.00**	**17851.35**	**17479.52**	**17909.59**	**17313.11**	**19262.29**	**19390.54**	**19157.48**
Total CO_2 equivalent emissions with land use, land-use change and forestry	**37015.28**	**37015.28**	**34263.58**	**25110.71**	**18513.04**	**19560.12**	**17281.14**	**17877.33**	**17478.05**	**15257.86**	**14520.30**	**13274.54**	**13578.34**	**13270.32**	**13206.98**	**15071.46**	**17881.75**
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Note: All footnotes for this table are given at the end of the table on **page 198.**

(Page 2 of 2)

NO – not occurring NE – not estimated
NA – not applicable IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year, %
	(kt CO_2 eq)															
Total (net emissions)[2]	**15817.59**	**19148.05**	**17323.76**	**12766.86**	**16345.42**	**16311.88**	**16476.44**	**19769.32**	**19420.86**	**15908.67**	**17627.09**	**19698.37**	**18687.44**	**14301.56**	**12853.08**	**-65.28**
1. Energy	**16065.92**	**19428.50**	**17322.73**	**14368.48**	**18899.50**	**18747.17**	**17328.20**	**19144.02**	**18593.00**	**15773.45**	**17519.24**	**18585.32**	**17770.83**	**12210.92**	**9461.45**	**-73.87**
A. Fuel combustion (sectoral approach)	16023.29	19385.80	17281.73	14340.39	18869.40	18720.20	17299.12	19114.51	18569.84	15752.71	17495.40	18564.41	17748.31	12189.96	9442.75	-73.88
1. Energy industries	11890.35	14850.62	12916.63	10684.26	15038.58	14706.07	13234.95	15074.60	14521.50	11862.68	13 512.41	14 483.00	13 639.33	8 203.31	5 847.70	-79.33
2. Manufacturing industries and construction	1033.75	1319.18	1213.05	766.22	792.61	917.17	915.94	950.70	877.06	658.11	696.16	734.05	740.19	716.38	511.27	-85.29
3. Transport	2324.01	2450.07	2372.16	2153.12	2288.39	2277.76	2299.82	2251.30	2256.28	2318.49	2 365.86	2 450.68	2 468.41	2 401.82	2 232.54	-10.05
4. Other sectors	775.18	765.92	779.89	736.79	749.82	819.19	848.41	837.91	915.00	913.42	920.96	896.67	900.38	868.45	851.23	-55.28
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
B. Fugitive emissions from fuels	42.63	42.71	40.99	28.09	30.10	26.98	29.07	29.51	23.16	20.74	23.84	20.91	22.52	20.96	18.70	-70.85
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
2. Oil and natural gas and other emissions from energy production	42.63	42.71	40.99	28.09	30.10	26.98	29.07	29.51	23.16	20.74	23.84	20.91	22.52	20.96	18.70	-70.85
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
2. Industrial processes	**767.07**	**960.05**	**967.69**	**478.45**	**539.51**	**663.63**	**909.07**	**1000.03**	**712.45**	**517.03**	**503.67**	**640.57**	**628.54**	**621.35**	**295.47**	**-69.34**
A. Mineral industry	460.68	645.80	644.12	281.14	338.51	452.19	669.10	694.29	464.28	262.84	237.20	374.67	363.04	359.22	70.31	-88.55
B. Chemical industry	117.58	110.64	141.62	14.19	NO	NO	16.62	68.63	NO	NO	NO	NO	NO	NO	NO	
C. Metal industry	2.37	2.45	2.49	2.39	2.45	3.15	3.37	3.10	3.04	3.03	3.48	3.42	3.35	3.29	2.90	282.06
D. Non-energy products from fuels and solvent use	24.12	24.28	21.88	16.39	15.50	17.19	19.40	19.27	20.81	21.59	22.30	24.67	24.02	26.54	31.50	-12.12
E. Electronic industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		
F. Product uses as ODS substitutes	155.05	170.89	150.94	158.13	176.11	183.98	193.91	208.11	218.20	223.35	234.30	231.76	232.36	226.33	184.74	100.00
G. Other product manufacture and use	7.26	5.99	6.64	6.22	6.94	7.11	6.67	6.62	6.11	6.22	6.39	6.05	5.78	5.96	6.01	10.36
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
3. Agriculture	**1169.22**	**1222.79**	**1281.22**	**1223.39**	**1253.80**	**1277.57**	**1359.61**	**1391.84**	**1437.90**	**1408.52**	**1369.13**	**1420.76**	**1417.62**	**1501.48**	**1508.38**	**-42.61**
A. Enteric fermentation	518.82	513.97	511.39	505.93	511.26	515.70	534.13	561.67	566.16	519.92	511.99	518.98	519.86	526.73	523.46	-57.36
B. Manure management	146.81	156.89	159.77	165.86	179.08	185.72	196.23	206.79	214.35	197.99	196.22	210.06	218.07	226.01	235.53	-14.33
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
D. Agricultural soils	497.01	546.13	604.73	550.18	554.08	572.21	622.24	616.91	648.72	681.54	646.89	675.32	660.29	733.14	733.51	-34.07
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
F. Field burning of agricultural residues	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
G. Liming	5.80	4.24	5.14	1.20	9.37	3.93	6.98	6.11	8.64	9.04	14.00	16.30	19.27	15.46	15.73	29.87
H. Urea application	0.76	1.55	0.18	0.22	0.01	0.01	0.03	0.37	0.02	0.03	0.03	0.10	0.13	0.13	0.13	-86.68
I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
4. Land use, land-use change and forestry[2]	**-2684.38**	**-2957.72**	**-2726.51**	**-3804.04**	**-4835.38**	**-4822.26**	**-3547.01**	**-2161.87**	**-1683.59**	**-2128.02**	**-2094.50**	**-1267.10**	**-1438.30**	**-334.56**	**1297.27**	**-141.05**
A. Forest land	-3849.27	-3918.06	-3723.45	-4887.03	-5629.05	-5508.95	-4271.23	-3384.53	-2822.70	-3308.88	-3 048.94	-2 439.09	-2 825.63	-1 617.96	139.17	-103.45
B. Cropland	30.59	66.17	74.01	87.31	69.49	-5.11	7.84	151.83	354.08	465.33	526.88	440.42	373.39	383.15	417.00	-37.52
C. Grassland	38.54	54.04	56.69	22.72	28.92	17.17	-4.60	-3.62	17.36	25.90	40.01	87.81	80.32	69.60	64.14	37.19
D. Wetlands	1286.25	815.00	914.83	979.45	1063.09	1061.45	900.56	1294.33	1031.54	1068.55	810.49	1 140.67	1 466.92	1 285.88	1 130.77	263.56
E. Settlements	332.58	369.44	362.94	386.31	383.62	400.32	439.28	439.37	455.17	492.82	502.27	473.15	472.88	443.61	394.58	100.00
F. Other land	103.09	107.68	120.23	114.01	94.29	29.49	29.78	23.47	41.69	42.70	80.84	83.02	83.57	67.22	68.27	100.00
G. Harvested wood products	-627.54	-453.81	-533.99	-509.49	-848.75	-819.88	-652.22	-686.62	-764.92	-918.97	-1 010.92	-1 058.16	-1 095.05	-971.53	-922.24	490.14
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
5. Waste	**499.77**	**494.43**	**478.62**	**500.59**	**488.00**	**445.77**	**426.58**	**395.30**	**361.10**	**337.69**	**329.55**	**318.82**	**308.74**	**302.38**	**290.51**	**-21.47**
A. Solid waste disposal	370.33	349.14	342.65	361.61	355.18	327.20	300.53	261.09	234.62	213.60	195.16	192.06	181.52	181.77	173.91	-18.63
B. Biological treatment of solid waste	16.69	32.98	30.74	35.14	33.45	22.88	25.45	35.23	31.10	33.13	44.86	39.92	42.04	34.39	31.22	2586.25
C. Incineration and open burning of waste	1.22	1.23	1.70	1.46	1.31	1.25	1.31	1.57	1.50	0.79	0.89	0.81	0.87	0.87	0.78	-78.90
D. Waste water treatment and discharge	111.52	111.08	103.53	102.38	98.06	94.44	99.28	97.41	93.88	90.18	88.64	86.03	84.31	85.35	84.60	-44.10
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
6. Other (as specified in summary 1.A)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**
Memo items:																
International bunkers	822.96	964.88	1004.43	825.87	804.14	731.10	1449.92	1480.37	1172.53	1064.54	996.56	1195.12	1164.42	777.97	982.62	43.45
Aviation	147.78	179.23	204.86	111.36	102.17	137.75	181.00	144.46	144.55	151.56	139.07	180.87	210.38	212.13	72.72	-32.46
Navigation	675.18	785.65	799.58	714.52	701.97	593.35	1268.92	1335.91	1027.98	912.98	857.50	1 014.25	954.04	565.84	909.90	57.61
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass	2458.90	2780.35	2985.41	3286.00	3886.65	3755.54	3837.15	3771.76	3765.96	3933.57	4 291.15	4 612.50	5 058.67	5 135.56	5 567.02	394.88
CO_2 captured	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	0.00
Long-term storage of C in waste disposal sites	2380.26	2615.46	2628.61	2338.40	3193.40	2541.05	2232.79	2936.98	3738.69	3356.28	3 529.36	3 631.19	3 624.52	2 059.24	1 643.24	-6.18
Indirect N_2O	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	0.00
Indirect CO_2[3]	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	0.00
Total CO_2 equivalent emissions without land use, land-use change and forestry	**18501.97**	**22105.77**	**20050.26**	**16570.91**	**21180.81**	**21134.14**	**20023.45**	**21931.18**	**21104.45**	**18036.69**	**19721.59**	**20965.47**	**20125.74**	**14636.12**	**11555.81**	**-71.24**
Total CO_2 equivalent emissions with land use, land-use change and forestry	**15817.59**	**19148.05**	**17323.76**	**12766.86**	**16345.42**	**16311.88**	**16476.44**	**19769.32**	**19420.86**	**15908.67**	**17627.09**	**19698.37**	**18687.44**	**14301.56**	**12853.08**	**-65.28**
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**0.00**
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Note: All footnotes for this table are given at the end of the table on **page 198.**

