Finland's Eighth
National Communication
under the United Nations
Framework Convention on

Climate Change

Committee for Preparing the Eighth National Communication

Sini Niinistö, Statistics Finland (Chair)
Paavo-Petri Ahonen, Ministry of Education and Culture
Saana Ahonen, Ministry for Foreign Affairs of Finland
Torsti Alhava, Finnish Transport and Communications Agency
Lotta Heikkonen, Ministry of Agriculture and Forestry of Finland
Petri Hirvonen, Ministry of Economic Affairs and Employment of Finland
Saara Jääskeläinen[1], Ministry of Transport and Communications
Tuomas Laiho, Ministry of Finance Finland
Bettina Lemström, Ministry of Economic Affairs and Employment of Finland
Katja Lohko-Soner, Finnish Transport and Communications Agency
Johannes Lounasheimo[2], Ministry of Finance Finland
Outi Myatt-Hirvonen, Ministry for Foreign Affairs of Finland
Riitta Pipatti[3], Statistics Finland
Noomi Saarinen[4], Ministry of Transport and Communications
Hanne Siikavirta[5], Ministry of the Environment
Kai Skoglund[5], Ministry of the Environment
Johanna Vanhatalo, Ministry of Agriculture and Forestry of Finland
Pia Forsell, Statistics Finland (Secretary)

1) until 28.4.2022, 2) until 18.2.2022, 3) until 1.6.2022, 4) from 29.4.2022, 5) from 20.4.2022

Members of working groups and other contributors that participated in the preparation of the national communication are listed at the end of the communication.

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Foreword

Global warming must be limited to 1.5°C to avoid the worst effects of climate crisis. Yet global emissions continue to increase and the implementation of nationally determined contributions is not sufficient to keep temperature rise below 1.5 degrees. It is thus crucial to swiftly implement the Paris Agreement and strengthen the efforts of all governments and stakeholders in climate action. Finland remains strongly committed to this work.

The EU has already finalized some elements of its Fit For 55 legislative climate package that will reduce emissions by at least 57 % by 2030 and help pave the way to a climate neutral EU by 2050. We continue to work closely to ensure ambitious outcomes for the remaining elements of the Fit For 55 package.

Finland's obligation under EU legislation was to reduce emissions from the effort-sharing sector by 16% by 2020 compared to the 2005 emission level. Finland achieved its 2020 emission reduction target through national measures. Finland's new effort-sharing obligation will be to reduce emissions by 50% by 2030. These negotiations are expected to be finalized before the end of 2022.

And of course, the work does not end there. Finland aims to be climate neutral by 2035. In connection with the reform of the Climate Act in 2022, new emission reduction targets were included in the Act. These targets were set based on the recommendation of the Finnish Climate Change Panel. Finland's new national target is to reduce emissions by 60% by 2030 and to be carbon neutral by 2035. The Climate Act also establishes a framework for systematic planning and monitoring of Finland's climate policy measures.

To achieve these necessary targets, new policy measures need to be introduced and existing instruments strengthened. Actions necessary to achieve the 2030 emission reduction targets and the 2035 carbon neutrality target are outlined in three new plans: the Medium-term Climate Change Policy Plan, National Climate and Energy Strategy and Climate Plan for the Land Use sector submitted to the Parliament in the summer of 2022. However, recent preliminary data shows that the carbon removals in the Land Use Sector might be significantly smaller than expected and consequently the Climate Plan for the Land Use sector must be re-evaluated in the future.

Participation of stakeholders is a key element of the Finnish climate policy at both national and international levels. Sectoral low-carbon road maps have been developed by industries and organisations as a sector-based approach to the national climate neutrality target in 2035. The Climate Policy Roundtable, set up in 2020, brings all key stakeholders even more closely together to prepare Finland's national climate actions.

Municipalities have taken an active role in climate policy at the local level. Many Finnish municipalities already have climate targets and the Climate Act will be supplemented by the end of 2022 to include a new obligation for the municipalities. In the future, the Act obliges municipalities to draw up climate plans once every four years, either alone or together with other municipalities in the region.

In Finland, there has been a growing interest towards the interface between science and policy in the field of climate change. Research funding institutions are developing innovative approaches to strengthen policy relevant research agendas with an active interaction with policymaking. The Finnish Climate Change Panel has a formal role in national climate policy under the Climate Act. The Panel is an independent multidisciplinary actor that produces recommendations and assessments to inform policy-making. In addition, Finnish researchers have collaborated actively with the international research community in the form of joint projects and programmes.

Adaptation to climate change is necessary alongside mitigation. Finland was among the first countries in the world to draw up a climate change adaptation strategy in 2005. The National Climate Change Adaptation Plan is being revised at the moment and it will steer adaptation work until 2030. Research and assessments on climate impacts are instrumental as a basis for adaptation measures. A proper understanding of the risks and vulnerabilities caused by climate change, both domestically and globally, is at the core of climate policy.

Finland's eighth National Communication was prepared in cooperation between several ministries, the Ministry of the Environment, the Ministry for Foreign Affairs, the Ministry of Finance, the Ministry of Education and Culture, the Ministry of Agriculture and Forestry, the Ministry of Transport and Communications, the Ministry of Economic Affairs and Employment, and the Ministry of the Interior, and Statistics Finland. Statistics Finland coordinated the preparations and compiled the National Communication. In addition, many research centers and expert organisations provided expertise in the preparations, including the Academy of Finland, the Finnish Environment Institute, the Natural Resources Institute Finland (Luke), the Finnish Meteorological Institute, VTT Technical Research Centre of Finland, the Finnish National Agency for Education, the Energy Authority, the Finnish Transport Infrastructure Agency, the Finnish Transport and Communications Agency, the Finnish Institute for Health and Welfare, Finance Finland and Motiva Oy.

I would like to thank all the experts for their valuable contributions in preparing this report.

Helsinki 7 December 2022,

Maria Ohisalo

Minister of the Environment and Climate Change

Photo: iStock.com

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Executive Summary

1 Executive Summary

1.1 National circumstances relevant to greenhouse gas emissions and removals

Finland is situated at a latitude between 60 and 70 degrees north, with a quarter of the country extending north of the Arctic Circle. With a total area of 338,400 km^2, it is Europe's seventh largest country. As a result of the country's low population density and geographical extent, the average distances travelled for different purposes can be quite long. The population of Finland was 5.5 million at the end of 2020. According to projections, the population will increase to 5.6 million by 2034 due to net migration but will then decline.

Boreal coniferous forest zone covers nearly all of Finland. Seventy-two per cent of the total land area is classified as forest land, while only some eight per cent is cropland. Finland has more than 34,500 km^2 of inland water systems, which is about 10 per cent of its total area. Peatlands cover almost a third of the total land area of Finland.

The mean temperature in Finland is several degrees higher than in most other areas at these latitudes because of the influence of the Baltic Sea, the inland waters, and the Gulf Stream. There is considerable regional variation in climate: the mean annual temperature is close to 7 °C in the southwestern archipelago and decreases to below –3 °C in the northern parts of the country.

Finland has an open economy with prominent service and manufacturing sectors. The main manufacturing industries include metal and its electrical and electronics subindustry, and the chemical and forest industries. Foreign trade is important, with exports accounting for about 40 per cent of the gross domestic product (GDP). In 2020, Finland's GDP fell by 2.3 per cent as the Covid-19 pandemic prevailed, but the national economy recovered swiftly and reached the pre-pandemic level in 2021.

Total energy consumption was 1,277 PJ (355 TWh) in 2020. Finnish industry used 38 per cent of the country's total primary energy and 45 per cent of its total electricity. Finland's domestic energy sources are wood-based fuels, hydropower, wind power, waste, peat and heat pumps. Black liquor, the by-product of chemical pulp production, is currently the most significant renewable energy source in Finland.

Renewable energy has increasingly replaced fossil fuels during the 2010s, which is the main reason for the decrease in greenhouse gas emissions, even though energy consumption has grown. In 2020, the share of renewable energy was 44.6 per cent of total final energy consumption. Moreover, more than half of Finland's electricity production was produced with renewable energy sources. Other recent trends in Finland's energy production are the ban on the use of hard coal, which will enter into force in 2029 but will have an effect before then, and the steady increase of wind power capacity. The EU Emissions Trading System has become a significant factor in the energy market and in emissions reduction in the EU.

Transport demand and supply are influenced primarily by developments in the economy, demographic factors, employment patterns and infrastructure provision. Domestic passenger transport, measured in terms of passenger-kilometres, has increased by approximately 16 per cent since 1990, with cars accounting for about 86 per cent of total passenger-kilometres in 2020. Road haulage is the most important form of transport for domestic goods traffic, whereas three quarters of Finland's foreign trade goes by sea. Traffic is becoming more electrified as the number of electric, hybrid and gas-powered passenger cars has recently increased.

Indoor heating is the biggest source of carbon dioxide (CO_2) emissions by households and within the public and service sectors, although the demand for heating energy has decreased as winters have become generally milder in recent decades. The use of district heating and electricity for heating indoor spaces has increased, while the use of heavy fuel oil and light fuel oil has decreased.

Finland's industrial structure has changed since the mid-1990s due to the rapid expansion of the metal products industry, especially electronics. Because of their high energy demand, energy-intensive industries have worked hard to improve their energy efficiency and have succeeded in growing the volume of industrial output more than final energy consumption. All pulp mills produce energy in excess of their own requirements.

Climatic conditions, i.e. the short growing season and harsh winters, are a decisive factor affecting the feasibility of crop production. Cultivation of wheat and oilseed plants is restricted to southern Finland, whereas barley, oats, grass, and potatoes can be cultivated in most parts of the country. In many parts of country, livestock farming is the only profitable form of agricultural production. Nearly 70 per cent of active farms practice crop production, and 25 per cent have livestock as their main line of farming. The number of active farms has decreased considerably during the last thirty years, while the average agricultural area per farm has increased. Agriculture is the most important employer in the countryside, and alongside forests, is the dominant element of the rural landscape.

Within the EU, the significance of forests for the national economy and society at large is greatest in Finland. The forest sector contribution has been two to five per cent of GDP and some 20 per cent of the export of goods. The volume of the growing tree stock has long been increasing, mainly because of the active and sustainable management of forests, in which the growth in volume has exceeded harvesting volumes and natural drain. In 2020, the total use of roundwood in Finland was 78 million m^3. The great majority, that is, 86 per cent, was used in the forest industry, and the rest was used for energy production. Forests absorb a significant proportion of Finland's carbon dioxide emissions. Fluctuating trends in demand for forest industry products and thus in demand for harvested wood have caused considerable variation in net removals from forest land.

The amount of waste deposited in landfill sites has been significantly reduced by effective waste regulation. Biodegradable municipal waste has no longer been deposited in landfills since the prohibition of organic waste in landfill came into force in 2016. In 2020, 41 per cent of municipal waste was recovered as material, and 58 per cent as energy. Solid municipal waste is responsible for most of the greenhouse gas emissions from the waste sector.

1.2 Greenhouse gas inventory information, including information on the national system and the national registry

In 2020, Finland's greenhouse gas emissions totalled 47.8 million tonnes of carbon dioxide equivalent (million tonnes CO_2 eq.). Total emissions in 2020 were approximately 33 per cent (23.4 million tonnes) below the 1990 emissions level (Table 1.1). Compared to 2019, emissions were approximately nine per cent, i.e. 5.0 million tonnes, lower. Finland's annual greenhouse gas emissions varied considerably from 1990 to 2020 due to changes in electricity imports and the production of fossil-fuel-based condensing power. In addition, emissions are influenced each year by the economic situation in the country's energy intensive industries, weather conditions, and the volumes of energy produced using renewable energy sources.

The energy sector is the most significant source of greenhouse gas emissions in Finland and is therefore the key driver behind the trend in emissions. The energy sector includes emissions from fuels used to generate energy, including fuel used in transport and the fugitive emissions related to the production, distribution and consumption of fuels. In 2020, the energy sector accounted for 72 per cent of Finland's total greenhouse gas emissions. The share of transport in energy-related emissions was more than 30 per cent in 2020.

The second largest source of emissions after the energy sector was the agricultural sector, with a share of approximately 14 per cent of the total emissions. Emissions from industrial processes and product use amounted to approximately 11 per cent. Emissions from industrial processes refer to emissions that result from the use of raw materials in industrial processes. Emissions from the waste sector amounted to four per cent of total emissions. The contribution of indirect CO_2 emissions from the atmospheric oxidation of CH_4 and NMVOCs to the greenhouse gas emissions is small – about 0.1 per cent of total greenhouse gas emissions in Finland. The land use, land-use change, and forestry (LULUCF) sector in Finland was a net sink throughout the 1990 to 2020 reporting period. The net sink has varied from approximately 13 to 49 per cent of the annual sum of emissions from other sectors, i.e. the total emissions without LULUCF between 1990 and 2020.

Greenhouse gas inventory system

According to the Government resolution of 30 January 2003 on the organisation of climate policy activities of Government authorities, Statistics Finland assumed the responsibilities of the national entity for Finland's greenhouse gas inventory from the beginning of 2005. In 2015, the role of Statistics Finland as the national entity was enforced by the Climate Change Act. Statistics Finland has overall responsibility for compiling and finalising inventory reports and submitting them to the Secretariat of the UNFCCC and the European Commission. It bears the responsibility for the general administration and quality management of the inventory and communicating with the UNFCCC, coordinating participation in the reviews, and publishing and archiving the inventory results.

In Finland, the national system is established on a permanent footing, and it guides the development of emissions calculation in the manner required by the Kyoto Protocol. The national system is based on laws and regulations concerning Statistics Finland, agreements between the inventory unit and expert organisations on the production of emissions and removal estimates, and related documentation[1]. Statistics Finland approves the inventory before the submissions to the UNFCCC and EU. The draft inventory submission to the EU on 15 January is presented to the advisory board, and before

1 In addition to Statistics Finland, Finland's inventory system includes the Finnish Environment Institute (SYKE) and Natural Resources Institute Finland (Luke) expert organisations as well as purchased services from VTT (VTT Technical Research Centre of Finland Ltd).

Table 1.1
Greenhouse gas emissions (+) and removals (–) by sector, 1990, 1995, 2000, 2005 and 2010 to 2020 (million tonnes CO_2 eq.)

Sector	Base year	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	Mt CO_2 eq.															
Energy	53.4	53.4	55.3	53.7	53.7	60.2	52.8	47.5	48.1	44.3	40.6	43.3	40.9	42.1	38.9	34.3
Industrial processes and product use[1]	5.3	5.3	4.9	5.2	5.6	4.8	4.7	4.6	4.4	4.2	4.4	4.7	4.6	4.6	4.4	4.1
F gases	0.1	0.1	0.2	0.7	1.2	1.4	1.4	1.4	1.4	1.3	1.3	1.2	1.1	1.1	1.0	1.0
Agriculture	7.5	7.5	6.7	6.6	6.5	6.7	6.5	6.4	6.5	6.6	6.6	6.7	6.6	6.5	6.6	6.6
Waste	4.7	4.7	4.6	3.8	2.8	2.6	2.5	2.4	2.3	2.2	2.1	2.0	1.9	1.8	1.8	1.7
Indirect CO_2-emissions[2]	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
TOTAL (exl. LULUCF[3])	71.2	71.2	71.8	70.2	69.9	75.7	67.9	62.4	62.8	58.6	55.0	57.9	55.1	56.2	52.8	47.8
TOTAL (exl. LULUCF and indirect CO_2 emissions)	71.0	71.0	71.6	70.1	69.8	75.6	67.8	62.3	62.7	58.5	55.0	57.9	55.1	56.1	52.7	47.7
LULUCF[3]	–13.4	–13.4	–13.2	–15.0	–20.5	–21.7	–22.0	–24.6	–18.3	–20.9	–18.8	–17.7	–16.3	–7.4	–13.6	–17.3

1 excluding F gases
2 indirect CO_2 emissions from NMVOC and CH_4 from fugitive emissions, industrial processes and product use
3 Land use, land-use change and forestry

(Note: Due to rounding, the sum of subtotals does not necessarily equal to total figures.)

submitting the final inventory to the UNFCCC on 15 April, the national inventory report is sent to the inter-ministerial network on climate policy issues for comment.

National registry

The EU Emissions Trading Scheme (EU ETS) began in January 2005 and is mandatory for specific industries in the EU. The EU ETS and wider international emissions trading under the Kyoto Protocol have operated parallel to one another since 2008. Both emissions trading schemes are underpinned by a system of electronically linked national registries, which are intended to keep track of national and international transactions involving EU allowances and Kyoto units.

Every EU Member State has been required to establish a national registry for the EU ETS and for emissions trading under the Kyoto Protocol. National registries must meet the technical and functional specifications issued by the European Commission and the UNFCCC Secretariat.

The Consolidated System of EU registries (Union Registry) has been in operation since 2012. The changes to the national registry, which have occurred since the last National Communication report are summarized in Table 3.4 of the Chapter 3. In Finland, the Energy Authority is the competent authority and the registry administrator for the national emissions trading registry.

1.3 Policies and measures

Policy framework and policy making process

Finland's climate policy is based on international agreements: the UNFCCC; the Kyoto Protocol; and the Paris Agreement. The common policies of the European Union, such as the EU Climate and Energy Packages for 2020 and 2030, play a key role in the implementation of the above international agreements. At national level, Finland's climate policy is defined in government policies and programmes, and since 2003, ministerial working groups have steered strategic work. In addition, national energy and climate strategies have been prepared since 2001 to implement international and EU commitments, as well as national targets, and to define sectoral policies and measures.

The Climate Change Act lays down provisions on climate change policy planning and the related monitoring and sets the national climate objectives. The Act was reformed in 2022 and now includes new emissions reduction targets: 60 per cent by 2030 and 80 per cent by 2040 compared to the 1990 levels. At the same time, the 2050 target was tightened from 80 per cent to at least 90 per cent, aiming for 95 per cent, by 2050. The reformed Act also includes, the 2035 carbon neutrality target, which was set in the Programme of Prime Minister Sanna Marin's Government in 2019.

The Finnish Government and Parliament make the most important decisions concerning climate policy. Parliament approves Finland's international commitments and decides on their implementation according to the constitution. The Ministry of the Environment bears the administrative responsibility for the climate negotiations. The Ministry of Economic Affairs and Employment coordinates the energy and climate strategy work. Municipal authorities also have a significant role in climate policy and emission reductions, for example due to their responsibilities in land-use and traffic planning, energy efficiency and waste management.

The Finnish Climate Change Panel, which was nominated for the first time in 2011, strengthens the interaction between research and policymaking. Other stakeholders, including industrial and environmental non-governmental organisations (NGOs), research institutes and labour unions, can present their views on climate policy at the Climate Policy Roundtable and the Ministry of the Environment's Climate Arena. A new type of cooperation was initiated in 2019-2021 when 13 sectors and industrial branch organisations produced their own sector-specific roadmaps to low-carbon operation with the support of the Ministry of Economic Affairs and Employment.

Under the UNFCCC, the EU and its Member States committed to achieving a joint quantified economy-wide greenhouse gas emissions reduction target of 20 per cent below the 1990 level by 2020 ("the Cancun pledge"). The commitment was implemented internally in the EU through EU legislation in the 2020 EU Climate and Energy Package and by individual binding annual limitation targets for the Member States for emissions not covered by the EU Emission Trading System (EU ETS). The EU overachieved its reduction target under the Convention, which means that its Member States also fulfilled their emissions reduction obligations.

Finland's emissions reduction target for the second commitment period of the Kyoto Protocol was defined based on its emissions reduction obligation under the EU's Effort Sharing Decision concerning emissions not covered by the EU ETS. In addition, Finland was responsible for the emissions and removals from the LULUCF activities. According to greenhouse gas inventory data, Finland is meeting its emissions reduction commitments for 2013 to 2020. The fulfilment of commitments is ensured after international reviews and the so-called true-up period during 2022 to 2024.

The EU's current emissions reduction target in its joint nationally determined contribution under the Paris Agreement has been raised to of at least 55 per cent by 2030 from the 1990 level. The previous target of 40 per cent was considered insufficient for achieving the EU's carbon neutrality target for 2050. The details of the effort sharing between the Member States, including Finland, are currently being negotiated.

Finland regularly prepares strategies on energy and climate policy. In 2022, three Government Reports were submitted to Parliament, namely the National Climate and Energy Strategy, the Medium-Term Climate Change Policy Plan and the Climate Plan for the Land-Use Sector. The National Climate and Energy Strategy outlines the policy measures by which Finland will meet the EU's climate and energy commitments for 2030 and achieve the targets set in the Climate Change Act for 2030 and 2035. The Medium-Term Climate Change Policy Plan specifies the key measures for achieving the binding emissions reduction targets in the effort sharing sector by 2030. The purpose of the Climate Plan for the Land-Use Sector is to promote the reduction of emissions from land use, forestry, and agriculture, the strengthening of carbon sequestration and carbon storage, and adaptation to climate change in accordance with the Sustainable Development Goals. Most new policies and measures reported in this National Communication are outlined in the above-mentioned Government Reports.

Sectoral policies and measures

A vast majority of the policies and measures reported in the Eight National Communication are already adopted or implemented; they are in other words existing measures. Planned or additional measures are mainly reported for the transport sector, international bunkers, agriculture and F-gases (see Chapter 4).

The main policies and measures in the energy sector include the EU Emissions Trading System (EU ETS), promoting renewable energy sources and energy conservation measures. The EU ETS is an EU-wide domestic measure, while renewable energy and energy efficiency are promoted by various national measures such as investment subsidies, taxation, regulation, energy efficiency audits and agreements and information measures. Finland is phasing out coal in the energy sector by prohibiting its use from May 2029. To accelerate the coal phase-out, a special incentive package to support replacement investments was introduced for energy utilities that undertook to give up the use of coal already by 2025. To reduce greenhouse gas emissions from light fuel oil, an obligation to blend bioliquids with light fuel oil used for heating buildings and for machinery was approved in 2019 and tightened in 2022. The share of biofuel oil increases annually until 2030, from which the share should be 30 per cent. The measures that are estimated to have the largest climate change mitigation impact are promotion of wind power (11.1 million tonnes CO_2 eq. mitigation impact in 2030), Energy Efficiency Agreements (9.5 million tonnes CO_2 eq. in 2030), promotion of wood chips (8.1 million tonnes CO_2 eq. in 2030) and the building regulations for new buildings (6.2 million tonnes CO_2 eq. in 2030).

In the transport sector, a Government Resolution on the Roadmap for Fossil-Free Transport was adopted in 2021. The policy measures can be grouped into following themes: 1) Replacing fossil fuels with alternative transport fuels; 2) improving the energy efficiency of vehicles; and 3) improving the energy efficiency of the transport system. The share of biofuels in road transport will be increased to 34 per cent in 2030. Finland also continues to subsidise electric and gas vehicles and related infrastructure and to promote the use of biogas in transport. For the following measures of the Roadmap for Fossil-Free Transport (2021), the additional emission reduction effect, i.e. in relation to the previous projection, will be around 0.3 million tonnes CO_2 eq. in 2030 for replacing fossil fuels with alternative transport fuels, 0.4 million tonnes CO_2 eq. for improving the energy efficiency of vehicles and 0.1 million tonnes CO_2 eq. for improving the transport system's energy efficiency.

As a member of the European Union, Finland is implementing the EU Emissions Trading System for aviation. Aviation has been included in the EU ETS since 2012 and covers today all intra-European Economic Area flights. Other policies and measures to mitigate emissions from international bunkers include implementing the measures of the International Maritime Organization (IMO) and the International Civil Aviation Organisation (ICAO). Furthermore, in 2021, the Government made Resolutions on reducing greenhouse gas emissions from aviation, as well as maritime and inland waterway transport. The Government Resolutions include measures to reduce greenhouse gas emissions through alternative fuels, energy efficiency, and pricing.

Measures for reducing CO_2 emissions from industrial processes are the EU ETS, investment grants for low-carbon technology and lowering of electricity tax in order to promote electrification. For F-gases, EU regulations constitute the most significant emission reduction measure. In total, the existing measures are estimated to cut F-gas emissions with 3.2 million tonnes CO_2 eq. in 2030.

Within the agricultural sector, the agri-environment-climate measures are part of the Rural Development Programme for Mainland Finland and the EU's Common Agricultural Policy. Agri-environment payments are essential tools for promoting sustainable development in agriculture, and in previous years, some 85 per cent of Finnish farmers have committed themselves to the agri-environment scheme.

The Climate Plan for the Land Use Sector specifies how climate emissions from the land use, land-use change and forestry sector can be reduced, and carbon sinks and reservoirs strengthened. The most important policy measures include legislation, the National Forest Strategy 2025, financial support and extensive public forestry organisations, which promote sustainable forest management, including maintaining the forest carbon sink. The targeted annual net impact for the new climate measures in the land-use sector is at least three million tonnes CO_2 eq. by 2035.

The general reform of waste legislation that was conducted in 2021 provides the basis for more effective waste management with respect to recycling and reuse, enhanced separate collection of waste, reduction of waste generation, and further reduced landfilling of organic waste, all contributing to reduced greenhouse gas emissions. The National Waste Plan for 2027 that was approved in 2022 includes both a plan to reduce the volume and harmfulness of waste and a waste management plan. The estimated total mitigation impact of waste management measures is 4.1 million tonnes of CO_2 eq. in 2030.

Finland strives to implement its climate policies in such a way that the social, environmental and economic impacts on other countries, and on developing countries in particular, are minimised. The Eight National Communication provides updated information on how to minimise adverse impacts.

1.4 Projections and total effect of policies and measures

With measures and with additional measures projections

The “with measures” (WM) and “with additional measures” (WAM) projections are based on data produced for Finland’s latest National Energy and Climate Strategy, the Medium-term Climate Change Policy Plan and the Climate Plan for the Land Use Sector. These reports were prepared in 2022 and policies and measures that have been implemented by July 2022 are included in the WM projection. The WAM projection considers policies and measures that are planned but not implemented before 1 August 2022 in addition to the WM projection.

Contrary to the population forecast used in the projections for the Seventh National Communication, the forecast, used in the projections, estimated that the population will increase only slightly from the current 5.53 million (2020) to 5.57 million in 2030 and will start slowly decreasing in 2031. The average size of households will also decrease slightly, while the number of households is expected to grow from 2.7 million to almost 2.9 million.

The projections consider the Covid-19 pandemic and its assumed effects on the economy. However, the energy crisis following Russia’s unprovoked and unjustified invasion of Ukraine has not been included in the projections, as most of the modelling work was conducted before February 2022. For the LULUCF sector, the most recent results from the national forest inventory on a decline in tree growth were not yet available when the latest annual greenhouse gas inventory submission and the WM projection for the LULUCF sector were prepared. Thus, the estimates of carbon removals in the LULUCF sector will be re-evaluated in future.

Economic growth is expected to recover during 2021, but remains modest at first before picking up later in the 2020s. As the shrinking working-age population cannot generate new growth through labour input, economic growth mainly depends on technological development and investment. By 2030, the projections expect technological development to generate growth of about 10 per cent compared to 2019 and about 20 per cent by 2040. Growth through capital is about half this. The average GDP growth rate is about 1.5 per cent.

Most of the measures included in the WAM projection of the Seventh National Communication have been implemented and are now part of the WM projection. The most significant of these are the group of measures promoting emissions-free and energy-efficient road transport, ban on the energy use of hard coal, measures phasing out oil heating, and several new measures in agriculture, LULUCF and machinery. The WAM projection includes only a few measures additional to the WM projection such as the estimated impact of planned future measures regarding F-gases and in the agricultural and transport sectors.

The WM projection estimates that the total greenhouse gas emissions (without LULUCF) will be 30 and 25 million tonnes CO_2 eq. in 2030 and 2035, respectively, which equal to reductions of 58 and 65 per cent compared to the 1990 base year. In the WAM projection, the estimated total emissions are 29 and 24 million tonnes for the same years. According to the projections, Finland is on track to achieve the current EU 2030 target for the emissions not included in the EU Emission Trading System.

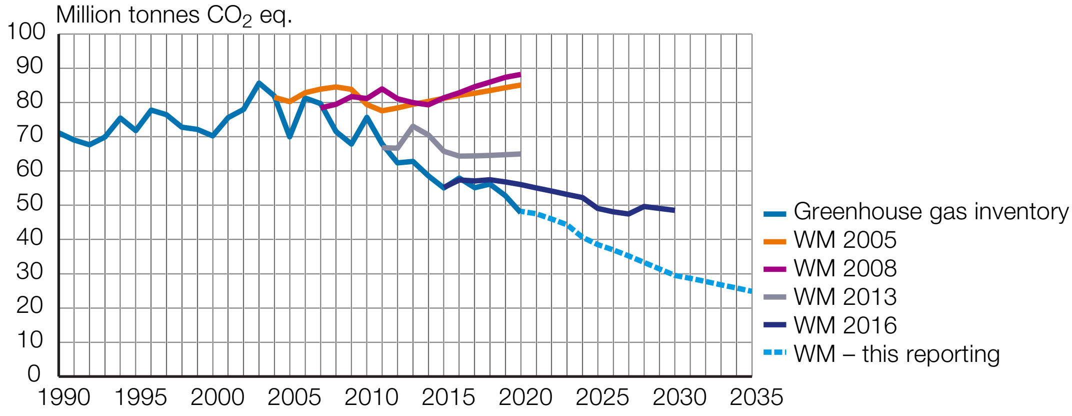
Total effect of policies and measures

The aggregated estimates for the greenhouse gas reduction impacts on individual WM policies and measures are 25 and 50 million tonnes CO_2 eq. for 2020 and 2030 (without LULUCF) respectively. The WAM measures will increasingly reduce greenhouse gas emissions in the 2020s, reaching an additional annual reduction of approximately 0.8 million tonnes CO_2 eq. in 2030. The small addition of the planned measures results from the fact that most of the previously planned measures (WAM measures) are now labelled as implemented or adopted measures (WM measures). New planned measures are currently in the development stage, and decisions on their implementation will be taken in the coming years.

Figure 1.1 shows Finland’s greenhouse gas emissions in the WM projections in the last four national climate and energy strategies, i.e. strategies from 2005, 2008, 2013, and 2016, as well as in this reporting. The WM projections in the national climate and energy strategies projected significantly higher emissions for 2020 than those reported in the latest greenhouse gas inventory and in the projections of this reporting. This suggests that the additional measures implemented in the 2010s have had a substantial impact on total emissions.

The total effect of implementing additional measures can be seen in the emission development trend after 2015, which levelled off in the 2013 and 2016 projections, whereas it continued to increase in the projections from 2005 and 2008. In turn, the WM projection of this reporting points clearly downwards.

Figure 1.1
Greenhouse gas emissions according to the most recent inventory for 1990 to 2020 and in the WM projections of the climate and energy strategies published in 2005, 2008, 2013, and 2016 until 2020 and 2030 respectively, and the WM projection from this reporting.



For comparison purposes, the WM projections from 2005 and 2008 can be considered reasonable WOM (Without Measures) projection substitutes, even though they already include some mitigation measures. The gap between the projections for 2005 to 2008 and the projection of this reporting is up to 40 million tonnes CO_2 eq. in 2020. By 2030, the gap would presumably increase to at least 60 million tonnes CO_2 eq. if the old projections had extended that far into the future. This is well in line with the bottom-up estimation of the total effect of policies and measures considering that not every single measure has been assessed and included in the estimation. The bottom-up approach gives 50 million tonnes CO_2 eq. emissions reduction in 2030, which, when added to the emissions of the WAM projection, would result in an emission level of at least 79 million tonnes CO_2 eq. in 2030 for a WOM projection.

1.5 Vulnerability assessment, climate change impacts and adaptation measures

Climate modelling, projections and scenarios for Finland

The average temperature change in Finland is expected to be 2.7 °C by mid-century and 3.7 °C by the end of the twenty-first century under the SSP2-RCP4.5 scenario representing moderate emissions. This is about 1.6 to 1.8 times higher than global mean warming. The projected increase in annual precipitation is about 11 per cent under SSP2-4.5.

Climate change is expected to result in longer and more frequent heatwaves and diminishing severe cold spells; intensifying heavy rain events in summer; an increasing number of days with precipitation in winter; a shortening snow season and decreasing duration and depth of soil frost, particularly in snow-free areas like roads and airports. Compared with the projections prepared with a model ensemble used in NC7, the summer temperature projections are about 0.7 °C higher at the end of the century.

Vulnerability, risks and climate change impacts

Finland has a long history of climate change impact and risk research, especially in natural resource sectors. The risk of pests and diseases and resulting losses are increasing in forestry, agriculture, and fisheries.

In recent years, there has been an increasing focus on human health research. The most notable health risk is related to the increasing frequency and duration of heatwaves, which threaten to increase future heat-related mortality and morbidity in Finland. The ageing population, increasing number of people living alone, low prevalence of air conditioning, and urbanisation further amplify the effect of heat. However, in global comparison, the health risk in Finland is low.

A recent study concluded that climate change could be expected to have slightly negative effects on the Finnish economy as a whole, expressed as a percentage change in gross domestic product (GDP) over the period between 2020 and 2070. Higher greenhouse gas emissions led to a larger percentage change in GDP.

The preparation of the second national adaptation plan in 2021 to 2022 included an up-to-date assessment of risks and vulnerabilities from three different perspectives: 1) a national risk and vulnerability assessment focusing on sectorial and cross-sectorial risks and vulnerabilities; 2) regional vulnerabilities; and 3) national and local institutional vulnerabilities.

Domestic adaptation policies and strategies

In 2014, Finland adopted the National Climate Change Adaptation Plan 2022, which describes the current national adaptation policy framework. A revised adaptation plan was prepared in 2022 and will steer adaptation work until 2030.

Since 2015, national adaptation planning has been stipulated as part of Finland's Climate Act. The act, revised in 2022, requires that the National Adaptation Plan will be adopted every other electoral period (essentially every eight years), and that it will be evaluated mid-term. The Ministry of Agriculture and Forestry is responsible for coordinating national adaption overall policy, and each ministry has the responsibility to ensure and follow up its implementation within their own areas of responsibility.

Several administrative branches have developed adaptation action plans. The Ministry of Social Affairs and Health adopted a plan in 2021, the Ministry of Agriculture and Forestry and the Ministry of Defence are updating or developing their plans, and the Ministry of the Environment has already had several rounds of adaptation planning. Furthermore, adaptation has been integrated into broader climate and environmental policy programmes in certain sectors, including transport and communication. The Ministry of Agriculture and Forestry coordinates the development of national guidelines for drought risk management. In the built environment sector, the Land Use and Building Act state that the national land-use guidelines must be considered in regional planning, municipal land use planning, and the operations of authorities. A reform of the Land Use and Planning Act is currently ongoing, and adaptation is one of its main aims. The Finnish Nature Conservation Act, revised in 2022, strengthens the link between climate change adaptation and biodiversity measures.

The financial industry considers climate change in its operations and as part of its risk management activities. The government does not provide any permanent compensation damage schemes in relation to hydro-meteorological events.

Climate resilience is one of the cross-cutting objectives of Finland's international development policy and development cooperation. The integration of the cross-cutting objectives in all development cooperation activities is a binding obligation, either through mainstreaming or targeted action.

Monitoring and evaluation framework

Since 2015, the implementation of the National Adaptation Plan (NAP) 2022 has been supported and monitored by a Monitoring Group for Climate Change Adaptation. The group has representatives from relevant ministries and other authorities, regional and local actors, research institutes, expert organisations in the fire and rescue services, and financial services. Annual monitoring of the NAP has focused on tracking the progress of the actions included in the plan. Between 2018 and 2019, a mid-term evaluation was carried out to assess progress in the implementation of the National Adaptation Plan. In the lead up to updating the plan, a final evaluation was carried out between 2021 and 2022.

Progress and outcomes of adaptation actions

Climate change impacts and risks are receiving increasing attention in all administrative sectors. This is evident in references to climate change in the development of regulation and other policies. The National Adaptation Plan 2022 has positively contributed to goal setting and increasing general awareness of the need for adaptation. However, the sectors have progressed at a different pace in terms of actions and guidelines that will tangibly strengthen the adaptive capacity. Advances have been made in sectors in which weather and climate fluctuations have long been relevant for normal operations such as construction, infrastructure maintenance, and water management. In other fields such as game management, fisheries and healthcare, climate change has only recently gained attention as a phenomenon that requires tangible action.

1.6 Financial, technological and capacity-building support

Finland's international cooperation and actions are grounded in the Paris Agreement on Climate Change and the goals of the 2030 Agenda for Sustainable Development. It is based on the development needs defined by the partner countries and their own development plans. Finland's contribution to international climate finance is channelled as part of financing allocated for development cooperation. The integration of climate change has been one of the cross-cutting objectives of Finland's development policy and development cooperation since 2012. Finland aims to provide long-term support for climate change mitigation and adaptation, development that is low in emissions and climate-resilient, and biodiversity protection.

The total international climate finance allocations were EUR 147 million in 2019 and EUR 131 million in 2020 (Annex 2, Tables 7). Total climate finance allocations are increasing, although there was a slight decrease in 2020 compared to the record figure in 2019. The division between mitigation and adaptation support varies according to year, but Finland aims for balance. In 2019, the division was 64 per cent for mitigation and 36 per cent for adaptation, and in 2020, 59 per cent for mitigation and 41 per cent for adaptation. There has been a significant increase since the baseline figure for overall Finnish climate funding (as grants) in 2009, which was EUR 26.8 million.

Besides providing funds to the operating entities of the financial mechanism of the UNFCCC, Finland provides support through bilateral, regional and other multilateral channels. Funding is directed at both climate change mitigation and adaptation. In addition to grant funding, Finland uses investment-based and loan-based funding to effectively accelerate private-sector investment in climate solutions. Research, cooperation with universities, and inter-institutional cooperation are also supported. Most Finnish climate finance is provided through multilateral channels.

Finland's development cooperation especially supports the least developed, fragile or conflict-prone countries, taking into account situations where climate change and other serious development challenges slow the achievement of sustainable development goals. The priority for Finland's climate finance is to support the least developed countries (LDC) and small island developing states (SIDS), as they are particularly vulnerable to the impacts of climate change. In 2020, contributions were made e.g. to the Least Developed Countries Fund and to the Climate Risks and Early Warning Systems Initiative, supporting primarily LDCs and SIDS.

The private sector plays a significant role in promoting climate action in developing countries as a developer of new technologies, developer and implementer of projects, and financier. The role of the private sector is particularly important in climate mitigation, which requires more innovative, scalable and commercially viable renewable energy and energy efficiency solutions, as well as other ways to avoid and mitigate GHG emissions. Finland therefore offers different types of funding and services for the private sector on climate, ranging from large-scale climate investments to small grants that help develop climate projects and get them started. Private sector projects in developing countries are being supported by the Finnish Fund for Industrial Cooperation Ltd (Finnfund), for example.

Finland has specific programmes and financial arrangements for transferring environmentally sound technology to developing countries (examples in Annex 2, Tables 8 and 9). These activities comprise the transfer of both "soft" technology such as capacity building, creating information networks, and enhancing training and research and "hard" technology, that is, technology to control greenhouse gas emissions and for adaptation measures.

Meteorological cooperation is one of the priority areas of Finland's development cooperation and an important part of Finland's adaptation finance. This cooperation includes weather observation infrastructure and equipment, weather forecasting and warning systems and software, technical assistance and capacity building, delivered by private- and public-sector actors and civil society organisations to develop weather, climate, and early warning services. Finland is a global leader in weather observation technology and systems. Over the years, Finland has transferred technology related to weather observation and climate services through bilateral and regional cooperation and concessional credit arrangements. In addition, Finland is one of the world leaders as a donor in supporting the capacity building of non-Annex I partner countries' national meteorological and hydrological services (NMHS), an example of the capacity-building support Finland offers.

1.7 Research and systematic observation

The state of climate-related research, its funding and its relationship with international cooperation is well established in Finland. The funding for climate-related research has been growing through several public policy instruments and private institutions. The Academy of Finland's and Strategic Research Council's (SRC) funding for climate-change-related research totalled EUR 175 million in the most recent five year period from 2017 to 2021, which indicated a significant increase compared to the EUR 95 million of the previous four-year period from 2013 to 2016.

The Academy of Finland has three ongoing research programmes (Climate Change and Health 2020 to 2023, Value Academy Programme on industrial green chemistry 2020 to 2023, and BioFuture 2017 to 2025) related to climate and energy and special funding for system-level research into climate change and adaptation (2021 to 2024). In addition, the Strategic Research Council has several climate-related programmes that have funded many large consortia, in which research institutes, universities and other actors, including the private sector, join forces in dealing with mitigation and adaptation. In addition, the recovery and resilience plan boosted additional funding for research and development related to the green transition.

Finland has a strong standing in research on climate process and climate system studies, climate modelling and prediction, and paleoclimatology, as well as systematic observations, including atmospheric, ocean, cryosphere, and terrestrial observation systems. Recently, an increasing number of studies has assessed climate change problems from a transdisciplinary perspective and integrated socioeconomic aspects. The arising themes have included energy transitions, the just transition, financial themes, the circular economy and the interrelation between biodiversity and climate change. The interactions between mitigation and adaptation actions are also increasingly recognised.

The Active Open science policy is a tool to overcome barriers to the free and open international exchange of data and information. Universities, state research institutes and other important higher education institutions and organisations have taken several initiatives to improve the openness of science and research. For example, missions of the "Declaration for Open Science and Research 2020 to 2025" seek to promote openness as a fundamental value throughout the research community, strengthen the societal knowledge base and innovation, and improve the quality of scientific research outputs and the educational resources based on them, and the impact of research outputs throughout society. In addition, Open Access (OA) has steadily gained ground in Finland. In 2020, more than 70 per cent of peer-reviewed scientific articles written in Finland were OA publications. Several other initiatives such as "The Year of Research-Based Knowledge" launched by the Ministry of Education and Culture, the Academy of Finland, and the Federation of Finnish Learned Societies in 2021 and "Sofi – Science Advice Initiative of Finland" (2019 to 2021) have promoted and advanced science policy dialogues on climate mitigation and adaptation.

Finland has also been active at the international level in relation to climate-related research as a co-founder or contributor. In the Finnish context, Nordic and Arctic cooperation has had long traditions and retains its important role. In addition, Finland has continued to finance and operate capacity-building programmes around the world in climate observations and research and higher education relevant to climate change mitigation and adaptation, meteorology, and the sustainable management of forests, water and other natural resources. The programmes have increased the endogenous capacities and capabilities of developing countries to tackle these issues through improved technological means and human resources. More than 70 organisations in 25 developing countries have benefitted from capacity building provided by their Finnish counterparts.

1.8 Education, training and public awareness

Climate change is incorporated into the Government's education and public awareness policies and practices. These policies and practices are under continuous development. Education policies are the responsibility of the Ministry of Education and Culture. Training and public awareness policies are considered in several sectors and by many actors.

Climate change issues are included in basic education and upper secondary level education as overarching values and as part of sustainable development education. The present National Core Curriculum for Basic Education was given by the Finnish National Agency for Education in 2014. With this curriculum, sustainability is is the overarching task of basic education and is strongly embedded in all elements of the core curriculum. The new National Core Curriculum for Upper Secondary Schools (2019) also highlights several sustainability and climate issues. Students aged 16 to 19 should be familiar with the main aspects of the ecological, economic, social, and cultural dimensions of sustainable development and be able and willing to act in support of sustainable development in their own lives.

Universities provide climate change education as part of various degree programmes, including environmental studies, environmental technology, chemistry, chemical technology, and energy technology. Some universities also offer postgraduate studies in climate change. Teaching related to climate change is closely tied to research in this field. Universities, universities of applied sciences and several training institutes also provide continuing education programmes and vocational training in climate change and related issues, e.g. energy efficiency and environmental technology, for individuals and companies.

Many higher education and research institutions in Finland provide international training and cooperate with similar and government institutions in developing countries to support institutional development. The training of experts from developing countries in managing forests and other natural resources is an integral part of the agricultural and forest science programmes at the University of Helsinki. In the Faculty of Science and Forestry at the University of Eastern Finland, six out of 12 master's degree programmes are directly targeted the sustainable use of natural resources and climate change mitigation. During the last decade, these programmes, which partner programmes in other countries' universities, have trained more than 100 experts, representing more than 50 nationalities.

Communication about climate change is performed by several ministries and government research organisations, each within the sphere of their own tasks and responsibilities. Since 2010, the Ministry of the Environment has had the official responsibility for coordinating the cooperation on climate change communications. The steering group for climate change communications was appointed for its fourth term in 2022.

Several climate change information best practices are provided as free web-based material. As an example, Climateguide.fi is a national web portal which aims to increase awareness of climate change by providing scientific background information on various aspects of climate change and to support society and citizens in mitigating climate change and adapting to it by presenting tangible means for mitigation and adaptation.

The municipalities play a decisive role as intermediators of information regarding attitudes towards climate issues and enabling changes in people's lifestyles. Many municipalities are committed to reducing their greenhouse gas emissions and encouraging citizens to contribute to combating climate change. A growing number of NGOs also have climate-related activities. NGOs and movements have also combined to conduct climate-change- or energy-related campaigns, some of which have received broad publicity.

Photo: Timo Seppäläinen

2

National circumstances relevant to greenhouse gas emissions and removals

This chapter describes the national circumstances relevant to Finnish greenhouse gas emissions and removals. Government structure as well as population, geographical and climate profiles are illustrated. Thereafter, the characteristics and development of the economy, energy supply and consumption, transport, industry, building stock, urban structure, waste, agriculture and forestry are described.

2 National circumstances relevant to greenhouse gas emissions and removals

2.1 Government structure

Finland is a representative democracy, with 200 members of Parliament elected every four years. The tasks of the Finnish Parliament include passing laws and approving national budgets. The head of state is the President of the Republic, who is elected for a period of six years and may serve a maximum of two consecutive terms. The President of the Republic directs foreign policy in cooperation with the Government, deciding, for example, on whether to join or withdraw from international organisations and on the signing, ratification, and entry into force of international conventions. In its narrower sense, the Government refers to the Cabinet, which runs the 12 ministries. The Prime Minister directs the activities of the Government and oversees the preparation and consideration of matters within the Government's mandate. Each ministry is responsible for the preparation of issues within its mandate and for the proper functioning of the departments and agencies within its administrative domain. The Government must enjoy the confidence of Parliament. It implements parliamentary decisions, presents legislative proposals to Parliament, directs state administrative activities, and represents Finland in the European Union.

Matters related to the United Nations Framework Convention on Climate Change (UNFCCC) fall within the administrative responsibility of the Ministry of the Environment, which acts as the national focal point for the UNFCCC.

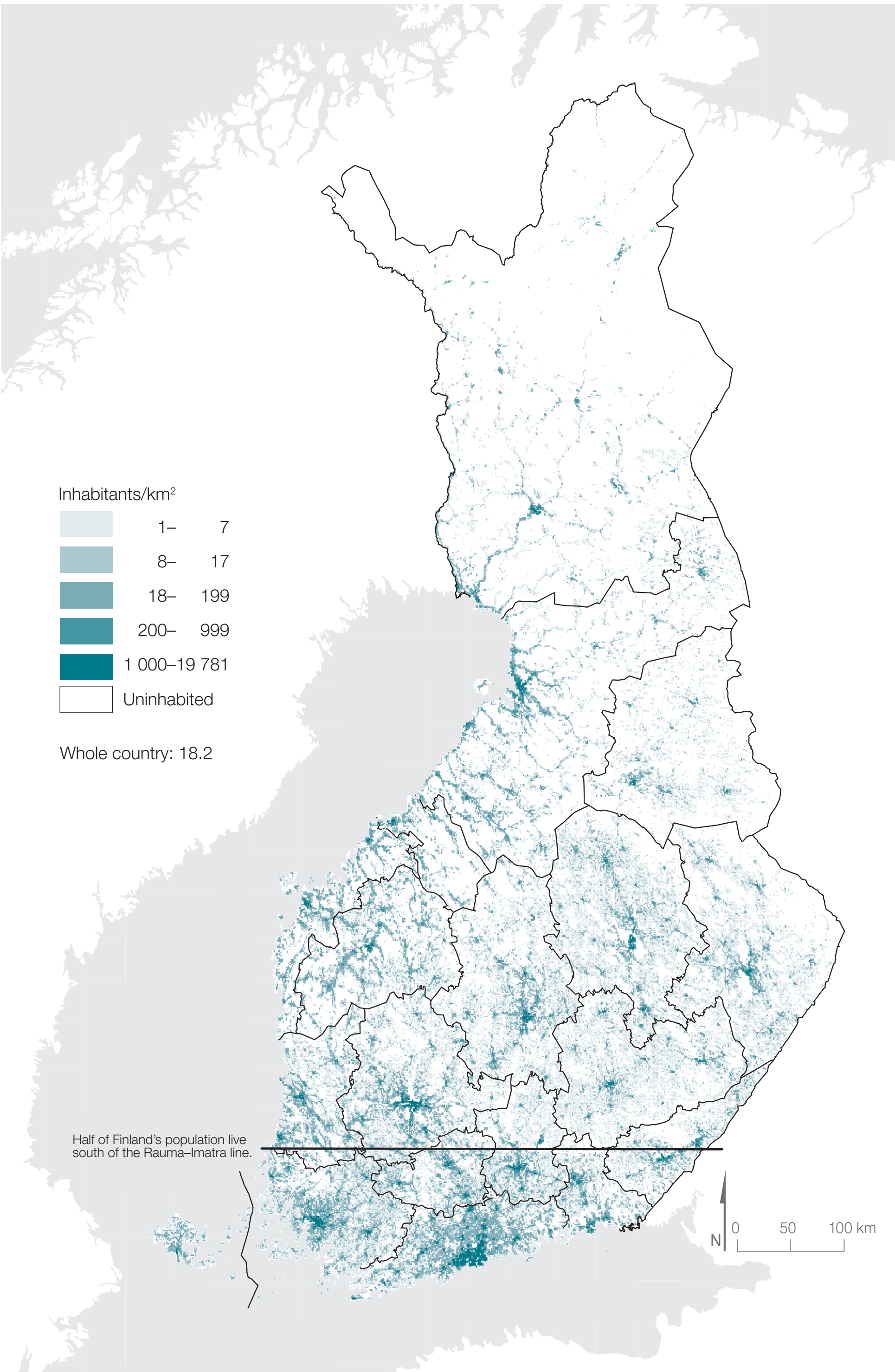
More information about the institutional framework of Finland's climate policy is presented in Section 4.2.

2.2 Population profile

The population of Finland was 5.5 million at the end of 2020. It increased by an annual average of 0.39 per cent between 1990 and 1999, by 0.35 per cent between 2000 and 2009 and by 0.30 per cent between 2010 and 2020. The population density averages 18 inhabitants per km^2 but ranges from two inhabitants per km^2 in Lapland in northern Finland to 187 inhabitants per km^2 in the south of the country in the Helsinki-Uusimaa region (Figure 2.1). The country's low population density and geographical extent mean long distances can be travelled for different purposes.

Many rural communities have a declining population, particularly in northern and eastern Finland. The urban population made up 72 per cent of the total population in 2020. The corresponding figure in 1990 was 63 per cent of a total population of 5.0 million. Internal migration from rural to urban areas was strong in the mid and late 1990s, when urban municipalities gained more than 10,000 migrations. Internal net migration to urban municipalities declined in the early 2000s but has increased steadily since, reaching an average of 9,000 internal migrations between 2015 and 2019. However, internal net migration to urban municipalities decreased to 5,000 in 2020.

Figure 2.1
Population density in Finland, 1 January 2021



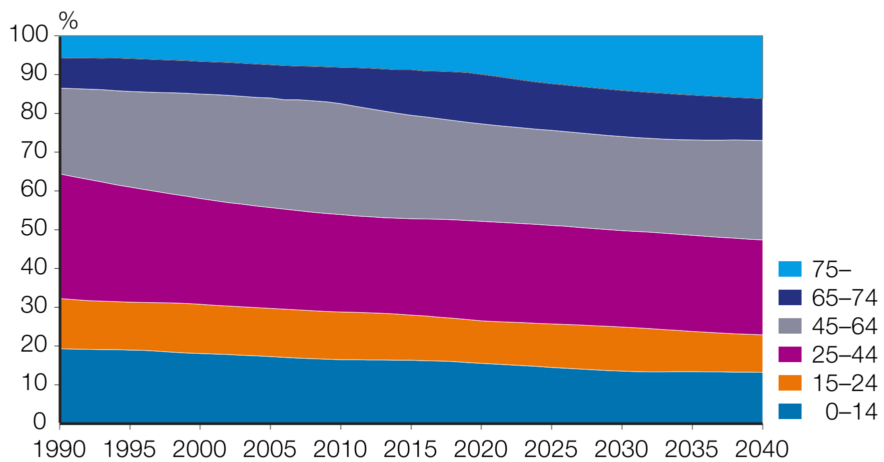
Source: Statistics Finland

Net migration to Finland increased steadily during the late 1990s and the 2000s. In 1994, the migration gain for Finland was about 3,000; in 2006, it reached more than 10,000 migrations. Between 2010 and 2020, net migration to Finland ranged between 12,000 and 18,000.

The number of one-person households has increased and the average household size has decreased. There was a total of 2.8 million households at the end of 2020. Forty-five per cent of households, or 1.3 million, consisted of only one person. The average size of a household was two people. In 1970, the average household size was still three people. Finland's current average household size is low compared with other countries.

The population is ageing. In 2020, the proportion of people aged over 65 was 29.2 per cent; in 1990, it was 13.5 per cent. This trend will accelerate in the coming years and decades. Life expectancy has risen rapidly during the past 30 years. At present, baby girls may expect to reach the age of 84.6, and baby boys the age of 79.0. The proportion of elderly people of the total population is increasing due to declining mortality rates and therefore longer life expectancy. Despite this trend, population growth has slowed down, and it is expected that the natural increase in population will decrease in the coming decades. According to population projections made by Statistics Finland in the autumn of 2021, it is estimated that the Finnish population will increase to 5.6 million by 2034 due to net migration gain but will then decline if fertility rates and amount of net migration remains at the current observed level in the future. By 2040, it is estimated that more than a quarter of Finland's population will be 65 years old or over (Figure 2.2).

Figure 2.2
Population profile for 1990 to 2040 (1990 to 2020 actual, 2021 to 2040 projected)



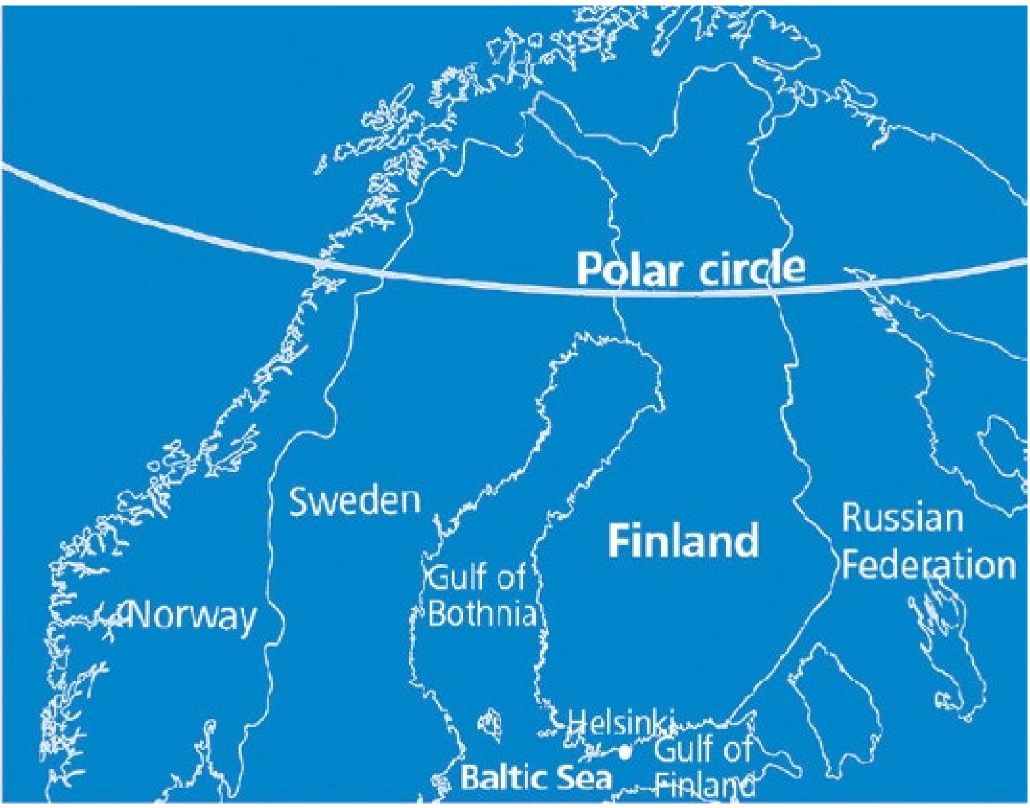
Source: Statistics Finland

2.3 Geographical profile

Finland is situated at a latitude between 60 and 70 degrees north, with a quarter of the country extending north of the Arctic Circle (Figure 2.3). In the west and south, Finland has a long coastline with numerous islands along the Baltic Sea coast. With a total area of 338,400 km^2, it is Europe's seventh largest country. The land boundary with Sweden is 614 km long, with Norway 736 km long and with Russia 1,340 km long.

Finland lies between the Scandinavian mountains and northern Russian plains. Its terrain is a varying mosaic of low hills, broad valleys and flat, low-lying plains, with higher fells in the north. The landscape is a mixture of forests, lakes and mires. Much of the country is a gently undulating plateau of mostly ancient bedrock. Nearly all of Finland is situated in the boreal coniferous forest zone, and 72 per cent of the total land area is classified as forest land, while only some eight per cent of it is cropland. Finland has more than 34,300 km^2 of inland water systems, which is about 10 per cent of its total area. There are some 190,000 lakes and 180,000 islands, with almost half the latter along the Baltic Sea coast.

Figure 2.3
Finland's location



Source: Statistics Finland

The Baltic Sea is the second largest brackish water basin in the world in terms of water volume. The water of the Baltic Sea is a mixture of ocean water and fresh water brought in by numerous rivers. The salinity of the surface water in the southern Baltic Sea is as high as 20 per mille, but in the northern reaches it drops to six per mille. Eutrophication is a severe problem affecting the Baltic Sea. It is the consequence of more than a century of nutrient loading caused by human activity (settlements, industry, agriculture, and forestry) in the Baltic Sea region.

Changes in land use since 1990 are shown in Table 2.1. The area of settlements has increased by 15 per cent, and that of grassland has decreased by nine per cent, whereas changes in areas of other land use categories have been small, one per cent or less (Table 2.1).

Table 2.1
Land use in 1990 and 2020

Land use classification [1]	1990 (km^2)	2020 (km^2)	Change, %
Forest land	221,090	218,493	–1.2
Cropland	24,719	25,017	1.2
Grassland	2,663	2,427	–8.9
Wetlands	30,070	29,777	–1.0
Settlements	12,235	15,058	23.1
Other land	13,139	13,104	–0.3
Total	**303,916**	**303,875**	
Inland waters	34,518	34,560	
Total with inland waters	338,435	338,435	

1 The classification is based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Vol.4. Agriculture, Forestry and Other land Use

Source: National Resources Institute Finland (Luke), Greenhouse Gas Inventory team

Box 2.1
Peatlands

Peatlands cover almost one third of the total land area in Finland, approximately 9.1 million hectares. Regional differences in coverage are considerable. The majority of the peatlands are located in the north, while only seven per cent are in southern Finland.

In Finland, two-thirds of the peatlands i.e. six million hectares is forest land of which over 70 per cent has been drained. Approximately 0.3 million hectares, three per cent of peatland is in agricultural use, i.e. cropland. Most of the drainage for forestry and agriculture has occurred in southern and central Finland.

The area of protected peatlands is approximately 1.3 million hectares, which is 14 per cent of peatlands. They consist mainly of areas under the national mire protection programme, areas in national parks and nature reserves, and old-growth forest conservation programme and wilderness areas. The total area of undrained peatlands is approximately four million hectares.

Peatland forests represent a significant share of the carbon sink of forests thanks to the increasing growing stock of trees. Undrained peatlands are carbon accumulating ecosystems in the long term. Depending on weather conditions, a particular peatland can vary on a year-to-year basis from a net sink to a net source of emissions. It is estimated that since the last ice age, peatlands have accumulated some 5,400 million tonnes of carbon, forming the largest soil carbon stock in Finland.

Approximately 67,000 hectares, 0.7 per cent of the surface area of peatlands, were in active peat production in 2020. Peat is used both as energy source and as horticultural, environmental and animal bedding peat. In recent years peat has accounted for approximately four per cent of Finland's energy production. On the other hand, peat-based growing medium is important for the greenhouse production as well as for the production of tree seedlings. According to revised Environmental Protection Act[1] the peat extraction must be situated to peatlands that have been drained or whose natural state has otherwise been significantly changed in a way that does not cause damage to a nationally or regionally significant nature value.

In 2012, the Finnish Government approved a resolution on the sustainable and responsible use and protection of mires and peatlands. The decision directs human activities to peatlands that have been drained or whose natural state has otherwise been significantly changed. It is used to implement sectoral policies and measures for sustainable and responsible use of mires and peatlands and it is used to improve the status of the existing network of protected peatlands.

The Mire Conservation Group (2012–2015) identified the most valuable mires nationally in terms of their natural value, which would complement best the current network of conservation areas. By 2020, around 44,000 hectares state-owned and private mire land both in Southern and Northern Finland were protected based on the proposal of the Mire Conservation Group.

Ongoing Helmi Habitats Programme continues the work of the Mire Conservation Group, aiming to protect at least 60,000 hectares mires by 2030. The implementation of the programme started in 2020, and in 2020 to 2021 almost 12,000 hectares both state-owned and private mire land were protected. In addition, the Helmi Habitats Programme aims to restore about 60,000 hectares of drained mires.

1 527/2014

2.4 Climate profile

The climate of Finland displays features of both maritime and continental climates, depending on the direction of airflow. Considering its northern location, the mean temperature in Finland is several degrees higher than in most other areas at these latitudes, i.e. Siberia, northern Canada, most of Alaska, and southern Greenland. The temperature is higher because of the Baltic Sea, due to the inland waters and above all, as a result of the airflows from the Atlantic Ocean, which are warmed by the Gulf Stream.

The mean annual temperature is close to 7 °C in the southwestern archipelago of Finland, decreasing towards the northeast. The 0 °C mean limit is slightly north of the Arctic Circle. Temperature differences between regions are greatest in January, when the difference between southern and northern Finland is an average of approximately 10 °C. In June and July, it is closer to 5 °C.

Finland enjoys long periods of daylight around midsummer, when the length of the day, including twilight, reaches 22 hours even at the latitude of the capital, Helsinki. North of the Arctic Circle (66.5°N), it remains light throughout the night at this time of year, as the sun does not descend below the horizon. In the far north, there is a period around midsummer of more than two months during which the sun never sets. Conversely, in winter, the northernmost region has two months of uninterrupted darkness.

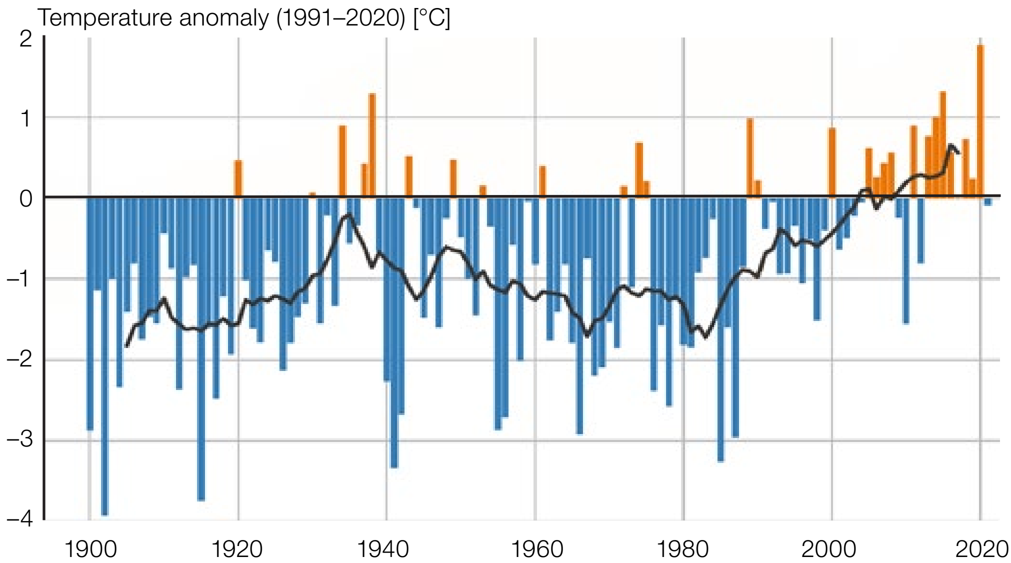
The Finnish climate is characterised by irregular precipitation, and there are typically rapid changes in the weather. The mean annual precipitation in southern and central Finland is usually between 600 and 750 mm, except near the coast, where it is slightly lower. In northern Finland, annual precipitation is approximately 450 to 650 mm.

The seasonal variation in precipitation is quite similar throughout the country, with the driest months February, March, and April. Precipitation then gradually increases until July and August, or until September and October on the coast, after which it decreases towards the winter and spring. Daily precipitation of 40 mm occurs in a certain location on average once every five years. During an average year, more than half the days have some precipitation, except near the coastal regions. Even in southern Finland, some 20 per cent of annual precipitation falls in the form of snow, which remains on the ground for about three to four months. In Lapland, 35 to 50 per cent of the annual precipitation falls as snow, and it remains on the ground for six to seven months. The lakes freeze over in October in Lapland and in early December in southern Finland. During severe winters, the Baltic Sea may freeze over almost completely, but during mild winters, it remains open for the most part, except for the Bothnian Bay and the eastern part of the Gulf of Finland. However, during the very mildest winters, even the Bothnian Bay does not freeze over completely.

The most common wind direction (around 20 per cent) is from the south or southwest. The average wind speed is three to four m/s inland; it is slightly higher on the coast and five to seven m/s in maritime regions. Damage due to storms and strong winds occurs most often during the autumn and winter, but also during the summer in connection with thunderstorms. Cloud cover is especially abundant in the autumn and winter, increasing from the northwest towards the southeast. The long-term average for the monthly cloud cover ranges from approximately 50 per cent in May to June to about 80 per cent in September to November.

The average annual temperature has increased since the beginning of the 20th century by about two degrees Celsius (Figure 2.4). The increase has been greatest in the winter and spring, but even in the summer and autumn, the temperature has increased by almost 1.5 °C. Most of the warming has taken place since the 1980s, and the new climatological normal period between 1991 and 2020 was approximately 0.6 °C warmer than the previous period between 1981 and 2010, and almost 1.3 °C warmer than the period between 1961 and 1990. Nevertheless, considerable temperature fluctuations occur between individual years, particularly in winter.

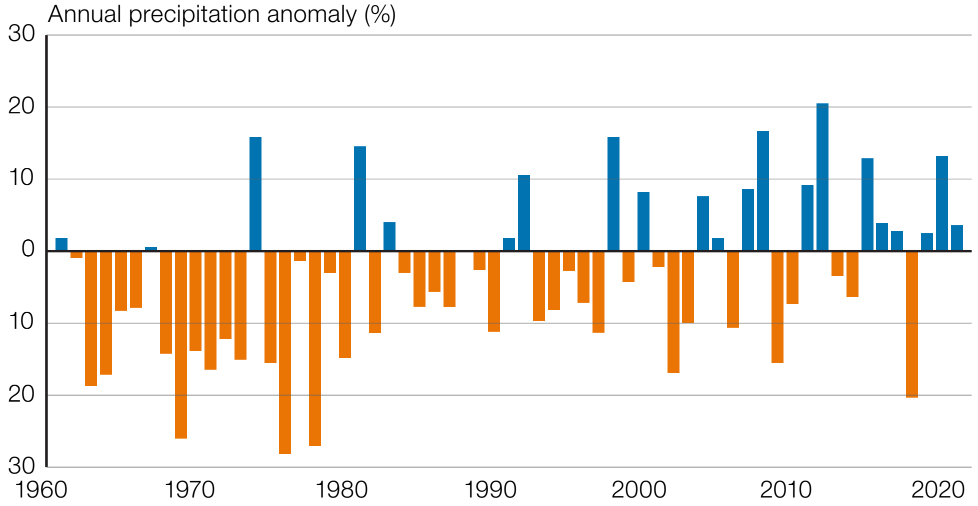
Figure 2.4
Annual mean temperature in Finland from 1900 to 2021, presented in anomalies (°C) relative to the reference period 1991 to 2020. The black line represents the 10-year moving average.



Source: Finnish Meteorological Institute

The average annual precipitation level shows significant variations from year to year (Figure 2.5). Long-term changes in the precipitation level are thus mainly obscured by the natural variability, but years with above-normal precipitation levels have recently occurred more often than in the 1960s and 1970s. Moreover, the countrywide average precipitation level was almost 10 per cent higher between 1991 and 2020 than between 1961 and 1990. Precipitation has increased mainly in the winter.

Figure 2.5
Annual mean precipitation in Finland, 1961 to 2021, presented as anomalies (%) for the reference period 1991 to 2020 in terms of mean precipitation

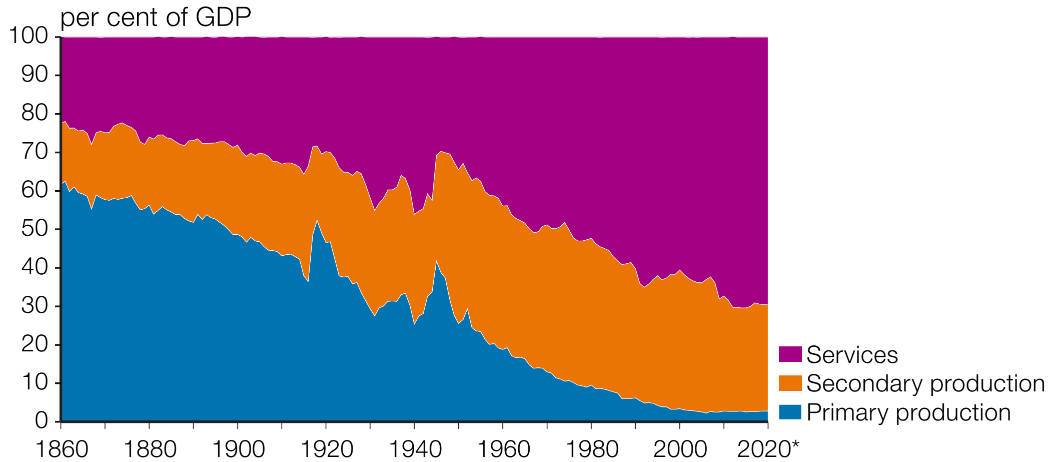


Source: Finnish Meteorological Institute

2.5 Economy

Finland has an open economy with prominent service and manufacturing sectors (Figure 2.6). As a member of the European Union and euro area, Finland's economy is integrated with the economies of other EU countries. The main manufacturing industries include the metal, electrical and electronics, chemical and forest industries. Foreign trade is important, with exports accounting for approximately 40 per cent of the gross domestic product (GDP). The cold climate, energy intensive industry structure and long distances have led to a relatively high energy intensity and per capita greenhouse gas emissions.

Figure 2.6
Structural change in the Finnish economy between 1860 and 2020



* Preliminary data

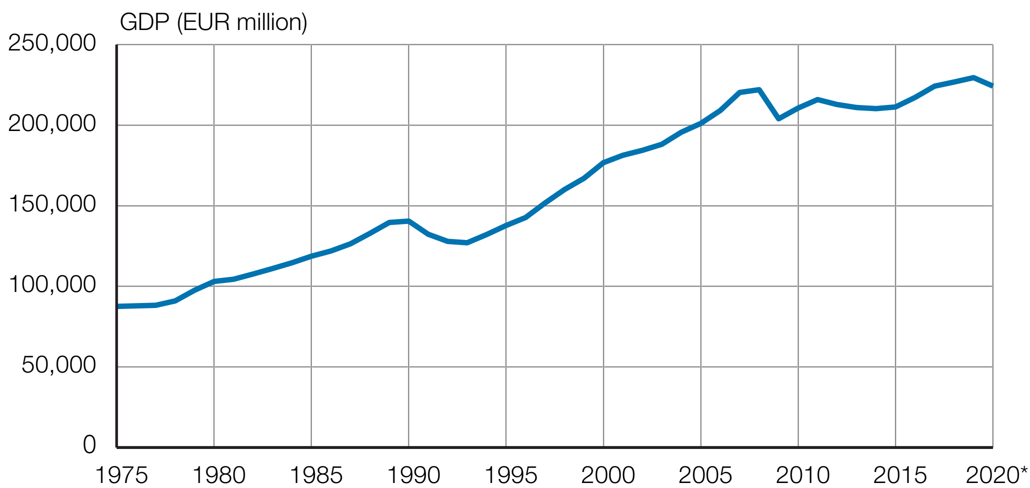
Source: Statistics Finland, Annual national accounts

For several decades, the Finnish economy was characterised by rapid growth combined with vulnerability to international cyclical fluctuations. Finland went through severe economic recessions in the early 1990s and again between 2008 and 2009 (Figure 2.7). The economy recovered rapidly after the first recession. During the 2008 to 2009 recession, the Finnish economy contracted by 10 per cent in the peak-to-trough period. By 2017, the Finnish economy had recovered from the recession that began in 2008.

In 2018 and 2019, GDP growth was modest. In 2020, the volume of Finland's GDP fell by 2.3 per cent as the Covid-19 pandemic prevailed but grew by 3.5 per cent the following year. The output of the national economy stood at EUR 43,440 in 2019, 43,032 in 2020, and 45,644 in 2021[2]. The national economy reached the pre-pandemic level in 2021. However, it is predicted that average GDP growth will remain moderate in the next few years because of a predicted decline in exports and manufacturing output due to economic sanctions imposed against Russia and declining growth in private consumption as a result of increases in consumer prices.

In 2020, net national income declined 1.3 per cent in real terms, which was significantly less than the decline in gross domestic product. The volume of investments decreased by one per cent, but aggregate demand in the economy was mainly maintained by consumption. The volume of total consumption contracted by three per cent from the previous year. However, net national income grew by 4.3 per cent in 2021.

Figure 2.7
Finnish gross domestic product 1975 to 2020 (at 2015 prices)



* Preliminary data

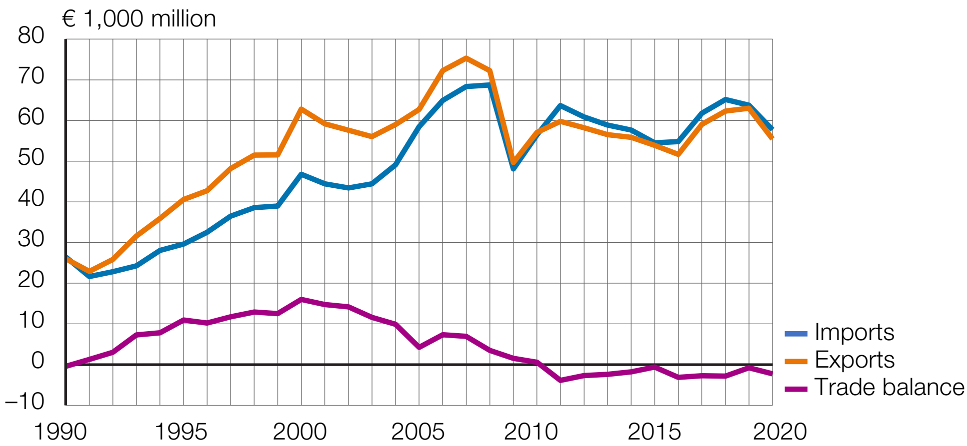
Source: Statistics Finland, Annual national accounts

2 Economic variables for 2021 are preliminary estimates published by the Annual National Accounts at Statistics Finland.

Finland's exports have recovered slowly from the recession of 2008 (Figure 2.8) and have yet to reach 2007 levels. Recovery has been slow particularly in the information and communication technology (ICT), forestry, and metal sectors. The slow recovery reflects falling demand for many products Finnish firms produce for the global market. To some extent, this development reflects a normalisation of the ICT sector's performance, following a lengthy boom before the 2008 recession.

The volume of exports of goods was 46 million tonnes in 2020, and the total value was EUR 57.3 billion, reflecting a decrease due to the Covid-19 pandemic (Figure 2.8). Machinery and equipment, forest and chemical industry products and metals and metal products have been the most significant groups of exported goods in recent years. More than half the total value is exported to the EU countries. The total value of exports of services was EUR 25.4 billion in 2020. Telecommunications, computer and information services are the largest item among exported services. The export of services has shown an increasing trend in recent years, except for 2020, when the Covid-19 pandemic decreased the export of travel and transport services especially. The degree of refining in exported goods is higher than in imported goods.

Figure 2.8
Finnish imports, exports, and trade balance of goods, 1990 to 2020 (at 2015 prices)



Source: Finnish Customs, Foreign trade of goods

Finland imported nearly 55 million tonnes of goods in 2020. The total value of imported goods was EUR 59.4 billion with a visible decline due to the Covid-19 pandemic (Figure 2.8). Industrial products represented some 80 per cent of the total value, with products of the chemical and electrical and electronics industries and vehicles the most significant groups of goods. For import of services, the most significant item was other business services. The import of services has usually exceeded the export of services in recent years; this was also the case in 2020, when the value of imports of services (EUR 27.8 billion) was greater than that of exports (25.4 EUR billion).

2.6 Energy

2.6.1 Energy supply and consumption

The energy-intensive basic industries, cold climate and long distances underline the significance of energy for the wellbeing of Finland's inhabitants and the country's competitiveness. Until the 1960s, Finland's energy policy relied on the electricity produced by hydropower stations and the extensive use of wood, after which the use of fossil fuels started to increase. The rapid increase levelled off after the oil crisis and with the advent of nuclear power (Figure 2.9). Renewable energy has increasingly replaced fossil fuels during the 2010s and is the main reason for the decreased greenhouse gas emissions despite the growth in energy consumption.

The use of fossil fuels and peat in energy production causes CO_2 emissions (see also Section 3.2.1). Nevertheless, the CO_2 emissions from fuel combustion per total primary energy supply are lower than in most other European countries. This is due to the high share of non-fossil energy sources in power and heat production, i.e. hydro, nuclear, and biomass sources (Table 2.2). Finland's share of renewable energy (43 per cent) in gross final energy consumption in 2019 was the second highest in the EU and continued at the same level in 2020 (44.6 per cent).

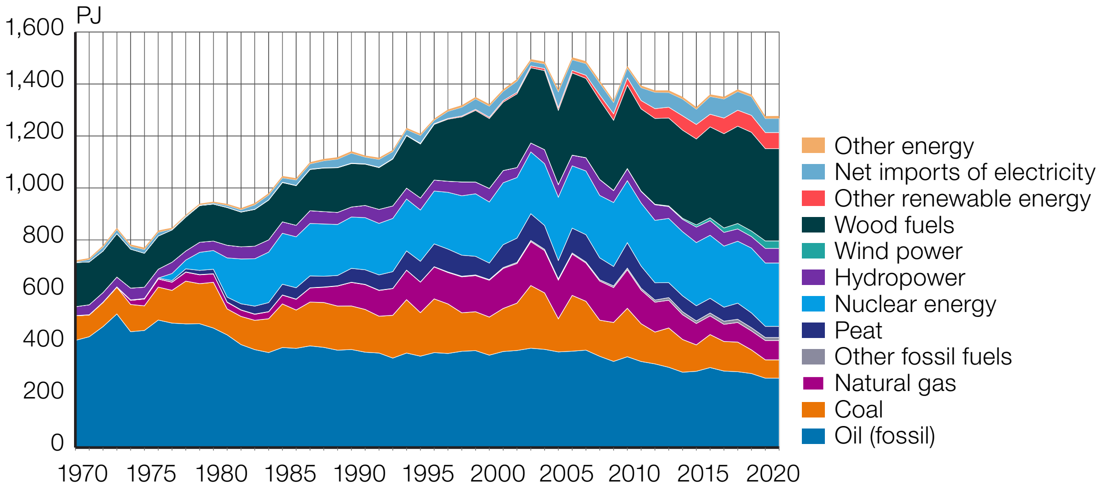
Table 2.2
Total energy consumption by sources in 2020

2020	Quantity (TJ)	Share of total energy consumption (%)
Wood fuels	355,404	27.8
Oil (fossil)	268,085	21
Oil (bio)	16,756	1.3
Nuclear energy	243,864	19.1
Coal	70,363	5.5
Natural gas	74,586	5.8
Peat	43,116	3.4
Net imports of electricity	53,917	4.2
Hydropower	56,410	4.4
Wind power	28,577	2.2
Heat pumps	23,723	1.9
Others (bio)	21,606	1.7
Others (fossil)	11,440	0.9
Others	9,391	0.8
Total	**1,277,238**	**100**

Source: Statistics Finland, Energy supply and consumption

For several decades, both total energy consumption and electricity consumption were increasing, and they reached their peak values in 2006. Demand rose more than GDP until 1994. Thereafter, both the energy intensity and the electricity intensity of the economy have decreased. The decrease reflects the structural change within the economy from basic industry towards services and less energy-intensive industry. Furthermore, increased energy efficiency has contributed to the positive development of energy intensity.

Figure 2.9
Total energy consumption, 1970 to 2020



Source: Statistics Finland, Energy supply and consumption [3] [4]

Total energy consumption

In 2020, total energy consumption was 1,277 PJ (355 TWh) (Table 2.2). Consumption fell by six per cent from the previous year due to both the Covid-19 pandemic and the exceptionally warm weather. The consumption of fossil fuels and peat dropped in total by 10 per cent compared to 2019, and their share of total energy consumption decreased to 37 per cent. The consumption of hard coal declined by 34 per cent and that of peat by 24 per cent. The ban on the use of hard coal for energy production, which will enter into force in 2029, is already affecting the use of hard coal.

In 1990, the share of renewable energy in total energy consumption was just 18 per cent, after which it has grown steadily. The growth of the share of renewable energy of total energy consumption has been the overall trend during the 2010s. Renewable energy has replaced the use of fossil fuels. In 2020, the share of renewable energy continued to grow, being 44.6 per cent of total final energy consumption in 2020 (i.e. 39.3 per cent of total energy consumption). Finland significantly exceeded the national target of 38 per cent of total final energy consumption by 2020 set in the EU's Renewable Energy Directive. In 2010, an extensive national package of specific targets concerning different renewable energy sources was launched to achieve the target. The package promoted the use of forest chips and other wood-based energy in particular, alongside wind power, the use of transport bio-fuels, and increased utilisation of heat pumps. Since 2010, measures have been strengthened and adjusted when required.

3 Coal includes hard coal and coke, blast furnace gas, coke oven gas, and until 1994, town gas.

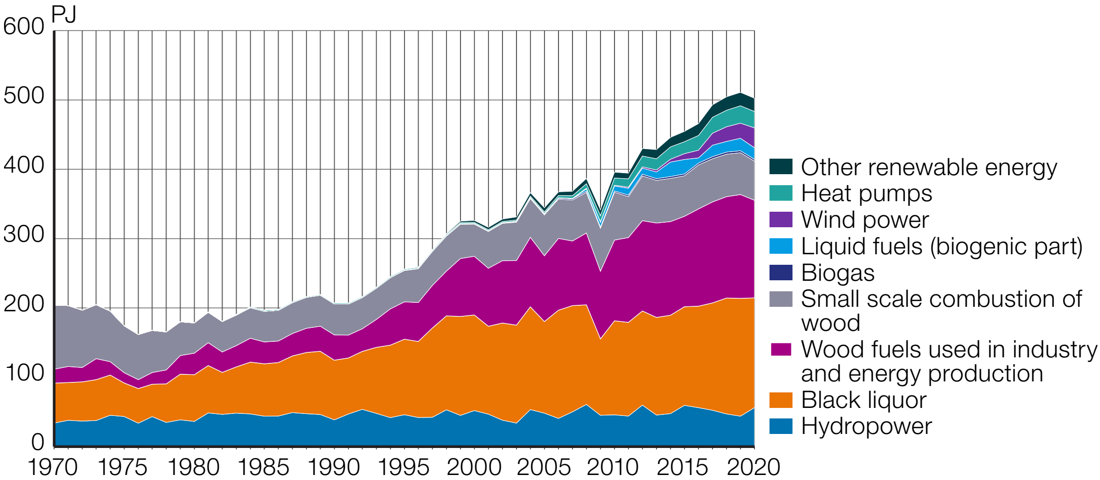
4 Other energy includes reaction heat of industry and hydrogen.

Policy measures promoting wind power have been highly successful, resulting in a viable industry and wind power being built in the 2020s fully on a market basis and without economic subsidies. Thanks to investment grants and tax support, the fastest relative growth can be seen in solar energy, even though the absolute amounts remain modest.

In 2020, wood fuels accounted for 28 per cent of total energy consumption, and they were the most used energy source in Finland from 2012 during the period from 1990 to 2020 (Figure 2.10). Their consumption fell by six per cent due to the warm weather and decreased production of energy-intensive industries in 2020. A major share of wood fuels is derived from the by-products of the forest industry, including black liquor derived from the pulp-making process and bark, sawdust, and other industrial wood residues. Logging residues or other low value biomass from silvicultural and harvesting operations are also used for energy generation. The share of black liquor from the consumption of wood fuels was 44 per cent in 2020.

Concerning fossil fuels, Finland depends on imports. Finland's domestic energy sources are wood-based fuels, hydropower, wind power, waste, peat and heat pumps. Its energy dependence, calculated as the proportion of imported net energy in the total primary energy supply (TPES), was 42 per cent in 2020. In reality, Finland relies more on imports than this energy dependency figure indicates, as the indicator considers nuclear energy to be domestic.

Figure 2.10
Total consumption of energy from renewable sources, 1970 to 2020



Source: Statistics Finland, Energy supply and consumption

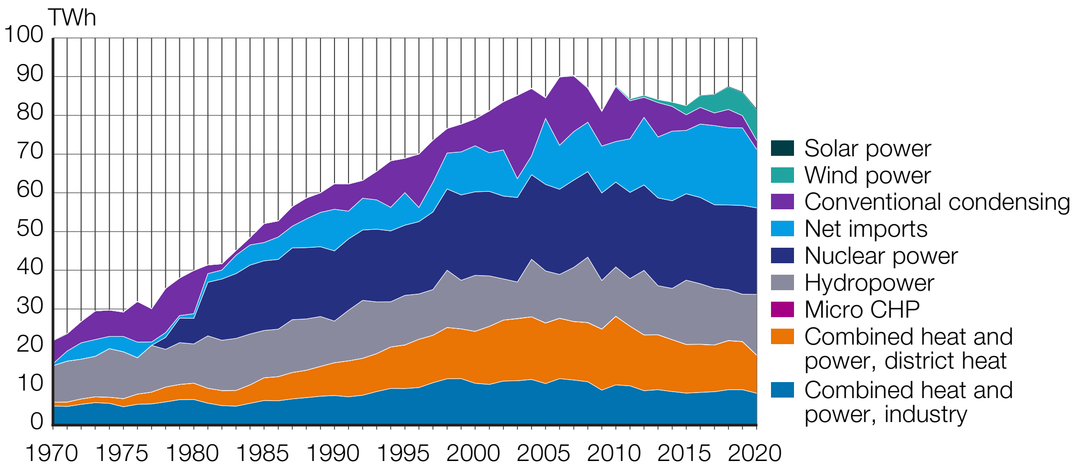
Electricity supply

In 2020, the volume of electricity used in Finland amounted to 81.6 TWh. Compared to the previous year, the use diminished by five per cent. In 2020, the production of electricity in Finland amounted to 66.6 TWh. This consisted of combined heat and power production (27 per cent), both in connection with district heat production and by industry for its own use, nuclear power (34 per cent), hydropower (24 per cent), conventional condensing power (three per cent), wind power (12 per cent) and solar power (0.3 per cent) (Figure 2.11).

In 2020, more than half Finland's electricity production was produced with renewable energy sources for the first time in around 50 years. The production of electricity with renewable fuels amounted to 10.9 TWh, of which 6.0 TWh were produced with black liquor and 4.3 TWh with other wood-based fuels.

Of total electricity consumption, 18 per cent (15 TWh) was accounted for by net imports of electricity from the Nordic countries, Russia and Estonia in 2020. Net imports contracted by 25 per cent from the previous year. Net imports vary considerably from year to year, mainly due to variations in hydropower production in the Nordic countries. Between 1990 and 2020, maximum net imports were 20.4 TWh (in 2017), while minimum net imports were 3.7 TWh (1996). When the availability of hydropower in the Nordic electricity market is scarce, Finland's net imports of electricity decrease. During such years, Finland has generated additional electricity using coal- and peat-fired power plants, which has resulted in higher CO_2 emissions for the years in question. However, in recent years, the share of electricity generation with conventional condensing power has declined, because the availability of wind power has grown (Figure 2.11). Installed wind power capacity has increased steadily in Finland since 1990 as a result of the Government's support measures. While Finland's wind power capacity was only about 1 MW in 1992, at the end of 2020, Finland's wind power capacity was 2.6 GW.

Figure 2.11
Electricity supply by production mode, 1970 to 2020 TWh



Source: Statistics Finland, Energy supply and consumption

District and industrial heat production

In 2020, the production of both district (35.1 TWh) and industrial heat (51.1 TWh) decreased by eight per cent from the previous year. Sixty-three per cent (54.7 TWh) of the production of district heat and industrial heat was produced with renewable fuels and 28 per cent (24.4 TWh) with fossil fuels and peat.

The reason for the decline in the production of district heat was the exceptionally warm year and winter in 2020. Most district heat was produced with wood fuels (38 per cent). The utilisation of excess heat with flue gas scrubbers and heat pumps has grown significantly in recent years, being 13 per cent in 2020. Although the use of peat in the production of district heat decreased from the previous year, it retained its position as the third most important source of energy for district heat production with a share of 13 per cent. In Finland, 57 per cent of district heat production is obtained in combined heat and power (CHP) generation. The share has diminished recently compared to previous years. Combined heat and power production (CHP) provides opportunities for the cost-effective use of renewables, both by industrial producers and at district heating plants. The amount of energy Finland saves annually through CHP approximately corresponds to a tenth of all primary energy used in the country compared with the same amount of electricity and heat produced separately.

The decline in the production of industrial heat in 2020 was affected by the lower production of the energy-intensive forest industry, which is one of the biggest users of industrial heat. The forest industry uses its own fuels like black liquor and other wood fuels in the production of industrial heat. Fifty-four per cent of heat produced for the needs of manufacturing came from black liquor[5].

Final energy consumption

In 2020, final energy consumption fell by 6.5 per cent from the previous year, totalling 288 GWh (1,036 PJ). Most energy was consumed in manufacturing, whose share in final energy consumption was 46 per cent (Figure 2.12). Space heating accounted for 25 per cent, and transport for 16 per cent, of final energy consumption, while the share of energy used for other purposes was 12 per cent.

In 2020, energy use in manufacturing decreased by seven per cent, being 133 TWh (480 PJ). Manufacturing was spared the worst Covid-19-related damage, because the long delivery cycles of the investment-commodity- intensive export industry boosted production. In 2020, record warm weather saw a decreased need for heating, and household energy consumption fell by seven per cent from the previous year. Reduced transport saw a decrease in the use of energy in transport by seven per cent in 2020.

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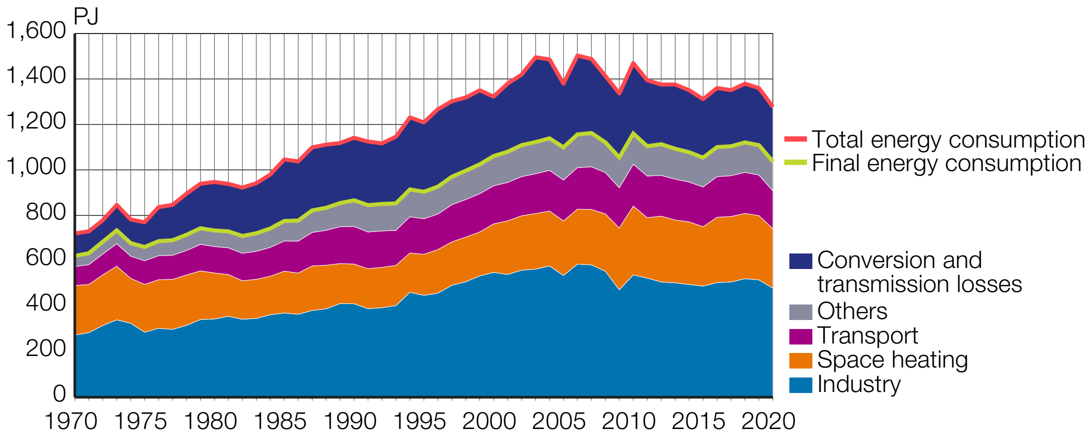
5 In the chemical, forest and metal industries, part of the use of heat is considered direct fuel use in the statistics and is thus not visible in the production figures for industrial heat.

Figure 2.12
Total energy consumption and final energy consumption by sector, 1970 to 2020



Source: Statistics Finland, Energy supply and consumption

2.6.2 Energy market

The Finnish electricity market was opened gradually to competition with the enactment of the Electricity Market Act in 1995. Since the autumn of 1998, it has been possible for all electricity consumers, including households, to invite tenders for their electricity purchases. The electricity generation sector is characterised by a large number of actors. The total number of companies producing electricity is around 150, and there are around 400 production plants. To serve Finland's 3.3 million electricity customers, there are currently about 70 retail suppliers.

The Finnish electricity wholesale market is part of the coupled European power market. For more than a decade, Finland has formed an integrated wholesale electricity market with Denmark, Norway, and Sweden, and in the 2010s, Estonia, Latvia and Lithuania joined the common market. Since 2014, the Nordic and Baltic power market has been price coupled with the continental electricity markets. Physical day-ahead and intra-day trading takes place in the Nord Pool power exchange and the EPEX Spot power change that started operations in Finland in June 2020. The formulation of area prices and the allocation of cross-border capacity between Finland and the other countries are managed by implicit auctions in the power exchange's day-ahead market. In 2020, 45.2 TWh electricity was sold and 59.0 TWh bought, in the economic area of Finland. Electricity is also traded on the Over-the-Counter-Market and directly between the buyer and the seller.

The transmission system operator, Fingrid Oyj, is responsible for managing the national power balance and ensuring that the transmission system is maintained and used in a technically appropriate manner. With the other Nordic system operators, Fingrid is responsible for safeguarding the necessary reserves for the operation of the power system.

The natural gas market in Finland was opened to competition at the beginning of 2020 after the Balticconnector pipeline from Finland to Estonia was commissioned. Finland has since been part of the Finnish-Baltic gas market and since the commissioning of the GIPL pipeline on 1 May 2022, the Finnish-Baltic area has also had a gas pipeline connection with the Central European gas network. Now it is possible for all gas consumers to choose their gas supplier in Finland. However, when choosing a gas supplier other than the incumbent, a remotely readable gas meter is required. A total of 20.7 TWh of natural gas was consumed in 2020. The largest natural gas user groups are the energy companies, the pulp and paper industry and the chemical industry; together, they use approximately 90 per cent of the gas. There are about 20 natural gas retail suppliers and approximately 29,000 retail customers. The majority of retail customers use gas only for cooking, and the share of the retail supply is small.

A long-term objective is to increase the alternatives for the supply of natural gas. This is important for the safeguarding of both the security of supply of natural gas and the functioning of the market. Until the end of 2019, natural gas was imported only from Russia. The commissioning of the Balticconnector pipeline has provided additional sources for natural gas. It enables the Finnish market actors and gas users to import gas via Klaipeda LNG terminal in Lithuania and to use Inčukalns underground gas storage in Latvia. In 2020, about a third of gas was imported via the Balticconnector pipeline. In addition, Finland has two off-grid LNG terminals in Tornio and Pori, serving mainly industrial customers in those regions. A grid-connected LNG terminal in Hamina will be commissioned in the autumn of 2022. After the Russian invasion of Ukraine, the Government commissioned the gas transmission system operator, Gasgrid Finland Oy, to negotiate and rent a floating FSRU LNG terminal in April 2022 with the Estonian transmission system operator.

Emissions trading within the EU is a market-based instrument for reducing emissions in the energy sector. The EU emissions trading system applies to large industrial installations and installations with a total rated thermal input exceeding 20 megawatts and to flights within the European Economic Area (EEA). In Finland, the system also applies to district heating plants with a generating capacity of 20 megawatts and to smaller combustion installations connected to the same district heating network. Any installation covered by the emissions trading system needs an emissions permit. In Finland, around 600 installations need a permit.

2.7 Transport

Transport demand and supply are influenced primarily by developments in the economy, demographic factors, employment patterns and infrastructure provision. Increased access to high-speed transport has increased the commuting distance between work and home.

The Finnish transport network consists of roads, rail transport, waterways, and the air traffic infrastructure, the main elements of which form part of the EU's Trans-European Networks. The Finnish road network has approximately 78,000 km of public roads. In addition, there are 350,000 km of smaller private roads, many of which are used for forestry purposes. Finland has about 933 km of motorways and 136 km of semi-motorways. The rail network amounts to a total of 5,918 km, of which 3,349 km is electrified.

Three quarters of Finland's foreign trade goes by sea, most of it from the country's principal ports. Most of Finland's many ports and harbours are small, and traffic flows vary considerably. Icebreakers play an important role, with eight responsible for assisting freighters and passenger ships access the 27 ports and harbours kept open all year round. In a normal winter, the harbours in the Bothnian Bay require icebreakers for half the year, while in the Gulf of Finland, they are needed for about three months.