TABLE 10 EMISSION TRENDS (CO_2)

(Page 1 of 2)

NO – not occurring
NA – not applicable
NE – not estimated
IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(kt)																
1. Energy	**35948.56**	**35948.56**	**33163.98**	**23865.55**	**19108.25**	**19472.37**	**17461.46**	**18428.69**	**18024.45**	**16221.01**	**15309.32**	**14871.61**	**15251.63**	**14914.91**	**16770.73**	**16715.91**	**16514.68**
A. Fuel combustion (sectoral approach)	35948.46	35948.46	33163.88	23865.49	19108.22	19472.33	17461.42	18428.64	18024.40	16220.97	15309.27	14871.56	15251.57	14914.86	16770.67	16715.84	16514.62
1. Energy industries	28270.64	28270.64	25890.50	19706.58	15169.18	15762.63	13792.87	14458.41	14306.67	12611.41	12225.32	11721.04	11413.02	11297.88	13032.01	12912.80	12613.15
2. Manufacturing industries and construction	3466.21	3466.21	3350.57	1948.53	1811.06	1535.11	1502.28	1582.56	1341.07	1205.86	858.24	908.92	1108.39	810.42	947.05	991.26	1031.13
3. Transport	2421.43	2421.43	2192.97	1134.28	1274.86	1569.78	1546.91	1629.60	1724.17	1787.10	1660.91	1639.59	1956.16	2085.57	2008.44	2047.14	2124.05
4. Other sectors	1790.18	1790.18	1729.85	1076.10	853.12	604.80	619.36	758.07	652.49	616.59	564.81	602.00	774.00	720.99	783.17	764.65	746.29
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	0.10	0.10	0.10	0.06	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.06	0.06
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	0.10	0.10	0.10	0.06	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.06	0.06
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Industrial processes	**958.29**	**958.29**	**960.30**	**551.81**	**326.83**	**568.37**	**597.73**	**606.92**	**651.30**	**693.21**	**616.78**	**606.11**	**625.20**	**446.72**	**488.37**	**614.62**	**585.02**
A. Mineral industry	613.95	613.95	621.95	380.00	246.08	346.96	364.36	377.22	413.91	436.01	387.47	399.87	407.48	391.01	372.83	405.39	413.59
B. Chemical industry	307.73	307.73	301.22	145.43	57.88	194.24	207.83	202.81	211.40	228.44	203.12	180.78	195.35	31.33	92.17	184.47	146.36
C. Metal industry	0.76	0.76	0.65	0.34	0.23	0.67	0.65	0.71	1.02	1.46	1.32	1.55	1.45	1.39	0.68	1.65	1.52
D. Non-energy products from fuels and solvent use	35.84	35.84	36.49	26.04	22.64	26.51	24.89	26.17	24.97	27.30	24.86	23.90	20.91	23.00	22.68	23.10	23.55
E. Electronic industry																	
F. Product uses as ODS substitutes																	
G. Other product manufacture and use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	**13.11**	**13.11**	**12.10**	**3.09**	**2.58**	**2.81**	**4.23**	**4.24**	**6.24**	**25.31**	**26.30**	**19.85**	**21.28**	**19.11**	**17.24**	**10.38**	**8.63**
A. Enteric fermentation																	
B. Manure management																	
C. Rice cultivation																	
D. Agricultural soils																	
E. Prescribed burning of savannas																	
F. Field burning of agricultural residues																	
G. Liming	12.11	12.11	11.17	2.60	2.38	2.16	3.59	3.65	5.76	24.95	25.84	19.41	20.83	18.83	16.85	9.73	7.22
H. Urea application	1.00	1.00	0.93	0.49	0.20	0.66	0.64	0.59	0.48	0.36	0.46	0.43	0.45	0.28	0.39	0.65	1.41
I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry [2]	**-3486.97**	**-3486.97**	**-3358.74**	**-2356.09**	**-3504.08**	**-2949.69**	**-3127.98**	**-3485.92**	**-3603.21**	**-4071.84**	**-3662.45**	**-4537.44**	**-4663.24**	**-4378.83**	**-6389.73**	**-4655.15**	**-1612.85**
A. Forest land	-4353.41	-4353.41	-4370.21	-4395.16	-4428.43	-4489.71	-4495.12	-4534.52	-4573.26	-4611.63	-4656.76	-4789.78	-4708.79	-4770.49	-6651.34	-4967.71	-2574.77
B. Cropland	667.40	667.40	718.41	675.48	507.91	361.96	316.75	259.26	334.85	388.32	342.98	301.86	117.19	9.10	37.79	-10.61	65.44
C. Grassland	46.74	46.74	46.25	63.98	80.46	103.96	127.93	142.38	135.27	155.10	141.15	134.37	109.99	97.21	56.52	63.65	31.97
D. Wetlands	308.58	308.58	267.65	1189.47	273.34	1048.47	944.56	789.33	904.24	422.01	1174.72	755.57	883.27	1366.47	1109.75	868.96	1176.49
E. Settlements	NO,NE,NA	NO,NE,NA	1.78	2.11	2.43	6.20	6.65	5.73	7.51	8.53	6.00	8.13	41.42	76.27	158.32	200.23	261.41
F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	10.99	35.02
G. Harvested wood products	-156.27	-156.27	-22.62	108.05	60.19	19.43	-28.75	-148.10	-411.81	-434.16	-670.54	-947.59	-1106.32	-1157.39	-1100.76	-820.65	-608.41
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Waste	**2.25**	**2.25**	**2.25**	**2.45**	**2.21**	**2.60**	**2.99**	**2.46**	**2.58**	**2.65**	**2.81**	**2.82**	**2.21**	**2.38**	**2.64**	**1.39**	**1.46**
A. Solid waste disposal	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Biological treatment of solid waste																	
C. Incineration and open burning of waste	2.25	2.25	2.25	2.45	2.21	2.60	2.99	2.46	2.58	2.65	2.81	2.82	2.21	2.38	2.64	1.39	1.46
D. Waste water treatment and discharge																	
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Other (as specified in summary 1.A)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items:																	
International bunkers	678.34	678.34	782.76	425.27	526.41	442.64	328.83	334.59	380.86	380.34	414.96	394.32	366.07	424.44	414.53	565.14	513.09
Aviation	106.75	106.75	109.21	35.89	53.52	43.92	50.49	46.76	65.33	46.38	65.53	63.58	51.13	53.66	62.33	93.09	136.64
Navigation	571.59	571.59	673.55	389.38	472.89	398.72	278.34	287.83	315.53	333.95	349.43	330.74	314.94	370.78	352.20	472.04	376.45
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	1124.93	1124.93	1136.35	1014.50	963.09	1658.69	2304.90	2844.50	2823.55	2372.29	2430.47	2398.49	2527.16	2562.61	2693.50	2801.68	2726.16
CO_2 captured	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	
Long-term storage of C in waste disposal sites	1751.44	1751.44	1761.65	1843.53	1871.01	2094.59	2259.90	2285.33	2384.17	2159.77	1849.46	2008.01	2053.53	2130.25	2633.60	2538.32	2540.89
Indirect N_2O																	
Indirect CO_2 [3]	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE
Total CO_2 equivalent emissions without land use, land-use change and forestry	**36922.21**	**36922.21**	**34138.63**	**24422.90**	**19439.86**	**20046.15**	**18066.41**	**19042.31**	**18684.56**	**16942.19**	**15955.20**	**15500.38**	**15900.31**	**15383.12**	**17278.98**	**17342.30**	**17109.78**
Total CO_2 equivalent emissions with land use, land-use change and forestry	**33435.24**	**33435.24**	**30779.89**	**22066.81**	**15935.78**	**17096.46**	**14938.43**	**15556.39**	**15081.35**	**12870.35**	**12292.76**	**10962.94**	**11237.07**	**11004.29**	**10889.25**	**12687.15**	**15496.94**
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Note: All footnotes for this table are given at the end of the table on **page 198.**

(Page 2 of 2)

NO – not occurring NE – not estimated
NA – not applicable IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	(kt)															%
1. Energy	**15842.32**	**19176.76**	**17073.70**	**14124.18**	**18635.84**	**18506.95**	**17078.47**	**18905.09**	**18362.62**	**15549.86**	**17281.74**	**18342.79**	**17524.68**	**11974.97**	**9221.94**	**-74.35**
A. Fuel combustion (sectoral approach)	15842.26	19176.69	17073.64	14124.14	18635.80	18506.90	17078.43	18905.05	18362.59	15549.83	17281.71	18342.76	17524.65	11974.94	9221.91	-74.35
1. Energy industries	11878.12	14838.69	12904.49	10666.71	15013.80	14677.08	13204.41	15048.79	14494.91	11834.64	13 479.92	14 447.31	13 602.24	8 166.44	5 808.56	-79.45
2. Manufacturing industries and construction	1028.69	1311.92	1205.30	761.65	788.16	910.95	909.92	944.16	869.99	653.28	691.72	727.55	734.25	711.74	508.51	-85.33
3. Transport	2280.38	2408.67	2336.25	2117.56	2247.60	2242.94	2266.38	2219.79	2227.15	2288.34	2 336.68	2 420.94	2 438.21	2 373.18	2 205.13	-8.93
4. Other sectors	655.06	617.42	627.59	578.21	586.23	675.94	697.73	692.31	770.54	773.56	773.39	746.96	749.95	723.59	699.70	-60.91
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
B. Fugitive emissions from fuels	0.06	0.06	0.06	0.04	0.05	0.04	0.04	0.04	0.04	0.03	0.04	0.03	0.03	0.03	0.03	-70.85
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
2. Oil and natural gas and other emissions from energy production	0.06	0.06	0.06	0.04	0.05	0.04	0.04	0.04	0.04	0.03	0.04	0.03	0.03	0.03	0.03	-70.85
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
2. Industrial processes	**604.76**	**783.16**	**810.11**	**314.10**	**356.46**	**472.53**	**708.49**	**785.30**	**488.14**	**287.46**	**262.98**	**402.77**	**390.41**	**389.06**	**104.72**	**-89.07**
A. Mineral industry	460.68	645.80	644.12	281.14	338.51	452.19	669.10	694.29	464.28	262.84	237.20	374.67	363.04	359.22	70.31	-88.55
B. Chemical industry	117.58	110.64	141.62	14.19	NO	NO	16.62	68.63	NO	NO	NO	NO	NO	NO	NO	
C. Metal industry	2.37	2.45	2.49	2.39	2.45	3.15	3.37	3.10	3.04	3.03	3.48	3.42	3.35	3.29	2.90	282.06
D. Non-energy products from fuels and solvent use	24.12	24.28	21.88	16.39	15.50	17.19	19.40	19.27	20.81	21.59	22.30	24.67	24.02	26.54	31.50	-12.12
E. Electronic industry																
F. Product uses as ODS substitutes																
G. Other product manufacture and use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
3. Agriculture	**6.56**	**5.80**	**5.32**	**1.42**	**9.37**	**3.94**	**7.01**	**6.47**	**8.67**	**9.07**	**14.03**	**16.40**	**19.41**	**15.60**	**15.86**	**21.00**
A. Enteric fermentation																
B. Manure management																
C. Rice cultivation																
D. Agricultural soils																
E. Prescribed burning of savannas																
F. Field burning of agricultural residues																
G. Liming	5.80	4.24	5.14	1.20	9.37	3.93	6.98	6.11	8.64	9.04	14.00	16.30	19.27	15.46	15.73	29.87
H. Urea application	0.76	1.55	0.18	0.22	0.01	0.01	0.03	0.37	0.02	0.03	0.03	0.10	0.13	0.13	0.13	-86.68
I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
4. Land use, land-use change and forestry (2)	**-3031.03**	**-3299.70**	**-3072.05**	**-4151.12**	**-5184.38**	**-5172.82**	**-3899.65**	**-2516.42**	**-2040.19**	**-2487.19**	**-2455.93**	**-1629.23**	**-1804.48**	**-698.77**	**932.20**	**-126.73**
A. Forest land	-4186.56	-4248.40	-4054.89	-5217.78	-5959.92	-5840.04	-4602.63	-3716.19	-3154.70	-3641.47	-3 381.92	-2 771.70	-3 161.03	-1 950.51	-193.38	-95.56
B. Cropland	30.17	65.50	73.06	86.10	68.09	-6.66	6.14	149.96	351.96	462.95	524.22	437.50	370.28	379.94	413.74	-38.01
C. Grassland	38.45	54.00	56.54	22.72	28.92	17.17	-4.61	-3.62	17.36	25.77	39.89	87.80	80.22	69.59	63.87	36.63
D. Wetlands	1284.03	812.77	912.58	977.17	1060.79	1059.14	898.24	1292.01	1029.21	1066.22	808.15	1 138.31	1 464.55	1 283.50	1 128.40	265.68
E. Settlements	327.84	363.35	355.54	377.56	373.77	389.53	427.23	426.15	440.83	477.32	485.66	455.97	455.10	425.24	375.84	100.00
F. Other land	102.59	106.88	119.11	112.60	92.74	27.92	28.20	21.89	40.07	41.00	79.00	81.04	81.44	64.99	65.98	100.00
G. Harvested wood products	-627.54	-453.81	-533.99	-509.49	-848.75	-819.88	-652.22	-686.62	-764.92	-918.97	-1 010.92	-1 058.16	-1 095.05	-971.53	-922.24	490.14
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
5. Waste	**0.69**	**0.66**	**1.10**	**0.94**	**0.84**	**0.80**	**0.86**	**1.04**	**0.97**	**0.51**	**0.60**	**0.53**	**0.58**	**0.57**	**0.49**	**-78.11**
A. Solid waste disposal	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
B. Biological treatment of solid waste																
C. Incineration and open burning of waste	0.69	0.66	1.10	0.94	0.84	0.80	0.86	1.04	0.97	0.51	0.60	0.53	0.58	0.57	0.49	-78.11
D. Waste water treatment and discharge																
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
6. Other (as specified in summary 1.A)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**
Memo items:																
International bunkers	814.97	955.55	994.75	817.85	796.30	724.03	1435.76	1465.99	1161.17	1054.05	986.71	1183.58	1153.18	770.77	973.09	43.45
Aviation	146.52	177.71	203.12	110.40	101.30	136.57	179.47	143.24	143.32	150.27	137.88	179.34	208.60	210.33	72.11	-32.45
Navigation	668.45	777.85	791.64	707.45	695.01	587.46	1256.29	1322.75	1017.86	903.78	848.83	1 004.24	944.58	560.44	900.99	57.63