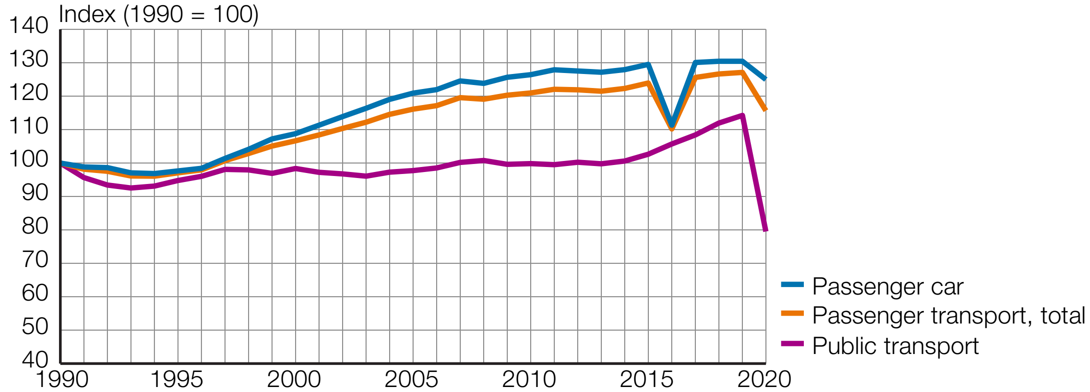
Finland has a network of 24 airports, of which 20 are maintained by Finavia (formerly the Civil Aviation Administration). Approximately 95 per cent of the country's international air traffic operates via Helsinki Vantaa Airport.

2.7.1 Passenger transport

Domestic passenger transport, measured in terms of passenger-kilometres, has increased by approximately 16 per cent since 1990. Cars account for approximately 86 per cent of the total passenger-kilometres. In 2020, the number of passenger-kilometres travelled by car was 25 per cent greater, and the number of passenger-kilometres by public transport was 20 per cent smaller compared to 1990 (Figure 2.13). The passenger-kilometres volumes in public transport were 30 per cent smaller in 2020, the first year of the Covid-19 pandemic, compared to the previous year. The decline was 78 per cent in air travel, 42 per cent in rail travel and 14 per cent in bus travel. Greenhouse gas emission trends in the transport sector are presented in Section 3.2.1.

The number of electric passenger cars in traffic has increased rapidly in recent years in Finland. The share of new passenger car registrations of alternative propulsion increased by 20 per cent between 2019 and 2020. An especially significant change happened in the number of full electric passenger cars registered in 2020, an increase of 124 per cent from the previous year. At the end of 2020, there were 45,260 plug-in hybrid electric cars in traffic and 9,697 all-electric cars.

Figure 2.13
Development of passenger-kilometres in domestic transport, 1990 to 2020*



* Due to changes in calculation methods figures since 2016 are not fully comparable with figure before 2016

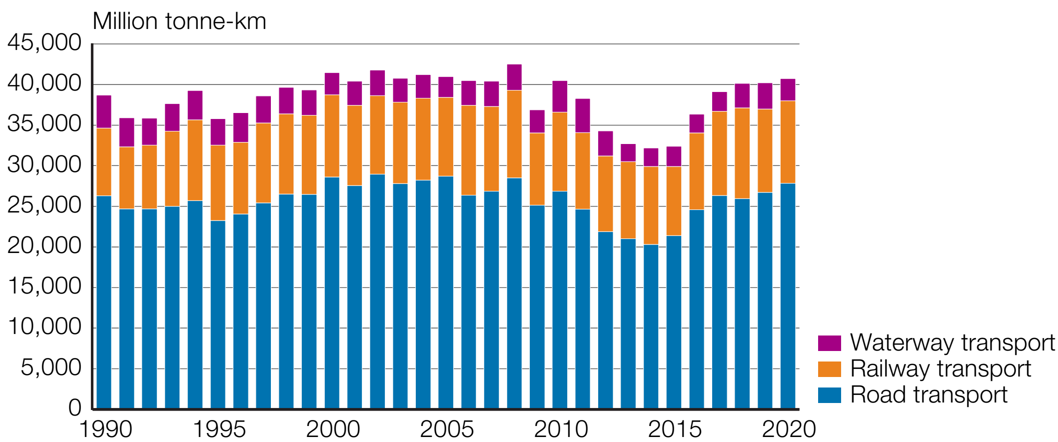
Sources: Statistics Finland and the Finnish Transport and Communications Agency Traficom

2.7.2 Freight transport

The number of freight tonne-kilometres in inland Finland per capita in 2020 was about 1.4 times as big as the number of freight tonne-kilometres in the EU, mainly because of the long distances and industrial structure. Heavy industries such as timber, pulp and paper, and metal and engineering have traditionally played a prominent role in the Finnish economy, and these industries all need transport for their raw materials and products.

Road haulage is the most important form of transport for domestic goods traffic (Figure 2.14). More than 66 per cent of all freight is transported by road, while rail transport accounts for 26 per cent of all transport, and inland waterways for just under eight per cent. The volume of domestic air freight has declined sharply during the 21st century, and air transport's share in domestic goods transport is almost negligible.

Figure 2.14
Tonne-kilometres in domestic goods transport, 1990 to 2020



Source: Statistics Finland

Almost 92 per cent of overseas freight travels by sea, while approximately six per cent travels by road. Air freight is almost negligible in terms of tonnes, whereas in terms of value, it accounts for more than nine per cent of all transport. Products with a high added value, such as electronics, are transported by air.

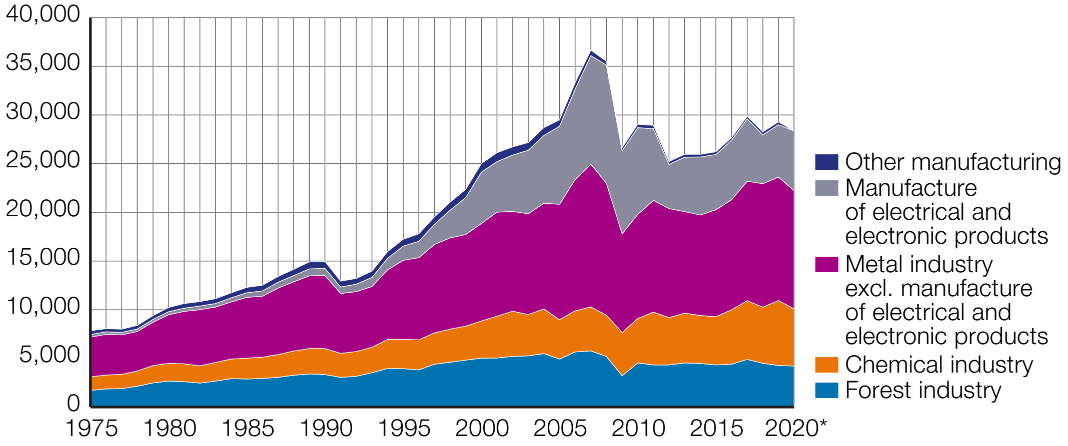
2.8 Industry

The main manufacturing industries include metal, chemical and forest industries. The rapid expansion of the metal products industry, especially electronics, has changed the traditional industrial structure starting from the mid-1990s (Figure 2.15). The share of electrical and electronic products of the total output of the metal industry has grown considerably from nine per cent in 1990 to 30 per cent in 2020. The increase in the technology intensity of the country's manufacturing sector has been strong.

The value of the output of industry was around 84 billion in 2020, the first year of the Covid-19 pandemic, whereas it was 77 billion in 2015. The value fell by 9.7 per cent from the previous year, which is notably more than what the average year to year fluctuation, two per cent, has been during the last decade.

In 2020, the metal industry accounted for 45 per cent in total value of sold output of manufacturing industries. The chemical industry accounted for 19 per cent, the forest industry 17 per cent, and the food industry 11 per cent. Proportional contribution of the industries has not undergone notable changes in the past decade. Total industry accounted for 20 per cent of the GDP in 2020 (25 per cent in 1990).

Figure 2.15
Output of manufacturing industries by sector, 1975 to 2020 (at 2015 prices)



* Preliminary data

Source: Statistics Finland, Annual national accounts

The value of sold industrial output of the metal industry, has grown over six per cent from 2015 to 2020. The Covid-19 pandemic affecting, the value of the metal industrial output diminished by six per cent in 2020. The annual change in volume of the metal industry from 2019 to 2020 however was 3.8 per cent, and especially the volume of manufacturing electronic products grew clearly generating an almost seven per cent change in the value of sold industrial output 2020.

The value of the sold output of the chemical industry has grown 22 per cent from 2015 to 2020. In 2020, the Covid-19 pandemic had a particular effect on the value of the output of the chemical industry, which contracted over twenty per cent.

The value added produced by forestry and the forest industries, one of Finland's traditional industrial sectors, diminished by 10 per cent to 7.7 billion in 2020, comprising 3.8 per cent of the total value added of the national economy. The forest industry has undergone structural change as manufacturers have downsized their capacity in certain paper segments. In general, paper production has declined, while paperboard production has shown an opposite trend. The volume of exported pulp has doubled from 2001 to 2020. In general, the trend in industrial output at constant prices is fairly similar to that of the GDP. In the chemical industry, especially in oil refining, the production of renewable fuels is growing.

In 2020 a total of 45 mines and quarries were operating in Finland. The yearly volume of mining has increased from around 30 million tonnes in 2001, to 115 million tonnes in 2020. The increase is mainly caused by few open pit operations. From 2015 to 2020, mining and quarrying products have accounted for a small, one to two per cent portion of the total sold output of total industry.

In 2020, Finnish industry used 38 per cent of the country's total primary energy and 45 per cent of its total electricity (Figure 2.12). In 2020 the most significant energy sources of the final energy consumption by the industrial sector were biomass (40 per cent), purchased electricity (21 per cent), purchased heat (10 per cent), and oil (10 per cent). Over the last ten years the share of biomass as an energy source has risen significantly, while the share of oil and heat have decreased (Figure 2.16).

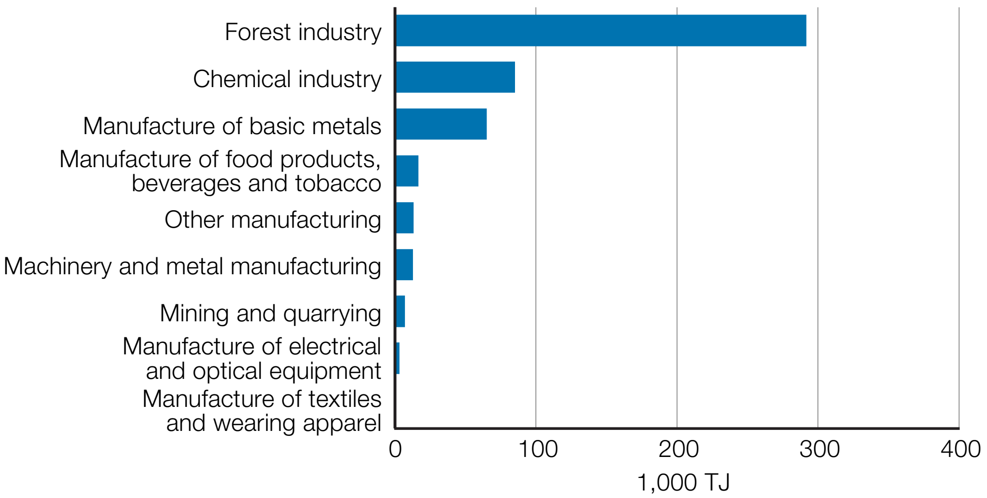
Figure 2.16
Energy use in manufacturing by source in 2010 and 2020

* Purchased (net), i.e does not include electricity and heat produced and used by the manufacturing industry

Source: Statistics Finland, Energy use in manufacturing

The forest industry uses more energy than any other industrial sub-sector (59 per cent), followed by the chemical industry (17 per cent) and the manufacturing of basic metals (13 per cent) (Figure 2.17). A considerable number of the energy-intensive industries are export oriented. More than 90 per cent of paper and board production is exported and the share of exports is also high in the basic metal industry and in the chemical industry's products.

Figure 2.17
Energy use in manufacturing by industry in 2020



Source: Statistics Finland, Energy use in manufacturing

Because of their high energy demand, energy-intensive industries have worked hard to improve their energy efficiency. For example, between 1990 and 2020 industrial output increased by over 58 per cent (measured in terms of value added in 2015 prices), while the final consumption of energy rose by only about 17 per cent. In other word, the overall intensity fell by a quarter. All pulp mills produce energy in excess of their own requirements. Currently, the by-product of chemical pulp production, black liquor, is the most significant renewable energy source in Finland. Forest industry side streams (bark, sawdust, wood chips) are also used elsewhere, especially in district heating. At many industrial sites, the heat left over from the pulping process is channeled to the municipal district heating network. Yet, in their search for higher profit margins, industrial installations have increasingly outsourced their electricity generation to the open electricity market.

2.9 Building stock

Finland's largest cities are in the southern and western parts of the country, and the size of settlements tends to decrease towards the northern and eastern parts of the country. Outside the relatively few larger towns and cities, Finland is a land of small towns and rural communities. Most of the economically important cities are on river estuaries along the coast or inland at the intersections of the various lake systems.

In 2020, the total heated building area amounted to 505 million m². Residential buildings accounted for 63 per cent of the area, while office, commercial, public and industrial buildings made up 36 per cent of the area. The remainder consisted of free-time residences, agricultural buildings and other small outbuildings. There were a total of 3,157,671 dwellings, of which 38 per cent were one-dwelling and two-dwelling houses, 13 per cent terraced houses, 47 per cent dwellings in blocks of flats and two per cent other buildings in 2020.

The number of dwellings increased by 42 per cent between 1990 and 2020. In addition to this increase in the number, there has previously also been a gradual increase in the average size of dwellings. In 1990, the average residential floor space per dwelling was 74 m²; by 2015, it had increased by six square meters to 80 m². From 2015 to 2020, the average residential floor space per dwelling remained nearly the same. The figure for residential floor space per person grew by more than the figure per dwelling. In 1970, the residential floor space per person was 19 m²; by 1990, it had increased to 31 m². By 2020, it had increased to 41 m². On average, Finns spent 25 per cent of their disposable income on housing in 2020, including energy costs. There have been no radical changes in the share of income spent on housing in recent decades.

The building stock is fairly new, with more than 50 per cent of all buildings having been constructed since 1970. More than 98 per cent of dwellings have flush toilets, and more than 99 per cent have a sewer and running water. In 2020, a total of 35,800 new dwellings was completed.

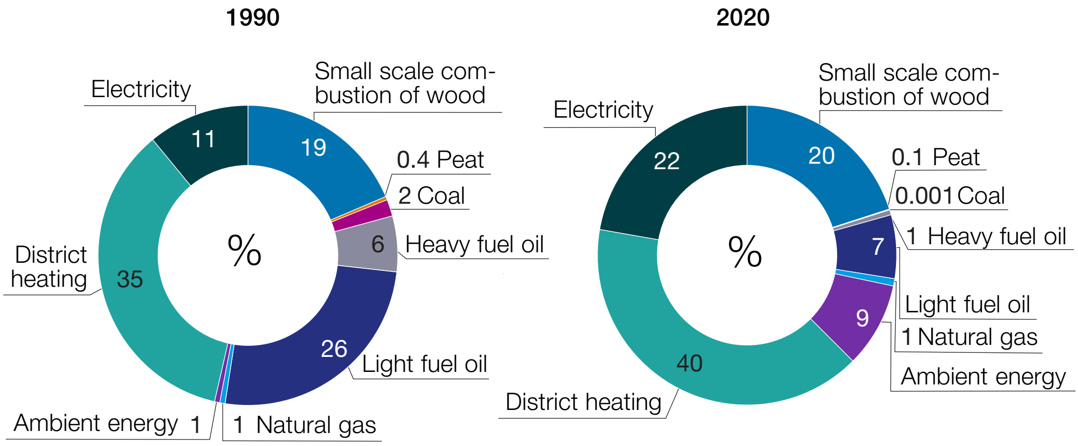
2.9.1 Energy use for indoor heating

Because of the country's northern location, a great deal of energy is used for indoor heating in Finland. The total area of heated buildings increased by some 50 per cent between 1995 and 2020. The heating of indoor spaces consumes roughly two thirds of the energy consumed in households. It is the biggest source of CO_2 emissions by household, as well as within the public and service sectors (see also Section 3.2.1).

The composition of energy sources used for heating changed significantly between 1990 and 2020 (Figure 2.18). As the share of district heating in the heating of indoor spaces has increased with an increase in the use of electricity in heating, there has been a shift in heating-related greenhouse gas emissions from the accounting under the EU Effort Sharing Decision to the EU Emissions Trading System. The use of heavy fuel oil has decreased by 90 per cent and the use of light fuel oil by 60 per cent. At the same time, energy obtained from natural gas has increased 40 per cent. Light fuel oil has lost some of its market share to electric heating and later also to heat pumps in detached houses.

The use of electricity in heating has doubled (Figure 2.18). In addition to electric heaters, this category contains the electricity used by heat pumps, as well as secondary electric heating. Heating with heat pumps has become more common. The share of heating energy produced by heat pumps was only one per cent in 1990, but in 2020, their share was nine per cent. The increase in the use of heat pumps is due to economic and environmental reasons, as well as to advances in technology. Small-scale combustion of wood has increased by 31 per cent since 1990. It is often used as a secondary heating system, but it is also used as the principal heating source in rural areas.

Figure 2.18
Energy sources for heating residential, commercial, and public buildings in 1990 and 2020



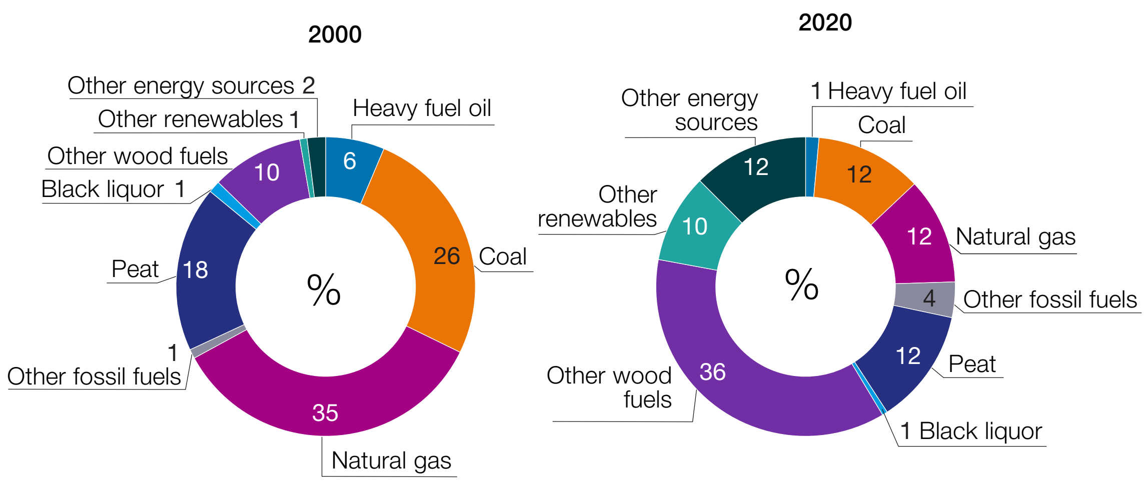
Source: Statistics Finland, Energy Statistics

District heating has also increased considerably, by 39 per cent. The district heating network now covers most areas with a cost-effective potential. The share of district heating was 40 per cent of the total heating energy in 2020. District heating is the primary heating system in blocks of flats, and half the country's total building stock relies on it. A wide range of fuels is used to produce district heat (Figure 2.19). Shares of coal and oil in the production of district heat have decreased in recent decades. Peat, an indigenous fuel, is used especially in inland areas.

Combined heat and power (CHP) accounts for more than 65 per cent of the total heat produced in district heating, i.e. practically all the potential for CHP has been exploited. CHP improves efficiency, especially compared with separate condensing power production. CHP is also an efficient way to decrease CO_2 emissions from energy production.

The share of renewable energy sources in the production of district heating has increased considerably (Figure 2.19). Government and industry efforts have helped increase the use of wood fuels, mostly in the form of by-products from forestry and the forest industry, such as chips made of harvesting residues and black liquor.

Figure 2.19
Fuels in district heating production in 2000 and 2020



Source: Statistic Finland, Energy Statics

In recent decades, demand for heating energy has decreased. According to the Finnish Meteorological Institute, winters especially have become generally milder. The figure for heating degree days (HDD) is a quantitative index, designed to reflect the demand for the amount of energy needed to heat a building; it is calculated using a 17 °C indoor temperature as the base. The HDD has decreased from a 5-year average of 4,700 in Helsinki, in southern Finland, to 3,200 per year from 1981 to 2020. In Oulu, in northern Finland, the corresponding decrease was 5,900 to 4,200.

In addition, energy conservation in heating has been aided considerably by technical advances in insulation and window designs, as well as by developments in combined heat and power (CHP) production, district heating, heat recovery and air-conditioning and ventilation systems.

2.9.2 Urban structure

The regional development in Finland has been characterised by increasing differences between regions. Population growth and new jobs have concentrated mainly on a few big growing urban regions, principally Helsinki, Tampere, Turku, Oulu, Jyväskylä and Kuopio. Growth has occurred due to migration, immigration, and large shares of young fertile age groups. Most middle-sized and small urban centres have either kept the number of population or have been suffering from population decline since 2010. In the rural areas close to the urban areas population grew in the beginning of the 2000's but has turned to decline since. Population decline has also worsened in the rural heartland areas from 2000 to 2020. In sparsely populated rural areas population has declined approximately 1.5 per cent per year for a long time.

Urbanization has accelerated in Finland since 2000. Share of population living in the urban regions has increased from 64 per cent in 2000 to 73 per cent in 2020 and share of workplaces in the urban regions from 73 per cent to 80 per cent. Pre-pandemic population and workplace growth centered to fewer urban regions than previously. The Covid-19 pandemic resulted in a period of more balanced regional growth when several municipalities that previously suffered net migration loss, gained positive net migration for the first time in a long time. Population projections estimate the population to peak in Finland in 2030's due to ageing population, low fertility, and relatively low immigration level. In the future, urbanization continues but slows down. Population growth will concentrate on the four biggest urban regions.

Finland became urbanized relatively late, and the urbanisation process is still continuing. The share of the population in densely built-up areas (urban areas and rural localities) has risen continuously, and these areas accounted for 87 per cent of the population in 2021. There are 712 built-up areas covering approximately 2.3 per cent of the land area in 2021. In 2000, the corresponding proportion was 1.8 per cent. The population density in these built-up areas was 683 inhabitants per km^2 in 2021. Density has declined by 70 inhabitants per km^2 since 2000 as the lower density fringes of these built-up areas have grown. However, in some of the biggest urban regions, the density has started to rise slightly in the main urban area particularly after 2010. Approximately 65 per cent of the inhabitants of all urban areas live in neighbourhoods with a population density of more than 20 inhabitants per hectare. The percentage has declined until 2011 but increased after that by 1.4 per cent. Approximately 72 per cent of the inhabitants of urban areas live in pedestrian or transit zones, and 28 per cent in car-dependent zones in 2020. Compared with the other Nordic and European countries, the population density of these built-up areas is still quite low. It is less than half the population density of comparable areas in Sweden or Norway.

Often there is no distinct boundary between urban and rural areas, as in many cases there are some tight restrictions on construction close to urban areas. This has led to a dispersed and fragmented urban structure. Urban areas have typically expanded inexorably outwards, leading to the creation of unstructured, low-density built-up areas. These low-density districts of built-up areas outside the urban plan cover 35 per cent of the land surface of the country's urban areas — even in the main growth centers. Low-density development causes problems in terms of arranging services, maintaining infrastructure and planning urban form. Many of the households in these areas need more than one car to manage their daily lives (commuting, school trips, acquiring services, and engaging in free-time activities). Despite the expansion of low-density areas, the share of population living in low-density areas and scattered settlements within urban regions has declined by 2.6 per cent since 2000.

Figure 2.20a
Share of commuting directed towards urban areas, 2000

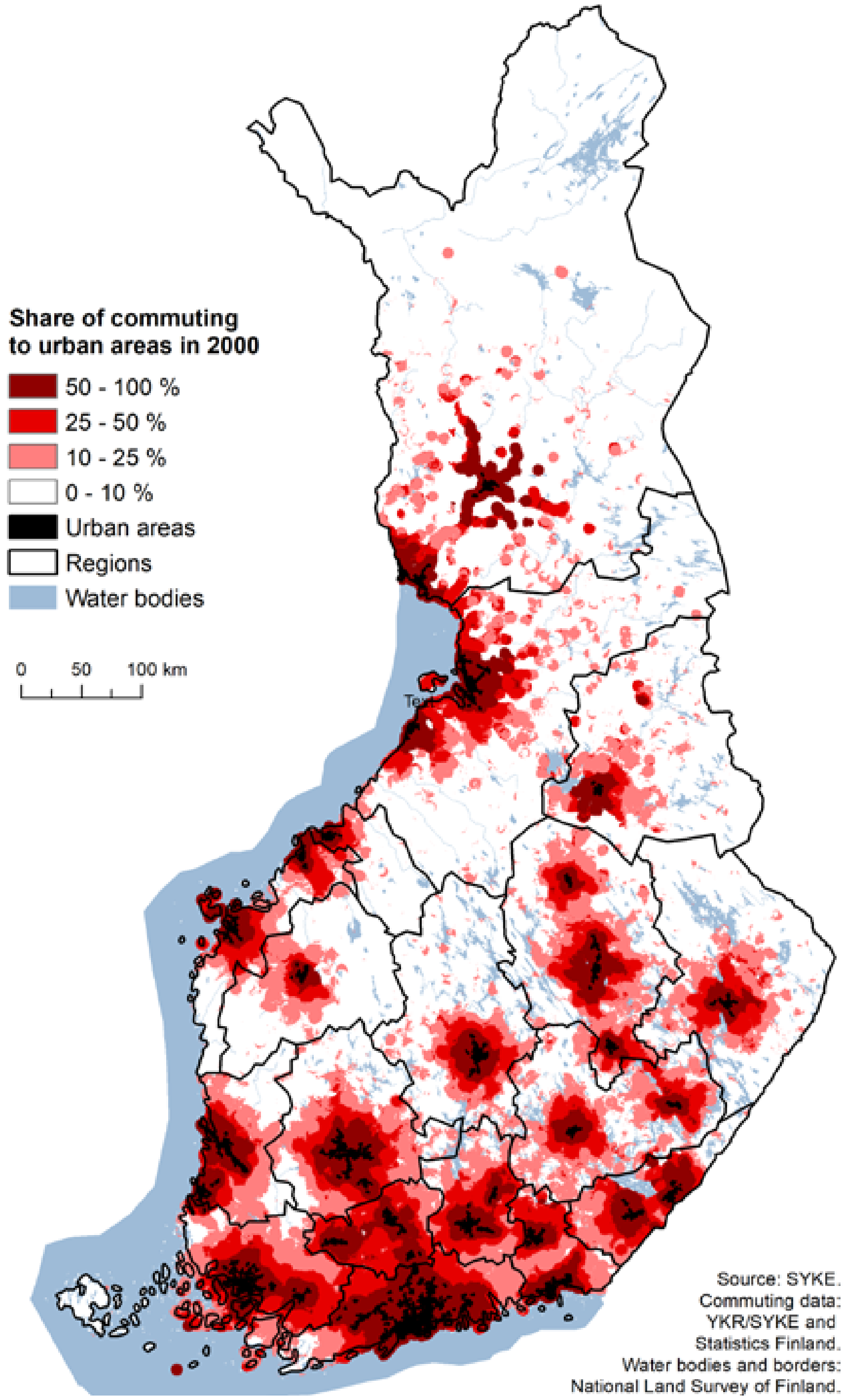
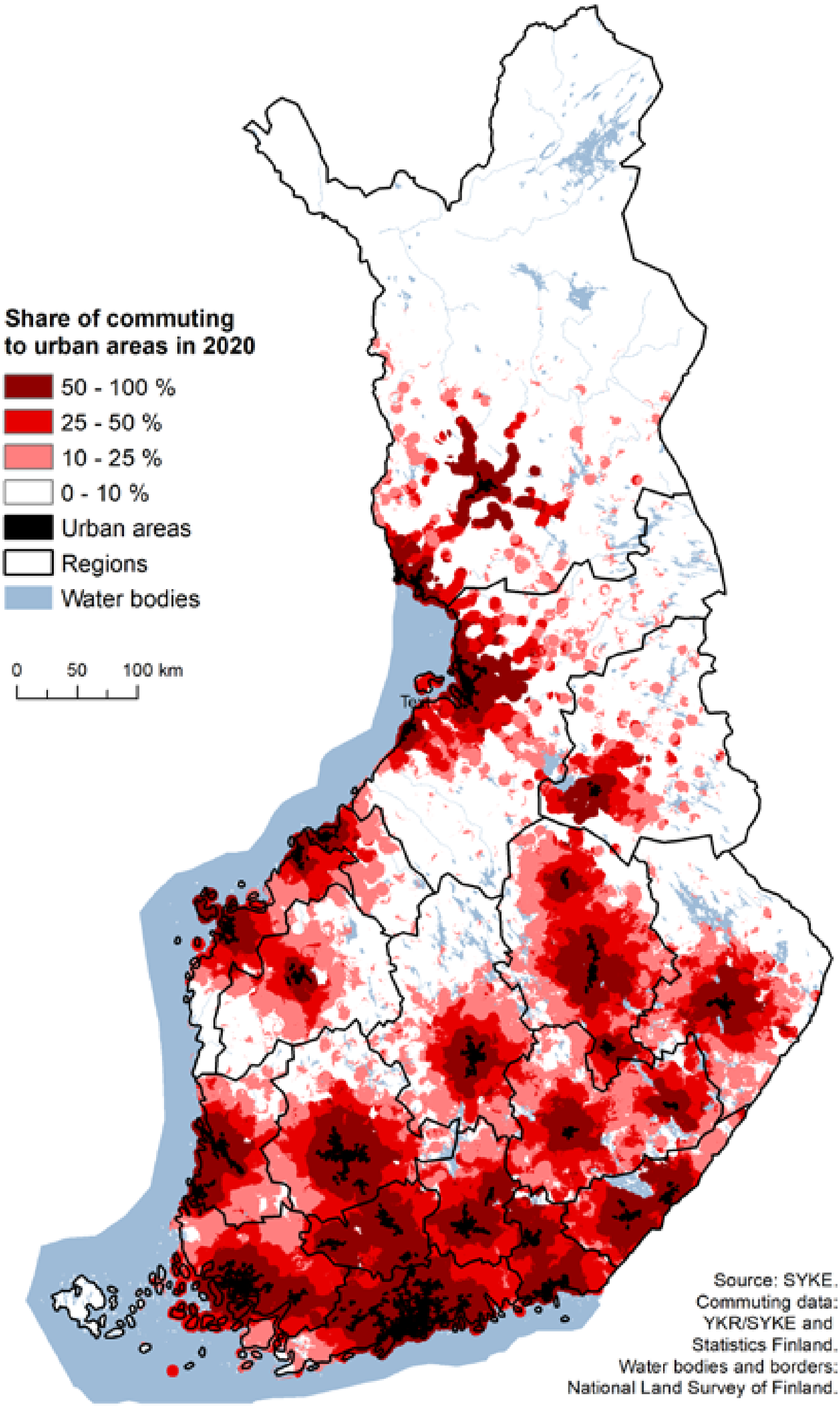


Figure 2.20b
Share of commuting directed towards urban areas, 2020

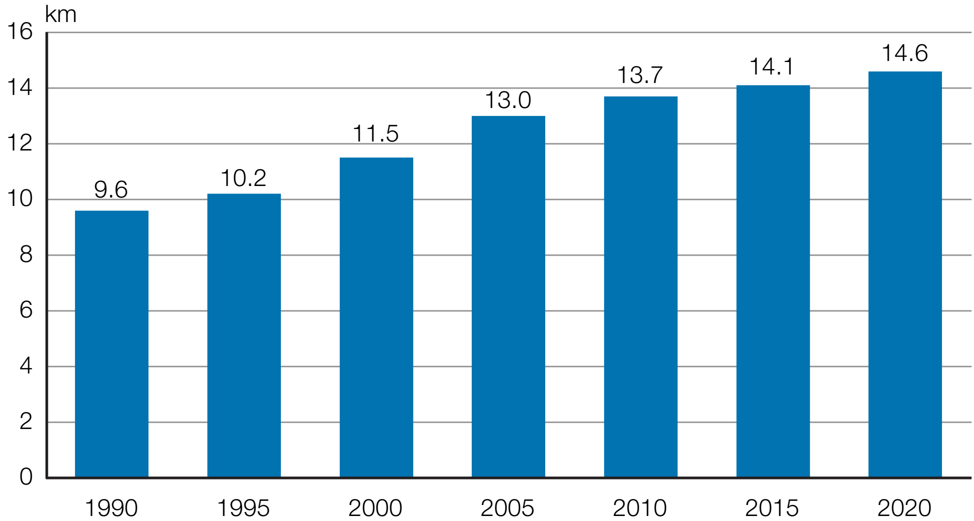


The average amount of kilometers travelled daily has increased due to the sprawl of residential areas, but also because of increased commuting distances and service-related mobility. Particularly retail trade has concentrated into bigger units, which are partly located on the fringe of urban areas.

The improvement of transport infrastructure has enabled people to travel longer trips to work than before. Commuting areas of cities have expanded significantly. This development can be seen in Figures 2.20a and 2.20b, which show the development in commuting to urban areas from 2000 to 2020.

The average distance to work has risen only moderately from 1990 to 2020 (Figure 2.21). The opportunities to use sustainable means of transport in commuting depend on the commuting distance and the location of both the home and the workplace in relation to public transport services. There are big differences between urban areas in the availability of sustainable options in commuting trips. The share of commuting trips, where sustainable means of transport are available, ranges between 46 and 80 in urban areas of urban regions. In most regions, the share declined until 2018 and a small increase has taken place since.

Figure 2.21
Average daily commuting distance, 1990 to 2020



Source: Statistics Finland

2.10 Agriculture

Farming in Finland is possible as a result of the warming effect of the Gulf Stream, which results in temperatures three to four degrees higher than would otherwise be expected at these latitudes. As Finland is nearly 1,100 kilometres long from north to south, there are considerable regional variations in the climate. Rainfall in the growing period is 370 mm on average in southern Finland and 260 mm on average in northern Finland. The thermal growing season (the period with an average daily temperature of more than +5 °C) varies from six months in the south to four months in the north. The growing season in Finland is too short for many cultivars grown elsewhere, and frost-resistant varieties have therefore been developed. Because of the short growing season, the yield levels of field crop species are considerably lower in Finland than in central Europe. The harsh winters also reduce productivity, as they restrict the cultivation of winter cereals.

Climatic conditions are a decisive factor affecting the feasibility of crop production. Cultivation of wheat and oilseed plants is restricted to southern

Finland, whereas barley, oats, grass and potatoes can be cultivated in most parts of the country. In many parts of Finland, livestock farming, especially dairy farming, is the only profitable form of agricultural production.

Finnish agriculture is based on family farms. In 2020, private persons owned 86 per cent of farms, while heirs and family companies owned 11 per cent of farms and other companies and entities about three per cent of farms.

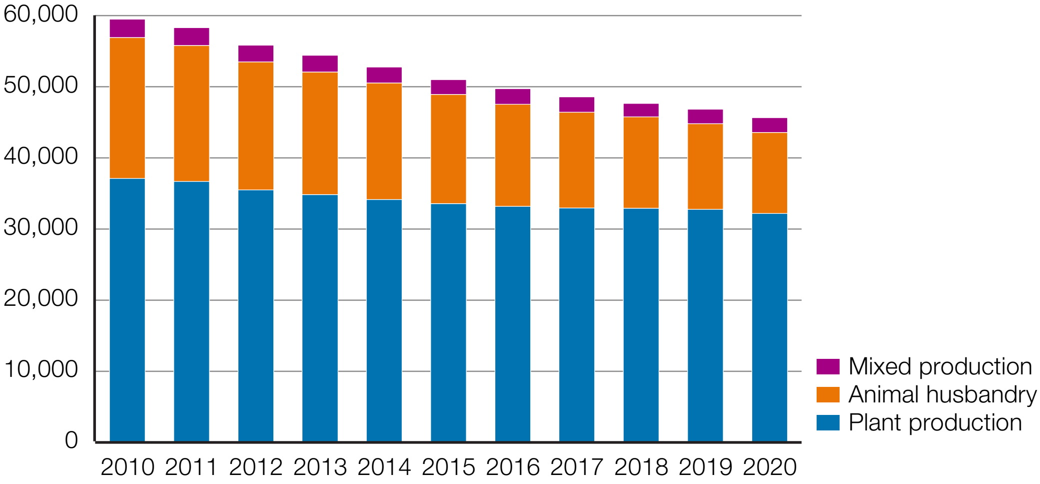
Between 1990 and 2020, the number of active farms fell from 130,000 to 45,600. At the same time, the average utilised agricultural area increased from 17 to 50 hectares. The total cultivated area has remained at almost the same level since 1990, but the shares of cultivated crops have varied somewhat over the years. The main change has been a shift from annual to perennial crops – mainly by decreasing the area cultivated for cereals by approximately 1.7 km^2, while the cultivation area of fodder grasses has increased by approximately 1 km^2 in three decades. The share of grassland crops was 38 per cent of the cultivated area, while the share of barley was 22 per cent, oats 17 per cent and wheat 10 per cent in 2020. In 2020, the utilised agricultural area was 22,700 km^2. Structural changes in agriculture among other factors have also led to a reduction in greenhouse gas emissions from the agriculture sector (see Section 3.2.3).

Nearly 70 per cent of active farms practise crop production as their main line of farming, and only 25 per cent have livestock as their main line of farming (Figure 2.22). Livestock production has undergone a structural change. Compared to 1990, beef production has decreased; poultry production has increased its relative share. The number of dairy cows decreased in this period from 490,000 to 260,000. Dairy production is the main production line of animal husbandry, with 12 per cent of all farms having it as their main line of farming. Approximately seven per cent of farms have beef production or combined dairy and beef production as the main production line. Approximately one per cent of farms specialise in pig husbandry, and one per cent in poultry husbandry. The share of other production lines (sheep, goat and horse husbandry) is approximately four per cent. The remaining four per cent of farms have mixed production, i.e. they have no dominant product. About eleven per cent of all farms are organic.

In 2020, agriculture, forestry, hunting and fishing together accounted for 2.8 per cent of Finland's gross domestic product (GDP). The economic significance of the total food chain is much greater than this percentage alone indicates. Transport and processing increase the role of food materials in the national economy considerably. Agriculture is the most important employer in the countryside, and alongside forests, is the dominant element of the rural landscape.

As a member of the EU, Finland follows the Common Agricultural Policy (CAP). The CAP is nationally implemented and aims to develop the agricultural production of the European Union in a balanced way, while taking the environment, climate and animal welfare into account. An important aim of the CAP is also to promote the vitality of rural areas.

Figure 2.22
Number of farms by production sector, 2010 to 2020



Source: Natural Resources Institute Finland

2.11 Forestry

According to the national classification, forestry land covers 26 million hectares, or 77 per cent of the total area, including inland waters, in 2020. Land classified as forestry land consists of the subcategories of forest land, poorly productive land and unproductive land. Of the total forestry land area, 22.6 million hectares are classified as productive or poorly productive forest land according to the national definition, which is based on annual tree growth. The area of forest land according to the national greenhouse gas inventory is 21.8 million hectares, because the inventory uses a definition based on FAO's definition.

Within the EU, the significance of forests for the national economy and society at large is greatest in Finland. The forest sector contribution has been two to five per cent of Gross Domestic Product and some 20 per cent of the export of goods (18 per cent in 2020).

Approximately twenty indigenous tree species grow in Finland. The most common are the Scots pine (Pinus silvestris), Norway spruce (Picea abies) and silver and pubescent birches (Betula pendula and B. pubescens). Usually, two or three tree species dominate a forest stand. More than one half the forest land area consists of mixed stands.

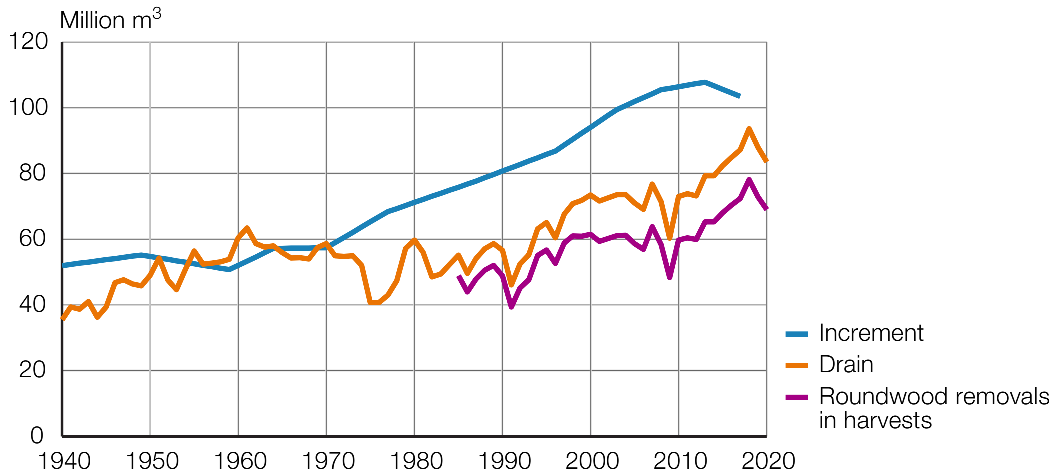
Sustainable forest management is the basis of Finland's forest policy. The aim is to ensure welfare founded on the use of forests and the diversity of forest nature. Policy measures include the Forest Act and other legislation, Finland's

National Forest Strategy 2025 (2014), financing and public forestry extension organisations (see Section 4.3.5: National forest legislation and programmes).

Finnish forests are managed sustainably. About a fifth of forests are regenerated naturally, while the rest are generated artificially using indigenous tree species with local provenance. According to the Forest Act, measures for the establishment of a new seedling stand must be completed within three years of the end of felling. Natural regeneration is based on seeding from trees already growing on the site, usually by leaving a number of seed trees standing at the time of felling. In forest cultivation with seedlings and seeds, a new stand is established on a clear-felled area, which accounts for approximately 100,000 hectares annually. Every year, 150 million seedlings are planted in forests.

The total volume of Finland's forest stock amounts to 2,506 million m^3 according to the results of the ongoing 13th national forest inventory. The growing stock volume has been increasing for a long time, mainly because of the active and sustainable management of forests, in which the growth in forest volume has exceeded harvesting volumes and natural drain (Figure 2.23).

Figure 2.23
Total roundwood removals in harvests, annual increment and drain of growing stock 1940 to 2020



Source: Natural Resources Institute Finland

In 2020, the total drain was 83.5 million m^3, while the total increment of the growing stock was 103.5 million m^3. The total drain includes cutting removals, harvesting losses and natural mortality. Of the total area undergoing felling annually, thinning accounts for roughly three quarters, while other cutting, e.g. clear felling and seed and shelter wood felling, accounts for the rest.

The growing stock has increased by 65 per cent in the last 40 years. Pine has contributed most to the increase due to the large number of rapid growth young stands. The draining of mires in the 1960s and 1970s has also improved the growing conditions for trees in peatlands. This has also added to the increase in the growing stock.

More than 50 per cent of Finland's forests are owned by private individuals, 35 per cent by the state, about seven per cent by private companies and the rest by other owners (in 2020). The average size of a forest holding owned by private individuals is small, approximately 30.5 hectares, averaged over holdings with a minimum size of two hectares. About 11 per cent of Finns are forest owners, i.e. 620,000 Finns with 344,000 forest holdings of at least two hectares of forest land in 2016. Forest management associations provide forest owners with advisory services in forest management and felling.

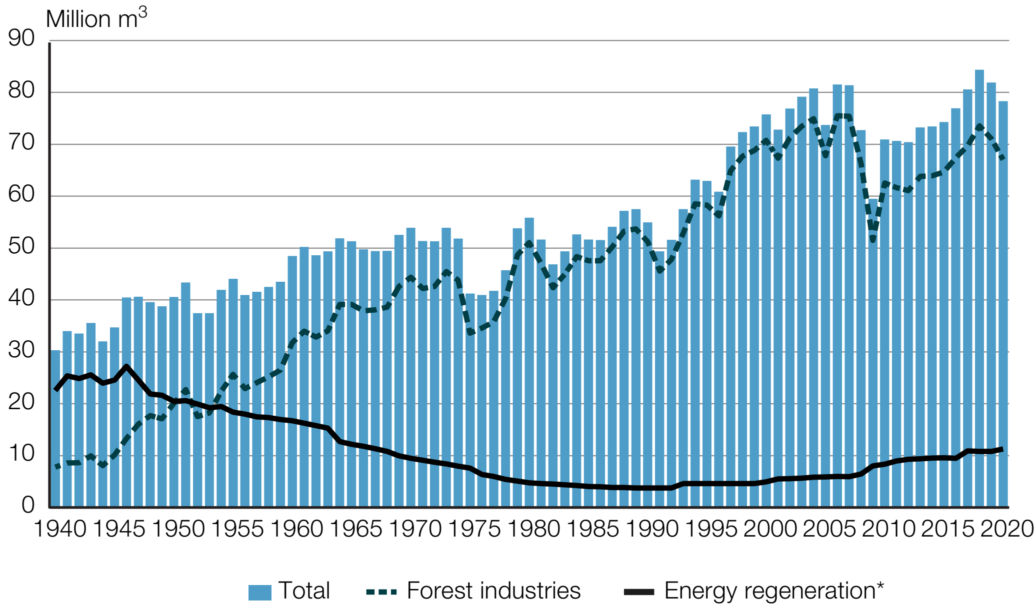
Earnings for wood production of non-industrial private forestry owners, organisations and companies whose primary line of business was other than wood production, averaged EUR 1.9 billion calculated as annual stumpage earnings. Investments in wood production, i.e. costs from silvicultural practices such as forest regeneration and young stand management, represent 77 per cent of the total average annual costs of EUR 280 million between 2015 and 2020. Some three quarters of the costs of silvicultural practices are financed by the owners, and the rest is covered by state subsidies. Some 90 per cent of Finland's forests are certified according to the national Programme for the Endorsement of Forest Certification (PEFC) standard or Forest Stewardship Council standard.

In 2020, the total use of round wood (raw, unmanufactured timber) in Finland was 78.3 million m^3. The great majority, that is, 86 per cent (67.1 million m^3), was used in the forest industry, and 11.3 million m^3 was used for energy production (Figure 2.24).

Forests (trees and soil) absorb a significant proportion of Finland's carbon dioxide (CO_2) emissions. Fluctuating trends in forestry activity have caused considerable variation in net removals from forest land (see Section 3.2.4). The forest land sink varied between 14.6 (in 2018) and 47.2 (in 2009) million tonnes CO_2 eq. during the period between 1990 and 2020, equalling 26 and 70 per cent of Finland's total emissions without the LULUCF sector for the years in question.

In recent decades, forest protection and biodiversity in managed forests have received special attention. Numerous protection programmes and decisions have contributed to a threefold increase in the area of protected forests over the last 30 years.

Figure 2.24
Total roundwood consumption 1940 to 2020



* Includes only roundwood consumption. Energy use of by- and waste products such as sawdust, bark and black liquor is not included.

Source: Natural Resources Institute Finland

Thirteen per cent of the forest area (productive and poorly productive forest land), or 2.9 million hectares, is protected or in restricted forestry use. Most of this, 2.3 million hectares, is in northern Finland, where the protected areas together account for 20 per cent of the forest area. In southern Finland, the protected area is approximately 0.6 million hectares, which is five per cent of the forest area. Some 75 per cent (2.2 million hectares) of the areas that are protected or in restricted forestry use are completely excluded from felling, i.e. under strict conservation.

The National Forest Strategy 2025 and national policies on nature and biodiversity conservation are mutually supportive and coherent. The Forest Biodiversity Programme for southern Finland from 2008 to 2025 (METSO) targets both private and state-owned land. It combines the protection and commercial use of forests. The funding used for the programme was approximately EUR 120.8 million between 2019 and 2021. A new tool for halting loss of biodiversity in Finland is the Helmi programme (2021 to 2030). The main objective of the Helmi programme is to take a comprehensive view of habitats and the necessary restoration and management measures. Actions are carried out both within and outside protected areas. The participation of landowners is voluntary.

2.12 Waste

The amount of waste deposited in landfill sites has been significantly reduced by effective waste regulation. Finland's waste policy aims to prevent waste, increase reuse and recycling and reduce landfilling and the environmental impact of various forms of waste management.

Almost 116 million tonnes of waste was generated in Finland in 2020, which was nearly the same amount of waste as in the previous year. The largest quantities of waste came from mining and quarrying and construction and manufacturing, and they were primarily of mineral origin. The amount of mineral waste was nearly 105 million tonnes, or 90 per cent of all waste. The amount of wood waste was 3 million tonnes.

The rest of the waste in the total waste figure is mixed waste, which comprises the solid municipal waste generated by households and services. The amount of solid municipal waste generated in Finland in 2020 was 3.3 million tonnes. Though accounting for only 2.7 per cent of the country's total waste, this solid municipal waste is responsible for most of the greenhouse gas emissions from the waste sector (see also Section 3.2.6). The quantity of municipal waste has been between 2.4 and 3.3 million tonnes per year in Finland since 2000. Total municipal waste generation was 596 kg per capita in Finland 2020, slightly more than the EU average of 505 kg.

The manufacturing industry generated more than 9 million tonnes of waste in 2020. The largest quantities of manufacturing waste were waste wood, mineral waste from the basic metal industry and the chemical industry. In 2020, the waste recovery rate was more than 95 per cent, i.e. 113 million tonnes of waste was recovered; altogether, 11.7 million tonnes of waste was recovered as material and 6.2 million tonnes as energy. The latter figure comprises nearly half of wood waste (almost 2.7 million tonnes). Wood waste was especially comprehensively recovered as material in addition to the high energy recovery rate.

Table 2.3
Waste generation by source and waste category in 2020

2020	Chemical waste	Wood waste	Mineral waste	Other waste[1]	Total
	Amount of waste, 1,000 tonnes				
Mining and quarrying	0	0	87,194	0	87,194
Electricity, gas, steam, and air-conditioning supply	3	1	848	105	957
Water supply; sewerage, waste management and remediation activities	44	16	241	826	1,127
Construction	0	273	12,453	963	13,689
Manufacturing	369	2,743	4,182	2,211	9,505
Households and services	42	103	1	3,376	3,522
Total	**458**	**3,135**	**104,919**	**7,483**	**115,995**

1 Metallic waste, paper and cardboad, animal and vetegal waste, household and mixed waste, sludges, other waste

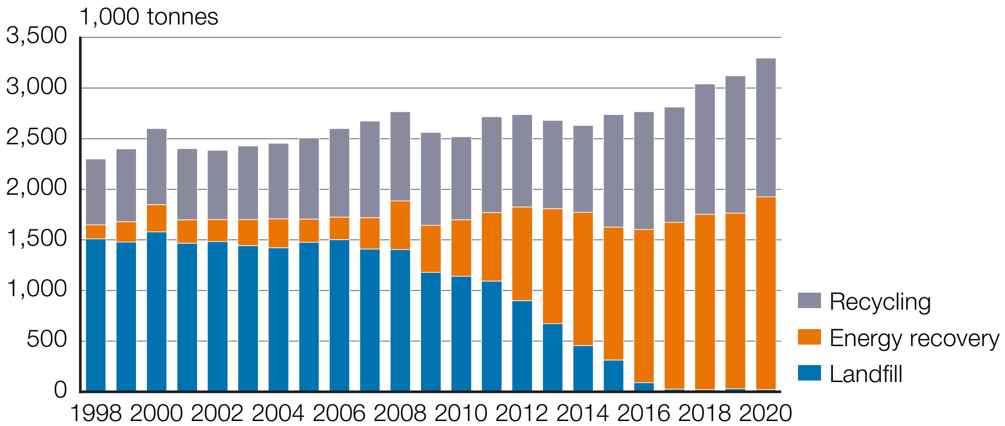
Source: Statistics Finland

In 2020, more than 95 per cent of all municipal waste was recovered as material (41 per cent) or energy (58 per cent) (Figure 2.25). Biowaste recycling doubled from 2006 to 2015, mainly due to improved sorting and the separate collection of municipal waste and the extension of treatment to anaerobic digestion. The amount of separately collected biodegradable waste has increased slightly every year since 2015. In 2020, 494 tonnes of biodegradable waste was collected, six per cent more than in 2019. According to the Finnish Forest Industries Federation, almost 94 per cent of all paper waste (e.g. newspapers, printed paper and cardboard) consumed in Finland in 2020 was recovered; the European-wide paper recycling rate in 2020 was about 74 per cent.

At the end of the 1990s, almost 65 per cent of all municipal waste was disposed of in landfills. The proportion of municipal waste sent to landfills has decreased every year since 2002 as a result of the increased waste recovery rate. In 2002, the proportion of municipal waste disposed of in landfills was 62 per cent, and in 2015, it amounted to 11 per cent, or 315 thousand tonnes. Due to the landfill prohibition of organic waste that came into force in 2016, biodegradable municipal waste has no longer been deposited at landfills. The share of landfill disposal of municipal waste in 2020 was about 20 thousand tonnes, or less than one per cent of the total amount of municipal waste.

The share of waste incineration has increased considerably in the last two decades. Initially, in the early 1990s, the focus of waste policy was on waste prevention and recycling. Waste incineration has started to become more important in municipal waste management, and there have been many investments in waste incineration plants since 2006. The amount of incinerated municipal waste has more than doubled since 2010. In 2020, a total of nine waste incineration plants were in operation. In 2015, 48 per cent of the total amount of municipal waste was incinerated, and in 2020, approximately 56 per cent of municipal waste was incinerated. All waste incineration plants produce heat and electricity for municipalities and industry.

Figure 2.25
Municipal solid waste treatment in Finland, 1998 to 2020



Source: Statistics Finland

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Photo: Kuvatoimisto Rodeo Oy

3

Greenhouse gas inventory information, including the national system and the national registry

This chapter describes Finnish greenhouse gas emissions and their development in 1990–2020 by sector. Thereafter, it outlines how the national greenhouse gas inventory is compiled, including a description of the national system, and how the high quality of the inventory is guaranteed. Finally, the national registry and its functioning are explained.

3 Greenhouse gas inventory information, including the national system and the national registry

3.1 Total greenhouse gas emissions and trends

In 2020, Finland's greenhouse gas emissions totalled 47.8 million tonnes of carbon dioxide equivalent (million tonnes CO_2 eq.). The total emissions in 2020 were approximately 33 per cent (23.4 million tonnes) below the 1990 emissions level. Compared to 2019, the emissions were approximately 9 per cent, i.e. 5.0 million tonnes, lower. Finland's annual greenhouse gas emissions varied considerably from 1990 to 2020 due to changes in electricity imports and the production of fossil-fuel-based condensing power. In addition, emissions are influenced each year by the economic situation in the country's energy intensive industries, weather conditions and the volumes of energy produced using renewable energy sources.

The emission trends by sector are presented in Figure 3.1 and described in detail in Section 3.2. Please see Annex 1 of this communication and Finland's latest National Inventory Report (2022) for more information.

The energy sector is the most significant source of greenhouse gas emissions in Finland and is therefore the key driver behind the trend in emissions. The energy sector includes emissions from fuels used to generate energy, including fuel used in transport and the fugitive emissions related to the production, distribution and consumption of fuels. In 2020, the energy sector accounted for 72 per cent of Finland's total greenhouse gas emissions (Figure 3.2). The second largest source of emissions was agriculture sector, with a share of approximately 14 per cent. Emissions from industrial processes and product use amounted to approximately 11 per cent. Emissions from industrial processes refer to sector emissions that result from the use of raw materials in industrial processes. Emissions from the waste sector amounted to four per cent of total emissions. The contribution of indirect CO_2 emissions from atmospheric oxidation of CH_4 and NMVOCs to the greenhouse gas emissions is small, about 0.1 per cent of total greenhouse gas emissions in Finland.

The land use, land-use change, and forestry (LULUCF) sector in Finland was a net sink throughout the 1990 to 2020 reporting period, because greenhouse gas removals in the sector exceeded emissions. The net sink has varied from approximately 13 to 49 per cent of the annual sum of emissions from other sectors, i.e. the total emissions without LULUCF between 1990 and 2020. The most important components of the forest sink are the tree biomass growth and biomass removed from forests due to felling. Based on the National Forest Inventory (NFI), the increment of growing stock has increased since 1990 from 78 million m^3 to 103 million m^3. There is less fluctuation between years in the estimated tree biomass growth, contrary to the harvest rates. In 2020, the total drain was 83 million m^3.

For the LULUCF sector, the most recent results on a decline in tree growth were not yet available when the latest annual greenhouse gas inventory submission and the WM projection for the LULUCF sector were prepared. Results from the first three years (2019–2021) of the current, ongoing 13th national forest inventory showed that the annual increment of the growing stock, i.e. tree growth, has declined compared to the previous, 12th national forest inventory (2014–2018). A lower tree growth indicates lower removals in the forest land, and may also mean a smaller carbon sink in the LULUCF sector. Estimates of carbon removals in the LULUCF sector will be re-evaluated in future.

Figure 3.1
Greenhouse gas emissions and removals in Finland by reporting sector (million tonnes CO_2 eq.) and total net CO_2 equivalent emissions (emissions plus removals). Emissions are positive and removals negative quantities.

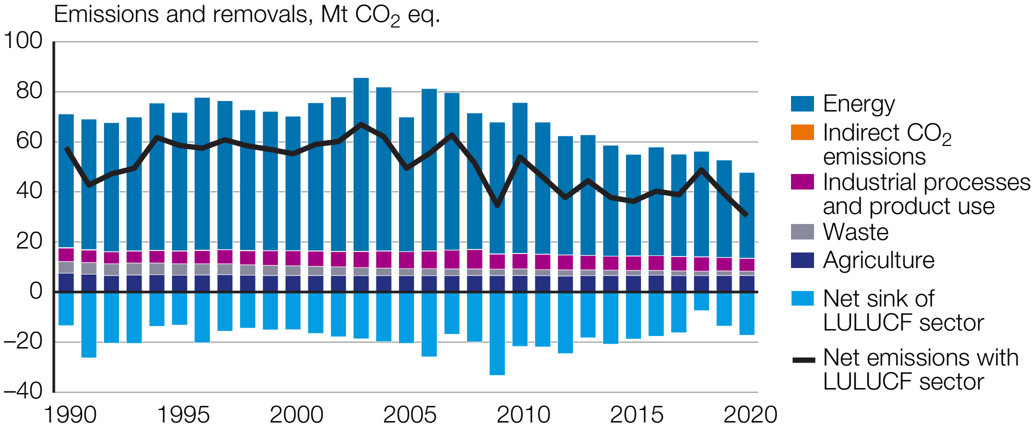
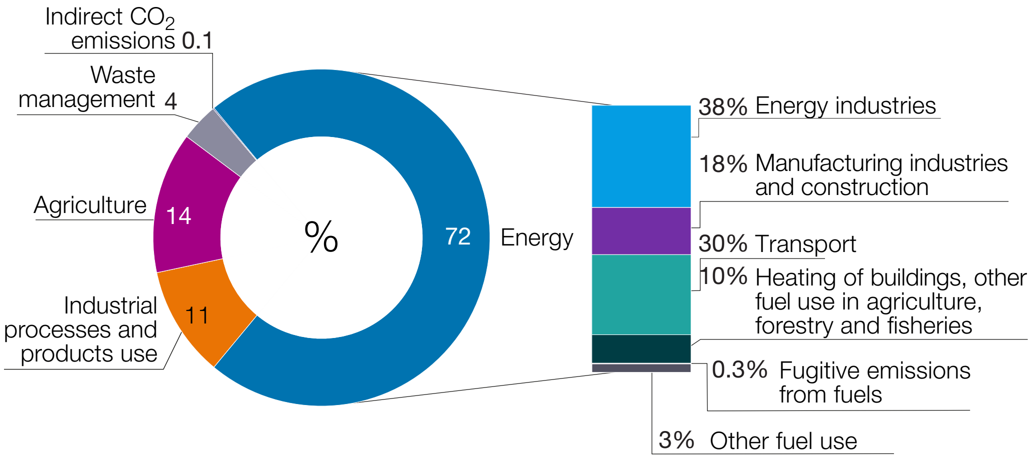


Figure 3.2
The composition of Finnish greenhouse gas emissions in 2020 (LULUCF sector excluded).*



* The sums do not add up because of independent rounding.

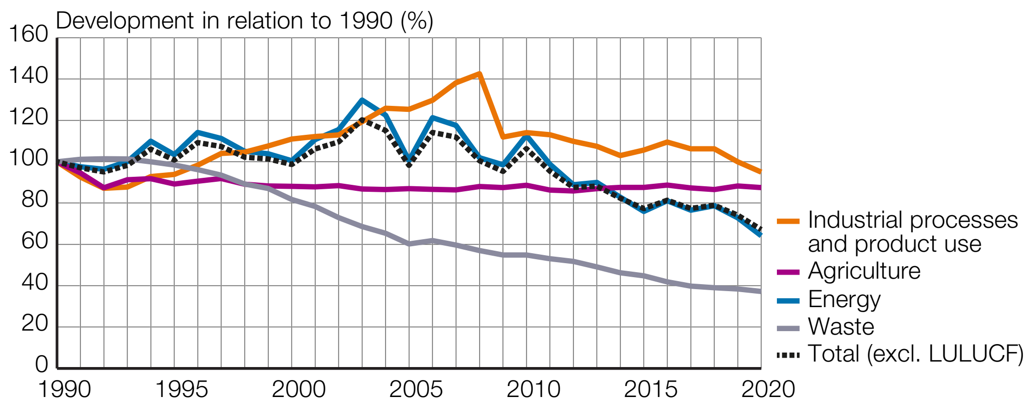
The most important greenhouse gas in Finland is carbon dioxide. The share of CO_2 emissions in total greenhouse gas emissions has varied from 79 per cent to 85 per cent. In absolute terms, CO_2 emissions are 19.4 million tonnes (i.e. 34 per cent) smaller than in 1990. The majority (89 per cent) of the CO_2 emissions originates from energy production based on the combustion of fossil fuels and peat. The CO_2 emissions from wood combustion are reported as a memo item in the CTF tables but are not included in the total national emissions, because they are reported as a loss from woody biomass stock in the LULUCF sector. The amount of energy-related CO_2 emissions has fluctuated greatly according to the economic trend, the energy supply structure (including electricity imports and exports) and climate conditions (Figure 3.3).

Methane emissions (CH_4) have decreased by 43 per cent from the 1990 level. This is mainly due to the improvements in the waste sector and reduced emissions from animal husbandry in the agricultural sector. The majority of methane emissions originated from the waste and agricultural sectors in 2020. The production and use of energy also generate methane and nitrous oxide emissions.

Emissions of nitrous oxide (N_2O) have also decreased by 26 per cent since 1990; the greatest decline occurred in 2009, when the implementation of a N_2O abatement technology in nitric acid production significantly reduced emissions. Another reason for the decrease of N_2O emissions is the reduced nitrogen fertilisation of agricultural fields. The majority of nitrous oxide emissions originated from agriculture.

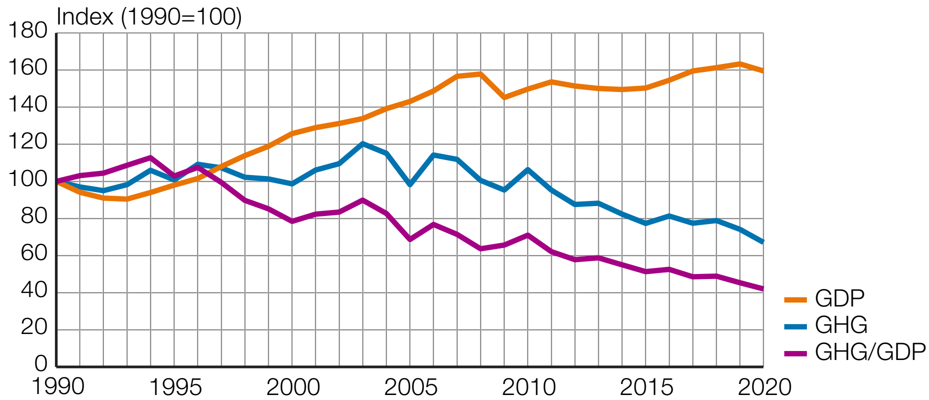
F gas emissions (HFC, PFC, SF_6) increased considerably between 1990 and 2008. A key driver of the trend was the substitution of ozone-depleting substances (ODS) by F gases in many applications. During the 2010s, F gas emissions have started to decline due to decreased leakage rates and the replacement of high-GWP HFC refrigerants with alternative low-GWP non-HFC refrigerants in many applications.

Figure 3.3
Relative development of greenhouse gas emissions by main category relative to the 1990 level (1990=100 per cent)



The overall trend in greenhouse gas emissions relative to Finland's gross domestic product (GDP) has been declining (Figure 3.4), although annual variations have been large. In the early 1990s, the GHG/GDP ratio rose almost 15 per cent above the 1990 level. This was largely due to the recession, which led to a steeper fall in GDP than in emissions. In 2020, the GHG/GDP ratio was almost 58 per cent below the 1990 level, indicating that the greenhouse gas intensity of the economy has decreased.

Figure 3.4
Greenhouse gas emissions relative to GDP, 1990 to 2020, excluding the LULUCF sector



More detailed information on emission trends by sector and gas can be found in the CRF Reporter Summary tables for 1990 to 2020 on emission trends included in Annex 1 of this communication and in Finland's latest National Inventory Report (2022).

3.2 Greenhouse gas emissions by sector

3.2.1 Energy

Overview of the sector

The energy sector is the main source of greenhouse gas emissions in Finland. In 2020, the sector contributed 72 per cent to total national emissions, totalling 34.6 million tonnes CO_2 eq. (Figure 3.2). Energy sector emissions can be divided into emissions resulting from fossil fuel combustion and fugitive emissions from fuels. Most of the emissions originate from fuel combustion, which reflects the high energy intensity of the Finnish industry, the extensive consumption of fuels during the long heating period, and the energy consumed for transport in this relatively large and sparsely inhabited country. Fugitive emissions make up only 0.3 per cent of the sector's total emissions.

Energy-related emissions vary greatly from year to year (Figure 3.5), mainly following the economic trend, the structure of the energy supply and climatic conditions. Compared with 1990, the emissions in the energy sector in 2020 were about 36 per cent lower. In 2020, emissions in the energy sector were about 12 per cent lower than in the previous year and approximately half the emission level in 2003, the year of the greatest emissions from the energy sector between 1990 and 2020.

The energy industries (mainly electricity and district heat production) caused approximately 38 per cent (13.1 million tonnes CO_2 eq.) of the total emissions in the energy sector in 2020. Emissions from the energy industries were 31 per cent lower in 2020 than in 1990. Manufacturing industries and construction produce a great deal of energy for their own use. Their share of energy-related emissions was around 18 per cent in 2020 (6.2 million tonnes CO_2 eq.). These emissions have declined by 53 per cent since 1990. The main reasons for this trend are the increased use of biofuels, i.e. black liquor a by-product of pulp industry, in the forest industry and the outsourcing of power plants from the manufacturing industries to energy industries. Share of biomass as a source of energy has significantly grown in the public electricity and heat production as well as in manufacturing industries and construction between 1990 and 2020 (Figure 3.6). See also Section 2.6 for trends in energy sources. Emissions from the residential sector have decreased by 67 per cent and from commercial sectors by 57 per cent compared with 1990 levels. The decrease is mainly due to the substitution of direct oil heating with district heating and electricity. The share of transport of energy-related emissions was more than 30 per cent in 2020. Emissions from transport have decreased by 14 per cent since 1990 and seven per cent since 2019. There was a decline of seven per cent in transport fuels activity data, mainly due to the Covid-19 pandemic, which explained the decrease in emissions. Since 2015, the diesel bioshare has varied annually, causing fluctuations in the annual emissions of road transport.

Figure 3.5

Greenhouse gas emissions in the energy sector, 1990 to 2020

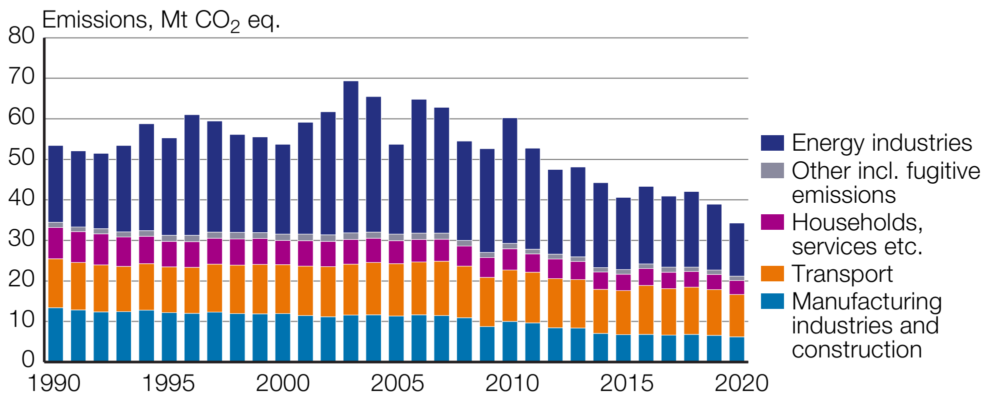
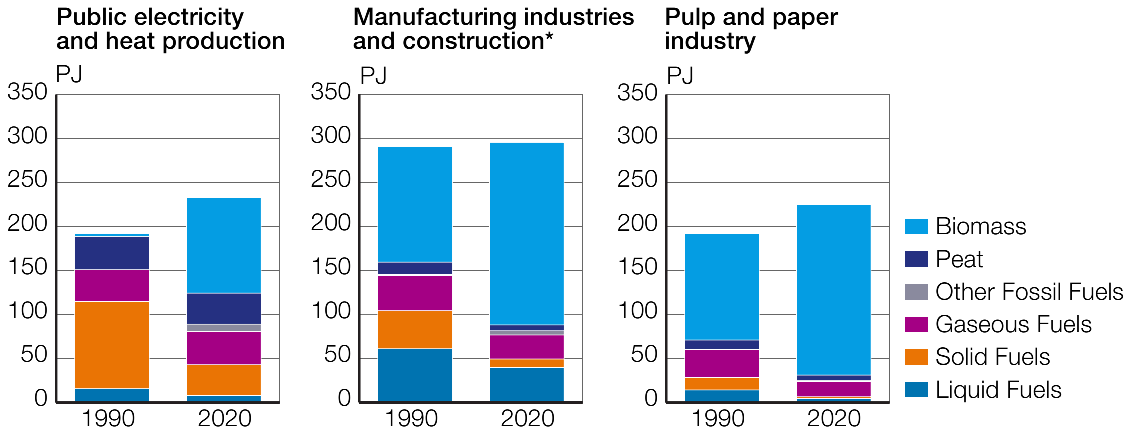


Figure 3.6
Fuel combustion in public electricity and heat production, manufacturing industries and construction, as well as in sub-sector of manufacturing industries, that is pulp and paper industry



* Fuel combustion in the pulp and paper industry is included in the manufacturing industry too.

Description and interpretation of energy emission trends

The important drivers in the energy sector's greenhouse emissions trend have been the changes in the amount of imported electricity and in the production of energy with fossil-fuel-based condensing power, as well as growth in the consumption of renewable energy (Figures 3.7 and 3.8). The availability of hydropower in the Nordic electricity market has significantly influenced the electricity supply structure and hence the emissions from fuel combustion during the time series. If the annual precipitation in the Nordic countries is lower than usual, hydropower will be in short supply and Finland's net imports of electricity will decrease. During such years, Finland has generated additional electricity using coal- and peat-fired power plants, resulting in higher CO_2 emissions from corresponding years. During recent years, the share of conventional condensing power in electricity generation has declined as the share of wind power has grown. In addition, the allowance price in EU ETS has risen, which is accelerating the replacement of fossil fuels with renewable energy.

Total energy consumption in 2020 amounted to 1.28 million terajoules (TJ). The trends in the energy sector driving greenhouse gas emissions are described in Section 2.6. In 2020, the energy sector's emissions were about 36 per cent below the 1990 level and half the emission level in 2003, which was the year of the greatest emissions from the energy sector between 1990 and 2020. At the end of the 1990s, total energy consumption increased, but emissions changed very little. The reasons for this were the increased use of wood fuels, nuclear energy, and net imports of electricity, which reduced the condensing power production and thus emissions. Net imports of electricity declined at the beginning of the 2000s, and energy sector emissions were at their peak in 2003. In 1990, the share of renewable energy in total energy consumption was just 18 per cent, since when it has grown steadily. The share of renewable energy sources from the final energy consumption grew to 44.6 per cent in 2020. In addition, the net import of electricity has been at a high level since 2012 (Figures 3.7 and 3.8). The increased use of renewable energy sources compared to the situation in 1990 has increasingly replaced fossil fuels and is the main reason for the decreased emissions despite the growth in energy consumption.

The ban on the use of hard coal for energy production, which will enter into force in 2029, is already decreasing coal consumption. For example, the total consumption of coal, which in addition to hard coal, includes coke and blast furnace and coke oven gas used by manufacturing, decreased by 23 per cent between 2019 and 2020. See Section 2.6 for further information on trends in energy.

Figure 3.7
Development of total energy consumption by energy source (PJ) and energy sector greenhouse gas emissions (million tonnes CO_2 eq.) in Finland, 1990 to 2020[1]

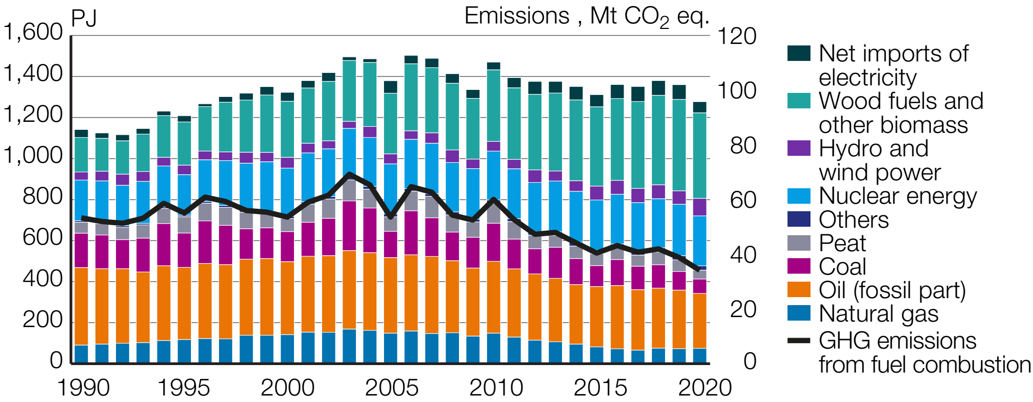
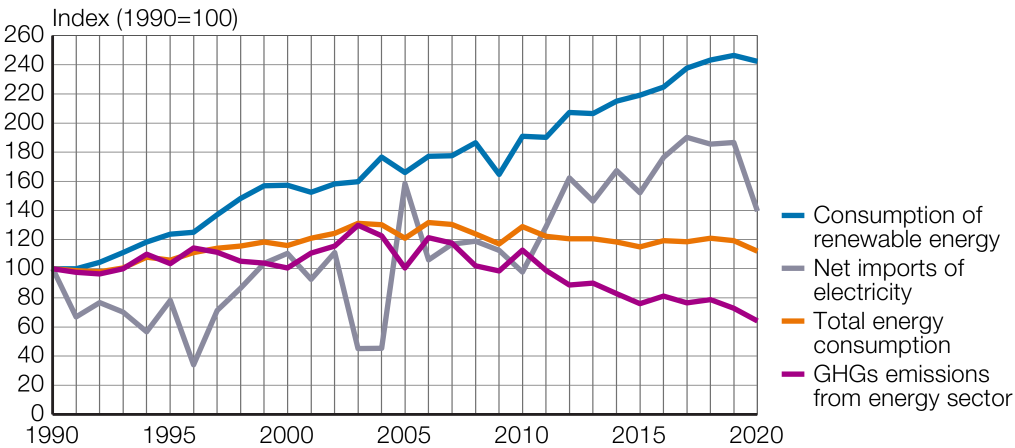


Figure 3.8
Development of the energy sector's emissions, net imports of electricity, and total and renewable energy consumption, 1990 to 2020



Transport

In 2020, the greenhouse gas emissions from transport amounted to 10.4 million tonnes CO_2 equivalent. Compared to 2019, emissions decreased by seven per cent in 2020. A decline of seven per cent in transport fuels activity data, due mainly to the Covid-19 pandemic, explains the decrease in emissions. The share

1 Coal includes hard coal and coke, blast furnace gas, coke oven gas, and until 1994, town gas.

of the transport sector of the total greenhouse gas emissions was approximately 17 per cent (12.1 million tonnes CO_2) in 1990 and 22 per cent (10.4 million tonnes CO_2) in 2020. Road transport is the most important emission source in the transport category (Figure 3.9). Road transport emissions were 9.9 million tonnes (CO_2 eq.) in 2020; this was 95 per cent of the transport emissions and 21 per cent of the total emissions.

CO_2 emissions from transport decreased considerably in the early 1990s due to the economic depression. Since 2008, emissions have fluctuated due to many simultaneous different factors, both societal and legislative. The Covid-19 pandemic since 2020 have decreased kilometrage and thus emissions as well (Figure 3.10). The fuel consumption of cars has been decreasing due to the CO_2 limits set for car manufacturers by the EU. A tax reform for cars in Finland caused a dramatic transition from petrol to diesel cars, which decreased CO_2 emissions in 2009. In the 2010s, the bioshare of diesel oil has varied annually and caused fluctuations in annual emissions. Finland's biofuel legislation allows the distributors to fulfil the bioshare obligation flexibly in advance.

Figure 3.9
Emissions from transport by subcategory (million tonnes CO_2 eq.), 1990 to 2020

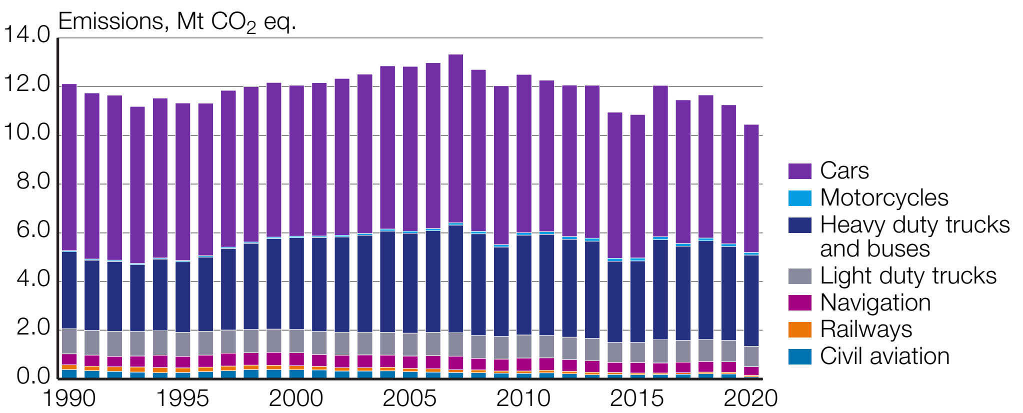
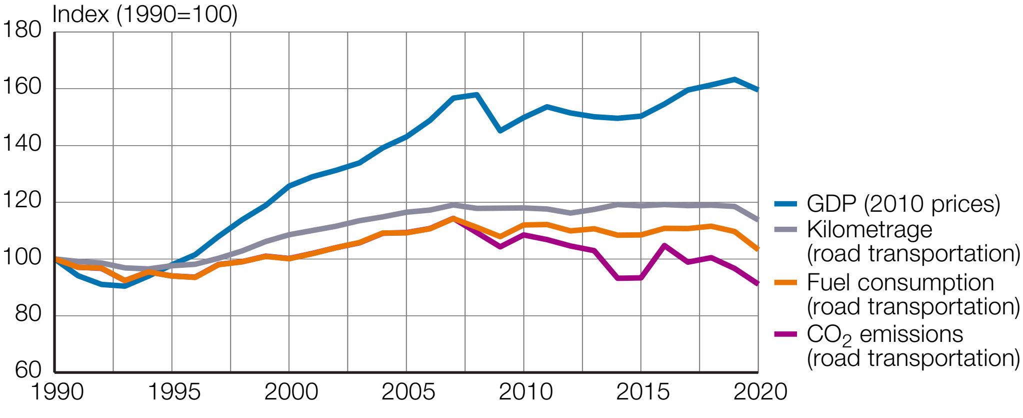


Figure 3.10
Development of GDP and fuel consumption, kilometrage and CO_2 emissions in road transport, 1990 to 2020

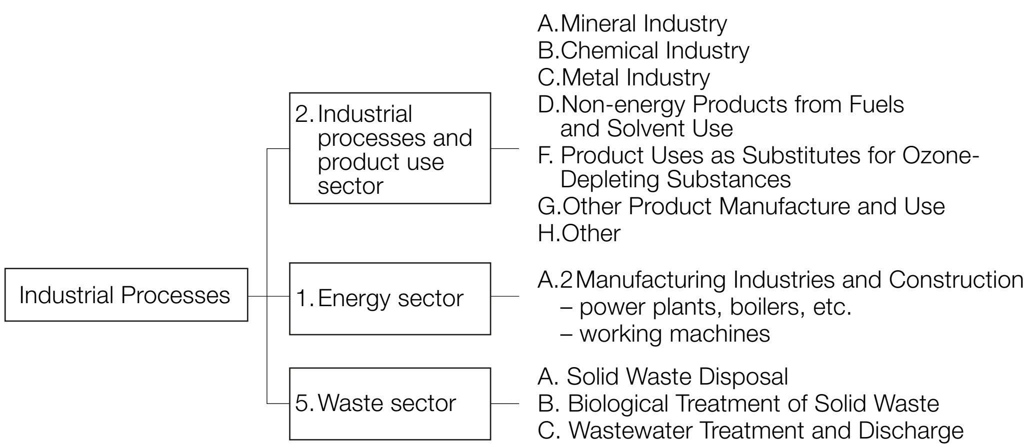


3.2.2 Industrial processes and product use

Greenhouse gas emissions from industrial processes and product use contributed 11 per cent to the total greenhouse gas emissions in Finland in 2020, totalling 5.1 million tonnes CO_2 eq. The most important greenhouse gas emission sources of industrial processes and product use in 2020 were CO_2 eq. emissions from iron and steel, hydrogen and cement production with 3.6, 1.9, and 1.2 per cent shares of total national greenhouse gas emissions respectively. CO_2 emissions were also generated to produce lime, glass, phosphoric acid, zinc, copper and nickel, as well as in the use of limestone, dolomite, soda ash, lubricant, paraffin vax and urea-based catalyst. Small amounts of methane (CH_4) were generated in coke production in the iron and steel industry, in ethylene production (fugitive emissions) and from lubricant use. Nitrous oxide (N_2O) emissions were generated to produce nitric acid and from product use. Indirect CO_2 emissions from CH_4 and NMVOC (non-methane volatile organic compounds) emissions are reported as aggregated in national totals.

Fluorinated greenhouse gases, or F gases, are reported under industrial processes. They are used to replace ozone-depleting substances (ODS) in refrigeration and cooling devices, as well as in air conditioning devices and aerosols, and they accounted for 2.1 per cent of total national greenhouse gas emissions and 19 per cent of the greenhouse gas emissions of industrial processes and other product use in 2020. The reporting categories of emissions from the sources of industrial processes in the national greenhouse gas inventory are presented in Figure 3.11.

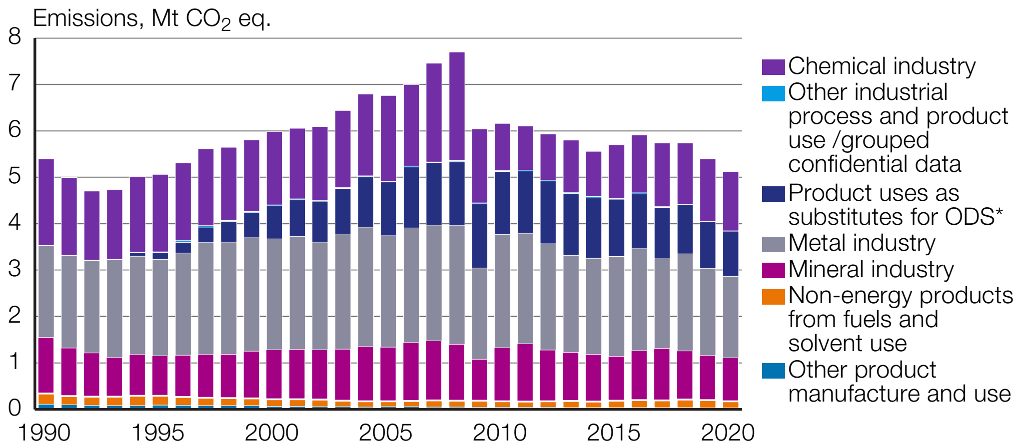
Figure 3.11
Reporting categories of emissions from industrial process sources in the national greenhouse gas inventory



The emissions resulting from industrial processes and product use are mostly affected by changes in production output, as they depend on the use of raw materials and production volumes, but the implementation of technical abatement measures in nitric acid production in 2008 resulted in a significant reduction in emissions (Figure 3.12). In the period from 1990 to 2020, the largest relative change occurred in F gas emissions, which at first increased rapidly but have now begun to decrease (Figure 3.13) due to decreased leakage rates and the replacement of high-GWP HFC refrigerants with alternative low-GWP non-HFC refrigerants in many applications.

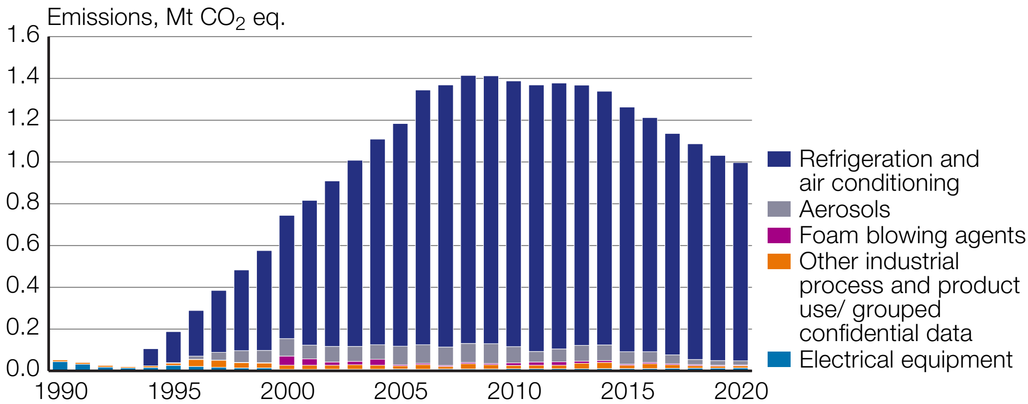
Total emissions of industrial processes and product use were five per cent (0.3 million tonnes CO_2 eq.) smaller in 2020 than in 1990. At the beginning of the time series, some production plants were closed and this caused a rapid decrease in emissions. After this, the production outputs and emissions increased and reached the level of 1990 in 1996. The increase in emissions continued until 2009, when they decreased rapidly due to the economic downturn as the demand for industrial products diminished. The implementation of N_2O abatement technology happened at the same time, which is why the emissions stayed at a lower level, even though production started to increase after the recession in 2010.

Figure 3.12
Greenhouse gas emissions from industrial processes, 1990 to 2020



* ODS= ozone-deleting substances (i.e. F gases replacing ODS)

Figure 3.13
F gas emissions, 1990 to 2020



CO_2 emissions were five per cent greater in 2020 than in 1990. The reasons are the increased production of steel and hydrogen and the use of limestone and dolomite. Methane emissions were 74 per cent lower in 2020 than in

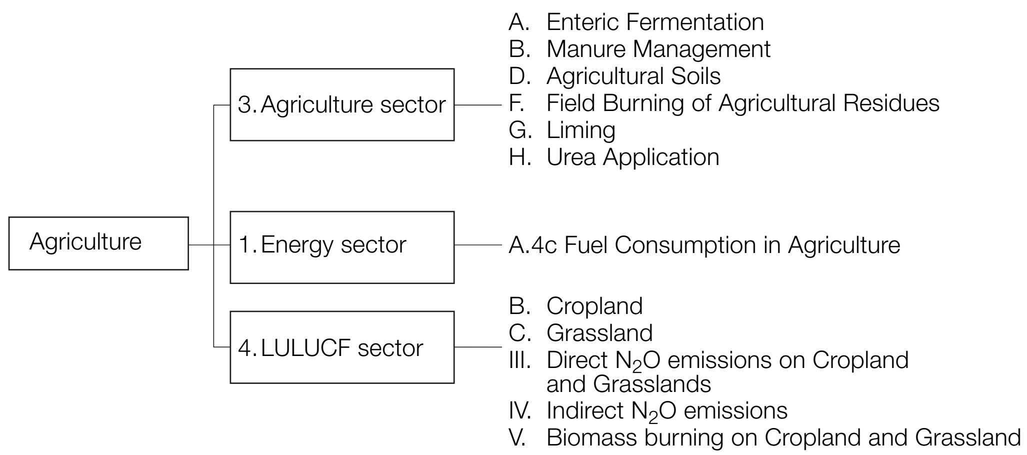
1990. Nitrous oxide emissions fluctuated between 1990 and 2020: first, there was a rapid decrease due to the closing of a nitric acid production plan; then a slow increase of emissions. The second rapid decrease that started in 2009 originated from the implementation of a new N_2O abatement technology in nitric acid production and the decreased demand of fertilisers. Since 1990, nitrous oxide emissions have decreased by 1.4 million tonnes CO_2 eq. (85 per cent). F gas emissions in 2020 were 19-fold compared to 1990.

3.2.3 Agriculture

Emissions from the agriculture sector were approximately 6.6 million tonnes CO_2 eq. in 2020. Agricultural emissions reported in the agricultural sector include methane (CH_4) emissions from the enteric fermentation of domestic livestock, manure management and crop residue burning, and nitrous oxide (N_2O) emissions from manure management and direct and indirect N_2O emissions from agricultural soils and crop residue burning. CO_2 emissions from liming and urea fertilisation are also included. Emissions from the agricultural activity are also reported in the energy and LULUCF sectors in the greenhouse gas inventory (Figure 3.14).

The agricultural sector accounted for approximately 14 per cent of Finland's total greenhouse gas emissions in 2020. In 2020, methane emissions from enteric fermentation were 32 per cent, methane emissions from manure management seven per cent, nitrous oxide emissions from manure management four per cent and nitrous oxide emissions from agricultural managed soils 54 per cent of total agricultural emissions. Liming and the application of urea comprise three per cent of emissions; the share of field burning of agricultural crop residues totals 0.03 per cent.

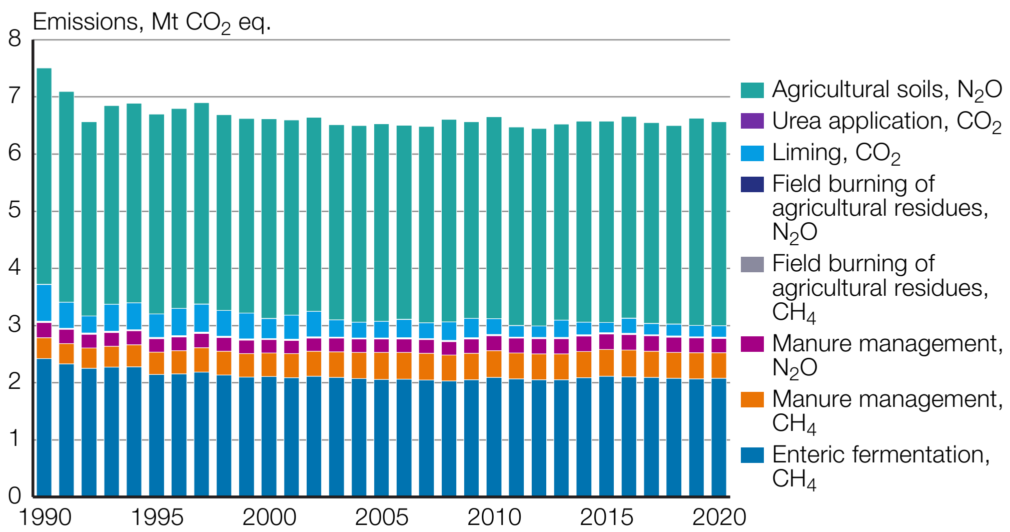
Figure 3.14
Agricultural sources of emissions and their reporting in the CRF categories in the national greenhouse gas inventory



Cattle generate most of the CH_4 emissions from enteric fermentation, but emissions generated by horses, pigs, sheep, goats, fur animals and reindeer are also reported. Most of the N_2O emissions from the agriculture sector are direct and indirect N_2O emissions from agricultural soils.

Emissions in the agriculture sector decreased by about 13 per cent during the 1990 to 2020 period (Figure 3.15). The most important factor behind the decrease is a reduction in the use of synthetic nitrogen fertilisers of 39 per cent between 1990 and 2020, which significantly reduced greenhouse gas emissions. Total N_2O emissions from agricultural soils were six per cent lower in 2020 than the 1990 level. The area of cultivated organic soils increased during the 1990 to 2020 period, which has also seen increased nitrous oxide emissions from agricultural soils. The decrease in CO_2 emissions from liming due to reduced use of lime is also significant.

Figure 3.15
Greenhouse gas emissions from agriculture, 1990 to 2020*



* Field burning of agricultural residues and urea application are not discernible, because their emissions range from 0.001 to 0.005 million tonnes each.

Since 1995, EU membership has resulted in changes in the economic structure of agriculture in Finland. The number of farms has decreased, average farm size has increased, and livestock numbers have decreased. For example, the number of cattle declined by more than a third between 1995 and 2020. The decline has slowed down over the last ten years. The decrease in cattle numbers over the time series has been counterbalanced by an increase in emission factors for enteric fermentation due to increased animal weights, growth and milk production. Emissions from enteric fermentation were 14 per cent lower in 2020 than in 1990.

Total emissions from manure management increased by 10 per cent between 1990 and 2020. The fluctuation in the emissions from manure management is related to both changes in animal numbers, which depend largely on agricultural policy, and changes in the distribution of the manure management systems. Direct nitrous oxide emissions from manure management first decreased and then increased in the time series. Cattle numbers have decreased, which explains the decreasing trend in manure management. However, nitrogen excretion figures increased over time for many animals, including cattle. The share of cattle slurry with a crust has also increased over time, increasing direct emissions from slurry. Methane emissions from manure management have increased by 21 per cent since 1990. This is due to an increase in the number of animals kept in slurry-based systems.

Some inter-annual variability can be detected in agricultural sector emissions. This is mainly caused by fluctuations in activity data between years due to changes in animal numbers and in the manufacture and import of lime for agriculture. Changes in animal numbers are largely affected by agricultural policy and subsidies, and they particularly affect methane and nitrous oxide emissions from manure management. Emissions from manure management are also affected by the distribution of manure managed in different manure management systems, which varies depending on the animal species. Nitrous oxide emissions from managed soils are affected by the quantity of synthetic fertilisers used annually, animal numbers and crop yields of cultivated crops, for example, which may have a large variation between years.

3.2.4 Land use, land-use change and forestry

Finland reports both greenhouse gas emissions and removals in the LULUCF sector. Removals refer to the absorption of CO_2 from the atmosphere by carbon sinks such as plant biomass or soil.

Changes in carbon stocks in six land-use categories covering the whole of Finland are reported in this sector. In accordance with the IPCC guidelines, the changes in different carbon pools, which include above- and below-ground biomass, dead wood, litter and soil, are reported for each category. In addition, carbon stock changes of harvested wood products and emissions originating from various sources are reported in this sector, including CH_4 and N_2O emissions from drained organic forest soils and managed wetlands such as peat extraction areas, emissions from the burning of biomass (forest fires and controlled burning), emissions from nitrogen fertilisation of forest land and N_2O emissions resulting from loss of soil organic matter. Emissions and removals are not reported for unmanaged wetlands and other land.

In 2020, the LULUCF sector as a whole acted as a CO_2 sink for –17.3 million tonnes CO_2 eq. This sum of removals and emissions, i.e. carbon stock changes and greenhouse gas emissions, in 2020 was 29 per cent larger than it was in 1990. For forest land, the largest sink was tree biomass, with –27.8 million tonnes CO_2 of net removals in 2020. Mineral soils on forest land were a sink of –5.2 million tonnes of CO_2, whereas organic forest soils were a source of 3.8 million tonnes of CO_2. Other emission sources in the forest land category are methane and nitrogen oxide emission from drained organic forest lands (2.6 million tonnes CO_2 eq.), nitrogen fertilisation (0.04 million tonnes CO_2

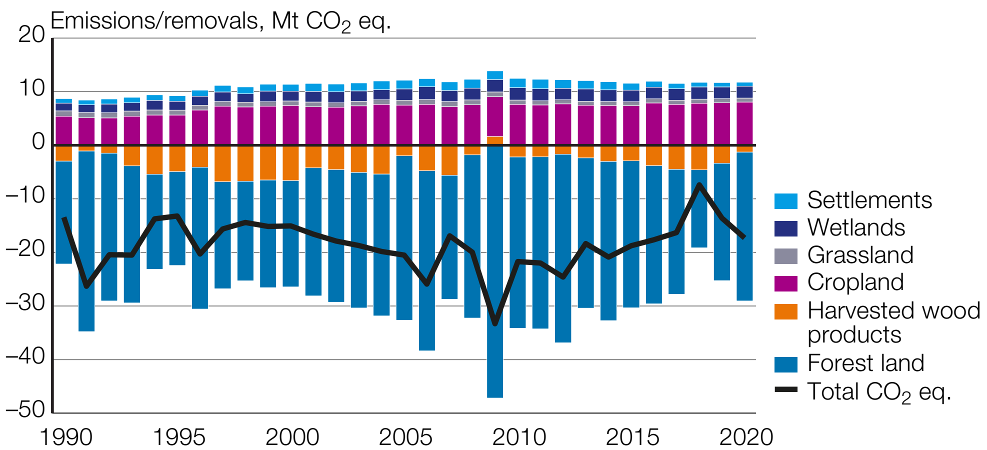
eq.) and biomass burning in forest fires and in controlled burning (0.004 million tonnes CO_2 eq. in 2020).