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass	2458.90	2780.35	2985.41	3286.00	3886.65	3755.54	3837.15	3771.76	3765.96	3933.57	4 291.15	4 612.50	5 058.67	5 135.56	5 567.02	394.88
CO_2 captured	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	0.00
Long-term storage of C in waste disposal sites	2380.26	2615.46	2628.61	2338.40	3193.40	2541.05	2232.79	2936.98	3738.69	3356.28	3 529.36	3 631.19	3 624.52	2 059.24	1 643.24	-6.18
Indirect N_2O																
Indirect CO_2 (3)	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	0.00
Total CO_2 equivalent emissions without land use, land-use change and forestry	**16454.33**	**19966.38**	**17890.23**	**14440.65**	**19002.52**	**18984.22**	**17794.83**	**19697.91**	**18860.40**	**15846.90**	**17559.35**	**18762.49**	**17935.07**	**12380.19**	**9343.01**	**-74.70**
Total CO_2 equivalent emissions with land use, land-use change and forestry	**13423.30**	**16666.67**	**14818.18**	**10289.52**	**13818.14**	**13811.40**	**13895.17**	**17181.48**	**16820.21**	**13359.71**	**15103.42**	**17133.25**	**16130.59**	**11681.42**	**10275.21**	**-69.27**
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**0.00**
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**0.00**

Note: All footnotes for this table are given at the end of the table on **page 198.**

TABLE 10 EMISSION TRENDS (CH_4)

(Page 1 of 2)

NO – not occurring
NA – not applicable
NE – not estimated
IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(kt)																
1. Energy	7.68	7.68	7.62	5.04	3.96	4.91	7.11	8.30	8.31	6.76	6.58	6.67	6.74	6.26	6.70	6.91	6.40
A. Fuel combustion (sectoral approach)	5.11	5.11	5.05	3.54	3.22	3.84	5.89	6.95	7.00	5.52	5.36	5.26	5.23	5.00	5.26	5.27	4.72
1. Energy industries	0.12	0.12	0.10	0.06	0.07	0.08	0.06	0.06	0.07	0.07	0.07	0.07	0.06	0.07	0.06	0.06	0.06
2. Manufacturing industries and construction	0.11	0.11	0.11	0.06	0.05	0.05	0.06	0.07	0.06	0.05	0.04	0.05	0.07	0.05	0.06	0.07	0.07
3. Transport	0.88	0.88	0.83	0.37	0.41	0.55	0.49	0.54	0.57	0.56	0.51	0.46	0.53	0.47	0.42	0.38	0.39
4. Other sectors	4.01	4.01	4.01	3.04	2.70	3.17	5.27	6.28	6.31	4.83	4.73	4.68	4.57	4.40	4.73	4.76	4.19
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	2.56	2.56	2.58	1.50	0.75	1.07	1.22	1.35	1.31	1.24	1.22	1.40	1.50	1.26	1.44	1.64	1.69
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	2.56	2.56	2.58	1.50	0.75	1.07	1.22	1.35	1.31	1.24	1.22	1.40	1.50	1.26	1.44	1.64	1.69
C. CO_2 transport and storage																	
2. Industrial processes	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
A. Mineral industry																	
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Non-energy products from fuels and solvent use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Electronic industry																	
F. Product uses as ODS substitutes																	
G. Other product manufacture and use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	55.69	55.69	52.58	45.12	36.10	33.51	29.86	27.58	27.53	26.66	23.13	22.59	23.60	22.53	23.01	23.60	24.11
A. Enteric fermentation	49.11	49.11	46.51	40.59	32.49	29.92	26.53	25.04	24.92	23.99	20.73	20.16	20.93	19.84	20.07	20.45	20.68
B. Manure management	6.58	6.58	6.07	4.53	3.60	3.59	3.33	2.54	2.61	2.66	2.41	2.43	2.67	2.69	2.94	3.14	3.43
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Liming																	
H. Urea application																	
I. Other carbon-containing fertilizers																	
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry [2]	2.57	2.57	2.56	2.66	2.60	2.59	2.58	2.61	2.64	2.58	2.62	2.63	2.59	2.70	2.61	2.63	2.61
A. Forest land	2.56	2.56	2.55	2.66	2.59	2.59	2.57	2.60	2.64	2.58	2.61	2.63	2.59	2.70	2.61	2.63	2.61
B. Cropland	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA
C. Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Settlements	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Harvested wood products																	
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Waste	13.13	13.13	13.65	14.11	14.96	14.91	14.41	15.98	18.30	19.03	19.29	21.14	21.49	20.95	20.36	20.25	19.07
A. Solid waste disposal	8.55	8.55	9.14	9.68	10.59	10.60	10.15	11.88	14.25	15.54	15.80	17.50	17.90	17.60	16.82	16.89	15.54
B. Biological treatment of solid waste	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.02	0.04	0.01	0.03	0.08	0.07	0.07	0.27	0.26	0.37
C. Incineration and open burning of waste	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.07	0.07	0.07	0.09	0.08	0.05	0.06	0.06	0.03	0.03
D. Waste water treatment and discharge	4.51	4.51	4.43	4.35	4.29	4.21	4.15	4.00	3.94	3.41	3.37	3.48	3.46	3.22	3.22	3.06	3.13
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Other (as specified in summary 1.A)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total CH_4 emissions without CH_4 from LULUCF	76.50	76.50	73.86	64.27	55.02	53.34	51.38	51.86	54.14	52.44	49.00	50.40	51.83	49.74	50.08	50.75	49.58
Total CH_4 emissions with CH_4 from LULUCF	79.07	79.07	76.42	66.93	57.62	55.93	53.95	54.47	56.79	55.02	51.62	53.03	54.42	52.44	52.69	53.38	52.19
Memo items:																	
International bunkers	0.05	0.05	0.06	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navigation	0.05	0.05	0.06	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass																	
CO_2 captured																	
Long-term storage of C in waste disposal sites																	
Indirect N_2O																	
Indirect CO_2 [3]																	