The high fluctuation in net biomass removals in the forest land category during the 1990 to 2020 period is mainly caused by the changes in the international market for forest industry products, which affects the amount of domestic commercial roundwood felling. In 2018, total roundwood removals reached 78 million m^3, the highest in statistical history. Roundwood removals in 2020, 69 million m^3, remained at a high level compared to the historical levels. The other significant factor affecting the trend in forest land sink is the increase in the annual volume increment. Forest growth has increased steadily since 1990 because of factors such as the large proportion of young forest at a strong growth phase and silvicultural measures. The annual growing stock increment was 77.7 million m^3, based on the 8th National Forest Inventory (NFI) (measured 1986 to 1994) and 107.8 million m^3, based on the NFI12 (2014 to 2018). The rapid increase in the increment in the 1980s and 1990s has levelled out according to the last inventory measurements. (See Section 3.1 on the latest results from the national forest inventory).

Although the LULUCF sector has been a significant net carbon sink, it also produces significant emissions. The largest emissions come from drained organic soils of forests and croplands. Other emission sources in the LULUCF sector include grasslands, peat production areas, forest fires and nitrogen fertilisation of forests. The trend in emissions and removals from the different land-use categories and Harvested Wood Products pool reported in the LULUCF sector is presented in Figure 3.16.

Figure 3.16

Net emissions and removals in the LULUCF sector by land-use category and harvested wood products pool, million tonnes CO_2 eq.



Harvested wood products

The Harvested Wood Products (HWP) pool was a net sink of 1.3 million tonnes of CO_2 in 2020. HWP has been a net sink for the whole reported time series, except in 2009. The annual fluctuations in the time series are generally due to changes in the economic situation and the demand for wood products. Factors behind the HWP carbon stock changes in 2020, such as strikes, the closure of some paper machines and decreased demand for harvested wood products because of the Covid-19 pandemic are described in more detail in Finland's National Inventory Report 2022 to the UNFCCC.

HWP is reported as a carbon stock change in production-based HWP stocks originating from wood harvested in Finland divided into two categories: HWP produced and consumed domestically; and HWP produced and exported. HWP comprises solid wood products (sawn wood and wood panels) and paper products (wood pulp). The production quantity of pulp was used as a proxy for paper and paperboard production. In Finland, 98.7 per cent of wood pulp is used for paper and paperboard production, and 1.3 per cent (part of dissolving wood pulp) for textile and hygiene products, which are exported (percentages are for 2013). Wood pulp production for purposes other than paper and paperboard started mainly in 2012. The annual change of HWP in domestic solid waste disposal sites (SWDS) is not calculated.

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

Under Article 3, paragraph 3 of the Kyoto Protocol, Finland reports emissions and removals from afforestation/reforestation (AR) and deforestation (D) activities, and under Article 3, paragraph 4, from forest management (FM). The reporting and accounting of these activities are mandatory for the second commitment period (CP) of the Kyoto Protocol. Finland had also elected forest management as a voluntary activity for the first commitment period. Finland has not elected other voluntary activities under Article 3, paragraph 4 for the second commitment period, as was the case in the first commitment period.

Net emissions from Article 3.3 activities, i.e. afforestation, reforestation, and deforestation, were 2.8 million tonnes of CO_2 eq. in 2020. Afforestation and reforestation resulted in a net removal of 0.6 million tonnes of CO_2 eq., while deforestation produced a net emission of 3.4 million tonnes of CO_2 eq. The area subject to AR was approximately 212,000 ha at the end of 2020. The area deforested was approximately 473,000 ha, of which 2,300 ha has been reforested.

Net removals as a result of forest management under Article 3.4 were 34.8 million tonnes of CO_2 eq. in 2020, including the carbon stock change in the Harvested Wood Products pool. Accounting for the KP LULUCF activities for the second commitment period is presented in Table 3.1.

Table 3.1

Summary of emissions (+) and removals (–) in tonnes CO_2 eq for 2013 to 2020 relevant for accounting under the second commitment period of the Kyoto Protocol*

	2013	2014	2015	2016	2017	2018	2019	2020	2013–2020
Finland's assigned amount for the second commitment period	**240,544,599**								
Total national emissions	62,784,046	58,602,565	55,025,810	57,923,441	55,109,448	56,178,737	52,788,022	47,782,251	
ETS emissions without aviation	31,365,840	28,653,801	25,371,154	27,147,677	25,058,970	26,169,997	23,241,865	19,576,138	
CO_2 emissions from aviation	180,143	181,754	178,920	181,827	189,505	210,353	205,701	86,017	
Non-ETS emissions[1)]	**31,238,063**	**29,767,010**	**29,475,736**	**30,593,937**	**29,860,973**	**29,798,387**	**29,340,456**	**28,120,096**	
Non-ETS emissions as cumulative percentage of the assigned amount	**13%**	**25%**	**38%**	**50%**	**63%**	**75%**	**87%**	**99%**	
Sum of Non-ETS emissions 2013–2019									**238,194,658**
Article 3.3 net emissions to be subtracted from the assigned amount[2)]	**3,587,485**	**3,337,762**	**3,359,836**	**3,210,995**	**3,065,656**	**3,018,433**	**3,474,088**	**2,809,177**	
Sum of Article 3.3 net emissions 2013–2019, to be subtracted from the assigned amount									**25,863,432**
Article 3.4 net removals (Forest Management, FM)	–47,335,049	–46,089,720	–41,400,742	–38,782,812	–35,735,041	–26,169,406	–31,938,319	–34,799,603	
Finland's FMRL[3)] (annual reference)	–20,466,000	–20,466,000	–20,466,000	–20,466,000	–20,466,000	–20,466,000	–20,466,000	–20,466,000	
Technical correction to the FMRL	–9,198,000	–9,198,000	–9,198,000	–9,198,000	–9,198,000	–9,198,000	–9,198,000	–9,198,000	
FM net removals minus FMRL and its technical correction	–17,671,049	–16,425,720	–11,736,742	–9,118,812	–6,071,041	3,494,594	–2,274,319	–5,135,603	
Sum of FM net removals minus FMRL and its technical correction 2013–2019									–64,938,691
FM cap[4)]									–19,978,041
Estimate of net addition to the assigned amount from Article 3.4[2)] for the entire commitment period									**19,978,041**

1) The emissions corresponding to the emission level allocated to Finland in the joint fulfilment agreement by the EU, its Member States and Iceland

2) Finland has chosen end of commitment period accounting for Articles 3.3 and 3.4 wherefore any additions or subtractions to the assigned amount will be done at the end of the commitment period

3) FMRL= Forest Management Reference Level

4) FM cap is –19,978,041 tonnes CO_2 eq for the whole second commitment period.

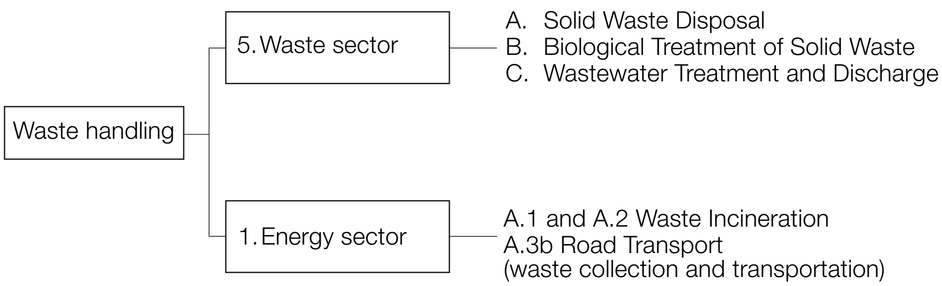
* Table does not include AAU units from the previous commitment period or CER and ERU units from the use of market-based Kyoto mechanisms that could be used to fulfill the commitment for the second commitment period.

The emissions and removals from ARD land vary between years, depending on the timing and quantity of the land-use changes, which vary depending on the economy. Interannual variation in the total CO_2 removals from FM is mainly due to variations in the amount of felling, which has a direct impact on the quantity of the biomass sink. In addition, the changes in soil carbon stock vary according to the variation in the carbon stocks of living biomass, as well as in the amount of carbon in logging residue inputs.

3.2.6 Waste

Methane (CH_4) emissions from landfills and CH_4 and N_2O emissions from composting and wastewater treatment are reported under the waste sector (Figure 3.17). Greenhouse gas emissions from the combustion of waste are reported fully in the energy sector, as waste incineration without energy recovery is almost non-existent. Waste sector emissions amounted to 1.7 million tonnes CO_2 eq. in 2020, which accounts for approximately four per cent of Finland's total emissions.

Figure 3.17
Reporting categories of emissions from waste handling in the national greenhouse gas inventory

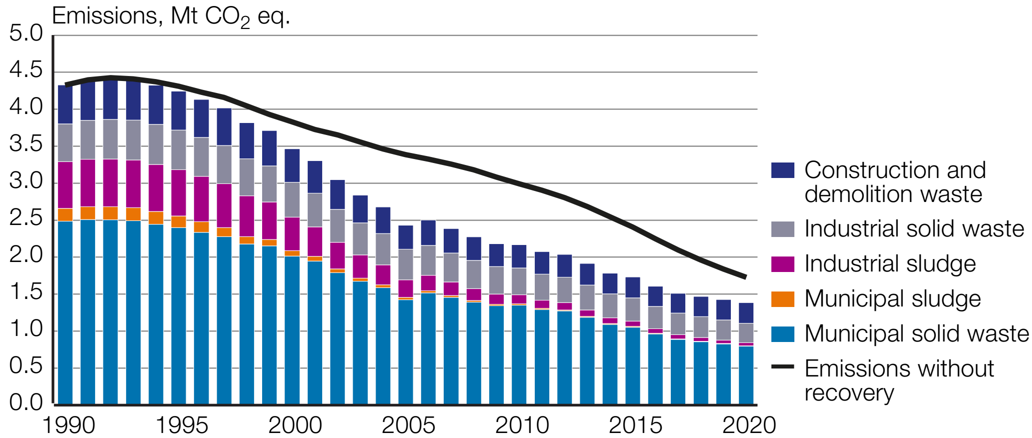


CH_4 emissions from landfills are the most important greenhouse gas emissions in the waste sector. Solid waste disposal on land contributes 80 per cent, wastewater treatment about 14 per cent and biological treatment (composting and anaerobic digestion) seven per cent of the sector's total emissions. Compared to 2019, emissions decreased by three per cent in 2020, and since 1990, these emissions have decreased by 63 per cent. A new Waste Act[2] entered into force in 1994, which has led to a reduction in methane emissions from landfill sites (Figure 3.18). The Waste Act has reduced the volume of waste deposited at landfills by promoting recycling and reuse, as well as the energy use of waste materials. The great increase in the amounts of recovered methane at the beginning of 2000 is a result of the regulations of landfill gas recovery (Council of State Decree on Landfills[3]). The amount of recovered methane in recent years has decreased due to the great decrease in the waste amounts to landfills after the ban of organic waste deposits at landfills. The recession of the early 1990s also reduced consumption and waste volumes.

2 1072/1993

3 861/1997

Figure 3.18
Methane emissions from solid waste disposal on land. The figure also shows the amount of methane generated (emission without recovery) at solid waste disposal sites



Emissions from wastewater treatment have also been successfully reduced by 20 per cent compared with 1990. For example, the reduction in emissions has been affected by the increasingly efficient treatment of wastewater (also in sparsely populated areas), as well as a lower nitrogen burden released from industrial wastewaters into waterbodies. Emissions from composting have more than doubled since 1990, being six per cent of the waste sector's emissions in 2020. The reason is the increased composting of waste, especially in semi-urban areas, due to separate collection of organic waste. Emissions from anaerobic digestion have also increased significantly in recent years for the same reason as the increase in emissions from composting. Yet this emission source is very small, being 0.6 per cent of the waste sector's emissions in 2020.

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

3.3.1 Institutional, legal and procedural arrangements

According to the Government resolution of 30 January 2003 on the organisation of climate policy activities of Government authorities, Statistics Finland assumed the responsibilities of the national entity for Finland's greenhouse gas inventory from the beginning of 2005. In 2015, the role of Statistics Finland as the national entity was enforced through the adoption of the Climate Change Act.[4]

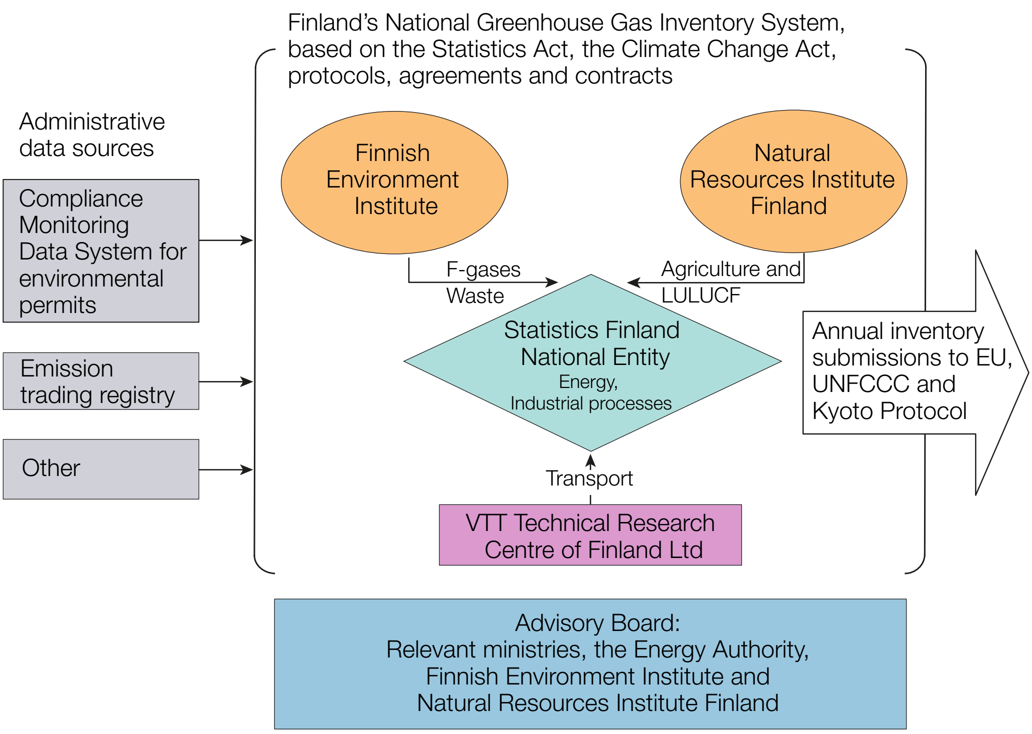
In Finland, the national system is established on a permanent footing, and it guides the development of emissions calculation in the manner required by the Kyoto Protocol. The national system is based on laws and regulations concerning Statistics Finland, agreements between the inventory unit and

4 609/2015 and 423/2022

expert organisations on the production of emission and removal estimates and related documentation. Statistics Finland also has agreements on cooperation and support for the expert organisations participating in Finland's national system with relevant ministries. The national system is designed and operated to ensure the transparency, consistency, comparability, completeness, accuracy and timeliness of greenhouse gas emission inventories. The quality requirements are fulfilled by consistently implementing the inventory quality management procedures. The national system for the greenhouse gas inventory in Finland is presented in Figure 3.19.

The contact person for the national entity and its designated representative with overall responsibility for the national inventory at Statistics Finland is Ms Pia Forsell, FI-00022 Statistics Finland, tel. +358-29-551 2937, email pia.forsell@stat.fi

Figure 3.19
The National System for the Greenhouse Gas Inventory in Finland



Statistics Finland as the national entity for the inventory

In Statistics Finland's activity as the national entity for the greenhouse gas inventory, the Statistics Finland Act[5] and the Statistics Act[6] are applied.

Statistics Finland defines the placement of the inventory functions in its working order. The advisory board of the greenhouse gas inventory established by Statistics Finland ensures collaboration and information exchange in issues

5 48/1992 and its amendment 901/2002

6 280/2004 and its amendment 361/2013

related to the reporting of greenhouse gas emissions under the UNFCCC and the Kyoto Protocol. The advisory board reviews planned and implemented changes in the inventory and the achieved quality. It approves changes to the division of tasks between the expert organisations preparing the inventory. In addition, the advisory board promotes research and review projects related to the development of the inventory and reporting. It also gives recommendations on participation in international cooperation in this area (UNFCCC, IPCC, and EU). The advisory board is composed of representatives from the expert organisations and the responsible Government ministries.

Statistics Finland oversees the compilation of the national emission inventory and its quality management in the manner intended in the Kyoto Protocol. In addition, Statistics Finland calculates the estimates for the energy and industrial processes (except for F gases: HFCs, PFCs and SF_6) sectors. As the national entity, Statistics Finland also bears the responsibility for the general administration of the inventory and communication with the UNFCCC and the EU Commission, coordinates the review of the inventory and publishes and archives the inventory results.

Statistics Finland has access to data collected for administrative purposes. Hence, by law, Statistics Finland has access to data collected under the EU ETS, the regulation on fluorinated gases, the European Pollutant Release and Transfer Register (E-PRTR) and energy statistics regulation. Access to EU ETS data is also ensured through the agreement between Statistics Finland and the Energy Authority. The EU ETS data and data collected under the energy statistics regulation are significant data sources and used both directly and/or for verification in inventory compilation. The use of the E-PRTR and data collected under the regulation on fluorinated greenhouse gases play a much more limited role in the inventory preparation.

Statistics Finland approves the inventory before the submissions to the UNFCCC and EU. The draft inventory submission to the EU on 15 January is presented to the advisory board, and before submitting the final inventory to UNFCCC on 15 April, the national inventory report is sent to the inter-ministerial network on climate policy issues for comment.

Responsibilities of the expert organisations

In addition to Statistics Finland, Finland's inventory system includes the Finnish Environment Institute and Natural Resources Institute Finland (Luke) expert organisations. Statistics Finland also acquires parts of the inventory as purchased services from VTT (VTT Technical Research Centre of Finland Ltd).

Table 3.2
Responsibility areas by expert organisation

Area		Organisations
CRF 1.A.	Stationary sources fuel combustion in point sources, such as power plants, heating boilers, industrial combustion plants and processes	Statistics Finland
CRF 1.A.	Mobile sources (transport and off-road machinery)	Statistics Finland, VTT Technical Research Centre of Finland Ltd (as a purchased service), Finavia (inventory years 1990 to 2010)
CRF 1.A.	Other fuel combustion (agriculture, households, services, public sector, etc.)	Statistics Finland
CRF 1.B.	Fugitive emissions from energy production and distribution	Statistics Finland
CRF 2.	Emissions from industrial processes and product use	Statistics Finland
CRF 2.	Emissions of F gases	Finnish Environment Institute (SYKE)
CRF 3.	Emissions from agriculture	Natural Resources Institute Finland (Luke)
CRF 4.	Emissions from land use, land-use change and forestry	Natural Resources Institute Finland (Luke)
CRF 5.	Emissions from waste	Finnish Environment Institute (SYKE)
Indirect CO_2	Non-methane volatile organic compounds, NMVOC	Finnish Environment Institute (SYKE)
KP(LULUCF)	Activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol (ARD and FM)	Natural Resources Institute Finland (Luke)

Until 2009, Finavia (formerly the Civil Aviation Administration) provided emission data on aviation to the inventory. In 2010, Finavia's status in Finland's inventory system changed. Finavia is no longer performing the calculations. Statistics Finland has taken over this task and has been responsible for the calculations since 2010. Finavia continues to support Statistics Finland in the task by providing Statistics Finland with expert advice.

The agreements between Statistics Finland and the expert organisations define the division of responsibilities (sectors/categories covered) and tasks related to uncertainty and key category analyses, QA/QC and reviews. They also specify the procedures and schedules for the annual inventory process coordinated by Statistics Finland. The responsibilities for estimating and reporting emissions/removals from different sectors/categories of the different expert organisations are based on established practices for the preparation and compilation of the greenhouse gas emission inventory. The scope of these responsibilities is presented in Table 3.2.

All the participating organisations are represented in the inventory working group set up to support the process of producing annual inventories and the fulfilment of reporting requirements. The working group advances collaboration and communication between the inventory unit and the experts producing the estimates for the different reporting sectors and ensures the implementation of the inventory's QA/QC and verification process.

The role of responsible ministries and the Energy Authority in the national system

The resources of the national system for the participating expert organisations are channelled through the relevant ministries' performance management (Ministry of the Environment and Ministry of Agriculture and Forestry). In addition, other ministries participating in the preparation of the climate policy advance the data collected in the management of public administration duties in their administrative branch so that they can be used in the emission inventory.

In accordance with the Government resolution, the ministries produce the data needed for international reporting on the contents, enforcement and effects of the climate strategy. Statistics Finland assists in the technical preparation of policy reporting. Statistics Finland also technically compiles the National Communications and the biennial reports under the UNFCCC. Separate agreements have been made on the division of responsibilities and cooperation between Statistics Finland and the ministries.

The Energy Authority is the National Emissions Trading Authority in Finland and supervises the monitoring and reporting of the emission data under the European Emissions Trading System (EU ETS) and international emissions trading under the Kyoto Protocol. Statistics Finland and the Energy Authority concluded an agreement in 2006 on collaboration between the national inventory system and registry, including a division of the responsibilities related to reporting. The most recent update to the agreement was made in 2018.

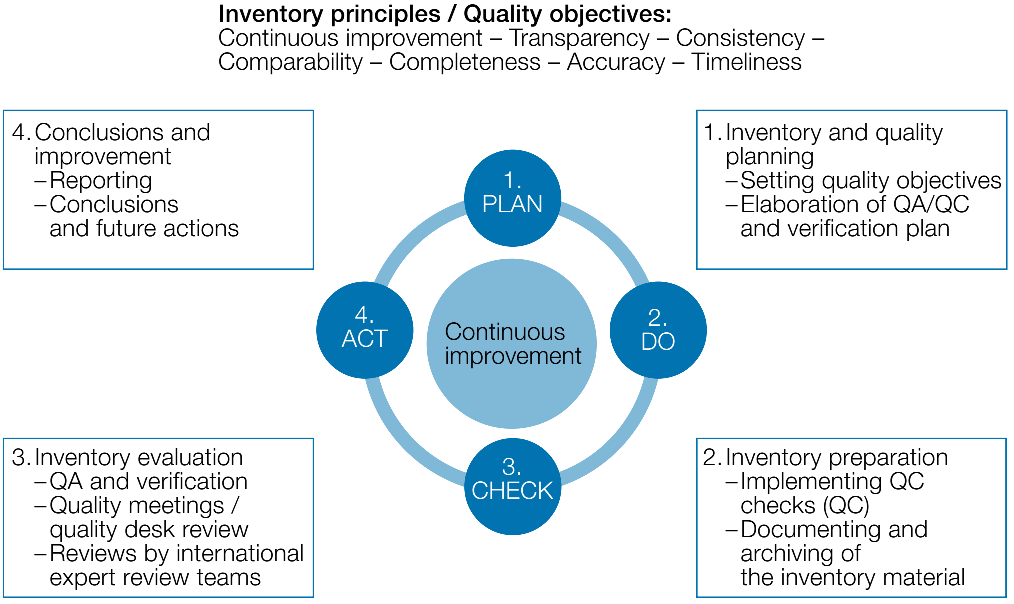
The Energy Authority provides the necessary information on emission reduction units, certified emission reductions, temporary certified emission reductions, long-term certified emission reductions and assigned amount units and removals units for annual inventory submissions in accordance with the guidelines for preparation of information under Article 7 of the Kyoto Protocol. This reporting is done using so-called standard electronic tables (SEF) and documentation provided in the National Inventory Report or made publicly available on the website of the Energy Authority.

3.3.2 Annual inventory process

The annual inventory process set out in Figure 3.20 illustrates at a general level how the inventory is produced within the national system. The quality of the output is ensured by inventory experts during compilation and reporting. The quality control and quality assurance elements are integrated into the inventory production system, which means that each stage of the inventory process includes relevant procedures for quality management (see also Section 3.3.3).

The methodologies, collection of activity data, and choice of emission factors are consistent with the guidance in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the IPCC 2013 Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.

Figure 3.20
Inventory and QA/QC process of the inventory



Advanced and country-specific approaches (Tier 2 and Tier 3 methods) are used wherever possible, as these are designed to produce more accurate emission estimates than the basic (Tier 1) methods. Detailed activity data are used for most categories, and the emission factors and other parameters are based on national research and other data. For large point sources within the energy and industrial processes sectors, the estimates are based on plant and process-specific data. The Compliance Monitoring Data System YLVA, used by the Centres for Economic Development, Transport and the Environment for processing and monitoring environmental permits, is the central data source for plant and process-specific data. Detailed descriptions of the methodologies used can be found in the sector-specific chapters of the National Inventory Report.

Statistics Finland conducts a Tier 2 key category analysis annually prior to submitting inventory information to the EC. The Tier 2 methodology uses category-specific uncertainty analyses. The analysis covers all the sources and sinks of the inventory.

The key category analysis functions as a screening exercise. The result is a shortlist (20+) of the subcategories that are the most important in terms of the level and trend of the emissions. This list forms the basis for discussions with the sectoral experts on the quality of the estimates and possible needs for improvement to the calculation methodology. The results of the key category analysis are included annually in the national inventory report and the common reporting tables. This information is archived following Statistics Finland's archival practices.

Recalculations are made to implement methodological improvements in the inventory, including changes in activity data and emission factors, or to include new source or sink categories within the inventory or to correct identified errors, omissions, overlaps, or inconsistencies within the time series.

Greenhouse gas inventory recalculations are based on an annual evaluation of the inventory's preparation and improvement needs, including input from the QA/QC activities. The driving forces when applying the recalculations are the need to implement the guidance given in the IPCC Guidelines and the recommendations in the UNFCCC and EU inventory reviews.

Statistics Finland coordinates the development of the inventory. Each organisation participating in the inventory preparation process bears the primary responsibility for developing its own sector. The advisory board discusses and promotes the horizontal development projects and resources needed for development work.

Inventory development needs and projects that require additional resources are identified at bilateral quality meetings between the inventory unit and the participating organisations. Statistics Finland keeps a record of the development needs and planned or proposed improvement measures and uses this information to compile an annual inventory improvement plan. Methodological changes are discussed and evaluated by the advisory board and approved by the inventory unit at Statistics Finland before being implemented.

Any changes made are documented in the CRF tables and in the National Inventory Report in accordance with the UNFCCC reporting guidelines. Changes in methodologies are implemented for the whole time series.

Finland has undertaken several research programmes and projects to improve the quality of the country-specific emission factors and other parameters, as well as the methods used in the greenhouse gas inventory (see also Chapter 8, Section 8.2.4). The results have been disseminated through articles in scientific journals and presentations at various national workshops and seminars, for example. Some of the research results have also been used by the IPCC in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, the IPCC Emission Factor Database, the '2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands' and '2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories', for example.

3.3.3 Quality management

The objective of Finland's GHG inventory system is to produce high-quality GHG inventories, which means that the structure of the national system (i.e. all institutional, legal and procedural arrangements) for estimating greenhouse gas emissions and removals, and the content of the inventory submissions (i.e. outputs, products) comply with the requirements and principles.

The starting point for accomplishing a high-quality GHG inventory is consideration of the expectations and requirements directed at the inventory. The quality requirements set for the annual inventories – transparency, consistency, comparability, completeness, accuracy, timeliness and continuous improvement – are fulfilled by implementing the QA/QC process consistently in conjunction with the inventory process (Figure 3.20). The quality control and quality assurance elements are integrated into the inventory production system, which means that each stage of the inventory process includes relevant procedures for quality management.

The inventory process consists of four main stages: planning, preparation, evaluation and improvement (Plan-Do-Check-Act (PDCA) cycle) and aims for continuous improvement. A clear set of documents is produced on the different work phases of the inventory. The documentation ensures the transparency of the inventory: it enables external evaluation of the inventory and its replication where necessary.

Statistics Finland has the overall responsibility for the GHG inventory in Finland, including the responsibility for coordinating the quality management measures at national level. The quality coordinator steers and facilitates the quality assurance and quality control (QA/QC) and verification process and elaborates the QA/QC and verification plan. The expert organisations contributing to the production of emission or removal estimates are responsible for the quality of their own inventory calculations. Experts on each inventory sector implement and document the QA/QC and verification procedures.

The inventory planning stage includes the setting of quality objectives and elaboration of the QA/QC and verification plan for the coming inventory preparation, compilation and reporting work. In addition, a schedule of the coming inventory round is prepared and presented to the expert organisations. The timetable includes deadlines for QC checks of the inventory compilation and draft meeting schedules of the inventory working group and advisory board.

The setting of quality objectives is based on the inventory principles. Quality objectives (Table 3.3) are specified statements about the quality level that is aimed at the inventory preparation regarding the inventory principles.

Table 3.3
The quality objectives regarding all calculation sectors for the inventory

Quality objectives
1. Continuous improvement
1.1. Treatment of review feedback is systematic
1.2. Improvements promised in the National Inventory Report (NIR) are carried out
1.3. Improvement of the inventory is systematic
1.4. Inventory quality control (QC) procedures meet the requirements
1.5. Inventory quality assurance (QA) is appropriate and sufficient
1.6. Verification of the inventory meet the requirements
1.7. Known uncertainties of the inventory are taken into consideration when planning the improvement needs
2. Transparency
2.1. Archiving of the inventory is systematic and complete
2.2. Internal documentation of calculations supports emission and removal estimates
2.3. CRF tables and the National Inventory Report (NIR) include transparent and appropriate descriptions of emission and removal estimates and of their preparation
3. Consistency
3.1. The time series are consistent
3.2. Data have been used in a consistent manner in the inventory
4. Comparability
4.1. The methodologies and formats used in the inventory meet comparability requirements
5. Completeness
5.1. The inventory covers all the emission sources, sinks, gases and geographic areas
6. Accuracy
6.1. Emissions and removals are not systematically over- or underestimated
6.2. Calculation is correct
6.3. Inventory uncertainties are estimated
7. Timeliness
7.1. High-quality inventory reports reach their receivers (EU/UNFCCC) within the set time

The objectives aim to be appropriate and realistic considering the available resources and other conditions in the operating environment.

The quality objectives and the planned general and category-specific QA/QC and verification procedures regarding all sectors are set in the QA/QC plan. This is a document that specifies the actions, schedules and responsibilities to attain the quality objectives and provide confidence in the Finnish national system's capability of delivering high-quality inventories. The QA/QC plan is written in Finnish and updated annually. It consists of instructions and a QA/QC form. The instructions include descriptions of quality objectives, general and category-specific inventory QC checks, information on quality assurance and verification, schedules and responsible parties. The QA/QC form addresses the actions to be taken at each stage of the inventory preparation. Sectoral experts enter into the form the QA/QC and verification procedures performed and their results. Discussions in the bilateral quality meetings or feedback given during the quality desk reviews are based on the information documented in these forms. The QA/QC plan is available in the shared workspace of the inventory and archived according to the inventory unit's archive formation plan.

The general and category-specific QC procedures are performed by the experts during inventory calculation and compilation according to the QA/QC and verification plan.

The QC procedures used in Finland's GHG inventory comply with the 2006 IPCC Guidelines. General inventory QC checks (2006 IPCC Guidelines, Vol 1, Chapter 6, Table 6.1) include routine checks of the integrity, correctness and completeness of the data, identification of errors and deficiencies, and documentation and archiving of the inventory data and quality control actions. Category-specific QC checks, including reviews of the activity data, emission factors and methods, are applied on a case-by-case basis, focusing on key categories and on categories in which significant methodological changes or data revisions have occurred.

The QA reviews are performed after the implementation of QC procedures concerning the finalised inventory. The QA system comprises reviews and audits to assess the quality of the inventory and the inventory preparation and reporting process to determine the conformity of the procedures taken and to identify areas where improvements could be made.

Specific QA actions differ in their viewpoints and timing. The actions include basic reviews of the draft report, quality meetings or quality desk reviews, internal and external audits, peer reviews, EU MMR comparisons, and UNFCCC and EU inventory reviews.

In addition, emission and activity data are verified by comparing them with other available data compiled independently of the GHG inventory system. These include measurement and research projects and programmes initiated to support the inventory system or for other purposes, but which produce information relevant to the inventory preparation.

The ultimate aim of the QA/QC process is to ensure the quality of the inventory and to contribute to its improvement. At the improvement stage of the QA/QC process, conclusions are drawn based on the realised QA/QC measures taken and their results, as well as UNFCCC and EU review feedback and uncertainty analysis where relevant. In addition, the inventory unit and experts performing the inventory calculations follow the development of the sector. When technologies and practices change, or new activity or research data become available, they evaluate the need for improvements and recalculations to improve the inventory. The methodological changes are communicated to the advisory board for evaluation and approved by the inventory unit before being adopted in production (see also Section 3.3.2).

3.4 National registry

This section of the National Communication summarises the national registry of Finland, which is part of the Union registry. More information is included in the National Inventory Reports of Finland.

The national registry of the EU and its Member States is maintained as a single European Union registry, operated by the European Commission, Directorate-General for Climate Action, BE-1049 Brussels, Belgium. 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 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.

The consolidated platform which implements the national registries in a consolidated manner (including the registry of the EU) is called the Union registry and was developed with the new EU registry on the basis of the following modalities:

- Each Party retains its organisation 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 to 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.

The changes to the national registry of Finland which have occurred since the last National Communication report are summarized in Table 3.4. For other parts, the description of the functions of the national registry and its conformity with the Data Exchange Standards (DES) under the Kyoto Protocol, reported in Finland's 7th National Communication, Chapter 3.4, remains valid. Changes to the national registry since the 7th National Communication have been reported annually in Finland's National Inventory Reports to the UNFCCC.

Table 3.4
Changes to the Union registry, including changes to Finland's national registry, since publication of the NC7

Reporting item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	No change has occurred to the administrator of the national registry of Finland, which is: Energy Authority rekisteri@energiavirasto.fi Address and phone number are available at homepage https://energiavirasto.fi/en/contact-information1 The address of the Energy Authority changed during the reported period.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	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.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	The registry has been updated to version 13.5.2. Some changes were applied to the database during the reported period. 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.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	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 Data Exchange Standards (DES) and are carried out prior to the relevant major release of the version to Production. No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The mandatory use of soft tokens for authentication and signature was introduced for the registry end users during the reported period.

Reporting item	Description
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	Publicly available information is provided via the Union registry homepage for the Finnish registry (https://ets-registry.webgate.ec.europa.eu/euregistry/FI/public/reports/publicReports.xhtml) and via the web page of the Energy Authority (https://energiavirasto.fi:8443/en/emissions-trading-registry#public_information).
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	The registry internet address changed during the reported period. The URL is https://unionregistry.ec.europa.eu/euregistry/FI/index.xhtml.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	No change occurred during the reported period.

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Photo: iStock.com

4

Policies and measures

This chapter describes the Finnish climate policy framework, the policy-making process and domestic and regional legislative arrangements and procedures for climate policy implementation under the UNFCCC, the Kyoto Protocol and the Paris Agreement. These are followed by a description of the national climate and energy strategies and plans for meeting the related targets. The policies and measures planned, adopted and implemented to achieve the emission reduction commitments under international agreements and the ambitious national goal of carbon neutrality by 2035 are presented by sector. Also, taxation and subsidies, use of Kyoto mechanisms and the effect of policies and measures on long-term trends are discussed. The end of the chapter examines mitigation benefits other than greenhouse gas reduction and minimising adverse effects in other countries.

4 Policies and measures

4.1 Climate policy framework in Finland

Effective climate change policies require global collaboration and actions. Finland's climate policy is therefore based on international agreements: the UNFCCC; the Kyoto Protocol; and the Paris Agreement. This chapter describes the Finnish climate policy framework, the policy-making process and domestic and regional programmes, legislative arrangements and procedures for climate policy implementation under the UNFCCC, the Kyoto Protocol and the Paris Agreement. The common policies of the European Union, such as the EU 2030 Climate and Energy Package, play a key role in the implementation of the above international agreements. At national level, Finland's climate policy is defined in government policies and programmes, and since 2003, ministerial working groups have steered strategic work. In addition, national energy and climate strategies have been prepared since 2001 to implement international and EU commitments, as well as national targets, and to define sectoral policies and measures.

4.1.1 Climate Act

The new Climate Act (423/2022) entered into force on 1 July 2022. The previous Climate Change Act, the first in Finland, was adopted in 2015. The Act sets out several plans that aim to reduce greenhouse gas emissions and adapt to climate change in Finland. It also obliges the central government authorities to monitor the trends in emissions and achievement of climate targets and report on them to Parliament.

The 2035 carbon neutrality target, which was set in the Programme of Prime Minister Sanna Marin's Government in 2019, was included in the reform of the Act. In addition, new emissions reduction targets for 2030 and 2040 were included in the Act, and the previous emissions reduction target of 80 per cent by 2050 was updated. The new targets are 60 per cent by 2030, 80 per cent by 2040, and at least 90 per cent, aiming for 95 per cent, by 2050 compared to 1990 levels.

The scope of the Act was also extended to cover the land-use, land-use change, and forestry (LULUCF) sector, and a target for the strengthening of carbon sinks was added. The planning system for national climate policy under the Climate Act was also reformed by including a new climate programme for the land-use sector.

4.1.2 UNFCCC and Kyoto Protocol

Under the UNFCCC, the EU and its Member States committed to achieving a joint quantified economy-wide greenhouse gas emissions reduction target of 20 per cent below the 1990 level by 2020 ("the Cancun pledge"). It is therefore a joint pledge with no separate targets for Member States under the Convention. The UK remained part of the joint EU 2020 target with the 27 EU Member States.

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 per cent 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)[1]. 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 and its Member States played their part in the joint commitment as follows. Emissions from categories covered by the EU Emissions Trading System (EU ETS) were to be reduced by 21 per cent by 2020 from their 2005 level, and emissions not covered by the EU ETS were to be cut by approximately 10 per cent from the 2005 level by 2020 within the EU as a whole. The EU ETS emissions reduction commitment was an EU-level commitment, and Member State specific caps were not defined for the EU ETS emissions reductions (for more information, see Section 4.1.3 below).

The EU substantially overachieved its reduction target under the Convention, which means that its Member States and the United Kingdom also fulfilled their emissions reduction obligations. As stated in the 2022 EU GHG inventory submission to the UNFCCC, the total GHG emissions, excluding LULUCF and including international aviation, decreased by 34 per cent in the EU-27 + UK compared to the 1990 base year, or 1.94 billion tonnes of CO_2 equivalent.

The EU's Effort Sharing Decision defined Finland's reduction obligation for the sources not covered by the EU ETS as 16 per cent of the 2005 emissions. This reduction obligation was determined in CO_2 equivalent (eq.) tonnes in the Commission Decision[2], and adjusted in the Commission Implementing Decision[3] to take changes in the coverage of the EU Emissions Trading System from 2013 onwards into account. For Finland, these annual adjustments increased the reduction commitment by 2020 by approximately five percentage units.

1 2009/406/EC

2 2013/163/EU

3 2013/634/EU

The Kyoto Protocol was amended with new quantified emission limitation and reduction commitments for the second commitment period, 2013 to 2020, which continue the commitments established for the first period. Finland's emissions reduction target for the second commitment period of the Kyoto Protocol was defined based on its emissions reduction obligation under the ESD described above. This target amounted to 240,544,599 tonnes of CO_2 eq. and covered only non-ETS emissions. In addition, Finland was responsible for the emissions and removals from the LULUCF activities as defined in Decision 2/CMP.7 during the second commitment period.

Based on the inventory data, the cumulative emissions of the Effort sharing sector during the entire commitment period were 238.2 Mt CO_2 eq. The additional burden from the emissions and removals from the LULUCF activities as defined in Decision 2/CMP.7 is 5.9 Mt CO_2 eq. Finland must therefore use additional emission units transferred from the previous Kyoto Protocol commitment period or acquired from the Clean Development Mechanism or Joint Implementation. Finland has enough such additional units at its disposal. The fulfilment of the commitment will be confirmed between 2022 and 2024 after international reviews and the True-Up Period. A description of the first commitment period of the Kyoto Protocol can be found in the 7th national communication.

Articles 3.3 and 3.4 of the Kyoto Protocol

Articles 3.3 and 3.4 of the Kyoto Protocol concern emissions and removals from land-use, land-use change and forestry (LULUCF) activities. Article 3.3 activities (afforestation, reforestation and deforestation) are based on land-use changes, and reporting these activities is mandatory for the Annex I Parties. Under Article 3.4, the selection of activities (forest management, cropland management, grazing land management and revegetation) was voluntary for Parties during the first commitment period. During the second commitment period, forest management (FM) became mandatory. Finland had already elected to apply FM in the first commitment period but did not select other voluntary activities for either commitment period. The accounting for the emissions and removals under Article 3, Paragraphs 3 and 4 was to be done at the end of the first commitment period and will also be done for the second commitment period.

Based on an initial study by the Natural Resources Institute (Luke), Article 3.3 activities were estimated to cause net emissions for the 2013 to 2020 period because of the conversion of forest land to other land uses, as well as low carbon sequestration rates in areas afforested or reforested since 1990. During the second commitment period of 2013 to 2020, the net emissions from the Article 3.3 activities, i.e. afforestation, reforestation and deforestation were an average of 3.2 million tonnes CO_2 eq. per year. Average net removals from afforestation and reforestation were 0.6 million tonnes CO_2 eq. per year, including carbon stock changes in harvested wood products from afforestation/reforestation areas. Net emissions from deforestation were an average of 3.8 million tonnes CO_2 eq. per year. Land-use change from forest land to other land uses is difficult to avoid in a country where forests cover 72 per cent of the land area. Most of the change is driven by settlements and infrastructure (e.g. roads and transmission lines), as well as agriculture. The emissions under Article 3.3, in total 25.9 million tonnes for the whole commitment period, will be subtracted from Finland's assigned amount at the end of the commitment period.

The FM net sink, i.e. the sum of emissions and removals during the second commitment period, was 37.8 million tonnes CO_2 eq. per year. These net removals for FM include the net removals by harvested wood products, which were an average of 13.7 million tonnes per year. Net removals from forest management vary significantly from year to year based on the demand for forest industry products driven by the overall economic situation.

The net emissions from FM will be compared to the reference level established for Finland (−20.466 million tonnes CO_2 eq.) in decision 2/CMP.2, adjusted by the technical correction (−9.1980 million tonnes CO_2 eq. in Finland's latest inventory submission). A higher sink will result in RMU units that can be used to meet the reductions target; a lower sink will mean the subtraction of assigned amount units equal to the difference between FM and reference level removals. Additional RMU units can be received only up to a value of 3.5 per cent of the 1990 national total emissions without the LULUCF sector (FM cap). Finland's cap value for the FM sink is −19.978 million tonnes CO_2 eq. At the end of the second commitment period, the sum of net removals from forest management exceeding the FM reference level and its technical correction was 64.9 million tonnes CO_2 eq.[4], which was greater than the FM cap. In total, net emissions from the Article 3.3. exceeded the maximum that could be accounted for from the forest management of Article 3.4., i.e. the forest management cap, by 5.9 million tonnes CO_2 eq., which will be subtracted from Finland's assigned amount.

The KP LULUCF accounting will be confirmed after the review and the True-Up Period at the end of 2023 or in 2024. Detailed information on Kyoto Protocol activities under Articles 3.3 and 3.4 is presented in Finland's latest National Inventory Report under the UNFCCC and the Kyoto Protocol.

4.1.3 Legislation on the Kyoto Mechanisms

An administrative framework for participating in the Joint Implementation (JI) and Clean Development Mechanism (CDM) project activities and emissions trading under the Kyoto Protocol (Articles 6, 12 and 17) is provided by the Act on the Use of the Kyoto Mechanisms.[5] Decrees on JI[6] and the

4 Also taking the reduction for one year into account when net removals were smaller than the forest management reference level and its technical correction

5 109/2007

6 91372007

CDM[7] include guidance on the content of the applications for project approvals and on authorisation for entities to participate in the projects.

The Ministry of the Environment decides whether to authorise legal entities to prepare for and participate in a JI project, and it approves the JI projects. The Ministry of the Environment may also participate in international emissions trading on behalf of the State. The Ministry for Foreign Affairs authorises preparations for and participation in CDM projects and approves the projects.

The Ministry of the Environment is the holder of the national account for Kyoto units and makes decisions regarding the transfer of units to and from national account. The Energy Authority is the competent authority for emissions trading and the administrator of the national emissions trading registry (see the section on the national registry in Chapter 3).

4.1.4 The Paris Agreement

The Paris Agreement was adopted in December 2015 and entered into force in November 2016. The EU ratified the agreement in October. The Finnish national ratification was completed in November 2016.

The Paris Climate Change Agreement is an international, legally binding agreement on climate change. It aims to limit the rise in global average temperature to well below 2 °C relative to pre-industrial levels and to pursue efforts by which warming could be limited to below 1.5 °C.

The Paris Agreement does not include any quantitative emissions reduction obligations, but the Parties commit to the preparation, communication, maintenance, and achievement of their successive national goals concerning emissions. The Parties are obliged to prepare their national contributions every five years, and the most recent goal must always be more ambitious than the previous one. Progress in relation to the objectives is to be reviewed every five years. The first global review, or "stocktake", will take place in 2023.

The EU's joint nationally determined contribution under the Agreement is to reduce greenhouse gas emissions by at least 55 per cent by 2030 from the 1990 level. The details of the effort sharing between the Member States, including Finland, are currently being negotiated. More information on the negotiations and the associated policy framework beyond 2020 is presented in the next section.

4.1.5 Climate policy of the European Union

EU legislation and policy programmes have a major effect on Finland's greenhouse gas emissions.

7 915/2007

In 2007, the EU heads of state or government agreed on targets to combat climate change through a commitment to reduce greenhouse gas emissions by 20 per cent by 2020 from the emission level in 1990 (see also Section 4.1.2). In the long term, or by 2050, the guideline target involved a reduction of emissions by 80 to 95 per cent. The EU 2020 Climate and Energy Package constituted the framework for the EU's climate policy for the 2013 to 2020 period.

To achieve the 2020 emissions reduction target, the EU Member States adopted a binding renewable energy target prescribing that at least 20 per cent of the EU's gross final energy consumption and 10 per cent of the final energy consumed in the transport sector must come from renewable energy sources by 2020.

According to the EU 2020 Climate and Energy Package, emissions from sectors not included in the EU ETS – such as transport, housing, agriculture and waste – had to be cut by approximately 10 per cent from the 2005 level by 2020 within the EU as a whole. The Effort Sharing Decision (ESD)[8] established binding annual greenhouse gas emissions targets for Member States for the 2013 to 2020 period.

Finland's target under the ESD is presented in detail in Table 4.1. The table also includes the emissions from non-ETS sectors from 2013 to 2020.

Table 4.1
Finland's target path for non-ETS emissions in accordance with the EU Effort Sharing Decision and corresponding emissions for 2013 to 2020

	2013	2014	2015	2016	2017	2018	2019	2020	sum (2013–2020)
Finland's annual emission allocations	31.8	31.3	30.8	30.3	30.2	29.6	29.1	28.5	241.559
Non-ETS emissions[1]	31.6	30.1	29.9	31.4	30.1	29.9	29.6	28.1	240.727
Distance from the target[2]	–0.2	–1.1	–0.9	1.0	–0.1	0.3	0.6	–0.4	–0.832

1 Due to the annual implementation of the EU ESD, the emissions used for assessing compliance are not updated after the compliance assessment. The emissions may therefore differ from the most recent inventory data.

2 Distance from the target is expressed as a negative number when actual emissions are below annual emission allocations.

As Table 4.1 shows, Finland met its emissions reduction commitments under the EU Effort Sharing Decision concerning the entire period from 2013 to 2020.

The 2020 Climate and Energy Package also required Finland to increase its use of renewable energy sources to 38 per cent of final energy consumption by 2020 and the share of biofuels in gasoline and diesel to 10 per cent by 2020. Finland has already reached these targets as well.

8 2009/406/EC

The EU also has a regulation on F gases[9], covering key applications in which F gases are used. The current regulation applies from 1 January 2015. The regulation limits the total amount of the most important F gases that can be placed on the EU market from 2015 onwards and phases them down in steps to a fifth of 2014 sales in 2030. In addition, the regulation bans the use of F gases in many types of equipment where less harmful alternatives are widely available, such as supermarkets, air conditioning, foams and aerosols, and imposes measures for preventing emissions of F gases from existing equipment by requiring checks, proper servicing and recovery of the gases at the end of the equipment's life. With the current F gas Regulation, the EU's F gas emissions will be cut by two thirds by 2030 compared with 2014 levels. In 2022, a revision of the F gas regulation was initiated. It is expected that the steps and timetable of the phase-down of certain F gases will be significantly tightened, new bans will be introduced and the containment of F gas emissions will be improved. The proposed new measures are expected to equate to additional emissions savings of 40 million tonnes CO_2 eq. by 2030 and 310 million tonnes CO_2 eq. by 2050 at the European level.

The policy framework for the period beyond 2020 is partly prepared and partly still in preparation in the EU. According to the European Council conclusions in 2014, the EU is committed to reducing total greenhouse gas emissions by at least 40 per cent by 2030 compared to 1990. The reduction target from the 2005 levels in the emissions trading sector is 43 per cent, and in the non-emissions trading sector, it is 30 per cent. The share of renewable energy (of final energy consumption) in the EU was set to 32 per cent, and the target of energy efficiency was revised to 32.5 per cent in connection with the revision of Renewable Energy and Energy Efficiency Directives in 2018.

In addition to the reform of the EU's emissions trading system (ETS) and the Effort Sharing on non-ETS emissions, for the first time the land-use, land-use change and forestry sector is also included in the EU's climate policy package. In the Effort Sharing Regulation, Finland's target for emissions reductions in 2030 compared to the 2005 level is 39 per cent. The legislative package includes flexibility mechanisms that allow Member States to achieve their targets in cost-effectively.

To achieve and implement the EU's 2030 Climate and Energy Package, as well as the Energy Union targets, in November 2016, the Commission submitted the Clean Energy Package, which included eight legislative proposals, a new eco-design working plan, and several communications and reports, all related to the clean energy transition. The Energy Union policy programme aims to provide EU citizens with reasonably priced, secure and sustainable energy.

In 2019, the Commission submitted a communication describing the European Green Deal, which included a target of carbon neutrality by 2050.

9 2014/517/EU

The target itself is already in the EU's binding legislation, but more detailed laws are still in preparation.

In 2020, the Commission presented its proposal to tighten the 2030 emissions target so that the new reduction in the EU's total emissions would be at least 55 per cent by 2030 compared to the 1990 level. The rationale is that the previous target is inadequate for achieving the carbon neutrality target by 2050. The Commission therefore submitted the preliminary Fit for 55 legislative climate package, which lays out measures for how to achieve the stricter 55 per cent reduction. For example, the current ETS would be expanded to maritime transport, and a new emissions trading system would be established for ground transport and space heating. Emissions reduction targets for the ETS and effort sharing sectors would be stricter (61 and 40 per cent compared to 2005 respectively), as well as the previously mentioned targets of the share of renewables and energy efficiency (40 and 36 to 39 per cent respectively).

It is also noteworthy that the Commission has the power to initiate an infringement proceeding against a Member State that fails to fulfil its commitments and obligations under EU law.

4.2 Climate policymaking process in Finland

4.2.1 Government and the role of ministries

The Government and Parliament make the most important decisions concerning climate policy. Usually, the President of the Republic directs foreign policy in cooperation with the Government and thus approves Finland's international commitments and decides on their implementation according to the constitution. However, some major decisions also require approval from Parliament (also see Chapter 2). Parliament also actively participates in the debate on how EU decisions are implemented nationally. The Ministerial Committee on European Union Affairs discusses and decides on Finland's positions on EU and international climate policy issues. Finland participates in the international climate negotiations as part of the European Union and therefore follows the EU's common positions.

The Ministry of the Environment bears the responsibility for coordinating the preparatory work for the climate negotiations and is the national focal point for the UNFCCC. Preparatory work for the climate negotiations is carried out in several ministries.

Since 2003, every Finnish government has appointed ministerial working groups responsible for energy and climate policy, with representatives from all government parties. These ministerial working groups have been responsible for preparing and updating the national strategies on energy and climate policy. The ministerial working group has a network of officials acting as its preparatory body, comprising representatives from the Ministry of Economic Affairs and Employment, the Ministry of Transport and Communications, the Ministry of Agriculture and Forestry, the Ministry of Education and Culture, the Ministry for Foreign Affairs, the Prime Minister's Office, the Ministry of Finance, and the Ministry of the Environment. The network of officials is led by the Ministry of Economic Affairs and Employment, which oversees the overall coordination of the strategy work. The current strategy on energy and climate policy, which was updated in 2022, is described in Section 4.3.1.

In Finland, climate policy is increasingly being integrated with the decision-making processes in energy production, transport, agriculture, forestry and land use and other planning. For example, both the transport sector and the land-use sectors have their own climate policy programmes.

The new Climate Change Act that entered into force on 1 July 2022 lays down provisions on climate change policy planning and the related monitoring and sets the national climate objectives. The act also imposes obligations on the authorities. According to the new Climate Change Act, the rights of the Sámi people must be taken into account, and negotiations with the Sámi Parliament must be conducted in the processes to prepare climate change policy plans. The act also includes provisions on the duties of a multidisciplinary expert body, Finland's Climate Change Panel, in support of the planning of climate policy.

Procedures included in the Climate Change Act enable annual assessment of the implementation of the Kyoto Protocol and of the progress in meeting the national emission reduction commitments. Also, the European Commission monitors annually that the EU Member States, including Finland, are in compliance with their emission reductions targets, in accordance with Decisions 406/2009/EU and 2018/842[10]. The legislation concerning the EU ETS, including compliance in the ETS sector, is harmonized across the EU. Finland has not established specific national rules for taking action against domestic non-compliance with emission reduction because such rules are established in the EU legislation (see the 4th Biennial Report of the European Union, Section 4.2.2 for the period of 2013–2020).

Finland was also one of the first countries to prepare a national climate adaptation strategy (NAS) in 2005. The strategy was evaluated in 2013 and superseded by the National Climate Change Adaptation Plan 2022 (NAP) in 2014. In 2022, a final evaluation of the NAP2022 was completed, and preparation of the new National Adaptation Plan 2030 was underway (more on national adaptation policy in Chapter 6).

Climate and energy policies and measures are also considered in the context of the promotion of the sustainable development. Society's Commitment to

10 https://eur-lex.europa.eu/legal-content/FI/TXT/PDF/?uri=CELEX:32018R0842&from=EN

Sustainability[11], was updated by the National Commission on Sustainable Development in 2016. With this commitment, the public sector and certain other actors pledge to promote sustainable development in all their work and operations. The commitment was later updated to respond to the new global agenda for sustainable development, the UN Agenda 2030. In 2020, the Government presented its latest report on the implementation of the UN Agenda 2030 for Sustainable Development to Parliament. The aim is a carbon neutral, resource-wise and competent Finland.

In reporting on policies and measures, including their implementation and effects on emissions, and projections to the European Commission and to the UNFCCC, the Ministry of Economic Affairs and Employment is responsible for the overall coordination and compilation of information from different sectors. The sectoral ministries are responsible for the projections and impact assessments concerning their own field. Several expert organisations assist in acquiring data and in the assessments of policies and measures and modelling sector-specific projections. The network of officials gives the final approval of the national communication.

The latest reporting requirements in the energy and climate sector were updated in connection with reforming the Climate Change Act in 2022. This act contains provisions on climate policy plans on which the Government will issue a report to Parliament. The Government's annual climate change report is coordinated by the Ministry of the Environment and all relevant ministries are involved in the work. The annual report informs Parliament on the achievement of climate targets and the impact of the measures taken. The first annual climate change report was issued in 2019. The Finnish Government's annual report to Parliament reports the progress of agreed measures in the energy sector.

The recent EU regulation on the Governance of the Energy Union and Climate Change Actions requires every EU Member State to regularly prepare an integrated national energy and climate plan (NECP) and a Long-Term Strategy (LTS) for low-carbon development. Finland submitted its first NECP to the EU in 2019 and its first LTS in 2020. The regulation also includes an obligation to biennially prepare the national energy and climate plan progress report (NECPR). The first report will be submitted in March 2023.

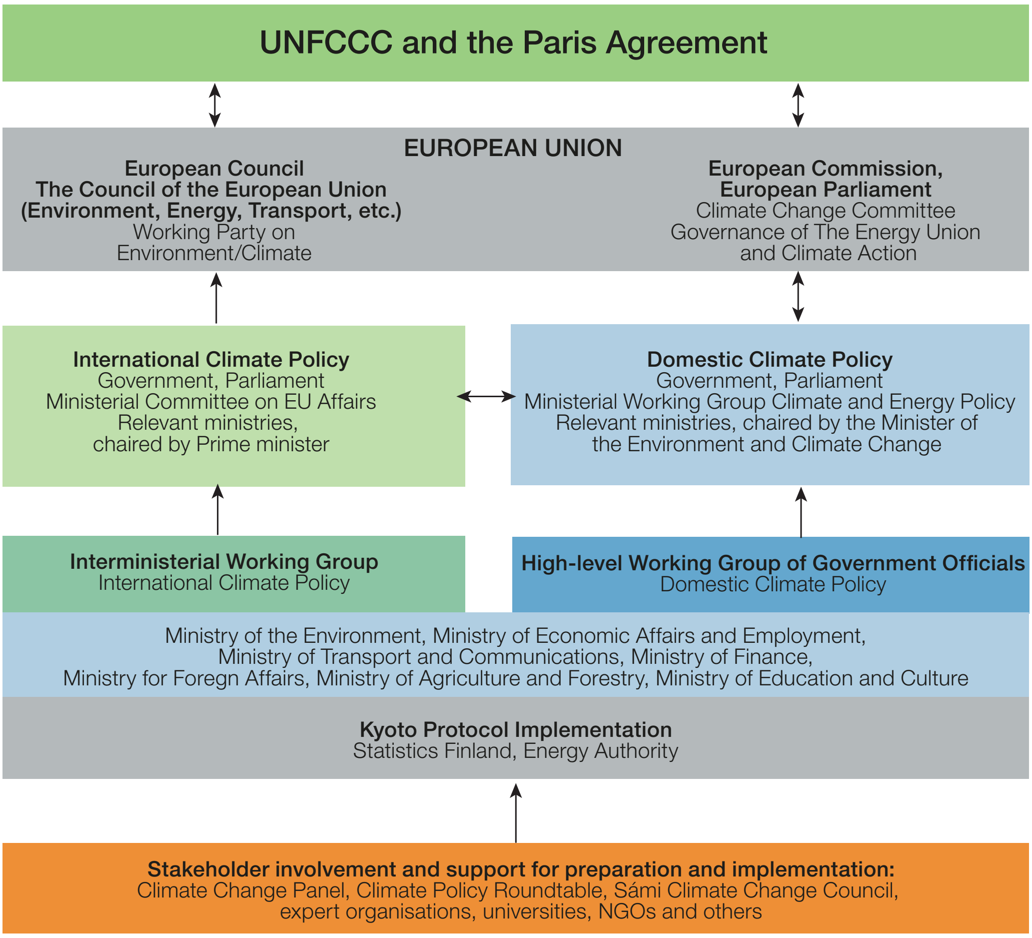
Statistics Finland is the national entity responsible for compiling the Finnish greenhouse gas inventory. Statistics Finland publishes the greenhouse gas inventory data three times every year. The publications include information on monitoring progress with Finland's commitments to reduce its greenhouse gas emissions under the EU and the Kyoto Protocol. The Finnish Environment Institute (SYKE), Natural Resources Institute Finland

11 http://www.ym.fi/en-US/The_environment/Sustainable_development

(Luke) and the VTT Technical Research Centre of Finland participate in the inventory preparation as part of the national system. The national system under Article 5, paragraph 1 of the Kyoto protocol and the inventory preparation process are described in Chapter 3.

The Energy Authority is the competent authority and the registry administrator for the national emissions trading registry under the Kyoto Protocol and the EU ETS (also see Chapter 3). The institutional arrangements related to climate policy and its implementation in Finland are described in Figure 4.1.

Figure 4.1
Institutional arrangements related to climate policy and its implementation in Finland



4.2.2 The Finnish Climate Change Panel

The Finnish Climate Change Panel[12] was nominated by the Ministry of the Environment for the first time in December 2011. The initially 12-member Panel was tasked to strengthen the interaction between research and policymaking. The Panel's members represent different branches of science from educational to atmospheric sciences. The Panel has published reports on

12 https://www.ilmastopaneeli.fi/en/

several topics relevant to climate policymaking, such as the Climate Change Act, a pathway for reducing net emission in Finland, climate education, adaptation to climate change, and the social acceptability of climate action.

The legal basis for the Finnish Climate Change Panel was established when the Climate Change Act came into force in the summer of 2015. The Panel is appointed as an independent body to support climate policy planning and decision making. The Government nominated the current 15-member Panel in December 2019 for a term of four years.

The Panel provides scientific advice for policymaking. The policy advisory role of the Panel has become stronger and more visible. The Panel gives its opinion on climate policy plans and produces reports to support the preparation and implementation of climate policy and legislation in Finland. Panellists have been invited to comment the National Climate and Energy strategy, the Medium-Term Climate Change Policy plan, and the Climate Plan for the Land-Use Sector.

4.2.3 Other stakeholders

The Climate Arena of the Ministry of the Environment is a network for other ministries and stakeholders (e.g. industrial and environmental non-governmental organisations (NGOs), research institutes, and labour unions), in which they can present their views concerning issues related to climate policy.

NGOs, including environmental, business, social, and research organisations, participate in various governmental working groups, seminars and official delegations. Industrial enterprises and the general public also play a major role in providing information and views for the decision-making process. The Ministry of the Environment also organises regular stakeholder meetings in advance of all major UNFCCC negotiations.

The Climate Policy Roundtable, established in 2020, brings all key stakeholders together to prepare Finland's national climate actions. It is a network for trade unions, municipalities, scientists, industrial sectors, interest groups, young people, and NGOs. The Climate Policy Roundtable does not make decisions; instead, it supports the national processes in preparing and implementing climate policy. The Roundtable meets five to seven times a year.

In April 2021, an online Citizens' Jury was convened to deliberate on climate actions planned by the Finnish government to reach its targets in reducing Finland's emissions. The jury was commissioned by the Climate Policy Roundtable with the Ministry of the Environment, and it was implemented by researchers from the University of Turku. This was the first nationwide deliberative mini-public event on climate issues in Finland. The results were used for the preparation of the most recent Medium-Term Climate Change Policy Plan.

The Government Programme for 2019 to 2023 states that sectoral low-carbon roadmaps will be prepared to provide a more detailed picture of the scale and cost of the measures required for the transition to a low-carbon society. The work started in cooperation with major companies, advocacy organisations, and other organisations in 2019, coordinated by the Ministry of Economic Affairs and Employment. A total of 13 sectors prepared their own roadmap. The ministry published a report summarising the main results of the sectoral roadmaps in 2020. The report was published in English[13] in 2021. The report includes summaries of the published roadmaps, the project's key conclusions, a description of the work process and estimates of further work. It also explores how the roadmaps will be utilised in climate and energy work for a low-carbon Finland. The roadmaps will be updated where applicable in 2023 in accordance with the National Climate and Energy Strategy.

The Government Programme for 2019 to 2023 includes a climate programme for the LULUCF sector. The work of this programme is regularly reported to a steering body which is led by the Secretary General of the Ministry of Agriculture and Forestry and includes government officials and a broad base of stakeholders. This steering body has also steered the work of the Catch the Carbon programme (see Section 8.2.1 for Catch the Carbon programme).

The implementation of the National Adaptation Plan is supported by a broad-based Monitoring Group chaired by the Ministry of Agriculture and Forestry. It brings together representatives of several government ministries, sector agencies, research institutions, local and regional administrations, and other relevant actors (see also Chapter 6).

4.2.4 Public access to information

The right of access to information in official documents is a basic civil right protected by the Finnish constitution. Under the constitution, everyone has access to documents in the public domain. Documents in the possession of the authorities belong to the public domain unless access to them has been specifically restricted by an act.

The Act on the Openness of Government Activities[14] ensures everyone has the right to information on the activities of public officials. Access to documents is the main principle, and secrecy is an exception. Up-to-date legislation on climate and energy is publicly accessible through the Finlex online database of legislative and other judicial information of Finland. Finlex is owned by Finland's Ministry of Justice.

13 https://julkaisut.valtioneuvosto.fi/handle/10024/162851
14 621/1999

4.2.5 Regions and municipalities

Municipalities and regions play an important role, as Finland aims to be carbon neutral by 2035. Local and regional authorities can reduce their direct greenhouse gas emissions in many ways and minimise their carbon footprint. The local and regional authorities can also support and accelerate emissions reduction measures made by residents, companies, communities, and other regional and local stakeholders.

There is a wide range of informational, economic and voluntary or agreement-based instruments and tools local and regional authorities can utilise when pronouncing on and accelerating climate work in their own regions and municipalities across Finland. Climate budgeting is a valuable tool for municipalities aiming for carbon neutrality. Several municipalities in Finland have included climate investments in their budgeting. Tampere was the first Finnish city to introduce a climate budget in 2019. About 230 million euros was budgeted for climate investments in the city's economic plan for the years 2021–2024.

The new Climate Act (423/2022) entered into force on 1 July 2022. The Ministry of the Environment has prepared a proposal supplementing the Climate Act. In future, the Act will oblige municipalities to draw up climate plans. Municipalities should prepare a climate plan that will set out an objective to reduce greenhouse gas emissions in the municipality and measures to reduce greenhouse gas emissions. Government grants will be awarded to municipalities for the preparation of the climate plans. The Government has decided to allocate EUR 2,631 million per year for the preparation of climate plans in municipalities.

Municipalities have several means of expediting and promoting the climate work of their stakeholders, such as norms, obligations, financial means or communications, service design, cooperation, and partnerships. Within their own municipality, local governments are responsible for zoning, land use, transport planning, ownership steering of their own energy companies, choices between alternative heating systems for buildings and public procurement within their own territories.

The Finnish municipalities are active in a diverse set of networks that constitute an important part of local climate action, providing crucial peer support and knowledge sharing. There are several different types of regional, national and international networks that have varied cooperation and ways of working. Regional networks are based on the coordination of climate work at different governance levels or on the pooling of resources for smaller municipalities. The agreements concerning land use, housing, and transport are concluded by the State of Finland with the largest urban regions. The purpose of the agreements is to facilitate and support the cooperation between municipalities in urban regions and between municipalities and the State in guidance related to the urban structure and coordination of land use, housing and transport. Although these agreements were originally made to solve other societal issues, they are also an essential tool covering the climate impacts of urban regional development.

Of the national networks, Hinku (Towards Carbon Neutral Municipalities) and Energy Efficiency Agreements represent older and larger networks, while the Climate Leadership Coalition (CLC) is a more recent and business-orientated network. The Hinku network brings together municipalities, businesses, and experts to create and carry out solutions to reduce greenhouse gas emissions. The Hinku criteria refer to the measures and policies municipalities have adopted to combat climate change. The municipalities in the network are committed to an 80 per cent reduction in greenhouse gas emissions from 2007 levels by 2030. There are 86 municipality members in the network, with a total of 2,265,000 inhabitants (42 per cent of the Finnish population).

Finland is committed to strict targets to improve energy efficiency. Energy Efficiency Agreements, chosen in cooperation by the Government and industrial/municipal associations, are a tool for fulfilling the EU energy efficiency obligations set for Finland, without resorting to legislation or other coercive measures. More than 120 municipalities and joint municipal authorities are committed to the energy efficiency targets set in the agreements. The parties to the agreements report annually on the energy efficiency measures they have taken and other activities aimed at improving energy efficiency.

The Climate Leadership Coalition is the largest non-profit climate business network in Europe. Six cities and several municipality-owned companies have joined the network.

Local Governments for Sustainability, the Covenant of Mayors, and Eurocities are international networks in which there are several municipality members from Finland. The larger cities are also active in other international urban climate networks, based on their own international strategies.

Finnish Sustainable Communities (FISU) aims for carbon neutrality, zero waste, and globally sustainable consumption. Integrating climate and other relevant goals at the municipal level brings synergies to local actors and businesses. The development of new types of cooperation is central in FISU actions.

At the regional level, the most important organisations for promoting climate work are the 18 Regional Councils (RCs) and 15 Centres for Economic Development, Transport, and the Environment (ELY Centres). The Regional Councils are responsible for compiling a Regional Land-Use Plan, which defines the principles of urban structure and the use of areas needed for specific purposes. All Regional Councils have included climate and energy issues in their strategies – either as separate climate strategy documents (climate roadmaps) or as a theme in comprehensive regional strategies.

The ELY Centres are responsible for the regional implementation and development tasks of national climate policy, for example, the four climate change policy plans. In recent years, ELY Centres have put more emphasis on climate change and circular economy issues. The first version of a roadmap to reduce ELY Centres' carbon footprint and to maximise their carbon handprint, i.e. their positive impact on regional stakeholders' mitigation measures for climate change, was published in 2021.

4.3 Strategies and plans

4.3.1 National energy and climate strategies

The Government Programme of Prime Minister Marin sets ambitious energy and climate targets, of which the most ambitious is Finland's national objective to be a carbon neutral society by 2035. National and EU-level legislation sets other energy and climate targets and commitments for 2030 and 2050 as well. In addition to the EU, certain international goals come from the UNFCCC, Paris Agreement and Kyoto Protocol , for example. The Government regularly prepares strategies and plans for achieving these energy and climate targets.

In 2020, Finland submitted its Long-Term Strategy to the EU and UN in accordance with the Implementing Regulation Act 2018/1999. The strategy includes Finland's latest national target, which is to achieve carbon neutrality by 2035. It is discussed further in Section 4.3.2.

Finland has prepared six national strategies on energy and climate policy, which were completed and submitted to Parliament as a Government Reports in 2001, 2005, 2008, 2013, 2016 and 2022, respectively. The focus of the 2008 and 2013 strategies was on policy measures for achieving the 2020 energy and climate targets. The 2016 strategy – National Energy and Climate Strategy for 2030 – outlined the actions enabling Finland to attain the targets specified in the Government Programme of former Prime Minister Sipilä (May 2015) and in the EU for 2030, and to systematically set the course for achieving an 80 to 95 per cent reduction in greenhouse gas emissions by 2050.

The latest strategy, called "Carbon Neutral Finland 2035 – National Climate and Energy Strategy", sets out the key starting points and objectives of the Government Programme goals, including the EU 2030 targets and national carbon neutrality target by 2035. It then assesses the adequacy of current measures for meeting the targets (the base scenario) and additional measures by which its targets can be attained (the policy scenario). The strategy also refers to the latest Medium-Term Climate Change Policy Plan, which specifies the key measures for achieving the binding emissions reduction targets in the effort sharing sector by 2030, and to the Climate Change Plan for the Land-Use Sector.

With minor exceptions, Finland is phasing out the use of coal in the energy sector. The share of transport biofuels will be increased to 34 per cent (of the fuel energy content), and an obligation to blend light fuel oil used in machinery and heating with 30 per cent of bioliquids will be introduced. Finland will continue to subsidise electric and gas vehicles and promote the use of biogas in transport. The minimum aim in the strategy was to have 750,000 electric and 130,000 gas-powered vehicles on the roads in 2030. The electricity market will be developed at the regional and European levels. The flexibility of electricity demand and supply and in general, system-level energy efficiency, will be improved. A continuously strong focus will be kept on the national Energy aid scheme, which funds energy projects based on new energy technologies.

With the additional measures outlined in the strategy, the share of renewable energy in primary consumption is expected to increase to approximately 50 per cent, and the self-sufficiency in energy to more than 50 per cent by 2030. Most of this is attributed to biomass and wind power, including offshore wind. The national carbon neutrality target by 2035 appears possible to achieve, but much depends on individual companies' timing in investing in reducing process-related emissions, as well as the kind of carbon sink levels the LULUCF sector will be able to sustain. Due to the high carbon prices in the EU's ETS, the target of halving the use of energy peat set out in the Government Programme by 2030 will be achieved well in advance. The greatest non-ETS sector reductions in emissions will be achieved in the transport sector, which is also the foundation of the latest Medium-Term Climate Change Policy Plan prepared in 2022.

The relevant ministries are responsible for implementing the measures set out in the National Climate and Energy Strategy and for their monitoring and evaluation. In some cases, this responsibility has been delegated to specialised government entities such as Motiva Oy, an entirely state-owned sustainable development company in Finland that promotes the efficient and sustainable use of energy and materials.

An example of sectoral climate policy progress reports are the summaries on the impact of energy efficiency agreements published on the internet[15] by Motiva Oy.

As a member of the European Union, Finland has reporting obligations to the EU concerning policies and measures and projections. The requirements are set by the EU Monitoring Mechanism Regulation[16]. The biennial report on policies and measures and projections has been compiled in cooperation with the Ministry of Economic Affairs and Employment (responsible for the overall

15 https://energiatehokkuussopimukset2017-2025.fi/tulokset/sopimusten-tulokset-yhteensa/ (Energy Efficiency Agreements 2017 to 2025, Results; platform only in Finnish)

16 2013/525/EU

coordination), the Ministry of the Environment, the Ministry of Transport and Communications, the Ministry of Agriculture and Forestry, the Ministry of Finance, Statistics Finland, the Finnish Environment Institute (SYKE), state owned sustainable development company Motiva Oy, and Natural Resources Institute Finland (Luke).

In the Government's annual report to Parliament, mitigation measures and emissions development are evaluated at a general level. Other energy and climate reporting activities include an annual report to Parliament on the implementation of the Medium-Term Climate Policy Plan and reporting once per government term on the national adaptation plan constructed based on the Finnish Climate Change Act.[17]

4.3.2 Long-Term Strategy (LTS)

In 2020, Finland submitted its Long-Term Strategy (LTS) to the UN and EU. It replaces the former Energy and Climate Roadmap 2050, published in 2014. The preparation of an LTS is stipulated in Article 4, Paragraph 19 of the Paris Agreement under the UNFCCC and in Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, also known as the "Governance Regulation". It was the first strategy to take Finland's carbon neutrality target into account before the latest National Climate and Energy Strategy in 2022.

Finland's Long-Term Strategy lays out scenarios and impact assessments concerning the national carbon neutrality target set for 2035 and developments in greenhouse gas emissions and removals by 2050. The strategy explores the following three scenarios. Alongside the reference scenario depicting the development achievable with current policy measures at that time, known as the "With Existing Measures" (WEM) scenario, the strategy presents two alternative low-emission scenarios, known as the "Continuous Growth" and "Savings" scenarios. The Continuous Growth and Savings scenarios describe alternative pathways for achieving the emissions reduction target at that time set by Finland (or by the European Union, if stricter) for 2050. The Long-Term Strategy does not consider the transition to a low-emission society from the perspective of regional or social justice; instead, its underlying calculations are based on the premise that emissions reduction costs will be minimised across the country. Nor does the Long-Term Strategy identify the sectors to which emissions reductions should be allocated; nor do the impact assessments derived from the scenarios include any quantitative analysis of the concrete measures or political decisions that would be required to achieve the carbon neutrality target or the 2050 targets considered here.

17 609/2015

With existing measures (WEM), carbon neutrality will not be achieved until 2050 – and even then, only with land-use net sinks at about 30 Mt CO_2 eq. per year. Conversely, the Continuous Growth and Savings scenarios will achieve carbon neutrality in 2035, but this will require substantial emissions reductions over the 2030 to 2035 period, while also keeping the size of forest carbon sinks at a reasonable level. The measures decided by the Government and their impact on emissions are described in the latest National Climate and Energy Strategy, prepared in 2022.

Going forward, Finland will prepare a new complementary national Long-Term Strategy in accordance with the requirements set out in the Climate Change Act. The new strategy will be submitted to Parliament by the end of 2025 at the latest.

4.3.3 Medium-Term Climate Change Policy Plan

The Climate Change Act contains a provision on a climate change policy planning system that includes a Medium-Term Climate Change Policy Plan adopted by the Government once every government term. The Medium-Term Climate Change Policy Plan will include an action plan that contains measures for the reduction of anthropogenic greenhouse gas emissions and the mitigation of climate change in the effort sharing sector (sectors outside emissions trading) and projections of greenhouse gas emissions and the effects of policy measures on the emissions. The preparation of the Plan is coordinated by the Ministry of the Environment, and all the relevant ministries are involved in the work. The Annual Climate report, which is submitted to Parliament every year, contains information on the implementation of the policy measures contained in the Medium-Term Climate Change Policy Plan.

The second Medium-Term Climate Change Policy Plan was finalised during 2022. Alongside the National Climate and Energy Strategy and the Climate Plan for the Land-Use Sector, this plan implements the climate policy objectives of the Government Programme. It specifies and complements the emissions reduction measures outlined in the National Climate and Energy Strategy and the Climate Plan for the Land-Use Sector. It also examines links between different sectors and crosscutting themes such as the role of consumption and regional climate action. The plan takes the energy policy measures included in the strategy and the measures included in the Climate Plan for the Land-Use Sector into account, because they will have an impact on the development of the total emissions.

The Medium-Term Climate Policy plan was updated to meet the increasingly stringent EU obligations for 2030 and the Government's target to achieve carbon neutrality by 2035. The plan sets a target for reducing greenhouse gas (GHG) emissions 50 per cent in the effort sharing sector by 2030 compared to the 2005 level. It also determines the measures for achieving the target. The target is based on the European Union's (EU) 2030 target of reducing emissions by at least 55 per cent compared with 1990 levels and is in line with Finland's long-term climate goal. As the existing measures are insufficient to achieve the 2030 EU target and the national target to be climate neutral by 2035, the plan identifies a range of additional measures. The greatest emissions reduction potential is identified in the transport sector. The plan also includes measures to reduce emissions in the agriculture, waste, and machinery sectors, as well as emissions from building-specific heating and F gas emissions.

A wide range of citizens and stakeholder groups was heard during the preparation of the Medium-Term Climate Change Policy Plan. The plan is based on the principle that carbon neutrality should be achieved as cost-effectively and fairly as possible.

4.3.4 Climate Plan for the Land Use Sector

The Climate Plan for the Land Use Sector (LULUCF) was prepared from 2021 to 2022 for the first time, and it will be one of the key elements of the planning system under the revised Climate Change Act. In line with the UN Framework Convention on Climate Change and the Paris Climate Change Agreement, the land use sector comprises land use, land-use change, and forestry (LULUCF).

The preparation of the Plan was coordinated by a working group, which included members from the Ministry of Agriculture and Forestry and other relevant ministries, as well as two experts from the Finnish Climate Change Panel. The key principle in the preparation was to reach the climate targets as cost-effectively, fairly and justly as possible. The Plan was preceded by an analysis of the most effective climate measures in the LULUCF sector and complemented by an environmental impact assessment, as well as an analysis of the cost-effectiveness of the proposed measures. The Plan was prepared in a participatory manner.

The purpose of the Plan is to promote the reduction of emissions from land use, forestry, and agriculture, the strengthening of carbon sequestration and carbon storage, and adaptation to climate change in accordance with the Sustainable Development Goals. The annual net impact, i.e. decrease in the emissions and increase in the removals, for which the additional climate measures in the land-use sector aim is at least three million tonnes of carbon dioxide equivalent by 2035.

Some measures were implemented already during the preparation of the Plan. Such measures include new ownership policy guidelines for the State Forest Enterprise Metsähallitus for 2020 to 2024, the act on fixed-term support for afforestation, and the act on fixed-term support for fertilisation of forests with wood ash. The Plan also includes measures targeting land-use changes, carbon dioxide emissions from agricultural land, the management of peatland forests, the promotion of carbon markets, as well as long-lived wood products and construction, and several crosscutting measures. The annual climate change report will contain information on the implementation of the policy measures included in the Climate Plan for the Land Use Sector. Links to the Medium-Term Climate Change Policy Plan and Climate and Energy Strategy were considered in the preparation process.

4.3.5 National forest legislation and programmes

The sustainable management of forests in Finland is based on legislation, high-level scientific knowledge, and good practices. Maintaining the forest carbon sink is part of sustainable forest management, and it has also been required as a means of conforming to the forest management reference level (−19.300 million tonnes CO_2[18]) set for Finland for the second commitment period of the Kyoto Protocol (2013 to 2020).

The means for steering the use of forests include legislation, Finland's National Forest Strategy 2025, financing, and public forestry extension organisations.

Forest legislation is the most important forest policy means for ensuring sustainable forestry. The key acts include the Forest Act[19] and the Act on the Financing of Sustainable Forestry.[20] There is also legislation dealing with the prevention of forest damage and the trade in forest reproductive material, timber measurement, jointly owned forests, and organisations in the forestry sector. Forest legislation ensured that the implementation of the KP LULUCF activities, i.e. Activities under 3.3 and 3.4 of the Kyoto Protocol were carried out taking into account sustainable use of natural resources and conservation of biodiversity.

The Forest Act sets requirements for the regeneration and conservation of certain key habitats. For example, a new seedling stand must be established within three years of the end of felling. The Forest Act is complemented by guidelines for good forest management and silviculture, which have been compiled and promoted by public forestry extension organisations. The current law allows for more diversified management methods such as uneven aged forest management. The amendments to the Forest Act increase the freedom of choice of forest owners in managing their own forest property, improve the profitability of forestry and operating conditions of the wood-producing industry, and enhance the biodiversity of forests. Best Practices for Sustainable Forest Management in Finland are continuously updated to reflect the most recent scientific knowledge and societal values among the key stakeholders, as well as the main targets set by the Finnish national forest policy. The development work related to the Best Practices is financed by the Ministry of Agriculture and Forestry.

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18 Assuming instantaneous oxidation for harvest wood products (HWP), (−20.466 million tonnes CO_2 eq. with HWP)

19 1093/1996 (amendment 1085/2013)

20 1093/1996

The Government Report on Forest Policy 2050 was adopted in 2014. The report, conducted in a participatory process, outlines a long-term vision and strategic objectives for the management of forests and the main measures to be taken. The vision of the Forest Policy Report, sustainable forest management is a source of growing welfare, stresses the diverse welfare derived from forests and the fact that the utilisation of forests offers solutions to the needs of people and society. Based on the Forest Policy 2050, Finland's National Forest Strategy (NFS)[21], adopted by the Government in February 2015, specifies the main objectives for forest-based business and activities until 2025. The strategy was updated in 2019. The NFS describes the priorities and measures for the development of forest-based business and activities, on which the Government will focus as part of the sector's joint development. The strategy is implemented by key projects.

According to the current NFS, climate change mitigation and adaptation in forests are supported by diversifying forest management. Forests' viability, i.e. growth and health, will be maintained and enhanced through active forest management. Over the long term, forest management techniques must be adapted to new and changing climate conditions. Timely and careful forest management can improve both the growth and the resistance of growing stock to damage, while safeguarding the ecosystem services of forests and producing wood biomass sustainably. Forests as a carbon sink have been a significant means of mitigating climate change in Finland.

The NFS is implemented and monitored in broad cooperation between the public and private sectors. The Ministry of Agriculture and Forestry, supported by the Forest Council, has the overall responsibility for the programme. The Forest Council includes representatives from different administrative sectors, industries, NGOs and specialist organisations. For more information on the national measures of the NFP, see Section 4.5.6. A new NFS until 2035 is currently being prepared (2022).

The NFS is also implemented through Regional Forest Programmes, in which the special regional characteristics are duly considered. Regarding the contribution to the conservation of biodiversity and the sustainable use of natural resources, the most important instruments are section 10 of the Forest Act (on preserving diversity and habitats of special importance) and the policies and measures outlined in the Forest Biodiversity Programme for Southern Finland 2014 to 2025 (the METSO programme), both of which are integral parts of the range of instruments in the NFS to protect biological diversity in the future.

The METSO programme is being implemented jointly by the Ministry of Agriculture and Forestry and the Ministry of the Environment. In southern Finland, 72 per cent of forests are owned by private persons. METSO therefore

21 https://mmm.fi/en/nfs

targets both private and state-owned land. It covers the protection and commercial use of forests. The aim is to halt the decline in forest habitats and species and to establish stable and favourable conditions for forest biodiversity in southern Finland. The programme is being implemented through ecologically efficient, voluntary, and cost-effective means. A Government decision-in-principle in 2014 sets goals for METSO up to 2025 that 96,000 ha of private and 13,000 ha of state-owned forests will be conserved on a permanent or temporary basis.

The new Helmi programme is a key tool for halting biodiversity loss in Finland. The programme (2021 to 2030) is a joint programme of the Ministry of the Environment and the Ministry of Agriculture and Forestry, implemented together by the administrative branches of both ministries and municipal authorities and organisations. Actions are carried out both within and outside protected areas. The participation of landowners is voluntary.

The main objective of the Helmi programme is to take a comprehensive view of habitats and the necessary restoration and management measures in collaboration between numerous stakeholders. Restoration and management actions are targeted to specific areas and sites to maximise their impact on biodiversity.

The SOTKA project of the Ministry of Agriculture and Forestry is part of the Helmi programme. In this project, wetlands and a network of resting areas for birds are built, mires and catchments are restored and small carnivores are captured.

Forestry is a significant income source for forest owners and provides benefits to society at large. Private and public organisations provide guidance and consultation services for forest owners. The provision of these services was liberalised by a new act on forest management associations.[22] A private forest owner may also receive assistance from the State for forest management and improvement work. State support encourages measures with long-term impacts. Managing the natural environment in commercial forests is promoted through environmental support and forest nature management projects. Public funding for forestry is based on the Act on the Financing of Sustainable Forestry, which is under preparation in 2022.

Environmental aid may be granted for additional costs and income losses due to preservation and management of habitats of special value. The State also finances forest nature management projects. The works to be designed and implemented in these projects are defined in further detail in the legislation. Most of the forest nature management projects have special regional importance. Apart from habitats of special value, the projects may concern landscape management, preventing damage to waters and the restoration of ditched areas.

22 534/1998 (amendment 1090/2013)

4.4 Sectoral policies and measures

Finnish regulations, policies, and measures are strongly affected by the increasing number of directives, policies, and measures of the EU. This chapter provides information on the most important policies and measures related to the reduction of greenhouse gas emissions. Both existing and planned measures are described. The mitigation actions, or policies and measures, and their effects are listed in tables and described by sector in the sections below.

Finland is continuously seeking to improve the information on the effects of the policies and measures. For some individual measures, Finland has been unable to provide quantified estimates on the impacts on national emissions. These are marked with the notation key NE (not estimated) in the tables. There are various reasons why it has not been possible to make the estimates, such as complexity and the overlaps with other measures (for example, the EU ETS), the measure is still in a phase in which the details of implementation are unknown (for example, recently decided agricultural measures such as new types of animal feed additives), the policy or measure targets heterogenous groups and/or many actors with different responses to the measure, or where the quantification of the effect is difficult (for example, measures providing customer advice and information).

For measures targeting F gas emissions and measures in the waste sector, only aggregate impact estimates of the policies and measures are provided to avoid double counting and improve the accuracy of the estimated effects. The impacts of the individual measures are marked with IE (included elsewhere) in the tables, and the aggregated estimates are provided for the group of measures. The notation Partly IE, partly included elsewhere, is used in the table for the emissions reduction impact of the investment aid for new energy technology demonstration projects. The emissions reduction has not been estimated separately for this measure because of the wide scope of possible projects being supported. The impact may partly be covered already by the emissions reduction figures for the measures promoting different renewable energy sources. In other words, the total emissions reduction figures for the renewable energy measures are presumably somewhat on the low side. The energy sector policies and measures are split under three headings. Section 4.4.1 presents all energy sector policies and measures except those targeted for the transport sector. Policies and measures in the transport sector are presented in Sections 4.4.2 and 4.4.3.

4.4.1 Energy

Policies and measures in the WM projection

The general objective of Finland's energy policy is to ensure energy security at competitive prices and with the lowest possible environmental impacts. Finland uses a diversity of energy sources, over about half of which are domestic (energy for transport not included) are domestic. The major trend is a steady increase both absolutely and in relative terms in the use of renewable energy. Direct governmental intervention to guide the choice of energy sources is rare in Finland. However, economic instruments, i.e. taxation and subsidies, are used to improve energy efficiency and to promote the development of domestic energy sources such as biomass, hydro, wind and solar. For example, new wind power projects established between 2011 and 2017 were eligible for substantial subsidies in the form of a feed-in tariff scheme. The feed-in tariff was also granted to biomass power plants until the end of 2018. The energy market has since undergone and is still undergoing a significant turning point in the investment climate. It is illustrated by the ongoing boom in new wind power projects, which have become profitable without subsidies, for example. In addition to actual energy taxes, the EU ETS acts as sort of tax on carbon, which directs new investments from fossil fuels to renewables. In addition, the recent disruption to the global energy market because of Russia's attack on Ukraine has accelerated the structural changes even further by underlining the need to advance domestic renewables from the energy security angle.

Within the energy sector, the greenhouse gas emissions are in practice reduced in two ways: 1) the primary energy consumption is reduced by cutting the end use or increasing the conversion efficiency in power plants; 2) fuels and energy use are shifted to alternatives with less emissions.

The main policies and measures in the energy sector include the EU Emissions Trading System (ETS), energy taxation, an increase in renewable energy, and energy conservation measures.

The EU ETS is an EU-wide domestic measure, while renewable energy sources are supported by various national measures: investment grants, taxation, support for research, and feed-in tariffs.

Energy conservation measures concern all sectors of the economy. Energy efficiency agreements, i.e. a voluntary scheme for industry and municipalities, have proved to be efficient measures along with taxes and subsidies. For both new and existing buildings, building codes and regulations play an important role.

The policies and measures included in the WM projection for the energy sector are described in more detail in the following sections. A list summarising the policies and measures can be found in Table 4.2 at the end of this section. Energy taxation and tax-related subsidies are described in Section 4.6.

EU Emissions Trading System

The EU ETS continues to be the most important economic policy instrument for reducing emissions in the EU and its Member States. Under the system, emissions are limited under an EU-wide cap, which sets the maximum amount of emissions for all operators obliged to participate in the system. The system is divided into periods for which the emissions reduction target and the representative cap are established. In addition, more significant rule changes usually take place as the period changes.

The EU ETS covers operators from power production, industrial processes and aviation limited to flights within the European Economic Area. The covered GHG gases are CO_2 and N_2O and PFC emissions from certain industries. EU-wide, some 11,000 installations are included in the EU ETS. There are around 600 installations in Finland. Greenhouse gas emissions in the emission trading sector and non-emissions trading sector from 2005 to 2020 are presented in Table 4.3. At the beginning of 2020, the EU ETS was linked with Switzerland's trading system, allowing more flexibility for the use of allowances for both entities.

Over the years, the EU ETS has undergone several reforms such as increasingly harmonised EU-wide rules, more ambitious emissions reduction targets, the introduction of auctioning as the primary allocation method and the establishment of the Market Stability Reserve (MSR), a mechanism that aims to decrease the allowance surplus in the market and improve its resilience to future recessions.

During Phase 4, that is, between 2021 and 2030, 57 per cent of allowances are allocated in auctions, and the rest is granted directly to installations as free allocation. Most Member States, including Finland, auction their allowance shares in joint auctions organised by the European Energy Exchange (EEX). During Phase 3, Finland's appointed auctioneer, the Energy Authority, accounted for a total EUR 1.10 billion of state revenues.

All sectors except electricity production and carbon capture, transport, and storage are entitled to apply for a free allocation. Sectors considered to have the highest risk of carbon leakage will continue to receive full free allocation; sectors considered to be less exposed will get 30 per cent compared to their demand. Starting from 2026, free allocation will gradually phase out for the less exposed sectors, with the exception of district heating.

Table 4.3
Greenhouse gas emissions in the emissions trading (ETS) sector and non-emissions trading sector in Finland in 2005, 2010, 2015 and 2020, million tonnes CO_2 eq. The ETS figures do not include emissions from aviation in the EU ETS as their coverage under the trading scheme is not consistent with the national greenhouse gas inventory. Total national emissions (also for 1990) and emissions from domestic aviation are also presented.

	1990	2005	2010	2015	2020
ETS	NA	35.5	41.9	25.4	19.6
of which energy	NA	29.6	37.3	21.5	16.0
industrial processes	NA	3.6	4.0	3.9	3.6
Non-ETS	NA	34.2	33.6	29.5	28.1
CO_2 emissions from domestic civil aviation	NA	0.3	0.2	0.2	0.1
Total	**71.18**	**69.9**	**75.7**	**55.0**	**47.8**

Due to a statistical difference between the greenhouse gas inventory and ETS data, sums may not add up.

Scope of the EU ETS in trading period from 2013 to 2020 has been used.

Phasing out coal

Finland has committed to phasing out coal in the energy sector. Achieving this consists of two measures. One is setting a deadline by law; the other is an additional financial incentive to act sooner.

In 2019, a law[23] prohibiting the use of coal in energy production from 1 May 2029 was enforced. The prohibition was estimated to reduce the use of coal by 3 TWh compared to market-based development without the prohibition. The avoided greenhouse gas emissions equal 0.65 million tonnes of CO_2.

To accelerate the coal phase-out, a special incentive package to support replacement investments was introduced for those energy utilities that undertook to give up the use of coal already by 2025.

The Ministry of Economic Affairs and Employment opened a call for investment subsidies for projects accelerating the replacement of coal in energy production. In 2021, almost EUR 23 million was granted for this purpose in the energy aid mandate. The aid was granted to projects that promoted the production or use of renewable energy, energy saving, or more efficient generation and energy use. Priority was given to projects based on technologies other than combustion. After these projects, the priority was given to combined heat and power production before separate heat production. Novelty and the demonstration potential of the projects was also considered. After these projects are completed by 2025 at the latest, coal will be virtually out of the fuel mix used in the energy sector.

Low-carbon roadmaps

The Government Programmes in 2019 stated that sector-specific roadmaps to low-carbon operation would be prepared in cooperation with the sector's operators. The roadmaps would be used to achieve a better understanding of the scale, costs, and conditions of the required actions.

A total of 13 sectors produced their own roadmaps in coordinated cooperation. In addition, a bioenergy association and one labour organisation published reports to contribute to the roadmap project. A separate Roadmap to fossil-free transport (Government resolution on reducing domestic transport's greenhouse gas emissions) was also adopted in 2021. The sectors had independent control over the drafting and execution of their roadmaps – the guiding principle was that each sector would know their field best. The sectors coordinated the production of their roadmaps internally by engaging with and listening to different operators at different stages of the process. The Ministry of Economic Affairs and Employment (MEAE) supported the sectors by coordinating the whole project, offering guidance, and arranging regular discussions and seminars. Low-carbon road maps were prepared for the following sectors [24]:

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23 416/2019

24 https://www.climate2035.fi/

- Agriculture
- Bioenergy industry
- Chemical industry
- Commerce
- Construction industry
- Energy industry
- Food industry
- Forest industry
- Hospitality industry
- Logistics and transport
- Property owners and developers
- Sawmill industry
- Technology industries
- Textile industry

Typically, the roadmaps include a comprehensive description of the current situation, an evaluation of emissions-reducing technologies and measures, and an estimate of achievable reductions. The roadmaps also use scenario analysis to assess coming developments. The scenarios include a baseline that depicts the effect of the current operating environment, and nearly all roadmaps included one or two low-carbon scenarios.

The roadmaps show potential for significant reductions in greenhouse gas emissions in different sectors. The results of the roadmap project was used as a direct input for the Government's climate and energy strategy, and many other government plans related to energy and climate policy. Furthermore, the roadmaps will guide the allocation of RDI investments and the preparation of sustainable recovery measures, for example.

Energy efficiency

The Finnish economy is relatively energy-intensive, which has led to fairly high per capita greenhouse gas emissions. Because energy use is efficient by international comparison, the high energy and emission intensities can be explained by structural factors. While the industrial structure has shifted significantly towards less energy-intensive industries, Finland still has a considerable number of energy-intensive industries.

The need for space heating, measured by average heating degree-days, is one of the largest in the world. In addition, the relatively large geographical area and sparse population are factors that increase energy intensity.

In terms of the efficiency of energy use and improving energy efficiency, Finland is among the world's leading countries. Co-generation of heat and electricity, the broad coverage of energy efficiency agreements (the first agreement period started as early as 1997; the third period, 2017 to 2025, is currently ongoing), and the systematic implementation of energy audits since the early 1990s are good examples of successful energy efficiency measures.

Energy Efficiency Directive

The Energy Efficiency Directive (EED) made the energy audits mandatory for big companies. The EED has been implemented mainly with the Energy Efficiency Law[25], which entered into force at the beginning of 2015.

Energy efficiency requirements have designated the public sector as liable for setting an example in promoting energy conservation. Other focus areas include the development of an energy-efficient community structure and enhancement of energy efficiency in the heating of buildings, transport, household use, agriculture, industry, and the entire service sector.

Most energy saving measures are based on EU-wide solutions, regulations and recommendations. Public financing is targeted, inter alia, at research and development activities and enhancement of competences, whereas fiscal solutions emphasise motivating energy savings while ensuring the conditions needed for industry to operate solidly.

For the subsidised energy audit programme, the realised annual CO_2 emissions reductions will decline and are estimated to be 0.37 million tonnes in 2020, and 0.11 million tonnes in 2040. In contrast, the realised annual CO_2 emissions reduction related to mandatory energy audits is estimated to grow, being 0.13 million tonnes in 2020 and 0.31 million tonnes in 2040. The great majority of the emissions reductions, around 95 per cent, is estimated to occur in the emissions trading sector due to the large share of electricity and district heat in energy savings. Buildings' energy use is discussed below in a separate section of this chapter.

Voluntary energy efficiency agreements

Voluntary Energy Efficiency Agreements[26] have played a central role since 1997 in increasing energy efficiency. They cover industries, private services, and municipalities, as well as oil-heated buildings. The agreements have played a central role in implementing both national energy policy and EU energy efficiency obligations. The role of the agreements has been especially important in achieving Finland's binding cumulative energy savings target under EED Article 7. Based on the implemented measures during the agreement period from 2008 to 2016, and the current period from 2017 to 2025, the annual savings in force were about 18.3 TWh of heat and fuels and 5 TWh of electricity at the end of 2020. Energy Efficiency Agreements accounted for well over 60 per cent of the total energy consumption in Finland at the end of 2020.

The estimated annual CO_2 emissions reductions achieved by the Energy Efficiency Agreement was 7.7 million tonnes in 2020, and will be 9.7 million

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25 1429/2014

26 https://energiatehokkuussopimukset2017-2025.fi/ (in Finnish, limited content in English https://energiatehokkuussopimukset2017-2025.fi/en/)

tonnes in 2040. Most of the emissions reductions, well over 95 per cent, are expected to occur in the emissions trading sector due to the large share of electricity and district heat in energy savings. The estimates reported for 2040 are calculated based on assumptions that the current agreement period from 2017 to 2025 will continue.

In 2010, an energy efficiency agreement was also launched in the agricultural sector under the Ministry of Agriculture and Forestry. The agreement was updated in 2016 for the period from 2016 to 2020. The new agreement is under preparation. Farms have received energy advice in the scope of the Farm Energy Programme (2010 to 2015) the Rural Development Programme for Mainland Finland (2016 to 2020) and the CAP transitional period 2021 to 2022. Energy efficiency measures in agriculture are farm re-parcelling to reduce energy use in farm traffic, support fresh grain silos where energy use for drying of grain is avoided, and support investments in unheated cattle buildings and heat recovery from pig slurry. The new CAP 2023 to 2027 period begins in January 2023, and it includes similar measures.

Renewable energy

Finland is one of the world's leading users of renewable energy sources, especially bioenergy. The most important renewable energy sources include bioenergy – wood and wood-based fuels and especially the side-products of the forest industry – hydropower, wind power, ground and air heat pump energy and solar energy. In 2020, the share of renewable energy sources increased to 44.6 per cent of final energy consumption. Finland has agreed statistical transfers with Belgium in the fulfilment of binding renewable energy obligations set by the European Union. When considering statistical transfers, the share of renewable energy sources in 2020 was 43.9 per cent of final energy consumption.

The most significant part of the renewable energy supply comes from biomass, especially from the side-products of the forest industry. The remainder of the renewable energy supply comes mainly from hydro and wind power. The capacity of onshore wind power is rapidly becoming market based. The National Energy and Climate Strategy outlines actions to further increase the share of renewable energy. In 2019, Finland set a target in its integrated energy and climate plan of a 51 per cent share for Finland's national contribution to the European Union's jointtarget of 32 per cent of renewable energy in 2030.

Policies and measures in the field of renewable energy focus on promoting renewable energy production from various renewable sources (e.g. wind power, wood chips, solar, biogas and bioliquids) and promoting new energy technology demonstration projects.

The sliding feed-in premium system for the production of electricity from renewable energy sources came into force in 2011. The aid scheme concerns government support for electricity production based on wind power, biogas and wood fuels. There is also a separate premium scheme for forest chip use (instead of peat and coal) for CHP plants. The sliding feed-in premium is paid for a maximum of 12 years per plant. The premium level slides according to the average electricity price, average emission allowance price, or tax on peat, depending on the energy source. New plants are not approved for the sliding feed-in premium system. The feed-in premium scheme has been replaced by a technology neutral premium scheme based on tendering.

In May 2018, Parliament approved the amendment to the act on production aid for electricity from renewable energy sources, which laid down provisions for the new premium system. The premium system is based on a competitive tendering process, and investments in different renewable energy sources compete so that the cost-effectiveness target is considered. Tendering for 1.4 TWh of renewable electricity took place in December 2018. No new tendering rounds are being planned.

In total, 2,300 MVA of wind power has been approved for the feed-in tariff scheme, and all the winners of the 1.4 TWh tendering process for the premium system were wind power projects. Currently, onshore wind farms have already been developed and built without public financing. Finland's first offshore wind farm was granted a EUR 20 million investment subsidy in 2014 and was completed in 2017. It has a total capacity of 42 MW. This project aimed to demonstrate wind power technologies suitable for winter conditions in the Baltic Sea area where ice conditions can be very challenging due to pack ice. In 2020, the wind power production in Finland was 7.9 TWh.

The Energy Aid (investment subsidy, annual budget approximately EUR 40 million) is targeted at the commercialisation of new technologies, the non-ETS sector (including plants producing advanced biofuels for transport), and non-ETS electricity and heat production (i.e. small-scale production). The aid can be up to 30 per cent of eligible costs for mature technologies and up to 40 per cent for new technology projects. However, the realised aid levels are typically much lower. Moreover, the objective is that the aid for different technologies will be phased out as the technology develops, the costs are reduced, and the competitiveness improves. Farms can also apply for investment aid for energy production plants such as bioenergy boilers or solar PV from another scheme.

The key aim of energy aid is to promote the development of innovative solutions for replacing the energy system with a low-carbon alternative in the long term. Energy aid can be granted for investment and investigation projects that promote:

1) the production or use of renewable energy, which in turn promotes new technology and its commercial utilisation, involves investments in a new plant, or is a replacement investment that significantly increases the production volumes of renewable energy, or that allows the achievement of another positive energy impact that complies with the goal;

2) energy savings or increase the efficiency of energy generation or use;

3) otherwise replacing the energy system with a low carbon one.

Energy aid is discretionary, and priority is given to projects involving new technology.

Since 2019, a separate investment aid budget and call for large-scale energy technology demonstration projects has also been available. For example, in 2021, EUR 90 million was granted to large-scale energy technology demonstration projects. The investment aid is intended for future energy solutions to meet national and EU targets for 2030. The categories of projects they support are renewable biofuels for transport, other than combustion-based heat production and other large-scale demonstration projects involving new technology. The objective of the scheme is to promote nationally and internationally replicable solutions based on new energy technologies.

Other measures that have been implemented to promote renewable energy include an electricity tax exemption for small-scale production, information measures, and in terms of wind power, the development of land-use planning.

The effect on emissions has been estimated based on the assumption that wind power reduces the need to produce electricity mainly in condensing power plants using fossil fuels and peat (for more information on the IMPAKTI calculation tool used to estimate the emissions reduction impacts of renewables, see Section 5.8.3). Using a marginal emission coefficient of 600 t CO_2/GWh, the promotion of wind power will reduce the emissions in 2020 by 4.8 million tonnes CO_2 and in 2030 by 11.1 million tonnes CO_2 (see Table 4.2). The reduction will occur entirely in the ETS sector. The estimate includes the impact of all policies and measures promoting wind power (including the impact of the feed-in tariff).

Increasing the use of forest chips in multi-fuel boilers is the most central and cost-effective way of increasing the use of renewable energy in the generation of power and heat. The use of forest chips will replace the use of other fuels (mainly peat) in heat and power production and heating oil on farms. The estimated emissions reduction achieved due to the use of forest chips was 5.5 million tonnes CO_2 in 2020 and will be 8.1 million tonnes CO_2 in 2030.

Energy taxation provides an incentive for the use of forest chips and forest industry by-products in CHP production and building-specific heat production. The objective is that most forest-based energy will continue to be produced on market terms from the sidestreams of other wood use. Plenty of wood material is produced in forestry management operations and timber harvesting that is unsuitable as raw material for wood processing. By means of various policy measures, this forest biomass will be channelled to replace fossil fuels in heating, CHP production and transport. The use of wood-based fuels will not be promoted by means of an aid scheme if the use of these fuels is profitable without any aid.

Wind power is promoted by reducing barriers for wind power investment and enabling new demonstration projects for offshore wind power. The historic use of and WM projection for renewable energy in Finland is shown in Figure 4.2 and Table 4.4.

Figure 4.2
Historic development and WM projection for renewable energy, TWh

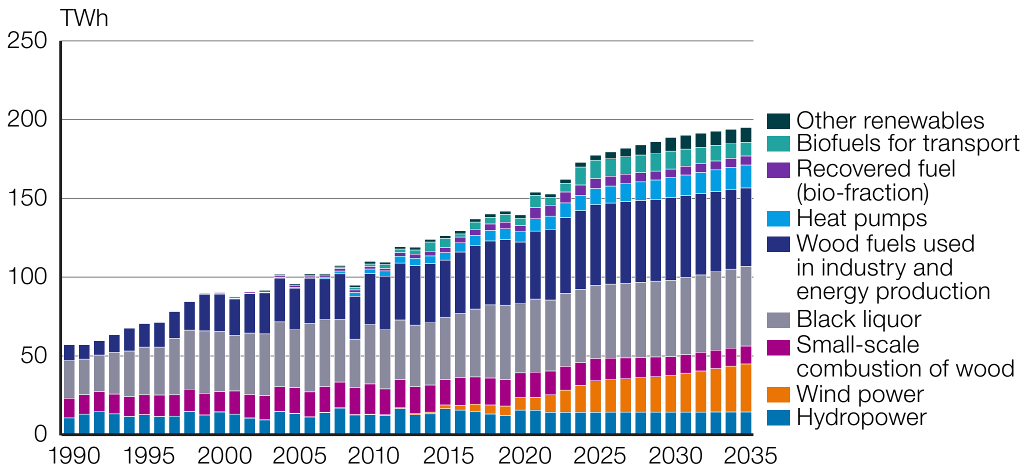


Table 4.4
Historic development and WM projection for renewable energy, TWh

				WM Projection		
	2010	2015	2020	2025	2030	2035
Black liquor	37.7	39.5	43.9	46.5	48.5	50.5
Wood fuels used in industry and energy production	32.3	36.2	39.1	51.1	52.5	49.8
Small-scale combustion of wood	19.2	16.2	15.7	14.1	12.1	11.3
Hydropower	12.7	16.6	15.7	14.3	14.4	14.5
Heat pumps	2.9	4.8	6.6	10.3	12.6	14.5
Wind power	0.3	2.3	7.9	20.0	23.2	30.5
Biofuels for transport	1.6	5.8	4.7	11.6	11.4	8.8
Recovered fuel (bio-fraction)	1.7	3.2	3.8	6.3	5.5	5.7
Other renewables	1.5	1.6	2.2	3.2	8.7	9.3
Total	**109.9**	**126.3**	**139.6**	**177.4**	**188.7**	**195.0**

Renewable energy policies and measures for the transport sector are described in Section 4.5.2.

Energy use in residential and other buildings

Policies and measures for buildings and housing aim to improve energy efficiency, making energy use in buildings smarter, reducing ETS and non-ETS emissions, and increasing the use of renewable energy sources. Policy measures include standard-setting, economic instruments, the dissemination of information, and education and research. Measures are targeted both at new buildings and the existing building stock, including the use and maintenance of the building stock. In addition to policy measures in the building sector, energy use is affected by the EU emissions trading system ETS via changes in the prices of heat and electricity.

Figure 4.4 shows the predicted development of emissions caused by space heating, according to which emissions will decrease sharply by 2050. CO_2 emissions from the use of energy in buildings are mainly covered by the EU ETS. District heating is the source of about half of all space heating in Finland. Most district heating production falls within the sphere of the EU ETS. The total space heating energy used in residential, commercial and public buildings was 70 TWh in 2020 (24 per cent of the total end use of energy in Finland). Slightly less than 28 TWh of the space heating belonged to the non-ETS sector in 2020.

Finland has some specific conditions in the heating and cooling of buildings. The most common heating source in Finland in 2020 was district heating (40 per cent of heat energy use). The second most common heating source in Finland in 2020 was electricity (22 per cent). The share of small-scale combustion of wood in heating energy consumption was 20 per cent. The number of heat pumps is increasing rapidly, especially in detached housing, and the share of heat energy use was nine per cent in 2020. The use of natural gas in building-level heating systems is practically non-existent in Finland, but oil boilers were still quite popular in 2020 (eight per cent). Demand for cooling remains low in Finland, but it is expected to increase due to climate change (Figure 4.3). The Directive on the Energy Performance of Buildings (EPBD) aims to reduce CO_2 emissions by improving the energy efficiency of buildings. The directive was implemented in Finland by a regulation that came into force at the beginning of 2008. This legislation on the energy efficiency of buildings includes the following:

– Act on Energy Certification of Buildings
– The Ministry of the Environment Decree on Energy Certification of Buildings
– Act on inspection of air conditioning systems
– Amendments to the Land Use and Building Act, which was expanded to cover energy efficiency requirements and details on how energy efficiency should be calculated.

The minimum requirements for thermal insulation and ventilation in new buildings have been set by the National Building Code since 1976. The energy efficiency requirements were tightened by 30 per cent compared to earlier requirements (2003) in December 2008 due to the implementation of the EPBD. The requirements were further tightened (by 20 per cent) in March 2011 due to the implementation of the Directive on the Energy Performance of Buildings (Recast). The building regulation came into force in July 2012, and it is based on the overall energy consumption, which considers, among other things, air conditioning, cooling, lighting and heating, washing water, and heating energy. The regulation favours the utilisation of district heating and renewable energy in defining the overall energy performance of a building. Moreover, due to the implementation of the Directive on the Energy Performance of Buildings, EPBD, the regulation for the energy efficiency of the existing building stock was given in February 2013, and this Ministry of the Environment Decree on improving the energy performance of buildings undergoing renovation or alteration came into force in June 2013. Due to the implementation of the EPBD, energy regulations were again revised in 2017, and nearly zero-energy regulations for new buildings were given, and new regulations entered into force, on 1 January 2018.

The Ministry of the Environment is responsible for legislation and guidelines for energy performance certificates, energy performance certificate templates, and other instructions concerning the issuance of certificates. All new buildings need an energy certificate when applying for the building permit. For existing buildings, energy performance certificates are needed when the building (or part of it, for example, an apartment) is sold or rented. The Housing Finance and Development Centre of Finland (ARA) is the administrative authority ensuring the quality of certificates and the qualified experts, and the appropriate preparation and use of the certificates.

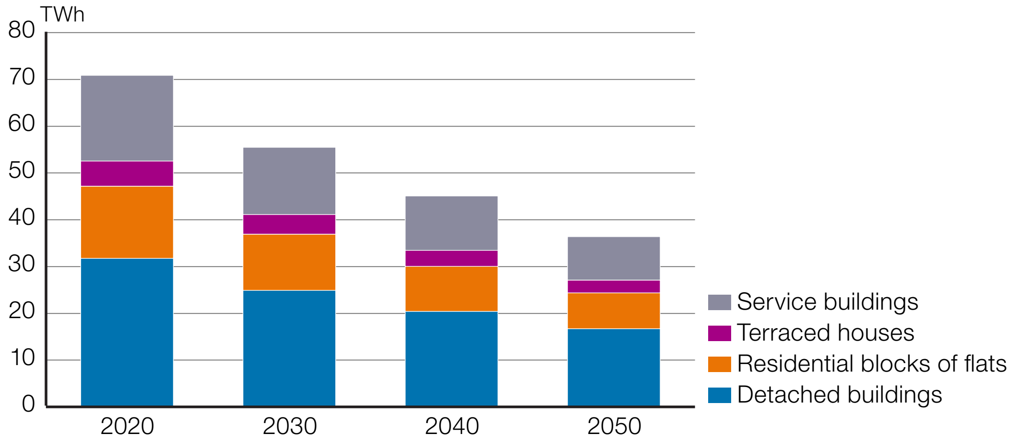
The regulation for the energy performance of new buildings entails about 6.2 million tonnes of annual emissions reductions of CO_2 by 2030. Almost all the emissions reduction will take place in the EU ETS sector through the reduced use of electricity and district heat.

Based on the amendment to the decree of the national building code for sewage and freshwater systems, water measurement instruments became compulsory in new apartment buildings at the beginning of 2011. The aim was to reduce the consumption of water and the need to heat it. The water measurement instruments provide information on the use of water in each apartment and ensure invoicing is done according to actual water use, which provides a direct price signal for inhabitants. The requirement was expanded into the existing building stock in 2013 in the case of pipe and plumbing system repairs subject to a building permit.

Information provision and the campaigns supported by the Government seek to influence the behaviour of building users and owners. Currently, activities exist for giving internet-based informational guidance, e.g. in repair, energy efficiency, and building maintenance issues.

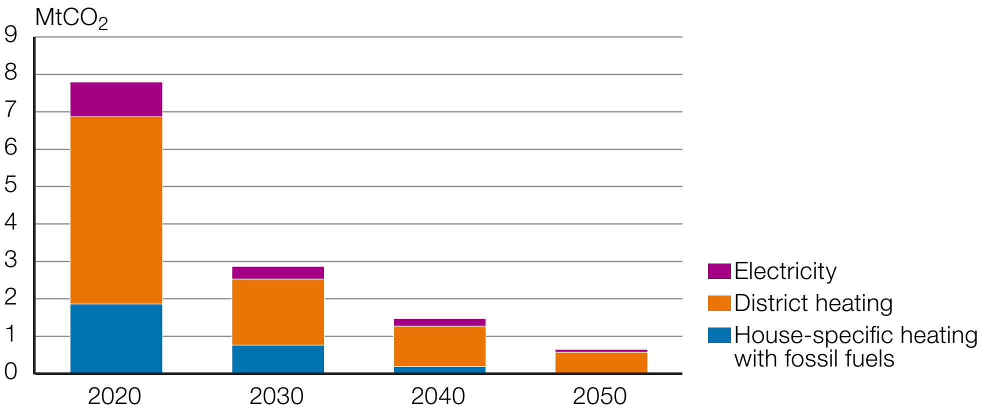
Finland submitted its Long-Term Renovation Strategy (LTRS) to the EU in 2020. It follows the EPBD 2018/844/EU revision and covers the 2020 existing building stock. The main goals of the Finnish strategy are to decrease the energy use of the existing building stock by 51 per cent by 2050 and the related CO_2 emissions by 92 per cent by 2050. The factors affecting the decrease of energy use and emissions are climate change, removals of buildings from the building stock, retrofitting and building maintenance, the change of heating sources in buildings, and decreasing the emission intensity of electricity and heating production. The improvements of energy performance in renovations and alterations, the phase-out of oil use in heating and related policies, as well as retrofitting subsidies are policy measures supporting the Finnish LTRS.

Figure 4.3
Heating and cooling use of buildings by building type, TWh



Source: Finland's renovation building strategy 2020–2050

Figure 4.4
Heating and cooling energy use CO_2 emissions (million tonnes CO_2)



Source: Finland's renovation building strategy 2020–2050

Due to the implementation of the Directive on the Energy Performance of Buildings (Recast), the regulation for the energy efficiency of the existing building stock was put into effect on 27 February 2013. It is estimated that the emissions reductions due to improvements in energy performance in renovations and alterations will be 1.03 million tonnes CO_2 annually in 2030. Most of the emissions reductions will take place in the EU ETS sector.

However, there are expected non-ETS emissions reductions from oil fuel boiler replacements, especially in detached houses.

Energy subsidies for retrofitting started in Finland as a new policy measure in 2020, and the subsidies have been decided until 2023. The subsidies are aimed at energy efficiency improvements in the housing sector. The estimated annual impact of the energy subsidies for retrofitting is 0.38 million tonnes of CO_2. The new subsidy is a subsidy for renewing the district heating equipment of residential buildings to be suitable for low-temperature district heating. The grant is available in 2022 and 2023. No methods or data to assess the impact of renewing the district heating equipment.

To reduce greenhouse gas emissions from light fuel oil, an obligation to blend bioliquids with light fuel oil used for heating buildings was approved by Parliament in February 2019. According to the Act on the Promotion of the Use of Biofuel Oil, the proportion of biofuel oil in the light fuel oil used for heating and machinery must be at least 3 per cent in 2021 and increasing thereafter by one per cent per year to at least 10 per cent in 2028. However, it is intended to tighten the obligation to distribute biofuel oil, and the proposed changes will be presented by the Government in the autumn of 2022. According to the stricter obligation, the share of biofuel oil should increase annually by 4.6 per cent from 2025 until 2030, from which the share of biofuel oil in heating should be 30 per cent. The effects of promoting the use of bioliquids on greenhouse gas emissions in heating buildings have been calculated in accordance with the stricter obligation – assuming that from 2030, the share of bioliquids in light fuel oil will be 30 per cent.

A commitment to phase out oil heating in the public sector is included in the Medium-Term Climate Change Policy Plan. Two new policy measures for phasing out oil heating started in 2020. The first subsidy system is for phasing out oil heating in detached houses, and the other subsidy system is for buildings owned by municipalities. The annual impact with the grants available in the budget is estimated be 0.22 million tonnes of CO_2. In 2022, the phase-out of fossil gas heating was included in the subsidy systems.

Finland has decided to take measures of advice as an alternative to obligatory inspections of heating and air conditioning systems laid down in articles 14 and 15 of the EPBD. The coordinating advice programme (advice forum) will cover almost all buildings and gather actors in energy efficiency agreements in the building sector. The annual impact is estimated to be 0.015 million tonnes CO_2. This measure is not included in the WM projection, as there is no detailed information on the impact of the measure on the energy balance.

The emission impacts of building-related policy measures have been evaluated using EKOREM and POLIREM calculation models (see Section 5.8.3) and information on the emission coefficients for district heating and electricity. These models calculate heat and energy consumption and the resulting greenhouse gas emissions of the building stock. The impacts of policy measures are evaluated by modifying the energy efficiency of the building elements (EKOREM) or specific consumptions of energy (POLIREM), or the distribution of heating systems. The energy savings are converted into emissions reductions with an average emission coefficient in the case of district heating (190 kg CO_2/MWh) and a mean marginal emission coefficient in the case of electricity (600 kg CO_2/MWh).

Machinery

There are several existing measures for reducing CO_2 emissions from non-road mobile machinery. Under Act 418/2019, which entered into force in 2019, the biofuel distribution obligation for light fuel oil stands at 3 per cent in 2021 and will rise to 10 per cent by 2028, leading to reduction of CO_2 emissions from non-road mobile machinery as well. According to the government proposal, the distribution obligation of biofuel oil in light fuel oil will be increased to 30 per cent by 2030. It is planned this will enter into force in the autumn of 2022.

The accounting criteria for taxation on heating fuel were revised at the beginning of 2019 to include fuel life cycle emissions in carbon dioxide emissions. At the same time, tax on light fuel oil was raised by about 2 per cent. From the beginning of 2021, tax on light fuel oil was further raised to EUR 2.7 per megawatt-hour, which is an increase of nearly 11 per cent. The tax increases will affect the price of – and therefore demand for – machinery fuels.

In October 2019, the Ministry of the Environment and the Association of Finnish Technical Traders signed a Green Deal on non-road mobile machinery to increase the percentage of low-emission machinery. Through voluntary commitments made under this agreement, those operating in the sector will aim to increase the supply of fully electric and other low-emission non-road mobile machinery and encourage its wider use. In September 2020, the Ministry of the Environment, Senate Properties, and the Cities of Espoo, Helsinki, Turku, and Vantaa signed a voluntary Green Deal to reduce emissions on construction sites. As part of the implementation of the voluntary Green Deals Motiva created in 2021, a training package for non-road mobile machinery with funding and coordination from the Ministry of the Environment. The training package is freely available for operators in the non-road mobile machinery sector.

The conversion of tractors to use biogas is supported as an environmental investment through agricultural investment subsidies. Subsidies are available for modifications to enable biogas use and for the equipment involved, but not for purchasing the tractor itself. Modifications of diesel engines and accessory purchases to convert tractors and other agricultural machinery to use biogas are eligible for a subsidy as environmental improvement measures. The subsidy covers 35 per cent of eligible costs, including costs of the purchase and installation of new equipment.

Municipal climate change solutions programme

The emissions of municipalities in the effort sharing sector decreased by 19 per cent between 2005 and 2020. This quite modest reduction in emissions relative to the carbon neutrality target shows that further action is still needed to promote climate work in municipalities. The municipal climate change solutions programme of the Ministry of the Environment boosts climate work in Finnish municipalities and regions. The aim is to accelerate climate work of municipalities and regions in a way that is fast, cost-effective, and widely accepted. The programme finances municipalities' and regions' own climate projects and national solutions that support their climate work. At the end of 2021, the programme had funded a total of 118 projects to strengthen municipal and regional climate work throughout Finland. Furthermore, 20 new local and regional projects received funding for climate and circular economy projects in 2022. The programme has a wide variety of measures supporting energy efficiency activities and emissions reductions, e.g. in housing and transport.

Customer energy advice

One main aim of the Action Plan for Energy Services[27] in the Energy Efficiency Agreement scheme and Energy Efficiency Agreement for oil-heated buildings[28] is to enhance their customer energy use. Energy advice actions have been running since the first agreement period starting in 1997. Customer energy advice is also one of the policy measures notified for Energy Efficiency Directive (EED) article 7 implementation in Finland. When calculating energy savings for these behavioural measures based on advice services, only conservative one-year energy savings lifetime has been considered. Annual estimated energy savings are constantly around one terawatt hour per year, and the CO_2 emissions reduction is about 0.4 million tonnes per year.

In parallel with customer advice related to voluntary Energy Efficiency Agreements, the Ministry of Economic Affairs and Employment has been building an energy advice infrastructure for consumers since 2010. In 2014, this responsibility was transferred to the Energy Authority. Motiva Oy, a hundred per cent state-owned sustainable development company in Finland, is the national coordination centre for consumer energy advice. In parallel with field activities in projects, coordination activities have been carried out to strengthen internet, telephone and email advisory services and develop advisor training, communications, marketing, and monitoring and evaluation. Energy advisory services enable consumers to rationalise how they use energy, while they also learn about the opportunities offered by renewable energy sources.

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27 https://energiatehokkuussopimukset2017-2025.fi/wp-content/uploads/2020/02/Company-Accession-Document-Action-Plan-for-Energy-Services.pdf

28 https://energiatehokkuussopimukset2017-2025.fi/wp-content/uploads/2020/02/Energy-Efficiency-Agreement-2017-2025-on-the-Distribution-of-Liquid-Heating-Fuels-H%C3%96YL%C3%84-IV.pdf

Besides, in 2018, the Energy Authority commenced strengthening of regional advice services as part of the Energy Authority's programme on regional energy and climate work. The main goal of the regional energy advice service is to increase awareness of energy efficiency and renewable energy. In addition to consumers, the target groups are municipalities and small and medium-sized enterprises. To avoid double counting, impacts on consumer advice activities are not assessed separately from customer advice services related to voluntary Energy Efficiency Agreements, as these actions overlap and support each other.

Policies and measures in the WAM projection

Additional measures planned for the energy sector are:
– Improving energy efficiency and promoting the use of alternative fuels in machinery

Machinery

Some of the planned additional measures for reducing emissions from non-road mobile machinery are extensions to current policy actions, and some are entirely new. Voluntary commitments through Green Deals on zero-emission worksites and non-road mobile machinery will be maintained and expanded. Actions that would promote the attainment of the sector's emissions reduction targets are the inclusion of new machinery classes in the non-road mobile machinery Green Deal and introducing new operators to the zero-emission worksite Green Deal. The aim is to further develop and expand the training project initiated in 2021 in line with the sector's trends.

The Government launched an analysis, assessment and research activity project in September 2021 to investigate political steering mechanisms for reducing emissions from non-road mobile machinery. The results of the investigation will be published in 2022, followed by an assessment of the necessary further measures. The Government is exploring the possibility of introducing procurement support for electric and biogas-powered tractors and other non-road mobile machinery. There is also a continuous effort to improve the knowledge base of emissions calculations from non-road mobile machinery.

The impact of the additional machinery measures on greenhouse gas reduction have yet to be assessed. The measures are thus not included in the overall WAM projection.

Summary of policies and measures.

A summary of the policies and measures in the energy sector is presented in Table 4.2.

Table 4.2
Policies and measures according to the WM (marked with *) and WAM projections in the energy sector (excluding transport)

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Implementation of the emission trade system in Finland	Reduction of GHG emissions (Energy, Industrial processes), Increase in renewable energy, Efficiency improvement in industrial end-use sectors	CO_2, N_2O	Economic, Regulatory	Implemented	The objective of the implementation of the ETS in Finland is reduction of greenhouse gas emissions in the emission trading sector. National implementation in Finland is carried out with national act of emission trade (311/2011) and decrees which are given under that act.	2005	Ministry of Economic Affairs and Employment	NE	NE	NE	NE
* Energy taxation	Switch to less carbon-intensive fuels, Efficiency improvement in industrial end-use sectors, Efficiency improvements of vehicles, Low carbon fuels/electric cars	CO_2, CH_4, N_2O	Fiscal	Implemented	The current tax structure and tax rates according to the Act on Excise Duty on Liquid Fuels (1472/1994) and the Act on Excise Duty on Electricity and Certain Fuels (1260/1996).	2021	Ministry of Finance	NE	NE	NE	NE
Municipal climate change solution programme	Efficiency improvements of buildings and in services, Modal shift to public transport or non-motorized transport, Improved transport infrastructure	CO_2, CH_4, N_2O	Regulatory	Implemented	Promotes, accelerates and influences the climate work of municipalities and regions.	2018	Ministry of the Environment	NE	NE	NE	NE
* Promoting wind power	Increase in renewable energy	CO_2	Economic, Fiscal, Regulatory, Planning	Implemented	Measures implemented since 1996 include investment subsidies for wind power plants, electricity tax subsidies, feed-in tariff (since 2011), information measures, support for land-use planning and adjustment of land use and building act, technology neutral feed-in premium scheme (auction organised in 2018).	1996	Ministry of Economic Affairs and Employment, Ministry of the Environment, Regional councils, Municipalities	4,763	8,934	11,140	11,708

Table 4.2 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Promoting solar power	Increase in renewable energy	CO_2	Fiscal, Economic, Information	Implemented	Solar electricity self-consumers exempted from grid fees and electricity taxes up to 100 kVA system size or 800 MWh yearly production, investment subsidies for municipalities, companies and farms, household tax deduction from solar system installation work and information measures.	2015	Ministry of Economic Affairs and Employment, Ministry of Finance, Ministry of Agriculture and Forestry	131	287	906	1,444
* Promoting wood chips	Increase in renewable energy	CO_2	Economic, Fiscal, Information	Implemented	Measures implemented since 1992 include investment subsidies for heat and power production plants using forest chips, subsidies for harvesting of forest chips, electricity tax subsidies, feed-in tariff and information measures.	1992	Ministry of Economic Affairs and Employment, Ministry of Acriculture and Forestry	5,547	8,017	8,098	7,675
* Promoting biogas in electricity and heat production	Increase in renewable energy, Enhanced CH_4 collection and use, Improved waste treatment technologies	CO_2, CH_4	Economic, Fiscal, Regulatory	Implemented	Measures implemented since 1997 include investment subsidies, electricity tax subsidies and feed-in tariff.	1997	Ministry of Economic Affairs and Employment, Ministry of the Environment, Ministry of Agriculture and Forestry	108	130	137	156
* Promoting the use of bioliquids in machinery	Low carbon fuels	CO_2, CH_4	Fiscal, Regulatory	Adopted	An obligation to blend bioliquids in light fuel oil used in machinery will be increased to 30 % by 2030. According to current legislation the blending obligation is 10 % 2028 onwards.	2022	Ministry of Economic Affairs and Employment	0	150	620	590
* Phasing out coal in energy production	Switch to less carbon-intensive fuels	CO_2	Regulatory, Economy	Implemented	Legislation prohibits use of coal in energy production from 1 May 2029. The act takes into account aspects related to the security of energy supply and emergencies. Investment aid for projects that rapidly phase out the use of coal energy.	2019	Ministry of Economic Affairs and Employment	NE	NE	650	400

Table 4.2 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Promoting new energy technology projects	Increase in renewable energy	CO_2	Economic	Implemented	Investment aid for new energy technology demonstration projects.	2019	MInistry of Economic Affairs and Employment	Partly IE	Partly IE	Partly IE	Partly IE
* Act on Ecodesign and Energy Labelling	Efficiency improvement of appliances	CO_2	Regulatory	Implemented	Improvement of energy efficiency of energy-using products by minimum efficiency requirements	2009	Ministry of Economic Affairs and Employment, The Energy Authority	NE	3,585	3,611	3,519
* Energy Audit Programme	Efficiency improvements of buildings, Efficiency improvement in services/tertiary sector, Efficiency improvement in industrial end-use sectors	CO_2	Economic, Information, Voluntary/ negotiated agreements	Implemented	Subsidized energy audits for non-SMEs in industry and in public and private services. Harmonized audit models. Qualification system for auditors. Quality control and monitoring of audits.	1992	Ministry of Economic Affairs and Employment, the Energy Authority	372	152	92	93
* Energy Efficiency Agreements 1997–2007, 2008–2016 and 2017–2025 (Voluntary energy efficiency agreements)	Efficiency improvements of buildings, Efficiency improvement in services/tertiary sector, Efficiency improvement in industrial end-use sectors, Efficiency improvement in the energy and transformation sector	CO_2	Fiscal, Voluntary/ negotiated agreements	Implemented	This measure covers Energy Efficient Agreements in industry, energy sector, municipalities, private services, property and building sector.	1997	Ministry of Economic Affairs and Employment, Ministry of the Environment, The Energy Authority	7,720	8,470	9,538	9,617

Table 4.2 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Energy Efficiency Agreements/Customer energy advice	Efficiency improvements of buildings, Efficiency improvement of appliances	CO_2	Information, Voluntary/ negotiated agreements	Implemented	In the Energy Efficiency Agreement for Industries in the Action Plan for Energy Services and in the Energy Efficiency Agreement for oil heated buildings one main aim is to enhance also efficient energy use of the contracting parties' customers. Customer energy advice includes both general information via different channels as well personal internet, telephone and e-mail advisory services etc. This work is in parallel supported by the national and regional energy advice services for consumers which has been ongoing since 2010 (on regional level since 2018).	1997	Ministry of Economic Affairs and Employment, Ministry of the Environment, The Energy Authority	389	393	386	385
* Mandatory Energy Audits	Efficiency improvement in the energy and transformation sector, Efficiency improvement in industrial end-use sectors, Efficiency improvements of buildings, Efficiency improvement in services/tertiary sector	CO_2	Regulatory, Information	Implemented	Mandatory Energy Audits for big companies (non-SMEs) required by EU Energy Efficiency Directive. These audits are not subsided.	2015	Ministry of Economic Affairs and Employment, the Energy Authority	130	232	293	306
* Fresh grain silos (no energy used for drying)	Energy efficiency in agricultural sector	CO_2	Economic	Implemented	Support to gresh grain silos (drying of grain avoided)	2008	Ministry of Agriculture and Forestry	5	6	8	7
* Energy efficiency of unheated cattle buildings and heat recovery in pig farms	Energy efficiency in agricultural sector	CO_2	Economic	Implemented	Support to investments to unheated cattle buildings and heat recovery from pig slurry	2008	Ministry of Agriculture and Forestry	3	3	1	0

Table 4.2 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Farm reparcelling to cut down energy use	Energy efficiency in agricultural sector	CO_2	Economic	Implemented	Support to farm reparcelling leading to reduced farm traffic	1995	Ministry of Agriculture and Forestry	27	42	57	72
* Farm Energy Programme and energy advice to the farms	Energy efficiency in agricultural sector	CO_2	Economic, Information	Implemented	Subsidies for the preparation of Farm Energy Plans and for other energy advice.	2010	Ministry of Agriculture and Forestry	4	5	5	4
* Act on energy certificates for buildings	Efficiency improvements of buildings	CO_2	Information	Implemented	Houseowners are obliged to provide information on energy efficiency	2008	Ministry of the Environment	NE	NE	NE	NE
* Building regulations (2003, 2008, 2010)	Efficiency improvements of buildings	CO_2	Regulatory	Expired	Provides minimum standards for new buildings	2003	Ministry of the Environment	3,432	4,559	5,687	6,814
* Renewed Building regulations (2012, 2017)	Efficiency improvements of buildings	CO_2	Regulatory	Expired/ implemented	Provides minimum standards for new buildings, from 2012 switch to full energy based calculation. The new regulations came into force in 2017 and the previous regulations expired, but the effects are still being evaluated with full energy based calculation.	2012	Ministry of the Environment	222	371	520	670
* Information dissemination and campaigns targeted to residents and other users of buildings	Efficiency improvements of buildings, Demand management/reduction	CO_2	Information	Implemented	New energy regulations and other energy use related matters, retrofitting, renovating and maintaining buildings have been disseminated to both professionals and consumers through versatile means like seminars, building fair events, presentations, articles and webpages.	2001	Ministry of the Environment, The dedicated state owned company Motiva	NE	NE	NE	NE

Table 4.2 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Subsidies for energy efficiency in buildings (single houses, residential apartment houses and row houses)	Efficiency improvements of buildings	CO_2	Economic	Implemented	Dedicated subsidies for improving energy efficiency and promoting the use of renewable energy	2007	Ministry of the Environment, Ministry of Finance	323	323	323	326
* Nearly zero-energy regulation	Efficiency improvements of buildings	CO_2	Regulatory	Implemented	Regulations for new buildings. A definition of a nearly zero-energy building and the demand to build all new buildings according to the nearly zero-energy building requirements were added to the Land use and building act in 2016 (in force January 2017). Accordingly, The Ministry of the Environment gave a decree on energy efficiency for new buildings in 2017. The decree deals also with building extensions.	2018	Ministry of the Environment, A number of companies/ businesses/ industrial associations	NE	NE	NE	NE
* Revision of the Land Use and Building Act (EV 123/2012 vp – HE 81/2012 vp)	Efficiency improvements of buildings	CO_2	Regulatory, Information	Implemented	Specific provisions demanding energy and resource efficiency in the renovation of buildings, possibility of detailed specification by decree and building regulations	2013	Ministry of the Environment, Municipalities	NE	NE	NE	NE
* Minimum standards for improving the energy performance of buildings undergoing renovation or alteration.	Efficiency improvements of buildings	CO_2	Regulatory	Implemented	Ministry of the Environment Decree (4/2013, amendment 2/2017) provides minimum standards for improving energy performance of buildings in renovations and alterations	2013	Ministry of the Environment	394	701	1,027	1,365
* Decree on water measurement instruments	Efficiency improvements of buildings, Demand management/reduction	CO_2	Information, Economic	Implemented	Provides information on the use of water in each apartment and allows billing that is based on the water consumption. The flat-specific invoicing reduces water consumption and the amount of the energy needed to heat the water.	2011	Ministry of the Environment	33	51	86	NE
* Long term planned real estate maintenance	Efficiency improvements of buildings	CO_2	Information	Implemented	Provide information for appropriate use of the buildings and the proper adjustment and settings of heating, ventilation and air conditioning equipment, as well as maintenance and repair plans	2000	Ministry of the Environment	NE	NE	NE	NE

Table 4.2 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Promoting the use of bioliquids in heating of buildings	Reduction of GHG emissions, Increase in renewable energy	CO_2	Regulatory, Fiscal	Implemented	An obligation to blend bioliquids in light fuel oil used for heating of buildings will be increased to 30% by 2030. According to current legislation blending obligation is 10% from 2028 onwards.	2019	Ministry of Economic Affairs and Employment	0	70	200	120
* Subsidies to replace fossil oil and gas heating in detached housing	Reduction of GHG emissions	CO_2	Economic	Implemented	The aim of the grant is to accelerate the abandonment of fossil oil and gas heating system and transition to other heating systems in detached houses. Available budget for grants is ca. EUR 28.7 million in 2020, 34.4 million in 2021 and 68.9 million in 2022.	2020	Ministry of the Environment	NE	174	174	174
* Commitment to phase out oil heating in the public sector	Reduction of GHG emissions	CO_2	Other, Voluntary/ negotiated agreements	Implemented	Commitment to phase out oil heating in central government premises and encouraging all public-sector operators to do the same	2021	Ministry of the Environment	0	130	130	130
* Subsidies to replace oil and gas heating in municipality owned buildings	Reduction of GHG emissions	CO_2	Economic	Implemented	The aim of the grant is to accelerate the abandonment of fossil oil and gas heating system and transition to other heating systems in buildings owned by municipalities. Available budget for grants in 2020 is ca. EUR 14.9 million and in 2022 EUR 9.9 million.	2020	Ministry of the Environment	NE	48	48	48
* Subsidies for retrofitting in housing	Efficiency improvements of buildings	CO_2	Economic	Implemented	The aim is to improve the energy performance of existing residential houses on a higher level than the energy regulations require and increase the production and use of renewable energy in a building. The aim is also to increase the number of nearly zero-energy buildings in renovation. Available budget for grants in 2020, 2021 and 2022 is EUR 138 million in total.	2020	Ministry of the Environment	NE	380	380	380

Table 4.2 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Advice to users on heating and air-conditioning systems	Efficiency improvements of buildings	CO_2	Voluntary/ negotiated agreements	Implemented	Energy performance of heating and air-conditioning systems are improved by means of coordinated advisory and communication activities for a broad target group based on extensive advice and communication carried out in Finland to promote the energy performance of systems. The measure is an alternative to the inspections required in EPBD (2018/844/EU), articles 14–15.	2020	Ministry of the Environment	NE	15	15	15
* Land-use planning	Demand management/ reduction (Energy, Transport)	CO_2	Regulatory, Planning	Implemented	General guidance for land use planning is based on law (Land Use and Building Act). Regional and municipal planning are directed by national land use guidelines. Land use planning creates the preconditions for a sound and vital residential and living environment and supports the regional availability of services and transport. Finland's land use planning system, as defined in the legislation, gives municipalities a high degree of autonomy in local land use planning and thus also possibilities to influence climate change mitigation.	2009	Ministry of the Environment, Regional councils, Municipalities	NE	NE	NE	NE
Improving energy effiency and promoting the use of alternative fuels in machinery	Efficiency improvement of appliances, Low carbon fuels	CO_2, CH_4	Information, Fiscal, Other	Planned	Promoting the use of biogas in machinery, increasing the share of energy-efficient and low emission machinery through public procurement, promoting the energy-efficient use of machinery through information and training, EU-level measures.	2022 and later	Ministry of the Environment	0	NE	240	NE

NE = not estimated
IE = included elsewhere

4.4.2 Transport

Policies and measures in the WM projection

This chapter focuses on measures related to road transport, although the biofuels distribution obligation also slightly reduces emissions from recreational boats. Measures related to maritime and air transport are described in Chapter 4.4.3, as they mainly concern international transport and bunker fuel emissions. In the WM and WAM projections, the maritime and aviation emissions are, nonetheless, reported in accordance with the CRF-classification of the greenhouse gas inventory.

By 2030, Finland will reduce emissions from domestic transport (without domestic aviation) by at least 50 per cent compared to the 2005 level. The aim is to achieve an entirely fossil-free transport sector by 2045. The measures also contribute to achieving the EU's Effort Sharing Decision target.

In line with the Government Programme, the Ministry of Transport and Communications has prepared a Roadmap for fossil-free transport to reduce greenhouse gas emissions from transport[29]. The Government resolution on the reduction of greenhouse gas emissions in domestic transport, i.e. the Roadmap to fossil-free transport, was completed in May 2021. It formed the basis for planning and sizing the emissions reduction measures for transport in the new Medium-Term Climate Change Policy Plan. The Roadmap includes three phases. In the first, a wide range of aids and incentives to promote emissions-free transport will be implemented. For example, these are the inclusion of biogas and electro-fuels in the distribution obligation legislation, various aids related to the procurement and distribution infrastructure of electric and gas vehicles, support for promoting walking, cycling, and public transport services, transport infrastructure maintenance, and digitalisation in logistics. In the second phase, more measures will be added. More information is needed on their effects on emissions before new decisions on measures can be taken. The possible measures include raising the level of obligations in the distribution obligation act, increasing remote work, promoting both combined transport operations in freight transport and digital solutions for transport, and promoting transport services. In the third phase, once the progress of EU-level measures and the impacts of all the measures of phases 1 and 2 are known, the Government will assess and decide on the possible need for additional national measures in the transport sector. Phase three of the Roadmap is conditional.

The WM projection describes the likely evolution of GHG emissions from road transport according to the best information available, and it includes all measures for which there is a decision by August 2022 (a financing decision on measures requiring funding, or which are otherwise likely to occur). In addition, the projection includes assumptions about the effects of remote work,

29 Publications of the Ministry of Transport and Communications 2021:19
http://urn.fi/URN:ISBN:978-952-243-604-7

HCT transport, and digitalisation in logistics, although they are not actual measures. The WM projection contains the following themes, under which there are several measures: 1) Replacing fossil fuels with alternative transport fuels; 2) improving the energy efficiency of vehicles; and 3) improving the energy efficiency of the transport system.

Replacing fossil fuels with alternative transport fuels

The main measures under this theme included in the WM projection are the Biofuels distribution obligation and the Inclusion of biogas and electrofuels in distribution obligation.

The amendment to the national Act on promoting the use of biofuels in transport[30] came into force on 1 January 2011. Under the Act, the annual minimum share of biofuels, measured from the total energy content of petrol, diesel and biofuels delivered for consumption, had to be six per cent in 2011 to 2014 and then gradually rise to 20 per cent in 2020. The energy content of second-generation biofuels, i.e. biofuels produced, for example, from waste material, was considered as double its actual energy content when calculating the share of biofuels for the distribution obligation.

The level of ambition was raised with the amendment to the national Act that came into force on 1 April 2019. Under the Act, the annual minimum share of biofuels, measured from the total energy content of petrol, diesel and biofuels delivered for consumption, must be 18 per cent in 2021 and gradually rise to 30 per cent in 2029. There is also a subtarget for advanced biofuels, starting from two per cent in 2021 and rising to 10 per cent in 2030. Advanced biofuels are produced from feedstock listed in Annex IX Part A of the EU's Renewable Energy Directive (RED II, recast)[31]. After this amendment, there will no longer be double counting of second-generation biofuels in the distribution obligation.

The national Act on promoting the use of biofuels in transport was amended in the spring of 2021 to transpose the EU's Renewable energy directive requirements (RED II, recast)[32] for the transport sector to national legislation. The amendment came into force on 30 June 2021. These requirements include limitations to the shares of food- and feed-based biofuels, biofuels produced from used cooking oil and category 1 and category 2 animal fats and biofuels with a high indirect land-use change-risk. Besides the RED II requirements, the amendment included biomethane and renewable liquid and gaseous transport fuels of non-biological origin in the distribution obligation. The annual minimum share of advanced biofuels and biogas produced from the feedstock listed in Part A of Annex IX of the Renewable Energy Directive and renewable liquid and gaseous transport fuels of non-biological origin

30 446/2007

31 (EU) 2018/2001

32 (EU) 2018/2001

must be two per cent in 2021 and rise to 10 per cent in 2030. The legislation has been applied to biogas since 2022 and will be applied to renewable liquid and gaseous transport fuels of non-biological origin from 2023. The name of the act changed to the Act on promoting the use of renewable fuels in the transport sector.

The national Act on promoting the use of renewable fuels in the transport sector was recently amended again so that the annual minimum share of biofuels would be temporarily lowered to 12 per cent during 2022. This amendment was made because of rising fuel prices. The amendment came into force on 8 July 2022. It is also planned to temporarily lower the obligation for the following year; the annual minimum share of biofuels would be 13.5 per cent in 2023. It is planned to raise the obligation on the annual minimum share of renewable fuels in transport to 34 per cent in 2030. These amendments to the national Act on promoting the use of renewable fuels in transport have been prepared and are expected to come into force on 1 January 2023.

The measure of biofuel distribution obligation achieved an estimated reduction of 1.2 million tonnes of CO_2 in transport-related greenhouse gas emissions in 2020. It is expected that biofuels will account for 34 per cent (no double counting) of all fuels consumed in transport in 2030. This means that fossil fuels equating to emissions of an estimated 3.1 million tonnes of CO_2 will be replaced by biofuels in 2030.

The WM projection includes new annual distribution obligation percentages for biofuels for 2022 to 2030, which are 12, 13.5, 28, 29, 29, 30, 31, 32, and 34 per cent (from 2030). The share of biofuels (biogas, biodiesel, electro-fuels) in consumption increases, and the share of fossil fuels (natural gas, diesel, gasoline) in consumption decreases. Biogas and electro-fuels must be included in the distribution obligation in accordance with the Act[33] during 2022 to 2050. The bio-share of transport gas will increase by 5 percentage points per year until the share reaches the 99 per cent level. Biogas replaces biodiesel in fulfilling the distribution obligation: biogas consumption increases, and the corresponding amount of energy decreases from the consumption of biodiesel.

The WM projection estimates that the emissions reduction effects of the increased distribution obligation percentage for biofuels and the inclusion of biogas will total around 0.33 million tonnes CO_2 eq. in 2030.

Improving the energy efficiency of vehicles

The main measures under this theme included in the WM projection are (1) CO_2 emissions performance standards for new passenger cars and new light commercial vehicles, (2) a purchase subsidy for electric passenger cars, (3) a conversion subsidy for passenger cars, (4) a purchase subsidy for electric or

33 446/2007

gas-powered light commercial vehicles, and (5) a purchase subsidy for electric or gas-powered heavy-duty vehicles. The vehicle taxation as well as for example support for charging and distribution infrastructures are important measures, but the emissions reduction effects of these measures are difficult to separate from that of other measures and therefore has not been assessed separately.

The regulation of the European Parliament and of the Council[34] setting binding CO_2 emissions performance standards for new passenger cars entered into force in 2009. The objective of the regulation was to establish manufacturer-specific emission performance standards for new passenger cars registered in the EU. The amended Regulation setting CO_2 emission performance standards for new passenger cars and new light commercial vehicles[35] (2019) sets new EU fleetwide CO_2 emissions targets for 2025 and 2030, for both newly registered passenger cars and light commercial vehicles. These targets are defined as a percentage reduction from the 2021 starting points: for cars, a 15 per cent reduction from 2025 and a 37.5 per cent reduction from 2030 on, and for light commercial vehicles a 15 per cent reduction from 2025 and a 31 per cent reduction from 2030.

The WM projection includes the CO_2 emission targets in accordance with the EU's Fit for 55 proposal, i.e. the CO_2 emission declared by the manufacturer for new passenger cars should be 55 per cent less in 2030 and 100 per cent less in 2035 than in 2021. The corresponding reductions are 50 per cent and 100 per cent for new light commercial vehicles. In addition, the EU's Fit for 55 proposal to revise the 2014 directive on the Alternative Fuels Infrastructure (AFIR) for the construction of electric car charging stations and hydrogen refuelling stations is considered.

In Finland, the tax on passenger vehicles consists of several elements differentiated according to vehicle-specific emissions (CO_2 g/km). Initially, at the first registration, a one-time tax ("car tax") is paid. The car tax rate for new passenger cars and light commercial vehicles powered entirely by electricity or hydrogen is 0 for vehicles introduced since October 2021. The highest tax rate (48.9 per cent) using the WLTP method applies to cars with CO_2 emissions exceeding 360 g/km.

Furthermore, the basic part of the vehicle tax, which is paid annually, is also differentiated according to the CO_2 emissions of each vehicle, as with the registration tax. This basic part of the emissions-based vehicle tax is EUR 0.15 to 1.80 per day, depending on the car's specific CO_2 emissions. Vehicle tax is collected from the period when it is declared that the vehicle will be used in traffic, or from a period of 365 days if it has been declared that the vehicle has been taken out of traffic. However, for zero-emission vehicles, the amount of tax is now also affected by the date of introduction in traffic. If such a vehicle

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34 2009/443/EU

35 2019/631/EU, adopted in 2019 and applied since 1 January 2020

was used in traffic for the first time on or after 1 October 2021, the amount of basic tax levied per day will be the lowest amount of tax in the tax table plus EUR 0.178.

The second part of the annual tax is based on the type of fuel the cars uses. Petrol-fuelled cars have no additional tax. Cars fuelled with diesel, methane, or electricity have an additional annual tax (fuel fee) that is relative to the mass of the car ("mass in running order"), but not to the specific CO_2 emission rate itself. However, the CO_2 rate and vehicle mass have a certain correlation.

In addition, some changes were implemented in the taxation of fringe benefits from the beginning of 2021. The taxable value of the company car benefit for fully electric vehicles has been reduced by EUR 170 per month for 2021 to 2025. Employer-provided charging of electric vehicles is exempted for 2021 to 2025. Employer-subsidised commuter tickets are tax-free up to EUR 3,400 of the taxable value per year, and employer-provided bicycles are tax-free up to EUR 1,200 of taxable value per year. The tax relief for low-emission cars, which applies to company cars with carbon dioxide emissions (WLTP) between 1 and 100 g/km, went into effect from 2022. The amount of the deduction from the taxable value of the company car benefit is EUR 85 per month, which equates to half the rateable value of fully electric cars of 170 EUR/month. All company cars below the emissions limit will receive a discount, regardless of their propulsion power. The emissions reduction effects of vehicle taxation measures are difficult to separate from that of other measures and have therefore not been assessed separately.

Vehicles' energy efficiency is also promoted by different purchase subsidies. The Act on periodic support for the purchase of an alternative propulsion vehicle or conversion of a vehicle to alternative propulsion will be effective between 1.1.2022 and 31.12.2026[36]. As of 2018, and currently until 31 December 2022, people who are either buying a new electric car or signing a long-term lease agreement for an electric car may receive a EUR 2,000 purchase subsidy from the Finnish government. For the same period, a conversion subsidy can be obtained for converting a petrol-fuelled passenger car for use with gas or ethanol. The conversion subsidy amounts to EUR 1,000 if the car is converted for use with gas and to EUR 200 if the car is converted for use with ethanol. Nearly 9,000 electric car purchase subsidies were granted between 2018 and 2021, amounting to roughly 18 million euros. A total of nearly EUR 1.7 million of conversion subsidies was granted between 2018 and 2021 to approximately 5,600 ethanol vehicles and 500 gas vehicles. Electric cars became increasingly popular between 2018 and 2021, and for the first time, more than 10,000 new fully electric cars were registered in Finland in 2021. Many factors are driving this development, and the purchase subsidy has certainly played a role in accelerating demand for low-emission vehicles.

36 1289/2021 and Government proposal HE 171/2022 vp for its amendme

The Government also promotes the use of alternative transport fuels by supporting the construction of public charging point infrastructure for electric cars and for renewable hydrogen and biogas distribution stations until 2025[37]. Between 2018 and 2021, a total of about EUR 15 million was spent on investment subsidies. In addition, vehicles' energy efficiency is promoted by the support designed for housing companies' charging point infrastructure. A total of EUR 31,5 million was reserved for the recharging infrastructure aid in the period 2018–2021. The aid has been very popular.

The purchase of a new electric- or gas-powered light commercial vehicle or lorry or electric trailer may also receive financial support from the Transport and Communications Agency Traficom. The amount of aid is between EUR 2,000 and EUR 50,000, depending on the size and the propulsion method of the vehicle. In the 2022 budgets, an appropriation of EUR 4.5 million has been allocated to the purchasing subsidies for vans. In addition, the Government has proposed an additional appropriation of EUR 1.5 million for 2023. A total of EUR 6 million was reserved for the subsidies for the lorries in the period 2020–2022. In addition, the Government has proposed an additional appropriation of EUR 1 million for heavy goods vehicles for 2023.

Finland has been active in providing people with more information about the CO_2 emissions and energy efficiency of passenger cars. Examples of this include the Car Calculator[38] published by the Finnish Climate Change Panel, which is designed to support a consumer's car purchase decisions and displays the cumulative full-life cycle greenhouse gas emissions and costs of different propulsion alternatives. Purchase subsidies and scrapping bonuses have been the subject of much communication and have been of great interest to consumers. The Finnish Transport and Communications Agency Traficom has published a Guidance[39] on the creation of an energy label for cars, as well as an information campaign for alternative power sources[40]. Motiva publishes information on sustainable choices along with a Choosing a Car website[41]. In addition, a Green Deal model for car dealerships was concluded in 2018, directing them to present low-emission vehicle alternatives to customers.

The method for measuring emissions from new passenger cars has changed from the NEDC (New European Driving Cycle) method to the WLTP (Worldwide Harmonised Light Vehicle Test Procedure) method. During the 2008 to 2018

37 Government Decree on infrastructure support for electric transport, biogas, and renewable hydrogen between 2022 and 2025 (178/2022) https://finlex.fi/fi/laki/alkup/2022/20220178

38 https://www.ilmastopaneeli.fi/autokalkulaattori/

39 https://www.traficom.fi/sites/default/files/media/regulation/Ohje_Kulutus-%20ja%20p%C3%A4%C3%A4st%C3%B6tietojen%20esitt%C3%A4minen%20henkil%C3%B6autoja%20myyt%C3%A4essa.pdf

40 https://www.traficom.fi/fi/ajavaihtoehtoa (only in Finnish)

41 https://www.motiva.fi/ratkaisut/kestava_liikenne_ja_liikkuminen/nain_liikut_viisaasti/valitse_auto_viisaasti (in Finnish)

period, the average CO_2 emissions (NEDC) of new cars decreased by 28 per cent. The average CO_2 emissions of new cars in 2021 was 103.2 g/km (WLTP). It decreased by 26 per cent between 2019 and 2021. A total of some 98,500 new cars were sold in 2021, of which 31 per cent were electric cars.

The WM projection estimates that the emissions reduction effects of improving the energy efficiency of cars and light commercial vehicles will total around 0.21 million tonnes CO_2 eq. in 2030, and 0.6 million tonnes CO_2 eq. in 2035. The estimate includes the impact of new CO_2 emission performance standards for new passenger cars and light commercial vehicles and the AFIR proposal.

In addition to passenger cars and light commercial vehicles, the energy efficiency of heavy-duty vehicles is expected to further improve. The EU Regulation[42] setting CO_2 emissions standards for heavy-duty vehicles entered into force on 14 August 2019. These first EU-wide CO_2 emissions standards for heavy-duty vehicles set targets for reducing the average emissions from new lorries for 2025 and 2030. The targets are expressed as a percentage reduction of emissions compared to the EU average in the reference period (1 July 2019 to 30 June 2020), and from 2025, the target is a 15 per cent reduction. From 2030, the target is a 30 per cent reduction.

A Car Scrapping Premium campaign took place in 2020 and 2021[43]. The State paid a scrapping premium of between EUR 1,000 and 2,000, depending on the power source of the car to be purchased. The premium could also be used for buying an electric bicycle, a seasonal ticket for public transport services, or a mobility service including public transport, in which case the maximum sum was EUR 1,000. A scrapping premium of EUR 2,000 was awarded for purchasing a new flex-fuel car, i.e. a high blend ethanol car, a gas-fuelled vehicle, a full-electric vehicle, or a rechargeable hybrid with maximum emissions of 95 grams per kilometre, and EUR 1,000 for purchasing a car with maximum CO_2 emissions of 120 grams per kilometre. A total of a little more than 6,500 scrapping premiums was granted, the majority (71 per cent) of which was used for purchasing an electrically assisted bicycle. This new interest in electrically assisted bicycles was a welcome surprise and tangible proof of the popularity of this relatively new mode of transport. The share of new vehicles of the amount of subsidies granted was a little over a quarter, whereas only a few per cent of the subsidies was used for public transport tickets. A total of eight million euros was allocated for the scrapping premiums.

Measures of vehicle fleet renewal create a so-called slow change in the development of road transport: the change accumulates over the years, as the vehicle fleet rebuilds towards zero emissions. With an increasing proportion of energy consumption in road transport being electricity and hydrogen, the emissions impact of fossil fuel substitution measures is reduced. Measures are

42 2019/1242/EU

43 839/2020

mutually supportive – the distribution of biofuels will create precise emissions reductions over the next 10 to 20 years, during which the vehicle fleet will be renewed, and the importance of the biofuel distribution obligation as an emissions reduction measure will decrease.

The stricter new CO_2 emission performance standards for new passenger cars and light commercial vehicles and the recharging and refuelling infrastructure to be built with the AFIR proposal will result in the largest GHG emissions reduction in the WM projection under this theme. The emissions reduction effect will increase in time, as the share of zero-emission vehicles in the fleet increases, especially after 2035. The impact of the purchase subsidy for electric passenger cars is the most significant of all purchase subsidies. The effect will peak in 2030 (−19 kt CO_2 eq.), followed by a steady decline.

The incentivising of various procurers to invest in environmentally friendly vehicles has been promoted since the EC Clean Vehicles Directive[44](CVD) entered into force. The revised Clean Vehicles Directive[45] promotes clean mobility solutions in public procurement tenders, providing a boost to demand and further deployment of low- and zero-emission vehicles. The Directive sets minimum procurement targets for the share of both light-duty vehicles and heavy-duty vehicles like lorries and buses. The Directive strongly promotes electricity, although biofuels, i.e. biogas or renewable diesel, are also accepted, especially at an early stage. Adopted in 2019, the revised Directive is implemented nationally by the Act on environmental and energy efficiency requirements in vehicle and transport services[46], which entered into force in August 2021, and it places obligations on local and central government to ensure a certain proportion of zero and low-emission vehicles in public procurement processes. For example, the Act applies to the procurement of vehicles and transport services in relation to school transport, waste collection, local bus transport, and transport reimbursed by the Social Insurance Institution of Finland.

The WM projection estimates that the emissions reduction effects of the new measures improving the energy efficiency of vehicles described above will total around 0.41 million tonnes CO_2 eq. in 2030.

Improving the energy efficiency of the transport system

The main measures or phenomena under this theme included in the WM projection are: (1) the investment programme for walking and cycling; (2) urban transport system plans; (3) remote work; and (4) High Capacity Transport (HCT) and digitalisation in logistics.

Finland is a sparsely populated country, which is why cars will be a vital means of transport both now and in the future. Fortunately, especially in urban areas

44 2009/33/EC

45 2019/1161/EU

46 740/2021

and inter-urban transport, there are also alternatives to cars, such as public transport, shared transport, walking and cycling. Goods transport can also be made more efficient or moved from roads to rail or waterways. The objective of the Roadmap to fossil-free transport[47] is that the vehicle-kilometres of passenger cars will no longer increase in the 2020s. If people's mobility needs continue to increase, the aim is that this growth in urban areas and inter-urban transport will be directed towards sustainable modes of transport. This would represent an increase of about 10 per cent growth in the traffic performance of each sustainable mode of transport in 2030. For individual households in rural areas, car vehicle-kilometres may continue to increase, but as the population concentrates in urban areas, the combined vehicle-kilometres of households throughout the country should remain at the 2019 level.

Improving the energy efficiency of the transport system can be achieved through measures such as promoting walking, cycling and public transport, as well as transport and land-use coordination. Energy efficiency in the transport sector can also be improved by enabling and developing new mobility services and shared mobility. Intelligent transport and the use of information technology (IT) will help improve both traffic safety and fluency, as well as achieving the environmental targets in the transport sector. It will also create significant business opportunities for companies.

A Programme for the Promotion of Walking and Cycling and a Government Resolution to promote walking and cycling were adopted in 2018. The resolution and the programme include ten sets of measures aiming to increase the number of walking and cycling trips by 30 per cent by 2030. At least half of this increase should come from replacing car journeys. An entirely new measure in the programme is a joint Investment Programme by the State and municipalities to improve the conditions for walking and cycling within cities' street networks. To launch the investment programme, a total of EUR 7 million has been allocated for 2018 to 2019, EUR 31.5 million for 2020, EUR 22.4 million for 2021, and an estimated EUR 6.5 to 11 million for 2022.

There is an annual state subsidy of EUR 12.25 million for large urban areas (4 areas) and EUR 8.625 million for medium-sized urban areas (10 areas) to support local public transport. In addition, there is separate EUR 20 million climate-based funding for the competent authorities for public transport. The funding will support low-emission public transport and increase the modal share of public transport. The main part of the climate-based funding is allocated to large urban areas and cities. Due to the Covid-19 pandemic, there was additional state funding for the competent authorities to ensure the level of public transport services. The additional state funding was approximately EUR 220 million between 2020 and 2021. In general, public transport is regulated with the requirements of the EU's PSO regulation. The competent public authorities organise public transport in their area if there is no market-oriented transport.

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47 Roadmap to fossil-free transport; http://urn.fi/URN:ISBN:978-952-243-604-7

The popularity of public transport, walking, and cycling is also promoted through Mobility Management. Mobility Management is a broad concept, the objective of which is to reduce dependence on private cars. The aim is to offer better information about alternative transport modes and services, and to promote public transport, cycling, walking, carpooling and car sharing. Mobility Management activities at the city or regional level are supported through an annual appropriation of approximately EUR 0.6 million from the Government. Cities, regions and non-profit organisations can apply for this funding every year. Around 30 to 35 projects have been funded annually since 2012.

The aim of the Mobility-as-a-Service (MaaS) concept is to improve the service level of transport by combining public and private transport services. The entity includes both existing services that have already been established, such as public transport and taxis, and new services that are still under development or becoming established, such as shared-use cars or peer rental. With respect to a positive impact, it is essential that MaaS solutions mainly reduce the vehicle-kilometres of cars and enable an increase in the proportion of public transport modes.[48]

Measures related to improving the efficiency of the transport system have been developed in connection with the preparation of the National Transport System Plan (Traffic12)[49]. The Plan is drawn up for a period of 12 years (2021 to 2032) and will be updated each Government term. The National Transport System Plan addresses the overall transport system, and its objectives are associated with sustainability, accessibility, and efficiency. Measures promoting the integration of different mobility services and new services will be specified in more detail as part of the preparation and implementation of the National Transport System Plan. The objective of the plan is that opportunities to choose more sustainable modes of mobility will improve, particularly in urban areas. In urban areas and inter-urban transport, there needs to be a systematic shift from the current car-centric system to a sustainable mobility system. Under a sustainable mobility system, mobility and transport needs are managed by utilising and combining various transport modes and services. Digitalisation and transport-related information are key. Automation can also help achieve transport emissions reduction targets by improving the competitiveness and attractiveness of public transport, for example.

The development of new service models and the revolution of the transport market has been promoted by the introduction of a unified regulatory act (Act on Transport Services[50]). The Act will provide a better response to user needs, facilitate companies' access to the market and promote the interoperability of different parts of the system. At the same time, the deployment of new technologies, digitalisation, and new business concepts is encouraged. The

48 Roadmap to fossil-free transport; Publications of the Ministry of Transport and Communications 2020:19; pages 38–39

49 The National Transport System Plan for 2021 to 2032; Publications of the Finnish Government 2021:77; http://urn.fi/URN:ISBN:978-952-383-804-8

50 320/2017

Act envisages that essential data on transport services will be made open, laying down provisions for the interoperability of different ticket and payment systems, to facilitate combinations of different transport services. The Act brings together transport market legislation and creates preconditions for the digitalisation of transport. Digitalisation of transport services in large urban areas was promoted through an annual EUR 3.5 million government subsidy between 2018 and 2022. This has especially supported the development of ticketing and payment systems.

Improving the energy efficiency of the transport system is also promoted by coordinating transport and land use in urban areas and in transport system planning, e.g. through land-use, housing and transport agreements (MAL agreements). Agreements are made between the State and municipalities of the biggest city regions. The aim is to build carbon neutral urban regions and increase the proportion of sustainable means of transport.

It is assumed that driving kilometres will decrease when the same mass can be transported with fewer vehicles. It is assumed that the vehicle-kilometre reduction will change linearly between 2022 and 2030 and remain constant after 2030, as enabling HCT[51] transports requires infrastructure investment such as extensions of intersection areas to suit large combinations. HCT transports have therefore presumably yet to achieve the full potential. It is assumed that digitalisation will contribute to the full potential of HCT transport by increasing operational efficiency, transport smoothness, and optimisation. The impact of digitalisation on emissions is estimated to be small in the short term, but the effect will increase in the longer term. However, Finland is a small country, and the volume of transports may be insufficient to introduce digitalisation cost-effectively. HCT transports and digitalisation are expected to support each other and potentially overlap in terms of impacts, and their impact reductions have therefore been assessed together in the WM projection.

HCT transport and digitalisation in logistics will result in the largest greenhouse gas emissions reduction in the WM projection under this theme. The WM projection estimates that the emissions reduction effects of improving the transport system's energy efficiency will total around 0.081 million tonnes CO_2 eq. in 2030.

51 High Capacity Transport

Policies and measures in the WAM projection

Table 4.6 sets out the main policies and measures included in the WAM projection for the transport sector. The WAM projection includes the measures that had not been decided or financed by August 2022 or were uncertain for other reasons. It contains the following themes, under which there are several measures: (1) replacing fossil fuels with alternative transport fuels (additional measure); (2) improving the energy efficiency of vehicles (additional measure); and (3) improving the energy efficiency of the transport system (additional measure).

Replacing fossil fuels with alternative transport fuels (additional measure)

In the longer term, renewable or zero-emission fuels and power sources such as electricity, biofuels, and electro-fuels must replace all fossil fuels in transport. In the WAM projection, the idea is to end the sale of fossil transport fuels for domestic transport in 2045. If fossil fuels continue to be used in transport in 2045, the objective of fossil-free transport cannot be realised.[52] The WAM projection includes annual distribution obligation percentages for biofuels for 2031 to 2045, which are: 35, 36, 37, 38, 40, 46, 52, 58, 64, 70, 76, 82, 88, 94, and 100 per cent from 2045.

Of all the measures in the WAM projection, increasing the biofuel distribution obligation to 100 per cent will result in the largest reduction in greenhouse gas emissions of all the measures considered in the WAM projection. The WAM projection estimates that the emissions reduction effects of replacing fossil fuels with alternative transport fuels (additional measure) will total around 0.089 million tonnes CO_2 eq. in 2031, peaking at approximately 2.8 million tonnes CO_2 eq. in 2045.

Improving the energy efficiency of vehicles (additional measure)

The main measures under this theme included in the WAM projection are new CO_2 emissions standards for heavy-duty vehicles and a new scrapping premium campaign.

In its Work Programme for 2022, the European Commission plans to review the CO_2 emissions standards for heavy-duty vehicles and establish a legislative framework for the harmonised measurement of transport and logistics emissions to support the transition to zero-emission mobility. It is planned to publish the proposal for the review of the CO_2 emissions standards for heavy-duty vehicles at the end of 2022[53]. The reduction in CO_2 emissions of heavy-duty vehicles with the tightening of standards creates significant GHG emissions reductions. The estimated emissions reduction effect will increase

52 Roadmap to fossil-free transport; Publications of the Ministry of Transport and Communications 2020:19; page 49

53 COM (2021) 645 final, page 4

until 2035 (0.16 million tonnes CO_2 eq. in 2035), after which the effect will decrease, although the level of uncertainty about this measure is relatively high.

Thus far, three scrappage premium campaigns have been implemented in Finland. Scrappage premium campaigns should occasionally be repeated to enhance functionality. If necessary, the terms of the campaign should be amended so that the criteria for the cars to be supported reflect the changing situation in the car market as much as possible. Petrol and diesel cars will have to be eliminated altogether in the long term, and support for them will no longer be appropriate closer to 2030.[54] The WAM projection assumes that anyone scrapping their car (model year 2010 or older) in 2023 will receive a scrapping premium when purchasing a new low-emission car (gas car, <95 g/km charging hybrid, full electric, or <120 g/km other internal combustion engine car), public transport season ticket or electric-assisted bicycle. The greenhouse gas emissions reduction effect of the scrappage premium campaign is greatest immediately during and after the implementation of the measure (0.015 million tonnes CO_2 eq. in 2023), although the reduction effect at the level of support studied is moderate. No decision on the new scrappage premium campaign has so far been taken, meaning it will have to be taken separately.

The WAM projection estimates that the emissions reduction effects of improving the energy efficiency of vehicles (additional measure) will total around 0.16 million tonnes CO_2 eq. in 2035 and decrease thereafter.

Improving the energy efficiency of the transport system (additional measure)

The main measures under this theme included in the WAM projection are (1) the Mobility-as-a-Service concept (full potential); (2) the combination of urban transport system plans (rest of the potential), increase in the State funding to public transport for large and medium-sized urban areas, and the increase in the state funding for Mobility Management; (3) the Investment Programme for walking and cycling (full potential); and (4) the EU Emissions Trading System for road transport.

In June 2021, the European Commission published a large legislative package that proposed the establishment of a separate emissions trading system for emissions from road transport. The new emissions trading system would operate alongside the existing one. In Finland, the new emissions trading would cover the emissions from fossil fuels used in road transport[55]. The EU Emissions trading for road transport was included in the theme of Improving the energy efficiency of the transport system, as its effect on the calculation model was to reduce vehicle-kilometres. It could also be transposed to the theme of

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54 Roadmap to fossil-free transport; Publications of the Ministry of Transport and Communications 2020:19; page 27

55 Medium-Term Climate Change Policy Plan – Towards a carbon neutral society in 2035; Publications of the Ministry of the Environment 2022, p. 103

Improving the energy efficiency of vehicles if the impact of emissions trading on the vehicle fleet was modelled. The emissions reduction effect of emissions trading will be greatest in the years immediately following the implementation of the measure. The impact will be reduced in line with other vehicle-kilometre reduction measures, while the share of zero-emission vehicles in the vehicle fleet increases. The uncertainty created by the synergies towards the emissions reduction effect of emissions trading will be lowest until 2035 and will increase thereafter, as with the measures in question. According to an estimate included in the WAM projection, the impact of the new emissions trading for road transport will be greatest in 2026 (approximately −0.25 million tonnes CO_2 eq.) and decrease thereafter.

The aim of the Mobility-as-a-Service concept is to improve the service level of transport by combining public and private transport services. The core purpose of MaaS is to provide user-friendly, reliable, affordable, and competitive door-to-door mobility services to reduce the need for use of a privately owned car and thus reduce passenger car kilometres. The environmental impact of promoting mobility services will depend on how they are implemented. According to an estimate included in the WAM projection, the impact of MaaS will be greatest in 2030 (approximately −0.029 million tonnes CO_2 eq.) and decrease thereafter.

Under the ´Transport system planning and sustainable transport subsidies theme, there are three measures for which emissions reductions must be jointly assessed. These three measures aiming to reduce passenger car kilometres were combined, as all of them were insufficient to calculate the individual impact of the measures. However, the measures have sufficient background data overlaps and similarities to be combined and thought of as mutually supportive measures. In the development of sustainable transport, it is important to pay attention to the fact that the development conditions depend on cooperation between many different parties and operators. For example, sustainable transport can be promoted through MAL[56] agreements or other contractual procedures, as well as urban transport system plans and related funding.

First, for the urban transport system plans, it was estimated[57] that 15 per cent of activities for promoting sustainable transport in urban areas by 2030 had taken place between 2020 and 2022. A similar rough estimate can also be used for the estimated CO_2 reduction related to the measure.

Second, a measure to increase the allocation of existing public transport support for large and medium-sized urban areas beyond 2024 was included in the projection. By increasing the subsidies for public transport, preparations can be made for increasing passenger volumes, especially in large and medium-sized urban areas, where the emissions reduction potential of public transport is greatest. The

56 Land-use, housing and transport agreements made between the State and municipalities of the biggest city regions.

57 The Finnish Transport and Communications Agency Traficom's impact assessment (1.7.2022).

funding levels for public transport after 2025 to 2032 will be further specified as part of the preparation and implementation of the Traffic12 plan.[58]

Third, sustainable transport can be supported by Mobility Management. Currently, between EUR 0.6 and EUR 0.9 million per year is spent on central government transfers for mobility management. It is proposed to increase the budget for state transfers to municipalities and non-profit organisations to EUR 2.5 million per year. In addition, the grant should be extended to private employers to manage workplace mobility.[59]

State funding will also be directed through the investment programme for projects that improve the conditions and attractiveness of walking and cycling and thus increase the number of walking and cycling trips and their contribution to modes of transport. Between 2022 and 2024, the State will direct EUR 30 million/year for the investment programme for walking and cycling. At least EUR 10 million/year of funding will be allocated to improving the conditions of walking and cycling infrastructure on highways and traffic nodes. Funding would therefore amount to EUR 40/year, or a total of EUR 120 million in 2022 to 2024, of which EUR 79.5 million would be additional funding. The subsidy levels after 2024 will be decided as part of the implementation of the Traffic12 plan.

The greenhouse gas emissions reduction effect of measures aimed at reducing passenger car kilometres will be greatest in the 2020s and 2030s and will begin to decline as the number of zero-emission vehicles in the vehicle fleet increases. The transport system plans in urban areas and the state funding of public transport have the greatest emissions reduction potential of these three measures. The emissions reduction impact of the Investment Programme for walking and cycling is moderate at a relatively low level of funding. The uncertainty created by the synergies towards the emissions reduction effect of these measures will be low until 2035, after which the uncertainty will increase significantly by all measures. The uncertainty is likely to be increased by different orders of magnitude of the effects of the different measures. The biofuel distribution obligation, which has a relatively high impact on emissions, will have a stronger impact from 2035.

The WAM projection estimates that the emissions reduction effects of improving the transport system's energy efficiency (additional measure) will peak at around 0.31 million tonnes CO_2 eq. in 2026 and decrease thereafter.

Summary of policies and measures

A summary of the policies and measures in the transport sector is presented in Table 4.5.

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58 Roadmap to fossil-free transport; Publications of the Ministry of Transport and Communications 2020:19; page 46.

59 Roadmap to fossil-free transport; Publications of the Ministry of Transport and Communications 2020:19; page 34.

Table 4.5

Policies and measures according to the WM (marked with *) and WAM projections in the transport sector

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Promoting the use of biofuels in the transport sector	Low carbon fuels	CO_2	Regulatory	Implemented	The annual minimum share of biofuels in road transport delivered for consumption shall be 18% in 2021 rising gradually to 30% in 2029.	2019	Ministry of Economic Affairs and Employment	1,201	2,509	2,689	2,129
* Promoting the use of biofuels in the transport sector, amending minimum levels	Low carbon fuels	CO_2	Regulatory	Implemented, changes adopted	This measure changes the level of biofuel shares in the distribution obligation legislation. The minimum share for 2022 is temporarily lowered to 12%. Also the share for 2023 is proposed to be temporarily lowered due to high fuel prices. In order to compensate for the decreased emission reductions, obligation levels for 2024 to 2029 are proposed to be increased. In addition, the 2030 distribution obligation is proposed to be increased to 34%.	2020	Ministry of Economic Affairs and Employment, Ministry of Finance	0	555	399	340
* Inclusion of biogas and electrofuels in the distribution obligation legislation	Low carbon fuels	CO_2	Regulatory, Fiscal	Adopted	Compliant fuels in the distribution obligation legislation will be extended to include biogas from 2022 and renewable liquid and gaseous transport fuels of non-biological origin from 2023.	2022	Ministry of Economic Affairs and Employment, Ministry of Finance	0	–44[1)]	–67[1)]	–96[1)]
* Car tax	Efficiency improvements of vehicles	CO_2	Fiscal	Implemented	This measure includes tax rates as the situations is 1.1.2020 according to Car Tax Act (1482/1994).	1967	Ministry of Finance	IE	IE	IE	IE
* Vehicle tax	Efficiency improvements of vehicles	CO_2	Fiscal	Implemented	This measure includes tax rates as the situations is 1.1.2020 according to Vehicle Tax Act (1281/2003).	1966	Ministry of Finance	IE	IE	IE	IE

Table 4.5 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
Temporary reductions of taxable values of company-car benefit for battery electric vehicles and employer-provided charging of electric vehicles	Efficiency improvements of vehicles, Electric cars	CO_2	Fiscal	Implemented	Taxable value of company-car benefit for zero emission cars is reduced by EUR 170 per month. Employer-provided charging of electric vehicles in workplace or in public charging point is exempted.	2021	Ministry of Finance	0	NE	NE	NE
Changes to taxable values of employer-provided commuter tickets and bicycles	Modal shift to public transport or non-motorized transport	CO_2	Fiscal	Implemented	From 2021 onwards employer-provided commuting ticket is tax-free up to EUR 3,400 and taxable value of bicycle is tax-free up to EUR 1,200.	2021	Ministry of Finance	0	NE	NE	NE
* Purchase subsidy for electric passanger cars	Efficiency improvements of vehicles, Low carbon fuels/electric cars	CO_2	Regulatory, economic	Implemented	The support for electric passanger cars will increase the use of electricity instead of petrol and diesel.	2018	Ministry of Transport and Communications, Ministry of Finance	NE	17	19	16
* Conversion subsidy for passanger cars	Efficiency improvements of vehicles, Low carbon fuels/electric cars	CO_2	Regulatory, economic	Implemented	The support for converting petrol or diesel engine car for use with gas or ethanol will decrease the use of fossil fuels.	2018	Ministry of Economic Affairs and Employment, Ministry of Finance	NE	–4[1)]	–2[1)]	–1[1)]
* Purchase subsidy for electric or gas-powered light commercial vehicles	Efficiency improvements of vehicles, Low carbon fuels/electric cars	CO_2	Regulatory, economic	Implemented	The support for electric or gas powered light commercial vehicles will increase the use of electricity and gas instead of petrol and diesel.	2022	Ministry of Transport and Communications, Ministry of Finance	0	4	4	2
* Purchase subsidy for electric or gas-powered heavy duty vehicles	Efficiency improvements of vehicles, Low carbon fuels/electric cars	CO_2	Regulatory, economic	Implemented	The support for electric or gas powered trucks will increase the use of electricity and gas instead of petrol and diesel.	2022	Ministry of Transport and Communications, Ministry of Finance	0	9	5	2

Table 4.5 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* CO_2 emission performance standards for new passenger cars and for new light commercial vehicles incl. AFIR (Alternative Fuels Infrastructure Regulation)	Efficiency improvements of vehicles, Low carbon fuels/electric cars	CO_2	Regulatory	Implemented/ Planned	CO_2 limit values according to the EU Fit for 55 proposal, by which the CO_2 emissions of new passenger cars reported by the manufacturer should be –55% less in 2030 and –100% less in 2035 than in 2021. The corresponding reductions are –50% and –100% for light commercial vehicles. The infrastructure of electric car charging stations and hydrogen filling stations according to the EU Fit for 55 AFIR proposal.	2022	Ministry of Transport and Communica-tions, Ministry of Economic Affairs and Employment, Ministry of Finance	0	41	210	604
* HCT transports and digitalisation in logistics	Demand management/ reduction	CO_2	Regulatory	Implemented/ Planned	The Regulation on the HCT (High Capacity Transport) vehicle combinations for road transport (1257/1992) was amended and entered into force in 2019 increasing the maximum length of combination to 34.5 metres. This will decrease kilometres driven when the same mass can be transported with fewer vehicles.	2022	Ministry of Transport and Communica-tions	0	30	60	55
* Urban transport system plans	Demand management/ reduction, modal shift to public transport or non-motorized transport	CO_2	Voluntary/ negotiated agreements, planning, economic	Implemented/ Planned	The aim is to reduce the number of solo car journeys and to halt the increase in the vehicle-kilometres in urban areas regardless of a growing population by promoting the conditions for walking, cycling, public transport and new travel services, especially in urban areas.	2023	Ministry of Transport and Communica-tions	0	6	13	10
* The investment programme for walking and cycling	Demand management/ reduction, modal shift to public transport or non-motorized transport	CO_2	Voluntary/ negotiated agreements, planning, economic	Implemented/ Planned	The aim is to enhance the requirements necessary for walking and cycling in Finland's municipalities, support the reduction of GHG-emissions in traffic and promote public health. The investment programme promotes the the target set for walking and cycling in 2030, i.e a 30% increase in the amount of travel.	2023	Ministry of Transport and Communica-tions, Ministry of Finance	0	4	8	6

Table 4.5 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Improved regulation of the development of major retail centres	Demand management/ reduction	CO_2	Regulatory, Planning	Implemented	Strenghtening of available policy instruments in land use and building act to avoid disruptive land use development and increased transportation needs due to construction of retail centres based on private car transportation	2000	Ministry of the Environment, Regional councils, Municipalities	NE	NE	NE	NE
* Other miscellanious changes	Efficiency improvements of vehicles	CO_2	Regulatory, economic, fiscal, other	Implemented/ Planned	Changes in vehicle taxation, charging and distribution infrastructure subsidies, market-based changes in new registrations and driving power of imported used cars.		Ministry of Transport and Communica-tions, Ministry of Finance	NE	101	175	222
Biofuel distribution obligation 100 per cent in 2045	Low carbon fuels/ electric cars	CO_2	Regulatory	Planned	Increasing the obligation to biofuel distribution to 100 per cent from 2030 by 2045. Consumption of bio-based and other fuels classified as renewable will increase and the share of fossil fuels in consumption will decrease and completely cease in 2045.	2031	Ministry of Economic Affairs and Employment, Ministry of Finance	0	0	0	447
CO_2 emissions performance standards for new heavy duty vehicles	Efficiency improvements of vehicles, Low carbon fuels/electric cars	CO_2	Regulatory	Planned	The proportion of first registered zero-emission electric and hydrogen-powered heavy duty vehicles among all first registrations will increase until 2030 so that the average CO_2 value of all first registrations is 30% less than the average in Finland in 2021. After 2030, the situation will remain constant.	2023	Ministry of Economic Affairs and Employment, Ministry of Finance	0	18	91	157
Scrapping premium campaign	Efficiency improvements of vehicles, Low carbon fuels/electric cars	CO_2	Regulatory, economic	Planned	New premium for scrapping car (model year 2010 or older) in 2023 for purchasing a new low emission car (gas car, <95 g/km charging hybrid, full electric or <120 g/km other internal combustion engine car), public transport season ticket or electric-assisted bicycle.	2023	Ministry of Transport and Communica-tions, Ministry of Finance	0	10	5	2

Table 4.5 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
Services in the Mobility-as-a-Service concept – full potential	Demand management/ reduction, modal shift to public transport or non-motorized transport	CO_2	Voluntary/ negotiated agreements, planning, economic	Planned	The main purpose of Mobility as a Service (MaaS) is to provide user-friendly, reliable, affordable and competitive door-to-door mobility services to reduce the need to use a privately owned car and thus decrease vehicle-kilometres.		Ministry of Transport and Communications, Ministry of Finance	0	15	29	19
Additional measures to improve the energy-efficiency of the transport system	Demand management/ reduction, modal shift to public transport or non-motorized transport	CO_2	Voluntary/ negotiated agreements, planning, economic	Planned	A combination of three measures aimed at the same goal to reduce the need to use a privately owned car and decrease vehicle-kilometres: – urban transport system plans (full potential) – increase the state funding to public transport for large and medium-sized urban areas – increase the state funding to mobility management		Ministry of Transport and Communications, Ministry of Finance	0	34	67	45
The investment programme for walking and cycling – full potential	Demand management/ reduction, modal shift to public transport or non-motorized transport	CO_2	Voluntary/ negotiated agreements, planning, economic	Planned	Assumed a funding level of > EUR 26.5 million/ year for the Walking and Cycling Investment Programme according to the Roadmap to Fossil Free Transport.		Ministry of Transport and Communications, Ministry of Finance	0	2	3	2
Emissions trading system for road transport	Efficiency improvements of vehicles, Low carbon fuels/electric cars	CO_2	Regulatory, economic	Planned	Emissions trading in transport sector fossil fuels under the EU's Fit for 55 proposal is estimated to decrease vehicle-kilometres for passenger cars and light commercial vehicles		Ministry of Transport and Communications, Ministry of Economic Affairs and Employment, Ministry of Finance	0	0	189	83

NE = not estimated
IE = included elsewhere

1) The measure increases the emissions of the WM projection in relation to the previous WM projection, where biogas was not included in the distribution obligation but provided additional emission reductions. In the new WM projection, biogas/high-blend ethanol fuel reduces the amount of other biofuel in the distribution obligation and therefore increases emissions compared to the previous projection.

4.4.3 International bunkers

Policies and measures in the WM projection

Finland has actively participated in the International Maritime Organization's (IMO) and International Civil Aviation Organisation's (ICAO) work to limit emissions from international transport.

The 2010 ICAO Assembly adopted the existing global aspirational goals for the international aviation sector of 2 per cent annual fuel efficiency improvements and carbon neutral growth from 2020. Finland welcomes that the ICAO Assembly in 2016 adopted a global carbon-offsetting scheme for international aviation, CORSIA. With this decision, aviation became the first industrial sector to have a global market-based measure scheme in place. Finland has fully supported ICAO's work on the development of Annex 16, Volume IV to the Convention on International Civil Aviation containing the Standards and Recommended Practices (SARPs) for the implementation of CORSIA and has confirmed its participation in the CORSIA from its outset.

Finland welcomes that the Initial IMO Strategy on Reduction of Greenhouse Gas Emissions from Ships was adopted in 2018. It envisages a reduction in total greenhouse gas emissions from international shipping and identifies three levels of ambition. First, the carbon intensity of ships should decline through the implementation of further phases of the Energy Efficiency Design Index (EEDI) for new ships. Second, the carbon intensity of international shipping should decline with reductions in CO_2 emissions per transport work, as an average across international shipping, by at least 40 per cent by 2030, pursuing efforts towards 70 per cent by 2050 compared to 2008. Third, greenhouse gas emissions from international shipping should peak as soon as possible, and the total annual emissions should be reduced by at least 50 per cent by 2050 compared to 2008. According to the Roadmap, by 2023, IMO Member States should agree a final strategy on short-, medium-, and long-term measures, taking the results from the IMO Data Collection System into account.
In 2021, the IMO agreed to initiate the revision of the Initial 2018 IMO Strategy on Reduction of GHG Emissions from Ships, recognising the need to strengthen the ambition during the revision process. A final draft Revised IMO GHG Strategy will be considered by 2023 with a view to adoption.

The EU MRV Regulation[60] on monitoring, reporting and verification of carbon dioxide emissions from maritime transport entered into force in 2015. The EU regulation applies to ships greater than 5000 gross tonnage, irrespective of their flag, undertaking following voyages in EU and EFTA regions and it requires ships to monitor and report their CO_2 emissions, fuel consumption, transport work and average energy efficiency. In 2016, the IMO approved amendments to the Annex VI on Data Collection System (DCS) for the fuel oil consumption of ships of the International Convention for the Prevention of Pollution from Ships

60 (EU) 2015/757

(MARPOL). Under the amendments, ships of 5,000 gross tonnage and above are required to collect consumption data for each type of fuel oil they use, as well as other additionally specified data including proxies for transport work. The aggregated data are reported annually to the flag State, which issues a Statement of Compliance to the ship. Flag States are required to subsequently transfer this data to an IMO Ship Fuel Oil Consumption Database. The IMO is required to produce an annual report for the MEPC, summarising the collected data. These measures were implemented in Finland's national legislation[61] in 2021.

In 2021, the IMO adopted amendments to MARPOL Annex VI, which will require ships to reduce their greenhouse gas emissions. These amendments combine technical and operational approaches to improve the energy efficiency of ships, also providing important building blocks for future GHG reduction measures. The new measures will require all ships to calculate their Energy Efficiency Existing Ship Index (EEXI) by following technical means to improve their energy efficiency and establish their annual operational carbon intensity indicator (CII) and CII rating. Carbon intensity links greenhouse gas emissions to the amount of cargo carried over the travelled distance. Ships will be rated for their energy efficiency (A, B, C, D, E – where A is the best). A ship rated D for three consecutive years, or E, is required to submit a corrective action plan to show how the required index (C or above) would be achieved. The new regulations on EEXI and CII will be implemented in Finland's national legislation between 2023 and 2024.

The EU Emissions Trading System (EU ETS) currently applies to aviation and covers all intra-European Economic Area flights. As a member of the European Union, Finland has participated in the EU ETS from its outset. The EU Emissions Trading System has generally been seen as a cost-effective way to reduce emissions from the activities it covers, as it provides a better incentive to reduce emissions and improve energy efficiency than through air passenger taxes, for example. On the other hand, the system enables additional purchases of emissions rights if it will be very expensive or impossible to reduce emissions by means of new technology, for example. The Commission has estimated that the EU ETS has reduced aviation CO_2 emissions by more than 17 million tonnes per year[62].

Based on the Roadmap for fossil-free transport described in Section 4.4.2 the Government made Resolutions on reducing greenhouse gas emissions from aviation, as well as maritime and inland waterway transport. According to the Government Resolution[63], emissions from domestic and international air traffic departing from Finland will be reduced by 15 per cent from 2018 levels by 2030 and by 50 per cent by 2045. The emissions reduction target concerns

61 29.6.2021/669

62 https://ec.europa.eu/clima/eu-action/transport-emissions/reducing-emissions-aviation_en

63 Government resolution on reducing greenhouse gas emissions from aviation; Publications of the Ministry of Transport and Communications 2021:22; http://urn.fi/URN:ISBN:978-952-243-616-0

emissions within the sector; in addition, aviation delivers emissions savings in other sectors through various market mechanisms. The Resolution includes 23 measures to reduce aviation emissions through renewable fuels, energy efficiency, and pricing. Finland's 5th Action Plan to Reduce CO_2 Emissions from Aviation[64] was submitted to the ICAO in 2021.

The Government Resolution[65] for maritime transport proposes several measures to facilitate the transition to alternative fuels and propulsion technologies and to support energy efficiency improvements in existing vessels and the development of new low-emission vessels in Finland. In addition, the Resolution highlights the importance of actively exerting influence internationally to reduce emissions from maritime transport, as the greatest impact on the international maritime sector can be achieved by global measures. Finland has shared its National Action Plan to address greenhouse gas emissions from ships at the IMO in 2022.

The Black Carbon (BC) emissions also have a large impact on climate change, especially in the polar regions, and Finland is committed to decreasing black carbon emissions. Accordingly, the Finnish Transport and Communications Agency Traficom with the Finnish Meteorological Institute (FMI), and VTT Technical Research Centre of Finland Ltd have been conducting studies to test the candidate measuring methods and collect data on black carbon emissions from shipping. The results of these studies will be introduced at the IMO. In 2021, the IMO adopted a resolution urging Member States and ship operators to voluntarily use distillate or other cleaner alternative fuels or methods of propulsion safe for ships and could contribute to the reduction of black carbon emissions when operating in or near the Arctic and report on measures and best practices to reduce black carbon emissions from shipping. Accordingly, in 2022, Finland and Denmark proposed draft Black Carbon Guidelines to specify the recommendations for the testing, survey, and certification of marine diesel engines, exhaust gas treatment systems, and low-emission fuels to ensure low black carbon emissions from the engine, installed equipment, or fuel used. The IMO guidelines will be developed based on this proposal.

Policies and measures in the WAM projection

As part of the EU's Fit for 55 package, the Commission has proposed a comprehensive set of changes to the existing EU Emissions Trading System (EU ETS), which should result in an overall emissions reduction of 61 per cent in the sectors concerned by 2030 compared to 2005. The increased ambition is to be achieved by strengthening the current provisions and extending the scope of the scheme. Aviation has been included in the EU ETS since 2012,

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64 https://www.traficom.fi/sites/default/files/media/publication/Finlands%20Action%20Plan%20to%20Reduce%20CO2%20Emissions%20from%20Aviation%20Revision%202021.pdf

65 Government Resolution on reducing greenhouse gas emissions from maritime and inland waterway transport; Publications of the Ministry of Transport and Communications 2021:11; http://urn.fi/URN:ISBN:978-952-243-615-3

and it applies to flights between airports in the European Economic Area. During aviation's third emissions trading period, which started in 2021, the total number of emissions allowances will be reduced annually with a linear reduction factor of 2.2 per cent. According to the proposal, the free allocation of allowances will be phased out by 2027, and their linear reduction factor will be tightened from 2.2 to 4.2 per cent from 2024. The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) aims to address any annual increase in total CO_2 emissions from international civil aviation above 2020 levels. Under CORSIA, aircraft operators will be required to purchase offsets for the growth in CO_2 emissions covered by the scheme from 2021. Finland welcomes that CORSIA will be integrated into the EU ETS and will be implemented in it.

The proposal concerning maritime transport in the Fit for 55 package notably aims to include emissions from maritime transport in the EU ETS, increase funding available from the modernisation and innovation funds, and revise the market stability reserve to continue ensuring a stable and well-functioning EU ETS.

The ReFuelEU Aviation and FuelEU Maritime proposals aim to ramp up the production and deployment of renewable and low-carbon fuels. The ReFuelEU Aviation proposal includes a blending obligation for fuel suppliers for sustainable aviation fuel (SAF) and a submandate for synthetic aviation fuel. The goal of FuelEU Maritime is to reduce the greenhouse gas intensity of the energy used onboard by ships by up to 75 per cent by 2050, by promoting the use of greener fuels by ships. Despite progress in recent years, the maritime sector still relies almost entirely on fossil fuels and constitutes a significant source of greenhouse gases and other harmful pollutant emissions.

The Fit for 55 package also includes other proposals related to international bunkers – for example, the Alternative Fuels Infrastructure Regulation (AFIR)[66]. According to the proposal, at least 90 per cent of container ships and passenger ships at the busiest seaports will have access to shoreside electricity supply and at most of the inland waterway ports, at least one installation providing shoreside electricity by 2030. At airports, there should be electricity supply for all aircraft stands next to the terminal by 2025 and all remote stands by 2030 (except airports with fewer than 10,000 flights per year).

In line with this momentum on climate change action, the ICAO has sought to explore the feasibility of a long-term global aspirational goal (LTAG) for international aviation. Over the last two years, the ICAO Committee on Aviation Environmental Protection (CAEP) undertook its technical work on the feasibility study of the LTAG. The LTAG report[67] was unanimously

66 https://www.consilium.europa.eu/en/infographics/fit-for-55-afir-alternative-fuels-infrastructure-regulation/

67 https://www.icao.int/environmental-protection/LTAG/Pages/LTAGreport.aspx

approved at the CAEP/12 meeting in February 2022. The High-Level Meeting on LTAG (HLM-LTAG) was held in July 2022 to prepare for the LTAG deliberations at the 41st ICAO Assembly. Finland welcomes that the Assembly finally reached in October 2022 a historic agreement and adopted a LTAG for international aviation of net-zero carbon emissions by 2050 in support of the UNFCCC Paris Agreement's temperature goal.

Summary of policies and measures

A summary of the policies and measures for international bunkers is presented in Table 4.6.