Note: All footnotes for this table are given at the end of the table on **page 198.**

(Page 2 of 2)

NO – not occurring NE – not estimated
NA – not applicable IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	(kt)															%
1. Energy	**6.31**	**7.29**	**7.32**	**7.04**	**7.36**	**6.61**	**6.96**	**6.67**	**6.39**	**6.11**	**6.53**	**6.55**	**6.65**	**6.41**	**6.55**	**-14.73**
A. Fuel combustion (sectoral approach)	4.60	5.59	5.69	5.91	6.16	5.53	5.80	5.49	5.46	5.28	5.58	5.72	5.75	5.58	5.80	13.40
1. Energy industries	0.06	0.05	0.05	0.16	0.26	0.33	0.38	0.26	0.29	0.31	0.35	0.40	0.42	0.47	0.52	348.15
2. Manufacturing industries and construction	0.07	0.10	0.11	0.06	0.06	0.08	0.08	0.09	0.10	0.06	0.06	0.09	0.08	0.06	0.03	-68.29
3. Transport	0.38	0.36	0.32	0.27	0.25	0.23	0.20	0.18	0.16	0.16	0.16	0.15	0.15	0.15	0.12	-86.18
4. Other sectors	4.10	5.08	5.21	5.42	5.59	4.89	5.14	4.96	4.91	4.74	5.01	5.08	5.09	4.90	5.12	27.63
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
B. Fugitive emissions from fuels	1.70	1.71	1.64	1.12	1.20	1.08	1.16	1.18	0.93	0.83	0.95	0.84	0.90	0.84	0.75	-70.85
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
2. Oil and natural gas and other emissions from energy production	1.70	1.71	1.64	1.12	1.20	1.08	1.16	1.18	0.93	0.83	0.95	0.84	0.90	0.84	0.75	-70.85
C. CO_2 transport and storage																
2. Industrial processes	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**
A. Mineral industry																
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C. Metal industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
D. Non-energy products from fuels and solvent use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
E. Electronic industry																
F. Product uses as ODS substitutes																
G. Other product manufacture and use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
3. Agriculture	**24.43**	**24.65**	**24.64**	**24.63**	**25.12**	**25.55**	**26.67**	**28.15**	**28.62**	**26.08**	**25.72**	**26.45**	**26.77**	**27.29**	**27.46**	**-50.69**
A. Enteric fermentation	20.75	20.56	20.46	20.24	20.45	20.63	21.37	22.47	22.65	20.80	20.48	20.76	20.79	21.07	20.94	-57.36
B. Manure management	3.68	4.09	4.18	4.39	4.67	4.92	5.31	5.68	5.97	5.28	5.25	5.70	5.98	6.22	6.52	-0.91
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
D. Agricultural soils	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
F. Field burning of agricultural residues	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
G. Liming																
H. Urea application																
I. Other carbon-containing fertilizers																
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
4. Land use, land-use change and forestry [(2)]	**2.87**	**2.61**	**2.65**	**2.62**	**2.62**	**2.62**	**2.62**	**2.63**	**2.63**	**2.65**	**2.66**	**2.64**	**2.74**	**2.64**	**2.65**	**3.30**
A. Forest land	2.86	2.61	2.64	2.61	2.62	2.62	2.62	2.62	2.63	2.64	2.65	2.64	2.74	2.64	2.64	3.11
B. Cropland	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	0.00
C. Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	2211.40
D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-3.05
E. Settlements	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	0.00
F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
G. Harvested wood products																
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
5. Waste	**18.48**	**17.95**	**17.30**	**18.14**	**17.67**	**16.16**	**15.36**	**13.87**	**12.62**	**11.65**	**11.11**	**10.81**	**10.31**	**10.22**	**9.81**	**-25.28**
A. Solid waste disposal	14.81	13.97	13.71	14.46	14.21	13.09	12.02	10.44	9.38	8.54	7.81	7.68	7.26	7.27	6.96	-18.63
B. Biological treatment of solid waste	0.39	0.77	0.72	0.82	0.78	0.53	0.59	0.82	0.73	0.77	1.05	0.93	0.98	0.80	0.73	2586.25
C. Incineration and open burning of waste	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	-80.38
D. Waste water treatment and discharge	3.26	3.20	2.86	2.84	2.67	2.53	2.73	2.58	2.50	2.32	2.25	2.18	2.06	2.14	2.12	-53.00
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
6. Other (as specified in summary 1.A)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**
Total CH_4 emissions without CH_4 from LULUCF	**49.21**	**49.90**	**49.27**	**49.81**	**50.15**	**48.32**	**49.00**	**48.68**	**47.63**	**43.83**	**43.37**	**43.81**	**43.73**	**43.93**	**43.82**	**-42.72**
Total CH_4 emissions with CH_4 from LULUCF	**52.08**	**52.51**	**51.92**	**52.43**	**52.77**	**50.94**	**51.62**	**51.31**	**50.26**	**46.48**	**46.03**	**46.46**	**46.47**	**46.57**	**46.47**	**-41.23**
Memo items:																
International bunkers	0.06	0.07	0.07	0.07	0.06	0.06	0.12	0.12	0.09	0.09	0.08	0.09	0.09	0.05	0.08	59.41
Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-45.01
Navigation	0.06	0.07	0.07	0.06	0.06	0.05	0.11	0.12	0.09	0.08	0.08	0.09	0.09	0.05	0.08	61.75
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass																
CO_2 captured																
Long-term storage of C in waste disposal sites																
Indirect N_2O																
Indirect CO_2 [(3)]																

Note: All footnotes for this table are given at the end of the table on **page 198.**