Table 4.6
Policies and measures for international bunkers according to the WM (marked with *) and WAM projections

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)	To offset and reduce emissions	CO_2	Regulatory, economic	Implemented	Global market-based measure Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) was adopted in ICAO and implemented in the EU.	2021	Ministry of Transport and Communications	0	NE	NE	NE
Energy Efficiency Design Index (EEDI) for new ships, Energy Efficiency Existing Ship Index (EEXI)	To save energy and reduce emissions	CO_2	Regulatory	Implemented/ adopted	The IMO regulations set binding energy efficiency targets based on EEDI for new ships and to calculate Energy Efficiency Existing Ship Index (EEXI) to improve energy efficiency.	2018	Ministry of Transport and Communications	NE	NE	NE	NE
IMO data collection system (DCS)	To reduce emissions from international shipping	CO_2	Regulatory	Implemented	Ships of 5,000 gross tonnage and above are required to collect and report consumption data for each type of fuel oil they use.	2021	Ministry of Transport and Communications	0	NE	NE	NE
Maritime Transport MRV Regulation	To reduce emissions from international shipping	CO_2	Regulatory	Implemented	In order to reduce CO_2 emissions from shipping at EU level, a system for monitoring, reporting and verification (MRV) of CO_2 emissions based on the fuel consumption of ships has been set up as a first step of a staged approach for the inclusion of maritime transport emissions in the EU's greenhouse gas reduction commitment.	2015	Ministry of Transport and Communications	NE	NE	NE	NE
Aviation Emissions Trading	To reduce emissions	CO_2	Regulatory, economic	Implemented	Aviation is included in EU emissions trading since 2012.	2012	Ministry of Transport and Communications	NE	NE	NE	NE
Government resolution on reducing greenhouse gas emissions from aviation	To reduce emissions, to increase the use of renewables	CO_2	economic, fiscal, regulatory, information, other	Implemented/ adopted/ planned	The Resolution includes 23 measures to reduce aviation emissions through renewable fuels, energy efficiency and pricing.	2021	Ministry of Transport and Communications	0	NE	NE	NE
Government resolution on reducing greenhouse gas emissions from maritime and inland waterway transport	To reduce emissions, to increase the use of renewables	CO_2	economic, fiscal, regulatory, information, other	Implemented/ adopted/ planned	This Resolution on reducing emissions from maritime and inland waterway transport addresses the possibilities of both exerting influence at the international level and taking national measures.	2021	Ministry of Transport and Communications	0	NE	NE	NE

Table 4.6 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
Maritime Emissions Trading	To reduce emissions	CO_2	Regulatory, economic	Planned	The Commision proposal to include maritime transport in the EU ETS.		Ministry of Transport and Communications, Ministry of Economic Affairs and Employment	0	NE	NE	NE
Liquefied natural gas and other alternative fuels in the sea transport	To increase the use of alternative fuels, including renewables	CO_2, CH_4, N_2O	Regulatory, economic, information	Planned	The use of alternative fuels in marine transport is promoted. FuelEU Maritime proposal aims to reduce GHG emissions of energy used on board ships with gradually increasing requirement on the GHG intensity targets. The Alternative Fuels Infrastructure Regulation (AFIR) proposal promotes ship's access to shore-side electricity supply.		Ministry of Economic Affairs and Employment, Ministry of Transport and Communications, Finnish Transport and Communications Agency Traficom	0	NE	NE	NE
Alternative fuels and Sustainable Aviation Fuels (SAF) in air transport	To increase the use of renewables	CO_2, CH_4, N_2O	Regulatory and/or economic	Planned	The use of Sustainable Aviation Fuels (SAF) in aviation is promoted. The ReFuelEU Aviation proposal aims to boost the supply and demand for sustainable aviation fuels in the EU. The Alternative Fuels Infrastructure Regulation (AFIR) proposal promotes electricity supply for aircrafts stands.		Ministry of Economic Affairs and Employment, Ministry of Transport and Communications, Finnish Transport and Communications Agency Traficom	0	NE	NE	NE
ICAO Long Term Aspirational Goal (LTAG)	To reduce emissions from international air transport	CO_2	Regulatory	Planned	To introduce a long-term global aspirational goal (LTAG) for 2050 for international aviation.		Ministry of Transport and Communications	0	NE	NE	NE
Regulations on Black Carbon (BC)	Mitigate GHG-emissions and decrease BC emissions in the polar regions	BC	Regulatory	Planned	To introduce legally binding regulations on black carbon in the Polar Code.		Ministry of Transport and Communications	0	NE	NE	NE

NE = not estimated
IE = included elsewhere

4.4.4 Industrial processes and product use

The most important greenhouse gas emissions from industrial processes are CO_2 emissions from iron and steel, hydrogen and cement production. The main factors affecting the development of these emissions have until now mainly included changes in industrial production activity. However, one can observe a clear change today, in which the manufacturing industry is actively seeking low-carbon technology alternatives and significantly reduced process emissions. This is typically not the result of a single measure but several measures strengthening the overall feasibility of new technology investments.

In the WM projection, the growth of industrial production increases emissions, while technology changes reduce them. Most of the industrial process emissions reported in this sector are part of the EU ETS, which is also the main measure for reducing process emissions. The steep rise in EU ETS prices with lower electricity tax, new investment grants and increased climate awareness is motivating manufacturing industry to reduce process emissions. The measures are the same as those for reducing energy emissions and a description of them can be found in Chapter 4.4.1. No additional measures targeting CO_2 emissions from industrial processes are planned.

The policies and measures described in this chapter therefore only address measures related to F gases.

Policies and measures in the WM projection

The amount of emissions from F gases (HFC, PFC, SF_6) was two per cent of the total greenhouse gas emissions in 2020. HFC emissions have increased significantly since the early and mid-1990s when they were introduced as substitutes for ozone-depleting substances in many applications. The peak level of HFC emissions occurred at the end of the 2000s but have since started to decline. The share of PFC emissions of total F gas emissions was only 0.2 per cent in 2020. There is a fluctuation in the total annual PFC emission level. In recent years, emissions have decreased from their peak. The peak level of SF_6 emissions occurred in the early and mid-1990s. The level of emissions has since decreased, but there is fluctuation in the total annual emissions level due to the use of SF_6 in specific applications in which the consumed amount of SF_6 varies year-on-year. F gases are not produced in Finland.

The most important regulations affecting the use and emissions of these gases are the F gas regulation[68] and the directive related to HFC emissions from air conditioning systems in motor vehicles.[69] Technical development has also affected the development of emissions. The main features of the F gas regulation in cutting F gas emissions are a phase-down of HFCs that can be placed on the

68 2014/517/EC
69 2006/40/EC

EU market, bans on the use of HFCs in certain applications and obligations related to leak checking and repairs, F gas recovery and technician training.

The WM projection for F gases includes the impacts of the EC regulation and the EC directive referred to above. Emissions from refrigeration and air conditioning equipment are expected to decline due to regulatory measures. The main features of the F gas regulation in cutting the emissions will lead to a replacement of HFCs with low GWP alternatives in most applications.

Emissions from electricity distribution equipment have declined from their peak because of voluntary actions by the industries. A steady increase of emissions is assumed in the future, but the peak emissions level in the 1990s will not be reached. Restrictions forced by the EU regulation will have a decreasing effect on emissions from foam blowing and aerosols in the future.

Policies and measures in the WAM projection

The current measures in the WM projection will already cut the emissions strongly. The WAM projection of F gases is based on a few additional measures that will slightly accelerate the decrease of emissions. These additional measures include the revision of the F gas Regulation, improved control of F gas banks and recovery of F gases, and promotion of alternative non-HFC technologies.

It is estimated that the emissions reduction achieved by these additional measures will be 0.2 million tonnes CO_2 eq. in 2030.

Summary of policies and measures

A summary of the policies and measures in the industrial processes and product use sector is presented in Table 4.7.

Table 4.7
Policies and measures according to the WM (marked with*) and WAM projections in the industrial processes and product use sector

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Regulation of the Finnish Transport Safety Agency TRAFI/437519/03.04.03.00/2017 on technical requirements of road vehicles and trailers	Replacement of fluorinated gases by other substances (Industrial Processes, Transport)	HFC, PFC, SF_6	Regulatory	Implemented	Implementation of the directive 2006/40/EC of the European Parliament and of the Council to reduce use of F-gases by restricting use of certain F-gases in air-conditioning systems of new passenger cars and light duty vehicles	2017	The Finnish Transport and Communications Agency Traficom	NE	IE	IE	IE
* Revised Environmental Protection Act (423/2015) and related Government Decree (766/2016)	Replacement of fluorinated gases by other substances (Industrial Processes)	HFC, PFC, SF_6	Regulatory	Implemented	Implementation of the EU F-gas regulation (Regulation 517/2014).	2015	Ministry of the Environment	NE	IE	IE	IE
* Improved enforcement of F-gas regulations	Replacement of fluorinated gases by other substances (Industrial Processes)	HFC, PFC, SF_6	Regulatory, Information	Implemented	Enhance cost effective compliance monitoring: further support and information for inspectors, targeted information dissemination on new regulation to different groups of stakeholders	2015	Ministry of the Environment, Finnish Environment Institute, Finnish Safety and Chemicals Agency	NE	IE	IE	IE
* The EU-wide measures of Regulation 517/2014/EU	Replacement of fluorinated gases by other substances (Industrial Processes)	HFC, PFC, SF_6	Regulatory	Implemented	The EU-wide measures of regulation 517/2014 where no national implementation takes place (e.g. phase-down schedule on placing on the market of HFCs, enhanced leackage prevention and bans on certain equipment)	2015	Ministry of the Environment	NE	IE	IE	IE
* Criteria for green public procurement to avoid equipment containing high GWP F-gases	Replacement of fluorinated gases by other substances (Industrial Processes)	HFC, PFC, SF_6	Information	Implemented	Criteria for green public procurement to avoid equipment containing F-gases to promote the transition from HFC technologies to alternative low GWP technologies.	2020	Ministry of the Environment, Finnish the Environment Institute	NE	IE	IE	IE

Table 4.7 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
Information and education campaign to promote alternative non-HFC technologies	Replacement of fluorinated gases by other substances (Industrial Processes)	HFC, PFC, SF_6	Information	Planned	Information and education campaign to promote alternative non-HFC technologies	2023	Ministry of the Environment, Finnish Environment Institute	0	IE	IE	IE
Revision of Regulation 517/2014/EU	Replacement of fluorinated gases by other substances (Industrial Processes)	HFC, PFC, SF_6	Regulatory, Information	Planned	Revision of the EU F-gas regulation (Regulation 517/2014)	2024	Ministry of the Environment	0	IE	IE	IE
Improved control of F-gas banks and recovery of F-gases	Replacement of fluorinated gases by other substances (Industrial Processes)	HFC, PFC, SF_6	Regulatory, Information	Planned	Improved control of F-gas banks and recovery of F-gases by way of information campaingns, education, guidance and direction and voluntary actions	2022	Ministry of the Environment, Finnish Environment Institute	0	IE	IE	IE
* PAMs related to F-gases in With Measures (WM) scenario (HFCs, PFCs and SF_6)	Replacement of fluorinated gases by other substances (Industrial Processes, Transport)	HFC, PFC, SF_6	Regulatory, Information	See individual PaMs	PAMs related to F-gases in With Measures (WM) scenario (HFCs, PFCs and SF6). Please see the single PAMs for more information	See individual PaMs	See individual PaMs	NE	2,665	3,204	3,464
PAMs related to F-gases in With Additional Measures (WAM) scenario (HFCs, PFCs and SF_6)	Replacement of fluorinated gases by other substances (Industrial Processes)	HFC, PFC, SF_6	Regulatory, Information	See individual PaMs	PAMs related to F-gases in With Additional Measures (WAM) scenario (HFCs, PFCs and SF_6). Please see the single PAMs for more details.	See individual PaMs	See individual PaMs	0	154	150	107

NE = not estimated
IE = included elsewhere

4.4.5 Agriculture

Policies and measures in the WM projection

Finnish agricultural policy is based on the view that the competitive disadvantage due to natural conditions such as the short growing period, low temperatures, frosts, and problematic drainage conditions must be compensated to have profitable domestic production and make agriculture sustainable and multifunctional. The objectives of sustainable and multifunctional agriculture include taking greenhouse gas emissions, the possible need for adaptation measures, and other environmental and socioeconomic aspects into account. These objectives can be reached through the Common Agricultural Policy (CAP) of the EU, as well as through national measures. According to conclusions of the European Council, agricultural production should continue in all areas of the Community.

The starting point of agriculture emissions projection is that domestic food production will be secured and maintained at the current level, and mitigation policies will be implemented where the most cost-effective reduction potential exists. Some of the effective climate policy measures may conflict with other agricultural policy objectives and measures such as securing the availability of food, animal welfare, and the biodiversity of rural areas. If Finnish food consumption patterns remain unchanged, a reduction in domestic agricultural production would probably not reduce global greenhouse gas emissions because domestic production would be replaced by production elsewhere.

There are measures in the CAP aim to reduce greenhouse gas emissions. Agri-environment-climate measures are part of the Rural Development Programme for Mainland Finland from 2014 to 2020 and the CAP transitional period from 2021 to 2022. Agri-environment payments are essential tools for promoting sustainable development in agriculture, and in previous years, some 85 per cent of Finnish farmers have committed themselves to the agri-environment scheme. Their objectives are to decrease nutrient loading from agriculture in surface waters and groundwaters and to preserve plant and animal biodiversity and the rural landscape. The measures also aim to maintain or improve the productive capacity of agricultural land and reduce greenhouse gas and ammonia emissions, as well as to adapt to climate change.

In the Rural Development Programme for 2014 to 2020 and for the CAP transitional period between 2021 and 2022, there are several measures for climate change mitigation and adaptation: an environment payment for the incorporation of slurry into the soil; recycling of nutrients and organic matter; control of runoff waters; environmental management of grassland; and plant cover on arable land in the winter. Agricultural investment support can be targeted to controlled subsurface drainage and more efficient handling, storage, and use of manure. There is also a support system for investments in renewable energy – for example, an investment system for biogas plants. As part of the programme, advisory services will be provided regarding cross-compliance conditions, greening payments, climate change mitigation and adaptation, biodiversity, the protection of water and soil, environment payments, the maintenance of agricultural land, organic production, and issues related to environmental efficiency, including more efficient energy use and renewable energies. The new CAP period from 2023 to 2027 begins in January 2023, and it includes similar, partly improved, climate and agri-environment measures. There will also be a new element: an eco-scheme. The eco-scheme's measures differ from the climate and agri-environment commitments and are more demanding than climate and environmental legislation.

The Rural Development Programmes for Mainland Finland have been the main instruments for implementing climate change mitigation and adaptation measures in the agricultural sector. Rural Development Programmes are evaluated as defined in the Parliament and Council regulation.[70] At programme level, Finland has defined evaluation and implementation plans to evaluate climate change issues[71].

As it is neither possible nor appropriate to implement all climate change mitigation or adaptation measures in agriculture through the EU's Common Agriculture Policy, national measures are also required.

The new Climate Plan for the Land Use Sector[72] complements the climate measures targeted at agricultural peatlands. Alternative measures include raising the groundwater level on peaty arable land to prevent peat decomposition, the promotion of perennial grasslands without tilling and converting agricultural land into managed wetlands (when the area would no longer be used for agricultural production). These measures targeted at agricultural soils also reduce CO_2 emissions in the land use, land-use change and forestry (LULUCF) sector.

In the most recent Medium-Term Climate Change Policy Plan, measures targeting agriculture are partly the same as mentioned in the CAP. However, the plan also includes other national measures that are currently implemented or adopted in Finland. Enteric methane emissions from ruminants can be reduced by changing feeding practices for dairy cows. Using rapeseed cake in the feeding of dairy cows can reduce methane emissions by approximately 10 per cent per litre of milk if the cows are fed predominantly with roughage, i.e. grass[73]. However, as more than 40 per cent of the feed of dairy cows is concentrated feed, rapeseed cake would mostly replace the currently widely used rapeseed meal, and the actual reduction in methane emissions would probably be three to five per cent per cow.

70 1305/2013/EU (rural development regulation)
71 http://urn.fi/URN:ISBN:978-952-326-822-7
72 https://urn.fi/URN:ISBN:978-952-366-388-6
73 Maanavilja L. et al. (2021)

Of the feed additives that reduce enteric methane production, research has advanced furthest regarding 3-NOP (3-nitrooxypropanol), which has recently been approved in the EU as a feed additive for dairy cows and cows for reproduction. In the best-case scenario, this additive may reduce methane emissions from dairy cows by up to 25 per cent, but would entail additional costs for farmers at the same time.

The food consumption measures highlighted in the Medium-Term Climate Change Policy Plan include reducing food waste and eating according to nutritional recommendations. The national target of halving food waste in Finland by 2030 is also in line with Sustainable Development Goal 12.3, "By 2030, halve per capita food waste". The total food waste in the Finnish food chain is estimated to be around 400 to 500 million kilogrammes a year. Food waste occurs at every stage of the food chain, and in terms of volume, it is divided as follows: primary production 12 per cent; industry 20 per cent; trade 18 per cent; food services 20 per cent; and households 30 per cent. The Natural Resources Institute Finland has developed a National Food Waste Road Map[74]. Measures for reducing food waste have been categorised in thematic areas: regulation and policy instruments; education and information guidance; changes in sustainability practices; technological solutions and new business models; research-driven solutions; and cooperation between operators. Emissions impacts of reducing food waste arise when the amount of food waste decreases, and correspondingly, the demand, production and imports of food decrease. As a result, the climate impact of food production will diminish in both the agricultural and land use, land-use change and forestry sectors. EU Member States are also obligated to measure the amount of food waste and report on it in accordance with the Commission's Delegated Decision (EU) 2019/1597.

In addition to the measures referred to above, many other factors may contribute to a reduction in the greenhouse gas emissions from agriculture in 2035. However, the magnitude remains difficult to estimate. For example, gender-selected semen is a relatively new technology. The goal is to reduce the number of male dairy calves and increase the share of faster-growing dairy–beef crossbreed calves among dairy cattle. More research is needed on the use and effects of gender-selected semen, but the method is already rapidly gaining popularity.

Prime Minister Sanna Marin's Government Programme also sets the following implemented measures for reducing emissions in the agricultural sector: improving real estate composition of fields; increasing organic production; the Catch the Carbon programme and recycling of nutrients; and promoting biogas production.

74 Riipi, I. et al. (2021)

The Ministry of Agriculture and Forestry of Finland has drawn up a development programme for the real estate composition of fields, including the preparation and implementation of the associated measures to improve the competitiveness of agricultural production, while taking the impact on the environment, waters, climate and biodiversity into account. The real estate composition of fields can be markedly improved by parcel or land arrangements. The composition could also be affected by measures in the upcoming Common Agricultural Policy plan and matters associated with ownership, renting systems, and taxation of fields.

One of the methods mentioned in the Government Programme for achieving a climate and environmentally friendly food system is to increase the share of domestic organic products in food production, food processing, domestic consumption, and exports. Organic production is based on good soil management. The cultivation methods used promote the sequestration of organic matter and carbon in soil, which is a precondition for the fertility of fields. At the same time, these methods promote nutrient recycling, reduce dependence on fossil energy and increase farms' nutrient self-sufficiency. The new national organic farming programme, Luomu 2.0[75], was published in the spring of 2021. A more detailed implementation plan and its performance indicators are currently being prepared in cooperation with stakeholders in the organic farming sector.

The Catch the Carbon Research and Innovation Programme is a new kind of climate programme for the agricultural, forestry, and land-use sectors. Catch the Carbon began in 2020 and is implemented under the Government Programme. More than 100 research, development and innovation projects have been funded as part of the programme. These projects create new knowledge on climate-sustainable solutions for agriculture and forestry, engage stakeholders and actors, reduce greenhouse gas emissions, and enhance carbon sinks and reservoirs. There is a special emphasis on communication, interaction and competence to build better and strong implementation of climate-smart agriculture and forestry practices.

The Making Use of Agricultural Nutrients Project[76] was a three-year pilot programme carried out between 2016 and 2018. It was part of the government key project for the circular economy, introduced in the Government Programme. It conveyed information on the funding possibilities related to the recycling of nutrients and essential research knowledge to practical operators. It identified the bottlenecks in nutrient recycling and facilitated their elimination. It also promoted the networking and new experiments of nutrient recycling operators. The project has also been continued in Prime Minister Sanna Marin's Government Programme 2019. In addition to the Making Use of the Agricultural Nutrients Project, there has been investment

75 http://urn.fi/URN:ISBN:978-952-366-196-7

76 https://mmm.fi/ravinteetkiertoon

aid for biogas and advanced biomass processing technologies, i.e. investment aid for nutrient recycling. The aid is intended for larger-scale activities, and it is granted for investments in machinery, equipment, and buildings for processing manure or biogas plant rejects into highly processed fertiliser or other nutrient products that are easily movable and storable. The pilot project and investment aid together support the entire biogas and nutrient cycling chain from the ideation and product development level to production-scale operations. Efforts have also been made to develop statistics for and monitor nutrient recycling, as nutrient recycling is a new challenge for the industry and needs statistical and monitoring mechanisms.

Ammonia is to some extent involved in greenhouse gas emissions because part of the ammonium nitrogen landing on the ground is transformed into nitrous oxide. International treaties and EU legislation oblige Finland to reduce its ammonia emissions into the air. Approximately 90 per cent of Finland's ammonia emissions originate from agricultural sources. The most effective measures for reducing ammonia emissions from agriculture involve manure, its storage, and its application. Ammonia emissions can also be reduced by measures involving the feeding of domestic animals, but these measures are more difficult to regulate, and impact is more difficult to assess, than measures related to the management of manure[77].

Policies and measures in the WAM projection

In December 2021, the Finnish government set an ambitious emissions reduction target of 29 per cent for Finnish agriculture (including agricultural emissions in the effort sharing sector and land use, land-use change and forestry sector) by 2035. This means emissions from agriculture should decrease by 4.6 Mt CO_2 equivalent by 2035. The potential measures to achieve this target are specified in the Carbon Euro Programme[78]. Many of these measures are also mentioned in the WM projection, but the scale and parameters vary. Controlled subsurface drainage, the promotion of paludiculture, the reduction and replacement of one-year cereal cultivation with grassland, the removal of poorly productive arable land from agricultural production and the afforestation of low-yield arable land are considered the most effective means to reduce emissions from agriculture in organic soils. For mineral soils, carbon sequestration and afforestation have been identified as potential measures for emissions reduction in Finland's conditions. The above-mentioned measures reduce emissions in the agricultural sector, as well as in the land use, land-use change, and forestry sector. Other measures that could help to achieve the 29 per cent emissions reduction target in agriculture are more precise nitrogen fertilisation, the use of additives in feeds for bovines, as well as a decrease in the number of bovines and utilising renewable energy in agriculture.

77 http://urn.fi/URN:ISBN:978-952-366-192-9

78 https://mmm.fi/documents/1410837/1516663/HERO_selvitys_2022.pdf/fd751aad-a2f2-a31a-396a-872d034f823b/HERO_selvitys_2022.pdf?t=1650519685134

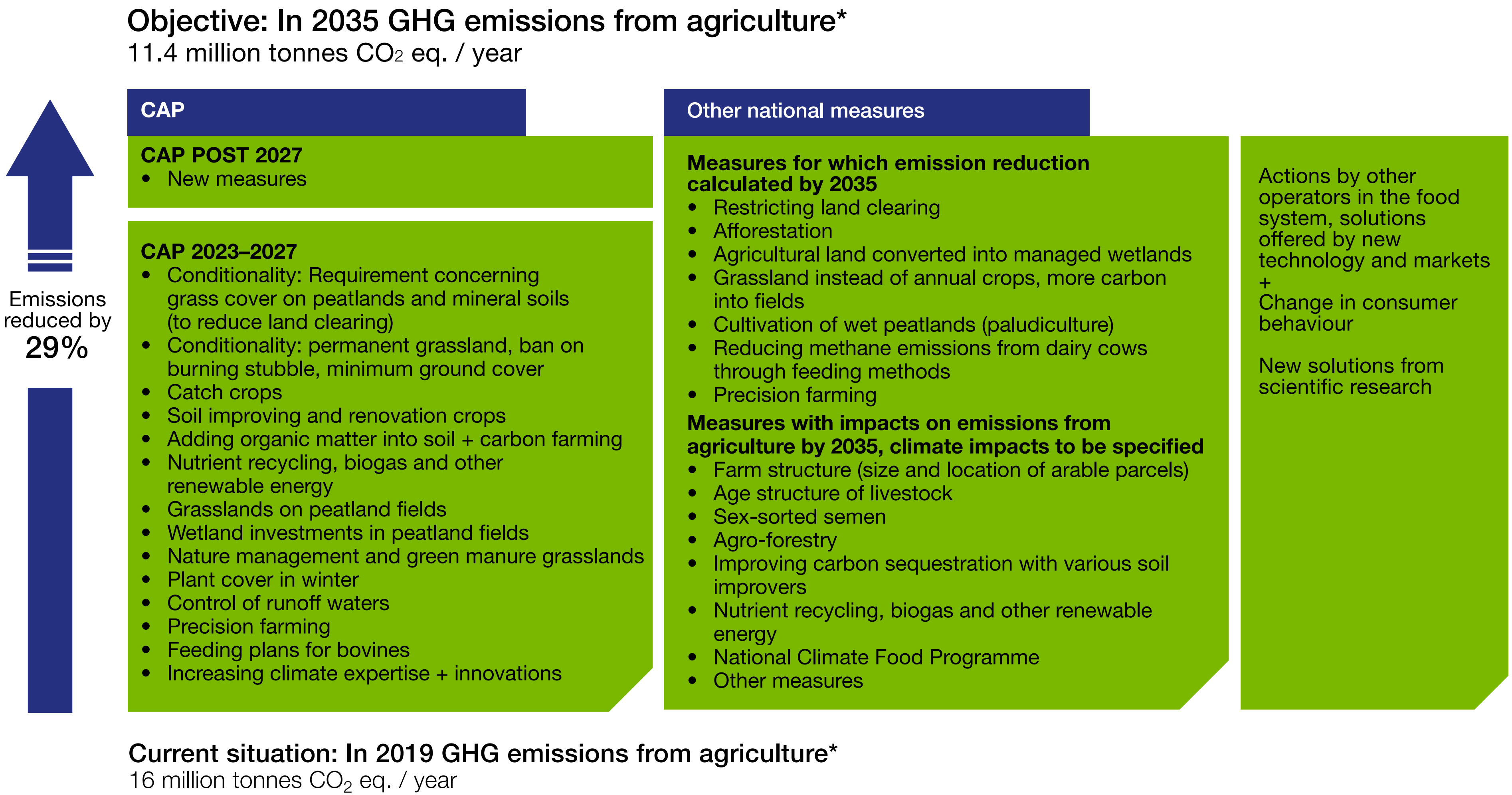
These measures are partly the same as those identified in the CAP strategic plan for 2023 to 2027, in the Climate Plan for the Land Use Sector, and in the Medium-Term Climate Change Policy Plan.

In addition to the mitigation measures mentioned above, it is important to ensure the adequate adaptation of agriculture to climate change. In the agricultural sector, adaptation measures are often also good for mitigation. There is more about adaptation in agriculture in Chapter 6.

Achieving the challenging 29 per cent emissions reduction target is unlikely to be possible with public guidance and incentives alone. Hence, private emissions compensation payments, food industry climate and responsibility programmes, and farm-level solutions and goals, including yield targets, will be needed.

Figure 4.5 specifies the potential measures to achieve the 29 per cent emissions reduction target. The measures are carried out either through the Common Agricultural Policy (CAP) or other national measures.

Figure 4.5
Potential measures to reach the 29% emission reduction target for Finnish agriculture by 2035



*Agriculture and measures concerning agricultural reneweable energy in the effort sharing sector and agricultural land in the land use sector. Based on current inventory estimates.

In line with the Government Programme, the Ministry of Agriculture and Forestry is currently preparing a Climate Food Programme that aims to support society's transition to a climate-resilient food system. The programme includes measures to enhance sustainable food production and food services. There is a particular emphasis on scaling up the plant protein sector. A climate-resilient food system takes all the dimensions of sustainability into account: social; economic; cultural; and ecological. The programme also supports the objective of the Finnish Government to achieve carbon neutrality in 2035.[79] The emissions reduction impact of the Climate Food Programme has not been estimated.

Finland's national nutrition recommendations are based on the Nordic Nutrition Recommendations, which are currently being updated. The new Nordic recommendation will be launched by the end of 2022, and it will seek to clarify the link between nutrition and sustainable development. There is a potential to reduce the climate impact of diets by changing diet content and taking care of carbon sequestration[80]. A climate-friendly diet may be achieved in multiple ways, but in all cases, it requires a reduction in meat consumption. The emissions reduction impact of the new nutrition recommendations has not been estimated.

A shift towards more plant-based consumer diet will change agricultural production and land-use in a direction with lower emissions, but the greatest emissions reductions will realize after 2035. This is due to dynamics and time lags in milk and beef production and implied land-use change.

Despite the national dietary change, the reduction of greenhouse gas emissions may be slow, if exports of dairy products increase due to strong global demand and prices. Then structural development and productivity will progress, and the change in production and land use will remain small.

Whether consumers reduce their consumption of meat and dairy products as assumed in the scenario depends on the development of consumers' taste and eating habits. When implemented, a more plant-based diet will significantly reduce emissions from livestock production and, together with land use measures, it will also give the opportunity to reduce emissions from cropland, which are currently around 75 per cent of total agricultural emissions.

In the Medium-Term Climate Change Policy Plan[81] in 2022, additional measures to cut emissions from the agriculture sector that are not yet included in the projections scenario are related to the age structure of cattle and agroforestry. As the life expectancy of cows increases, fewer new heifers will be needed. This will contribute to reducing methane emissions in agriculture.

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79 https://mmm.fi/en/climatefriendlyfoodprogramme

80 http://urn.fi/URN:ISBN:978-952-287-773-4

81 http://urn.fi/URN:ISBN:978-952-361-262-4

Currently, however, no policy measures influence the age structure of cattle. By means of agroforestry, it may be possible to improve the fertility of fields, reduce erosion and nutrient leaching, increase biodiversity, and sequester carbon to both soil and vegetation. There is currently very little agroforestry production in Finland. Hence, no concrete policy measures for agroforestry are in practice. Suitable operating models for agroforestry in northern conditions are currently being identified. Therefore, the emission reduction estimate is pending.

Summary of policies and measures

A summary of the policies and measures in the agricultural sector is presented in Table 4.8.

Table 4.8
Policies and measures according to the WM (marked with *) and WAM projections in the agricultural sector

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
Implementation of the Nitrates Directive (1991/676/EEC)	Reduction of fertilizer/ manure use on cropland, Improved animal waste management systems	N_2O	Regulatory	Implemented	Decreases greenhouse gas emissions and the use of mineral fertilisers.	2014	Ministry of Agriculture and Forestry	NE	NE	NE	NE
* Organic soil activities 1)	Improved management of organic soils, Activities improving grazing land or grassland management, Other LULUCF	CO_2, N_2O	Economic, Information, Research	Implemented, Adopted	The target is to reduce emissions from organic soils for example by intensifying long-term grass cultivation. Alternative measures also include cultivation of wet peatlands (paludiculture) and agricultural land converter into managed wetlands (when the area would no longer be used for agricultural production). Same measures reduce the N_2O emissions from agriculture sector and the CO_2 emissions from the LULUCF sector. Measures are implemented through CAP and Climate Change Plan for the Land Use Sector.	2014	Ministry of Agriculture and Forestry	NE	350	748	1,084
* Mineral soil activities 1)	Other activities improving cropland management	CO_2, N_2O	Economic, Information, Research	Implemented, Adopted	The target is to increase the amount of carbon in mineral soils. Measures are implemented through CAP.	2014	Ministry of Agriculture and Forestry	126	202	273	245
* Reducing methane emissions from dairy cows through feeding	Improved livestock management	CH_4	Economic, Information	Adopted	The aim is to reduce emissions, especially from the digestion of cattle, by refining feeding, using emission-reducing feed additives, etc.	2022	Ministry of Agriculture and Forestry	0	298	295	289
* Food loss and food waste 3)	Other agriculture	CO_2, N_2O	Other, Information	Implemented	Emission impacts are caused by a reduction in food waste and, correspondingly, a reduction in food demand, production and imports, which reduces the climate impact of food production in both the agricultural and land use sectors.	2020	Ministry of Agriculture and Forestry	NE	NE	NE	NE

Table 4.8 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Gender-Selected Semen	Improved livestock management	CH_4	Information, Education, Research	Implemented	Gender selection of semen affects the sex of the calf born. The aim is to reduce the number of bull calves and to increase the number of faster-growing beef-milk crossbreed calves in dairy herds. Gender Selected Semen is a relatively new technology so more research on the use and effects of the method is needed. However, the method is rapidly becoming more widespread.		Ministry of Agriculture and Forestry, Public and private sector actors	NE	NE	NE	NE
* Real estate composition of fields [3)]	Other activities improving cropland management, activities improving grazing land or grassland management, improved management of organic soils	CO_2, N_2O	Economic, Other	Implemented	The aim of the programme is to prepare and implement measures related to the structure of arable lands to improve the competitiveness of agricultural production, taking into account environmental, waterway, climate and biodiversity impacts. The structure of arable land can be improved clearly through land consolidation. The structure can also be affected, for example, by the measures implemented through CAP as well as matters related to the ownership and leasing systems and tax subsidies for arable land.	2020	Ministry of Agriculture and Forestry	NE	NE	NE	NE
* Programme for Organic Production 2030 [3)]	Other agriculture	N_2O, CO_2, CH_4	Other	Implemented	The programme promotes the share of organic farming and organic products at the market towards sustainable food systems.	2021–2030	Ministry of Agriculture and Forestry	NE	NE	NE	NE

Table 4.8 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Catch the carbon – programme [3)]	Other activities improving cropland management, improved livestock management, activities improving grazing land or grassland management, improved management of organic soils, other agriculture and LULUCF objectives	N_2O, CO_2	Other, Information	Implemented	The programme funds projects that produce new knowledge and innovative solutions for agriculture and land use sector. Development projects are practical projects based on research data that promote the transition towards climate-resilient agriculture, forestry and other land use. The projects speed up the reduction of emissions in the land use sector, enhance carbon sinks and reservoirs, and promotes preparation for and adaptation to climate change.	2020	Ministry of Agriculture and Forestry	NE	NE	NE	NE
* Recycling of nutrients	Improved livestock management, other agriculture	CH_4, N_2O	Economic, Information	Implemented	Government's Key project on nutrient recycling. The aim of recycling of agricultural nutrients is the processing of manure, water treatment sludge and other side products of agriculture in order to recycle and utilise the beneficial nutrients they contain – particularly phosphorus and nitrogen – as fertiliser, for instance.	2016	Ministry of Agriculture and Forestry, South Ostrobothnia Centre for Economic Development, Transport and the Environment	NE	9	14	18
* Action plan to Reduce Ammonia Emissions from Agriculture in Finland 2021–2027	Other agriculture	NH_3, N_2O, CH_4	Regulatory, Information, Education	Implemented	International treaties and EU legislation oblige Finland to reduce its ammonia emissions into the air. The most effective measures to reduce ammonia emissions from agriculture involve manure, its storage, and its application. Ammonia emissions can also be reduced by measures involving the feeding of domestic animals, but these measures are more difficult to regulate and to assess their impact than measures relating to the management of manure.	2021	Ministry of Agriculture and Forestry	0	NE	NE	NE

Table 4.8 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Promoting the use of biogas in agriculture [2)]	Increase in renewable energy, Reduction of GHG emissions (Energy, Agriculture)	CO_2, CH_4	Economic	Adopted	The target is to replace fossil fuels with biogas in agriculture	2021	Ministry of Agriculture and Forestry	0	150	279	390
Climate Food Programme [3)]	Other agriculture	N_2O, CO_2, CH_4	Other, Information	Planned	The program includes measures to enhance sustainable food production and food services. Special focus is in scaling-up plant protein sector.	2022	Ministry of Agriculture and Forestry	0	NE	NE	NE
Nutrition recommendations [3)]	Other agriculture	N_2O, CO_2	Other, Information	Planned	The Nordic Nutrition Recommendations for humans are currently being updated. The new recommendations aim to clarify the links between nutrition and sustainable development. The reform of the national recommendations will begin after the Nordic recommendations have been accepted.	2022–2023	Ministry of Social Affairs and Health, Ministry of Agriculture and Forestry	0	NE	NE	NE
Age structure of cattle	Improved livestock management	CH_4	Information, Education	Planned	As the life expectancy of cows increases, less new heifers will be needed, and methane emissions will also decrease. At the moment, there are no policy measures to influence the age structure of cattle.		Ministry of Agriculture and Forestry	0	NE	NE	NE
Promoting agroforestry [3)]	Other activities improving cropland management, improved management of organic soil, afforestation and reforestation, other LULUCF	N_2O, CO_2	Economic	Planned	By means of agroforestry, it may be possible to improve the fertility of fields, reduce erosion and nutrient leaching, increase biodiversity and bind carbon to both soil and vegetation. At the moment, there is very little agroforestry production in Finland and that is why there are no concrete policy measures for agroforestry in practice. Suitable operating models for agroforestry in northern conditions are currently being identified.		Ministry of Agriculture and Forestry	0	NE	NE	NE

NE = not estimated

1) The measure affects emissions both in the agriculture sector and the LULUCF sector. The total reduction in N_2O and CO_2 emissions is presented in this table. In the projections for the agricultural sector, however, only the impact on the emissions from the agricultural sector, as defined in the GHG inventory, is included.

2) The mitigation impact figures for promoting the use of biogas include also emissions reduction in energy use. In the projections for the agricultural sector, however, only the impact on the emissions from the agricultural sector, as defined in the GHG inventory, is included.

3) The measures are estimated to affect the agriculture and LULUCF sectors, but no impact assessment is available

4.4.6 Land use, land-use change, and forestry

Policies and measures in the WM projection

The land use, land-use change, and forestry (LULUCF) sector contributes to the mitigation of climate change in three different ways, by:

- Maintaining and enhancing carbon storages and sinks
- Creating new carbon storages and sinks
- Substitution, i.e. replacing fossil-based energy, raw materials, and products with renewable biomass.

The overall LULUCF sector is a net sink in Finland because the emissions for which it accounts are smaller than the removals. This net sink from the LULUCF sector can vary greatly from one year to the next: the highest sink was 33.8 million tonnes CO_2 eq. in 2009, and the lowest was 10.3 million tonnes CO_2 eq. in 2018. According to the National Forest Inventory, the annual increment of growing stock has been increasing since the 1970s, reaching its current level of 108 million cubic metres, of which 103 million cubic metres are in forests available for wood supply. The high fluctuation in net biomass removals in the forest land category have been caused mainly by the changes in the international market for forest industry products, which affect the amount of domestic commercial roundwood felling.

The Climate Plan for the Land Use Sector, published in 2022, specifies how climate emissions from the land use, land-use change and forestry sector can be reduced, and carbon sinks and reservoirs strengthened. The Plan brings together ongoing measures such as the updated ownership policies of the State Forests (Metsähallitus), the ash fertilisation of peatland forests (part of the Fixed-term Act on the Financing of Sustainable Forestry since 2020), and the Act on Fixed-Term Support for Afforestation, and outlines additional measures categorised in four themes: resource-efficient land use and land-use change; climate-resilient use of peatlands; other measures to promote carbon sequestration and carbon storage; and crosscutting measures (see Table 4.9 and 4.10). In addition to the ongoing measures presented above, the new measures focus on, e.g. actions in the peatland fields and forests, development of carbon markets, the swift and timely forest regeneration, increasing the amount of dead wood for climate and biodiversity perspectives, promoting training and expertise and communication. The most effective measures have been identified in halting deforestation and promoting actions in the peatlands. The Catch the Carbon programme has been advancing climate measures in the LULUCF sector since its launch in 2020[82].

Finland's forest policy aims for sustainable forest management, and the policy measures include legislation, the National Forest Strategy 2025 (NFS), financial support, and extensive public forestry organisations. More information on them is provided in Finland's Seventh National Communication, Section 4.3. The National Forest Strategy 2025 was adopted by the Government in 2015. It is implemented by ten key projects that were updated in 2019.

82 In line with the Government Decree 5/2021.

According to the NFS, forest growth and health will be maintained and enhanced through active forest management. Climate change mitigation and adaptation in forests are supported by diversifying forest management. Over the long term, forest management techniques must be adapted to new and changing climate conditions. Timely and careful forest management can improve both the growth and resistance of growing stock to damage, while safeguarding the ecosystem services of forests and producing wood biomass sustainably. The strong legislative and structural basis already in place in Finland can be used to reach multiple climate and forest related objectives of current policies: this includes legislation to prevent forest pests and diseases; ensure forest regeneration and protect habitats and species biodiversity; a long-term programme of forest tree improvement to ensure good-quality seeds to different climatic conditions; ongoing projects to further develop research-based silvicultural measures; and extensive extension services for forest owners in forest management and silviculture. Several updates have been made over the years to this legislative and structural basis, such as amendments to the Forest Act[83] and the Forest Damages Prevention Act[84] to take climate change adaptation into account by allowing more diverse forest management and adjusting timber removal practices to earlier occurrence of pests due to the warming climate. Measures related to the adaptation to climate change are described in more detail in Chapter 6 and in NC7. The relevance and functioning of both the Forest Act and the Forest Damages Prevention Act were reviewed recently.

Forests will be a key part of the Finnish bioeconomy, and the NFS therefore aims to increase the use of wood to replace fossil resources with renewable biomass. The objectives and measures in the National Energy and Climate Strategy for 2030 are consistent with the policy defined in the NFS regarding the increase in industrial roundwood and energy wood, and they will help achieve the target set by the directives on promoting the use of energy from renewable sources.[85] Global economic development will greatly influence the achievements of the NFS goals.

The national measures are set out in the NFS[86]. The measures, consistent with the National Energy and Climate Strategy for 2030, aim to secure the climate advantages provided by forests and ensure the availability of renewable raw materials. The strategy is implemented by ten strategic projects updated in 2019. The completely new projects added to the National Forest Strategy apply to climate sustainable forestry, international forest policy, and EU policies, as well as new products made from wood. More projects than before also include the diversification of forest management methods, the safeguarding of biodiversity, water protection and the diversification of business. Projects to be considered crosscutting include the improvement of the availability and

83 1093/1996 (amendment 1085/2013)

84 1087/2013 (amendment 1168/2021)

85 2001/77/EC and 2009/28/EC

86 http://mmm.fi/en/nfs

usability of forest, nature and environmental data and the facilitation of their integration with other data sources. The crosscutting projects also include an aim to build common understanding and cooperation between various actors with pluralistic communication and interaction.

Regarding agricultural soils, measures affecting CO_2 emissions and removals from croplands and grasslands are presented in Table 4.9.

Table 4.9
Measures identified in the Climate Plan for the Land-Use Sector

Resource efficient land use, land use change	Climate-resilient use of peatlands	Other measures to promote carbon sequestration and carbon storage	Enabling environment – cross-cutting measures
To prevent forest conversion to other land uses: • Preventing the conversion of forests into fields • Developing the structure of arable land • Preventing the clearing of forests for settlements • Land use change fee for all land uses	Climate-resilient use of peatland fields: • Raising the groundwater level in peatland fields to prevent the decomposition of peat • Managed wetland on peatland field • Perennial grasslands without tilling • Wetting of low-yield, thick-peat fields and cut-over peatlands to establish managed wetlands • Preparing a roadmap for the use of peatland fields	Climate actions in state owned forests (Metsähallitus)	Competence, training and guidance
			Communication and interaction
		Promoting markets and incentives related to carbon sequestration and storage and the reduction of emissions	
			EU and international cooperation
		Promoting carbon sequestration and storage in fields	
			Development and adoptation of technologies
		Promoting the fertilisation of mineral soil forests	
			HERO programme
		Promoting rapid and efficient forest renewal	Sectoral low-carbon roadmaps
			Local and regional cooperation
To promote afforestation: • Act on fixed-term support for afforestation • Afforestation of low-yield fields suitable for afforestation			
		Increasing carbon stocks of decaying wood in commercial forests due to biodiversity and climate considerations by leaving retention trees in place	
			Development of the greenhouse gas inventory and monitoring system
			Catch the Carbon Research and Innovation Programme
	Climate-resilient management and use of peatland forests: • Comprehensive planning of peatland forest management • Promoting ash fertilisation of peatland forests		
		Climate-resilient continued use of cut-over peatlands	Piloting and implementation (Catch the Carbon development projects)
		Promoting carbon stocks in long-lived wood products and structures	
	Catchment area planning		

Table 4.10

Preliminary climate impacts in 2030 and 2035 of the measures presented in the Climate Plan for the Land Use Sector (million tonnes of carbon dioxide equivalent)

Measure	Area	Climate impact in 2030, million tonnes CO_2 eq.	Climate impact in 2035, million tonnes CO_2 eq.
Owner policy of Metsähallitus		0.4	0.7–0.9
Preventing the conversion of forests into fields	about 1,700–1,900 ha per year		0.5
Act on fixed-term support for afforestation	3,000 ha per year, of which 40% in peat production areas	0.09	0.11
Afforestation of low-yield fields	9,000 ha in 2024–2028	0.09	0.10
Raising the groundwater level in peaty agricultural lands (grasslands) –30 cm	2030: 20,000 ha 2035: 32,500 ha	0.135	0.219
Paludiculture, groundwater level –30 cm	2030: 5,000 ha 2035: 10,000 ha	0.047	0.094
Paludiculture, groundwater level –5 – –10 cm	2030: 2,500 ha 2035: 5,000 ha	0.047	0.094
Managed wetlands	2030: 4,000 ha 2035: 7,500 ha	0.072	0.136
Perennial grasslands without tilling	2030: 40,000 ha 2035: 40,000 ha	0.081	0.081
Wetting of low-yield, thick-peat fields to establish wetlands	2030: 10,000 ha 2035: 10,000 ha	0.181	0.181
Comprehensive planning of peatland forest management (avoidance of remedial ditching)	–	–	–
Comprehensive planning of peatland forest management (continuous cover forestry in mires)	6,000 ha per year	0.21	0.21
Ash fertilisation of peatland forests	26,000 ha per year	0.18	0.40
Promotion of forest fertilization on mineral soils	25,000 ha per year	0.46	0.28
Increasing the carbon stocks of decaying wood in commercial forests due to biodiversity and climate considerations by leaving retention trees in place	–	–	–
Total		**1.99**	**3.11–3.31**

Source: Natural Resources Institute Finland 2022

Policies and measures in the WAM projection

The Climate Plan for the Land Use Sector was adopted in 2022. There are no additional measures targeted especially at the LULUCF sector. However, some agricultural measures also affect the emissions in the LULUCF sector.

Information on the 29 per cent emissions reduction targets set for agriculture and measures to achieve this target can be found in paragraph 4.4.5. "Policies and measures in the WAM projection".

Measures identified in the Medium-Term Climate Change Policy Plan related to reducing emissions from organic soils from the agricultural sector also affect emissions from the LULUCF sector (see Section 4.4.5).

Summary of policies and measures

A summary of the policies and measures in the LULUCF sector is presented in Table 4.11.

Table 4.11
Policies and measures according to the WM (marked with *) and WAM projections in the LULUCF sector

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* National Forest Strategy 2025	Conservation of carbon in existing forests, Enhancing production in existing forests, Increasing the harvested wood products pool, Enhanced forest management, Strengthening protection against natural disturbances, Substitution of GHG-intensive feedstocks and materials with harvested wood products. Contribute to increase in renewable energy supply.	CO_2, CH_4, N_2O	Economic, Regulatory, Fiscal, Information	Implemented	The main elements of Finnish forest policy are defined in the National Forest Strategy. A large number of non-governmental organisations (NGOs) and other stakeholders have been closely involved in the preparation and further development of the strategy. Regional objectives are outlined in Regional Forest Programmes.	2015	Ministry of Agriculture and Forestry, Public and private sector actors	NE	NE	NE	NE
Fixed-term act on the financing of sustainable forestry 34/2015	Enhancing production in existing forests, Increasing the harvested wood products pool, Enhanced forest management, Restoration of degraded lands, Protection of waters	CO_2, CH_4, N_2O	Economic	Implemented	The purpose of the Act is to promote economically, ecologically and socially sustainable management and use of forest. The purposes of the aids are to increase the growth of forests, maintain the road network for forestry purposes, secure the biodiversity of forests and promote the adaptation of forests to climate change.	2015	Ministry of Agriculture and Forestry, Finnish Forest Centre	NE	NE	NE	NE
* New owner policy of Metsähallitus (Climate actions in state owned forests)	Conservation of carbon in existing forests, Enhanced forest management	CO_2, CH_4, N_2O	Regulatory	Implemented	The new policy measures aim to coordinate even better the different forms of land use and the objectives relating to sustainable forestry, supply of wood raw material, biodiversity, recreational use and climate policy. The new actions include changes in the treatment of peatlands, increasing forest growth through fertilisation and bred planting material, and a programme on new nature management measures.	2020	Ministry of Agriculture and Forestry, State Forests Enterprise	NE	NE	400	700–900

Table 4.11 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Actions to prevent deforestation (Prevent forest conversion to fields, Developing the structure of arable land, Preventing the clearing of forests for settlements, Land use change fee for all land uses)	Prevention of deforestation	CO_2, CH_4, N_2O	Economic, Fiscal, Voluntary/ negotiated agreements, Regulatory, Information, Education, Planning, Other	Adopted	The Climate Plan for the Land Use Sector includes several measures aiming at halting deforestation. These include: preventing conversion of forest land to cropland (CAP), improving spatial distribution of cropland, prevention of deforestation due to construction and exploring the possibility of taxation on land use change or requiring permission for forest clearance.	2022–2035	Ministry of Agriculture and Forestry, Public and private sector actors	0	NE	NE	500
* Actions to promote afforestation (Act on fixed-term support for afforestation, Afforestation of low-yield arable land)	Afforestation and reforestation	CO_2, CH_4, N_2O	Economic	Implemented/ planned	The purpose of the Act is to promote with financial support afforestation to increase forest area and carbon sinks, decrease greenhouse gases from afforested sites without undiminishing biodiversity. Subsidies can be granted to private landowners. The Finnish Forest Centre is responsible for the implementation of the Act. The purpose is to develop a system for afforesting low-yielding, mineral and (thin peat) peaty arable land.	2021–2028	Ministry of Agriculture and Forestry, Public and private sector actors	0	NE	180	210
* Climate-resistant management of peatland forests (continuous cover forestry and avoidance of remedial ditching)	Conservation of carbon in existing forests, Enhanced forest management, Prevention of drainage or rewetting of wetlands	CO_2, CH_4, N_2O	Fiscal, Information, Education	Adopted	The aim is to reduce emissions from peatland forests by avoiding remedial ditching and promoting continuous-cover forest management in lush forests. The measures are included in the new act on financing of sustainable forestry, which is due to become effective in 2023. Estimate includes only the effect of continuous cover forestry in mires.	2023	Ministry of Agriculture and Forestry, Public and private sector actors	0	NE	210	210

Table 4.11 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Other non-quantifiable measures to improve carbon sequestration in the land use sector	Conservation of carbon in existing forests, Enhancing production in existing forests, Enhanced forest management, Other LULUCF	CO_2	Economic, Voluntary/ negotiated agreements, Information, Education, Research, Planning, Other	Adopted	The aim is to improve carbon sequestration and to increase carbon storage in the land use sector. The measures are included in the Climate Plan for the Land Use Sector: Catchment area planning, promoting carbon markets, education and training, information and knowledge sharing, international and EU-level cooperation, development of new technologies, sectoral low-carbon roadmaps, local and regional cooperation, promotion of rapid and efficient renewal of forests, Increasing carbon stocks of decaying wood in commercially utilised forests by leaving trees for biodiversity and climate reasons, climate-friendly usage of former peatlands, promotion of the use of wood in long-lived products and construction, research and innovation programme, piloting and dissemination, development of GHG emission inventory and monitoring system.	2022–2035	Ministry of Agriculture and Forestry, Public and private sector actors	0	NE	NE	NE
* Ash fertilisation of peatland forests (temporary)	Enhanced forest management	CO_2, CH_4, N_2O	Economic	Implemented	The ash fertilisation of peatland forests is to promote the growth of trees that lack of potassium, phosphorus or boor on peatlands. The measure is included in the new act on financing of sustainable forestry, which is due to become effective in 2023.	2020	Ministry of Agriculture and Forestry, State Forests Enterprise	NE	NE	180	400

Table 4.11 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Catch the carbon programme	Other activities improving cropland management, Improved livestock management, Activities improving grazing land or grassland management, Improved management of organic soils, Other agriculture, Other LULUCF	CO_2, N_2O	Other, Information	Implemented	The programme funds projects that produce new knowledge and innovative solutions for agriculture and land use sector. Development projects are practical projects based on research data that promote the transition towards climate-resilient agriculture, forestry and other land use. The projects speed up the reduction of emissions in the land use sector, enhance carbon sinks and reservoirs, and promotes preparation for and adaptation to climate change.	2020	Ministry of Agriculture and Forestry	NE	NE	NE	NE
Fixed-term act on the financing on sustainable forestry (renewal in process)	Enhancing production in existing forests, Increasing the harvested wood products pool, Enhanced forest management, Restoration of degraded lands, Protection of waters	CO_2, CH_4, N_2O	Economic	Adopted	The purpose of the Act is to promote economically, ecologically and socially sustainable management and use of forest. The purposes of the aids are to increase the growth of forests, maintain the road network for forestry purposes, secure the biodiversty of forests and promote the adaptation of forests to climate change.	2023	Ministry of Agriculture and Forestry	0	NE	NE	NE

NE = not estimated

4.4.7 Waste management

Policies and measures in the WM projection

A Waste Tax Act (1126/2010) entered into force at the beginning of 2011. The purpose of the Waste Tax Act is to collect tax from those waste fractions which could be technically and environmentally recovered, but which are disposed of in landfill sites. The tax list of waste is based on Commission Decision 2000/532/EC on the Waste List. The industrial landfills are also under taxation. The waste tax has been EUR 70 per tonne since 2016.

The National Waste Plan for 2027 was approved by the Government in March 2022. The National Waste Plan includes both a plan to reduce the volume and harmfulness of waste and a waste management plan. The vision of the plan is e.g. to reduce the generation of waste and increase recycling, while reducing greenhouse gas emissions. The Waste Plan proposes measures to achieve the vision and objectives.

The general reform of waste legislation has been conducted in 2021. For example, the following legislation has been amended: the Waste Act[87]; the Decree on Waste[88]; the Government Decree on Landfills[89]; and the Government Decree on Packaging and Packaging Waste[90]. For example, the reform provides the basis for more effective waste management with respect to recycling and reuse, enhanced separate collection of waste, reduction of waste generation, and further reduced landfilling of organic waste, all contributing to reduced greenhouse gas emissions. It applies to all forms of waste production and waste management. Enforcement of the amended Waste Act[91] and the Decree on Waste[92] will increase recycling and recovery. Landfilling has been reduced, and greenhouse gas emissions of the waste sector have diminished. The Decree on Packaging and Packaging Waste[93] is also intended to increase recycling.

The restrictions on the landfilling of biodegradable municipal solid and other organic wastes have been made stricter. The Decree on Landfills[94] restricts the amount of biodegradable and other organic waste to less than 10 per cent of total organic carbon or loss on ignition. These restrictions increased the incineration of waste and decreased landfilling. A Biowaste-strategy was prepared in 2004. The objective of the strategy was to ensure that the amount of biodegradable municipal waste placed in landfills would be reduced in

87 646/2011
88 978/2021
89 331/2013
90 1029/2021
91 646/2011
92 978/2021
93 1029/2021
94 331/2013

accordance with the schedule and numerical targets given in the directive on the landfill of waste[95]. Those targets were achieved and the landfilling of organic waste was heavily restricted in Finland from 2016.

The estimated total emissions reduction of waste management measures is roughly 4 million tonnes of CO_2 eq. per year.

Policies and measures in the WAM projection

The Waste Tax Act is currently being amended, and if the amendment is adopted, the amount of the waste tax will be EUR 80 per tonne from the beginning of 2023. In addition, small changes to the tax list of waste have been proposed in the same context. The changes are likely to have a minor impact on greenhouse gas emissions, but it is challenging to assess them. The impact of planned waste sector measures is therefore not included in the overall WAM projection.

Summary of policies and measures

A summary of the policies and measures in the waste sector is presented in Table 4.12.

95 1999/31/EC

Table 4.12
Policies and measures according to the WM (marked with *) and WAM projections in the waste sector

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Government decree on packaging and packaging waste 962/1997, 1025/2000, 987/2004, 817/2005, 2014/518, 1029/2021	Demand management/ reduction, Enhanced recycling, Waste incineration with energy use, Reduced landfilling	CO_2, CH_4, N_2O	Regulatory	Implemented	The Degree (1092/2021) is regulatory by specifying the essential requirements and labelling of the packaging as well as recycling targets for packaging waste, reporting oblications and requirements for organizing the reception of packaging waste. It is basically regulatory, but also economic in nature by specifying the system for the economic handling of waste obligations in terms the conditions for handling packaging waste.	1997	Ministry of the Environment	NE	IE	IE	IE
* Government decree on Landfills (861/1997) revised 2013 (331/2013), revised in 2021 (1030/2021), Biowaste strategy 2004.	Improved landfill management, Reduced landfilling	CO_2, CH_4, N_2O	Regulatory	Implemented	Regulation on landfills setting quantitative limits on amount and proportion of organic waste in land fill waste. Implementing and going beyond landfill directive.	2016	Ministry of the Environment, Regional and local environmental authorities	NE	IE	IE	IE
*Waste tax (1126/2010)	Demand management/ reduction, Enhanced recycling, Enhanced CH_4 collection and use, Improved treatment technologies, Improved landfill management, Waste incineration with energy use, Improved wastewater management systems, Reduced landfilling	CO_2, CH_4, N_2O	Regulatory	Implemented	The waste tax is EUR 70 per tonne.	2011	Ministry of the Environment	NE	IE	IE	IE

Table 4.12 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Decree on waste (978/2021)	Demand management/ reduction, Enhanced recycling, Enhanced CH_4 collection and use, Improved treatment technologies, Improved landfill management, Waste incineration with energy use, Improved wastewater management systems, Reduced landfilling	CO_2, CH_4, N_2O	Regulatory	Implemented	Decree on waste was revised in 2021. The repealed Decree was from 2012.	2021	Ministry of the Environment	NE	IE	IE	IE
* Waste Act (646/2011)	Demand management/ reduction, Enhanced recycling, Enhanced CH_4 collection and use, Improved treatment technologies, Improved landfill management, Waste incineration with energy use, Improved wastewater management systems, Reduced landfilling	CO_2, CH_4, N_2O	Regulatory	Implemented	Waste Act was revised in 2021. The Act provides the basis for more effective waste management with respect to for example reduction of the quantity and harmfulness of waste, recycling, source separation and separate collection of waste.	2021	Ministry of the Environment	NE	IE	IE	IE
* Updated National Waste Plan 2027	Enhanced recycling, Improved treatment technologies, Objectives and measures for waste management and prevention	CO_2, CH_4, N_2O	Information, Planning	Implemented	Waste plan lays down the objectives and measures for waste management and prevention in Finland to 2027.	2022	Ministry of the Environment, Regional environmental authorities	NE	IE	IE	IE
* Biowaste strategy 2004	Improved landfill management, Reduced landfilling of biowaste	CO_2, CH_4, N_2O	Information, Planning	Implemented	National strategy to reduce landfilling of the amount of biowaste. In 2006, 75% of biodegradable municipal waste will be landfilled, 50% in 2009 and in 2016, only 35% of the amount of biodegradable waste generated in 1994.	2005	Ministry of the Environment	NE	IE	IE	IE

Table 4.12 continued

Name of policy or measure/ mitigation action	Objective and/or activity affected	GHG(s) affect-ed	Type of instrument	Status of implementation	Brief description	Start year of imple-mentation	Implementing entity or entities	Estimate of mitigation impact in kilotonnes CO_2 equivalent			
								2020	2025	2030	2035
* Aggregated all implemented PAMs/WASTE	Demand management/ reduction, Enhanced recycling , Waste incineration with energy use, Reduced landfilling, Enhanced CH_4 collection and use, Improved treatment technologies, Improved landfill management, Objectives and measures for waste management and prevention	CO_2, CH_4, N_2O	Regulatory, Economic, Information, Planning, Planning	See individual PaMs	The total combination of measures directed to improve waste management and reduce GHG emissions from waste.	See individual PaMs	See individual PaMs	NE	3,825	4,077	4,295
Waste tax act amendment	Demand management/ reduction, Enhanced recycling, Enhanced CH_4 collection and use, Improved treatment technologies, Improved landfill management, Waste incineration with energy use, Improved wastewater management systems, Reduced landfilling	CO_2, CH_4, N_2O	Regulatory	Planned	The waste tax amendment. Waste tax will be EUR 80 per tonne from the beginning of 2023.	2023	Ministry of the Environment	NE	NE	NE	NE

NE = not estimated
IE = included elsewhere

4.4.8 Land-use planning and spatial structure

The development of the urban structure has long-term effects on greenhouse gas emissions from transport and buildings. The most significant solutions that concern the cutting of emissions in the urban structure are associated with sustainable urban development: the urban structure and effective functioning of urban subregions; the coordination of land use and transport; the creation of preconditions for renewable energy production; and enabling a low-emission lifestyle. In urban subregions, the preconditions for this include good public transport services and a network of pedestrian and cycling routes, a living and well-functioning city centre, and good accessibility to recreational and green areas. Effective urban subregions are a prerequisite for a thriving business life and Finland's competitiveness. There may be significant differences between the practical solutions used to reduce emissions in different parts of the country.

The preconditions for increasing wind power production include the coordination of wind power construction with land use in the surrounding areas, giving sufficient consideration for negative impacts and ensuring local acceptability. To promote planning, the Land-Use and Building Act[96] contains specific provisions on local master plans that directly apply to wind power construction. Rapid progress has been made in recent years in land-use planning for wind power construction. An amendment to the Land Use and Building Act (2017) for the installation and construction of solar panels and solar collectors harmonises and streamlines the permit procedure so that permit consideration will only be required for solar panels or collectors that have significant impacts on the townscape or the environment.

In land-use planning, Finland will prepare to extensively utilise the country's wind power potential. To minimise the negative impacts of wind power plants, the primary effort will be made to centralise wind power construction in large units at a sufficient distance from permanent housing.

Nearly all the regions in Finland and many individual municipalities have prepared their own climate strategies. However, it is difficult to provide quantitative emissions reduction potentials for the policies and measures concerning land-use planning and the urban structure. For example, the urban form influences emissions mainly in the energy sector through its effects on transport and the heating of buildings. Emissions from daily mobility especially may be many times higher in car-oriented zones than in urban centre areas. Emissions from the heating of buildings depend greatly on energy solutions for the dwelling and possible district heating. The location of a dwelling is also connected with emissions via the consumption of goods and services, as well as long leisure trips, mainly due to spatial differences in income levels. The overall reductions in emissions in different regions thus depend not only on the urban

96 132/1999

structure but on complex processes that include lifestyle changes, as well as economic conditions and development.

The land-use planning measures are included in the energy and transport sector Tables 4.2 and 4.5.

4.5 Energy taxation and related measures

4.5.1 Energy taxation

Energy taxation is a key instrument of the Government's climate and energy policy. Energy taxes are levied on electricity, coal, natural gas, peat, tall oil and liquid fuels.[97] The energy taxation of fuels is based on the energy content, life cycle carbon dioxide emissions and local emissions of fuels. The energy content component is levied on both fossil fuels and biofuels, based on their volumetric energy content. The CO_2 component is based on the lifetime CO_2 emissions of the fuel in question, and biofuels are therefore subject to a CO_2 tax rate that is reduced from 50 to 100 per cent if they meet the European Union's sustainability criteria. In connection with the excise duties on electricity, coal, natural gas and liquid fuels, the Government also collects a strategic stockpile fee, which is transferred to the National Emergency Supply Agency.

The energy tax rates of fuels used in transport are presented in Figure 4.6. The basis for calculating the carbon dioxide tax on petrol and diesel oil, as well as the corresponding biofuels, is the price of carbon dioxide, or EUR 77 per tonne, and the carbon dioxide emission coefficient specific to each fossil product.[98] The energy content tax on petrol and corresponding biofuels is EUR 0.01681 per MJ, except for small engine petrol, which has a tax reduction of EUR 0.20 per litre. The energy content tax on fossil and bio-based diesel is approximately EUR 0.0072 per MJ lower than on petrol. By imposing a lower tax on diesel, an effort has been made to reduce the costs of HGV transport and consequently the export industry, as well as bus and coach transport. Furthermore, until the end of 2022, a reduction of EUR 0.02 per litre for paraffinic fossil diesel oil and biodiesel is granted on the energy content tax, as the fuels have lower local emissions than conventional fossil fuels. Fuels for commercial aviation and shipping are exempt. Gas oil used in rail transport is taxed at a lower rate; the rate on light fuel oil and electricity used in rail transport is exempt.

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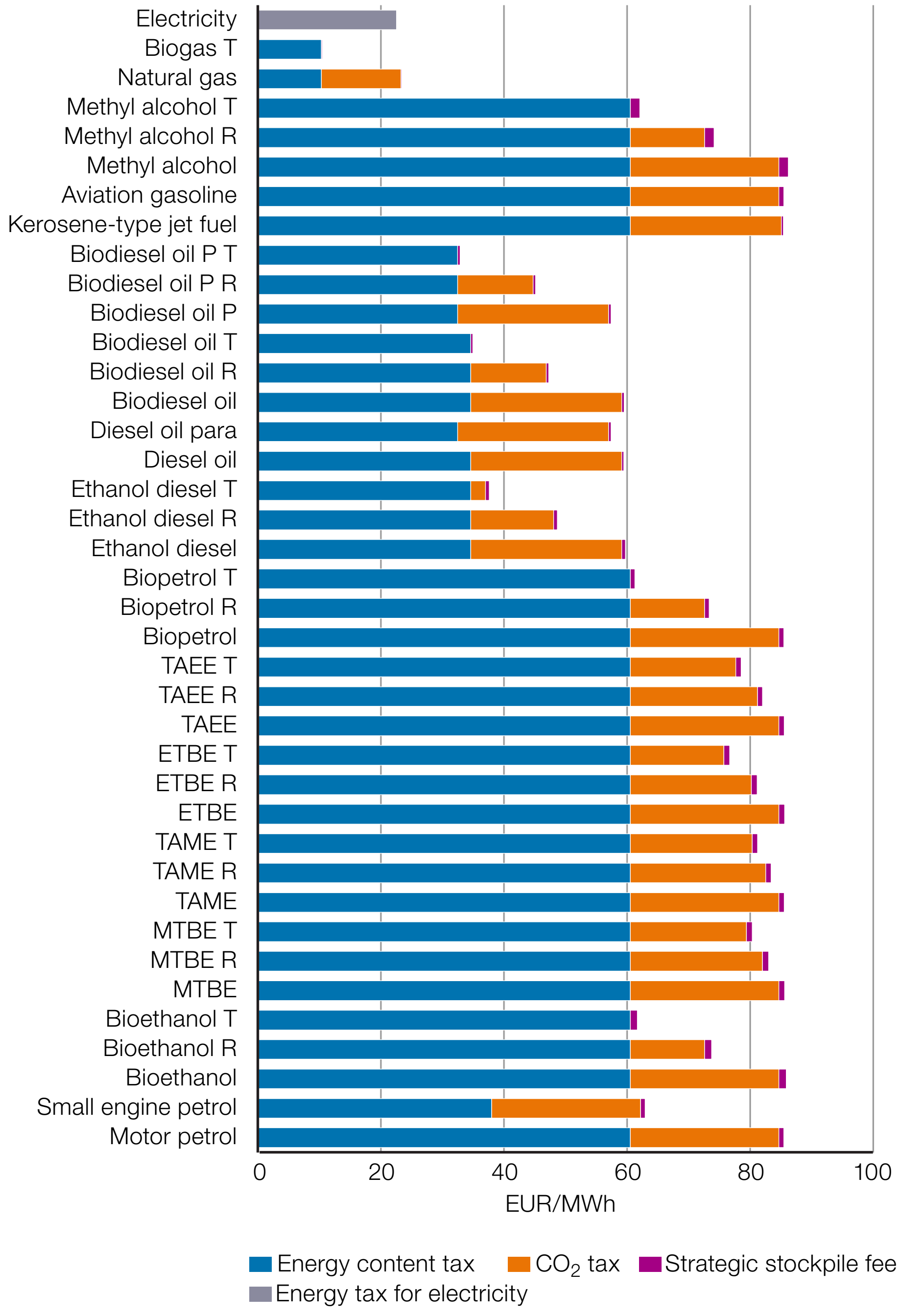
97 1260/1996 and 1472/1994

98 As the carbon dioxide tax also factors in the fuel's life cycle carbon dioxide emissions, the price per tonne of carbon dioxide used in the calculation of the CO_2 tax (EUR 77) should be increased by approximately 20 per cent to be comparable to the price of carbon dioxide tonnes calculated based on emissions from combustion alone.

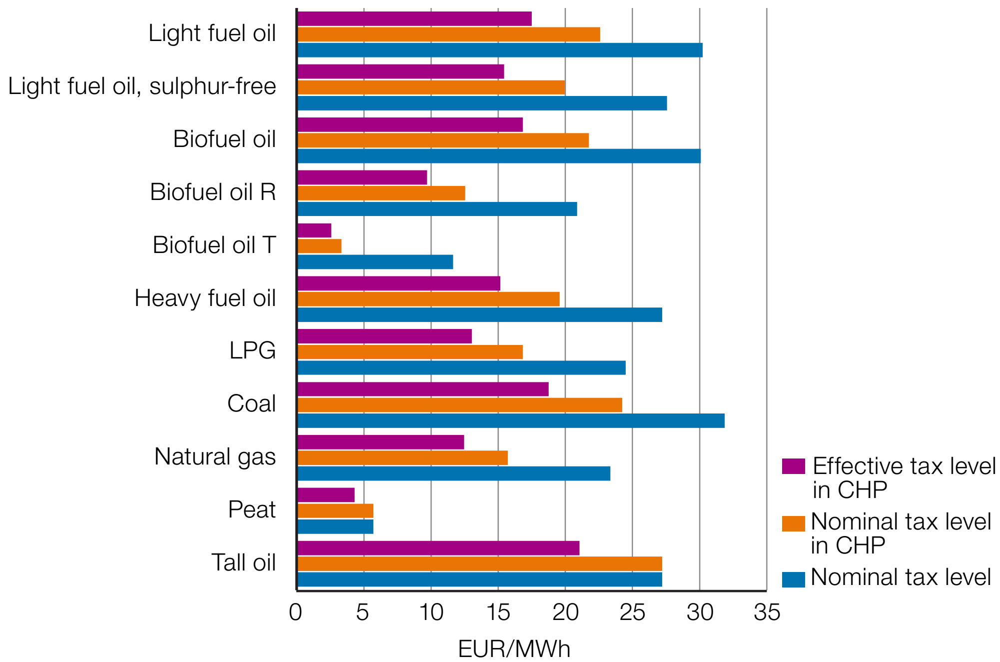
Figure 4.6
Energy tax rates of fuels used in transport in 2022



As the energy content tax on diesel is lower than the environmental criteria of the tax require, and there are no other environmental or other grounds for favouring diesel cars, diesel-powered cars are subject to the tax on driving power as part of annual vehicle tax. It complements fuel taxation and harmonises the cost differences for motorists, arising from the different tax treatment of petrol and diesel based on the average annual transport performance. In addition to diesel cars, the tax on driving power is levied on cars fuelled by other driving powers such as electricity or gas, whose taxation is based on less stringent criteria than the taxation on petrol. Tax on driving power for passenger cars is set as cents per day for each partial or complete 100 kilograms of total vehicle mass. The tax level is 5.5 cents for diesel, 1.5 for electricity, 0.5 for electricity and petrol, 4.9 for electricity and diesel, and 3.1 for methane.[99]

Energy tax rates for fuels used for heating, as well as in power plants and mobile machinery, which are later referred to as heating fuels, are presented in Figure 4.7. The value used in the calculation of the carbon dioxide tax is EUR 53 per tonne of carbon dioxide, and the energy content tax is EUR 10.33 per MWh. As the taxation of peat and tall oil is not based on the environmentally related tax model, they are subject to a separate energy tax rather than the energy content and carbon dioxide taxes. In addition, peat is only subject to tax for the part exceeding 10,000 MWh per plant.[100] Tall oil used for heating is subject to excise duty equivalent to that on heavy fuel oil. The purpose of the tax is to encourage the further processing of tall oil as a chemical industry raw material rather than using it for energy. Gaseous and solid biofuels in heating use are exempt. For professional agriculture, the energy content tax component included in the price of light fuel oil, heavy fuel oil, and biofuel oil is refunded.[101]

Figure 4.7
Energy tax rates for fuels used for heating, as well as in power plants and mobile machinery in 2022



99 [1281/2003]

100 The limit for tax-free use of peat for energy will be 10,000 MWh per plant for the period between 2022 and 2026, and 8,000 MWh per plant for the period between 2027 and 2029. From 2030, peat will be subject to a tax in heat production when used in a power plant or heating plant whose peat use exceeds 5,000 MWh.

101 [603/2006 https://finlex.fi/fi/laki/ajantasa/2006/20060603]

The fuels used to produce electricity are exempt from tax in both separate condensing power plant production and CHP. Electricity consumption is subject to tax, and taxes are levied on all electricity, regardless of the production method.[102] The tax exemption for fuels used to produce electricity is based on the EU Energy Taxation Directive and motivated by the need to coordinate the functioning of the electricity market and taxation, especially in the import and export of electricity. The excise duty on electricity is differentiated into two categories. Category I tax is generally levied on business activities such as services, forestry, and construction, as well as on electricity used in the public sector and households. Category I electricity tax is EUR 22.4 per MWh. The lower Category II tax covers electricity consumption in industry, mining, data centres, and greenhouses, as well as electricity supplied to certain heat pumps, electric boilers, and recirculating water pumps. While other areas of agriculture also fall into tax Category II, this reduction takes the form of an energy tax refund for agriculture. Category II electricity tax is EUR 0.5 per MWh.

Energy-intensive industry (including mining and greenhouses) is eligible for a tax refund insofar as the amount of excise duties included in the price of taxable energy products used or purchased by it, other than electricity, transport, and machinery fuels, exceeds 1.7 per cent of the company's value added. In this respect, the company is eligible for an 85 per cent refund of the excise duties it has paid. However, a contribution of EUR 50,000 is deducted from the refund. Under the currently valid act, the tax refund for energy-intensive enterprises will be phased out gradually by 2025.

Taxation is included in the mitigation measure tables for the energy and transport sector, ie. Table 4.2 and 4.5. In the WM and WAM projections, the taxation structure and levels remain constant as they are in 2022 as there is no plans of changes at the present.

4.5.2 Government expenditure on energy and climate policy

The Finnish government supports the transformation to a greener economy with a variety of different subsidies. The total Government expenditures on energy and climate policy have increased significantly in recent years, with the budget for 2022 being EUR 2,554 million. This expenditure covers a wide range of sectors, and the largest outlays are in subsidies given to energy and agriculture.

Government appropriations for the energy and climate policy are discussed, and the relevant decisions are made within the central government spending

102 However, exemptions apply to small-scale electricity production for one's own use. If electricity generated in a micro or small power plant is transmitted through the electricity grid for consumption, however, the tax exemption is not transferred with the electricity, and the network operator transmitting the electricity for consumption is liable to pay Category I or II energy tax on it.

limits in the General Government Fiscal Plan, coordinated with the public economy's other expenditure needs.

One of the main ways in which the Government supports the transition to greener energy production is a direct subsidy for projects that aim to cut emissions at the firm or municipality level ("Energy Subsidy"). The current total level of this subsidy is EUR 230 million for 2022 (including RRF[103] funding), which is substantially higher than just a few years ago, when it was around EUR 50 million.

In addition, there have been separate fixed-term aid schemes for renewable energy and additional budget authorities for different large demonstration projects. As renewable energy has become more profitable, direct subsidies for renewable production have decreased. These energy-related measures include the Government's key projects related to energy (in total, EUR 100 million between 2016 and 2018), energy projects replacing coal (in total, EUR 90 million between 2020 and 2021), and current Recovery and Resilience Facility (RRF) energy projects (around EUR 500 million between 2022 and 2023) and large demonstration projects. Initially, a total of EUR 200 million was earmarked for large demonstration projects in the period from 2019 to 2022. The Ministerial Working Group on Preparedness decided to increase the budget authority for the energy aid item for the period from 2022 to 2023 by a total of EUR 150 million. At the same time, an additional budget authority was decided for hydrogen projects (EUR 150 million) and battery ecosystem projects (EUR 50 million). The development is partly based on the policies of the previous climate and energy strategy on shifting the focus of renewable energy subsidies from production subsidy type aid schemes to supporting new technologies. In addition, the number of projects has increased significantly and national targets have become stricter.

On top of these subsidies, the Government also actively provides support for R&D projects and rail projects and funding for private sector projects that aim to cut emissions. While this support is divided over several smaller measures, they amount to a total of several hundred million euros annually.

Table 4.13 shows a compilation of funding related to the energy and climate policy from 2018 to 2022 under the General Government Fiscal Plan.

103 EU's Recovery and Resilience Facility

Table 4.13
Funding under the current General Government Fiscal Plan in accordance with the Government report on the National Energy and Climate Strategy for 2030.

Appropriation	2018	2019	2020	2021	2022
	EUR million				
Ministry of Economic Affairs and Employment					
Energy aid	58	47	61	101	231
Investment and operating subsidies for renewable energy and new energy technologies	354	215	337	294	135
Subsidies for green R&D and innovation	120	121	130	143	176
Other measures	189	146	155	180	190
Ministry of Agriculture and Forestry					
Agri-environment payment measures	218	218	185	236	263
Other measures	313	313	398	353	413
Ministry of Transport and Communications					
Investment in rail infrastructure	0	0	8	26	123
Other measures	150	127	521	267	281
Ministry of the Environment					
Investment subsidies for lower emission heating systems	65	70	306	261	323
Other measures	85	86	116	105	105
Ministry for Foreign Affairs					
Development aid for environmental, water and energy related projects	144	159	199	266	283
Other measures	65	70	236	186	184
Total appropriations	**1,761**	**1,573**	**2,651**	**2,418**	**2,706**

4.6 Use of Kyoto mechanisms

The Kyoto Protocol includes the use of project mechanisms (the Clean Development Mechanism (CDM) and Joint Implementation (JI)) or acquisition assigned amount units (AAU) through international emissions trading (JI) or acquisition assigned amount units (AAU) through international emissions trading.

Finland's Government activities to provide Kyoto mechanisms started in the form of the CDM/JI pilot programme from 1999 until early 2006, followed by the Kyoto mechanism purchase programme that covers the period from 2006 to 2020. The total budget for the acquisition of emissions reductions from the Kyoto Protocol flexible mechanisms has been approximately EUR 70 million. The programme includes 10 bilateral projects and investments in several multilateral carbon funds.

In total, in the first Kyoto commitment period, Finland procured approximately 6.2 million tonnes of project units. These units have been carried over to the second commitment period.

4.7 Effect of policies and measures on longer-term trends

Finland has a long tradition of assessing longer-term energy and climate development. The Government's Foresight Report on Long-Term Climate and Energy Policy (published in 2009) highlighted possible paths to a low-carbon Finland. Moreover, the report of the parliamentary committee from 2014, the Energy and Climate Roadmap 2050, analysed the means of constructing a low-carbon society and achieving an 80 to 95 per cent reduction in greenhouse gas emissions from the 1990 level in Finland by 2050. The background material for the 2014 roadmap included four scenarios on alternative development paths for a low-carbon society until 2050 made by the Low Carbon Finland 2050 platform research project. Finland's target of carbon neutrality by 2035 was officially laid out as part of the Government Programme in 2019. The target is reflected in the Long-Term Strategy (LTS), which was submitted to the UN and EU in 2020 and contains updated possible scenarios for how to achieve the target. The latest Climate and Energy Strategy prepared in 2022 is also closely tied to the carbon neutrality target and includes the most recent scenarios assessing if the target can be achieved with the current existing and additional policy measures.

A large proportion of current Finnish climate and energy policies also contributes to reducing greenhouse gas emissions in the longer term, in particular when they are based on creating structural changes in the respective systems. For example, buildings have long lifetimes, and the regulations for improving the energy efficiency of new and existing buildings will therefore have long-lasting impacts.

Land-use planning also yields permanent emissions reductions in buildings and transport, for example, by allowing the use of low-emission heating modes or improving the possibilities for walking, cycling, and using public transport. However, the actual emissions reductions will depend on a large array of factors, including general economic development.

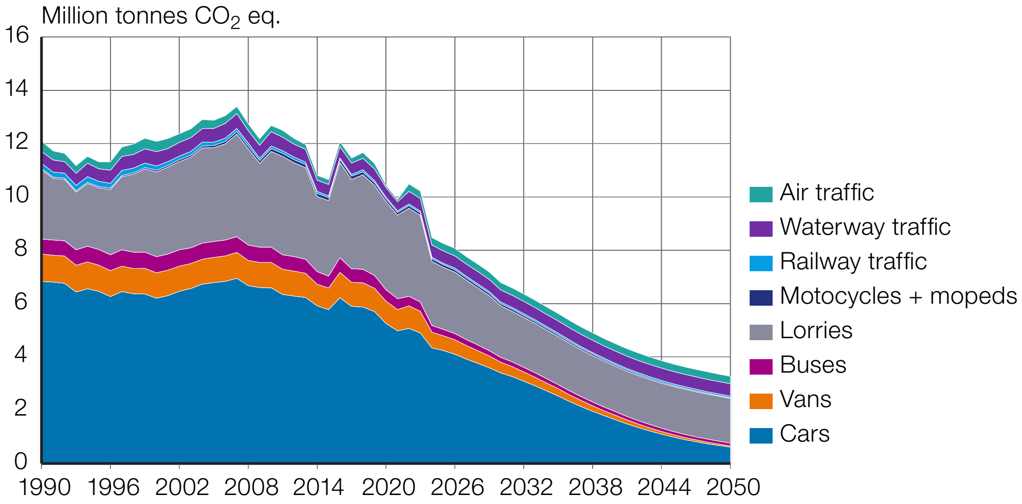
Investments in the energy infrastructure have long lifetimes. Measures that promote investment in renewable energy and improve the competitiveness of renewable energy sources will therefore reduce greenhouse gas emissions in the longer term. Measures that would in principle contribute to emissions reductions only if the measure is ongoing, such as feed-in tariffs for renewable energy, also have long-term emissions reduction effects, provided the measure has triggered investment.

Prohibiting uses of certain F gases and the replacement of F gases with low GWP alternatives or halting the disposal of biodegradable waste on landfills can be expected to lead to permanent changes in current practices, and therefore to yield permanent emissions reductions.

Since 2022, the impact of policies and measures on the longer-term trend in greenhouse gas emissions from road transport have been calculated using a new standalone model called ELIISA, which is an upgraded version of its predecessor ALIISA. ELIISA computes the development of the vehicle fleet, kilometrage, consumption and greenhouse gas emissions (including CO_2, CH_4 and N_2O) until 2050. ELIISA considers all possible powertrain options for vehicles in Finland. The changes in the vehicle fleet are based on the estimated annual sales of new vehicles and imported vehicles and the vehicle scrappage rate. Fuel and energy consumption estimates are based on actual fuel sales.

According to the projections, transport volumes continue to grow over the forecast period, whereas the GHG emissions start to decline (see Figure 4.8). The main reasons for emissions reductions are the replacing of fossil fuels with alternative transport fuels and improving the energy efficiency of the vehicles and the transport system.

Figure 4.8
Projection of the longer-term trend in greenhouse gas emissions in transport



4.8 Mitigation benefits other than greenhouse gas reduction

Environmental impact assessments (EIAs) have been made for all of Finland's national energy and climate strategies and for the Medium-Term Climate Change Policy Plan. The EIAs include a general examination of the benefits and adverse impacts of the strategies and the Medium-Term Climate Change Policy Plan, specifically evaluating the relationship between measures for climate mitigation and air pollution. In addition to climate change and air pollution, the National Climate and Energy Strategy and the Medium-Term Climate Change Policy Plan affect biodiversity and waters, natural resources use, and people's health and living conditions.

If the current climate targets are accomplished, they will have both positive and negative impacts on the environment and society. Positive impacts entail consequences that promote the achievement of the set societal objectives, whereas negative impacts entail consequences that hamper the achievement of objectives other than the climate targets in the previously mentioned sectors.

The most significant environmental impacts concern air pollution, biodiversity, forest carbon sinks and waterbodies. These environmental impacts are linked to people's health, comfort, and wellbeing, and they can also be influenced by the policies or economic instruments used to implement them, such as taxes and charges. These impacts are also closely linked to the overall acceptability of measures, perceived social fairness, and overall sustainability as part of the transition to a carbon neutral society. Some of these impacts will also be felt outside Finnish borders.

As a rule, the achievement of climate targets is expected to have positive environmental impacts when climate change mitigation is successful in preventing the extensive, partly irreversible, and unpredictable impacts of climate change on the environment and society. However, many measures also come with adverse effects such as the significant amounts of natural resources required for new infrastructure.

The amount of air pollution is expected to decrease. However, the risks for health caused by air pollution remain significant. At present, the emissions from power plants have only a small effect on air quality.

The largest domestic emissions sources are small-scale burning of firewood and street dust, to which current climate measures are not significantly connected. In addition to methane and black carbon, which contribute to global warming, small particles with negative health impacts are also released from small-scale wood burning. Small-scale wood burning does not cause notable changes to the present state, and it is possible to affect the emissions by technical standards, innovations, and information guidance. In the scenarios modelled in connection with the Climate and Energy Strategy, small-scale burning is expected to decline from 2020 levels in both the base (about five per cent) and policy scenario (about 20 per cent by 2040).

Exhaust emissions from transport have already significantly decreased and will continue to decrease as engine technology develops. Therefore, future changes in the driving power of vehicles will not have a significant impact on particulate matter emissions from exhaust gases. However, nitrogen oxide emissions will decrease as the use of electric cars replaces petrol and diesel cars, especially in passenger car transport. The impact of transport-related air pollution on the air quality of cities and the exposure of humans to air pollution will ultimately depend on the development of vehicle performance, regional distribution, and community structure.

The current policies point to increasing the use of biofuels in transport, buildings, and machinery through distribution obligations. The scale of the impacts of biofuel production will greatly depend on the raw materials used and the total resources needed for the production of biofuels, such as energy, materials, and productive land area. The main domestic feedstocks in the future biofuel production in Finland are expected to be e.g. biodegradable wastes, forest industry residues such as sawdust, other industrial residues, and logging residues. By using biofuels made from domestic raw materials, Finland can reduce its dependence on crude oil.

However, the growing share of renewables results in greater demand for forest-based bioenergy, even though most of the wood-based energy use comes in the form of by-products and sidestreams from the forest industry. This adds to the pressure to increase felling and collect logging residues, which can reduce the carbon sink of forests and add to the risk of biodiversity loss and harmful impacts on waterbodies. These impacts will strongly depend on the extent to which the felling and harvesting of stumps and felling residues will increase because of increased wood use. Felling, fertilisation and ditch reconditioning are some of the key factors among measures on agricultural lands in causing stress to water systems. Key measures for preventing biodiversity loss include saving more dead trees in felling, promoting the conservation of old-growth forests and sites of high natural value, avoiding harvesting on valuable natural sites, leaving more large live trees standing in regeneration felling and burning for environmental management purposes.

4.9. Minimising the adverse effects of policies and measures in other countries

Finland has provided information on the minimisation of adverse impacts in accordance with Article 3, paragraph 14 in previous national inventory reports and national communications in accordance with the guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol (Decision 15/CMP.1, Section I. H. and in paragraph 36 in Section II. G.). The main principles of minimising adverse impacts have not changed since the previous National Communication. The information provided in Finland's 7th National Communication and the previous inventory are incorporated in this communication.

Finland strives to implement its commitments under the Kyoto Protocol so that social, environmental and economic impacts on other countries, and especially developing countries, are minimised. Applicable notification requirements under international trade conventions are also followed. Finland takes knowledge and understanding of the possible adverse impacts of its measures into account, based on the available information received from other Parties.

All major policies and activities undergo environmental impact assessments, including impacts on other countries. Environmental impact assessments have been performed for Finland's national energy and climate strategies. The assessments have qualitatively identified the kind of impact the measures may have. A life cycle analysis of fuel import takes impacts arising beyond Finnish borders into account. Finland has also participated in the work on developing sustainability criteria for biofuels through scientific studies. In line with the most recent energy and climate strategy, the identified potential adverse environmental impacts due to the increased use of bioenergy are addressed as early as possible.

Finland's development policy includes both climate change mitigation and adaptation in developing countries (see Chapter 7 of Finland's 8th National Communication for more details). Climate financing is part of Finland's development cooperation funding, and disaster risk management is also covered by our development cooperation.

The overall aim of Finland's development policy is to reduce poverty and inequality in the context of sustainable development. With its development policy, Finland supports the realisation of human rights, the rules-based multilateral system and the Sustainable Development Goals (SDGs) adopted by the UN. Finland's international cooperation and actions are grounded in the UNFCCC, the Kyoto Protocol and the Paris Agreement on Climate Change and the goals of the 2030 Agenda for Sustainable Development. The cross-cutting objectives that Finland promotes through its development policy include gender equality, non-discrimination, climate resilience and low emission development, as well as protection of the environment, with an emphasis on safeguarding biodiversity. The integration of climate change has been one of the cross-cutting objectives of Finland's development policy and development cooperation since 2012. Overall, Finland's development cooperation aims to strengthen developing countries' own capacities and resilience.

Finland supports developing countries by helping them build their capacities and develop their economic infrastructure, thereby helping them diversify their economies and improve energy efficiency and renewable energy production. Economic diversification and private sector development are particularly important targets in various Finnish bilateral programmes and Finnish-supported multilateral programmes in developing countries. A regional programme that promotes the role of the private sector in providing energy services is being funded in Sub-Saharan Africa. Through funding to the Partnership for Market Implementation, a multi-donor fund managed by the World Bank, Finland supports carbon pricing in developing countries, thus steering companies and societies on a low-emission path.

As one of its core objectives, Finland's development policy seeks to diversify the economies of developing countries, including developing countries that are highly dependent on the export and consumption of fossil fuels. Finland supports the business environment of developing countries through legal and regulatory reforms, as well as economic infrastructure. Finland also provides direct support to companies active in developing countries. Recently, the direct support instruments that strengthen private sector financing, capacity, and global technology and trade networks have especially been developed further and have received additional financing.

Finland and the International Finance Corporation (IFC) have developed the Finland-IFC Blended Finance for Climate Program (EUR 114 million) to spur private sector financing for climate change solutions in low-income countries. Furthermore, Finland has joined Asian Development Bank's Ventures Investment Fund in 2020 by investing EUR 20 million in the fund. The fund provides financing to early-stage and growth companies applying technology-enabled climate mitigation solutions in Asia. The Finnish government-owned financial institution, Finnfund, also makes investments in renewable energy, sustainable forestry, and other sectors in developing countries that help reduce greenhouse gas emissions.

Among the actions listed in the Annex to Decision 15/CMP.1, Part I.H, "Minimisation of adverse impacts in accordance with Article 3, paragraph 14", Finland especially prioritises the following actions:

- Action (a): Finland has addressed the progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions, and subsidies in all greenhouse-gas-emitting sectors
  - Domestically, with a major revision of energy taxation (2011), after which fuels are taxed broadly and explicitly based on their energy and fossil carbon content and emissions over the whole lifecycle. The revised energy tax structure takes the sustainability of biofuels directly into account and does not include energy tax rate differentiation between business and non-business use. However, certain sectoral exceptions remain. Energy tax rates in Finland are among the highest in the world.
  - In its development policy, by including in the support provided to developing countries through multinational development banks criteria that are targeted at removing subsidies for fossil fuels and ending financing to new coal power plants, while promoting the achievement of climate neutrality by 2050. Additionally, Finland supported the work of the Partnership for Market Readiness, a multi-donor trust fund, between 2012 and 2020 and has supported the successor programme (Partnership for Market Implementation) since 2021. Both support developing countries' design and deployment of carbon pricing and carbon. Market instruments facilitate the reduction of emissions. The revenue from carbon pricing can be used to minimise potential adverse impacts from response measures.

- Action (f): Finland has assisted developing country parties that are highly dependent on the export and consumption of fossil fuels in diversifying their economies in several projects:
  - Through the Energy and Environment Partnership (EEP) Trust Fund, Finland supports early-stage companies in developing, delivering, and scaling up appropriate and affordable renewable energy and energy efficiency technologies for improved energy access and local employment. A Finnish-supported EEP programme is being implemented in Southern and Eastern Africa.
  - Through Finnfund and the Finland-IFC Blended Finance for Climate Programme, private sector financing for climate change solutions is incentivised in low-income countries. In addition, through the Asian Development Bank's Ventures Investment Fund, Finland provides funding for early-stage and growth companies in seeking new climate mitigation solutions in Asia.
  - Through the Global Environment Fund (GEF) and the Green Climate Fund (GCF) (the Operating Entities of the UNFCCC Financial Mechanism), Finland supports developing countries' efforts to improve energy efficiency, transition to cleaner sources of energy, introduce more sustainable transport, and preserve and restore carbon sinks.

More details on the actions Finland is taking to minimise the adverse impact of response measures in developing countries are provided in Table 4.14 below.

Finland promotes policy coherence for sustainable development at the national, EU, and global levels. Policy Coherence and global partnership are among the key policy principles in the Government Report[104] submitted to Parliament in 2020 on the implementation of Agenda 2030. Finland's Development Policy is largely based on Agenda 2030. Policy coherence on themes such as food security, trade and development, tax and development, and security and development have been strengthened both nationally and internationally.

Finland has consistently and in the long term worked to reform harmful fossil fuel subsidies for both climate and wider environmental, social, and economic reasons. We are part of the Friends of Fossil Fuel Subsidy Reform (FFFSR), playing an active role in all relevant policy arenas on behalf of reform. The latest achievement in which the FFFSR has played a key role is a ministerial statement on fossil fuel subsidies reform launched among 37 WTO members in December 2021. The European Union, and Finland as its Member State, co-sponsors the ministerial statement. This statement will help anchor and guide FFFSR-related work in the WTO.

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Table 4.14
Summary of specific actions to minimise the adverse impact of response measures in developing countries

Action	Implementation in Finnish policy
(a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking the need for energy price reforms to reflect market prices and externalities into account.	These factors are considered for all greenhouse gas emitting sectors, with consideration of national preferences and circumstances and the need for economic efficiency and feasibility. Various methodologies, including economic modelling, are used in the planning of economic instruments.
	Starting in January 2011 Finland made a major revision in energy taxation according to which all fuels are taxed based on their energy and fossil carbon content.
	Finnish development policy guidelines for support to developing countries through multinational development banks include criteria that target the removal of fossil fuels subsidies and the phasing out the support to fossil-fuel-fired investment by 2050. Finland is a member for the Friends of Fossil Fuel Subsidy Reform group. Support for PMR (2012 to 2020) and PMI (2021 onwards).
	Finland is committed to ending financing for new unabated thermal coal power projects overseas.
(b) Removing subsidies associated with the use of environmentally unsound and unsafe technologies.	Finland has no support activities in this field.
(c) Cooperating in the technological development of non-energy uses of fossil fuels and supporting developing country Parties to this end.	Finland has no support activities in this field.
(d) Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil fuel technologies, and/or technologies, related to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort.	Finland has no any support activities in this field.
(e) Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities related to fossil fuels, considering the need to improve the environmental efficiency of these activities.	Finland has no any support activities in this field.

Action	Implementation in Finnish policy
(f) Assisting developing country Parties that are highly dependent on the export and consumption of fossil fuels in diversifying their economies.	Action has been undertaken both through support by international organisations such as UNCTAD (United Nations Conference on Trade and Development) and through bilateral and multilateral partnerships. For example, the Green Climate Fund, to which Finland contributes, reduces risks for investors in developing countries to attract global financial flows and to shift private investment to renewable energy-based power systems. The GEF, on the other hand, contributes to mainstreaming mitigation concerns in sustainable development strategies and promoting innovation and technology transfer for sustainable energy breakthroughs.
	Finland is supporting early-stage companies to provide access to renewable energy through the Energy and Environment Partnership (EEP) Trust Fund in Southern and Eastern Africa. Similar programmes in the Mekong Region, Central America, the Andean Region and Indonesia have been successfully completed.
	Finland is also supporting early-stage and growth companies in reducing greenhouse gas emissions through Asian Development Bank's Ventures Investment Fund. It provides funding for applying technology-enabled climate mitigation solutions in Asia.
	The Finnish government-owned financial institution, Finnfund, invests, among others, in renewable energy, sustainable forestry, and other sectors in developing countries to help reduce greenhouse gas emissions. The Government supports Finnfund financially by providing the financial institution with loans, capital injections, and a special guarantee instrument targeted at high-risk projects.
	The Finland-IFC Blended Finance for Climate Programme (EUR 114 million) has been designed to spur private sector financing for climate change solutions in the least developed countries, other low-income countries, and lower-middle income countries and territories. The projects have thus far focused on climate change mitigation (renewable energy and energy efficiency in buildings)

4.10 Policies and measures no longer in place

Finland reports a total of 114 individual or groups of policies and measures in the tables in Chapter 4. 84 of these are fully or mainly implemented, eight adopted, one has expired, and 21 are planned. Regarding the Seventh National Communication, there are a further 52 measures in this reporting. Some regrouping of measures has been done for this reporting. In some cases, measures that have been implemented since the last reporting have now been merged with previous existing measures of the same type, and some measures have been removed since the last reporting. In some sectors, the impact assessment has developed to enable the emissions reduction impact of measures to be calculated at a more detailed level than in the Seventh National Communication. For road transport, for example, more single measures are reported in the transport sector table now than previously, when they were reported more in groups. Consequently, the number of measures itself gives no indication of the climate policy ambition level.

In the agricultural sector, the Climate Programme for Finnish Agriculture – Steps towards Climate Friendly Food is no longer valid. The programme has been replaced partly by the new CAP strategic plan, the Medium-Term Climate Change Policy Plan, and the Climate-Friendly Food Programme, which is currently under preparation.

The Decree of the Ministry of the Environment on the energy efficiency of new buildings 1010/2017 entered into force on January 1, 2018. The building regulations that preceded the new regulation (2003, 2008, 2010, 2012) have expired. Although the building regulations in force in 2003, 2010, 2008, and 2012 are no longer valid, their effects continue as long as the buildings affected remain in use.

Other expired measures are the car scrapping premium campaigns that took place in 2020 and 2021. The campaigns were reported in the Fourth Biennal Report but not yet in the Seventh National Communication. A new car scrapping premium campaign is included in the WAM projection of this reporting.

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Photo: IStock.com

5

Projections and total effect of policies and measures

This chapter describes projections on Finnish greenhouse gas emissions and how the emissions are influenced by various factors such as energy consumption, production and policies and measures. Two projections are presented: ‘with measures’ and ‘with additional measures’, to show the projected greenhouse gas emissions from Finland up to 2035. The chapter also describes the total effect of policies and measures and supplementarity relating to Kyoto Protocol mechanisms. The chapter ends with a description of a sensitivity analysis of the projections and the methodology used in developing them.

5 Projections and total effect of policies and measures

5.1 Overview of WM and WAM projections

The projections presented in this chapter are based on data produced for the National Energy and Climate Strategy, the Medium-term Climate Change Policy Plan and the Climate Plan for the Land Use Sector. All three Government Reports were submitted to Parliament in 2022. For the reports, comprehensive modelling and assessments were conducted by experts from various research fields in an extensive project “Carbon neutral Finland 2035 – measures and impacts of the climate and energy policies” (HIISI project) financed by the Government’s analysis, assessment and research activities. The analysis and results of the HIISI project have been complemented by other studies and updated with recent information and data.

The projections’ starting point is 2020 (the most recent inventory year available in the annual greenhouse gas emission inventory submission to the UNFCCC in 2022). Policies and measures that have been implemented by July 2022 are included in the “With Measures” (WM) projection. The “With Additional Measures” (WAM) projection includes in addition policies and measures that are planned but not implemented before 1 August 2022. The policies and measures included in the WM and WAM projections, including estimated impacts on greenhouse gas emissions, are presented in more detail in Chapter 4. A pure “Without Measures Projection” (WOM) is not applicable for Finland’s national circumstances and has therefore not been provided: mitigation policies and measures (such as measures related to energy efficiency improvements and use of renewable energy) have been implemented since the 1970s; any WOM projection created based on previous climate and energy strategies (e.g. 2016, 2013, 2008, or 2005) would therefore be very complicated and require significant effort, particularly in predicting the industrial structure. The technology development outlook in the energy sector would also be quite different without the current emissions trading system and binding renewable energy targets set by the EU. In other words, the outcome would be a quite arbitrary WOM projection. A more reliable and suitable approach is to compare current projections with WM projections from previous years. This is done in Section 5.4.

Most of the measures included in the WAM projection of the Seventh National Communication have been implemented and are now part of the WM projection. The most significant implemented new policy measures affecting future emissions compared to the Seventh National Communication are the group of measures promoting emissions-free and energy-efficient road transport, ban on energy use of hard coal, measures phasing out oil heating, and several new measures in agriculture, LULUCF and machinery.

The “With Additional Measures” projection (WAM) includes only a few measures additional to the WM projection, as the National Energy and Climate Strategy, the Medium-term Climate Change Policy Plan and the Climate Plan for the Land Use Sector have recently been approved, and most new measures are therefore adopted or implemented and included in the WM projection. The WAM projection includes the estimated impact of planned future measures regarding F-gases and in the agriculture and transport sectors. These WAM measures are described in Chapter 4.

Statistics Finland’s population forecast is used in the projections. The forecast, published in 2019, estimates that the population will increase only slightly from the current 5.53 million (2020) to 5.57 million in 2030. Based on the current development, Finland’s population will start decreasing in 2031. In 2050, the population will be some 100,000 lower than today. The average size of households will decrease slightly, while the number of households is expected to grow from 2.7 million to almost 2.9 million during the period. In this population forecast, the population is smaller and flattens out and starts to shrink, contrary to the forecast used in the projections for the Seventh National Communication, which anticipated continuous growth.

The economic outlook provided by the Ministry of Finance forms the basis for the estimate regarding the development of the Finnish economy in the near future, whereas longer-term development assumptions are based on the “What kind of expertise will Finland need in 2040?” report of Pellervo Economic Research PTT and Merit Economics[1], which has been complemented and updated in the HIISI project with industry-specific low-carbon strategies and recent energy and climate policies and measures. The macro-economic projections are described in the report “Macroeconomic scenarios: Carbon neutral Finland 2035 – measures and impacts of climate and energy policies”[2].

The Covid-19 pandemic and its assumed effects on the economy have been considered in the modelling. In contrast, the energy crisis following Russia’s unprovoked and unjustified invasion of Ukraine has not been included in the projections, as most of the modelling work was conducted before February 2022. For the LULUCF sector, the most recent results from the national forest inventory on a decline in tree growth were not yet available when the latest annual greenhouse gas inventory submission and the WM projection for the LULUCF sector were prepared (See Section 3.1). Thus, the estimates of carbon removals in the LULUCF sector will be re-evaluated in future.

1 Millaista osaamista Suomi tarvitsee 2040? What kind of expertise will Finland need in 2040? (in Finnish). PTT Reports 269. https://www.ptt.fi/julkaisut-ja-hankkeet/kaikki-julkaisut/millaista-osaamista-suomi-tarvitsee-vuonna-2040.html

2 Macroeconomic scenarios: Carbon neutral Finland 2035 – measures and impacts of climate and energy policies, Publications of the Government’s analysis, assessment and research activities 2021:65. http://urn.fi/URN:ISBN:978-952-383-295-4

According to the Ministry of Finance's forecast used in the modelling of the projections, economic growth would recover during 2021, but remain modest at first thereafter. During the 2020s, the world economy was expected to recover from the pandemic, which would also begin to impact Finland. It was assumed employment would recover during 2021, but towards the end of the decade, the shrinking working-age population would result in no new growth through labour input. Economic growth therefore depends on technological development and investment. By 2030, the projections expect technological development to generate growth of about 10 per cent compared to 2019 and about 20 per cent by 2040. Growth through capital is about half this. The average GDP growth rate is about 1.5 per cent, but per capita GDP growth will remain at 1.2 per cent. The conditions for economic growth will improve in the 2030s, so GDP growth may also be higher.

Regarding the forest industry, the growth assumptions are based on several sources, of which one of the most essential is the expertise of Pöyry Management Consulting, published in the "Suomen metsäteollisuus 2015–2035" report (Finland's forest industry 2015 to 2035)[3]. As some of the information is starting to be somewhat outdated, it has been updated and complemented by other sources that consist of two low-carbon roadmaps published in 2020 by the Finnish Forest Industries Federation and the Finnish Sawmills association and the expertise of Natural Resources Institute Finland (Luke). Pöyry bases its assessment on regional and global demand projections of pulp, paper, and wood products, the competitiveness of production facilities in Finland, and investment plans published by the forest industry. The Finnish Forest Industries' roadmap mainly follows the Pöyry report, but some production volumes have been updated in accordance with the association's more recent views. The Finnish Sawmills roadmap focuses only on the sawmill industry, whereas the experts from Natural Resources Institute Finland (Luke) provide valuable insights into recent changes in paper production capacities, capacity-derived production volumes, and how they will develop in the future. Compared to the figures used in the projections of the Seventh National Communication, the estimated production of printing and writing paper is 1.2 million tonnes lower in 2035, a total of only 2.1 million tonnes. The volume of sawmill products is also expected to be smaller than the previous estimate, whereas the production of other papers is expected to be 0.9 million tonnes higher than previously estimated, i.e. 6.1 million tonnes in 2035. The total volume of paperboard and corrugated cardboard is expected to be some 0.4 million tonnes lower in 2035 and that of market pulp 1.0 million tonnes higher than in the Seventh National Communication. The most remarkable difference between the new and previous projections is a new category, so-called new products, which consists of biomass-based biofuels, chemicals, bioplastics, and textiles, and which has the projected total volume in 2035 of 2 million tonnes.

3 Suomen metsäteollisuus 2015 – 2035 (Finland's forest industry 2015 to 2035) Final Report X304203, 19 January 2016, Pöyry Management Consulting, https://docplayer.fi/22653047-Suomen-metsateollisuus-2015-2035-19-tammikuuta-2016-loppuraportti-x304203.html

Table 5.1 shows a summary of the main assumptions of the WM projection for 2020 to 2035. The numerical values for key variables and assumptions are presented in Section 5.8.

Table 5.1
Assumptions of the WM projection

Parameter	Trend 2020 to 2035
GDP growth	1.6 per cent annually
Structure of economy	Increasing share of services
Structure of industry	Less capital and energy intensive
Population growth	Increasing by 0.6 per cent in 10 years until to 2030, slowly decreasing after 2030
Population structure	Ageing
Technology development	Gradual introduction of improved and more energy efficient technology, increased electrification

5.2 "With Measures" projection

5.2.1 Total effects

Total emissions in the WM projection for 1990 to 2035 are shown in Figure 5.1 (total emissions without the LULUCF sector) and Table 5.2 (without and with the LULUCF sector).

Compared with the 1990 base year, the total greenhouse gas emissions without LULUCF are projected to be 58 per cent lower in 2030, and 65 per cent lower in 2035. The corresponding figures for CO_2 emissions are 62 and 69 per cent. CH_4 emissions are expected to continue to decline steadily, being 57 per cent lower in 2030 and 60 per cent lower in 2035 than in 1990. N_2O emissions are projected to decrease slightly, being 32 per cent lower in 2030 and 34 per cent lower in 2035 than in 1990. The amount of emissions from F-gases is small and expected to decrease in the coming years.

Figure 5.1
Greenhouse gas emissions without LULUCF, with indirect CO_2, by gas according to the latest greenhouse gas emission inventory (1990 to 2020) and the WM projection (up to 2035), million tonnes CO_2 eq.

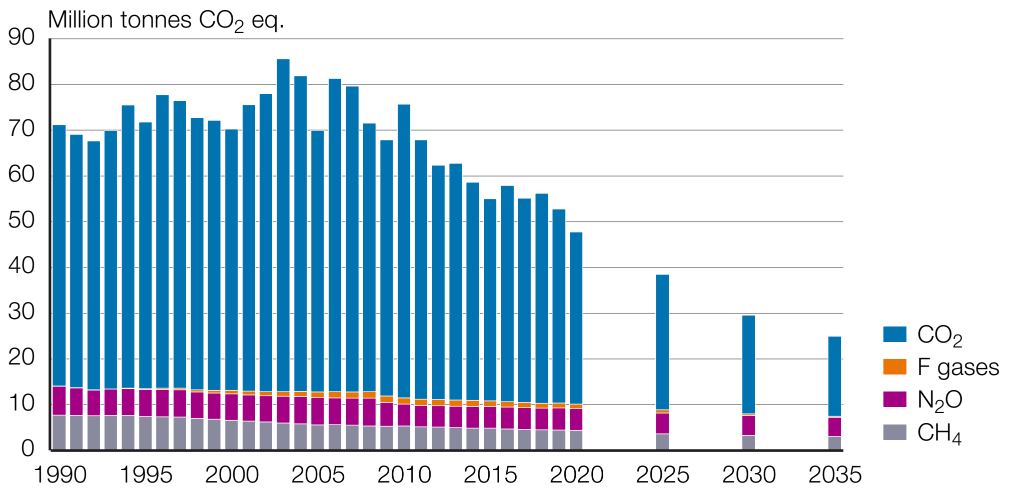


Table 5.2

Greenhouse gas emissions according to the most recent inventory data (1990 to 2020) and the WM projection (2025 to 2035)

	GHG emissions and removals (kilotonnes CO_2 eq.)									
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Sector										
1. Energy	53,442	55,275	53,710	53,743	60,230	40,602	34,290	25,368	18,051	14,984
2. Industrial processes and product use	5,398	5,064	5,988	6,765	6,159	5,704	5,124	5,763	4,649	3,471
3. Agriculture	7,507	6,698	6,615	6,529	6,651	6,574	6,566	5,938	5,682	5,477
4. Land use, land-use change and forestry	−13,441	−13,193	−15,048	−20,494	−21,711	−18,762	−17,303	−22,947	−20,890	−22,633
5. Waste	4,669	4,596	3,817	2,812	2,562	2,092	1,736	1,383	1,152	984
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Indirect CO_2 emissions	166	133	108	88	70	55	66	41	31	26
Gas										
CO_2 emissions without net CO_2 from LULUCF[1]	57,081	58,249	57,118	57,135	64,151	44,154	37,662	29,589	21,582	17,476
CO_2 emissions with net CO_2 from LULUCF[1]	39,976	41,468	38,574	33,308	39,361	22,576	17,571	3,868	−2,095	−7,975
CH_4 emissions without CH_4 from LULUCF	7,687	7,426	6,566	5,583	5,350	4,857	4,402	3,647	3,305	3,056
CH_4 emissions with CH_4 from LULUCF	9,219	8,876	7,912	6,788	6,325	5,653	5,168	4,443	4,151	3,942
N_2O emissions without N_2O from LULUCF	6,362	5,903	5,809	6,035	4,784	4,753	4,722	4,539	4,327	4,189
N_2O emissions with N_2O from LULUCF	8,494	8,040	7,959	8,164	6,888	6,773	6,744	6,517	6,268	6,122
HFCs	0	150	715	1,158	1,363	1,239	976	689	321	189
PFCs	0	2	3	4	3	1	2	1	1	1
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	52	37	26	22	22	22	19	27	29	31
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (without LULUCF)	71,016	71,632	70,130	69,849	75,602	54,971	47,716	38,452	29,534	24,916
Total (with LULUCF)	57,575	58,439	55,082	49,356	53,892	36,209	30,413	15,505	8,644	2,283
Total (without LULUCF, with indirect)	**71,182**	**71,766**	**70,238**	**69,938**	**75,672**	**55,026**	**47,782**	**38,493**	**29,565**	**24,942**
Total (with LULUCF, with indirect)	**57,741**	**58,573**	**55,190**	**49,444**	**53,962**	**36,264**	**30,479**	**15,546**	**8,675**	**2,309**

NO = not occurring

1) including indirect CO_2 emissions

The split of greenhouse gas emissions between the EU ETS sector and the non-ETS sector is illustrated in Figure 5.2. and Table 5.3. The historical ETS emissions correspond to the EU ETS scope in the emissions trading period from 2013 to 2020. The emissions in the EU ETS sector reached their peak in the mid-2000s and have declined since. In 2020, emissions in the EU ETS sector accounted for 41 per cent of the total greenhouse gas emissions, whereas the non-ETS sector accounted for 59 per cent. The ETS emissions are expected to decrease further in the future.

The emissions from the non-ETS sector have decreased steadily since 2005, and the decrease is expected to continue. In the WM projection, the emissions from the non-ETS sector in 2030 are 42 per cent, and in 2035, 49 per cent below the 2005 level when using the 2013–2020 scope for the EU ETS. Approximately 2.4 million tonnes CO_2 eq. non-ETS emissions in 2005 originate from sources that have since been moved to the ETS sector.

Figure 5.2
The split of greenhouse gas emissions between the EU ETS sector and the non-ETS sector (2005 to 2020) based on the latest greenhouse gas inventory and the WM projection (until 2035). The development of the total emissions without the LULUCF sector is also presented.

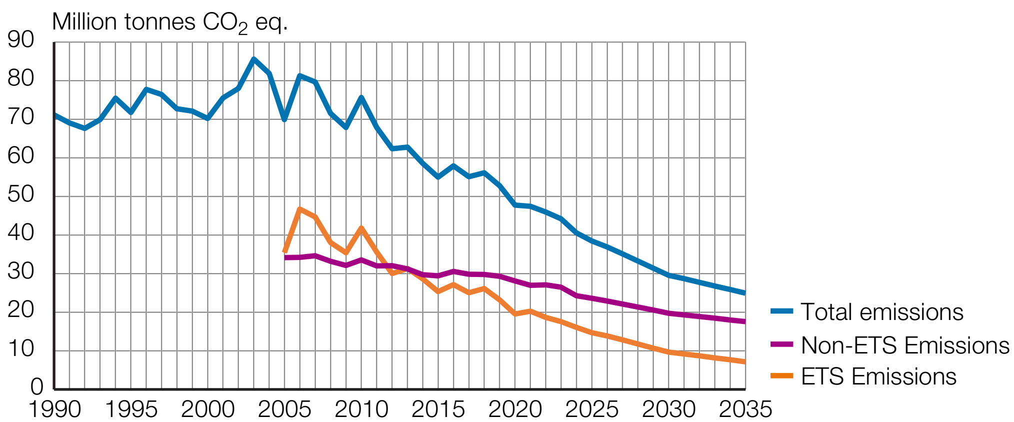


Table 5.3
Historical (2005 to 2020) and projected (2025 to 2035) greenhouse gas emissions in the Non-ETS and ETS sector and civil aviation based on the latest greenhouse gas inventory and the WM projection respectively

	Historical			WM Projection		
	2005	2010	2020	2025	2030	2035
	million tonnes CO_2 eq.					
Non-ETS	34.2	33.6	28.1	23.6	19.7	17.6
ETS	35.5	41.9	19.6	14.7	9.7	7.2
Civil aviation, CO_2	0.3	0.2	0.1	0.2	0.2	0.2
Total emissions[1]	**69.9**	**75.7**	**47.8**	**38.5**	**29.5**	**25.0**

1) For the non-ETS and ETS split, the 2013 scope of EU ETS has been used

The development of total emissions regarding the number of inhabitants, primary energy use, and economic development is presented in Table 5.4. All indicators show a steady downward trend that continues in the WM projection. Today, the emissions are decoupled from both the GDP growth and energy use development and decline steadily.

Table 5.4
Greenhouse gas emission intensity based on the latest greenhouse gas inventory for 2010 to 2020 and the WM projection for 2025 to 2035

	Historical			WM projection		
	2010	2015	2020	2025	2030	2035
Emissions per capita, tonnes CO_2 eq./capita	14.08	9.56	8.70	6.92	5.31	4.49
Emissions per GDP, kg CO_2 eq./EUR	0.35	0.22	0.21	0.15	0.11	0.08
Emissions per primary energy, tonnes CO_2 eq./MWh	0.19	0.14	0.13	0.10	0.08	0.07

5.2.2 Sectoral emissions

Energy

The energy sector is strongly affected by policy measures to reduce the emissions, enhance energy efficiency and increase the share of renewable energy sources. Both the supply and demand sides have faced significant changes in the last decade: part of the changes results from policy measures; part from technological development and the development of the energy and fuel markets. The transition is only half completed, and the emissions will decline further in the energy sector. As many of the changes involve or concern investments like power plants, the effects are robust and enduring.

The supply and demand situation in the Nordic-Baltic regional electricity market to which Finland belongs was a very important factor affecting the Finnish power supply's greenhouse gas emissions in the past. However, 85 per cent of the Finnish electricity production is emissions-free today and the positive development is expected to continue further, resulting in lower and less varying total greenhouse gas emissions for Finland.

In the WM projection, the most significant future changes in electricity and heat production are the start-up in 2022 of a new 1,600 MW nuclear power plant unit and the increase in the use of renewable energy sources and waste heat. Use of coal for energy will be banned from May 2029, and the use of peat will rapidly decrease in the 2020s due to high prices of emission allowances. All these changes reduce emissions.

Factors affecting the future energy demand are primarily energy efficiency measures, as well as the economic development and structural and technology changes within the industry. According to the WM projection, energy used to heat residential and service sector buildings will decrease, even though the volume of buildings is expected to increase continuously. The emissions from space heating are decreasing even faster than energy demand due to the increased use of renewable energy. District heat production from heat-only plants is expected to slightly increase its share at the expense of combined heat and power production, which has been struggling with feasibility. Low electricity prices in the 2010s and rising prices of emission allowances and fuel prices in the 2020s have challenged combustion-based heat and power production.

District heating, power generation, and industrial energy use are strongly affected by the EU ETS price, which makes the use of fossil fuel increasingly infeasible and with energy taxation, efficiently cuts emissions in these sectors. This trend will lead to increased electricity demand replacing some fossil fuel consumption, which is also reflected in the low-carbon roadmaps prepared by all major industries and sectors. In power generation, the emphasis is shifting from fossil fuels (especially coal and natural gas) and peat to renewables. In district heating and industry, fossil fuels are increasingly being replaced with renewables and waste heat recovery. In specific industrial sectors, electrolysis-based hydrogen production is also expected to take off, although the exact timing is difficult to predict. Carbon Capture in its various forms (such as CCS, CCSU, BECCS) could reduce emissions even further, but its timing is even more difficult to estimate, and it has therefore been omitted from the WM projection. Electrification is also true of other sectors like transport, due to which (with Finland's biofuel and other policies) the refining volumes of fossil oil are also decreasing.

The historical and projected emissions from the energy sector (excluding transport) in the WM projection are presented in Table 5.5. The emissions in the energy sector are mainly CO_2 emissions from the combustion of fossil fuels and peat. Most of the energy production, as well as the industrial energy use, belongs to the EU Emissions Trading System.

Table 5.5
Historical (1990 to 2020) and projected (2025 to 2035) greenhouse gas emissions from the energy sector (excluding transport) based on the latest inventory and the WM projection respectively

	Historical							WM Projection		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
	million tonnes CO_2 eq.									
Total emissions	**41.3**	**44.0**	**41.6**	**40.9**	**47.6**	**29.7**	**23.8**	**17.3**	**11.5**	**9.6**
CO_2	40.8	43.2	40.9	40.0	46.7	29.0	23.2	16.6	10.9	9.0
CH_4	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.2
N_2O	0.4	0.4	0.5	0.5	0.6	0.5	0.4	0.4	0.4	0.3

Historically, emissions from space heating on site, as well as district heating, have varied according to heating demand (cold or warm winters). Likewise, emissions from condensing power have varied strongly, depending on the hydro situation in the Nordic-Baltic electricity market. In the projections, future years are assumed to be standard years (i.e. the long-term average plus the impact of climate change) with respect to heating demand and hydro levels. Consequently, the energy sector emissions are smoother in the future years (i.e. they have less interannual variability) of the WM projection than in the historical years.

The importance of CH_4 and N_2O emissions within the energy sector is small. Less than 10 per cent of all CH_4 emissions in Finland come from incomplete combustion of fuel, which is mainly caused by fireplaces and small heating boilers. CH_4 emissions from power and heating plants are low.

Non-ETS emissions within the energy sector (excluding transport) are mainly the result of using fossil fuels for machinery and driers, space heating of buildings and industry outside the EU ETS. In the WM projection, the emissions from individual heating of residential and commercial buildings decrease from the recent 1.5 to 2 million tonnes CO_2 eq. to 0.6 million tonnes CO_2 eq. in 2030. The emissions from machinery are expected to decrease from their current level, i.e. 2.4 million tonnes CO_2 eq. to 1.6 million tonnes by 2030. The reasons for this favourable development are more efficient equipment (including some electric machinery) and a more efficient use of the equipment. The emissions from non-ETS industrial energy use remain at around the current level of 0.6 million tonnes CO_2 eq. in the WM projection at first and slightly decrease later, despite an increase in activity. The energy-related emissions from agriculture and forestry are 1.3-1.4 million tonnes CO_2 today, of which 0.8 million tonnes CO_2 eq. comes from machinery. By 2030, the energy-related emissions in agriculture and forestry are expected to decrease to 0.8 million tonnes CO_2 eq.

Transport

The WM projection describes the likely evolution of GHG emissions from transport according to the best information available, and it includes, with a few exceptions, all measures for which there is a decision by August 2022 (a financing decision on measures requiring funding, or which are otherwise likely to occur). The WM projection contains the following themes, under which there are several measures: 1) replacing fossil fuels with alternative transport fuels; 2) improving the energy efficiency of vehicles; and 3) improving the energy efficiency of the transport system.

The effect of following recently implemented measures are not included in the WM projection because of difficulties in estimating the effects of the measures:

- Temporary reductions of taxable values of the company car benefit for battery electric vehicles and employer-provided charging for electric vehicles (long-term effects difficult to estimate)

– Changes to taxable values of employer-provided commuter tickets and bicycles (no assessment available).

A phenomenon with emissions reduction potential is the increase of remote work. Remote work is a new phenomenon created by the Covid-19 pandemic, which was unforeseeable in the NC7, but which is now included in the WM projection. During the pandemic in 2020, the number of remote workers more than doubled from pre-Covid numbers. This is assumed to be the maximum in the current regional and employment structure. The increase in remote work facilitates work and leisure coordination and mainly reduces emissions from transport as well, as it may reduce vehicle kilometres and the annual CO_2 emissions from passenger car traffic, with the reduction being approximately 61 kt CO_2 eq. in 2030 according to the WM projection.

According to the WM projection, GHG emissions from road transport will decrease significantly in the long term. Temporary changes in the biofuel distribution obligation in road transport will bring a short-term increase in emissions in 2022 and 2023. However, the tightening of the distribution obligation after a temporary reduction will create the most significant emissions reductions in the near future, while in the long term, the emissions reduction effect of vehicle fleet renewal will be highlighted. In particular, the EU Regulation[4] setting stricter CO_2 emission standards for cars and light commercial vehicles will contribute to a significant reduction in the WM projection, where domestic transport emissions will decrease by 49.4 per cent compared to 2005 emissions, i.e. close to the target of 50 per cent emissions reduction. The reduction in emissions takes place mainly in road transport. Compared to the current situation, emissions from water transport will also decrease slightly. Emissions from rail transport will remain the same. Greenhouse gas emissions from the transport sector are expected to decrease by 1.7 million tonnes from 2005 to 2020 and by 4.8 million tonnes from 2005 to 2030 (Table 5.6).

Table 5.6
Historical (1990 to 2020) and projected (2025 to 2035) greenhouse gas emissions from transport based on the latest greenhouse gas inventory and the WM projection, respectively

	Historical							WM Projection		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
	million tonnes CO_2 eq.									
Total emissions	**12.1**	**11.3**	**12.1**	**12.9**	**12.7**	**10.9**	**10.4**	**8.1**	**6.6**	**5.4**
CO_2	11.8	11.1	11.9	12.7	12.6	10.8	10.3	8.0	6.5	5.3
CH_4	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N_2O	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

4 2019/631/EU, adopted in 2019 and applied since 1 January 2020

International bunkers

According to the most recent greenhouse gas emission inventory, the fuel consumption for international aviation was 11,873 TJ and for international marine transport 12,718 TJ in 2020. The Covid-19 pandemic has especially affected international aviation, as the corresponding fuel consumption prior to the pandemic in 2019 was 35,166 TJ for aviation bunkers and 13,563 TJ for marine bunkers.

According to the latest EUROCONTROL most-likely base scenario[5], the annual flight growth rate for Finland between 2019 and 2050 will be an average of 1.6 per cent. This scenario was prepared before the start of Russia's invasion of Ukraine, and it therefore does not take into account the current geopolitical situation, which greatly affects Finnish air transport. The annual growth rate by 2030 is estimated to be two per cent for international marine transport. Based on these assumptions and 2020 emissions, the total greenhouse gas emissions from bunker fuels are projected to be 2.2 million tonnes CO_2 eq. in 2030 (1.0 million tonnes CO_2 eq. from aviation bunkers and 1.2 million tonnes CO_2 eq. from marine bunkers). As the Covid-19 pandemic has impacted international transport and air transport especially strongly, the 2019 emissions can also be considered departure data. Using the emissions in 2019 as the basis, the total greenhouse gas emissions from bunker fuels are projected to be 4.4 million tonnes CO_2 eq. in 2030 (3.1 million tonnes CO_2 eq. from aviation bunkers and 1.3 million tonnes CO_2 eq. from marine bunkers). The most likely growth may be something between these two projections, although there are many uncertainties in the current geopolitical and market situation. The average of the above figures is therefore selected in Table 5.7.

These projected emissions of marine and aviation bunkers do not as such consider the impact of the measures presented in Section 4.4.3, which aim to improve energy efficiency and increase the use of alternative fuels.

Table 5.7
Historical (1990 to 2020) and projected (2025 to 2035) greenhouse gas emissions from international bunkers based on the latest greenhouse gas inventory and the WM projection, respectively

	Historical							WM Projection		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
	million tonnes CO_2 eq.									
Total emissions	**2.9**	**1.9**	**3.1**	**2.9**	**2.3**	**2.9**	**1.9**	**3.0**	**3.3**	**3.6**
Aviation	1.0	0.9	1.1	1.3	1.7	2.0	0.9	1.9	2.0	2.2
Navigation	1.9	1.0	2.1	1.6	0.7	0.9	1.0	1.1	1.3	1.4

5 EUROCONTROL Aviation Outlook 2050. Main Report April 2022; https://www.eurocontrol.int/sites/default/files/2022-04/eurocontrol-aviation-outlook-2050-main-report.pdf

Industrial processes and other product use

The most important greenhouse gas emission sources in this sector are iron and steel, hydrogen, and cement production. The main factors affecting the development of emissions include changes in industrial production volumes and technology. In the WM projection, the growth of the industrial production volumes increases these emissions. Most of the emissions other than F-gases in this sector are part of the EU ETS, which is also the main measure for reducing process emissions. Other measures driving low-carbon technology investments in the manufacturing industry are increased funds for new technology investments and the reduction of the electricity tax.

In the WM projection, it is assumed that the industrial use of fossil fuels decreases thanks to the above measures. In carbon steel production, Finland's largest steel mill has disclosed plans to replace the existing two blast furnaces with electric arc furnaces and the use of carbon-free direct reduced iron (or sponge iron), which is produced in and imported from Sweden. However, the exact timing of this shift is still a significant uncertainty, but the assumption in the WM projection for the first blast furnace is by 2030 and for the second one by 2035. In the chemical industry, the share of fossil fuels will probably decrease due to the largest plastic producer's plans to replace the existing chemical cracking furnace with an electric cracking process. In the WM projection, the replacement will be implemented by 2030. The low-carbon roadmaps prepared by different industries also include additional but more high-level measures that are not yet finally decided but are expected to decrease industrial emissions further in the future.

The WM projection for F-gases includes the impacts of the EU regulation on F-gases[6] and the EC directive related to emissions from air-conditioning systems in motor vehicles[7]. Emissions from refrigeration and air-conditioning equipment are expected to decline because of the regulatory measures.

The main features of the F-gas regulation in cutting F-gas emissions are a phase down of HFCs that can be placed on the EU market, bans on the use of HFCs in certain applications and obligations related to leak checking and repairs, F-gas recovery and technician training.

Emissions from electricity distribution equipment have declined from the peak level because of the industries' voluntary actions. A steady increase of emissions is assumed in the future, but the peak level of emissions in the 1990s will not be reached. Restrictions forced by the EU regulation will have a decreasing effect on emissions from foam blowing and aerosols in the future. Emissions from other sources are expected to remain quite steady. Emissions from refrigeration and air-conditioning equipment account for more than 90

6 2014/517/EU

7 2006/40/EC

per cent of Finnish F-gas emissions, and the projected overall emissions trend is therefore declining.

Emissions from solvent and other product use are expected to remain at their present level in the WM projection. Historical and projected greenhouse gas emissions from industrial processes and other product use are presented by gas in Table 5.8.

Table 5.8
Historical (1990 to 2020) and projected (2025 to 2035) greenhouse gas emissions from industrial processes and other product use based on the latest greenhouse gas inventory and the WM projection respectively

	Historical							WM Projection		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
	million tonnes CO_2 eq.									
Total emissions	**5.4**	**5.1**	**6.0**	**6.8**	**6.2**	**5.7**	**5.1**	**5.8**	**4.6**	**3.5**
CO_2	3.7	3.4	3.9	4.0	4.6	4.2	3.9	4.8	4.0	2.9
CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N_2O	1.7	1.5	1.4	1.6	0.2	0.3	0.2	0.3	0.3	0.3
F gases	0.1	0.2	0.7	1.2	1.4	1.3	1.0	0.7	0.4	0.2

Agriculture

In recent years, changes in the emissions from agriculture have been small. The projections were updated in 2022. In the WM projection, the total emissions from the agricultural sector are expected to decrease[8]. Emissions from the agricultural sector will decrease by around 0.9 million tonnes of CO_2 eq. by 2030 and 1.1 million tonnes of CO_2 eq. by 2035 (compared to the 2020 level) (Table 5.9).

The decline in livestock numbers and increase in use of feed additives will reduce methane emissions from cattle's digestion. In addition, the decrease in cattle and pig numbers will reduce emissions from manure processing and manure application. However, there is uncertainty about the future price and scale of adoption of feed additives and thus the emissions reduction from cattle.

Measures identified to reduce N_2O emissions from organic soils will also affect the CO_2 emissions from the LULUCF sector. The increasing grass area in crop rotations and continuous use of catch crops will increase the emissions of plant residues but reduce nitrogen mineralisation emissions from mineral soils, leaving the net effect in the agricultural sector small per hectare but positive for the climate. Energy-related emissions related to agriculture are reported in the energy sector and are not included in Table 5.9.

8 Miettinen et al. (2022)

Table 5.9
Historical (1990 to 2020) and projected (2025 to 2035) greenhouse gas emissions from agriculture based on the latest greenhouse gas inventory and the WM projection, respectively

	Historical							WM Projection		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
	million tonnes CO_2 eq.									
Total emissions	**7.5**	**6.7**	**6.6**	**6.5**	**6.7**	**6.6**	**6.6**	**5.9**	**5.7**	**5.5**
CO_2	0.6	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2
CH_4	2.8	2.5	2.5	2.5	2.6	2.6	2.5	2.1	2.0	1.9
N_2O	4.1	3.7	3.7	3.7	3.8	3.8	3.8	3.6	3.5	3.3

LULUCF

The land use, land-use change, and forestry sector (LULUCF) as a whole is expected to be a net sink in the WM projection (Table 5.10).

Table 5.10
Historical (1990 to 2020) and projected (2025 to 2035) greenhouse gas emissions and removals from the LULUCF sector based on the latest greenhouse gas inventory and the WM projection respectively

	Historical							WM Projection		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
	million tonnes CO_2 eq.									
Total emissions and removals	**−13.4**	**−13.2**	**−15.0**	**−20.5**	**−21.7**	**−18.8**	**−17.3**	**−22.9**	**−20.9**	**−22.6**
CO_2	−17.1	−16.8	−18.5	−23.8	−24.8	−21.6	−20.1	−25.7	−23.7	−25.5
CH_4	1.5	1.5	1.3	1.2	1.0	0.8	0.8	0.8	0.8	0.9
N_2O	2.1	2.1	2.2	2.1	2.1	2.0	2.0	2.0	1.9	1.9

The measures mentioned in the Climate Plan for the Land Use Sector aim to reach the annual net climate impact of at least three million tonnes of carbon dioxide equivalent by 2035 (Table 5.11). The measures target agricultural land, forest, and land-use changes. In 2035, the net sink of the land-use sector is estimated to be −22.6 million tonnes of carbon dioxide equivalent. The net sink is expected to increase by a total of 5.3 million tonnes of carbon dioxide equivalent by 2035 compared to the 2020 level, exceeding the minimum target set for the Plan.

In the WM projection for the agricultural sector, measures targeted at organic soils are also expected to decrease emissions in the LULUCF sector by around one million tonnes of CO_2 eq. by 2030, 1.3 million tonnes of CO_2 eq. by 2035, and around 1.6 million tonnes of CO_2 eq. by 2040 (compared to the 2020 level). This is due to a reduction in land clearing and conversion of land from cropland and grassland to afforested land and wetlands. In addition, grassland cultivation with increased water levels and paludiculture are expected to decrease emissions from organic soils.

The projections for the agricultural sector and the LULUCF sector include to some extent different measures for cropland and grassland, different implementation areas, and different assumptions about the cultivation history, i.e. different parameters. The LULUCF projection also includes a few measures targeted at organic soils that are not included in the WM projection for agriculture. The LULUCF sector projection therefore produces higher emissions reductions for cropland and grassland than using the measures and parameters of the agriculture WM projection.

Finland's National Forest Strategy (NFS), adopted by the Government in February 2015 and operationalising government policy, specifies the main objectives for forest policy and forest-based business and activities until 2025[9]. The vision of the Strategy is "Sustainable forest management is a source of growing welfare".

The strategy is implemented by ten key projects. NFS projects were updated in 2019. According to the NFS, climate change mitigation and adaptation in forests are supported by diversifying forest management. Forests' viability, i.e., growth and health will be maintained and enhanced through active forest management. Over the long term, forest management techniques must be adapted to new and changing climate conditions. Timely and careful forest management can improve the growth but also the resistance of growing stock to damage, while safeguarding the ecosystem services of forests and producing wood biomass sustainably. Current forest legislation and ongoing measures for climate- and forest-related objectives are briefly described in Section 4.3.5.

Forests will be a key part of the Finnish bioeconomy, and the NFS therefore aims to increase the use of wood to replace fossil resources with renewable biomass. In the WM projection, the harvesting increases by up to 80 million cubic metres (including the use of wood for bioenergy) in 2026 to 2035, the estimated carbon sink of forests (including trees and soil) will be approximately at the level of −22.6 million tonnes of CO_2 eq. per annum by 2035. The decreasing trend in emissions from wetlands is due to the decreasing energy use of peat, resulting in a smaller area being needed for peat extraction.

9 Ministry of Agriculture and Forestry 2019

Table 5.11
Preliminary climate impacts in 2030 and 2035 of the measures presented in the Climate Plan for the Land Use Sector (million tonnes of carbon dioxide equivalent)

Measure	Area	Climate impact in 2030, million tonnes CO_2 eq.	Climate impact in 2035, million tonnes CO_2 eq.
Owner policy of Metsähallitus		0.4	0.7–0.9
Preventing the conversion of forests into fields	about 1,700–1,900 ha per year		0.5
Act on fixed-term support for afforestation	3,000 ha per year, of which 40% in peat production areas	0.09	0.11
Afforestation of low-yield fields	9,000 ha in 2024–2028	0.09	0.10
Raising the groundwater level in peaty agricultural lands (grasslands) –30 cm	2030: 20,000 ha 2035: 32,500 ha	0.135	0.219
Paludiculture, groundwater level –30 cm	2030: 5,000 ha 2035: 10,000 ha	0.047	0.094
Paludiculture, groundwater level –5 – –10 cm	2030: 2,500 ha 2035: 5,000 ha	0.047	0.094
Managed wetlands	2030: 4,000 ha 2035: 7,500 ha	0.072	0.136
Perennial grasslands without tilling	2030: 40,000 ha 2035: 40,000 ha	0.081	0.081
Wetting of low-yield, thick-peat fields to establish wetlands	2030: 10,000 ha 2035: 10,000 ha	0.181	0.181
Comprehensive planning of peatland forest management (avoidance of remedial ditching)	–	–	–
Comprehensive planning of peatland forest management (continuous cover forestry in mires)	6,000 ha per year	0.21	0.21
Ash fertilisation of peatland forests	26,000 ha per year	0.18	0.40
Promotion of forest fertilization on mineral soils	25,000 ha per year	0.46	0.28
Increasing the carbon stocks of decaying wood in commercial forests due to biodiversity and climate considerations by leaving retention trees in place	–	–	–
Total		**1.99**	**3.11–3.31**

Source: Natural Resources Institute Finland 2022

Waste

Greenhouse gas emission projections for the waste sector include CH_4 from landfills and anaerobic digestion and CH_4 and N_2O emissions from composting and wastewater treatment. Emission figures for the waste sector do not include emissions from waste incineration, which are reported in the energy sector.

The landfilling of waste is increasingly replaced with recycling and energy recovery. In 2010, the amount of municipal waste incinerated at waste incineration plants was approximately 0.24 million tonnes. Several new waste incineration plants have since been constructed, and the incinerated amount was already more than 1.7 million tonnes in 2019. Currently, waste co-incineration is included in the emissions trading sector, whereas waste incineration plants are in the effort-sharing sector.

Greenhouse gas emissions from the waste sector will decrease in the WM projection (Table 5.12). The main reason for this reduction is the implementation of the Landfill Directive[10] and national legislation[11] and strategies aimed at reducing the amount of waste generated and minimising the amount of waste disposed at landfills. Over a longer period, the amount of greenhouse gases from landfills will decline because of the restrictions on organic waste landfilling.

Table 5.12

Historical (1990 to 2020) and projected (2025 to 2035) greenhouse gas emissions from the waste sector based on the latest greenhouse gas inventory and the WM projection respectively (waste incineration not included)

	Historical							WM Projection		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
	million tonnes CO_2 eq.									
Total emissions	**4.7**	**4.6**	**3.8**	**2.8**	**2.6**	**2.1**	**1.7**	**1.4**	**1.2**	**1.0**
CH_4	4.6	4.5	3.7	2.7	2.4	2.0	1.6	1.3	1.0	0.9
N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Indirect CO_2 emissions

The WM projection for indirect CO_2 assumes that their share of the total national emissions without LULUCF will remain at the present level, 0.1 per cent of total national emissions without the LULUCF sector.

10 Landfill Directive 99/31/EC

11 Government decree on Landfills (331/2013)

5.3 "With Additional Measures" projection

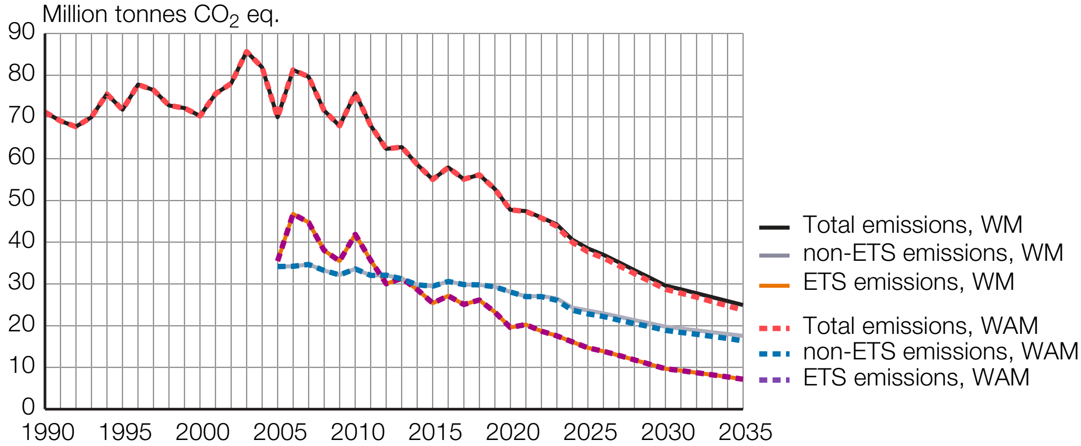
The WAM projection presented in this chapter includes measures already decided at a governmental level and described in Chapter 4. There are planned measures for the transport sector, machinery, F-gases, agriculture, and the waste sector.

With a few exceptions, all the planned measures described in Chapter 4 are included in the WAM projection. Measures for which the impact on the energy balance or the emissions remains unknown or has not been assessed have not been included in the WAM projection. Such measures are:

- Improving energy efficiency and promoting the use of alternative fuels in machinery (no assessment available yet)
- Amendment of the waste tax legislation (only minor impact on emissions, difficult to estimate, no assessment available)
- Influencing the age structure of cattle (measures not yet defined)
- Promoting agroforestry (measures not yet defined).

The effect of the policies and measures included in the WAM projection on the total greenhouse gas emissions is illustrated in Figure 5.3. Solid lines portray the WM projection, and dashed lines the WAM projection. The effect of the additional measures is aimed at the 2020s except for the transport sector, where the additional measures increasingly diminish emissions in the 2030s.

Figure 5.3
Greenhouse gas emissions in EU ETS and non-ETS sectors in the WAM projection (dashed lines) compared to the WM projection (solid lines) in 2021 to 2035 and historical emissions for 1990 to 2020 based on the most recent inventory



The total greenhouse gas emissions (without the LULUCF sector) in 2030 are 29.6 million tonnes CO_2 eq. in the WM projection and 28.7 million tonnes CO_2 eq. in the WAM projection. The additional emissions reduction measures in the WAM projection will only affect transport, industrial processes and agriculture in the non-ETS sector (Table 5.13). The emissions in the ETS sector remain the same as in the WM projection.

Table 5.13
Historical (2005 to 2020) and projected (2025 to 2035) greenhouse gas emissions in the Non-ETS and ETS sectors and civil aviation based on the latest greenhouse gas inventory and the WAM projection, respectively

	Historical			WAM Projection		
	2005	2010	2020	2025	2030	2035
	million tonnes CO_2 eq.					
Non-ETS	34.2	33.6	28.1	22.8	18.9	16.4
ETS	35.5	41.9	19.6	14.7	9.7	7.2
Civil aviation, CO_2	0.3	0.2	0.1	0.2	0.2	0.2
Total emissions	**69.9**	**75.7**	**47.8**	**37.7**	**28.7**	**23.8**

Table 5.14 presents a summary of the WAM projection emissions and the difference between them and the emissions levels in the WM projection.

Table 5.14
Greenhouse gas emissions on a gas-by-gas basis for the WAM projection and the difference between them and the WM projection between 2025 and 2035, million tonnes CO_2 eq. (the greenhouse gas emissions in 2010 and 2020 are based on the most recent inventory and shown for comparison.)

	Historical		WAM Projection		
	2010	2020	2025	2030	2035
	million tonnes CO_2 eq.				
CO_2	64.2	37.7	29.1	21.1	16.6
CH_4	5.4	4.4	3.6	3.2	3.0
N_2O	4.8	4.7	4.4	4.2	4.1
F-gases	1.4	1.0	0.6	0.2	0.1
Total	**75.7**	**47.8**	**37.7**	**28.7**	**23.7**
Difference to WM			–0.8	–0.8	–1.2

When the different emission sectors are examined, the sectoral WAM projections do not differ from the WM projections in the following cases:

– the energy sector, excluding transport
– international bunkers
– industrial processes and product uses other than F-gases
– the LULUCF sector
– waste management.

The WAM projections differ from the WM projections for transport, F-gases, and agriculture, and marginally, for indirect CO_2 emissions. Of the sectors with separate WAM projections, transport has the largest absolute difference between WM and WAM emissions, whereas F-gases have the largest relative difference.

The WAM projection includes those transport measures that had not been finally decided or financed by August 2022 or were uncertain for other reasons. It contains the following themes, under which there are several measures: 1) replacing fossil fuels with alternative transport fuels (additional measures); 2) improving the energy efficiency of vehicles (additional measures); and 3) improving the energy efficiency of the transport system (additional measures).

Transport sector emissions decrease somewhat faster in the WAM projection than in the WM projection in the 2020s. From 2030, the difference in emissions increases significantly faster along with the heavily increasing share of biofuels in the WAM projection. In the long term, fossil fuel substitution will have the greatest emissions reduction effect, bringing GHG emissions from road transport close to zero in 2045. The impact of the renewal of the vehicle fleet in the WAM projection remains the smallest of these categories and the most uncertain of all. It is estimated that the emissions reductions in transport achieved by these additional measures, including the effect of increased remote work, will be 0.5 million CO_2 eq. in 2030 compared to the WM projection.

The current F-gas measures in the WM projection will already cut the emissions strongly. The WAM projection of F-gases is based on a few additional measures that will slightly accelerate the decrease of emissions. These additional measures include the revision of the F-gas Regulation, improved control of F-gas banks and recovery of F-gases, and promotion of alternative non-HFC technologies. It is estimated that the emissions reduction achieved by these additional measures will be 0.2 million tonnes CO_2 eq. in 2030.

The WAM projection of agriculture[12] was updated in 2022 and assumes gradual changes in consumers' diet until 2035, which in turn will affect agricultural production and the use of arable land. In the agricultural sector, the estimated additional total emissions reduction is 0.2 million tonnes of CO_2 eq. by 2030 and 0.2 million tonnes of CO_2 eq. by 2035. However, the WAM projection involves major uncertainties. For example, the change in food consumption may differ for different population groups. Large changes in consumers' diet cannot be achieved by economic policy instruments alone.

The Government of Finland has set an emissions reduction target of 29 per cent for Finnish agriculture by 2035 (emissions should decrease by 4.6 million tonnes CO_2 eq. by 2035 compared to 2019). It is likely that agriculture will not fully achieve this emissions reductions target with the actions of the WAM scenario alone. The existing actions should be intensified, and new actions should be developed.

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For cropland and grassland, the WAM measures also have effects on emissions from the LULUCF sector. The WAM scenario, with fewer livestock, less organic matter spread on fields in manure, and fewer grasslands, implies a lower carbon input into soils and slightly higher LULUCF emissions from soils compared with the WM scenario. However, the difference is small, 0.1 to 0.2 million tonnes of CO_2 eq. and less than the achieved emissions reductions of the agricultural sector in the WAM scenario, especially after 2035. Measures identified to reduce N_2O emissions from organic soils will also affect emissions from the LULUCF sector (see Table 5.10).

For the LULUCF sector, the WAM projection does not differ from the WM projection. Hence, the abovementioned impacts of the additional measures included in the WAM projection for the agricultural sector are not included in the WAM projection for the LULUCF sector.

The assumptions for indirect CO_2 emissions are the same in the WAM and WM projections, i.e. emissions equal 0.1 per cent of total national emissions without the LULUCF sector. The absolute amount of indirect CO_2 emissions is therefore marginally smaller in the WAM projection than in the WM projection.

5.4 Assessment of aggregate effect of policies and measures

The aggregated estimates for the greenhouse gas reduction impacts of individual WM policies and measures presented in Chapter 4 are 25 and 52 million tonnes CO_2 eq. for 2020 and 2030 (without LULUCF) respectively. The WAM measures will increasingly reduce greenhouse gas emissions in the 2020s, reaching an additional annual reduction of approximately 0.8 million tonnes CO_2 eq. in 2030. The small addition of the planned measures results from the fact that most of the previously planned measures (WAM measures) are now labelled as implemented or adopted measures (WM measures). New planned measures are currently in the development stage, and decisions on their implementation will be taken in the coming years. The total effect of the current policies and measures calculated bottom-up is shown in Table 5.15.

Table 5.15
The total i.e. aggregate effect of the policies and measures (PaMs) calculated based on the estimated impact of PaMs (see Tables 4.2, 4.5, 4.7, 4.8 and 4.12) for 2020, 2025, 2030 and 2035 (million tonnes CO_2 eq). The total emissions in 2020 based on the most recent inventory are also given for comparison

	Total emissions in 2020*	Total effects of PaMs			
		2020	2025	2030	2035
WM measures	47.8	24.9	44.2	52.0	55.0
WAM measures[1]		0.0	0.2	0.8	0.9

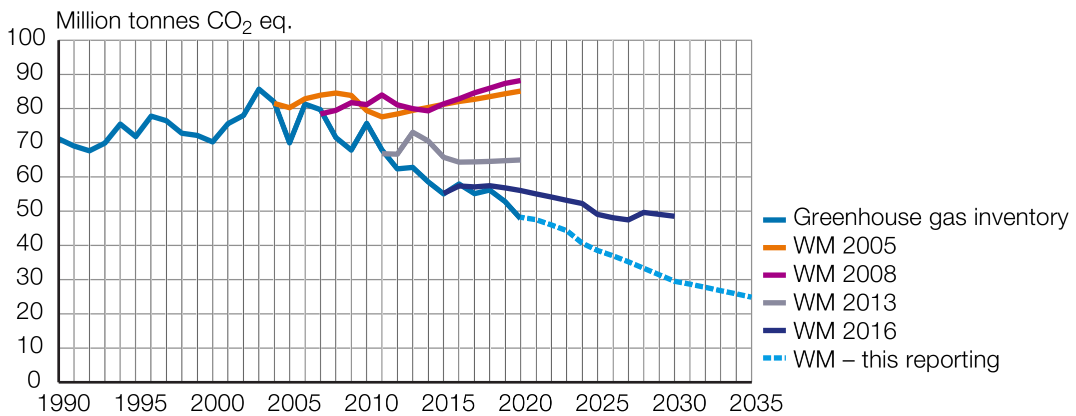
* Without LULUCF

1 In addition to the total effect of PaMs included in the WM projection

The estimated total effect of policies and measures contains noticeable uncertainties. The mitigation impact has not been estimated for all policies and measures. Furthermore, the impact estimates of individual policies and measures are not always fully additive, which may result in an overestimation of the mitigation impact in certain sectors. The overlapping effect of measures has been paid due attention in the case of the simultaneous increase of biofuel content and energy efficiency in machinery, the transport sector, and heating, for example. Altogether, the total emissions reduction is probably larger than the reported total effect.

A top-down assessment of the overall effect of mitigation policies and measures is possible by comparing the greenhouse gas emissions of this reporting with WM projections from earlier reporting rounds. Figure 5.4 shows Finland's greenhouse gas emissions in the WM projections in the last four national climate and energy strategies, i.e. strategies from 2005, 2008, 2013, and 2016, as well as in this reporting. The WM projections in the national climate and energy strategies projected significantly higher emissions for 2020 than those reported in the latest greenhouse gas inventory and in the projections of this reporting. This suggests that the additional measures implemented in the 2010s have had a substantial impact on total emissions.

Figure 5.4
Greenhouse gas emissions according to the most recent inventory for 1990 to 2020 and in the WM projections of the climate and energy strategies published in 2005, 2008, 2013 and 2016 until 2020 and 2030 respectively, and the WM projection of this reporting



The main difference between the projections shown in Figure 5.4 is that most measures from previous WAM projections have been implemented since the previous reporting and are therefore included in the following WM projections. The biofuel quota obligation in road transport is one of the measures with the greatest impact. Another significant difference since the WM projections of 2013 and earlier years is the result of domestic conventional condensing power capacity being shut down almost entirely. Furthermore, combined heat and power plants are struggling with their feasibility and are being shut down ahead of time due to market circumstances and the prohibition of coal energy use. The electrification of society and the introduction of new emissions-free technology in all sectors are accelerating earlier and faster than previously expected. The projections have been updated accordingly to reflect the most recent development. The use of fossil fuels and greenhouse gas emissions are therefore significantly lower than anticipated in the previous National Communications.

The total effect of implementing additional measures can be seen in the emission development trend after 2015, which levelled off in the 2013 and 2016 projections, whereas it continued to increase in the projections from 2005 and 2008. In turn, the WM projection of this reporting points clearly downwards.

For comparison purposes, the WM projections from 2005 and 2008 can be considered reasonable WOM (Without Measures) projection substitutes, even though they already include some mitigation measures. The gap between the projections for 2005 to 2008 and the projection of this reporting is up to 40 million tonnes CO_2 eq. in 2020. By 2030 the gap would presumably increase to at least 60 million tonnes CO_2 eq. if the old projections would have extended that far into the future. This is well in line with the bottom-up estimation of the total effect of policies and measures considering that not every single measure has been assessed and included in the estimation. The bottom-up approach gives 52 million tonnes CO_2 eq. emissions reduction in 2030, which added to the emissions of the WAM projection would result in an emission level of at least 81 million tonnes CO_2 eq. in 2030 for a WOM projection.

5.5 Economic impacts

Most of the effects of the WM projection on the economy stem from the need to invest in new carbon-free and energy-efficient technologies in the energy sectors, industry, and the transport sector. These very large investments will probably dominate economic activity for most of the next two decades and entail current account deficits, but once completed, they will facilitate a structural shift of the economy towards an energy- and material-efficient low-carbon economy, in which many of the current industries will become newly competitive and create export growth.

Economic growth and changes in the structure of the economy also play a key role in the estimation of energy consumption and emissions. The rate of economic growth is determined by the growth rates of labour input and average labour productivity. In the long term, economic growth is determined almost solely by the growth of labour productivity because labour input cannot grow without limits. However, in the short and medium term, factors affecting labour input growth also matter because changes in labour input directly affect the economy’s potential output. In Finland, the ageing population is the single most significant factor in terms of its effect on labour input and thus the development of the national economy in the short and medium term. Another factor that will affect the availability of labour is the level of structural unemployment.

The above new investments will result in both increased costs and changes to economic consumption and production structures. At the microeconomic level, the WM projection assumes that businesses make mostly profitable investments. Nevertheless, less profitable investments are also necessary to meet the strict emission targets. Such investments usually require subsidies or investment aid from the Government, which contributes to households being susceptible to a decline in their purchasing power due to the additional costs of cutting emissions. The costs typically include different direct and indirect taxes and other policies. For example, if the government implements a costly investment aid scheme to reduce emissions, it is likely that part of the funding will need to come from income tax increases. Indirect taxes can mean higher costs of fossil fuels, and other policies may even force households to make new investments such as purchasing electric vehicles if new gasoline cars are no longer available in the future. In absolute terms, the impact is most significant on households that consume the most energy and energy-intensive commodities and services, i.e. middle- and high-income households. However, in relative terms, the impact may be even more significant for lower-income households, because energy is a necessity in modern societies.

Yet at the macroeconomic level, the new structures are expected to lead to improved economic efficiency, including labour productivity and new business opportunities especially adding value to exports. Structural changes in the economy will also have impacts on employment. The total employment rate is expected to grow slightly thanks to new investments, but as is often the case, some sectors will benefit more than others. It is expected that industrial and construction sectors will receive most of the benefits, whereas agriculture and services especially will add fewer jobs.

5.6 Sensitivity analysis of the projections

Energy use and hence greenhouse gas emissions are sensitive to the assumptions made for economic growth. Two sensitivity analyses have therefore been carried out for the WM projection, varying the economic growth of industry and service branches. No sensitivity analysis of the transport sector was made, but lower economic growth could generally have both a reducing and an increasing impact on energy use and greenhouse gas emissions for transport. On the one hand, the need for transport is likely to be lower; on the other, the renewal of the transport fleet will be slower. The situation is similar for buildings in which lower economic growth results in slower growth of the building volume, but also in less investment in energy efficiency. In the sensitivity analyses, energy uses in the transport sector and buildings remain unchanged.

The manufacturing industry uses about 45 per cent of both the country's final energy and electricity. The forest industry has a significant impact on the energy sector, including renewable energy production, energy consumption, and electricity generation. Iron and steel production is another energy-intensive branch, the development of which significantly influences the projections. The energy balance projections for these branches are based on product-group-specific volume estimates. Both branches develop generally positively in the WM projection, even though some product groups already decrease (e.g. paper manufacturing) in the base case WM. In the sensitivity analysis, the annual growth of the product volumes in the forest and metal industries varies by 1 percentage point in both directions from 2020 compared to the WM projection.

In addition to the branches and sectors mentioned above, the annual growth rate of the other industry and service branches was varied by plus and minus 1 percentage point from the WM assumptions. No dynamic effects were considered.

The results of the sensitivity analyses are presented in Table 5.16 below. The overall effect of a lower economic growth (WM –) results in a steadily decreasing final energy consumption in contrast with higher economic growth (WM +), which steadily increases the energy use in the period from 2021 to 2030. In turn, in the base case WM projection, the final energy consumption is almost flat.

In 2030, the final energy consumption would be only 284 TWh in the low growth case, but 307 TWh in the high growth case compared to 295 TWh in the base case WM. The corresponding figures for primary energy consumption are 364 TWh (WM –), 391 TWh (WM +), and 377 TWh (base case WM). The relative impact of economic growth is therefore somewhat higher on final energy consumption than on primary energy. The greenhouse gas emissions in 2030 differ in both cases in total by about 0.9 to 1.0 million tonnes of CO_2 eq. from the emissions in the base case WM projection.

Most of the emission increase and reduction respectively would take place in the ETS sector, with only 0.2 to 0.4 million tonnes of CO_2 eq. reduction in the non-ETS sector.

Table 5.16
Main results for the sensitivity analysis on how the economic growth rate affects the overall energy balance and GHG emissions

	Unit	2020	2030			2035		
			WM	WM +	WM –	WM	WM +	WM –
GHG emissions								
Total excluding LULUCF	million tonnes CO_2 eq.	47.8	29.6	30.6	28.7	24.9	26.1	23.9
Total ETS	million tonnes CO_2 eq.	19.6	9.7	10.5	9.0	7.2	8.1	6.4
Total non-ETS	million tonnes CO_2 eq.	28.1	19.7	19.9	19.5	17.6	17.9	17.4
Primary energy consumption	TWh	354.7	376.6	390.6	363.8	371.4	393.1	352.4
Gross final energy consumption	TWh	285.0	294.9	307.2	283.7	292.0	311.0	275.3

WM +, projection with higher economic growth than the WM projection
WM –, projection with lower economic growth than the WM projection

Source for historical data: Energy Statistics and Finnish Energy

5.7 Supplementarity relating to the Kyoto Protocol mechanisms

Finland's total greenhouse gas emissions in the first commitment period from 2008 to 2012 were 338,353,531 t CO_2 eq., approximately five per cent lower than the assigned amount, which was 355,017,545 tonnes CO2 eq. Finland met its commitment by retiring 338,353,531 Kyoto Protocol units at the end of the commitment period.

Of the total amount, 12,273,471 were CERs, and 4,088,755 were ERUs. These Kyoto Protocol mechanisms units were acquired by Finnish ETS operators which, according to EU ETS legislation, were entitled to cover part of their EU ETS obligations through Kyoto Protocol mechanisms. Finland did not retire any Kyoto Protocol mechanisms units to cover its emissions from the non-ETS sector.

Finland has requested 6,798,242 CERs and 2,917,220 ERUs to be carried over to the second commitment period of the Kyoto Protocol. When CERs and ERUs generated in the second commitment period are also considered, Finland has a total of 9,986,208 CERs and 2,912,592 ERUs that are eligible for the second commitment period. Finland can further request 14,018,572 AAUs to be carried over from the first to second commitment period. The AAU amount includes 10,000,000 AAUs transferred by the European Union from the Union Registry to Finland's party holding account. The transfer was designed to enable Finland's compliance with its commitments in the second commitment period under the Kyoto Protocol after the international LULUCF accounting rules were changed by Decision 2/CMP.7.

As mentioned in Section 4.1.2 based on the GHG inventory data, Finland will also fulfil its commitments under the second commitment period of the

Kyoto Protocol. Due to the additional burden arising from KP LULUCF activities, Finland will also have to use additional emission units transferred from the previous Kyoto Protocol commitment period or acquired from the Clean Development Mechanism or Joint Implementation. Any use of Kyoto Mechanisms would be supplemental to domestic actions.

5.8 Methodology

5.8.1 Approach and responsibilities

The approach and responsibilities in preparing the projections have not changed since the preparation of the Seventh National Communication.

The reported WM–and WAM-projections are integrated energy and climate projections that were originally modelled for the preparation of three Government Reports, namely the National Energy and Climate Strategy, the Medium-term Climate Change Policy Plan, and the Climate Change Plan for the Land Use Sector. The modelling and assessments were conducted by experts from various research fields in the "Carbon neutral Finland 2035 – measures and impacts of the climate and energy policies" project (HIISI project)[13] financed by the Government's analysis, assessment, and research activities. The analysis and results of the HIISI project were complemented in 2022 by the current information and updates of sectoral projections.

Finland uses a sectoral approach with detailed sector-specific modelling that is coordinated and manually interlinked across sectors. The preparation of the reported WM and WAM projections was coordinated by the Ministry of Economic Affairs and Employment. The Ministry of Economic Affairs and Employment was responsible for the projections regarding the amount of energy used by industry, households and services and for the calculations of fuel and carbon dioxide emissions in the energy production sectors as a whole. The Ministry of the Environment was responsible for the projection regarding space heating, the analysis of the regional and urban structure, and emission projections and calculations for F-gases, waste and machinery. The duty of the Ministry of Transport and Communications included projections for fuel and electricity use, as well as emissions from the transport sector and international bunkers. The Ministry of Agriculture and Forestry oversaw the calculation of emissions and removals in the agriculture and land use, land-use change, and forestry sectors. The Ministry of Finance was responsible for forecasting short-term economic development and taxation.

The sectoral projections, assessments of policies and measures, and other calculations, modelling, and analysis were made by expert organisations, research institutes, and consultants selected for the purpose by the

13 Koljonen, T. et al. 2021, https://urn.fi/URN:ISBN:978-952-383-257-2

ministries. The following authorities and expert organisations contributed to the reporting in 2022: the Energy Authority; the Finnish Environment Institute; VTT Technical Research Centre of Finland Ltd; Motiva Ltd; Natural Resources Institute Finland; the Finnish Institute for Health and Welfare; Pellervo Economic Research PTT; the Finnish Transport and Communications Agency; Sitowise Group Oyj; and Statistics Finland.

The main models and methods used in the work are briefly described in Section 5.8.3.

5.8.2 Assumptions underlying calculations

A summary of key variables and assumptions is presented in Table 5.17.

Table 5.17
Key variables and assumptions used in the projections analysis for 1990 to 2035

	Unit	Historical							Projected		
		1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Population	Million inhabitants	5.00	5.12	5.18	5.26	5.38	5.49	5.53	5.56	5.57	5.56
Gross Domestic Product	Million EUR, 2020 prices	146,000	143,000	183,000	208,000	218,000	219,000	232,000	257,000	276,000	297,000
Coal wholesale price	EUR/GJ LHV, 2020 prices for history, 2022 prices for the future	NA*	3	4	5	5	8	10	3	3	3
Crude oil wholesale price	EUR/GJ LHV, 2020 prices for history, 2022 prices for the future	NA*	4	7	9	9	8	9	12	14	15
Natural gas wholesale price	EUR/GJ LHV, 2020 prices for history, 2022 prices for the future	NA*	4	5	6	9	13	13	6	6	7
Emission allowance price	EUR/t nominal prices	NO	NO	NO	23	14	7	25	25	30	35
Tax components: **											
Electricity, tax category I	cent/kWh, 2020 prices for history, 2022 prices for the future	NA*	NA*	NA*	NA*	0.98	2.33	2.24	2.24	2.24	2.24
Electricity, tax category II	cent/kWh, 2020 prices for history, 2022 prices for the future	NA*	NA*	NA*	NA*	0.28	0.72	0.69	0.05	0.05	0.05
Calculation basis of excise duty rates for heating, power plant and machinery fuels (coal, natural gas)											
Energy content component	EUR/MWh LHV, 2020 prices for history, 2022 prices for the future	NA*	NA*	NA*	NA*	NA*	6.92	7.63	10.33	10.33	10.33
Carbon dioxide component***	EUR/t lifetime CO_2 emissions, 2020 prices for history, 2022 prices for the future	NA*	NA*	NA*	NA*	NA*	NA*	53.00	53.00	53.00	53.00
Calculation basis of excise duty rates for liquid transport fuels											
Energy content component	EUR/MWh LHV, 2020 prices	NA*	NA*	NA*	NA*	NA*	59.90	58.72	60.52	60.52	60.52
Carbon dioxide component***	EUR/t lifetime CO_2 emissions	NA*	NA*	NA*	NA*	NA*	60.32	62.00	77.00	77.00	77.00

* No data available or regarding taxes, the taxation structure was significantly different from the present and thus not comparable
** The values in the table represent base case rates. Several reductions and exemptions exist (more information in Section 4.5)
***For combustion only, the value would be 20% higher.

In addition, please note that the historical data on population and gross domestic production represents the data used in the projections and may slightly differ from the latest statistics

Sources: AFRY, Statistics Finland

Finland's population will increase only slightly from the current 5.53 to 5.57 million in 2030. In 2031, the population will start to decrease. The population's age structure will change significantly over the next couple of decades as the share of older age groups increases. The number of households is expected to grow from the current 2.7 million to almost 2.9 million by 2050. However, at the same time, the average size of households will decrease. The number, structure, and location of households will have an impact on energy demand.

The impact of the Covid-19 pandemic was also considered when projecting the economic development and to the extent possible in the sector projections. Economic growth will recover during 2021, but it will remain modest at first thereafter. During the 2020s, the world economy is expected to recover, which will also begin to have an impact in Finland. The average annual GDP growth rate in the 2020s is 1.5 per cent in the projections. The activities that will sustain most growth in production in the 2020s are expected to be machinery and equipment manufacturing, the forest industry, and the financial and insurance business.

The fuel taxation structure was recently overhauled to make energy content and carbon dioxide the main components. They are applied to two categories shown in the table above and described in more detail in Section 4.5. The electricity tax is divided into two categories, of which the lower (category II) is applied to industry and heat pumps in district heat production, and the higher mostly to consumers, for example. As the table illustrates, the ongoing trend is that electricity for industry is taxed less and combustion fuels more. The 2025 figures in the table correspond to taxation in 2022. After 2025, the taxation structure and levels remain constant in the projections, as no changes are currently planned.

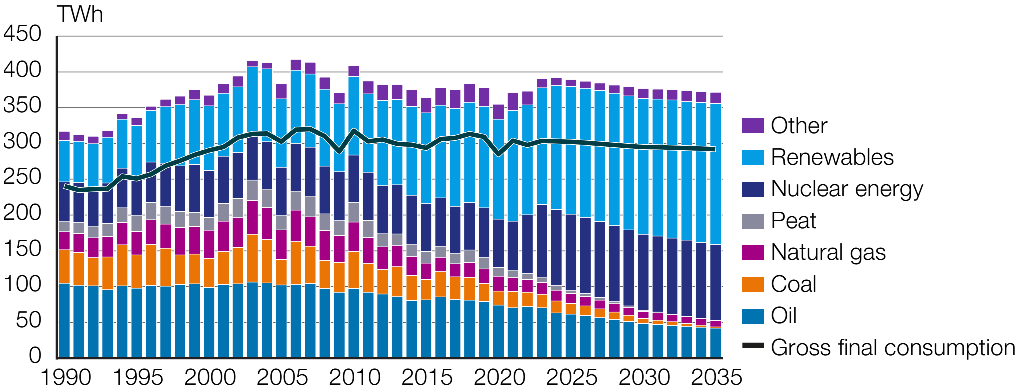
Assumed fossil fuel prices in the world market and the assumed prices of emissions allowances in the EU's emissions trading system correspond to the recommended harmonised values provided by the EU Commission for greenhouse gas emission projections before the current energy crisis in Europe.

The primary energy by source, energy sources for district heat and combined heat and power production, electricity supply, electricity consumption in the forest industry and energy sources in the transport sector are presented in Tables 5.18 to 5.22.

Gross final energy consumption is levelled off in the projections because of increased energy efficiency in all sectors. The decreasing energy sector emissions are the result of policy measures that replace fossil fuels with renewables and electricity. Despite the flat final consumption projection, the primary energy consumption significantly varies in the projections. The main reason for this is the substantial changes in domestic nuclear power production (increase in early 2020s and 2030s), which replaces electricity imports. Expressed in primary energy, the value of nuclear power is three times that of imported electricity, despite the same amount of electricity fed to consumption. The development of the primary energy supply and gross final energy consumption in the WM projection is shown in Figure 5.5 and Table 5.18.

Figure 5.5

Historical development (1990 to 2020) and WM projection (until 2035) of the primary energy supply by energy source and gross final energy consumption (solid line), TWh



Source for historical data: Energy Statistics

Table 5.18

Primary energy by energy source and gross final energy in 2010, 2015, 2020 and in the WM projection for 2025, 2030 and 2035, TWh

	Historical			WM Projection		
	2010	2015	2020	2025	2030	2035
Oil	97.2	81.6	74.3	61.7	48.2	42.1
Coal	51.8	28.3	19.5	14.8	7.2	1.5
Natural gas	41.3	22.9	20.7	13.8	10.0	8.8
Peat	27.2	16.1	12.0	4.9	1.6	0.4
Nuclear energy	66.3	67.7	67.7	106.2	106.2	106.2
Renewables	109.9	126.3	139.6	178.4	189.8	196.6
Other	14.6	21.4	20.9	9.6	13.6	15.8
Gross final consumption	317.7	293.9	285.0	302.4	294.9	292.0

Source for historical data: Energy Statistics

The trend of replacing fossil fuels and peat with renewables and electricity is also clear in the district heating sector, as the table 5.19 below illustrates. The share of waste heat recovery especially is expected to grow rapidly in the coming years, being three times the 2020 level after 2025. Most of the increase is attributed to heat pumps, as almost all the waste heat streams that can be directly utilised are already harnessed. The table also presents the fact that the total district heat consumption, and therefore the energy sources, is in decline due to buildings' improving energy efficiency.

Table 5.19
Energy sources for district heat (heat-only boilers and CHP-heat) and CHP-electricity in 2010, 2015, 2020 and in the WM projection for 2025, 2030 and 2035, TWh

	Historical			WM Projection		
	2010	2015	2020	2025	2030	2035
Fuel oils	3.5	1.5	0.8	0.6	0.3	0.3
Coal	14.2	11.7	6.9	0.6	0.0	0.0
Natural gas	25.7	11.9	9.1	3.6	1.5	0.9
Peat	13.3	9.3	7.7	2.0	0.4	0.2
Wood-based fuels	19.5	24.1	27.9	24.4	23.4	19.6
Other renewables (mainly biogas and renewable part of waste)	1.0	2.3	3.0	2.7	2.8	2.7
Other fossil fuels (mainly non-renewable part of waste)	1.0	1.9	2.5	2.3	2.1	2.1
Other sources (mainly waste heat and electric boilers, includes both electricity and heat of heat pumps)	1.2	2.6	4.5	9.4	10.4	11.1

Source for historical data: Energy Statistics

In electricity supply, the share of wind power especially will probably grow even more rapidly than in the past (Table 5.20). At the same time, the share of wood-based fuels is expected to grow to some extent, and that of fossil fuels to decrease. The need for electricity imports depends on many factors, but the annual net import should generally remain substantially lower than in the past, despite the continuously growing electricity demand that results from decarbonisation and electrification.

Table 5.20
Electricity supply in 2010, 2015, 2020 and in the WM projection for 2020, 2030 and 2035, TWh

	Historical			WM Projection		
	2010	2015	2020	2025	2030	2035
Hydro	12.7	16.6	15.7	14.3	14.4	14.5
Wind and solar	0.3	2.3	8.2	20.6	25.6	33.9
Wood-based biomass	10.0	10.1	10.3	13.6	13.6	13.7
Other renewables (mainly renewable part of waste)	0.4	0.6	0.6	0.7	0.5	0.6
Nuclear	21.9	22.3	22.4	35.0	35.0	35.0
Oil	0.4	0.2	0.2	0.1	0.0	0.0
Coal	13.6	4.8	2.3	1.3	0.3	0.0
Natural gas	11.0	5.1	3.9	2.9	2.3	2.2
Peat	5.9	2.9	2.0	0.8	0.2	0.0
Others (mainly fossil part of waste)	0.4	0.3	0.9	0.6	0.5	0.5
Imports	10.5	16.3	15.0	1.7	6.1	7.9

Source for historical data: Energy Statistics

The forest industry is both a significant energy consumer and an electricity and heat producer. Pulp mills especially produce large amounts of electricity and heat from black liquor, which is the main by-product from the kraft process, which digests pulpwood into paper pulp. In addition, biomass by-products from the forest industry, such as bark and sawdust from the mechanical forest industry, are utilised as fuels in both the forest industry and the energy sector. For example, these by-products equated to approximately 24 TWh and black liquor to 46 TWh in 2021. At the same time, the total use of wood-based fuels was approximately 110 TWh.

Conventionally, all black liquor has been combusted in specially designed boilers for heat and electricity. In the WM projection, it is expected that some black liquor will be converted into biofuels for transport in the future. Large amounts of black liquor should be available, as the market trends seem to decrease print, special, and soft paper production but increase the production of pulp and new products (such as textiles, chemicals, and bioplastics) that generate black liquor as a by-product. The table 5.21 below shows historical and projected electricity consumption in the forest industry. The product volumes are included in the table listing LULUCF parameters (Table 5.26a).

Table 5.21
Electricity consumption in the forest industry in 2010, 2015 2020 (historical) and 2025, 2030 and 2035 (WM projection)

	Historical			WM Projection		
	2010	2015	2020	2025	2030	2035
Electricity consumption, TWh						
Pulp and paper	20.6	17.5	15.6	16.5	16.4	16.4
Mechanical forest industry	1.6	1.3	1.4	1.3	1.4	1.3

Source for historical data: Statistics Finland

In the transport sector, greenhouse gas emissions are influenced by a decline in specific energy consumption and especially by replacing fossil fuels with alternative transport fuels (Tables 5.22 and 5.23). The WM projection's annual distribution obligation percentages for biofuels for 2022 to 2030 are 12, 13.5, 28, 29, 29, 30, 31, 32, and 34 per cent (from 2030 onwards). The share of biofuels in consumption increases, and respectively, the share of fossil fuels in consumption decreases. Biogas and electric fuels are included in the distribution obligation between 2022 and 2050. In the WM projection, the bio-share of transport gas will increase by 5 per cent units per year until the share reaches the 99 per cent level. Biogas replaces biodiesel in fulfilling the distribution obligation: biogas consumption increases, and the corresponding amount of energy decreases from the consumption of biodiesel. In the WAM projection, the share increases to 100 per cent in 2045.

Table 5.22
Energy sources in transport in 2010, 2015, 2020 and in the WM projection for 2025, 2030 and 2035, TWh

	Historical			WM Projection		
	2010	2015	2020	2025	2030	2035
Gasoline, fossil	17.8	15.8	13.6	12.9	11.1	8.5
Diesel, fossil	27.1	23.4	24.5	15.6	11.9	10.1
Biofuels	1.5	5.8	4.7	11.6	11.6	9.0
Aviation fuels, fossil	1.6	1.2	1.0	1.1	1.1	1.1
Light fuel oil	1.7	1.6	1.3	1.3	1.1	1.0
Heavy fuel oil, gas, hydrogen	0.5	0.1	0.2	0.8	1.2	2.0
Electricity	0.7	0.7	0.8	2.1	4.6	7.9

Source for historical data: Energy Statistics

Table 5.23
Main assumptions for the transport sector

	Unit	Historical			WM Projection		
		2010	2015	2020	2025	2030	2035
Number of vehicles – in total	**pieces**	**3,340,794**	**3,461,862**	**3,461,451**	**3,566,784**	**3,656,316**	**3,706,248**
Passenger cars	pieces	2,486,283	2,612,922	2,748,448	2,797,311	2,891,542	2,938,448
Vans	pieces	289,824	307,706	338,389	331,924	327,795	329,174
Buses	pieces	11,610	12,455	9,955	11,573	12,615	13,409
Trucks	pieces	94,334	95,250	94,691	99,247	104,451	110,180
Motorcycles, mopeds, 4-wheels	pieces	458,743	433,529	269,968	326,729	319,913	315,037
Passenger cars by operating forces							
Petrol and Diesel	%	100	100	97	85	68	48
Battery Electric and Plug-in Hybrid	%	0	0	2	14	30	48
CNG Gas and Flexible Fuel Vehicles	%	0	0	1	1	1	1
Hydrogen	%	0	0	0	0	0	3
Vehicle kilometres – in total	**Million kilometers**	**54,860**	**56,365**	**49,668**	**53,060**	**57,639**	**64,333**
Passenger cars	Million kilo-meters	46,245	47,355	39,092	42,166	46,597	53,138
Others	Million kilo-meters	8,615	9,010	10,576	10,894	11,042	11,195

The main assumptions for the F-gases are listed in Table 5.24. Significantly more than 90 per cent of the emissions of F-gases originate from refrigeration and air-conditioning equipment. The single most significant emission source is commercial refrigeration. The sector is comprised of refrigeration in food retail stores and professional kitchens. The most significant factor affecting the emissions of F-gases is the replacement of HFC refrigerants with natural refrigerants (carbon dioxide and hydrocarbons). By 2035, it is assumed that all the remaining HFC refrigerants will have been replaced by natural refrigerants in existing commercial refrigeration equipment. The replacement is assumed to be slightly faster in the WAM scenario.

Table 5.24
Main assumptions for F gases

	Historical			Projection		
	2010	2015	2020	2025	2030	2035
	%					
WM projection						
Share of centralized refrigeration systems with CO_2 or hydrocarbons annually in use						
in food retail stores	3	8	15	36	83	100
in professional kitchens	NO	NO	10	25	65	100
WAM projection						
Share of centralized refrigeration systems with CO_2 or hydrocarbons annually in use						
in food retail stores	3	8	15	36	89	100
in professional kitchens	NO	NO	10	25	75	100

Source: Finnish Environment Institute

For agriculture, the development of livestock numbers has been estimated using the Dremfia agricultural sector model[14], which considers the prices of agricultural inputs and outputs and agricultural policy.

Farm sizes and productivity are increasing in dairy cattle farming, which will see a large-scale shift from single dairy robot units to units of two or more robots between the 2020s and 2030s. Total milk production will fall by 3 per cent from the 2020 level by 2035, but the number of dairy cows will be reduced by approximately 15 per cent. Fewer cows will be needed to produce the same amount of milk because the average milk yield of dairy cows will increase in the future.

The development in the dairy sector is reflected in the lower numbers of calves and heifers. Instead, the number of suckler cows will increase by about 1,500 cows by 2035. The slow reduction in the real price of beef and the expected constant agricultural subsidy for cattle do not give economic opportunities for greater suckler cow production growth.

Production of pork and poultry meat, and hence also animal numbers, depends on domestic demand. Pork consumption is decreasing, but the annual consumption of poultry meat is expected to reach 150 million kilograms and remain at this level. It has been assumed that the number of sheep will remain the same.

In the Dremfia model, total fertilisation and synthetic nitrogen fertilisation, which complements nitrogen from manure, are determined according to

14 Lehtonen 2001

nitrogen yield response and nitrogen and plant product prices. The amount of manure decreases as the numbers of farmed animals decrease. Hence, the amount of nitrogen input from the application of manure will decrease by 8 per cent between 2020 and 2035. The nitrogen requirement of crops is complemented by synthetic nitrogen fertilisation, the amount of which will increase by 2 per cent between 2020 and 2035. Rising synthetic nitrogen fertiliser prices caused by rising fossil energy prices will reduce the growth of synthetic fertiliser application.

The increasing grassland area and use of catch crops will increase the nitrogen emission of crop residues returned to soils. The area of agricultural land will decrease by 2035 as more agricultural land will be converted to other land uses than new agricultural land is cleared. Reduction is proportionately strongest on cultivated organic soils, the area of which will decrease by 3 per cent between 2020 and 2035.

Table 5.25
Main assumptions for the agricultural sector

	Unit	Historical			WM Projection		
		2010	2015	2020	2025	2030	2035
Livestock							
Dairy cattle	1,000 heads	289	285	260	238	231	219
Non-dairy cattle	1,000 heads	636	630	587	566	537	525
Sheep	1,000 heads	126	155	140	140	140	140
Pig	1,000 heads	1,340	1,239	1,104	1,010	984	967
Poultry	1,000 heads	9,587	12,927	13,577	14,072	13,896	13,829
Nitrogen input from application of synthetic fertilizers	kt nitrogen	157	143	139	148	143	142
Nitrogen input from application of manure	kt nitrogen	73	74	71	69	67	65
Nitrogen in crop residues returned to soils	kt nitrogen	87	99	91	84	89	92
Area of cultivated organic soils	1,000 hectares	317	327	338	341	336	328

The main assumptions for the LULUCF sector are presented in Table 5.26a, with additional information in Table 5.26b. Assumptions are based on three scenario studies: the HIISI scenario; the updated HIISI for agriculture; and the scenario for the Climate Plan for the Land Use Sector. The HIISI scenario for the LULUCF sector was compiled in 2021. It was updated with the Climate Plan for the Land Use Sector in 2022. At the same time, the HIISI scenario for agriculture was updated. The LULUCF projection in this NC8 is a compilation of these three scenarios. The whole LULUCF projection was not updated in 2022, because a new scenario study will start at the beginning of 2023.

Table 5.26a

Main assumptions for the LULUCF sector

	Unit	Historical			WM Projection		
		2010	2015	2020	2025	2030	2035
4.A Forest land							
Forest harvest removals for energy use	1,000 m^3	7,734	9,186	10,308	9,300	10,800	10,800
Forest harvest removals for non- energy use	1,000 m^3	51,957	58,849	58,546	61,800	67,800	67,800
Forest increment	1,000 m^3	106,400	105,640	105,640	106,800	108,600	108,600
Forest land remaining forest land	1,000 ha	21,781	21,754	21,754	21,723	21,692	21,676
Land converted to forest land	1,000 ha	162	130	95	118	156	161
4.B Cropland							
Cropland	1,000 ha	2,474	2,490	2,502	2,489	2,475	2,465
4.C Crassland							
Grassland	1,000 ha	238	238	243	245	243	241
4.D Wetlands							
Peat extraction sites	1,000 ha	108	112	111	99	67	47
Other wetlands	1,000 ha	6,336	6,325	6,322	6,306	6,305	6,310
4.E Settlements							
Lands converted to settlements	1,000 ha	232	252	227	212	190	175
4.G Harvested wood products							
Production of sawn wood	1,000 m^3	9,473	10,640	10,916	11,580	12,260	12,350
Production of wood panels	1,000 m^3	1,347	1,314	1,206	1,291	1,286	1,288
Production of paper and paperboard	1,000 tonnes	10,508	10,247	10,120	7,713	7,919	8,217
Export of pulp	1,000 tonnes	2,159	3,136	4,333	5,222	5,744	6,139

m^3 = cubic meters, ha = hectares

Table 5.26b
Main assumptions for the LULUCF sector

	Assumption	Source
Forest		
Roundwood demand	Based on production volumes of different branches of forest industry and roundwood import	HIISI scenarios
Energy wood demand		HIISI scenarios
Wood prices	Average of 2008 to 2017	Forest Statistics
Costs of silviculture	Average of 2007 to 2026	Forest Statistics
Climate	Increase in temperature and CO_2 concentration has increased increment of trees	HIISI scenarios
Avoidance of remedial drainage	1,000 hectares less annually on drained most fertile and poorest peatland forests	Climate Plan for the Land Use Sector
Comprehensive peatland forest management, thinning from above	6,000 hectares annually on most fertile drained peatland forests	Climate Plan for the Land Use Sector
Ash fertilisation on peatland forests	50,000 hectares per year	Climate Plan for the Land Use Sector
Forest fertilisation on mineral soils	67,000 hectares per year	Climate Plan for the Land Use Sector
Increased volume of dead wood in commercially utilised forests	Increase of up to 7 cubic meters per hectare	Climate Plan for the Land Use Sector
Immediate regeneration after regeneration felling	No delays	Climate Plan for the Land Use Sector
Agricultural lands	years 2025, 2030, 2035	
Raising the groundwater level in peaty agricultural lands (grasslands) –30 cm	7,500, 20,000, 32,500 hectares	Climate Plan for the Land Use Sector, Updated HIISI AGRI
Paludiculture, groundwater level –30 cm	2,000, 5,000, 10,000 hectares	Climate Plan for the Land Use Sector, Updated HIISI AGRI
Perennial grasslands without tilling	40,000, 40,000, 40,000	Climate Plan for the Land Use Sector, Updated HIISI AGRI
Land-use change		
Afforestation of arable lands and peat production areas 2021 to 2023	3,000–4,000 hectares per year	Climate Plan for the Land Use Sector
Afforestation of low-yield fields 2024 to 2028	9,000 hectares per year	Climate Plan for the Land Use Sector
Deforestation, from forest to arable land	Decrease of 900 hectares per year on organic soils and 800 hectares per year on mineral soils	Climate Plan for the Land Use Sector
Wetting of poorly productive, thick-peaty fields to establish wetlands	4,000, 10,000, 10,000 hectares	Climate Plan for the Land Use Sector
Managed wetlands, peaty arable land to wetland (no longer in agricultural use)	1,500, 4,000, 7,500 hectares	Climate Plan for the Land Use Sector, Updated HIISI AGRI
Paludiculture, groundwater level –5 – –10 cm, peaty arable land to wetland	1,000, 2,500, 5,000 hectares	Climate Plan for the Land Use Sector

The main assumptions for waste sector are listed in Table 5.27. The landfilling of waste is increasingly replaced with recycling and energy recovery. In 2010, the amount of municipal waste incinerated at waste incineration plants was approximately 244,000 tonnes (2,444 TJ) and in REF burning plants 313,000 tonnes (6,260 TJ). Several new waste incineration plants have been constructed in recent years and in 2020 the incinerated amount outside the emissions trading sector was already more than 18,400 TJ[15]. The WM projection estimates from 2023 onwards the incinerated amount outside the emissions trading sector to be 20,200 to 20,400 TJ. Since 2017, there has been a comprehensive landfill ban on biodegradable waste and biodegradable waste could only go to landfills in waste batches (e.g. rejects) with a very low biodegradable fraction. In the WM projection, it is assumed that 15 thousand tonnes of municipal waste would go to landfills per year from 2021. The share of methane recovery from landfills WM-projection is assumed to be 25 per cent of the total methane generation for years 2025, 2030 and 2035. No new recovery plants are assumed to be built and no changes are assumed to the technical level of the plants' operation in the current situation.

Table 5.27
Main assumptions for the waste sector

	Unit	Historical			WM Projection		
		2010	2015	2020	2025	2030	2035
Municipal solid waste (MSW) going to landfills	tonnes	1,093,000	316,000	15,000	15,000	15,000	15,000
Share of CH_4 recovery in CH_4 generation (excluding industrial wastes) from landfills	%	33	33	24	25	25	25

For the projections, the split of emissions in those included in the EU Emissions Trading System (EU ETS) and those outside the EU ETS is based on a data set of greenhouse gas emissions covering 2005 to 2020 and provided by Statistics Finland. The relative shares of EU ETS and non-ETS emissions to be used in the projections are set for the individual branches and greenhouse gases and are listed in Table 5.28. The individual shares are assumed to remain constant for each branch over time in the projections.

15 also including small amounts of fuels other than municipal waste

Table 5.28
Projected EU ETS and non-ETS shares of GHG emissions
The split is based on GHG inventory data for the years 2018 to 2020

	EU ETS	Non-ETS
	%	%
CO_2 emissions		
Energy sector		
Energy industries excl. small plants	100	0
Energy industries, small plants	0	100
Waste incineration plants	0	100
Food industries and manufacture of beverages	60	40
Manufacture of wood and of products of wood	9	89
Manufacture of paper and paper products	92	8
Petroleum refining	96	4
Chemical industry excl. petroleum refining	80	20
Manufacture of non-metallic mineral products	89	11
Manufacture of basic metals, iron and steel production	100	0
Manufacture of basic metals, non-ferrous metal production	0	100
Other manufacturing industry	7	93
Civil aviation	99	1
Transport sector excl. civil aviation	0	100
Machinery	0	100
Building specific heating	0	100
Agriculture	0	100
Fishing	0	100
Other energy sector emissions	0	100
Fugitive emissions	90	10
Industrial processes		
Mineral industry	89	11
Chemical industry, hydrogen production	100	0
Chemical industry, production of phosphoric acid and other chemicals	0	100
Metal industry, iron and steel production	100	0
Other		
CO_2 captured	100	0
Liming	0	100
Other product and solvent use	0	100
Indirect CO_2 emissions	0	100
N_2O emissions		
Fuel combustion incl. transport and machinery	0	100
Nitric acid production	100	0
Manure management	0	100
Agricultural soils	0	100
Waste disposal and treatment	0	100
Other emissions	0	100
CH_4 emissions		
Fuel combustion incl. transport and machinery	0	100
Fugitive emissions	0	100
Enteric fermentation	0	100
Manure management	0	100
Waste disposal and treatment	0	100
F gas emissions		
F gas use	0	100

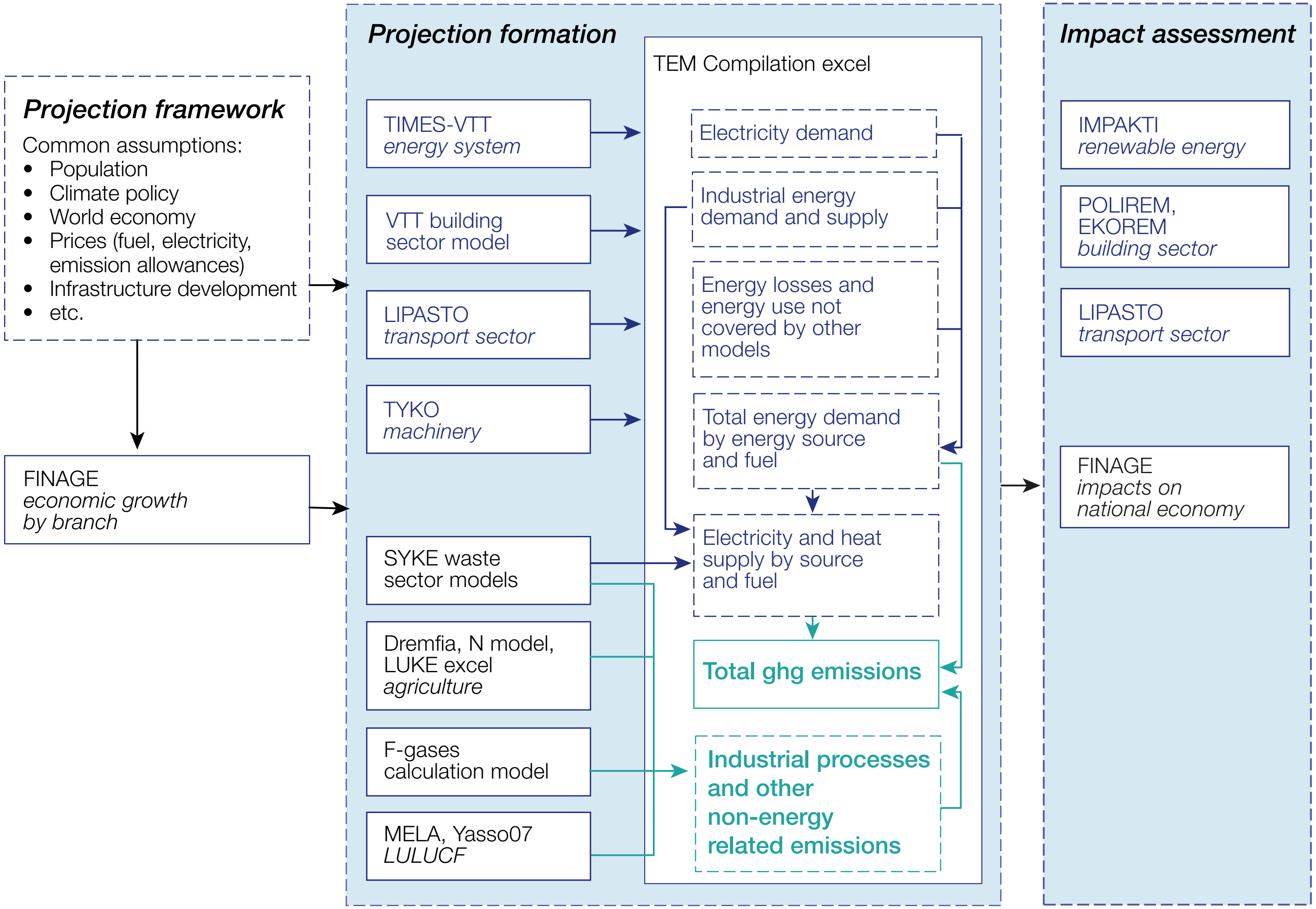
Assumptions and data sources for the different sectors are presented in more detail in the background reports that were prepared for the National Climate and Energy Strategy[16].

5.8.3 Description of models and methods

A fairly large number of models are applied for the preparation of the greenhouse gas emission projections and impact assessment of policy measures. The individual models that are central for energy and greenhouse gas emission projections are described in the sections below. The relationship and data flow between the different models is shown in Figure 5.6. Data from sector-specific models and studies are compiled by the Ministry of Economic Affairs and Employment in the module named "TEM Compilation excel" in Figure 5.6. The same Excel spreadsheet is used to calculate the projected energy balances and greenhouse gas emissions of the industry and the electricity and district heat production. The methodology for this is presented below under the Energy demand and production heading.

16 Koljonen, T. et al., 2021, 2022 https://publications.vtt.fi/pdf/technology/2022/T402.pdf https://urn.fi/URN:ISBN:978-952-383-257-2

Figure 5.6
Schematic diagram of the relationship and data flow between the different models applied in the projections and impact assessment of policy measures



Buildings

The development of the energy consumption of the building stock has been modelled in accordance with the Long-term Renovation Strategy (LTRS)[14], which follows the EPBD 2018/844/EU revision and covers the 2020 existing building stock. The calculation of the goals of the LTRS and the data were created by VTT and SYKE experts. To implement the strategy in Finland, three key actions were identified: 1) removal of buildings and improving spatial efficiency; 2) improvements in energy efficiency in connection with maintenance and repairs; and 3) ceasing the use of fossil fuels in heat production. The guidance of the Energy Efficiency of Buildings Directive (EPBD) applies to residential and non-residential buildings in permanent use. Leisure, agricultural, industrial and storage buildings are therefore excluded.

The energy consumption scenario for buildings considers climate change, the removal of buildings, development of heating methods, repair measures and maintenance giving up the use of heating oil. The primary sources for the scenario are the data describing the building stock of Statistics Finland and energy certificates defined by Ministry of the Environment Regulation 1048/2017 of the register maintained by ARA.

The removal of buildings has been modelled by examining the life cycle of the building stock based on building register data. Based on this information, the expected service life has been calculated for buildings of different ages. The development of the strategy's heating methods was modelled[17] as part of the PITKO project[18] based on 2018 Statistics Finland data. The development of heating sources is based on the results of the TIMES-VTT optimisation model. The effect of global warming was considered in the strategy so that it reduced the heating energy demand of buildings and increased the cooling energy demand. The impact of repairs on the energy consumption of old buildings is based on energy efficiency improving measures in exterior envelope repairs and technical system repairs. The calculation assumes that terraced houses and apartment buildings will give up property-specific oil heating by 2030, and detached houses and non-residential buildings by 2050. It is assumed that fossil fuels and the electricity they consume will be replaced by heat pumps. An exception is that it is assumed that a small part of non-residential buildings will continue to be heated by oil. It is assumed that this oil heating will be completely covered by bio-oil in non-residential buildings in 2050. The Government Regulation[19] on energy subsidies for residential buildings from 2020 to 2022 has also been considered – it is assumed that a third of the energy savings will be realised as an improvement in structural energy efficiency, and two thirds through an increase in the use of heat pumps.

17 Kangas et al. 2020

18 Koljonen, T. et al. 2019, https://urn.fi/URN:ISBN:978-952-287-656-0

19 1341/2019

The methodology and modelling of the building sector projections described above are new for the Eighth National Communication. The building sector projections in the Seventh National Communication were based on modelling by the Finnish Environment Institute[20].

The impacts of policies and measures in the WM projection were estimated using the EKOREM and POLIREM models. The EKOREM[21] model is a bottom-up building stock calculation model developed by the unit of Construction Management and Economics at Tampere University of Technology and VTT Technical Research Centre of Finland. The calculation model is based on part D5 (2007) of the National Building Code of Finland: "Calculation of energy needs for heating of buildings". The model can be used to calculate energy consumption and greenhouse gas emissions and to analyse the energy savings and greenhouse gas emissions reduction potentials achieved by various policy scenarios. These scenarios can include building-related structural measures, as well as changes in the energy production structure. The model is further developed, and a calculation and visualisation approach for energy use and greenhouse gas emissions is presented.

In the EKOREM model, the building stock is divided into building-type categories like those used by Statistics Finland, so that official building statistics can be used as a basis for the calculations. Building stock data can further be divided into different age classes to better describe the methods of construction in different eras. The model includes a great deal of descriptive data such as U-values[22] for structures, technical specifications for ventilation, and information about electricity consumption. The model also includes heating system distributions for the different building types. These distributions and emission coefficients are used to determine greenhouse gas emissions (CO_2 eq.) for the studied building stock.