TABLE 10 EMISSION TRENDS (N_2O)

(Page 1 of 2)

NO – not occurring
NA – not applicable
NE – not estimated
IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(kt)																
1. Energy	**0.24**	**0.24**	**0.23**	**0.15**	**0.15**	**0.17**	**0.19**	**0.22**	**0.22**	**0.21**	**0.20**	**0.20**	**0.22**	**0.23**	**0.22**	**0.22**	**0.23**
A. Fuel combustion (sectoral approach)	0.24	0.24	0.23	0.15	0.15	0.17	0.19	0.22	0.22	0.21	0.20	0.20	0.22	0.23	0.22	0.22	0.23
1. Energy industries	0.05	0.05	0.05	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04
2. Manufacturing industries and construction	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3. Transport	0.13	0.13	0.12	0.07	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.11	0.12	0.14	0.12	0.12	0.12
4. Other sectors	0.04	0.04	0.04	0.04	0.04	0.04	0.07	0.08	0.08	0.07	0.06	0.07	0.07	0.06	0.07	0.07	0.06
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. CO_2 transport and storage																	
2. Industrial processes	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**
A. Mineral industry																	
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Non-energy products from fuels and solvent use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Electronic industry																	
F. Product uses as ODS substitutes																	
G. Other product manufacture and use	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	**4.10**	**4.10**	**4.01**	**3.36**	**2.57**	**2.29**	**2.01**	**1.85**	**1.89**	**1.99**	**1.70**	**1.80**	**1.72**	**1.61**	**1.74**	**1.86**	**1.88**
A. Enteric fermentation																	
B. Manure management	0.37	0.37	0.35	0.30	0.25	0.23	0.20	0.17	0.17	0.17	0.15	0.15	0.16	0.16	0.16	0.16	0.18
C. Rice cultivation																	
D. Agricultural soils	3.73	3.73	3.66	3.05	2.33	2.07	1.82	1.68	1.72	1.82	1.55	1.65	1.55	1.45	1.58	1.70	1.70
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Liming																	
H. Urea application																	
I. Other carbon-containing fertilizers																	
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry [2]	**0.88**	**0.88**	**0.88**	**0.88**	**0.88**	**0.89**	**0.89**	**0.89**	**0.89**	**0.89**	**0.89**	**0.89**	**0.90**	**0.90**	**0.90**	**0.91**	**0.91**
A. Forest land	0.87	0.87	0.87	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.89	0.89	0.89	0.89	0.89
B. Cropland	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	0.00	0.00	0.00	0.00	0.00
C. Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Wetlands	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
E. Settlements	NO,NE,NA	NO,NE,NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00	0.00
G. Harvested wood products																	
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Waste	**0.13**	**0.13**	**0.13**	**0.13**	**0.12**	**0.12**	**0.12**	**0.11**	**0.11**	**0.10**	**0.10**	**0.10**	**0.10**	**0.11**	**0.12**	**0.11**	**0.12**
A. Solid waste disposal																	
B. Biological treatment of solid waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02
C. Incineration and open burning of waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Waste water treatment and discharge	0.13	0.13	0.13	0.13	0.12	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.10
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Other (as specified in summary 1.A)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total direct N_2O emissions without N_2O from LULUCF	**4.50**	**4.50**	**4.40**	**3.66**	**2.86**	**2.60**	**2.34**	**2.20**	**2.24**	**2.32**	**2.03**	**2.14**	**2.06**	**1.97**	**2.10**	**2.21**	**2.26**
Total direct N_2O emissions with N_2O from LULUCF	**5.38**	**5.38**	**5.28**	**4.54**	**3.74**	**3.49**	**3.23**	**3.09**	**3.13**	**3.21**	**2.92**	**3.03**	**2.96**	**2.87**	**3.00**	**3.12**	**3.17**
Memo items:																	
International bunkers	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navigation	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass																	
CO_2 captured																	
Long-term storage of C in waste disposal sites																	
Indirect N_2O	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
Indirect CO_2 [3]																	

Note: All footnotes for this table are given at the end of the table on **page 198.**

(Page 2 of 2)

NO – not occurring
NA – not applicable
NE – not estimated
IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	(kt)															%
1. Energy	**0.22**	**0.23**	**0.22**	**0.23**	**0.27**	**0.25**	**0.25**	**0.24**	**0.24**	**0.24**	**0.25**	**0.26**	**0.27**	**0.25**	**0.25**	**4.37**
A. Fuel combustion (sectoral approach)	0.22	0.23	0.22	0.23	0.27	0.25	0.25	0.24	0.24	0.24	0.25	0.26	0.27	0.25	0.25	4.37
1. Energy industries	0.04	0.04	0.04	0.05	0.06	0.07	0.07	0.06	0.06	0.07	0.08	0.09	0.09	0.08	0.09	76.66
2. Manufacturing industries and construction	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	-69.84
3. Transport	0.11	0.11	0.09	0.10	0.12	0.10	0.10	0.09	0.08	0.09	0.08	0.09	0.09	0.08	0.08	-36.78
4. Other sectors	0.06	0.07	0.07	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	80.55
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
B. Fugitive emissions from fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
2. Oil and natural gas and other emissions from energy production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C. CO_2 transport and storage																
2. Industrial processes	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**-43.28**
A. Mineral industry																
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C. Metal industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
D. Non-energy products from fuels and solvent use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
E. Electronic industry																
F. Product uses as ODS substitutes																
G. Other product manufacture and use	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-43.28
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
3. Agriculture	**1.85**	**2.02**	**2.21**	**2.03**	**2.07**	**2.13**	**2.30**	**2.29**	**2.40**	**2.51**	**2.39**	**2.49**	**2.45**	**2.70**	**2.70**	**-34.09**
A. Enteric fermentation																
B. Manure management	0.18	0.18	0.19	0.19	0.21	0.21	0.21	0.22	0.22	0.22	0.22	0.23	0.23	0.24	0.24	-34.33
C. Rice cultivation																
D. Agricultural soils	1.67	1.83	2.03	1.85	1.86	1.92	2.09	2.07	2.18	2.29	2.17	2.27	2.22	2.46	2.46	-34.07
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
F. Field burning of agricultural residues	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
G. Liming																
H. Urea application																
I. Other carbon-containing fertilizers																
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
4. Land use, land-use change and forestry (2)	**0.92**	**0.93**	**0.94**	**0.95**	**0.95**	**0.96**	**0.96**	**0.97**	**0.98**	**0.98**	**0.99**	**0.99**	**1.00**	**1.00**	**1.00**	**13.65**
A. Forest land	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.90	0.89	0.89	2.28
B. Cropland	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	100.00
C. Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2211.40
D. Wetlands	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-3.05
E. Settlements	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.06	100.00
F. Other land	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	100.00
G. Harvested wood products																
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
5. Waste	**0.12**	**0.15**	**0.15**	**0.15**	**0.15**	**0.14**	**0.14**	**0.16**	**0.15**	**0.15**	**0.17**	**0.16**	**0.17**	**0.16**	**0.15**	**13.55**
A. Solid waste disposal																
B. Biological treatment of solid waste	0.02	0.05	0.04	0.05	0.05	0.03	0.04	0.05	0.04	0.05	0.06	0.06	0.06	0.05	0.04	2586.25
C. Incineration and open burning of waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-78.73
D. Waste water treatment and discharge	0.10	0.10	0.11	0.11	0.11	0.11	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	-18.15
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
6. Other (as specified in summary 1.A)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**
Total direct N_2O emissions without N_2O from LULUCF	**2.22**	**2.42**	**2.60**	**2.43**	**2.50**	**2.54**	**2.71**	**2.70**	**2.79**	**2.91**	**2.82**	**2.93**	**2.89**	**3.12**	**3.12**	**-30.64**
Total direct N_2O emissions with N_2O from LULUCF	**3.14**	**3.34**	**3.54**	**3.38**	**3.46**	**3.49**	**3.67**	**3.67**	**3.77**	**3.90**	**3.81**	**3.92**	**3.89**	**4.12**	**4.12**	**-23.38**
Memo items:																
International bunkers	0.02	0.03	0.03	0.02	0.02	0.02	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02	39.27
Aviation	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	-32.54
Navigation	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.02	0.01	0.02	53.66
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass																
CO_2 captured																
Long-term storage of C in waste disposal sites																
Indirect N_2O	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	0.00
Indirect CO_2 (3)																

Note: All footnotes for this table are given at the end of the table on **page 198.**

TABLE 10 EMISSION TRENDS (HFCs, PFCs, SF_6, and NF_3)

(Page 1 of 2)

NO – not occurring
NA – not applicable
NE – not estimated
IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(kt)																
Emissions of HFCs and PFCs - (kt CO_2 equivalent)	**NO**	**NO**	**NO**	**17.51**	**20.02**	**22.91**	**28.45**	**34.56**	**41.31**	**52.25**	**63.39**	**79.15**	**97.19**	**98.83**	**104.87**	**119.33**	**134.96**
Emissions of HFCs - (kt CO_2 equivalent)	**NO**	**NO**	**NO**	**17.51**	**20.02**	**22.91**	**28.45**	**34.56**	**41.31**	**52.25**	**63.39**	**79.15**	**97.19**	**98.83**	**104.87**	**119.33**	**134.96**
HFC-23	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-32	NO	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-41	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-43-10mee	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-125	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
HFC-134	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-134a	NO	NO	NO	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05
HFC-143	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-143a	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
HFC-152	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-152a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00
HFC-161	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-227ea	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236cb	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-236ea	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-236fa	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-245ca	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-245fa	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-365mfc	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00	0.00
Unspecified mix of HFCs[4] - (kt CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions of PFCs - (kt CO_2 equivalent)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO,NA**	**NO,NA**	**NO,NA**
CF_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C_2F_6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C_3F_8	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA,NO	NA,NO	NA,NO
C_4F_{10}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
$c\text{-}C_4F_8$	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C_5F_{12}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C_6F_{14}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
$C_{10}F_{18}$	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
$c\text{-}C_3F_6$	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Unspecified mix of PFCs[4] - (kt CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs - (kt CO_2 equivalent)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Emissions of SF_6 - (kt CO_2 equivalent)	**NO**	**NO**	**0.05**	**0.09**	**1.39**	**2.97**	**3.07**	**3.33**	**2.85**	**2.86**	**2.88**	**2.61**	**1.68**	**1.39**	**1.30**	**1.07**	**1.08**
SF_6	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emissions of NF_3 - (kt CO_2 equivalent)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Note: All footnotes for this table are given at the end of the table on **page 198.**

(Page 2 of 2)

NO – not occurring
NA – not applicable
NE – not estimated
IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	(kt)															%
Emissions of HFCs and PFCs - (kt CO_2 equivalent)	**155.15**	**170.97**	**150.99**	**158.13**	**176.11**	**183.98**	**193.91**	**208.11**	**218.20**	**223.35**	**234.30**	**231.76**	**232.36**	**226.33**	**184.74**	**100.00**
Emissions of HFCs - (kt CO_2 equivalent)	**155.05**	**170.89**	**150.94**	**158.13**	**176.11**	**183.98**	**193.91**	**208.11**	**218.20**	**223.35**	**234.30**	**231.76**	**232.36**	**226.33**	**184.74**	**100.00**
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	100.00
HFC-41	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-43-10mee	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-125	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	100.00
HFC-134	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-134a	0.06	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.04	0.04	0.04	0.04	100.00
HFC-143	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-143a	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	100.00
HFC-152	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-152a	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.01	100.00
HFC-161	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-227ea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
HFC-236cb	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-236ea	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-236fa	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-245ca	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-245fa	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-365mfc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Unspecified mix of HFCs(4) - (kt CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Emissions of PFCs - (kt CO_2 equivalent)	**0.09**	**0.08**	**0.05**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**
CF_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C_2F_6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C_3F_8	0.00	0.00	0.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C_4F_{10}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
$c\text{-}C_4F_8$	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C_5F_{12}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C_6F_{14}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
$C_{10}F_{18}$	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
$c\text{-}C_3F_6$	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Unspecified mix of PFCs(4) - (kt CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Unspecified mix of HFCs and PFCs - (kt CO_2 equivalent)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**
Emissions of SF_6 - (kt CO_2 equivalent)	**1.17**	**1.04**	**1.45**	**1.50**	**1.83**	**1.87**	**1.99**	**2.12**	**2.21**	**2.35**	**2.64**	**2.55**	**2.67**	**2.84**	**2.92**	**100.00**
SF_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Emissions of NF_3 - (kt CO_2 equivalent)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00

Note: All footnotes for this table are given at the end of the table on **page 198.**

TABLE 10 EMISSION TRENDS (SUMMARY)

(Page 1 of 2)