One of the main purposes of the model has been to produce assessments for the climate and energy policy reporting that show how developments in Finnish climate policies have affected the energy consumption and the greenhouse gas emissions of the Finnish building stock.

POLIREM is also a bottom-up building stock model. It covers less technical details than the EKOREM model. Instead, it considers the different primary energy sources in a more detailed manner than EKOREM. The POLIREM model uses official energy and building stock statistics of Finland and is suitable for analysing the impacts of policy measures on emissions, the use of renewable energy resources and the division of impacts between the ETS

20 Mattinen, M. et al. 2016, https://helda.helsinki.fi/handle/10138/166673

21 Heljo et al. 2005

22 U-values (sometimes referred to as heat transfer coefficients or thermal transmittances) are used to measure how effective elements of a building's fabric are as insulators: how effective they are at preventing heat from transmitting between the inside and the outside of a building

and non-ETS sectors. These two modelling tools have been used for previous National Communications.

Strengths and weaknesses of the EKOREM and POLIREM models can be summarised as follows. Strengths include the following: (1) Strong methodological basis; (2) The data of the models is carefully selected from official statistics and research data, so that the model describes national conditions well; (3) Detailed technical characteristics are a strength of the bottom-up approaches, allowing the models to be used for examining various alternative technologies. Weaknesses include the following: (1) Insufficient information about changes in the heating method of old buildings and the selection of heating methods for new buildings; (2) Many default values and their updateability.

Energy demand and production

The Ministry of Economic Affairs and Employment compiles the projections for energy production, using demand projections for each consumption sector as a basis. Except for the energy used by industry, households, and services, as well as the energy used for other smaller consumption purposes, the demand projections are produced by other organisations using the models described in this section. The energy demand projections for industry and services are determined by industrial production per product group (pulp and paper, basic metals), branch-specific economic growth (other industry, public, and commercial services), specific energy use trends, and expected energy efficiency improvements. The household projection is based on population and household forecasts. The demand projection assumptions are based on statistics, expert judgements, and surveys by consultants, research organisations, and branch organisations.

The global TIMES-VTT energy system model is the main tool for the energy system modelling. The energy needed from power and heat generation plants (main activity producer plants) is based on modelling the total electricity and heat demand, the calculated electricity and heat generated by the industry itself (auto-producer plants), as well as assumptions about electricity net imports. Information on existing and planned power plants and their possible dismantling and construction schedule respectively is used.

The TIMES-VTT model has been developed by VTT Technical Research Centre of Finland Ltd, which also runs the model and produces projections and analyses for the ministry. TIMES-VTT contains a detailed representation of the Finnish, Swedish, Norwegian and Danish energy systems and data on other countries in a more aggregated form. The model is based on the global ETSAP TIAM model, which was developed through international cooperation, building on the IEA ETSAP TIMES modelling system. Methodologically, it is a so-called partial equilibrium model, which maximises the total economic surplus of consumers and producers. The model includes detailed descriptions of both the current system of energy production and consumption and future technologies in terms of several different investment options. The TIMES-VTT model's strength lies in its sector integrating and holistic modelling ability as well as in the model's large geographical coverage. The TIMES-VTT model's extensive database contains a detailed description of the current energy system, including the energy production and distribution system, building stock, energy uses in housing and services, the stock of cars and other vehicles, processes and plants for manufacturing energy-intensive industrial products, other industrial energy end uses, as well as energy use in agriculture and forestry. The model database also covers estimates for energy system removals such as removals from energy production plants, buildings and vehicles. However, the downside is that largest part of the database naturally consists of technological descriptions of investment options and assumptions in future energy systems, including estimated trends in their costs and technical performance (energy production efficiencies, service life, usability, etc.). The model also depicts regional technical potential of energy commodities, the global fuel trade, emissions trading, including trade in CO_2 transport and storage services. The TIMES-VTT model and its databases have been discussed in several scientific articles[23]. Finally, energy sector CO_2 emission projections are obtained by multiplying the fuel consumption of different fuels by the corresponding emission factors. Historical emissions and amounts of fuel are used to calculate CH_4 and N_2O emissions.

As for policy measures, the IMPAKTI calculation tool[24] is used to calculate the emissions mitigation impact of measures that promote the use of renewable energy. The IMPAKTI calculation tool assumes that forest chips, wind power, and biogas from digesters will not be used without existing policies and measures. The aggregated impact of policies and measures promoting the use of these energy sources is therefore estimated based on energy production (wind power and biogas plants) or fuel use (forest chips) and the assumptions concerning the energy source that is being replaced by the renewable energy source. It is assumed that forest chips will mainly replace peat in power and heat production and other fuels to a small extent. For agricultural farms, it is assumed that the use of forest chips will replace light fuel oil. It is assumed that the electricity produced by renewable energy sources (wind, biogas) will mainly replace marginal electricity, i.e. electricity produced by condensing power plants using fossil fuels or peat. However, as these marginal production modes may not be in operation at each point of time, it is assumed that the production of electricity using renewables may also replace other electricity generation modes or electricity imports. The emission factor used for replaced electricity (600 t CO_2/GWh) is therefore smaller than the emission factor used for electricity production in condensing power plants that use fossil fuels or peat (an average of 850 t CO_2/

23 Koljonen, T. & Lehtilä, A. 2012, https://www.sciencedirect.com/science/article/pii/S0140988312001053?via%3Dihub#ec0005

24 Lindroos, T. J. et al. 2012, https://www.vtt.fi/inf/pdf/technology/2012/T11.pdf

GWh). The emission factor for electricity defined in the IMPAKTI calculation tool (600 t CO_2/GWh) is also used to estimate the mitigation impact of the energy efficiency measures presented in Chapter 4. Strengths of the IMPAKTI model include the strong methodological basis, consisting both of scientific knowledge and up-to-date understanding of the developments in the policy area, transparency owing to the relatively simple methodology and suitability to the national circumstances. A weakness of the model is the lack of disaggregated impact by policy and measure. Due to strong interlinkages of policies and measures promoting renewable energy, the approach used in IMPAKTI would not produce meaningful results for disaggregated policies and measures.

Transport

The transport sector projections are compiled using the LIPASTO calculation system, which is also used to estimate emissions for the greenhouse gas inventory (see Finland's National Inventory Report for a description of the methodology). The LIPASTO calculation system[25] includes five sub-models: LIISA for the road transport inventory; ELIISA for road transport scenarios; RAILI for the railway inventory; MEERI for the waterborne transport inventory; and TYKO for the non-road mobile machinery inventory. LIPASTO models are updated and compiled by VTT Technical Research Centre of Finland. Since 2022, the road transport scenarios are being calculated using a new stand-alone model called ELIISA, which is an upgraded version of its predecessor ALIISA. ELIISA computes the development of the vehicle fleet, kilometrage, consumption, and GHG emissions (includes CO_2, CH_4, and N_2O) until 2050. ELIISA considers all possible powertrain options for vehicles in Finland. The changes in the vehicle fleet are based on the estimated annual sales of new vehicles and imported vehicles and the vehicle scrappage rate. Fuel and energy consumption estimates are based on actual fuel sales.

One of the strengths of the LIPASTO submodels is that the method is compliant with the 2006 "IPCC Guidelines for National Green House Gas Inventories" and the EMEP/EEA's "Emission Inventory Guidebook". However, the transport sector is changing rapidly, e.g. as a result of the electrification of traffic. As technical calculation models, LIPASTO's sub-models do not necessarily fully take into account rapid economic changes in an up-to-date manner which is their weakness (see also Section 3.2.5.2 in Finland's National Inventory Report 2022).

The kilometrage projections for transport are based on the national projections modelled by Finnish Transport and Communications Agency. Since the national projection is produced only every four years, and road transport scenarios produced typically once a year, the national kilometrage projection is implemented through vehicles' average annual kilometrage (estimated per vehicle type, for passenger vehicles, also per powertrain, as in the national

25 http://lipasto.vtt.fi/en/inventaarioe.htm

kilometrage projection). As vehicle fleet estimates change, road transport kilometrage estimates therefore also change and may not fully match the national projection.

In rail transport, the kilometrage development forecasts are based on the estimates given by the Finnish State Railways, VR Ltd. The developments in emission coefficients are based on research carried out at VTT and in other countries. The projection for waterborne transport emissions is based on estimates by the Finnish Transport Agency. The future development of the emissions coefficients for navigation is based on estimates and research results from other countries.

Machinery

Emissions for machinery are estimated with the TYKO model[26] which is part of LIPASTO. TYKO is a deterministic model that gives results of emissions and the amounts of fuels used. The emissions for the following gases are calculated: carbon monoxide (CO); hydrocarbons (HC); nitrogen oxides (NO_x); particles (PM); methane (CH_4); nitrous oxide (N_2O); sulphur oxide (SO_2); carbon dioxide (CO_2). The period of the calculations is 1980 to 2040, and the model includes 50 types of machinery.

The calculation is based on the following key elements: performance and related emission factors (g/kWh); and fuel usage (g/kWh). For example, the method is widely used in the Nonroad model used by the US EPA (Environmental Protection Agency) and the CORINAIR Off-Road vehicle and Machines model. It has been adjusted for Finnish circumstances, e.g. the age and attrition of the machinery. The method is compliant with the 2006 "IPCC Guidelines for National Green House Gas Inventories" and the EMEP/EEA's "Emission Inventory Guidebook" which is one of its strenghts. The TYKO model is the only machinery-model of its kind in Finland, but it needs renewal. The typical usage of machinery in different sectors is estimated based on secondary data; more research is needed to improve model assumptions, as usage of machinery is a key factor affecting the model's output. The model also needs technical improvements: the extension of the time series until 2060 and inclusion of CNG-powered, hybrid, and electric machinery. Development funds have been granted, and it is planned that the development project will begin at the end of 2022.

F-gases

The F-gas emission projections (including HFCs, PFCs, and SF_6) are prepared by the Finnish Environment Institute.

The total F-gas emission projections are sums of the subsector emission scenarios. The F-gas emission sectors are: refrigeration and air-conditioning equipment; foam blowing and the use of foam products; aerosols; electrical equipment; and

26 TYKO model http://lipasto.vtt.fi/inventaario.htm (in Finnish), a part of the LIPASTO http://lipasto.vtt.fi/en/inventaarioe.htm (in English)

grouped emission sources (e.g. fixed firefighting systems and semiconductor manufacturing). The calculation model[27] for F-gas emissions and emission projections in the refrigeration and air conditioning equipment sector (CRF 2.F.1) are part of the official Finnish GHG emission inventory reporting system. The model has 15 different subsectors (equipment types), and the total F-gas emissions of sector 2.F.1 are sums of the subsector emissions. Each of the 15 subsectors is linked to one of the six 2.F.1.a-f reporting sectors under the UNFCCC GHG inventory reporting. The model covers 1990 to 2050. The emissions estimation methodology in the model is the Tier 2 emission factor approach of the 2006 IPCC Guidelines (Volume 3, chapter 7.5).

Emission projections of F-gas sectors other than refrigeration and air-conditioning equipment (CRF 2.F.1) are calculated in separate simplified Excel spreadsheet calculation modes and are based on the calculation spreadsheets used in GHG emission inventory reporting.

A particular strength of the calculation model is that the emissions of the future years are also calculated with the same methodologies within the same model as the historical years. Whenever the emission calculation of the historical years is updated, the effects to the emission projections are visible in real time. The greatest challenges in the emission projections are related to defining the predicted future refrigerant shares and filling rates and leakage rates in different applications.

Agriculture

An economic model and several greenhouse gas calculation models were used to compile the projections for the agricultural sector (CH_4, N_2O). Natural Resources Institute Finland has prepared the projections for the agricultural sector.

Future agricultural production intensity was estimated using the Dremfia[28] agricultural sector model, which considers the prices of agricultural inputs and outputs and agricultural policy. The model has frequently been used to evaluate the impacts of agricultural and agri-environmental policies. The model has therefore also been continuously updated and revalidated based on the available statistical information about input and output prices, food consumption, use of inputs, production, land use, and productivity in agriculture. The parameters and principles of agricultural policy have been updated annually, as well when necessary. The results from Dremfia were fed into the calculation models, which are used for the greenhouse gas emission inventory (see the National Inventory Report for details). Dremfia produced most of the input data for the greenhouse gas modelling: the area

27 Finland's NIR (Chapter 4.7.2) contains a detailed description of the calculation model.

28 Lehtonen, H. & Niemi, J.S. (2018) Effects of reducing EU agricultural support payments on production and farm income in Finland, https://doi.org/10.23986/afsci.67673

of cultivated farmland; the use of mineral fertilisers; and the numbers for the most important animal species in agriculture. In addition, the development of some variables (not included as such in the Dremfia model) in the future was estimated using expert judgements: the area of organic soils; the spread of manure management systems; and developments in the weight of cattle and N excretion of animals. It was assumed that the number of horses, sheep, fur animals, reindeer, and turkeys would remain stable.

Strengths and weaknesses of the Dremfia model can be summarised as follows. Strengths include the following: (1) Regional disaggregation of the model is well suited for analysing effects of agricultural policy; (2) The data of the model is carefully selected from official statistics and research data so that the model includes relevant country specific bio-physical and economic relationships; (3) The model allows simultaneous imports and exports of the same commodity (Armington assumption); (4) The model includes endogenous technological and structural change of dairy sector which accounts approximately 50 per cent of the value of production; (5) Flows of nitrogen and phosphorous are very close to published studies on nutrient balances.

Weaknesses include the following: (1) Some sensitivity of crop area allocation on exogenous EU prices; (2) almost entirely exogenous food demand per capita; (3) fully exogenous farmland area per region; (4) adding new products to the model requires a lot of data and validation work, and (5) The model excludes horticulture, reindeers, fur animals, horses, lambs and goats.

The method and assumptions were done in the same way in previous National Communications. The method makes it possible to consider all measures that are related to agricultural policies, and it produces time series that are consistent with the reported emissions.

Waste

The Finnish Environment Institute calculates the projections for the waste sector. The waste scenarios are based on statistics and modelling following IPCC guidelines. The scenario tool is thus primarily an emissions calculation model, which is complemented by expert judgements on how rapidly the measures will affect the waste sector. The same basic modelling tool has been used for previous National Communications.

The scenario calculations are based on assumptions concerning developments in the amount of waste related to standard population projections and the rate at which different waste treatment facilities are introduced. The modelling deals separately with solid municipal waste, municipal sludge, industrial sludge, industrial solid waste, and building waste. Different treatments are considered separately (landfilling, biological treatment, incineration, recycling). Emissions from wastewater treatment, composting, and anaerobic digestion are dealt with separately, and methane collection from landfills is also considered. CH_4

and N_2O emissions are treated separately. After the waste amounts have been defined, the greenhouse gas emissions are calculated according to the IPCC instructions and the methods used in the Finnish inventories.

The modelling builds on aggregating information for the waste sector, and there are therefore only limited opportunities to project the detailed effects of individual policy measures in terms of emissions reductions. There has thus far been only limited information about the costs and benefits of the measures included in the analyses. There are no direct overlaps with projections from other sectors, as the projections of the waste sector do not include emissions from waste incineration, which are reported in the energy sector.

LULUCF

The LULUCF projection is a compilation of the projections for different land-use categories and harvested wood products (HWP). Projections are prepared for forest land, cropland, grassland, wetlands, and settlements. The emissions (CO_2, CH_4, N_2O) and removals (CO_2) are estimated and calculated using several models and GHG inventory calculation procedures modified for projections. Natural Resources Institute Finland has prepared the projection.

To produce the emission projections, areas for each land use and land-use change category were estimated applying trends in land-use changes based on historical GHG inventory data complemented the policy targets – for example, the increase in afforestation. The land-use input from the agricultural and energy sectors was considered. The area needed for peat extraction was based on the TIMES-VTT modelled peat consumption for energy. New land areas required for the construction of wind power and solar-power plants were also based on TIMES-VTT modelling. The applied method is developed for LULUCF scenario work[29].

The development of forest resources was estimated using MELA software. The modelled results on tree biomass stocks, harvest volumes of commercial timber and energy wood, and natural mortality were used to estimate CO_2 emissions and removals of trees. Roundwood demand was determined from the wood consumption of the forest industry and production volumes (see Section 5.1). The demand for and consumption of wood energy use was derived from the TIMES-VTT energy system model results. Annual carbon stock change in living tree biomass was estimated as a difference between tree biomass stocks in two sub-periods divided by 10 years (which is a sub-period of the total calculation period). The change in biomass is converted to carbon multiplying by 0.5. This differs from the method applied in the GHG inventory, in which a gain – loss method is applied. The MELA model also provided the input data for the Yasso07 soil model[30] (carbon stock changes in mineral forest soils)

29 Haakana et al. 2015

30 https://en.ilmatieteenlaitos.fi/yasso

and CO_2 emission calculation from drained peat forest soils. N_2O and CH_4 emissions from soils were calculated using the GHG inventory methodology.

MELA has a long development history, starting with being an analysis tool for wood production potential. It is currently a tool for forest resource modelling, used for policy support and decision making at national and regional levels. The MELA programme has two parts: 1) an automated stand simulator based on individual tree growth and development models; and 2) an optimisation package based on linear programming. National forest inventory data are used to establish the initial state for the modelling. It is possible to incorporate climate scenarios into the programme. For these projections, the effects of changes in historical long-term temperature and CO_2 concentration on the increment of trees are included. MELA is developed for Finnish conditions and uses several country-specific models applying Finnish forest management recommendations. Due to optimisation, MELA seeks the best solution to reach the target. Compatibility with the historical GHG inventory data may therefore be weak.

Strengths of the MELA include: (1) For the initial stage of the modelling, the measured regional National Forest Inventory data on forest resources are used; (2) Measured individual tree-level data is the base for modelling; (3) The applied growth models are calibrated employing the measured increment tree of NFI data; (4) The long term growth indices are used to eliminated occasional interannual variability, for example, due to weather factors; (5) The family of integrated growth models is well documented[31]; (6) The optimization problem and decision variables can be defined by the user; (7) The model produces the input data for the soil modelling.

Weaknesses include: (1) Creation of the initial data from the NFI data is time-consuming; (2) Novel forest practices can easily be implemented into the management selection, but the lack of appropriate growth models is the limiting factor; (3) The use of growth indices can also be seen as a weakness, if in a long term there is a change in the growth trend, but at the same time the use of growth indices prevents temporary changes in growth to impact too much on future growth trend in scenario. (4) The method applied to estimated future carbon stock changes in tree biomass is based on the MELA results on tree biomass stocks for 10 years sub-periods (national biomass models are applied in MELA). The annual change in biomass was estimated as a difference between two sub-periods divided by 10. A gain - loss method is applied in the GHG inventory: tree volume increment and total drain are converted to biomass by biomass expansion and conversion factors computed from the data measured in the NFI. In theory, if the GHGI method would be applied to the scenario data, the result should be the same as the stock change method produces. In practice, these two methods have given different history results. Thus, there is in consistency between scenario and historical data.

31 Hynynen et al. 2002, http://urn.fi/URN:ISBN:951-40-1815-X

The projections for cropland and grassland were produced with the GHG inventory methods, including the use of the Yasso07 soil carbon model for mineral croplands. The Dremfia agricultural sector model provided input data for the modelling. For some new policy measures which are not yet included in the GHG inventory, either national research-based or IPCC emission factors were used. This applies mainly to new measures for agricultural land. Yasso07 is a dynamic model for cycling the organic carbon in mineral soils. The model was applied for forest land, cropland, and land-use transition areas in the same way as in the GHG inventory.

The HWP projection was estimated with a model modified from the production-approach-based GHG inventory HWP model (see National Inventory Report, Chapter 6.11). The assumed production of the forest industry (see above) was an input in the model.

Main differences in the LULUCF projection in the current NC8 compared to the NC7

Changes in assumptions and methods have been applied in the projection estimation due to model development and changes in the GHG inventory methods.

Updated assumptions on
- production of the forest industry
- harvest rates for commercial wood and energy wood
- development of land use and land-use changes, including afforestation and deforestation
- prices of timber assortments and costs of silviculture in MELA

Changes in methods:
- The development of forest resources was modelled with MELA2016, whereas the MELA2012 version was used for NC7. The main changes were: (1) the growth calibration model for trees was modified to better fit the new increment data measured by the National Forest Inventory (NFI); (2) simulations for the previous projections produced a higher stem number and volume for small trees, meaning a high natural mortality rate for small trees for the first years of the simulations as well. This part of the modelling was modified to better match the natural mortality measured in the NFI. Other changes can be found in the MELA2016 Reference Manual[32].
- The proportion of cutting waste of harvest removal was calibrated based on the 12th NFI.
- The SF-GTM model was not used to estimate wood use and demand.

32 Hirvelä, H., Härkönen, K., Lempinen, R., & Salminen, O. (2017) MELA2016 Reference Manual. Natural Resources Institute Finland (Luke). 547 p. URN: http://urn.fi/URN:ISBN:978-952-326-358-1

In the NC7 projection, the LULUCF's sink decreased from the reported 26.0 million tonnes of CO_2 eq. to close to 4 million tonnes of CO_2 eq. in 2025 and 2030. In the new projection, the net sink is 23 and 21 million tonnes of CO_2 eq. respectively. The main reason is the forest projections, but it is impossible to specify the reasons and effect of different components. Presumably, the changes in MELA modelling are an important factor.

Economic effects

FINAGE is a dynamic applied general equilibrium (AGE) model of the Finnish economy. FINAGE is based on the MONASH model developed at the Centre of Policy Studies. MONASH-style models are used in countries ranging from China and South Africa to the United States and Australia[33]. In Europe, models based on MONASH have been developed for Denmark, Finland, and the Netherlands. VATTAGE, a precursor of FINAGE, is described in detail in Honkatukia (2009).

Several factors explain the popularity of MONASH. The main ones are the advanced and user-friendly software packages that facilitate data handling and the setup of complicated policy simulations, and that also allow a very detailed post-simulation analysis of simulation results. MONASH-type models are also very adaptable to analyses of different types of policies and different timeframes. In a forward-looking policy analysis, MONASH-type models offer a disciplined way to forecast the baseline development of the economy. Last, but not least, they also allow the user to replicate and explain the historical development of an economy in greater detail, which is not true for most AGE models.

In FINAGE, there are normally three types of inter-temporal links connecting the consecutive periods in the model: (1) the accumulation of fixed capital; (2) the accumulation of financial claims; and (3) lagged adjustment mechanisms, notably in the labour markets and for balancing the public sector budgets. Together, these mechanisms result in gradual adjustments to policy shocks to the economy. In the model, capital is sector-specific, which means it takes time for an industry to adjust to the increased energy costs caused by emissions trading and increased energy taxes. In energy-intensive industries, a rise in energy costs lowers the return on capital, which slows down investments until a new equilibrium is reached. In other industries, similar effects are caused by a rise in domestic energy taxes. However, some industries gain from the subsidies granted to renewable energy, and even in energy-intensive industries, subsidies can dampen the rise in costs if they can substitute renewable energy for fossil fuels. The model assumes sluggish real-wage responses to policy shocks. Real wages will adjust sluggishly to deviations from the expected equilibrium wage growth, with the result that in the short run, adjustments will occur partly through increased unemployment levels. In the long run, wages will adjust fully to one-off shocks, and full employment will be restored. However, in the case of gradually tightening emissions targets, the shocks are not one-off, implying sustained above-equilibrium unemployment rates.

33 Dixon and Rimmer 2002

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Photo: iStock.com

6

Vulnerability assessment, climate change impacts and adaptation measures

This chapter describes how the Finnish climate is expected to change in this century and how the change is expected to affect nature, different sectors of the economy and society. The chapter includes a description of the framework for assessing risks and vulnerability to climate change. National adaptation policies and strategies as well as adaptation planning at sectoral and regional levels are discussed, together with progress of adaptation action. Finally, Finland's participation in international cooperation on adaptation is briefly discussed.

6 Vulnerability assessment, climate change impacts and adaptation measures

6.1 Climate modelling, projections and scenarios for Finland

Climate change projections have been derived from simulations performed with 28 global climate models. These models constitute a subset of the ensemble evaluated in the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2021). Using an ensemble of models to represent uncertainty in climate change projections is important, as the future climate cannot be predicted accurately due to uncertainties in future emissions and natural climatic variability, and the different representation of the climate system in the various models.

Figure 6.1 shows multi-model mean estimates for the future evolution of annual mean temperatures and precipitation rates in Finland for four forcing scenarios, with the SSP1-2.6 scenario representing small, SSP2-4.5 moderate, SSP3-7.0 large and SSP5-8.5 very large emissions. If the recent advances in global climate policy are realised in rapid and sustained mitigation, the two scenarios with the largest GHG emissions might be avoided.

According to the mid-level SSP2-4.5 scenario, the annual mean warming in Finland is expected to be 2.7 °C by mid-century and 3.7 °C by the end of the 21^{st} century, i.e. about 1.6 to 1.8 times as large as the global mean warming. The projected increase in annual precipitation is also substantial, about 11 per cent under SSP2-4.5. Note that all the forcing scenarios lead to quite similar responses until the 2030s but start to diverge markedly thereafter.

Both the increases in temperatures and precipitation rates are likely to be larger in winter than in summer (Figure 6.2). If the SSP2-4.5 scenario were realised, the January mean temperature would increase by 2 to 7 °C and precipitation by 0 to 30 per cent by the end of the 21^{st} century. In other SSP scenarios, the seasonal distribution of changes is qualitatively similar, but the amplitude of the change depends on the magnitude of forcing. An analogous seasonal distribution can be seen when studying less distant future periods.

Compared to the climate projections prepared with a previous model ensemble (which was used in the 5^{th} IPCC Assessment Report) using a comparable forcing scenario, the present summer temperature projections are about 0.7

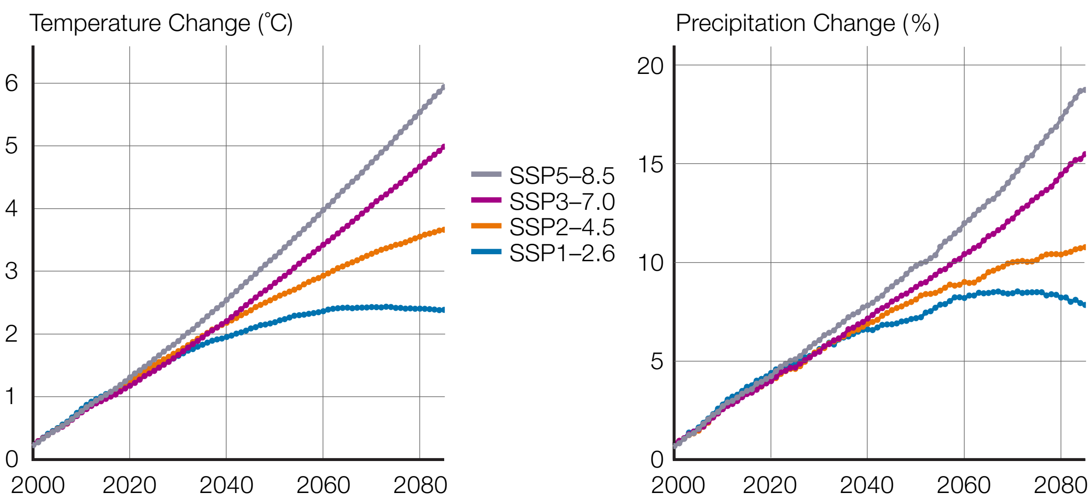
°C higher at the end of the century. Conversely, temperature projections for winter and precipitation scenarios for all seasons are fairly similar in both model ensembles.

These most recent temperature and precipitation projections were not published until early 2022, and hence most of the impact and adaptation research described in this chapter still makes use of older scenarios.

Other examples of projected climatic changes in Finland (mainly derived from older model generations) include the following:

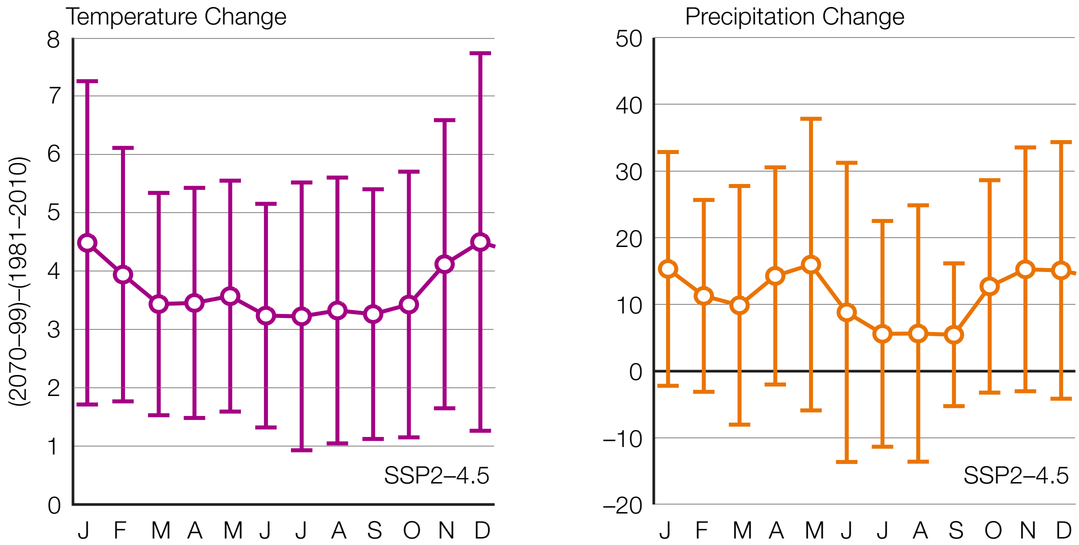
- Heatwaves become longer and more frequent, whereas severe cold spells gradually diminish.
- Heavy precipitation events intensify in summer.
- The number of days with precipitation increases in the winter.
- The snow season becomes shorter, and the average snow water equivalent decreases, particularly in southern Finland.
- The duration and depth of soil frost decreases, particularly in snow-free areas such as roads and airports. This also holds true for sea and lake ice cover.
- Winters become slightly cloudier, and solar radiation decreases. Conversely, summers and early autumns become slightly sunnier.
- For wind speeds, no significant changes are anticipated.

Figure 6.1
Projected temporal evolution of annual mean temperature (left, °C) and precipitation (right, per cent) in Finland by 2085, relative to the means for the period from 1981 to 2010; multi-model mean responses to four greenhouse gas scenarios: SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5.



Source: Ruosteenoja & Jylhä, 2021, the Finnish Meteorological Institute

Figure 6.2
Projected temperature (left, °C) and precipitation (right, per cent) changes in Finland for calendar months (J = January, F = February, etc.). The circles and the curve denote the multi-model mean projection. The 90 per cent probability interval for the change is denoted by the vertical bars. The changes are presented for the period 2070 to 2099, relative to 1981 to 2010, under the SSP2-4.5 scenario.



Source: Ruosteenoja & Jylhä, 2021, the Finnish Meteorological Institute

Climate monitoring and modelling framework

The Government research institutes, especially the Finnish Environment Institute (SYKE), the Finnish Meteorological Institute (FMI), the Finnish Institute for Health and Welfare (THL) and Natural Resources Institute Finland (Luke), all have activities linked to climate monitoring and modelling. The FMI is the main institute for physical climate variables, Luke focuses on effects related to renewable natural resources, SYKE on hydrology and water management as well as impacts on terrestrial and marine ecosystems and THL on human health. The Finnish Museum of Natural History (Luomus) plays a particular role in monitoring changes in species and biodiversity. Examples of the activities related to scenarios include the following:

- The FMI has constructed projections for the future climate at various temporal resolutions based on global (CMIP6) and regional (EURO-CORDEX) climate model simulations.
- SYKE has carried out joint work with other research institutes (Luke, FMI, THL) on the application of the SSP-based (formerly RCP-SSP) global scenario framework for Finland and specific sectors with national, sub-national and sectoral extensions (see Box 6.1).
- THL has participated in joint work carried out by SYKE on the application of the SSP-based framework for the health sector.

Box 6.1
Using shared socioeconomic pathways (SSPs) for defining future climate and socioeconomic development

There are five shared socioeconomic pathways (SSPs) that describe future socioeconomic development to the end of the 21st century. They are available as narrative descriptions, as well as quantitative projections of key socioeconomic variables. They are used in two ways for generating scenarios.

First, quantified SSPs can be used alongside shared policy assumptions about mitigation policy (SPAs) in integrated assessment models (IAMs) for generating pathways of greenhouse gas concentrations and radiative forcing of the atmosphere. These are inputs for global climate models for simulating the future climate. The most recent pathways used for climate modelling are labelled SSPs. The previous pathways, developed before SSPs were available, were labelled RCPs (representative concentration pathways).

Second, narrative SSPs can be used for co-creating with local experts and stakeholders' regional or sectoral socioeconomic narratives (SSP-extensions). These are richer and more detailed than the original global narratives. Quantified projections consistent with the narratives can also be developed.

Risk is a function of hazard, exposure and vulnerability. The SSP-based climates can be used to describe how the climate hazard may change in the future. The SSP-based socioeconomic narratives can help to define exposure and vulnerability. Combining these into integrated scenarios can allow an analysis of the relative effects of climate and socioeconomic development on elements of future risk.

Figure 6.3
Scenario matrix on the use of shared socioeconomic pathways (SSPs)

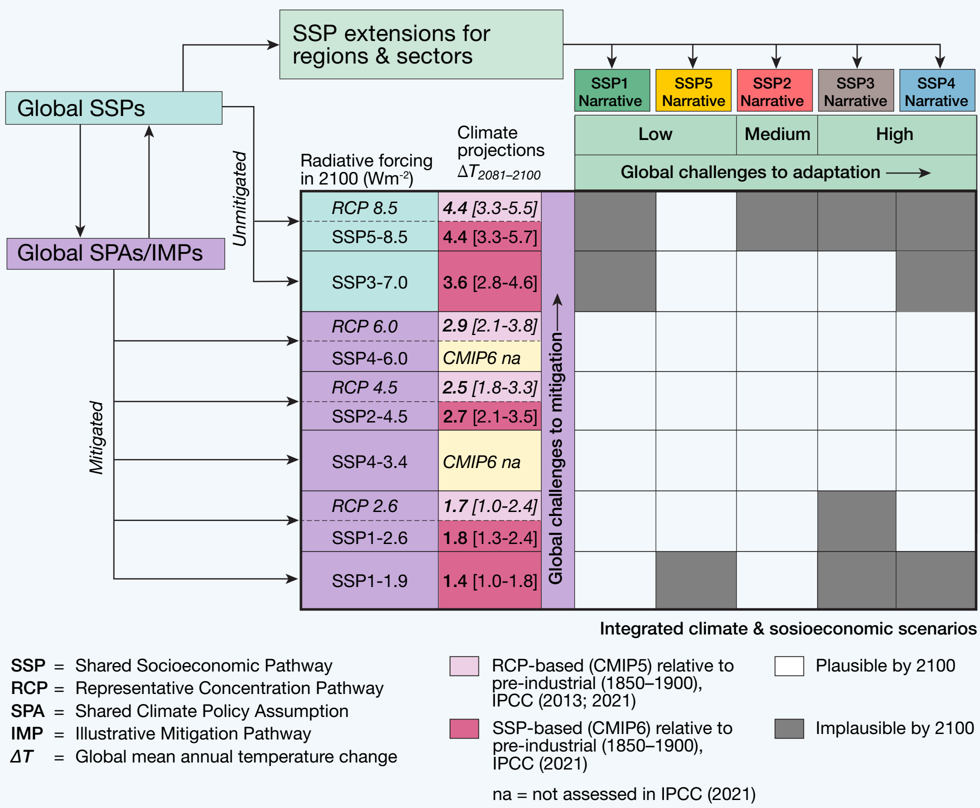


Figure 6.3 demonstrates how global shared socioeconomic pathways (SSPs) are applied in combination with shared climate policy assumptions (SPAs) to represent various mitigation levels (illustrative mitigation pathways – IMPs) used to define radiative forcing in models needed to project future climate (rows). Also shown are global mean temperature projections for 2081 to 2100 relative to pre-industrial times published by the IPCC based on two sets of climate model simulations: CMIP5 using RCPs in light pink (IPCC, 2013) and CMIP6 using SSPs and IMPs in dark pink (IPCC, 2021). Values are means (bold) and likely ranges (CMIP5) and very likely ranges (CMIP6). Global climate models also provide information on climate change for different regions of the world, including Finland.

Socioeconomic pathways can also be extended as SSP narratives describing socioeconomic conditions affecting exposure and vulnerability of regional systems and sectors at national and sub-national scale in Finland (columns). Information on future regional climate and future regional socioeconomic conditions for Finland can be combined into integrated scenarios at the intersection of the rows and columns (white cells in the figure). Note that not all combinations are regarded as physically plausible by 2100 (grey cells).

Source: Academy of Finland-funded FINSCAPES project[1]

1 https://www.syke.fi/projects/finscapes

Main approaches, methodologies and tools, and associated uncertainties and challenges

A basis for scenario work in recent years has been the global scenario framework organised around the shared socioeconomic pathways (SSPs). These are alternative descriptions of future socioeconomic development. The SSP-based climates can be used to describe how the climate hazard may change in the future. The SSP-based socioeconomic narratives can help to define exposure and vulnerability (Box 6.1).

Climate change projections for Finland have been mainly derived from the output of 28 global climate models. The rigour of the multi-model approach provides confidence that estimates for the inter-model spread of future climate changes in Finland and its sub-regions capture the major model uncertainties and are robust. The wide range of model outcomes associated with this approach presents some challenges for analysing climate change impacts (e.g. on water resources or agriculture) due to the large number of model simulations required. One approach to overcoming this challenge is to combine a sensitivity analysis of impacts to climate with the climate model projections presented probabilistically – the impact response surface approach. This approach also allows an estimation of likelihoods of exceeding certain pre-defined impacts.

6.2 Climate change impacts

Research, reviews and analyses provide a foundation for the assessment of the climate change impacts and related risks and vulnerabilities presented in this chapter. Research and assessments on climate impacts, risks and vulnerability have been carried out in national research efforts and as part of Nordic and European research efforts. Such knowledge is instrumental as a basis for adaptation measures, as is also called for by the National Plan for Adaptation to Climate Change 2022.

Examples of recent research and assessment efforts include the following:
– Overall Evaluation of the Implementation of the National Policy on Climate Change Adaptation (KOKOSOPU) – a project under the Government's analysis, assessment, and research activities between 2021 and 2022[2];
– Assessment of the Cost of Inaction Regarding Climate Change (KUITTI) – a project under the Government's analysis, assessment and research activities between 2020 and 2022[3];
– Report on the state of the research supporting adaptation to climate change by the Ministry of Agriculture and Forestry between 2021 and 2022;
– Climate change adaptation: regional aspects and policy instruments (SUOMI) – a project funded by the Finnish Climate Change Panel and coordinated by the Finnish Meteorological Institute between 2020 and 2022[4].

The list of references contains more examples of the research and assessments utilised in compiling this chapter. Section 6.2 of Finland's Seventh National Communication also provides various examples of relevant research in the recent past.

6.2.1 Impacts on environment and natural resource sectors

Natural environment and biodiversity

Different components of biodiversity will have different vulnerabilities depending on local conditions, species and habitats. The increase in mean temperature and annual heat summation and decrease in severe frost periods have already given rise to wide-ranging changes in the Finnish natural environment and biodiversity. Many native species in the south could find favourable living conditions further north in the warming climate. The prevalence of certain species of southern origin such as butterflies and birds has increased, and the distribution has moved northwards. At the same time, the number of species of northern origin has decreased in Southern Finland.

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2 Hildén et al. 2022a and 2022b http://urn.fi/URN:ISBN:978-952-383-118-6 https://tietokayttoon.fi/julkaisu?pubid=42102

3 Perrels et al. 2022 http://urn.fi/URN:ISBN:978-952-383-056-1

4 Gregow et al. 2021 https://www.ilmastopaneeli.fi/wp-content/uploads/2021/09/SUOMI-raportti_final.pdf

It has also been identified that changes in the ratio of abundance of certain species are reflected in the composition of species communities. For example, the average composition of communities of birds has moved towards the northeast during the last 20 years. In the future, a continued rise in mean temperate will lead to a continued decrease of numbers of species that have adapted to colder northern climates, and there is a risk that these species will largely disappear from Finland. On the other hand, southern-oriented species will increase in numbers and will partly replace species adapted to a cooler climate. In lakes, the spring peak of phytoplankton will occur earlier and will be considerably more pronounced than it is today. The littoral zone is likely to be more sensitive to the effects of climate change than the pelagic ecosystem.

The effect of non-native species on the displacement of native species is currently most significant in Southern Finland, but the effect is predicted to strengthen and spread more broadly by the end of the century. Non-native species can already now displace native species specifically in human-influenced environments, and it is expected that the effect will also increase in waterbodies.

An increasing mean temperature also affects habitats across the whole of Finland. Habitats that are typically found in cooler climates, such as fjelds in Northern Finland, are especially vulnerable to climatic changes, and may completely disappear by the end of the century. Especially species that are limited to specific habitats (e.g. the Saimaa ringed seal and freshwater pearly mussel) are highly vulnerable to climate-induced changes in their habitats. Northern boreal species of forests, mires and Arctic mountain habitats are threatened and predicted to decline due to the warming climate. The most sensitive habitat types identified are coastal drift lines and the habitat types related to primary succession stages, snowbeds, mountain birch forests, mountain heaths, first-order streams, small inland waters in northern Lapland, traditional rural biotopes, southern aapa mires, springs and spring mires, and open and semi-open rock outcrops.

Increased precipitation induced by climate change is also projected to affect the natural environment. Open habitats are vulnerable to overgrowth due to mild rainy winters, increasing carbon dioxide content in the atmosphere, and nitrogen deposition. For example, taken together, these contribute to the growth of moss and trees in dunes, and accelerate overgrowth. The increase of precipitation during the winter also increases the washing away of nutrients in waterbodies. For coastal waters, this can be identified along the coast of the Baltic Sea as higher prevalence of reed beds, filamentous alga, and overgrowth. Increased runoff in winter will also influence the washing away of nutrients and solid matter into inland waters. It is expected that climate change will be a threat to more than 80 per cent of inland water and coastal habitats.

Protected area networks of natural habitats alleviate the negative effects of climate change and provide resilience in preserving declining species of conservation concern. However, recent studies have indicated that there is great variation in the growing degree days, the mean temperature in January, and the annual water balance across protected areas in Finland, and by the end of the century, significant changes to the microclimates of Finnish protected areas are expected. This calls for consideration and anticipation of changes in conservation planning.

Water resources

The most significant climate risks in the water resources sector are related to the increase of pluvial floods, changes in fluvial floods, and the increase in droughts. Other risks include increases in frazil ice and coastal floods, decreasing water quality, and increases in algal blooms. Of the above risks, increases in frazil ice floods have already occurred, and frazil-related problems will be common in the near future. The role of climate change in increasing flood risks and damage in Finland is expected to become more pronounced from mid-century onwards. This is especially the case for coastal floods, but continuous monitoring of the risk is required, as the potential effects of such floods can be significant.

Floods in Finland rarely have direct impacts on human health and security, but especially if floods become more widespread and enduring, these impacts will become more significant. Based on the EU Floods Directive[5] and the national Finnish Flood Risk Management Act[6], areas of potential significant flood risk are identified through preliminary flood risk assessments. Currently, 22 areas of significant flood risk have been identified in Finland – 17 of these are located inland, and five along the coast.

Occurrences of heavy rain are expected to increase due to climate change. Pluvial floods resulting from heavy rain and snow melting can generate considerable damage in urban areas, and anticipating these floods is challenging. Damage is usually incurred to property, human health, security, and the transport sector. The densifying trend in the built environment in urban areas is expected to continue for the next couple of decades, which increases the share of impervious surfaces. In turn, it increases the amount and intensity of surface runoff water. Due to denser and more technical construction, the vulnerability increases, and possible spillover effects become more complex.

The effect of climate change on fluvial floods varies across different waterbodies. The effect is expected to be greatest in central lakes and outlet rivers. The greatest risk of fluvial flooding is assessed to be in the City of Pori on the coast of the Gulf of Bothnia. Apart from damage to property, floods can have negative impacts on water quality, as they wash away debris, waste,

5 2007/60/EC

6 620/2010

sand, organic matter, nutrients, and acidifying compounds from fields, forests, and riverbeds. On the other hand, spring floods caused by melting snow are expected to become less frequent, except in the Lapland area. With spring floods currently the most common type of flood, this may signify an overall decrease in flood risks in many locations.

In the Baltic Sea, the effects of climate change can be identified as physical, chemical, and biological changes in the sea. An increasing water temperature enhances biological processes and may increase the intake of harmful substances in organisms. Studies have shown that the spring bloom of phytoplankton has been brought forward, and the length of the growing season has doubled. An increasing temperature probably also alleviates the spreading of non-indigenous species originating from more southern seas. Moreover, due to the increase in atmospheric CO_2, it has been projected that the pH of the seawater will decline, which may affect the living conditions of bivalves with calcium-containing shells.

Salinity is also a fundamental factor in the Baltic Sea, because many organisms live at the edge of their salinity tolerance levels. Recent modelling suggests that the distribution areas of marine species like bladderwrack, blue mussel, and eelgrass will be significantly reduced if the surface water salinity decreases. The reduction of these habitat forming species will affect the structure and functioning of the ecosystems and may decrease the ecosystem services such as fish yield provided by these habitats.

Climate change has also been predicted to worsen the eutrophication of the Baltic Sea because of increasing nutrient runoff into the sea. As the temperature also rises, the decomposition of organic matter caused by microbes will accelerate, and especially in late summer, anoxia can increase. Cyanobacterial blooms are especially projected to increase, although this forecast is also subject to uncertainties. However, model studies have shown that direct human activity has a greater impact on the state of the Baltic Sea than climate change. A recent study has shown how climate change affects agricultural practices (crops, cultivars, land use), how climate affects the hydrological cycle, and how soils and lakes retain nutrients in a changing climate. The results show that climate change increases nitrogen loading into the sea, but that economic factors such as crop and fertiliser prices significantly affect the outcome, and that a significant reduction in nutrient loading can be achieved by farm-level adaptation to climate change.

Climate change and alien species pose new threats to the small waters of Finland, the status of which has been assessed as poor in the national habitat threat assessment. Small waterbodies, streams, and ponds are particularly sensitive to temperature stress. At worst, streams can dry out almost completely, which can damage their ecology. For example, changes in the hydrological seasonal rhythm have been found to affect the species composition of benthic organisms, especially in small waters.

Water supply

Droughts generate risks for agriculture, industry, and the water supply of communities and properties. Droughts in the summer are expected to increase in Southern and Central Finland due to earlier spring onset, less snow, and an increase in evaporation. Droughts give rise to water sufficiency problems, and the lowering of surface water levels creates water quality issues. For example, the summer droughts of 2018 and 2020 showed the need for preparedness in water supply management. Reduced groundwater levels may lead to a shortage of dissolved oxygen and high concentrations of dissolved iron, manganese and other metals in the groundwater. The shortage of dissolved oxygen may generate ammonium, organic matter, methane and hydrogen sulphide gases, causing the water to taste and smell bad. In the winter, increasing precipitation and snowmelt will produce fresh and oxygen-rich groundwater.

The expected increase in droughts, storms, and heavy rainfall can be identified in water supply as drying of smaller groundwater areas, lower quality of ground- and surface water stemming from washed away nutrients and pathogens in flood water and the limited capacity of wastewater networks. Storms and heavy rainfall and winds also increase water quality risks. Storms generate risks for the supply of electricity to water supply sites, especially peripheral regions and areas, thereby endangering both water distribution and treatment. It also remains necessary to prepare for larger power outages that affect larger regions.

In general, the Finnish water utility sector is in a good position to adapt to climate change. According to a recent survey conducted by the Finnish Climate Panel in 2019, water supply site actors are highly aware of climate change, seeing it as a general threat to water security in Finland. The survey results show that almost all actors find that their site can respond adequately to threats generated by weather variability. Some actors see that climate change threatens water security on their own sites. However, only less than half the survey respondents are prepared for heatwaves, prolonged droughts, mild winters, or floods. This finding can be explained by the fact that the respondents represent smaller groundwater sites that have yet to suffer from the aforementioned weather phenomena.

Different forms of floods, including runoff water and melted snow, can threaten the water quality of the inlet wells of urban areas and properties, which in turn generates risks to human health (e.g. waterborne diseases) and the reliability of water supply. These risks also affect about a quarter of a million Finnish households that rely on their own wells for the supply of water.

Agriculture

Climate change is projected to improve crop productivity in Finland if the rise in temperature is moderate, and if the adaptation measures are implemented in a timely manner. Due to the longer thermal growing season, higher accumulated temperature sum and milder overwintering conditions, the current cash crops are cultivated further north, and many novel crops may be introduced in cultivation.

However, possible increases in the variability of climatic conditions within and between seasons, more frequent extreme weather events, and increased risks of disease and pest outbreaks may cause uncertainties for agricultural production. Variation in precipitation within a growing season may further increase and cause substantial challenge for the sustainable development of agricultural systems. Early summer droughts may become more frequent and interfere with crop growth and yield formation, while increasing rains outside the growing season may put soils and their functionality at risk. It may also increase the leaching of pesticides and nutrients into the water systems, which are particularly vulnerable, as a third of the field parcels in Finland are next to waterways.

The risk of animal diseases may also increase, although it is expected to remain relatively low in the future. Diseases associated with the poor quality of water may become more common. All these potential changes call for early and powerful adaptation measures to reduce risks induced by climate so that society can benefit from the opportunities.

Forestry

Climate change affects forest ecosystems. The rise in average temperatures and atmospheric CO_2 levels has already accelerated the growth rate of trees, but the risk of more severe forest damage has increased simultaneously. Compared to Central and Eastern Europe, large-scale forest damage has been relatively rare in Finland, but this is likely to change due to climate warming. For Finland, the relevant risks are both abiotic (wind, drought, snow, etc.) and biotic (insects, diseases, wildlife, etc.), but as they also interact, the potentially negative effects on the forestry sector are complex. Yet it is noteworthy that tree mortality is always a natural and essential component of any healthy forest ecosystem. The management of forest damage is therefore never about suppressing it completely, but more about pre-emptive measures that can be used to prevent large-scale damage.

Wind and snow are amongst the most severe damage agents in Finland. Wind damage in the form of windthrow are predicted to increase in the future due to loss of ground frost, which makes trees more susceptible to wind damage – even though the winds themselves will not be any stronger. Snow damage is predicted to decrease in the southern parts of the country, but it is likely to increase in northern and eastern areas. Trees damaged due to wind or snow can increase the risk of cascading biotic damage.

Climate change increases the frequency 'fire weather', suitable weather for ignition and the spread of fire. In the long-term, the amount of burning material in forests is also expected to increase. Days with simultaneous high winds, high temperatures and low humidity increase the risk of fires spreading. However, most forest fires ignite due to human behaviour. In general, fires are not a major issue in Finland due to efficient fire monitoring and suppression work, and a dense forest road network that allows efficient fire suppression. The risk caused by droughts will therefore be more related to large-scale weakening of trees (esp. spruce), and how this increases the risks of insect damage.

Various biotic pest agents will benefit directly from climate warming, with more rapid development, a prolonged growing season, a further northward spread, etc. Yet they will also benefit from the increased number of weakened trees (e.g. due to wind or droughts) they use as breeding material. This is especially valid for the spruce bark beetle, which has caused unprecedented damage across Central and Eastern Europe, and the occurrence of damage is also becoming more common in southern Finland. Other bark beetles (such as *Ips acuminatus*) are also benefiting from warming, which may increase their future role as pests.

Decaying fungi such as the *Heterobasidion* root rot can remain active and produce spores for a longer time as the spring and autumn warm. Root rot also benefits from increased windthrow and diminishing snow cover, which often results in harvesting damage to unprotected tree roots: both phenomena result in cuts in the trees through which the spores can infect them. Here, Finland is also facing difficulties because of the increased use of spruce in forest regeneration: spruce is the tree species most susceptible to droughts and wind damage, while its main pests, the spruce bark beetle and root rotting fungi, benefit from warming. Here, forest management should emphasise mixed forests and the use of optimal tree species at any given site, but in certain areas, dense ungulate populations prevent the use of deciduous species to replace spruce.

In addition to the native pests, climate change and global trade will bring new species into Finland. Insect species such as the nun moth (*Lymantria monacha*) have become increasingly abundant in the 2000s. Similarly, a new fungal pathogen, *Diplopia sapinea*, was confirmed to cause mortality to Scots pines in the record-hot summer of 2021 – something researchers assumed the fungus could not do in Finland. While the spread of these two species is natural, global trade is a pathway for invasive alien species. Climate change is not a direct factor here, but the Finnish climate will also become more suitable for various invasive pests because of it. The increasing global trade and current legislative restrictions in controlling the spread of exotic pests and pathogens will unfortunately ensure that the risks of invasive alien species will remain topical, regardless of the progress of climate change.

Fisheries and game

The effects of climate change on aquatic ecosystems are especially strong with extreme weather events such as prolonged hot summers. In general, there is variation in how well fish species can tolerate the changing conditions, with some species and life-stages more vulnerable than others.

An increasing water temperature generally benefits fish species that prefer warmer and more nutrient-rich waters, and this has improved the reproduction of many spring and summer spawners. However, the dissolving of oxygen from the air into the water is weaker as the air temperature increases. During extreme warm temperatures, this can result in oxygen deprivation, and the consequences can be severe. During hot summers, the stratification of water can be strong, resulting in a layer of warm water in which oxygen dissolving from the air is poor, and fish that cannot tolerate warm surface waters move deeper. Simultaneously, various other species benefit from the warming, and as their activity increases, they consume oxygen from within lakes, including from the bottom. This causes difficulties for bottom-dwelling fish, but also to those that have moved to deeper waters to escape the warm surface waters. An increasing water temperature also affects the spatial distribution of fish species.

Eutrophication is coupled with climate-induced impacts in aquatic systems. An increasing water temperature exacerbates eutrophication. With more eutrophied conditions, additional risks of anoxia and widespread algal blooms emerge, as the decaying algae consume oxygen from the bottom areas and further increase the dissolving of nutrients from bottom sediments. This results in 'internal' load, a state in which the eutrophication process continues even though no nutrients flow into the waters from any external sources. This process concerns the Baltic Sea, as well as Finland's isolated small ponds and inland waterbodies.

Aquaculture facilities with flow-through water intake will suffer from increasing water temperatures, which have already led to widespread fish deaths in the hot summers of 2014, 2018 and 2020, for example. Similarly, increasing eutrophication also has negative effects on aquaculture production, both inland and in coastal waters, through potentially more strict environmental licensing.

Commercial fishing is affected directly by what happens to fish stocks, but also by changing environmental conditions such as ice conditions. While prolonged ice-free periods may lengthen the season for marine trawling fishing, other winter fishing will suffer from a shortage of ice.

Invasive alien species will remain highly relevant for aquatic ecosystems, as Finland has already seen the establishment of several alien fish species in coastal waters (for example, the round goby, *Neogobius melanostomus*), as well as in inland waterbodies (for example the pumpkin seed *Lepomis gibbosus*). While climate change does not itself cause the relocation of these species, it may make the Finnish climate more suitable for certain invasive species that might not otherwise survive.

Climate change affects the abundance, species composition and distribution of game populations in Finland. Southern species and certain invasive species are benefiting and becoming more abundant, and the range of species adapted to winter conditions is narrowing. Climate change will affect all levels of the food web and change the relationships between species. Changes in snow and ice conditions can drive certain species into crowded conditions, increase winter predation or loss of breeding habitat for cubs.

Reindeer husbandry and herding

Reindeer herding is a large-scale Arctic subsistence livelihood based on both the reindeer's ability to obtain food and survive on natural pastures and reindeer herders' traditional knowledge of reindeer and the grazing environment. Reindeer husbandry is a traditional livelihood of the indigenous Sámi people and is therefore an integral part of the Sámi culture.

Reindeer herding is vulnerable to the negative effects of climate change. Climate change is expected to be particularly severe in the northern regions where the Sámi homeland and the reindeer husbandry area are located. Climate change and changing weather conditions directly affect reindeer food supply, health and wellbeing, as well as practical reindeer husbandry activities. Climate change also has indirect effects through changes in the grazing environment. Regional and annual variations in weather and snow conditions and their changes have a significant impact on the ability of reindeer to obtain food from the wild and on the quality of the food, as well as on the prevalence of parasites and diseases.

In addition to the industry's own activities and weather variability and climate change, the ecological, social and economic sustainability of reindeer husbandry is influenced by many local, regional and global factors. The effects of the changes caused by reindeer grazing, forestry, and a range of other land uses, such as gold mining, tourism development and tourism services accumulate. At the same time, interlinked changes have degraded, reduced and fragmented reindeer pastures.

Changing conditions due to weather variability and climate change, combined with land-use changes, create economic uncertainty for reindeer herders. The consequences of significantly variable weather conditions result in disadvantages for reindeer husbandry, increase costs, reduce income for reindeer herders, and cause a significant reduction in wellbeing.

Natural Resources Institute Finland regularly assesses the quantity, quality and availability of reindeer grazing resources through reindeer pasture inventories. Based on the reindeer pasture inventories for 2016 to 2018, the lichen biomasses in the experimental areas are most significantly influenced by the seasonal timing of grazing with lichens and the reindeer densities on areas covered by lichens, as well as by changes in forest structure and old-growth forest in the reindeer herding cooperatives. The extent of other land uses in the cooperatives and probably ecosystem changes caused by climate change have contributed to the condition of lichen pastures and changes in plant species.

Adverse changes in the reindeer grazing environment have gradually altered reindeer management and increased the need for additional winter feeding and the use of feeding enclosures. The reduction and fragmentation of pastures have created conflicts and problems between reindeer husbandry and other livelihoods. In areas covered by lichens that have not been grazed for a long time, the impact of forestry on the amount of lichen was much lower. In recent decades, changes in the structure of commercial forests have been more favourable to reindeer grazing. The limited possibilities to control the pressure of other land uses make it difficult to organise and develop reindeer management in a controlled way, to regulate the use of pastures, and to respond to changes in climate.

6.2.2 Impacts on infrastructure and other economic sectors

Energy

Weather-related hazards like wind and snowstorms, lightning strikes and floods are the major source of weather and climate risks for the energy sector in Finland. Challenges to energy production and distribution are also created by some enduring weather episodes often coinciding with relatively high energy demand and demanding conditions for the maintenance of power systems, such as long periods of extreme cold, long-term snowfall, and snow load. Storms and heavy snow loads on tree crowns have caused power outages for customers. Nuclear power plants have had issues with seawater being too warm for optimal cooling, leading to part-load operation and with stormwater levels. Long periods of very low precipitation causing hydrological drought reduce hydropower production. This matters in Finland, because hydropower plays a central role as a regulating power source, and more widely, because Scandinavian precipitation largely determines the electricity price on the Nordic power exchange.

The renewal of the energy infrastructure is slow due to long-term investments. Therefore, for example, electricity blackouts caused by weather events will also be experienced in the future, although investments in the electricity network are increasing its resilience to weather events.

There are opportunities to reduce CO_2 emissions with renewable energies. Especially wind but also solar energy production is increasing (see Section 2.6), which also increases weather-related variability in production. Weather risks to wind turbines, e.g. due to icing, seem manageable. Bioenergy production and harvesting face risks due to climate change: in the winter, long warm periods and frost delay may hinder access to remote sites on soils with a low bearing capacity.

Energy systems need to be resilient and not under-dimensioned, because very cold winter episodes will remain possible during the latter part of the century, leading to high demand for heating capacity, especially in Eastern and Northern Finland. On the other hand, due to warming summers, heatwaves which increase the need to cool buildings can affect the country in any location.

Future impacts of climate change will partly depend on how the energy system changes as a result of the ongoing green energy transition. The impacts are likely to affect both energy production, transmission, distribution and consumption.

Land-use planning and buildings

In the land-use and building sectors, the impacts of climate change are fairly well known, and the need for adaptation measures is commonly acknowledged. The main climate-related risks to land-use planning and buildings are related to a shifting temperature, rainfall, floods, rising sea levels and droughts. Climate change presents complex challenges to the built environment in Finland due to variability across regions and seasons. For example, there is a need to prepare for both increased snow loads in some regions and humidity risks to buildings caused by increased precipitation in the form of rain in others.

Climate change gives rise to moisture risks, which affect all the buildings in every part of Finland. Moisture risks generated by precipitation are already currently significant, and these risks are expected to grow in the future due to increased rainfall. The increase in mean temperature also converts snow into rain, which further increases buildings' moisture risks. Increasing humidity and a rise in temperature intensify the growth of mould and microbes in building structures. The most risk-prone structures among the current building stock are poorly ventilated wooden frame constructions and brick-clad structures.

Prolonged heatwaves increase the risks of heat-related sickness and residents' mortality if the buildings cannot be ventilated and the room temperature cannot be lowered.

Concrete structures are susceptible to frost shattering during the winter due to increasing wind-driven rain load in the form of water and sleet. Buildings along the coast are currently the most vulnerable to such risks. In the future, the current coastal climate conditions are expected to spread to inland Finland, where risks of frost shattering have been lower. High wind speeds are increasingly causing material damage to buildings, e.g. through the detachment of surface structures and trees falling nearby.

The main flood risks to the built environment are related to pluvial and fluvial floods, which place burdens on urban sewer networks and cause significant economic damage. Pluvial flood risks are greatest in the most densely populated areas like the Uusimaa region. In recent decades, the share of impervious surfaces in the built environment has increased sharply, which in turn intensifies pluvial floods.

The largest risks related to the rise in sea level affect the existing building stock. In coastal areas, the risk of flooding due to the sea level rise is relatively low so far, especially in areas where the land uplift is the most significant. In the long term, the risk of coastal floods is expected to increase, as the average rate of sea level rise exceeds the speed of land uplift. The most problematic areas on the Finnish coast are those where coastal and fluvial floods coincide – the best known of these areas is Pori.

Cultural heritage

Cultural heritage sites – or the 'cultural environment' as they are called in Finland – are places and environments created by human activity and through interaction between humans and the natural environment. The sites include the built and natural environments, cultural landscapes and archaeological sites, typically with elements of historical significance.

Climate change has a tangible impact on the preservation of cultural heritage and the cultural environment. Cultural heritage sites are strongly influenced and damaged by climate change. According to the Cultural Heritage Barometer (2021), 51 per cent of the respondents to the survey estimated that climate change posed a threat to the preservation of cultural heritage.

Increasing humidity and rising temperatures, eutrophication and constipation, the acidity of air and rain, freezing and melting cycles and extreme weather phenomena such as storms, flooding, erosion, heavy rains and thick snow may damage the landscape and other cultural heritage places and objects on land, underground, or in the water. The degradation of biodiversity and loss of natural habitat affect cultural landscapes and semi-natural habitats by threatening traditional biotopes and impoverishing the natural heritage.

The impacts of climate change are more severe, and global warming is faster in the Arctic than elsewhere in the world. Therefore, for example, the Sámi indigenous people are facing drastic changes in the Sámi homeland in Finland, Norway, Sweden and Russia. The traditional livelihoods of the Sámi, such as fishing, gathering, and reindeer husbandry, as well as the traditional knowledge associated with them, are especially vulnerable to climate change (see Section 6.2.1 for reindeer herding). Traditional knowledge of nature is subject to change. The intangible cultural heritage is disappearing and will no longer be passed on to future generations.

Industry and commerce

Finnish industry is energy-intensive, and the need to mitigate climate change has been a focus in the industrial sector. The effects of climate change and the need to adapt to its effects have not had a central role in the discussion. However, climate change does cause varying risks to industrial operations in Finland. For example, disruptions in industrial production caused by floods and storms may be significant, and rare major floods may pose major risks to some industrial operations, especially if the disruptions in operations are prolonged.

However, the most significant impacts of climate change on industrial operations and commerce in Finland are most likely to be indirect. Such indirect risks result from the global impacts of climate change or in other sectors within Finland. The relevant risks vary, depending on the industry sector, value chains, and the location of operations. For example, the effects of climate change on the Finnish transport and energy sectors may indirectly affect industrial operations and commerce through logistics and power outages. The challenges to wood harvesting posed by the worsening and longer thaw weakening period may affect industries reliant on wood supply. The effects of climate change and the natural phenomena related to it, such as floods, storms, and droughts, may pose risks to industries requiring an industrial water and cooling water supply.

Value chains are in a key position when considering the vulnerability of Finnish industrial sectors to the indirect effects of climate change. The industries most vulnerable are those with critical points in the value chain in areas outside Finland. For example, if the operations at these critical points are sensitive to extreme weather events, the effects may be serious. Such disruptions may affect the price and availability of raw materials and thus affect both industrial operations and commerce. For example, supply chains relevant for agriculture or the food industry in Finland are affected by weather and climate events related to crop failures and supply chain logistics and the availability of fertilisers. Although cross-border impacts are considered a very relevant category of climate change impacts, they have been little addressed thus far (see Section 6.7 for cross-border effects in general).

Mining

The most significant climate impacts on the mining sector are related to water management. In particular, with the increase in heavy rainfall, the risks of water management in mines may increase. Historical data show that roughly half the documented exceptional situations in mines have been caused by water management problems. In turn, more than half of these were related to dams. A Mining Environmental Safety Report published in 2014 emphasised the significance of design floods stemming from sudden and/or large amounts of excess water. However, the report does not examine the potential impact of climate change on these specific floods or on mining in general.

Climate change needs to be addressed when planning overall water management. With cold winters, recycling of process water is restricted, while large amounts of frozen water from tailings is added to the water management system in the spring with ordinary snowmelt water. A sudden and very warm spring can cause melting to be extremely quick, so facilities need the capacity to address this. So in some sense annual water management can be more evenly distributed if winters get milder, with less snow and freezing. Long dry periods and warmer summers require increased attention to management of dusting, as dust from mines can contain harmful particles.

Securing energy supply is crucial, as processes are controlled or operated by electric technologies and machinery. Typically, water management is based on collecting water and steering waterflow by pumping. If pumping is prevented, control of water masses can become impossible. A longer power blackout may cause various environmental and health risks and endanger the whole operation. Steering the process at the plant can be endangered if power is cut. This can create a risk of unexpected emissions.

Access to and from a mining area must be secured, even in unusual weather conditions. Critical points can be bridges and low-lying areas, which are sensitive to flooding. Buildings and constructions on a mine site should be placed and planned so that rainwater has natural ways and places to gather and be absorbed without mixing with process water that requires more treatment. Otherwise, the capacity of water treatment can occasionally be overloaded.

In the mine planning stage, all aspects of risks caused by climate change must be addressed and considered. Risks and threats to mining operations are analysed in the mining safety permit required from all operating mines according to the Finnish Mining Act[7]. A mining safety permit requires that all risks that the operation can face are identified, and that the risks and any consequences are mitigated and avoided. The mining operator is responsible for the internal rescue plan. The rescue plan specifies how to manage possible incidents, and how environmental and human accidents are prevented.

Transport and communications

The transport and communication sector and its infrastructure are highly vulnerable to changeable weather conditions, and disturbances in the transport sector affect other sectors. Due to weather conditions (e.g. heavy rain and snowfall), accidents and/or delays in the transport chain may occur which mean that goods are not delivered on time, commuters cannot rely on timetables and businesses suffer from loss of earnings. Besides rain

7 621/2011

and snow, roads, railways, ports, airports and communication networks in Finland are occasionally subjected to other weather conditions such as storms, floods, extreme cold, and heatwaves. However, conditions vary within and tend to affect different parts of the country, as well as transport modes, in different ways, e.g. due to the population distribution and the condition of road network.

Key climate risks in the transport sector include complications in seafaring and shipping due to ice conditions, difficulties in air traffic due to storms and increased rainfall, challenges in the road and railway network due to erosion, changes in ground frost and poor weather conditions, and problems in conveyance dependability. Changes in ground frost, soil moisture, groundwater level and snow cover cause problems to the road, railway, and airport infrastructure. The transport of raw materials from forests will get more difficult as the period during which the ground is frozen shortens, and changes in the load-bearing capacity of roads may have significant cost impacts as the repair and maintenance costs of the road network rise. In road traffic, road closures remain the most significant vulnerability. A reasonable amount of natural resources (aliments, soil and forest industry raw materials) in Finland is transported by way of the minor road network, which is mainly gravel and sensitive to rainy winters and dry summers. Road and railway infrastructure and traffic are affected by frost heave, which also occurs during the winter, not only in the spring. The surface structure of roads and bridges is damaged by icing-melting periods occurring more often and weakened by hot and dry periods, which also cause dusting problems. Heat may also cause problems to rollingstock. Floods, which may be stronger due to climate change, can cause breakages in roads and railway banks and bridges.

The risks vary depending on the season, the section of the transport sector, and the region of the country. In sea areas, ice cover in the Gulf of Finland and the Sea of Bothnia will continue to form in winters, but it will happen increasingly later. Strong winds can cause packing of ice, which increases the need for icebreaking. Rising sea levels will change the location of sediment layers and shallows. All these will make navigation more demanding and expose safety equipment to a strong weather burden. These in turn will increase transport time and costs. For rail, wind impacts, causing e.g. the falling of trees (during the autumn) are expected to cause harm more often. Fog with increases in humidity and freezing rain are risk factors for aviation. Winter conditions will cause challenges to air traffic and airports and their safety in Finland. De-icing of planes and removing snow from runways will take more time. In telecommunications, the aerial cables network may be especially vulnerable to storms and icy rain. Sea cables may be damaged by packed ice causing problems to electric and communication networks, which in turn causes power outages, leading to delays and cancellations. Power outages affect traffic control and electric traffic. Challenges in energy supply increase energy costs. Lightning can cause disturbances and harm hardware and equipment. Heat may cause overheating of data centres and affect information systems.

Tourism and recreation

Finland is an attractive destination for tourists mainly because of its nature. Dependence on nature and seasonal variation makes tourism and recreational activities vulnerable to climate change.

Snow-based activities such as cross-country skiing, alpine skiing, riding snowmobiles, and ice fishing are vulnerable to climate change. The vulnerability of cross-country skiing is strongest in southern and western Finland, particularly in coastal regions. However, at least in the near future, ski resorts in the north may benefit from relatively good snow conditions compared to ski resorts in central Europe or southern Finland. Awareness of climate change and the capacity to adapt to it are improving among tourism enterprises, but many regional differences remain. The type of tourism and its economic importance in the region, the image of tourism, and the region's social and community characteristics define how vulnerable to climate change the region is as a tourism destination.

A warmer and longer summer season would improve the conditions for summer sports and many water-based recreational activities (e.g. boating, swimming, and fishing). On the other hand, algal blooms in warmer waters, increased amounts of summer precipitation, or extreme weather events may reduce the attraction of such activities in the summer.

The impacts of key changes have already been observed: snow conditions have weakened, including the number of snow cover days, which is especially seen in the delay of the arrival of snow cover in the early season. This is already affecting winter tourism, especially in southern parts of the country.

In the future climate, snow cover days will decrease even further in the season, particularly at the beginning of the season. They will decrease by at least 30 per cent by the end of the century, which is, however, less than in other winter tourism areas in Europe. Long delays to the onset of winter are expected to become more common in the future, posing challenges for Christmas and other Arctic nature-based tourism, including downhill skiing and other winter sports. Average winters will become shorter. The magnitude of the change will vary according to the climate scenario and time horizon.

Winter tourism is vulnerable to the changing climate, as it is highly dependent on reliable winter conditions. Adaptive measures such as snow storage and snowmaking can be too costly or create greenhouse gas emissions, depending on the energy sources. Other strategies include alternative activities and technical solutions like indoor sports arenas.

Finance and insurance

In Finland, bank loans are often secured by real estate. Population and economic activity, and thus also properties used as loan guarantees, are mainly located in coastal areas, and the share is increasing. This exposes the collaterals to increasing coastal flood risks, amounting to hundreds of millions of euros of collateral exposed to climate risks if no further protection measures are taken.

Climate change is likely to increase damage caused by extreme weather, and indemnities for damage are thus also expected to increase in the future. In addition, insurance companies will face higher levels of uncertainty in their risk estimates, and as a result, they may have to pay higher than anticipated amounts in damages. These changes may be reflected in insurance premiums and available coverage. Climate change will affect insurance companies directly in three different ways: through claims; their investments; and the terms of trade of reinsurance. Growing risks and changing attitudes will also affect who will be insured in the future; many investors have already withdrawn their investments in companies that create a heavy environmental load.

Forests are insured by private insurance companies in Finland. Private forest owners have little by little insured more of their forests: some 50 per cent of private forest owners are now insured against forest damages, while twenty years ago, only 30 per cent of private forests were insured. Forest insurance products offered by insurance companies provide variable cover against damage caused by storms, snow loads, forest fires, floods, pests and fungal diseases, for example. On average, some 60 to 70 per cent of forest insurance compensations are paid for storm damages, making annual compensation highly dependent on storm activity in each year. For example, in December 2011, the Boxing Day storm alone led to compensations totalling nearly EUR 30 million. Between 2012 and 2021, insurance companies paid storm compensation amounting to EUR 139 million.

Weather episodes favourable for forest fires are becoming more common due to higher temperatures increasing potential evaporation and the drying of the soil surface layer. When high temperatures, strong winds and low humidity coincide, they increase the risk of forest fires igniting and spreading. By the end of this century, the average number of forest fire warning days per year will probably be five to ten days larger than currently. The growth in the forest fire risk will be stronger in southern Finland. Despite the effectiveness of forest fire prevention in Finland, the cost of large fires can rise to tens of millions of euros.

6.2.3 Impacts on health and welfare

The effects of climate change on health will be significantly less drastic in countries like Finland with a highly developed economy and technological and institutional infrastructure than in developing countries. However, climate change will also affect health and wellbeing in Finland via multiple pathways. Maintaining and strengthening the existing public health and other infrastructure, including housing, transport and energy, and preventing poverty are crucial for successful adaptation.

Increasing summer temperatures and especially the increased frequency and duration of heatwaves threaten to increase future heat-related mortality and morbidity in Finland. The ageing population, increasing number of people living alone, the low prevalence of air conditioning, and urbanisation further amplify the effect of heat. Heat also poses a challenge for occupational health. The number of days with heat stress will increase in both outdoor and indoor work environments, resulting in a need to revise instructions regarding work-rest cycles among high-risk groups. The thermal control of the built working environment will also need to be modified.

In future, milder winters will probably lead to lower cold-related mortality from cardiopulmonary diseases. On the other hand, because of the large winter climate variability, society and individuals will also have to be prepared for cold spells in future. During the winter, darkness and icy walkways and roads cause health risks. The number of days when the temperature hovers around 0 °C will increase and may lead to an increased number of slipping injuries and traffic accidents. Thinner ice and the shorter duration of ice cover on waterways will be a safety risk. Darker winters, caused by a shorter snow cover period, increased precipitation, and cloudiness, may also increase cases of winter blues or seasonal affective disorder and related medical conditions. In part of the population, climate change causes environmental or climate anxiety.

Changing climate contributes to the northward spread of ticks, partly via changes in ecological factors such as the density of key host species, and may therefore result in an increased incidence of tick-borne diseases. The incidence of tick-borne diseases also depends on social and societal factors. An increased incidence of Lyme disease (borreliosis) and tick-borne encephalitis have already been observed in Finland. Changes in ecosystems associated with a warmer climate will probably also affect the spread of other infectious diseases. For example, warmer winters may lead to less pronounced population fluctuations of small rodents, which may decrease the incidence of some rodent-borne diseases. On the other hand, the anticipated increase in the number of medium-sized predators such as the red fox and the raccoon dog may increase the risk of rabies and *Echinococcus multilocaris* spreading to Finland.

Changes in hydrology such as an increase in heavy precipitation events and winter flooding may increase water epidemics in the future. The leaching of nutrients into waterways due to increased precipitation, with higher summertime temperatures, increases the risk of blue-green algae blooming. A warming climate may also increase the risk of infectious diseases spreading via swimming water and introduce new infectious species such as *Vibrio cholerae*.

Increased precipitation and higher temperatures threaten to increase the risk of crop diseases and pests, which may require increased use of biocides, further leading to human exposure to chemicals; more effort is needed to prevent health risks related to mycotoxins in crops. The same changes in climate will also increase the risk of moisture damage in buildings, which may further aggravate microbial indoor air problems. Finally, climate change may lead to increased exposure to allergenic pollen and therefore severer symptoms via e.g. changes in the distribution of plant species and increased amount of pollen.

In Finland, socioeconomic health inequalities are already relatively large, so as the possibilities for adaptation vary depending on socioeconomic status, these differences may also increase health inequalities. For example, a stable financial position facilitates adaptation to extreme weather phenomena such as making energy-efficient and cost-effective air conditioning decisions in households. At worst, climate change adaptation will increase societal division, as different types of climate-friendly housing and mobility are available for some of the population, while some will have to settle for old technology. If the structural change in society continues to mean the destruction of jobs in industrial and old technologies, attitudes may become even less favourable to policies promoting adaptation. At worst, strong societal divisions may lead to the strengthening of 'identity politics' if, for example, vegetarian food and cycling are strongly linked to a certain urban lifestyle in which there is no desire to participate. The regional perspective should be considered to reduce inequality. In addition, consideration of different population groups in both social welfare and healthcare should be kept in mind, considering especially children and young people and the indigenous Sámi people.

In adapting to climate change in healthcare, changes affecting the need for health services or counselling in the population should be considered. These changes may be caused by e.g. the spread of vector-borne diseases and increased risk of weather-related accidents. On the other hand, the need for services may also reflect changes in the living conditions of different population groups, caused by climate change adaptation actions in other sectors and the impacts of these actions on the operating environment of healthcare. Most phenomena related to climate change are progressing slowly and can be at least partly anticipated. It is therefore possible to prepare for changes in the long term. The potential impacts of climate change on healthcare may be complex, and they also involve issues in other sectors and society in general. The general requirements for improving efficiency in the use of resources and energy are also reflected in the adaptation of healthcare, which is responsible for a significant part of the total production of societies and the use of resources.

6.2.4 Economic impacts

According to a recent national study, climate change can be expected to have slightly negative effects on the Finnish economy as a whole, expressed as a percentage change in gross domestic product (GDP) over the period between 2020 and 2070 (Table 6.1). In a scenario with higher greenhouse gas concentrations (RCP4.5), and hence more global warming, the percentage change in GDP is larger than in a scenario with less global warming (RCP2.6). The study was unable to account for all potential economic impacts, but the results are sufficiently indicative for the period covered, and somewhat beyond, provided global warming pathways exceeding three degrees can be avoided globally.

In the study, climate change scenarios RCP2.6 and RCP4.5 were combined with socioeconomic scenarios. RCP2.6 is combined with SSP1[8], which represents a cooperative sustainable development-oriented world in which innovations spread quickly. RCP4.5 is combined with SSP3, which represents a divided world inclined to defend current interests, and in which innovations spread more slowly and only within certain regions.

Considering the uncertainties and incompleteness of the collection of included effects, the study's most important message was that a proactive adaptation approach was clearly more beneficial for the economy than a reactive approach. A proactive approach entails adaptation in which public and private actors concertedly make timely use of risk projections and act accordingly, aiming to avoid the occurrence of major damage. In a reactive approach, emphasis on certainty postpones serious action until significant damage occurs. Even for a country like Finland, with a considerably more modest expected value of climate change damage than the global average, the cumulative benefit of proactive adaptation over the period between 2020 and 2070 was estimated to be between EUR 5 and 8 billion (present value at 2 per cent discount rate), depending on the scenario. The model exercise included differentiation of results at provincial level, which showed that some provinces, with overrepresentation of vulnerable economic sectors, were expected to suffer more than others, even though disparities did not rise to very high levels.

Table 6.1
Estimated changes in Finnish GDP at national level and indications of regional variability in different climate economy scenarios by 2070 due to climate change while distinguishing between a proactive and a reactive adaptation approach*

	SSP1-RCP2.6		SSP3-RCP4.5	
	Proactive, %	Reactive, %	Proactive, %	Reactive, %
GDP: percentage change from baseline	–0.05	–0.11	–0.10	–0.26
GDP: regional variability of change in GDP	–0.4 ~ +0.2	–0.6 – 0	–0.5 ~ +0.1	–1.0 – 0

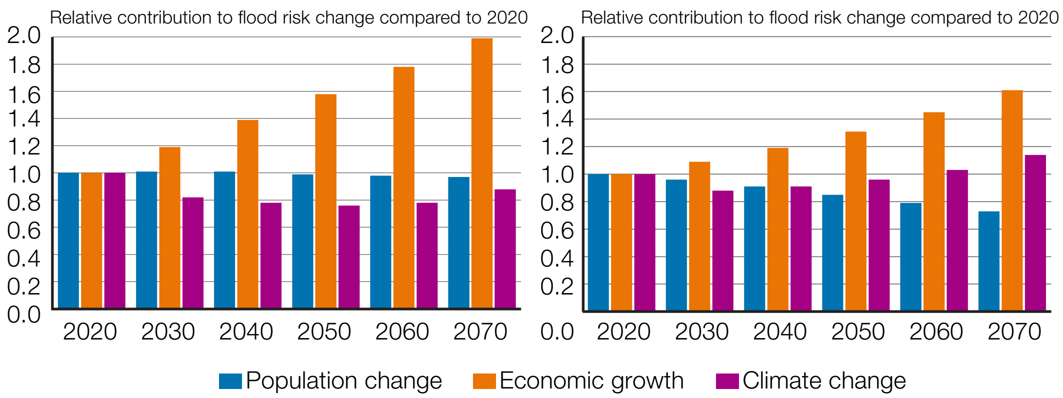
*) Only a selection of effects could be accounted for. Not included are international logistic disruptions (however, these are temporary), effects of increased heat stress, part of the biotic risks for humans, agriculture, the forest sector, land-based and marine ecosystems, or possible surpassing of climate tipping points.

In contrast to the macro-economic results, results become often less clear-cut when measured in absolute monetary terms at sectoral level. An important reason for this complication is that stronger economic growth in a sustainability driven world as represented by SSP1 with less global warming

8 SSP=Shared Socioeconomic Pathway

(RCP2.5) creates more asset value that can be damaged compared to a divided world as represented by SSP3 with less economic growth and more global warming (RCP4.5). For example, as illustrated in figure 6.4, in the case of coastal and riverine flooding in Finland, the changes in expected damage value in the absence of further adaptation are dominated by the effects of economic growth and associated changes in the value of real estate. On top of the economic growth effect, the climate change effects on flood risks do start to kick in after 2060 in the scenario with more global warming (RCP4.5) because of changes in river discharge and stronger storm surge risks along the southern coast. The economic risks of flood nonetheless remain very moderate by international standards. When the current flood risk management plans are all realised, the residual economic risks will remain small.

Figure 6.4
Relative contributions of changes in population, economic growth, and climate change effects on water levels to the development of the expected monetary value of flood damage in SSP1-RCP2.6 (left) and SSP3-RCP4.5 (right) starting from reference year 2020 (=1).



The study also indicated that permanent changes in the operating environment of various economic sectors, e.g. related to average temperature trends, development in average precipitation, typical duration and thickness of snow cover, etc., will eventually be more important for economic development than damage caused by extreme events, even though the latter may cause significant disturbance for a limited period. This is summarised in Table 6.2. It should be noted that the first two items, floods and power disruptions, are expressed in terms of rising costs. In contrast with the forest[9] and agriculture sectors, the effect is expressed in terms of change in earnings, and hence the effect is negative, as earnings go down compared to the reference development.

Proactive adaptation with respect to these gradually progressing changes in operating environments can significantly reduce the negative effects of climate change and enhance the positive effects of new opportunities, either created

9 In this case the forest sector encompasses both the forest product industry and forest resources management.

through adaptation-aware innovation efforts or resulting from climate change as such. An example of the former is innovations in forest management and the cultivation of subspecies, while an example of the latter is the relative improvement of the tourist amenity value of the Finnish summer climate. Generally, these notions are especially relevant for sectors strongly dependent on ecosystem services such as agriculture and the forest sector (Table 6.2). The same notions apply also to tourism and urban planning and architecture, as these largely determine working conditions in service sectors, as well as for daily life in general.

Table 6.2
Expected risk developments in terms of extra damage or reduced earnings in selected sectors associated with climate change in two socioeconomic climate scenarios for the period between 2041 and 2070 compared to the current levels of expected damage*

	SSP1-RCP2.6		SSP3-RCP4.5	
	Proactive	Reactive	Proactive	Reactive
Sectoral effects – extra costs or production loss (EUR million/year)				
Built environment – floods	decreasing**	+6	decreasing**	+16
Households – Electricity distribution disruptions	stable/decreasing**	+9	stable/ ecreasing**	+20
Forest sector (output value)	–450	–600	–550	–800
Agriculture (farm income)***		–180		–290

*) Only a selection of effects could be accounted for. Not included are international logistics disruptions (however, these are temporary), effects of increased heat stress, part of the biotic risks for humans, agriculture, the forest sector, land-based and marine ecosystems, or the possible surpassing of climate tipping points.

**) For both coastal and inland flooding and electricity distribution, disruptions apply that, if existing adaptation plans are completed, the expected cost levels of these hazards are projected to decrease or at least stabilise in the case of electricity, as the significant cost of underground cabling is eventually borne by consumers.

***) The change (loss) in farm income in the reactive approach is expressed as the difference with the proactive approach.

The cost figures presented above are mostly based on physical damage and production losses. These are referred to as 'tangible cost'. Costs can also be 'intangible', referring to a reduction in levels of wellbeing and non-monetisable environmental changes. Examples of intangible costs are extreme weather-related disruptions in electricity distribution to households (which also include tangible costs) and the loss of wellbeing associated with the temporary or permanent health effects of vector-borne diseases. A crude guideline for inferring the cost of non-pecuniary welfare losses (i.e. net of actual expenditures) is that these add between 100 and 200 per cent to the original – pecuniary – cost levels. The resulting cost figures can be used to assess justifiable investment levels for adaptation plans. On the other hand, such compound cost figures should not be used for macroeconomic comparisons or the assessment of public budget developments without recourse to their foundation. Part of these welfare effects may later nevertheless result in tangible costs.

Availability of sectorial impact data is essential for efficient adaptation planning and implementation. Physical impact data tend to be better available than economic impact data, but significant impediments exist for both categories. Problems with missing or poor economic impact data are partly caused by the lack of (exact) physical data. Furthermore, private ownership of data and absence of damage prices for nature, and various health effects add to the availability problems of economic impact data.

The regional economic impacts vary by region due to regional differences in climate change and the shares of climate change sensitive economic activities. For example, analysis of ski lift ticket sales data across Finland has shown that the number of visitors to ski centres in Southern and Central Finland are about twice as sensitive to adverse snow conditions than ski centres in Northern Finland. Furthermore, a lack of snow in Southern and Central Finland tends to increase ski lift ticket sales in Northern Finland. Given the gradual reduction in the duration of the ski season, especially in Southern and Central Finland, where these durations are already shorter than in the north, an inter-regional rebalancing of visitor numbers can be foreseen to the benefit of Northern Finland, which may also face a growth in foreign visitors. Overall, at a national level the turnover of ski centres may therefore grow moderately over the next few decades, even though this also depends on the effects of mitigation policies on long-distance travel. The impact of climate change becomes more visible and diversified when zooming in to the regional level. This notion underlies the regional variation summarized in Table 6.1. Regions in Finland with higher shares of agriculture and forest sector in their regional product tended to face stronger setbacks owing to effects of climate change.

6.3 Assessment of risks and vulnerability to climate change

6.3.1 Methodological approaches for assessing risks and vulnerability

In the context of climate change, risk is often defined arising from dynamic interactions among hazards, exposure and vulnerability. Here, hazard refers to climate-related events and trends that may induce adverse impacts such as losses or damages to livelihoods and environmental resources. Exposure is described as the presence of people, livelihoods, species or resources in places and settings that could be adversely affected by the hazard. Vulnerability is defined as the propensity or predisposition of the exposed entity to be adversely affected. It encompasses concepts such as sensitivity, susceptibility and lack of capacity to cope and adapt[10].

10 IPCC (2022)

To improve the efficiency of disaster risk management and climate change adaptation, a government funded research project proposed a governance model to produce sector-specific risk assessments from inter-operable basic data, ultimately combining them cost-effectively into a national climate risk assessment at regular intervals, has been proposed.[11] It can also guide regional and municipal risk assessments. It is suitable for assessing the consequences of harmful weather events, emerging risks, and cross-border effects.

The proposed operating model consists of 1) cross-sectoral, joint monitoring, and anticipatory work that monitors and anticipates hydro-meteorological and climate hazards, and general societal development with the help of scenarios; 2) sector-specific risk assessments in which exposure, vulnerability, and risk realisation and management are assessed; and 3) a joint, synthesising, climate risk assessment that merges sector-specific risk assessments into a national climate risk assessment.

The climate risk assessment is linked to the preparation and evaluation of policy measures. It utilises societal development scenarios for exposure and vulnerability assessments and provides a knowledge base for developing climate change adaptation measures and governmental security and foresight activities.

The governance model requires nationwide coordination with a wide range of expertise, e.g. key ministries, research institutes, and other stakeholders. Each sector would be responsible for its own risk assessments, but the model would ensure that the monitoring, forecasting, and scenario information of risk management was common across sectors.

The model suggests an update of the national climate risk assessment every six years. It is thus possible to integrate the climate risk assessment with the National Risk Assessment, which is carried out every three years in accordance with the national Security Strategy for Society.

A multi-sectorial climate change risk assessment was undertaken in 2018, and the results were used in the national risk assessment[12]. The climate change risk and vulnerability assessment was updated in 2022 as part of the development of the second national climate change adaptation plan. Assessment included three different perspectives: 1) national risk and vulnerability assessment with a focus on sectorial and cross-sectorial risks and vulnerabilities, 2) regional vulnerabilities, and 3) national and local level institutional vulnerabilities.

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11 https://tietokayttoon.fi/documents/113169639/113170760/23-2018-Assessing+and+monitoring+hydrometeorological+and+climate+risk.pdf/67449197-bb59-439c-a96f-6d7d507bfa20/23-2018-Assessing+and+monitoring+hydrometeorological+and+climate+risk.pdf?version=1.0&t=1536559699000

12 National Risk Assessment 2018, https://intermin.fi/julkaisut/julkaisu?pubid=URN:ISBN:978-952-324-249-4

The results will also be used as an input to the update of the national risk assessment. In addition, a government funded project assessed institutional vulnerabilities, with a particular focus on regional and local level[13].

The operating model also provides an input for other reports and assessments that are required by the Climate Act, the Energy Union Governance Regulation of the EU, reporting on the planned implementation mechanism of the Sendai Framework, the EU Civil Protection Mechanism, the National Rescue Service Reform, and the UN Framework Convention on Climate Change, for example. The model has yet to be put fully into practice but forms a framework for ongoing development work within and across sectors. The revised National Climate Change Adaptation Plan 2030 aims to develop means to implement the proposed model.

Work is also ongoing to test a model-based response surface approach for a national-scale climate change impact and adaptation assessment, applying impact models across sectors within a standard analytical framework. This seeks to represent three aspects potentially relevant for policy: (i) sensitivity – examining the sensitivity of the sectors to changing climate for readily observable indicators; (ii) urgency – estimating risks of approaching or exceeding critical thresholds of impact in alternative scenarios as a basis for determining the urgency of response; and (iii) response – determining the effectiveness of potential adaptation and mitigation responses.

6.3.2 Assessment of disaster risks

In Finland, extreme weather events include low-pressure storms, thunderstorms, hot and dry spells, frosty periods, heavy rain and heavy snowfall. Climate change will affect their likelihood and thus alter the associated risks. Climate change will also increase the risk of large-scale forest fires. As the climate warms, days with simultaneous high winds, high temperatures, and low humidity will become more frequent and increase the risk of fires spreading. The risk of flooding, for example, from the sea, watercourses and stormwater, will also change as the climate warms. Sea levels will rise in the Gulf of Finland, and storms may intensify, increasing the risk of marine flooding. Exposure will depend significantly on where you are on the coast. Similarly, the change in the risk of watercourse flooding will depend on location: in some places, it will decrease due to there being less snow, but in large central lakes and their estuaries, for example, the risk of flooding will increase.

Extreme weather events can pose immediate risks, for example, to human health and safety, and damage or disruption to infrastructure in a region. For example, storms can cause electricity supply disruptions when trees fall on power lines. In turn, electricity supply disruptions can cause further disruption

13 Hildén et al. 2022a and 2022b http://urn.fi/URN:ISBN:978-952-383-118-6 https://tietokayttoon.fi/julkaisu?pubid=42102

to infrastructure and critical functions in the area through cascading effects. However, in global comparison, extreme hydro-meteorological events do not generally create disasters in Finland.

6.4 Domestic adaptation policies and strategies

6.4.1 National adaptation policy framework

In publishing its first National Strategy for Adaptation to Climate Change in 2005, Finland was among the first countries in the world to produce such a strategy. The current national adaptation policy framework is described in the Government Resolution of the National Climate Change Adaptation Plan 2022 (Nov 2014)[14].

The aim of the adaptation plan is that Finnish society has the capacity to manage the risks associated with climate change and adapt to changes in the climate. Three objectives were set to be achieved by the end of 2022:

A. Adaptation has been integrated into the planning and activities of both the various sectors and their actors.

B. The actors have access to the necessary climate change assessment and management methods.

C. Research and development work, communication, and education and training have enhanced the adaptive capacity of society, developed innovative solutions, and improved citizens' awareness of climate change adaptation.

The first objective highlights the approach of mainstreaming adaptation, i.e. integrating the perspective of managing climate risks and adaptation needs into regular activities in different sectors. Following this, further identification and definition of more detailed adaptation measures has been tasked to each sector ministry for their areas of responsibility.

Implementation of the NAP has been supported and monitored by a broadly based Monitoring Group for Climate Change Adaptation since 2015. The group is chaired by the Ministry of Agriculture and Forestry, with representatives from the relevant ministries and other authorities, regional and local actors, research institutes, expert organisation in fire and rescue services, and financial services.

14 https://mmm.fi/documents/1410837/5120838/MMM-_193086-v1-Finland_s_National_climate_Change_Adaptation_Plan_2022.pdf/582041ee-3518-4a63-bf60-7133aed95a9c/MMM-_193086-v1-Finland_s_National_climate_Change_Adaptation_Plan_2022.pdf?t=1507187377000

Between 2018 and 2019, a mid-term evaluation was carried out to assess progress in the implementation of the NAP. In the lead up to updating the National Adaptation Plan, a final evaluation of the NAP was carried out between 2021 and 2022.

National adaptation planning has been stipulated as part of Finland's Climate Act since 2015. The law provides a framework for planning, implementing, and assessing climate policies and improves cooperation among government offices in mitigation and adaptation. According to the Climate Act, the Government approves and presents to Parliament long-term and short-term strategic mitigation and adaptation plans. According to the Climate Act, a national adaptation plan should be approved at least every ten years. Between 2020 and 2022, the Climate Act was revised, and the updated Climate Act[15] entered into force on 1 July 2022. In the future, a National Adaptation Plan will be adopted every other electoral period (essentially every eight years). The revised Climate Act further stipulates that an evaluation will be carried out halfway through the NAP's implementation period to assess progress and needs for additional measures.

The Climate Act stipulates that each ministry is responsible for implementing and monitoring the progress of the climate plans included in the climate policy planning framework defined by the Act. In essence, this means that while the Ministry of Agriculture and Forestry is responsible for coordinating overall national adaption policy, each ministry has the responsibility to ensure and follow up its implementation within their own areas of responsibility. The current NAP includes a measure that detailed climate risks and vulnerability assessments, as well as the identification of measures needed to manage them, should be undertaken by each sector ministry. Where required, sectoral adaptation (action) plans should be developed to guide more detailed adaptation actions in different sectors. Currently, sectoral adaptation plans have been developed by the following sector ministries (further information in Section 6.4.2):

- The Ministry of the Environment's Action Plan (2008, revised in 2011 and 201616). The environmental administration's sectoral adaptation action plan includes measures for biodiversity, land use, buildings and construction, environmental protection, and the use and management of water resources.

- The Ministry of Agriculture and Forestry's Adaptation Action Plan (2011, revised 202217). The sectoral adaptation action plan includes measures for

15 423/2022

16 Adaptation to Climate Change in the Administrative Sector of the Ministry of the Environment Action Plan 2022, http://urn.fi/URN:ISBN:978-952-11-4736-4

17 https://mmm.fi/en/adaptation-in-the-ministry-of-agriculture-and-forestry-administrative-branch

agriculture, forestry, fisheries, game management and reindeer husbandry, water supply, and flood risk management.

– The Ministry of Social Affairs and Health's Adaptation Plan (2021[18])

Furthermore, adaptation has been integrated into broader climate/environmental policy programmes in other sectors, including transport and communications, and defence. In 2022, work is underway in the Ministry of Defence to develop a dedicated sectoral climate change adaptation plan.

Adaptation to climate change has been recognised in National Energy and Climate Strategies (2005, 2008, 2013, 2016, 2022). Climate change adaptation has been further integrated in various national policies, such as Finland's Strategy for Arctic Policy adopted in June 2021 where mitigation and adaptation to climate change is one of the strategy's four priorities (further information in Section 6.7).

6.4.2 Sectoral adaptation planning

Water resources and water supply

In the water resources sector, climate change has been integrated into the implementation of the EU's water framework and flood directives, national dam safety legislation, water supply site risk assessment, and the review process of watercourse regulation permits. The selection and prioritisation of measures presented in the 2nd flood risk management plans and 3rd river basin management plans include the estimation of climate resilience of different strategies and measures. The Finnish Environment Institute has produced preliminary stormwater flood maps for municipalities' stormwater risk assessments and regional Centres for Economic Development, Transport and the Environment (ELY Centres) have prepared flood maps to enhance preparedness and to be considered in land-use planning. A national drought risk management strategy is under development. A pilot for a regional drought management plan was carried out in 2020, and a national drought risk analysis is in progress. Indicator-based drought early warning systems are also under development. Watershed regulation and permits require reassessment due to seasonal changes in water levels and discharges. Adaptation may require changes in the regulation permits. Dam safety legislation requires the estimation of design floods for classified dams. Climate change affects the magnitudes of the design floods, and this should be considered in the estimation of the design floods in the watersheds where floods are expected to increase. The new Water Resources Management Strategy 2030[19] also

18 Climate change in the healthcare and social welfare sector: Climate change adaptation plan of Ministry of Social Affairs and Health (2021–2031), http://urn.fi/URN:ISBN:978-952-00-8424-0

19 http://urn.fi/URN:ISBN:978-952-366-185-1

emphasises climate change adaptation and mitigation in the management of water resources.