NO – not occurring
NA – not applicable
NE – not estimated
IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 equivalent (kt)																
CO_2 emissions without net CO_2 from LULUCF	36922.21	36922.21	34138.63	24422.90	19439.86	20046.15	18066.41	19042.31	18684.56	16942.19	15955.20	15500.38	15900.31	15383.12	17278.98	17342.30	17109.78
CO_2 emissions with net CO_2 from LULUCF	33435.24	33435.24	30779.89	22066.81	15935.78	17096.46	14938.43	15556.39	15081.35	12870.35	12292.76	10962.94	11237.07	11004.29	10889.25	12687.15	15496.94
CH_4 emissions without CH_4 from LULUCF	1912.52	1912.52	1846.43	1606.63	1375.46	1333.38	1284.38	1296.53	1353.58	1311.05	1225.11	1259.91	1295.69	1243.43	1252.03	1268.80	1239.50
CH_4 emissions with CH_4 from LULUCF	1976.66	1976.66	1910.40	1673.22	1440.44	1398.15	1348.85	1361.70	1419.70	1375.55	1290.58	1325.76	1360.51	1311.05	1317.27	1334.56	1304.74
N_2O emissions without N_2O from LULUCF	1340.45	1340.45	1310.22	1089.53	851.84	775.77	698.21	656.80	667.79	691.65	604.76	637.47	614.73	586.34	625.12	659.04	672.16
N_2O emissions with N_2O from LULUCF	1603.37	1603.37	1573.24	1353.07	1115.41	1039.62	962.32	921.34	932.82	956.85	870.69	904.09	881.90	854.77	894.30	929.35	944.03
HFCs	NO	NO	NO	17.51	20.02	22.91	28.45	34.56	41.31	52.25	63.39	79.15	97.19	98.83	104.87	119.33	134.96
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	NO	NO	0.05	0.09	1.39	2.97	3.07	3.33	2.85	2.86	2.88	2.61	1.68	1.39	1.30	1.07	1.08
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (without LULUCF)	**40175.17**	**40175.17**	**37295.32**	**27136.66**	**21688.57**	**22181.18**	**20080.53**	**21033.53**	**20750.10**	**19000.00**	**17851.35**	**17479.52**	**17909.59**	**17313.11**	**19262.29**	**19390.54**	**19157.48**
Total (with LULUCF)	**37015.28**	**37015.28**	**34263.58**	**25110.71**	**18513.04**	**19560.12**	**17281.14**	**17877.33**	**17478.05**	**15257.86**	**14520.30**	**13274.54**	**13578.34**	**13270.32**	**13206.98**	**15071.46**	**17881.75**
Total (without LULUCF, with indirect)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total (with LULUCF, with indirect)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 equivalent (kt)																
1. Energy	36213.16	36213.16	33424.21	24036.91	19251.80	19646.39	17697.15	18701.35	18297.74	16452.74	15534.89	15098.87	15484.70	15139.28	17002.73	16954.07	16742.41
2. Industrial processes and product use	963.74	963.74	966.14	574.61	353.55	600.01	635.29	651.14	702.07	755.23	690.55	695.97	731.23	553.40	601.01	741.59	727.83
3. Agriculture	2628.34	2628.34	2522.19	2130.93	1671.31	1524.38	1350.11	1245.41	1258.82	1283.51	1110.47	1122.23	1123.63	1062.48	1112.09	1154.70	1172.06
4. Land use, land-use change and forestry[5]	-3159.90	-3159.90	-3031.74	-2025.94	-3175.53	-2621.07	-2799.39	-3156.20	-3272.06	-3742.13	-3331.04	-4204.98	-4331.25	-4042.78	-6055.30	-4319.08	-1275.73
5. Waste	369.93	369.93	382.78	394.21	411.91	410.40	397.97	435.64	491.47	508.51	515.44	562.45	570.03	557.94	546.46	540.17	515.18
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)[5]	**37015.28**	**37015.28**	**34263.58**	**25110.71**	**18513.04**	**19560.12**	**17281.14**	**17877.33**	**17478.05**	**15257.86**	**14520.30**	**13274.54**	**13578.34**	**13270.32**	**13206.98**	**15071.46**	**17881.75**

Note: All footnotes for this table are given at the end of the table on **page 198.**

(Page 2 of 2)

NO – not occurring
NA – not applicable
NE – not estimated
IE – included elsewhere

Inventory 2020
Submission 2022 v4
ESTONIA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	CO_2 equivalent (kt)															%
CO_2 emissions without net CO_2 from LULUCF	16454.33	19966.38	17890.23	14440.65	19002.52	18984.22	17794.83	19697.91	18860.40	15846.90	17559.35	18762.49	17935.07	12380.19	9343.01	-74.70
CO_2 emissions with net CO_2 from LULUCF	13423.30	16666.67	14818.18	10289.52	13818.14	13811.40	13895.17	17181.48	16820.21	13359.71	15103.42	17133.25	16130.59	11681.42	10275.21	-69.27
CH_4 emissions without CH_4 from LULUCF	1230.33	1247.42	1231.67	1245.17	1253.87	1208.02	1224.90	1217.11	1190.78	1095.87	1084.24	1095.35	1093.14	1098.30	1095.46	-42.72
CH_4 emissions with CH_4 from LULUCF	1302.02	1312.80	1297.94	1310.64	1319.36	1273.58	1290.50	1282.80	1256.59	1162.10	1150.68	1161.42	1161.75	1164.37	1161.72	-41.23
N_2O emissions without N_2O from LULUCF	660.99	719.97	775.92	725.47	746.47	756.04	807.83	805.93	832.87	868.22	841.06	873.33	862.50	928.46	929.68	-30.64
N_2O emissions with N_2O from LULUCF	935.94	996.58	1055.19	1007.08	1029.98	1041.05	1094.86	1094.80	1123.65	1161.16	1136.06	1169.40	1160.08	1226.59	1228.48	-23.38
HFCs	155.05	170.89	150.94	158.13	176.11	183.98	193.91	208.11	218.20	223.35	234.30	231.76	232.36	226.33	184.74	100.00
PFCs	0.09	0.08	0.05	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
SF_6	1.17	1.04	1.45	1.50	1.83	1.87	1.99	2.12	2.21	2.35	2.64	2.55	2.67	2.84	2.92	100.00
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Total (without LULUCF)	**18501.97**	**22105.77**	**20050.26**	**16570.91**	**21180.81**	**21134.14**	**20023.45**	**21931.18**	**21104.45**	**18036.69**	**19721.59**	**20965.47**	**20125.74**	**14636.12**	**11555.81**	**-71.24**
Total (with LULUCF)	**15817.59**	**19148.05**	**17323.76**	**12766.86**	**16345.42**	**16311.88**	**16476.44**	**19769.32**	**19420.86**	**15908.67**	**17627.09**	**19698.37**	**18687.44**	**14301.56**	**12853.08**	**-65.28**
Total (without LULUCF, with indirect)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**0.00**
Total (with LULUCF, with indirect)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**0.00**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	CO_2 equivalent (kt)															%
1. Energy	16065.92	19428.50	17322.73	14368.48	18899.50	18747.17	17328.20	19144.02	18593.00	15773.45	17519.24	18585.32	17770.83	12210.92	9461.45	-73.87
2. Industrial processes and product use	767.07	960.05	967.69	478.45	539.51	663.63	909.07	1000.03	712.45	517.03	503.67	640.57	628.54	621.35	295.47	-69.34
3. Agriculture	1169.22	1222.79	1281.22	1223.39	1253.80	1277.57	1359.61	1391.84	1437.90	1408.52	1369.13	1420.76	1417.62	1501.48	1508.38	-42.61
4. Land use, land-use change and forestry[5]	-2684.38	-2957.72	-2726.51	-3804.04	-4835.38	-4822.26	-3547.01	-2161.87	-1683.59	-2128.02	-2094.50	-1267.10	-1438.30	-334.56	1297.27	-141.05
5. Waste	499.77	494.43	478.62	500.59	488.00	445.77	426.58	395.30	361.10	337.69	329.55	318.82	308.74	302.38	290.51	-21.47
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Total (including LULUCF)[5]	**15817.59**	**19148.05**	**17323.76**	**12766.86**	**16345.42**	**16311.88**	**16476.44**	**19769.32**	**19420.86**	**15908.67**	**17627.09**	**19698.37**	**18687.44**	**14301.56**	**12853.08**	**-65.28**

(1) The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the COP. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

(2) Fill in net emissions/removals as reported in table Summary 1.A. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(3) In accordance with the UNFCCC reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

(4) In accordance with the UNFCCC reporting guidelines, HFC and PFC emissions should be reported for each relevant chemical. However, if it is not possible to report values for each chemical (i.e. mixtures, confidential data, lack of disaggregation), this row could be used for reporting aggregate figures for HFCs and PFCs, respectively. Note that the unit used for this row is kt of CO_2 equivalent and that appropriate notation keys should be entered in the cells for the individual chemicals.

(5) Includes net CO_2, CH_4 and N_2O from LULUCF.