Agriculture

Adaptation measures for agriculture are included in the Ministry of Agriculture and Forestry's sectoral adaptation plan for 2022 to 2027. Guidelines for water management in agriculture and forestry in a changing environment (2020)[20] set out objectives and measures for sustainable water management in agriculture and forestry, including in the light of changing climate conditions. A work programme has been published to support the guidelines' implementation. In addition, emergency plans and risk assessments for various existing and emerging pests and diseases are discussed in Section 6.6.2.

Forestry

Adaptation measures for forestry are included in the Ministry of Agriculture and Forestry's sectoral adaptation plan for 2022 to 2027. The Forest Damages Prevention Act[21] took effect in 2014, and it was altered most recently in 2022 to decrease the risk of extensive forest damage caused by insects or root rot due to climate change.

Climate-resilient forestry is an integral part of the National Forest Strategy 2025. The main goal is to maintain and improve the resilience of forests by integrating climate change considerations into forest management. This is achieved by improving knowledge of and practical tools for the enhancement of carbon storage and sequestration in forests, as well as on the impacts of forests and forest management on climate change adaptation. The preparation of the new Strategy is underway and will be finalised by the end of 2022. Increased financing for research and development, as well as updated legislation and guidelines on forest management and climate change, also contributes to improved risk management carried out by forest owners, operators and the authorities. The updating of the state financing scheme for sustainable forest management in private forests is also underway. One of the main goals is to promote management practices that enhance forests' resilience.

Reindeer husbandry and herding

In 2021, the Ministry of Agriculture and Forestry established a working group on the future of reindeer husbandry with the aim of 1) promoting active, sustainable and progressive reindeer husbandry, 2) developing the subsidy system and securing investment support for reindeer husbandry, and 3)

20 Maa- ja metsätalouden vesitalouden suuntaviivat muuttuvassa ympäristössä - Valto (valtioneuvosto.fi)

21 1087/2013

promoting the development of reindeer husbandry as a profitable, sustainable, and culturally significant livelihood. The working group's first task is to prepare a working model for reindeer pasture management plans for each reindeer herding cooperative, which will ensure the sustainable use of reindeer pastures in accordance with the reindeer numbers stipulated in a government decree[22]. The working group's work will also include the sector's work on anticipating the effects of climate change and planning adaptation measures.

Fisheries and game

Commercial fishing is steered by the Fishing Act[23]. The Fishing Act provides for national fisheries management plans to ensure the sustainable use and management of fisheries resources. Climate change plays a marginal role in policymaking and commercial fishing documents.

Finnish hunting legislation and hunting activities are based on the principle of sustainable use. Sustainable use is determined by estimates of the size of animal populations and species-specific management plans. The impact of climate change on the success of animal populations has not been considered in recent management plans.

Energy

Adaptation measures in the energy sector are included in the National Climate and Energy Strategy published in 2022.

In energy distribution the Act on Electricity Markets[24] requires the network operators to prepare for extremes and also to compensate users for failures to maintain distribution of electricity. This has made network operators invest in ways to reduce the risk of distribution failures due to for example storms.

Act on Peak Load Reserve[25] secures a balance between electricity production and consumption. Amendments in 2021[26] make it possible to secure supply of electricity also in abnormal situations and disturbances. In the future, the need for and volume of peak-load capacity would be assessed at least every two years. Participation in peak-load reserve would be extended when necessary.

Transport

The Ministry of Transport and Communications is responsible for adaptation planning in the transport and communications sector at national and strategic

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22 414/2020
23 379/2015
24 588/2013
25 117/2011
26 1239/2021

levels. Adaptation is part of standard sectoral policies, plans, and programmes in the transport sector.

In 2021, the Government adopted the National Transport System Plan for 2021 to 2032, which is a strategic plan for the long-term development of the entire transport system. The plan includes an action plan and brings together the measures taken by central and local government. The plan notes that climate change is changing the transport system's operating environment. According to the plan, adaptation to climate change will require transport system operators to be more aware of weather and climate risks, for example. There is a need for measures in the planning of both the rail and road networks and especially in the winter maintenance of the networks. Sustainability is one of the key goals of the plan, and the plan's measures will increase opportunities for climate change adaptation policies in the sector.

In March 2022, the Government adopted a new Transport Safety Strategy[27]. The strategy notes that acknowledging the needs of climate change adaptation throughout the transport network is key to the improvement of traffic safety. All the authorities responsible for the transport network's maintenance must ensure that changing conditions and increasingly extreme weather are considered in the maintenance and development of the transport network. The plan also includes policy measures on the better collection and communication of meteorological information.

The Finnish Transport Infrastructure Agency (FTIA), which operates under the Ministry of Transport and Communications, is responsible for road, railway, and waterway construction and maintenance and operates in close cooperation with the regional Centres for Economic Development, Transport and the Environment (ELY Centres). According to the steering contract between the Ministry and the Agency, as part of its continuous tasks, the Agency produces information regarding adaptation.

Built environment, natural environment, and biodiversity

In the built environment sector, the legislative steering of adaptation to climate change is based on the Land Use and Building Act[28]. Another important method for steering land use regarding adaptation has been the national land-use guidelines (Government Decision 2008), one of the focus areas of which is adaptation. According to the Land Use and Building Act, the national land-use guidelines must be taken into account in regional planning, municipal land-use planning and in the operations of the authorities. In 2014, the Land Use and Building Act was amended with provisions on stormwater management. Increasing rain levels have been considered through the issuing

27 https://www.lvm.fi/-/government-resolution-transport-safety-strategy-aims-to-improve-the-safety-of-all-modes-of-transport-1703498

28 132/1999

of a decree on the preparation of moisture control plans in construction in 2014. Urban flood management is also covered by the Flood Risk Management Act[29]. A reform of Land Use and Planning Act is currently ongoing, and its main targets are the mitigation and adaptation of climate change.

Adaptation actions in the built and natural environments are included in the Action Plan for the Adaptation to Climate Change of the Environmental Administration 2022[30], adopted in 2016. Progress of the plan's implementation from 2016 to 2019 was reported in 2020 (for further discussion see Sections 6.6.1 and 6.6.2).

Cultural heritage

The Ministry of the Education and Culture, with other ministries, agencies, and third sector actors, prepares the first national cultural heritage strategy. The Cultural Environment Strategy from 2014 to 2020, which was completed under the leadership of the Ministry of the Environment, will continue to direct the work on the cultural environment. In addition, the Ministry of the Environment is currently preparing the definition of landscape policy. In all these strategies, climate change is a key theme.

Industry and commerce

The most significant risks caused by climate change to the Finnish industry and commerce are indirect and closely connected to other sectors within Finland as well as to global developments. Because of the cross-sectoral nature of the risks, no specific adaptation plan has been prepared for Finnish industrial operations or commerce[31]. The adaptation planning is carried out through cross-sectoral work in which the adaptation needs of the Finnish industry and commerce are taken into consideration.

The mitigation and adaptation needs caused by flooding, droughts and other extreme weather conditions are researched and implemented in connection with the ongoing reform of the Land Use and Building Act. Climate change mitigation and adaptation as the main objectives of the reform improve the ability of the Finnish industry and commerce to adapt to the direct effects of climate change.

Research has identified problems in logistics caused by climate change as a potential indirect risk to Finnish industrial operations. In March 2021, the Finnish National Emergency Supply Agency under the Ministry of Economic Affairs and Employment of Finland started the implementation of the Logistics 2030 programme. Logistics 2030 programme takes into account

29 620/2010

30 http://urn.fi/URN:ISBN:978-952-11-4736-4

31 No specific plan for adaptation has been prepared for mining either. As for the built environment in general, securing the function of infrastructure is essential.

the impacts of climate change on the logistics sector and aims to strengthen the operating conditions and operational capacity of critical logistics infrastructure.

Indirect risks caused by disruptions in the energy supply are addressed as part of the Finnish Climate and Energy Strategy prepared by the Finnish Ministry of Economic Affairs and Employment. Energy security and security of supply play a major role in the Finnish approach to climate change adaptation and as such support the ability of the Finnish industry to adapt to problems in the energy supply.

Tourism

Adaptation measures for the tourism sector are an integral part of Finland´s tourism strategy 2019–2028 and action plan 2022–2023. The updated strategy will be finalized by autumn 2022. The strategy states the role of tourism as a cross-sectoral industry and its potential to enhance a shift towards more sustainable, cleaner, lower-carbon economic growth to minimize the effects of climate change. At the same time, the strategy calls for new, innovative solutions for sustainable tourism products and experiences.

According to the strategy, proactive adaptation measures and successful green transition are a prerequisite for ensuring the profitability and social acceptability of tourism business activities. The tourism sector needs investments in measuring and reducing carbon dioxide emissions, reforming operating practices and in-creasing cooperation. These all actions are included into the Finland´s tourism strategy. In addition, in June 2022, 60 tourism businesses, destinations and associations together with Visit Finland signed Glasgow Declaration for Climate Action in Tourism. By signing the organizations commit to halve emissions by 2030 and reach Net Zero as soon as possible before 2050.

Tourism is a horizontal sector and many adaptation planning described in this chapter has direct or indirect impact on the tourism sector. Especially transport is an essential part of the tourism sector.

Health and welfare

Adaptation actions for health and welfare sectors are included in the Climate Change Adaptation Plan for the Social and Health Sector[32] published by the Ministry of Social Affairs and Health in 2021. The aim of the sectoral Adaptation Plan is to assess the current state of adaptation and the structures supporting it, identify current and new adaptation measures in the health and wellbeing sector, and translate the measures into more concrete terms within the administrative branch of the Ministry of Social Affairs and Health.

32 http://urn.fi/URN:ISBN:978-952-00-8424-0

The intention is to introduce the Adaptation Plan to healthcare and social welfare operators and to increase risk awareness in the healthcare and social welfare sector. The Adaptation Plan contains 43 objectives and 92 recommendations for measures. The measures cover areas related to environmental health, health, and social services (incl. occupational safety and health), social effects, and mitigation measures and repercussions. The Ministry of Social Affairs and Health is responsible for implementing, monitoring, and assessing the Adaptation Plan. The Drinking Water Directive[33] (EU) on the quality of water intended for human consumption to ensure healthy drinking water is being implemented. Planning on legislative amendments across several branches of government, particularly in the administrative branches of the Ministry of Social Affairs and Health, the Ministry of the Environment, and the Ministry of Agriculture and Forestry, is currently ongoing.

6.4.3 Disaster prevention and management

There is no single national disaster risk reduction strategy in Finland, but there are legislative government resolutions, various strategies and programmes that together form the necessary preparedness of the society to various disasters. The legislation includes the Emergency Powers Act[34], Rescue Act[35], and Act on Security of Supply[36].

The Security Strategy for Society 2017[37] is a government resolution that harmonises national preparedness principles and guides preparedness in the various administrative branches. The first part of the strategy presents a cooperation model for comprehensive security, based on which preparedness measures and other actions are taken concerning a range of incidents in Finland. The principles of the Security Strategy for Society cover preparedness in different types of incidents and emergencies. The strategy lays out seven vital functions in society, i.e. the basic functions that must be safeguarded in all conditions and at all operative levels. The second part of the strategy outlines the tasks and areas of responsibility of the Government's ministries pertaining to preparedness. They are the starting point for preparedness planning at all activity levels. To safeguard the vital functions, the Security Strategy for Society 2017 defines 57 tasks and areas of responsibility for the Government's ministries pertaining to preparedness.

The Report on Internal Security assesses the state of internal security in Finland, and the national and global drivers of change affecting it. It defines the internal security objectives and the direction of development until 2030.

33 Drinking Water Directive (EU) 2020/2184
34 1552/2011
35 379/2011
36 1390/1992
37 https://turvallisuuskomitea.fi/wp-content/uploads/2018/04/YTS_2017_english.pdf

It aims to ensure the further development of internal security so that Finland will be an even safer country for all people and population groups in the future. Climate change was identified as one of the drivers affecting internal security.

The statutory tasks of the Regional State Administrative Agencies include coordinating regional preparedness and organising the related cooperation, which includes cooperation with the various authorities in the region, as well as with non-governmental organisations and the private sector. The Regional State Administrative Agencies organise large-scale preparedness exercises to promote a common regional risk management capability between actors. Regional risk assessments are actively used for preparedness exercises and for general preparedness planning and training activities.

In 2018, climate change impacts were included in the National Risk Assessment by describing the diversity of weather and climate risks and the challenges posed by growing risks to society. Ministry of the Interior re-established the National Sendai Network in 2021 to offer a common national podium for the relevant 26 different stakeholders. The Network consists of ministries, research and development, central national agencies and non-governmental organisations, all having responsibilities in implementing the Sendai Framework. This Network strengthens national and international cooperation, forms the audience for better information sharing and enhances implementing national strategies within the Disaster Risk Reduction (DRR) issues.

6.4.4 Sub-national and local adaptation plans

A significant share of adaptation measures is implemented at the regional and local levels. Various measures promoting preparedness for climate change, such as flood protection, have already long been implemented at regional or municipal level. Adaptation measures are included in many recent programmes and strategies at the regional and local levels, but the dominant focus of climate action has been on climate change mitigation.

The need for systematic implementation of adaptation measures has been widely recognised in municipalities, and regional climate risk knowledge and awareness have increased. This has led to active development efforts and collaboration with different actors. Typical adaptation measures focus on improving preparedness for climate risks, such as flood risk mapping or emergency planning related to water management and storms.

Bigger cities and municipalities have been especially active in developing and implementing adaptation policies and actions. In 2021, the Helsinki Region Environmental Services Authority (HSY) finalised their Sustainable Urban Living Programme, which includes new measures for climate change adaptation in the metropolitan area. The programme supersedes the metropolitan region’s adaptation strategy adopted in 2012. Individual cities in the metropolitan region have since engaged in more detailed adaptation planning, and the focus of measures at the metropolitan region level have therefore shifted to common learning, supporting awareness raising, networking, and monitoring and evaluation. Some larger cities are involved in the Covenant of Mayors for Climate and Energy, which requires cities to prepare risk and vulnerability assessments and plan adaptation measures as part of their climate action plans.

Finland's Regional Councils established a collaboration network in 2020 to improve knowledge sharing and cooperation in relation to climate issues, including adaptation to climate change. The regional Centres for Economic Development, Transport and the Environment (ELY Centres) have carried out a systematic assessment of the current and future needs of adaptation action in their areas of work. ELY Centres are active across the country, and through the ELY Centres' internal network on climate change issues, the Centres collaborate on national-level actions. Many regions are also proactive in promoting regionally important adaptation action and creating adaptation plans in collaboration with other regional actors.

6.5 Monitoring and evaluation framework

National adaptation actions are guided by the National Adaptation Plan (NAP) of 2014. A mid-term evaluation of the NAP was published in the spring of 2019, and a final evaluation of the plan was carried out between 2021 and 2022. Annual monitoring of the NAP has focused on tracking the progress of the actions included in the plan. Efforts to monitor adaptation more broadly are ongoing. Some sectoral adaptation plans have also included efforts to follow up their implementation: for example, the Ministry of the Environment has monitored its own adaptation programme by systematically tracking the actions and identifying progress and challenges. Evaluations of the Ministry of Environment's adaptation plan were published in 2013 and 2020.

The final evaluation of the current NAP (2014 to 2022) focused on assessing the success and challenges of the plan's implementation, as well as identifying needs for further adaptation efforts. The evaluation approach combined multiple methods. Policy and legislation documents were assessed to identify, inter alia, the state of climate adaptation in different policy fields and the policy coherence of adaptation across fields. Three workshops involving public officials working at the regional level across Finland were organised, in which the participants provided inputs on the current state, challenges, and knowledge gaps of climate adaptation work in their respective regions. Two national-level workshops involving representatives from multiple ministries were organised to discuss how to better concretise adaptation work within the next 10 years and to present objectives and actions to achieve them. A survey was sent out to all Finnish municipalities to gain a better understanding of the current state of climate adaptation at the local level. Interviews with regional and national public sector actors were conducted to assess the level of both human and economic resources dedicated to adaptation measures. In addition, various adaptation policy development paths were identified through a literature review of reports across EU countries.

Prior to the recent final evaluation of the NAP, a mid-term evaluation was carried out between 2018 and 2019, in which a two-phase process applied. In the first phase, a facilitated self-evaluation process was carried out with sectoral administrations at the national level, consisting of group interviews with representatives of ministries and associated agencies and national research institutes in eight sectors, as well as key regional and local level representatives. The second phase focused on engaging stakeholders beyond the national-level administrations. Regional and local stakeholders from 11 different sectors were consulted via an online survey, and five regional stakeholder workshops were organised around the country to discuss the progress of adaptation work from a regional perspective.

Further to periodical evaluation efforts, more regular monitoring of the implementation of adaptation policies is undertaken by the National Monitoring Group for Climate Change Adaptation. The monitoring group brings together a broad range of stakeholders from both the national and regional levels. As part of this work, key indicators for monitoring climate impacts, risks and adaptation were compiled between 2015 and 2017 in dialogue with stakeholders. The further development, application and communication of adaptation indicators is an ongoing process led by the national adaptation monitoring group. In 2022, work is ongoing with Finland's national Climate Change Panel to identify indicators suitable for monitoring adaptation, especially in the human health and water services sectors.

The Helsinki Metropolitan Area had formulated a regional adaptation strategy for 2012 to 2020 focusing on urban adaptation. In 2021, the implementation and effectiveness of the strategy, coordinated by the Helsinki Region Environmental Services Authority (HSY), was assessed by an external evaluator. According to the assessment, the strategy was most influential in the first years of its implementation, because the concept of adaptation was still novel, bringing a new perspective to urban planning. The strategy was considered useful for recognising climate hazards and vulnerabilities. What added most value to the adaptation planning during the strategy period was the development of fruitful cooperation and knowledge exchange between the cities in the Metropolitan Area. During the strategy period, the need for the cities' own adaptation measures gained more attention, and some of the measures of the regional strategy were exported in the cities' adaptation action plans.

6.6 Progress and outcomes of adaptation action

6.6.1 Progress of national adaptation plan

A mid-term evaluation of Finland's National Adaptation Plan 2022 was carried out in 2018–2019. Results of the evaluation were used to steer and strengthen the Plan's implementation. In August 2022, a final evaluation of the progress of Finland's national adaptation policy was published. Results of the final evaluation have informed preparation of Finland's next NAP that looks to the year 2030.

According to the final evaluation, climate change impacts are receiving increasing attention in all administrative sectors in Finland. This is evident in references to climate change in the development of regulation and other policies. It is assessed that the NAP has positively contributed to goal setting and increasing general awareness of the need for adaptation. Sectors have, however, progressed at a different pace in terms of actions and guidelines that would concretely strengthen adaptive capacity. For example, advances have been made in construction, infrastructure maintenance, water management, and the use and protection of water bodies. These are typically sectors in which weather and climate fluctuations have long been relevant for normal operations. In other fields, such as game management, fisheries and healthcare, climate change has only recently gained attention as a concrete phenomenon that requires action.

Finland has maintained R&D activities that support the development of adaptation measures and the preparation of policies promoting adaptation. Until recently, R&D activities have focused either on short-term examinations on the one hand or long-term academic research. However, there is also a need for applied R&D projects, in which joint development methods would be created using tools such as checklists and guides for different sectors to implement concrete adaptation measures.

In Finland, monitoring the state of the environment has developed over a long period of time, and the data has also been used to verify and assess climate change impacts. Adaptation measures are reported nationally in connection with the Annual Climate Report to Parliament. Policy measures promoting adaptation are also regularly reported to the EU and the UN Paris Climate Agreement. Monitoring of individual adaptation measures at the regional and local level is developing, but monitoring is still fragmented. Moreover, there is no unified data base which could be utilised to develop adaptation planning measures and activities and to share good practices of actions taken.

In addition to evaluations of the NAP, progress in the implementation of certain sectoral adaptation plans has also been assessed. In 2020, Progress in the implementation of the Action Plan for the Adaptation to Climate Change of the Environmental Administration from 2016 to 2019 was reported.

The results show that the implementation of almost all measures described in the Action Plan for which a timetable had been set has progressed as planned, and they have been completed. In terms of the steering instruments, progress has been made in considering the needs for adaptation, but the consistency of the guidance should be further improved. Further details on the progress of actions are described in Section 6.6.2 below.

6.6.2 Progress of sectoral adaptation actions

Natural environment and biodiversity

The Action Plan for the Adaptation to Climate Change of the Environmental Administration 2022 was adopted in 2016. The Action Plan contributes to the implementation of the National Climate Change Adaptation Plan 2022 (Government Resolution of 20 November 2014).

The Finnish Nature Conservation Act is one of the key instruments to ensure the biodiversity of the Finnish natural environment. The act has recently been revised. Compared to the Conservation Act of 1996, in the revised version, adaptation to climate change-induced impacts is more clearly integrated into the aim of the act, and the need for identifying interdependences between climate change and biodiversity measures has been acknowledged. As the need to consider climate change impacts has become part of the proposed new law, the linkages between conservation and climate change adaptation are therefore further strengthened.

The protection of habitats takes a major leap forward in the new Act. The protection of certain habitat types that are already protected will be further strengthened. In addition, the Act provides the statutory framework for the protection of threatened habitat types and imposes a prohibition on degrading strictly protected habitats. The protection of species will also be intensified and clarified, which, with the protection of habitats, will significantly promote the protection of biodiversity in Finland. The Act also promotes the rights of the Sámi people by taking their rights as an indigenous people into account in the implementation of the Nature Conservation Act more strongly than before. The new Act includes a prohibition on weakening traditional Sámi livelihoods and culture.

Worldwide and in Finland, invasive alien species constitute one of the leading threats to biodiversity. Climate change is anticipated to substantially increase the number of alien species in Finland and the damage they cause. Climate change also affects the relationships between plants and plant diseases. The EU Regulation on Invasive Alien Species, Finland’s national legislation on Invasive Alien Species, and related national management plans will increase preparedness to react to changing circumstances, as climate change increases the potential for invasive alien species to spread northwards and thus extends their range, as well as their invasiveness. The more tangible actions are used to address the negative effects by invasive alien species, the more biodiversity will be maintained and adapted to the climate.

Water resources

Adapting to the impacts of climate change has long been important for the water sector. The current water conservation enhancement programme (2019 to 2023) funds projects that support adapting to climate change and prevent biodiversity loss in different sectors. For example, the programme is expected to generate and develop measures to prevent nutrient runoffs in the agricultural sector and manage rainwater in an integrated fashion (incl. nature-based solutions). The water conservation enhancement programme also funds studies and assessments of the state of the Baltic Sea and inland lakes, which supports adaptation to climate change. In addition, the new Programme of Measures of Finland's Marine Strategy from 2022 to 2027 deals with anthropogenic stress factors, as well as the impacts of climate change, which can aggravate other problems and thus call for more effective measures. In addition, the flood risk management plans for 2022 to 2027 for significant flood risk areas were updated in 2021. The objective of the plans is to develop measures to minimise flood damage and flood risks, such as flood forecasting and flood warnings. In 2022, new river basin management plans and action programmes were adopted for 2022 to 2027 to achieve and sustain the good state of waters.

Water supply

In the new Programme for the National Water Services Reform, attention has been paid to securing the undisturbed operation of water supply management and improving the management of risks, including climate risks. The Water Resources Management Strategy 2030[38] lists key change factors to the operating environment, such as the use of water resources, management of risks and self-sufficiency, and adaptation to climate change, by utilising nature-based solutions, for example. The goal of the strategy is to support and enable the supply of clean water, the reliability of water supply, and the water-related wellbeing of society and nature. Additionally, water responsibility and security are given more attention, and these will also be advanced at an international scale.

Agriculture

Further development of cultivation methods and systems is required to reduce risks and increase the resilience and competitiveness of agricultural production in a changing climate. The existing networks in place for farmers, farmers' associations, and advisory services help improve the exchange of knowledge about the means for adapting to climate change and variability. Agricultural research has been well designed to support and prioritise the development of primary adaptation measures. Research on climate change impacts and

38 http://urn.fi/URN:ISBN:978-952-366-185-1

available adaptation means has thereby already provided useful information for farmers and agricultural entrepreneurs. In the agricultural sector, measures for adaptation to climate change often also work as climate change mitigation measures. Adapting to a changing climate is also instrumental in achieving the climate mitigation targets set for the agricultural sector.

The adaptation measures include developing risk profiles and emergency plans for various existing and emerging pests and diseases. Although the main drivers for the risk assessment have been the pest and disease risks caused by increasing international trade, the impacts of climate change are also included where relevant. Finnish plant breeding has expanded the breeding strategies to cover novel crops that will probably be introduced to diversify Finnish crop rotations in the future. These, coupled with improved disease resistance and resilience through plant breeding, are important elements in improving the future adaptive capacity of Finland's agriculture.

The EU's Common Agricultural Policy (CAP) provides many tools for the abovementioned adaptation needs. Diversified production, the stability of the business economy, and the management of the growing condition of the field and water management play a key role in adapting to climate change. Organic production also promotes biodiversity and thus helps farmers adapt to climate change. Investment subsidies, advice services and various data transfer projects have helped develop production and modernise the equipment base. Adaptation to climate change in livestock farming is strongly linked to animal welfare and production hygiene. In Finland, animal welfare and hygiene are at a high level, and measures to promote them are well funded by the Rural Development Programme. Measures related to adaptation are included to the Finnish national CAP plan for the new CAP period from 2023 to 2027.

An indication of farmer's readiness to adapt to climate change is that they have already adopted later-maturing cultivars and crops, and they have started sowings earlier than a couple of decades ago. Since 1995, there has been a significant shift to the cultivation of more diverse cash crop choices in larger field areas. The warming climate has been the primary driver, but such a change has been possible only when supported by well-adapted cultivars, active markets and financial compensation. Cultivation methods and systems have been further developed to reduce risks and increase the resilience and competitiveness of agricultural production in a changing climate. These include sustaining soil structure and conditions by diversifying crop rotations, applying measures that increase soil organic content, increasing the period with soil cover by using autumn-sown and cover crops, and developing warning systems for the occurrence of pest and disease epidemics. However, farmers have prioritised the maintenance of subsurface drainage over the future use of irrigation. Farmers hesitate to adopt irrigation because of uncertainties in future precipitation, crop prices, irrigation costs, and thus whether investment pays back, and how long it will take. Adaptation measures on farms have been supported and monitored by several recent or ongoing research projects in collaboration with farmers, advisory services, farmers' unions, policymakers and private companies. To enhance adaptation to exceptional weather conditions, measures to improve and increase farms' energy self-sufficiency and energy security of supply have been promoted and implemented.

Forestry

The Forest Damages Prevention Act[39] took effect in 2014, and it was altered most recently in 2022 to decrease the risk of extensive forest damage caused by insects or root rot due to the changing climate.

Finnish forest administration has prepared contingency plans for extensive storms and other damage in forests. The plans cover storm damages, forest fires, snow damage, drought and frost damage, air pollution carried over a distance, and pests previously unobserved in Finland. The authorities have also started to draft contingency plans for various invasive alien species, as well as domestic pests such as the spruce bark beetle, which are expected to cause more damage in the future.

One of the foremost targets of the genetic improvement set in the Forest Tree Breeding Programme 2050 (2008) is the adaptation of future reforestation materials to climate change. The use of high-quality seed, suitable for different climatic conditions, is promoted by establishment of new seed orchards. Next generation seed orchard programme is being prepared during 2022. New deployment area maps that take into account climate warming predictions have been released in 2017 for improved seeds and seedlings of pine and are under preparation for spruce.

Energy

Finland has taken measures to adapt to the changing climate conditions, especially to the severe winter and summer storms that cause extensive and long-lasting power outages. Energy utilities have replaced a significant amount of the overhead electricity lines with underground cables. This has drastically decreased the number of blackouts throughout the country compared to the situation in 2011, when a major storm caused a blackout for more than 500,000 households. After the storm, the new requirements of a weatherproof network were introduced to the Electricity Market Act[40]. Among other things, the Act sets time limits for power outages beyond which compensation must be paid and includes measures for increasing the security of supply.

The Government is currently introducing new measures to the Electricity Market Act to enable the energy transition and help consumers better manage

39 1087/2013

40 Electricity Market Act 588/2013

their consumption and deliver energy-efficient solutions. New provisions allow consumers to save money. They contribute to the overall reduction of energy consumption. New types of services will enable more efficient system use. Intelligent electricity networks will work as a service platform in the transition to a more decentralised and carbon-neutral electricity system. Almost all users of electricity in Finland have smart meters that allow customers to participate in a variety of markets, improve security of supply, and cost-effectively create new business opportunities for companies. The smart meters provide network companies with online information about the network status, including detailed geographical information about disturbances caused by trees that have fallen on overhead lines, for example. This enables network companies to quickly restore the electricity supply and minimise the duration and consequences of events.

To fully use the demand side response and optimise the system, distribution network companies must also prepare a network development plan explaining how to employ demand response and storage and energy efficiency measures as an alternative for network investments for more efficient system use.

Land-use planning and buildings

In the land-use planning and building sectors, climate change and its impacts present significant challenges, which are also commonly recognised. In the currently ongoing reform of the Land Use and Building Act (2021 to 2022), one of the central goals is to better take climate change into account. The ambition is to make changes to the existing land-use planning system so that planning can better contribute to climate change mitigation and adaptation.

The Action Plan for the Adaptation to Climate Change of the Environmental Administration 2022 was adopted in 2016. The Action Plan contributes to the implementation of the National Climate Change Adaptation Plan 2022 (Government Resolution of 20 November 2014).

Cultural heritage

The major legal basis for protecting cultural heritage sites and the environment is the Land Use and Building Act. The national land-use guidelines also contribute to the efforts to adapt to climate change and extreme weather events and their consequences. Cultural environments are among the guidelines' themes.

The Constitution defines nature and its diversity, as well as the intrinsic value of cultural inheritance intrinsic. Furthermore, the Sámi indigenous people have the right to maintain and develop their own language and culture. According to the Act on the Sámi Parliament[41], the Sámi indigenous people have

41 1727/1995

autonomy over their own language and culture in the Sámi homeland. The new Climate Act (2022)[42] contributes to ensuring the ability of the Sámi to maintain and develop their own language and culture.

The Cultural Environment Strategy from 2014 to 2020, completed under the leadership of the Ministry of the Environment, pointed to the recognition of how the cultural environment helps in mitigating climate change and adaptation to it. However, the measures focused mostly on the impacts of the management of the built heritage in the mitigation of climate change. The Ministry of the Environment is to update the 'Climate Change and the Cultural Environment – Recognised Impacts and Challenges in Finland' report (2008). The threats to cultural heritage caused by climate change and related mitigation and adaptation measures will be discussed in the revised report.

A practical tool to assess the impact of floods on the built heritage and landscape is the flood map service of the Finnish Environment Institute. It can be used to map risks to the cultural environment.

The national cultural heritage strategy, which is under preparation, will propose measures related to adaptation and mitigation to climate change. For example, cultural heritage should be included in climate change mitigation and adaptation plans, and the impacts of climate change on cultural heritage and the cultural environment should be monitored.

Finland actively participates in international networks that promote the adaptation of cultural heritage to the effects of climate change. The Finnish Heritage Agency is part of the international Climate Heritage Network that seeks solutions for the tensions between the protection of cultural heritage and climate change mitigation and adaptation. In 2021, The Nordic and Baltic countries arranged a forum, called Cultural Heritage in a Changing Climate, in which Finnish delegates participated. Cooperation is also active at the European Union level.

Industry and commerce

The need for risk management due to weather variability and extreme weather conditions has been obvious in some weather-sensitive industries, and the general ability of the Finnish industrial sector to adapt to the direct effects of climate change is good. Adaptation measures for the direct and indirect risks in the industrial sector have been mapped.

Contingency plans, the development of supply routes and methods and increasing the flexibility of the energy supply have been suggested as suitable adaptation methods for the direct effects of climate change. Adaptation measures to the indirect effects of climate change can include the strengthening

42 423/2022

of value chains and networks with alternative supply areas and routes, as well as with the addition of new export markets. A more demanding way is to help improve the resilience and adaptive capacity of the most vulnerable parts of the value chain.

Studies on adaptation needs for industry suggest that adaptation to climate change presents an opportunity for the industry sector. For example, new products, processes, technologies and expertise related to adaptation can be exploited as part of CleanTech and other business opportunities. However, the need to identify and possibly promote these opportunities has only recently been introduced to the wider discussion. Such new opportunities are also available outside the industrial sector, as the shift in commerce from goods to services presents new opportunities for innovation. For companies in technical trading, the role of services is already central. Additionally, the growing importance of services mitigates the indirect effects of climate change on commerce and therefore improve its adaptability.

Mining

A new Mining Act is currently under preparation. One of the goals of the new Act is to enhance the level of the environmental protection of mining, which indirectly strengthens the linkages with climate change adaptation. In the future, risks induced by climate change may increase in certain regions and thereby have impacts on the secure operation of the mining sector, such as water balance management in mining areas. In the preparation of the new Mining Act, the need to coordinate and accommodate different concerns, including biodiversity and the protection of waters, has been acknowledged.

Transport and communications

Adaptation is part of standard sectoral policies, plans and programmes in the transport sector. Real-time traffic and weather information and the situation picture assist operators, traffic control, and the whole traffic system to adapt. In the revision of the Road Traffic Act[43], the effects of changing winter conditions have been considered, and meteorological research has been utilised.

The Finnish Transport Infrastructure Agency (FTIA) has considered adaptation to climate change when updating guidelines and policies for the drainage of roads and railways (2018), the dimensioning of culverts, bridge arches and sewers, the winter maintenance of roads (2018), and the maintenance of gravel roads (2022). The flood risk areas, alternative routes, drainage and culverts of roads have been inventoried regionally. The lack of alternative routes increases the vulnerability of railways. Risk trees alongside the railways have been harvested. Reserve power equipment has been renewed, and its use has been further developed. Maintenance contracts have been

43 729/2018

developed to take risks caused by climate change into account. The need for adaptation in the planning, design and building of railways is recognised. Ensuring adequate financing of the maintenance and repair of infrastructure is essential in adaptation to climate change.

Awareness of climate change and its predictions have been recognised as risk management means for seafaring. The service reliability of safety equipment and different systems has and is being improved by adding e.g. remote control. The safety and serviceability of seafaring is secured by preparing for various disturbances and exceptions and practising with seafaring actors.

The effects of climate change on runoff water and adaptation to flooding in airports have been studied. Research needs on de-icing means and the durability of airport structures have been identified. Good adaptability/ resilience is essential for airports, because the effects of climate change are realised over a long period.

To decrease the risk of damage to the networks, aerial cables are being replaced with ground cables when legacy copper networks are dismantled, especially in sparsely populated areas. The Finnish Transport and Communications Agency Traficom's regulation on the resilience of communications networks and the regulation of the electrical protection of communications networks define obligations concerning preparedness for and adaption to normally expected climate conditions. Telecommunications operators are obliged to implement measures defined in regulations to protect their networks against possible climate impacts such as power cuts, cooling system failures, cable cuts and damaged hardware, as well as overvoltage and overcurrent of climatic origin, such as lightning strikes. Detailed requirements for communications networks hardware redundancy, reserve routes and the resilience of cooling systems, as well as power supply obligations and the resilience of the power supply, have been defined in the regulations. Provisions on electrical safety, grounding and overvoltage and overcurrent protection have also been provided. The purpose of regulations is to improve reliability and the resilience of communications networks and services in challenging weather conditions and in normal operation, as well as to prevent the communications network causing danger in any expected conditions. Traficom coordinates and monitors telecommunications operators' compliance with obligations.

Tourism and recreation

Finland's Tourism Strategy from 2019 to 2028 and action plan from 2019 to 2023 react to climate change. The strategy states the role of tourism as a cross-sectoral industry and its potential to enhance a shift to cleaner and more sustainable lower-carbon economic growth to minimise the effects of climate change. At the same time, the strategy calls for innovative solutions for sustainable tourism products and experiences. The update of the action plan from 2022 to 2023 is almost finalised.

Finance and insurance

The financial industry in Finland overall considers climate change in its operations and as part of its risk management. Finland's earnings-related pension sector's responsible investments were analysed for the first time in 2021. According to the analysis, 49 per cent of Finnish overall pension assets are invested in alignment with Finland's goal of being carbon neutral in 2035.

An insurance programme for damage caused by exceptional floods was introduced at the end of 2013. The programme replaced the old government-based system and extended the coverage from fluvial to all types of floods. Private insurance companies offer home and property insurance that covers damage caused by exceptional floods and severe weather events. The great majority of households and property owners have this insurance. Between 2018 and 2020, Finnish insurance companies paid EUR 7.2 million in flood compensation. The Flood Centre operated by the Finnish Environment Institute (SYKE) and the Finnish Meteorological Institute (FMI) offers an early warning system for floods, including daily watershed forecasts and online flood warnings, and provides estimates on the exceptionality of flood and weather events.

The Government compensation scheme for crop damage ended at the end of 2015, but some private insurance products that cover risks of extreme weather conditions have since been introduced to the market by private insurance companies. The Government introduced a tax exemption for insurance products covering crop damage, plant pests, and animal health in 2019. The exemption lasts until the end of 2027.

Health and welfare

An increasing number of adaptation measures has been taken to reduce the risk of the adverse health effects of climate change. The Ministry of Social Affairs and Health published a climate change adaptation plan for the social care and healthcare sector in 2021, which recommends adaptation measures in multiple health and welfare fields.

Multiple research projects, funded by the Academy of Finland and the Government's analysis, assessment and research activities, are ongoing in the field of climate change and health, healthcare and adaptation. In these projects, the health effects and questions on adaptation and cross-sectoral impacts in healthcare with ecological healthcare are identified and assessed.

Furthermore, communication and raising risk awareness is becoming an increasingly important part of climate change adaptation. The Finnish Institute for Health and Welfare (THL) communicates on, e.g. slipping accidents, water quality issues, and preparedness for heatwaves and infectious diseases.

THL recently published an overview of the health effects of heat in Finland and the measures taken to mitigate them, as well as recommendations for improving heat preparedness. New information has been produced on the health effects and vulnerable population groups and heat preparedness in the healthcare sector. Research projects are ongoing to provide national guidance on the heat-related burden of disease and the cost-effectiveness of mitigation scenarios. An update to the government decree on housing and health is underway, including a health-based evaluation of the upper-limit values for the indoor temperature during the summer.

The main effort to prevent water-borne epidemics in future has been the recent implementation of the Drinking Water Directive[44] on the quality of water intended for human consumption, which aims to ensure healthy drinking water. Additionally, water epidemics are monitored by a municipal investigation team in the event of an epidemic, and water epidemics are reported to the reporting system for food and waterborne epidemics.

6.7 International cooperation on adaptation

Climate resilience is one of the crosscutting objectives of Finland's development policy and development cooperation. The aim is to enhance climate change adaptation, reduce vulnerability, and strengthen the resilience of people, ecosystems and societies to climate risks and the impacts of climate change. The integration of the crosscutting objectives in all development cooperation activities is a binding obligation, either through mainstreaming or targeted action. In addition, climate change and natural resources is one of the priority areas of the Development Policy of Finland (2016) under which climate-change-related support is outlined more broadly. Finland promotes low carbon development and the capacity of its partner countries to adapt to climate change advancing the integration of these goals into partner countries' own development planning. Particular attention is paid to the roles people in vulnerable positions play in adapting to and combating climate change.

Moreover, the human and economic losses caused by natural disasters are a major obstacle to development. Finland supports long-term measures that reduce the vulnerability of people and communities to natural disasters. Strengthening the capacity of developing countries' own administrations to prepare for natural disasters and investing in disaster risk reduction is a necessity (see Section 8.4 for capacity building programmes in developing countries). Internationally, Finland is a forerunner in building resilience to weather- and climate-related disasters, having financed the improvement of the weather and climate services of more than 50 national meteorological and hydrological services (NMHS) around the world in the past decade.

Recognition of the cross-border impacts of climate change is an additional justification for international cooperation to address the consequences of

44 (EU) 2020/2184

climate change wherever significant adverse impacts occur. Several different cross-border impact chains have been identified for Finland, concerning trade, infrastructure, finance and insurance, human mobility, ecosystems, geopolitics and cognitive changes (see Section 6.4. in Finland's NC7). Some of the effects are also discussed in the sectoral sections in this chapter. Recently, the global trade effects, among others, of the covid-19 pandemic and Russia's attack on Ukraine have emphasized the link between adaptation to the climate change and factors unrelated to the climate. As an example, weather-driven crop failures in the main areas of cereal production lead to more serious cross-border effects when the pandemic and the war have reduced availability of production inputs to the agriculture and industry and increased prices. There are also recent and ongoing assessment efforts related to cross-border effects, such as one funded by the Nordic Council of Ministers[45].

The Council of the Baltic Sea States (CBSS) has established an Expert Group on Sustainable Development. The group is made up of officials from relevant ministries of the CBSS Member States. Together, the Expert Group has gained more than 20 years of experience in working on sustainability policies within the Baltic Sea Region through knowledge-sharing, outreach and project work. One aim is to share responsibility and participate in finding sustainable solutions on all levels of the society. Therefore, the Experts Group continuously builds purpose-oriented partnerships, commissioning studies, conducting trainings, facilitating projects and providing policy input to strengthen sustainability practices and climate adaptation processes.

Climate change mitigation and adaptation is one of the four priorities of Finland's Strategy for Arctic Policy adopted by the Government in June 2021. According to the strategy, all activities in the Arctic must be based on the carrying capacity of the natural environment, the protection of the climate, sustainable development principles, and respect for the rights of indigenous populations. International agreements, the cooperation of the Arctic Council and the Barents Euro-Arctic Council, and EU policy programmes will support the development of solutions to halting climate change, safeguarding biodiversity, and addressing other environmental issues in the Arctic.

The Arctic Council's Working Groups produce information on the warming of the Arctic region, the state of biodiversity, and the impacts of climate change on snow, water, ice and permafrost, the acidification of the seas, ecosystems, and land and marine species. Action plans have been prepared to support adaptation, and a framework programme has been drawn up to strengthen resilience. This information has an extensive impact on decision making, both at the level of the Arctic region and globally. In 2017, the Arctic Council adopted a collective aspirational goal of reducing black carbon emissions by between 25 and 33 per

45 Report "Nordic Perspectives on Trans-boundary Climate Risk" in 2022 https://www.norden.org/en/publication/nordic-perspectives-transboundary-climate-risk

cent by 2025. The Arctic Council also works to prevent environmental pollution, forest and grass fires, and marine litter, as well as to improve waste management.

The Barents Euro-Arctic Council has drawn up an Action Plan on Climate Change, which was updated in 2021. Implementation of the Action Plan was launched during the Finnish Chairmanship of the Council between 2021 and 2023. National funding has been granted to support international collaboration and capacity building between practitioners, academics, and civil servants on Arctic adaptation for implementation of Finland's Arctic Strategy and strategies of the Arctic Council and the Barents Euro-Arctic Council. In 2020 and 2021 activities focused on connecting actors from different countries and sharing adaptation knowledge and best practises across countries.

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Heikki Lihavainen, the Finnish Meteorological Institute

7

Financial, technological and capacity-building support

Finland supports developing countries in their efforts to mitigate climate change and adapt to its impacts. This chapter provides information on Finnish financial contributions to the Financial Mechanism of the Convention and to other multilateral funds and programmes as well as on bilateral support to developing countries. In addition, this chapter provides information related to private sector cooperation, and support to technology transfer and capacity building. It also includes information on Kyoto Mechanisms.

7 Financial, technological and capacity-building support

This section aims to give an overview of the financial, technological and capacity-building support to developing country Parties provided by Finland. Financial support provided with exact figures is reported in the CTF Tables 7 for 2019 and 2020 in Annex 2. The provision of technology development and transfer support and capacity-building support is summarised in CTF Tables 8 and 9 in Annex 2.

7.1 Tracking climate finance

Finland uses the “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. As the markers give qualitative rather than quantitative information, there is a need for follow-up work to obtain quantitative results. Depending on whether adaptation or mitigation is the principal or a significant objective, the share usually varies between 10 and 100 per cent. Based on the project document or other relevant documentation from the implementing organisations (e.g. budget information or agreed strategies), the desk officer responsible for the respective intervention gives a value for the markers. For the MDBs, Finland uses a similar approach to that of the OECD when calculating imputed multilateral contributions. To avoid double-counting, an important element of this phase is to ensure that the total sum of all Rio markers does not exceed 100 per cent. The shares of adaptation or mitigation of the core support for multilateral organisations are based on data provided by the organisation on exact thematic budget allocations.

7.2 Climate finance in 2019 and 2020

The overall aim of Finland’s development policy is to reduce poverty and inequality in the context of sustainable development. With its development policy, Finland supports the realisation of human rights, the rules-based multilateral system and the Sustainable Development Goals (SDGs) adopted by the UN. Finland’s international cooperation and actions are grounded in the UNFCCC, Kyoto Protocol and the Paris Agreement on Climate Change and the goals of the 2030 Agenda for Sustainable Development. The cross-cutting objectives that Finland promotes through its development policy include gender equality, non-discrimination, climate resilience and low emission development, as well as protection of the environment, with an emphasis on safeguarding biodiversity. The integration of climate change has been one of the cross-cutting objectives of Finland’s development policy and development cooperation since 2012. Overall, Finland's development cooperation aims to strengthen developing countries' own capacities and resilience.

Finland takes a long-term perspective on development cooperation. The Government Report on Development Policy across Parliamentary Terms confirms Finland's commitment to long-term development policy. A parliamentary monitoring group representing all parliamentary parties participated in the preparation of the report, which was adopted by the Government in 2021 and approved by Parliament in 2022. The report confirms Finland's aim to provide long-term support for climate change mitigation and adaptation, development that is low in emissions and climate-resilient, and biodiversity protection.

Finland's development cooperation focuses on a limited number of priorities building on its values and strength. "Climate change, biodiversity and sustainable management and use of natural resources" is one of them. It emphasises the strengthening of adaptation alongside the mitigation of climate change, food security, water and energy, meteorology and disaster risk prevention, forests and safeguarding biodiversity.

Finland's contribution to international climate finance is channelled as part of financing allocated for development cooperation. Financing is continued in a way that takes Finland's international obligations into account, and that targets resources equally to both mitigation of and adaptation to climate change. In 2019, Finland's development aid disbursements were EUR 1,010 million[1], which was 0.41 per cent of gross national income (GNI). The Official Development Assistance (ODA) figures for 2020, which is the final year in this report, amounted to EUR 1,121 million[2] (0.47% of GNI).

After the Copenhagen fast-start finance pledge, Finland decided to use 2009 as a baseline for defining new and additional funding. The Finnish fast-start finance commitment of EUR 110 million was implemented through a net increase of Finnish funding directly allocated to developing countries' climate activities in 2010 to 2012 compared to 2009. The baseline figure for overall Finnish climate funding (as grants) in 2009 was approximately EUR 26.8 million. While the fast-start finance period is now over, the international public climate finance that Finland has provided has continued to be higher than in the base year used for fast-start finance. The total allocations were about EUR 147 million in 2019 and EUR 131 million in 2020 Annex 2, Tables 7. Total climate finance allocations are projected to increase, even though there was a slight decrease in 2020 compared to the record figure of 2019. The division between mitigation and adaptation support varies according to year, but Finland aims for balance. In 2019, the division was 64

1 1 USD = EUR 0.8933 (2019)
2 1 USD = EUR 0.8775 (2020)

per cent for mitigation and 36 per cent for adaptation, and in 2020, 59 per cent for mitigation and 41 per cent for adaptation.

Besides providing funds to the operating entities of the financial mechanism of the UNFCCC, Finland provides support through bilateral, regional and other multilateral channels. Funding is directed at both climate change mitigation and adaptation. In addition to grant funding, Finland uses investment-based and loan-based funding to effectively accelerate private sector investment in climate solutions. Research, cooperation with universities, and inter-institutional cooperation are also supported to strenghten national capacity building in developing countries (see also Section 8.4). Most Finnish climate finance is provided through multilateral channels (Annex 2, tables 7).

Finland's development cooperation especially supports the least developed, fragile or conflict-prone countries, taking into account situations where climate change and other serious development challenges are slowing down the achievement of sustainable development goals. The priority for Finland's climate finance is to support the least developed countries and small island developing states, as they are particularly vulnerable to the impacts of climate change. This approach is taken into account when any new funding opportunities are considered. For example, Finland is a long-term funder of the Least Developed Countries Fund (LDCF), which helps least developed countries build resilience and reduce vulnerability to climate change. In 2020, Finland contributed EUR seven million to the LDCF (Annex 2, Table 7a). In addition, in late 2020, Finland joined CREWS[3] (the Climate Risk and Early Warning Systems Initiative) as a funder. This is a mechanism that funds Least Developed Countries (LDC) and Small Island Developing States (SIDS) for risk informed early warning services to better equip them to forecast and respond to climate risks.

Finland's development cooperation is based on the development needs defined by the partner countries and their own development plans. The objective is to strengthen developing countries' own carrying capacity. Accordingly, Finland's resources are especially directed at bringing about system-level changes that strengthen the opportunities and ability of the partner country and its society and communities to respond better and more sustainably to the country's own economy and wellbeing.

Similarly, in climate finance, Finland's support is based on developing country ownership and national plans, which, however, must be in line with internationally agreed development goals and values such as the Paris Agreement and Sustainable Development Goals. Most Finnish climate finance is channelled through multilateral funds and organisations. In 2019, the top receivers of Finland's climate finance were the Finland-IFC Blended Finance Climate Program, the Green Climate Fund and the Asian Development

3 https://www.crews-initiative.org/en

Bank (Annex 2, Table 7a). Many of these support climate-resilient and low emissions pathways, e.g. development and implementation of NDCs and NAPs in developing countries. One example is the GCF and its Readiness and Preparatory Support programme, which finances the formulation and implementation of NDCs and NAPs.

7.3 Multilateral assistance

UN agencies, development finance institutions and multilateral climate funds play an important role in the mitigation of and adaptation to climate change. Finland defends the multilateral system and international law, recognises the significant results obtained through multilateral cooperation, and thus sees this system as one of the most important climate action. A large part of Finland's international climate finance is therefore channelled through multilateral organisations and funds. The strengths of multilateral cooperation are its wider coordination of climate finance and larger common funding base, which also has great potential for effectiveness. Finland works with other likeminded countries from its various constituencies to influence the full Paris-alignment of the strategies and operations of the multilateral development banks and funds.

As a party to international climate agreements, Finland supports the official financing mechanisms under which developed countries finance climate action in developing countries in accordance with the objectives of the climate agreements. Of the official financing mechanisms for international climate agreements, Finland financed the Global Environment Facility (GEF), the Least Developed Countries Fund (LDCF) and the Green Climate Fund (GCF) in 2019 and 2020.

Finland supports other multilateral climate funds with their own specific purposes. These include the Climate Risks and Early Warning Systems initiative, which supports the development of early warning systems and meteorological capacities in the Least Developed Countries and Small Island Developing States and the Partnership for Market Implementation managed by the World Bank, which supports the readiness and implementation of carbon pricing in developing countries. During the reporting period, Finland has contributed EUR five million to each of these funds. In addition, Finland invested EUR 46 million in a bilateral climate fund established with the International Finance Corporation (IFC) in 2019. This was part of a EUR 114 million investment in the Fund between 2017 and 2019. The Finland-IFC climate fund invests in large climate mitigation projects especially in least developed, low-income and lower-middle-income countries globally. Finland also invested EUR 20 million in the Asian Development Bank's Ventures Investment Fund in 2020. The Fund focuses on combating climate change and improving adaptation to climate change by investing capital in start-up and growth companies in Southeast and South Asia that aim to develop and scale up new climate solutions technology.

Finland contributes to a holistic view of climate change and biodiversity in terms of both challenges and solutions (for example, an ecosystem-based approach or nature-based solutions). Finland's biodiversity funding is primarily channelled through the Global Environment Facility (GEF), which is the funding mechanism for the UN Convention on Biological Diversity and has targets for climate change mitigation.

7.4 Bilateral, regional and other channels

The bilateral cooperation in long-term partner countries is based on country programmes that are prepared in collaboration with partners and that build on national development plans. The main sectors for climate-related cooperation, especially with public sector counterparts, include energy, forestry, natural resource management, water and sanitation and meteorology.

The forest projects implemented in Tanzania aim principally to increase forest-based livelihoods and employment but also provide significant climate benefits (mitigation and/or adaptation). Likewise, the projects focusing on water, sanitation and hygiene (WASH) in Nepal, Kenya and Ethiopia also include measures for climate change adaptation. In the energy sector, the regional energy and environment partnerships in the Mekong and in Southern and Eastern Africa support energy access through renewable sources, providing also significant mitigation benefits.

Meteorological cooperation is one of the priority areas of Finland's development cooperation and an important part of Finland's adaptation finance. This cooperation includes weather observation infrastructure and equipment, weather forecast and warning systems and software, technical assistance and capacity building, delivered by private and public sector actors and civil society organisations to develop weather, climate and early warning services (see also Sections 6.3.5 and 6.4).

The national Development Finance Institution of Finland, Finnfund, plays a key role in financing private-sector climate mitigation and adaptation projects in all developing countries and especially in the least developed and lower-middle-income countries. Finnfund makes new investments worth approximately EUR 200 to 250 million per year, with the aim of allocating at least 50 per cent of its new investments to climate projects annually. The Government of Finland granted Finnfund new equity worth EUR 70 million during 2019 and 2020 and a EUR 105 million loan earmarked for climate investments in 2019.

Finnish NGOs and their local counterpart organisations also play an important role in supporting local communities in their endeavours to adapt to climate change, as well as in protecting the environment.

7.5 Private finance

The private sector plays a significant role in promoting climate action in developing countries as a developer of new technologies, developer and implementer of projects and financier. The role of the private sector is particularly important in climate mitigation, which requires more innovative, scalable and commercially viable renewable energy and energy efficiency solutions, as well as other ways to avoid and mitigate GHG emissions. Finland therefore offers different types of funding and services for the private sector on climate, ranging from large scale climate investments to small grants that help develop climate projects and get them started.

Finland has used investment-based and loan-based climate finance since 2016 to complement traditional grant-based climate finance. According to the current Government of Finland policies, 75 per cent of the investment- and loan-based ODA finance must be allocated to climate action. Besides concrete climate mitigation and adaptation targets, one of the objectives of this investment finance is to leverage large amounts of other financing, especially private sector financing, for climate projects. Most of the investments made by the Government of Finland have been targeted at the special climate-focused funds and activities of the international financial organisations (IFIs). They produce and share data on the overall leveraged amount of financing for climate funds and projects, but despite constant requests, not all of them separately report to donors the amount of leveraged private financing of the total leveraged amount of financing. Finland continues to advocate more accurate and transparent data on leveraged private sector financing figures from IFIs.

7.6 Technology development and transfer

Finland has specific programmes and financial arrangements for transferring environmentally sound technology to developing countries thus enhancing access to it (examples in Annex 2, Tables 8 and 9). These activities comprise the transfer of both “soft” technology such as capacity building, creating information networks, and enhancing training and research and “hard” technology, that is, technology to control greenhouse gas emissions and for adaptation measures. The differences between these types of technologies are not always clear, and some activities have characteristics of both.

Many climate funds which Finland supports provide funding for technology transfer among other project types. These could be installation of renewable energy equipment in new areas or grey technology for adaptation, such as flood walls. However, it is rarely reported separately in their project portfolios.

Finland is a global leader in weather observation technology and systems. Over the years, Finland has transferred technology related to weather observation and climate services through bilateral and regional cooperation and concessional credit arrangements (see Table 7.1 for an example and Sections 8.3.5 and 8.4 for more details).

Table 7.1
Description of selected projects or programmes that promoted practicable steps to facilitate and/or finance the transfer of or access to environmentally-sound technologies

Project/programme title:
Upgrading the rainfall, storm and lightning detection capabilities of the national hydrometeorological service, Vietnam

Purpose: To strengthen the capacity of Vietnam's hydrometeorological service

Recipient Countries	Sector	Total Funding	Years in operation
Vietnam	Meteorology	Grant approximately EUR 12.4m	2017 to 2020 (*disbursements for the interest subsidy ongoing)

Description:
The goal of the project was to strengthen the capability of Vietnam to mitigate the adverse impacts of climate change and weather, thus providing safer living conditions, decreased economic losses, and improved overall preparedness for civil crisis management. In this project, a world-class meteorological monitoring infrastructure was established in Vietnam, specifically targeting the remote monitoring capabilities of rainfall and tropical storms. The project consisted of an upgrade of the current weather radar observation network adding five new weather radars and upgrading three existing weather radars, and also establishing a lightning detection network. In addition to modern observation infrastructure, the project included the installation and commissioning of the meteorological data visualization and automated forecast production system, SmartMet, from Finnish Meteorological Institute (FMI).

Factors which led to the project/programme's success:
High-quality products and extensive technical assistance and capacity-building by the Vaisala corporation throughout the project phases, plus extensive capacity-building by the Finnish Meteorological Institute (FMI). Counterpart funding from the partner / host country for infrastructural works including for example establishment of data communication for equipment and road access to installation sites.
Continued support and capacity-building by the FMI through the ongoing Institutional Cooperation Instrument (ICI) project (2019- ongoing).

Technology transferred:
Weather radars, lightning detection system, weather radar and lightning central site servers and application software, meteorological data visualization and automated forecast production system (SmartMet).

7.7 Capacity building

Finland supports capacity building through its climate finance to developing countries in several types of projects. Most of the Finnish bilateral projects that have a climate-related objective as their principal or significant objective also include a capacity-building component as a response to existing and emerging capacity-building needs in our partner countries. Finland also supports several multilateral climate funds (such as GCF, GEF, LDCF, CREWS and the World Bank's Partnership for Market Implementation), which include a strong capacity-building component in their activities. This can be in the form of capacity building for developing country stakeholders for developing mitigation and/or adaptation projects to apply for funding or capacity development in a specific climate change theme.

For example, Finland is one of the world leaders as a donor in supporting the capacity building of non-Annex I partner countries' national meteorological and hydrological services (NMHS). During the reporting period, capacity support programmes for hydro-meteorological institutions were ongoing in Africa and Asia. The main instrument for channelling funds for hydrometeorological cooperation is the Institutional Cooperation Instrument (ICI). Other channels for funding capacity building include Higher Education Institutions Institutional Cooperation Instrument (HEI-ICI) and the Academy Programme for Development Research (DEVELOP). Detailed information about these funding instruments and the capacity building projects is provided in Chapter 8.4. and in Annex 2, table 9.

Since 2004, Finland has funded an international course on environmental law and diplomacy. The support is also expected to continue in the coming years. This "Course on Multilateral Environmental Agreements" is organised annually by the University of Eastern Finland in cooperation with the UNEP and partners in developing countries. The course transfers experience in the field of international environmental law to current and future negotiators of multilateral environmental agreements (MEAs), including the UNFCCC. In addition to teaching environmental law, the course aims to foster contacts between developing and industrialised countries and thus support international environmental negotiations. Due to the Covid-19 pandemic, it was impossible to organise the course in 2020, and the course was held in virtual format in 2021.

7.8 Kyoto Mechanisms

Finland's Kyoto mechanism purchase programme covered the period from 2006 to 2020. The total budget for the acquisition of emissions reductions from the Kyoto Protocol flexible mechanisms was approximately EUR 70 million. Approximately EUR 20 million was invested during the CDM/JI pilot programme, which was in operation from 1999 until early 2006. The rest was allocated between 2005 and 2012.

Finland committed about EUR 12.2 million through ten bilateral projects for the purchase of project units during the prompt start phase and the first commitment period of the Kyoto Protocol. Two of these projects also continued to generate units after 2012. As part of its purchase programme, Finland also invested in multilateral carbon funds. USD 10 million was invested in the World Bank's Prototype Carbon Fund (PCF), EUR 4.25 million in the Nordic Environmental Financing Corporation's (NEFCO) Testing Ground Facility (TGF), EUR 10 million in the European Bank for Reconstruction and Development's Multilateral Carbon Credit Fund (MCCF), USD 25 million in the Asian Development Bank's Asia Pacific Carbon Fund, EUR 3 million in the Nordic Environment Finance Corporation's NEFCO Carbon Fund, and USD 20 million in the Asian Development Bank's Future Carbon Fund. Of these funds, the Asian Development Bank's Future Carbon Fund continued to generate a small amount of units between 2013 and 2020.

Photo: IStock.com

8

Research and systematic observation

This chapter describes Finnish research on climate change and systematic observation systems. Policies, framework and financing of the research, international research cooperation and major research programmes and research organisations are presented. Studies on climate processes and systems, climatic modelling and prediction, research that supports the greenhouse gas inventory as well as research on impacts, mitigation and adaptation are also covered. Atmospheric, ocean, terrestrial and cryosphere climate observing systems are portrayed. In the end of the chapter there is a summary of the Finnish contribution to capacity building in developing countries, supplementing reporting in Chapter 7.

8 Research and systematic observation

8.1 General policy on research

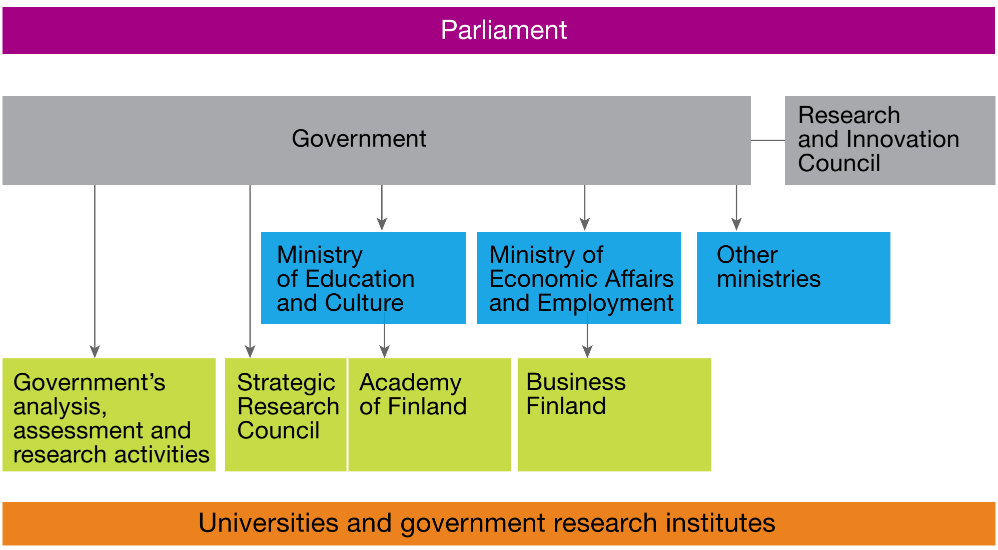
8.1.1 Domestic activities

In 2020, Finland's research and development (R&D) expenditure was EUR 6,930 million, or 2.94 per cent of the country's gross domestic product. It is a higher percentage than the average among the OECD and European Union countries. The national R&D expenditure has been rising since 2016. In 2020, 67 per cent of the R&D expenditure was in the private sector, around eight per cent in the public sector and around 25 per cent in the higher education sector. Funding of systematic observations is discussed in Section 8.3.

Regarding financing of public sector R&D, 46 per cent was financed from central government budget funds. The budget funding of this share increased by two percentage points compared to 2019. Research organisations' own finances accounted for seven per cent. The architecture of public research funding is described in Figure 8.1. The distribution of public R&D funding in 2020 is presented in Figure 8.2.

In 2020, a total of 80,560 people worked in R&D positions, of whom 52 per cent worked in companies, 39 per cent in higher education institutions, and nine per cent in the public sector.

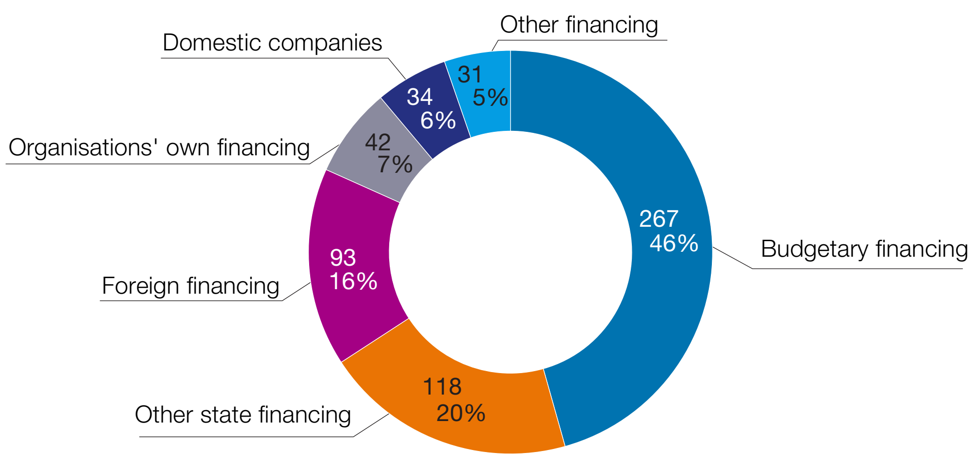
Figure 8.1
Public research funding architecture.



The Research and Innovation Council, chaired by the Prime Minister, supports the Government in developing and combining visionary science, technology and innovation (STI) policy. The Academy of Finland is an expert organisation in science and research within the administrative branch of the Finnish Ministry of Education, Science and Culture. It funds high-quality scientific research (EUR 469[1] million in 2020[2]). The Strategic Research Council (SRC) established within the Academy of Finland funds high-quality research of great societal relevance and impact (EUR 55 million in 2020). Business Finland is a business operator consisting of a financing centre providing internationalisation and financing services and a company carrying out customer activities. Business Finland offers funding services for research groups that cooperate with companies or want to build their research into a new business and commercialise ideas (research funding of EUR 89 million in 2020)[3]. The Ministries' joint analysis, assessment and research activities (VNTEAS), coordinated by the Government, generate information that supports decision making, working practices and management by knowledge (annual funding approximately EUR 10 million).

Climate change has been recognised as an important topical subject in Finnish research policy for decades. Climate change research policies are cooperatively implemented by several ministries, and climate change continues to be a priority area in many research programmes and projects (see Section 8.2 for details). Large cross-sectoral climate change programmes have aimed to increase understanding of the scientific basis of climate change, as well as the impacts and options for mitigation and adaptation, including the addressing of environmental and socioeconomic questions. Research in general has been partly shifted to concern larger views and to promote knowledge-based decision making and management. In addition, the cross-cutting nature of climate change has been integrated into many environmental, sectoral and technology research programmes and projects.

Figure 8.2
Public research financing in Finland in 2020 (EUR million; per cent)



1 The sum also including Strategic Research Council's 55 million, mentioned below.

2 By Statistics Finland. Note that there was a lot of temporary funding in the budget in 2020 because of the Covid-19 pandemic, for example.

3 https://tietopankki.businessfinland.fi/anonymous/extensions/MyonnettyRahoitus/MyonnettyRahoitus.html

Finland's Government Programme (2019) strongly includes aspects of climate change and climate policy. For example, it mentions that "Climate change, declining biodiversity and the overconsumption of natural resources are among the most critical issues facing humanity". Measures in the Programme include new climate policy decisions and nearly emission-free electricity and heat production by the end of the 2030s, reducing the carbon footprint of construction, and promoting the circular economy and climate-friendly food policy. In addition, the focus of taxation will be shifted to the taxation of environmental damage.

The instrument of the Government's annual plans for joint analysis, assessment, and research activities generates information that supports decision making, working practices, and management by knowledge. Climate change related research subjects have been on the plan since its presence from 2014. Subjects are clearly linked to the information needs and topics in the Government's decision-making processes.

There has been increasing interest in research infrastructures in Finland in recent years, and more competitive funding has become available. The Academy of Finland coordinates national research infrastructure investments. It also participates in European and international research infrastructures. The role of research infrastructures in the green and digital transitions has been recognised. Indeed, responsibility and sustainable development, as well as digital platforms and data, have been named among the six strategic development areas identified in the Strategy for National Research Infrastructures, 2020 to 2030[4]. The Integrated Carbon Observation System (ICOS) research infrastructure has been headquartered in Finland since 2014. Finland is also leading the implementation of the ESFRI[5] landmark Aerosols, Clouds and Trace gases Research Infrastructure (ACTRIS). ACTRIS will be coordinated from Finland. See Section 8.1.2 for more information.

Another of the six strategic development areas identified in the Strategy for National Research Infrastructures 2020 to 2030, is open access and collaboration. This, with the objective of digital platforms and data (mentioned in Chapter 8.1.1), seeks to advance the openness and accessibility of research infrastructure services and of data produced with research infrastructures. Research Infrastructures are expected to have a publicly available Data Management Policy that outlines the location and accessibility of data.

Open science is one of the spearheads of Finnish science policy, and it is promoted throughout the scientific community (see example in Box 8.1). Universities, state research institutes and other important higher education institutions and organisations have committed to the Declaration for Open

4 Strategy for National Research Infrastructures in Finland, 2020 to 2030 https://www.aka.fi/globalassets/1-tutkimusrahoitus/4-ohjelmat-ja-muut-rahoitusmuodot/4-tutkimusinfrastruktuurit/aka_tik_strategia_2019_en_digi_a.pdf

5 EU's European Strategy Forum on Research Infrastructures

Science and Research, 2020 to 2025 to improve the openness of science and research. The missions of the Declaration seek to promote openness as a fundamental value throughout the research community and its activities, strengthen the societal knowledge base and innovation, and improve the quality of scientific and artistic research outputs, and the educational resources based on them, and the fluid mobility and impact of research outputs throughout society. The promotion of open science is tightly linked to developing responsible practices for researcher evaluation in Finland. In addition to the open science policy within the country, Finland has been operating extensive capacity building programmes to promote the free and open exchange of information and expertise, as well as to support endogenous capacities and capabilities in developing countries. The capacity building programmes have focused on climate observations, research, higher education cooperation relevant to climate change mitigation and adaptation, and the sustainable use of forests (see Section 8.4). Free and open international exchange of data and information has been further promoted by participation in several international research programmes, networks and data collection schemes, and databases (see Chapters 8.1.2, 8.2, and 8.3).

The Active Open science policy is a tool to overcome barriers to the free and open international exchange of data and information. Publishing research results in peer-reviewed international journals is advocated in all fields of research. Open Access (OA) has steadily gained ground in Finland. In 2020, more than 70 per cent of peer-reviewed scientific articles written in Finland were OA publications. Finnish Scholarly Journals Online has become the main platform and service for Finnish OA journals. FinELib funds various international publishing platforms that support OA and/or pre-prints. Domestic research data services support all disciplines and research organisations in opening their data when possible. Finnish research organisations participate attentively in developing the European Open Science Cloud. Finland has invested heavily in developing and maintaining both local and international research infrastructures for environment and climate research. The final reports of research projects funded by the Academy of Finland show that researchers on environmental sciences especially have adopted open data and metadata as everyday practices in their research processes.

The "avoindata" (open data) portal[6] provides direct links to the available open data sources throughout Finland, including research institutes, national authorities, regional councils, and municipalities (see also Box 8.1).

6 https://www.avoindata.fi/data/en_GB/dataset

Box 8.1
Open Datasets Example

As an example of realising the open science objectives, the Finnish Meteorological Institute (FMI) and the Finnish Environment Institute (SYKE) have set up online services that make it possible to search for, browse, and download the Institutes' datasets in machine-readable format free of charge. The technical implementation of the online services complies with the requirements laid down in the INSPIRE Directive (2007/2/EC) for the Member States of the European Union, and the content of the service is wider than that defined in the Directive. The INSPIRE Directive requires that Member States ensure that metadata are created for the spatial datasets and the services that are needed for the establishment of the Infrastructure for Spatial Information within the European Community; this needs to be done for the purposes of Community environmental policies or activities that may have an impact on the environment. The climate and weather-related data of FMI and SYKE, including information on floods and ecosystem change, are utilised in various economic sectors in Finland, e.g. transport, natural resource management, energy, IT, and education. Access to available sources can be gained through the dedicated www pages http://www.syke.fi/opendata and https://en.ilmatieteenlaitos.fi/open-data-manual or the general portal https://www.avoindata.fi/data/en_GB/dataset.

Communication on new research information to decision makers, other stakeholders, and the general public is very important (see also Chapter 9). The Finnish Climate Change Panel was nominated by the Ministry of the Environment for the first time in 2011 to enhance science policy interaction between climate and energy policy, as well as public discussion. The Finnish Climate Change Panel has been an active knowledge producer and partner in the field (Box 8.2). Furthermore, several recent initiatives have fostered engagement between societal actors and research to contribute to policy needs (Box 8.3).

Box 8.2
The Finnish Climate Change Panel

The Finnish Climate Change Panel is an independent advisory council of top-level Finnish scholars that promotes dialogue between science and policymaking. The Panel provides scientific advice for policymaking and reinforces interdisciplinary insight in the climate action of various sectors. The Panel is tasked with assessing climate policy documents and the sufficiency of the implemented measures to respond to the challenges of climate change. The Panel produces reports to support the preparation and implementation of climate policy and legislation in Finland.

In recent years, the Panel has been advising the Finnish government on the EU Fit for 55 package. It has focused on key issues in advancing climate action in Finland to meet the 2035 greenhouse gas neutrality target – the problem of continuous peat and peatlands use, what needs to be considered for electrification and sector integration, and how to assess and measure climate adaptation. The Panel is also in the process of producing criteria to facilitate evaluation of climate policy justice in decision-making. The Panel has also focused on working more closely with climate advisory councils around the world.

According to the Finnish Science Barometer 2019[7], the public's expectations are optimistic on science and the worldview. Science is believed to be the answer to many important issues. For example, the barometer argument that "the progress of climate change is a real and serious threat, which requires efficient action from political decision-makers" is supported by a majority (73 per cent). The percentage decreased from to 2016 by nine percentage points. The percentage of those who disagree has increased between 2016 and 2019 from six to 14 per cent. Although the mitigation of climate change is seen as a relatively difficult task, optimism about the solutions is relatively high. About 50 per cent of the respondents thought that science has very good or fairly good abilities to provide solutions, which is, however, less than the confidence in the ability to solve energy issues, for which the corresponding figure was nearly 70 per cent. The high confidence may reflect the fact that media coverage of climate issues and solutions has remained at a high level.

Box 8.3
Interaction and Cooperation as Cornerstones of Impactful Research

A major development in the field of research is the increasing emphasis on societal impact and interaction with various societal stakeholders. It has become broadly accepted that the urgency of complex societal challenges such as climate change requires closer interaction between researchers and decision makers. Several initiatives have fostered engagement between societal actors and research to contribute to policy needs.

The Strategic Research Council (SRC) is one of the new key science policy measures on this front (see 8.2.1). Every project funded by the SRC includes resources specifically devoted to interaction with society, and the programmes that specify the topics of projects to be funded focus on developing interaction with societal stakeholders. In addition, the creation of the Government's analysis, assessment, and research activities (VNTEAS) funds research that serves policy needs as defined by the Ministries. Research on climate change has been one of the focal areas for both SRC and VNTEAS (see 8.2.1). Furthermore, research institutes and universities are

7 http://www.tieteentiedotus.fi/files/Tiedebarometri_2019.pdf (in Finnish) http://www.tieteentiedotus.fi/files/Sciencebarometer_2019_23122019.pdf (in English)

increasingly paying attention to social interaction, including collaboration with industry and businesses and in other partnerships such as doctoral training.

A novel initiative in research communication has been “Sofi – Science Advice Initiative of Finland”. This development project (2019 to 2021) aimed to build a permanent science policy platform and promote interaction and dialogue between researchers and decision makers. Climate change was one of the topics addressed. The Sofi project was initiated by the four Finnish science academies and funded by the Ministry of Education and Culture. The Sofi project was carried out in close collaboration with universities and research institutes and other stakeholders and included workshops and training for researchers. From 2022 onwards, Sofi’s activities will be continued under the Finnish Academy of Science and Letters.

The science policy interface has also been strengthened in legislative processes to address climate change. The Ministry of the Environment has therefore published a guide on the assessment of climate impacts in legislative proposals. It is distributed as general guidance for improving the quality of the mandatory impact assessment of legislative proposals.

In 2021, the Ministry of Education and Culture, the Academy of Finland, and the Federation of Finnish Learned Societies conducted a joint initiative, “The Year of Research-Based Knowledge”. The initiative aimed to increase awareness of research and the importance of research-based knowledge among the general public, decision makers, and the private sector. One of the core aims was to increase the visibility and accessibility of different sources of knowledge (e.g. statistics, reports, and analyses) and highlighting the fundamental nature of science and knowledge, i.e. that knowledge is constantly updated and re-evaluated as new research results emerge. The Year was an open initiative: around 20 events were devoted to climate change or energy issues, but many more addressed related topics such as the transformation of the food system. Altogether, more than 400 events or other activities by 382 different actors (e.g. higher education institutes, research organisations, the administration sector, museums, and associations) were implemented as part of the Year.

There are also many other initiatives and actors in the field. Some are more recent; some are well established. The Forum for Environmental Information is an exemplary well-established non-profit organisation in the field of environmental research that focuses on transferring scientific information to national policymaking and advances the interaction between researchers and the users of information. It organises seminars, workshops, and other events concerning timely environmental questions. It is funded by the Nessling and Kone foundations (see also Foundations in Section 8.2.1).

8.1.2 International activities

Finnish researchers have collaborated actively with the international research community in the form of joint projects and programmes. Finland has participated in international programmes such as World Climate Research Programme (WCRP).

These have included many Finnish research projects funded by the Academy of Finland and other funding organisations. Key partners in Finnish climate research include the other Nordic countries, the United Kingdom, Germany and the United States.

Finland has built up an archive of systematic atmospheric, oceanic, and terrestrial observations based on the regulations of corresponding international organisations. Finland is participating in the World Weather Watch at an operational level through the synoptic network of surface and upper-air stations, as well as in the Global Atmosphere Watch.

Finland has actively participated in the work of the Intergovernmental Panel on Climate Change (IPCC). Several experts from Finland served as authors for the Working Group reports and the Special reports of the IPCC Sixth Assessment Report (AR6), and many more experts participated in the review process. Due to their widespread expertise, for example, in greenhouse gas inventories and land-use issues, Finnish experts have served as authors for the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

In another major effort, Finland is overseeing the implementation of the ICOS (Integrated Carbon Observation System) organisation, which is a European distributed infrastructure for the online in-situ monitoring of greenhouse gases (CO_2, CH_4 and N_2O) necessary for understanding present and future sinks and sources. The ICOS Head Office is in Helsinki. The ICOS puts the GHG observations within the global GCOS (Global Climate Observing System) and GEOSS (The Global Earth Observation System of Systems) networks in Europe into effect, and the data can be used to verify greenhouse gas inventories. The partners of ICOS Finland are the University of Helsinki, the University of Eastern Finland, and the Finnish Meteorological Institute (FMI), with the University of Oulu and the Natural Resources Institute starting as partners in 2022. Finnish funding for the ICOS will be around EUR three million annually during its operational phase (more information on ICOS in Section 8.3.1).

Finland is also leading the implementation and establishment of the ACTRIS (Aerosols, Clouds and Trace gases Research Infrastructure) organisation, which is a European distributed research infrastructure for near-surface monitoring and research on short-lived climate forcers in the atmosphere. These are the other crucial group of components (besides greenhouse gases) for determining the atmospheric component of climate warming. ACTRIS is currently in the implementation phase. ACTRIS links research, education, and innovation to promote data use, technological developments, and demonstrations related to the atmospheric components of aerosols, clouds, and trace gases. The ACTRIS Head Office will be in Helsinki, with a secondary node in Rome. The partners of ACTRIS-Finland are the FMI, the University of Helsinki, the University of Eastern Finland, and Tampere University of Technology. In addition to the Head Office, Finland hosts several National Facilities, and a Data Centre Unit for Cloud Remote Sensing and two calibration nodes on in-situ aerosol particles and trace gases in ACTRIS. Finnish funding for ACTRIS will be around EUR five million annually during its operational phase (ACTRIS is also presented in Section 8.3.1 under atmospheric observations).

Climate change is and has been a very important priority for the Horizon 2020 framework programme and the Horizon Europe funding programme, which is the EU's key funding programme for research and innovation from 2021 to 2027.

Finnish researchers, enterprises, and other actors participated actively in climate-change-related research and innovation activities under the Horizon 2020 framework programme for research and innovation. Between 2016 and 2021, 241 projects with Finnish participant organisations were funded under the Horizon 2020 programme. Of these, a total of 39 projects were led by a Finnish coordinator.

The Technical Research Centre of Finland Ltd (VTT), the Finnish Meteorological Institute (FMI), and the University of Helsinki were involved in the largest number of projects. The total costs of Finnish participants were approximately EUR 237 million, and the total costs of the projects EUR 2,293 million. EU funding from the Horizon 2020 budget for Finnish participants was EUR 188 million, and for those 241 projects a total of EUR 1,899 million.

Horizon Europe's new generation of objective-driven and ambitious partnerships are designed to work in support of agreed EU policy objectives. Partnerships bring the European Commission and private and/or public partners together to address some of Europe's most pressing challenges through concerted research and innovation initiatives. New Partnership models help avoid the duplication of investments and contribute to reducing the fragmentation of the research and innovation landscape in the EU. Examples of new co-funded partnerships directly participating in research and innovation connected with climate change on the verge of being adopted by the European Commission, and in which the Finnish research and innovation funders are involved, are Biodiversity, Blue Economy, and Water4All. The precise amount with which Finnish participants will fund these partnerships will be determined later.

The European Commission also has a completely new approach for how to approach and solve some large societal questions and problems, and climate change is the single most important challenge. The European Commission has created five Missions which will create more impact through mission orientation and citizen participation. Research and innovation will be key to deliver on the Missions, and Horizon Europe will be a critical component for their implementation. Missions will require an entire policy toolbox (regulations, policies, investments, etc.) at European level national and local levels to succeed. The Missions have ambitious goals, and they should deliver concrete results by 2030. From the perspective of fighting climate change, the two main missions are Adaptation to Climate Change, which supports at least 150 European regions and communities in becoming climate resilient, and 100 Climate-Neutral and Smart Cities.

Some Joint Programming Initiatives (JPIs) (such as JPI Climate, FACCE JPI and Water JPI), networks and initiatives (such as Biodiversa, LEAP-Agri, LEAP-RE) connected with climate change remain from the previous funding programme period, existing and functioning alongside the new Horizon Europe partnerships, and they will run for several years in the future. The aim of JPIs is to strengthen research and research funding cooperation in Europe in the interest of addressing specific societal challenges. Finnish researchers have also succeeded in several joint calls of these initiatives. The Academy of Finland's International co-funding activities (related to its Climate Change and Health (CLIHE) research programme) are described in 8.2.1.

The Nordic countries have together committed to ambitious climate goals towards 2050 in terms of developing energy-efficient and low-carbon societies. The Academy of Finland has participated in two Nordic collaborative programmes: the Nordic Green Growth Research and Innovation Programme (2016 to 2020) led by NordForsk, Nordic Innovation, and Nordic Energy Research. They aim to accelerate the transition to a sustainable Nordic society by promoting green economic growth, sustainability, and competitiveness. NordForsk's Nordic Bioeconomy Programme (2015 to 2022) seeks to generate new knowledge about how to promote and advance the transition to a bioeconomy-based society in the Nordic countries.

NKL (the Nordic Working Group for Climate and Air) is a working group under the Nordic Council of Ministers. It continues the work of its predecessors – for example, the NOAK working group – and supports the Nordic countries in their preparations for the UNFCCC climate negotiations. The NKL produces studies for Nordic and international climate negotiators and arranges workshops supporting the negotiations. Finland was the chair of the NKL between 2019 and 2020.

Finland is actively engaged in the work of the Arctic Monitoring and Assessment Programme (AMAP), which is one of the permanent working groups of the Arctic Council. AMAP provides reliable information on the status of and threats to the Arctic environment by collecting monitoring data and assessing levels of pollutants and their effects on the Arctic environment. Monitoring and assessing the impacts of climate change on the Arctic environment is also one of the priority areas. Based on the scientific work, AMAP provides policy-relevant information to support Arctic governments in their efforts to take remedial and preventive actions relating to contaminants and climate change. AMAP publishes scientific assessment reports with summaries for policymakers that serve the scientific community, decision makers and the general public. For example, in 2021, AMAP published the "Arctic Climate Change Update 2021:

Key Trends and Impacts" and "Impacts of Short-Lived Climate Forcers on Arctic Climate, Air Quality and Human Health" reports.

Finland is a member country and currently the chair (for 2021 to 2023) of the Barents Euro-Arctic Council (BEAC), which is a forum for intergovernmental and interregional cooperation in the Barents Region. The Barents Region consists of the 13 northern regions of Finland, Sweden, Norway, and Russia. In Finland, the regions are Lapland, Oulu, and Kainuu. The Action Plan on Climate Change for the Barents Region was adopted in the autumn of 2013. It includes several measures and projects and identifies concrete actions to be carried out by the working group for the BEAC. The BEAC Working Group on Environment (WGE) focuses on the so-called Barents Environmental Hot Spots, where enhanced environmental and cleaner production measures will lead to CO_2 and black carbon emission reductions, among other things. The WGE is also implementing several climate-relevant activities in the Barents Region, such as promoting regional climate strategies, enhancing the network of protected areas, and arranging conferences and projects covering climate change mitigation and adaptation themes. More details on the climate research carried out in the Arctic can be found in Box 8.4.

Capacity building in developing countries related to climate change research and systematic observation is described in Section 8.3.4.

Box 8.4
Climate Research in the Arctic

Arctic Research Policy and Goals

Finland's Strategy for Arctic Policy[8] was updated in 2021 and sets out Finland's key objectives in the Arctic region. Arctic expertise, including livelihoods and leading-edge research, is one of the four priorities the strategy identifies. With respect to research, the policy is to invest in expertise and gain knowledge of northern areas. A diverse array of Arctic research is conducted by higher education institutions and research institutes. Expertise is also possessed by many companies. Arctic research policy is cooperatively implemented by several ministries.

International cooperation is seen as very important. Finland is an active member of the Arctic Council and its Working Groups. For example, Finland has contributed significantly to the Arctic Council's Arctic Monitoring and Assessment Programme, AMAP, and to its recent reports related to climate change.

Arctic Research Funders

Many sectoral ministries are involved in the funding and steering of Arctic research in higher education institutes and research institutes.

8 https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/163247/VN_2021_55.pdf?

The Academy of Finland, as a national research funding agency, funds high-quality scientific research projects. The Academy of Finland is also a stakeholder in Arctic research priorities.

As part of its operations, Business Finland can provide internationalisation and financing services and carry out customer activities related to business activities and opportunities.

Major Arctic Research Initiatives

The Arctic Academy Programme (ARKTIKO, 2014 to 2018) was launched to study the changing factors affecting the development of the Arctic region; the transformation process; and the dynamics of change. The programme contributed to increasing knowledge and strengthening the position of Finnish Arctic research at the top of international rankings. It promoted the identification of novel research paths and therefore new solutions. It also promoted the networking of researchers and cooperation with concurrent international projects. ARKTIKO consisted of 20 national research projects and international collaborative joint research projects.

ARKTIKO especially aimed to strengthen the transdisciplinary and multidisciplinary approach within the field of Arctic research. Specifically, the programme aimed to generate new knowledge and approaches related to the sustainable development of individuals and communities in terms of social life, health, and culture; the sustainable exploitation of Arctic environments and natural resources; and the protection of sensitive Arctic ecosystems and securing the ecosystem services they produce. The Academy of Finland's total funding for the programme was EUR 15.7 million for 2014 to 2018. The results of the ARKTIKO programme will be evaluated soon.

Joint Projects in Arctic Research (funders the Academy of Finland and the Russian Foundation of Basic Research, RFBR) (funding 1.8 million EUR, 2018 to 2020) with the following themes: Changing Arctic climate, changing diseases; Ecosystem adaptation to the rapidly changing Arctic; Information technologies for exploration and geo-monitoring in the Arctic; and Youth's coping strategies in industrial towns in the north.

Arctic Seas Programme. The primary goal of this national programme is to strengthen Finland's reputation as an internationally attractive centre of Arctic expertise.

Universities in Lapland and Oulu strategically prioritise the Arctic region. Most Finnish universities and other academic institutions have research programmes focusing on the Arctic, the North, and cold climate regions.

Arctic Centre. The Arctic Centre conducts internationally recognised and highly regarded multidisciplinary research on the Arctic region. Its emphasis on science communication and on public exhibitions improves the visibility of Finland's Arctic expertise and increases international access to Arctic information.

The Finnish Meteorological Institute's (FMI) research focuses on understanding various climate forcing mechanisms and feedbacks in the Arctic, as well as linkages between the Arctic warming and mid-latitude weather. Processes in the atmospheric boundary layer and snow and atmosphere-sea ice-ocean interactions are studied to improve capabilities to model the weather and climate.

The Finnish Environment Institute SYKE brings expertise in research to various projects in northern areas and in the Arctic Council's work. The Institute's expertise in environmental research jointly focuses on the impacts and scenarios of climate change and ways of securing sustainable development in Arctic areas with other research organisations such as the Natural Resources Institute Luke, which has particular expertise in the use and management of renewable natural resources.

Arctic Research Infrastructure

The several field stations operated by universities and research institutes are bases for field campaigns and long-term follow-up studies with an Arctic focus and in the Arctic area. The long-term continuous measurements provide unique monitoring and research material, e.g. on greenhouse gases, atmospheric aerosols, clouds, and trace gases (by FMI at Pallas, Finland, and Tiksi and Baranova in Russia) and by University of Helsinki at Värriö, Finland. Similarly, operational observations are needed to study feedback processes like polar ozone and Arctic snow.

The Finnish National Satellite Data Centre, located in Sodankylä north of the Arctic Circle, is an excellent location for receiving data from all polar orbiting spacecraft. The centre collaboratively provides Arctic satellite data and products for international research and operational entities.

The Finnish Marine Research Infrastructure (FINMARI) supports polar oceanography and sea ice research, e.g. the ocean and sea ice processes and climate interactions in the polar oceans to support the development and improvement of forecasts and operating models and services.

R/V Aranda is an ice-reinforced research vessel (ice classification Super A1) that mostly operates in the Baltic Sea, but it has also made expeditions to the Arctic Ocean. Finland has a fleet of icebreakers, several of which are multipurpose vessels capable of offshore tasks, including serving as research platforms. Finland also has special infrastructure for large-scale laboratory studies of Arctic conditions. Aalto University operates a large-scale ice tank infrastructure which can produce sea ice at model scales. In addition, there is also a special test facility for icebreakers, operated in Helsinki by a privately owned shipyard.

8.2 Research

8.2.1 Major overarching research programmes and funding organisations

Government's analysis, assessment, and research activities

Since 2014, the Government has adopted an approach based on annual plans for analysis, assessment, and research[9] which underpins policy decision making and steers studies and research towards specific priority areas selected by the Government. The annual resources available for implementing the plan amount to approximately EUR 10 million. Between 2018 and 2021, there have been 17 projects whose various topics were directly related to climate change. The projects have given the required new knowledge for policymaking in the various administrative sectors. The projects have been conducted by many different organisations such as universities, research institutes, and consultants and cumulatively amount to several million euros in research funding.

Academy of Finland's research funding

The Academy of Finland is a science and research organisation within the administrative branch of the Finnish Ministry of Education and Culture. In 2020, it funded high-quality scientific research amounting to EUR 469[10] million and EUR 55 million for its Strategic Research Council (SRC). In addition, it provides expertise in science and science policy and strengthens the position of science and research in Finland. The provision of funding for excellent scientific research is at the core of the Academy of Finland's activities. The research is also expected to have a major scientific and social impact and follow the principles of responsible science.

There has also been a notable increase in research funding for climate-change-related topics between this and the previous reporting period. The Academy of Finland's and the Strategic Research Council's (SRC) funding for climate-change-related research together totalled more than EUR 175 million between 2017 and 2021[11]. Research funding allocated to climate-change-related topics by the Academy of Finland and the Strategic Research Council increased significantly, from more than EUR 95 million to more than EUR 175 million between 2013 and 2016 (four years) and between 2017 and 2021 (five years). The increase is mainly due to strategic research funding since the establishment of the SRC in 2014, especially given that many of the ongoing SRC programmes are related to climate change (see below for more details).

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9 https://vnk.fi/en/government-s-analysis-assessment-and-research-activities

10 The sum also including Strategic Research Council's 55 million, mentioned below.

11 with a narrow keyword analysis and considerably more with a more inclusive analysis

The Academy of Finland's ongoing climate and energy programmes:

- The Climate Change and Health (CLIHE) research programme (funding EUR 9.7 million, duration 2020 to 2023) examines and anticipates the health risks and uncertainties caused by climate change and the social consequences of its health impacts. The programme seeks ways to combat adverse health effects and adapting to climate change. The CLIHE programme also involves international cooperation with the Belmont Forum, in which the Academy of Finland participated with EUR one million for Finnish projects, funding three consortia under the Climate, Environment and Health theme. In addition, the Academy of Finland participated in the EU Joint Programming Initiative "Connecting Climate Knowledge for Europe" (JPI Climate) for EUR 700,000.

- The C1 Value Academy Programme (funding: EUR 6 million, 2020 to 2023) seeks solutions for industrial green chemistry manufacturing from CO_2 emissions. The programme's research fields include synthetic chemistry and catalysis research, process engineering and systemic studies, industrial ecology and biotechnology, as well as modelling based on them.

- The Academy Programme on a biobased economy (BioFuture2025, 2017 to 2025) was launched to support the creation of a new knowledge base and promote major scientific breakthroughs through new ways of doing science. A biobased economy promises solutions that will help curb climate change and excessive natural resource consumption. Funding in the first call totalled EUR 10.3 million euros between 2017 and 2020, after which there has been few international calls that continue the programme, including ForestValue – Innovating Forest-based Bioeconomy ERANET, co-funded for EUR 1.36 million and the ForestValue Joint Call 2021 for EUR 0.75 million.

- There is special funding for system-level research into climate change mitigation and adaptation (funding EUR 10 million, 2021 to 2024) for increasing the impact of the conducted research. The aim is to examine the entirety of several subsystems (e.g. food, transport, energy, community systems) and interdependencies between the systems in terms of mitigation of and/or adaptation to climate change. It is also to provide funding for the pooling of research already carried out and based on this for conducting new research, while increasing the impact of research outside the scientific community.

- The Academy of Finland is also responsible for funding Finland's Antarctic research projects. In accordance with Finland's Antarctic Research Strategy (2014), the funding supports interactive and multidisciplinary research.

In addition, a huge number of research projects in other Academy funding schemes, with no pre-set thematic focus besides research excellency, such as Academy Projects, Postdoctoral Researchers, Academy Research Fellows, Centres of Excellence, research infrastructures and the Finnish Flagship Programme concern climate change (for an overall estimate of the Academy of Finland's and the Strategic Research Council's funding allocated to climate change research, see above). Among them, the Atmosphere and Climate Competence Center (ACCC) Flagship (2020 to 2024, involving 450 researchers) seeks ways to mitigate CO_2 emission sources and reliably verify them and assess the climate neutrality of mitigation measures and air quality management actions. There are also ongoing Centres of Excellence on climate change: Tree Biology (2022 to 2029) and the Virtual Laboratory for Molecular-level Atmospheric Transformations (2022 to 2029), in addition to the recent Centre of Excellence in Atmospheric Science – From Molecular and Biological Processes to the Global Climate (2014 to 2019).

To tackle this multitude of climate change research, the Academy of Finland has recently established the Academy Programme for Climate Change and Carbon Neutrality Research (Climate-Synergy) (no additional research funding, 2022 to 2023). The Climate-Synergy coaction programme pools research on climate change and carbon neutrality funded through various Academy of Finland and Strategic Research Council (SRC) grants, incorporating it into a broad network-based programme. As its name indicates, the Climate-Synergy programme aims to create synergies and strengthen the impact of climate change and carbon neutrality research and promote the utilisation of research in society. Through the programme, the Academy seeks to increase support for high-quality, innovative and high-impact research, promote national and international research cooperation and enhance the societal impact of research in the field.

The Academy of Finland also supports the implementation of Finland's national Recovery and Resilience Plan (RRP) (see Box 8.5), part of the Sustainable Growth Programme for Finland, with EUR 25 million in 2021 to promote the twin digital and green transition. The green and digital transition will support structural changes in the economy and the development of a carbon neutral welfare society through digital solutions. The funding is provided for research that promotes solutions related to carbon neutrality and adaptation to climate change, as well as associated digital technologies. In addition, the competitive funding calls for local and national infrastructures enabled by the Recovery and Resilience Facility are expected to accelerate their twin transition.

The recently finished Academy of Finland Research programmes for climate change and energy include:

- The Arctic Academy Programme (ARKTIKO, 2014 to 2018). See Box 8.3.
- The Academy Programme New Energy (2015 to 2018) harnessed scientific methods to resolve complex issues related to the great energy transition. Several projects, including joint calls with international partners, have received funding from New Energy.

Programmes of the Strategic Research Council

The Strategic Research Council (SRC) is an independent body that was established within the Academy of Finland in 2014. The SRC funds high-quality long-term research of great societal relevance and impact. SRC-funded research seeks concrete solutions to grand societal challenges that require multidisciplinary approaches. An important element of the strategic research is active and ongoing collaboration between producers and users of knowledge throughout the project cycle.

Each year, the SRC prepares a proposal on key strategic research themes for the next SRC programmes to be decided by the Finnish Government. SRC funding combines bottom-up and top-down elements in a rather unique manner: the SRC formulates the theme proposal through an interactive participatory process with the scientific community and knowledge users. Through the theme decision, the Government determines the research needs for the next strategic research programmes. The SRC then formulates the programmes and opens the funding calls. Although the calls are thematic, they leave it to research consortia to define what multidisciplinary approach to take to tackle the societal challenge in question. SRC programmes typically run for six years. The SRC's annual funding budget is more than EUR 55 million.

The Strategic Research Council's (SRC) ongoing programmes relevant to climate change are the following:

- Adaptation and Resilience for Sustainable Growth (ADAPT) (funding EUR 34.4 million, 2018 to 2023). The aim of the programme is to identify the best ways of supporting comprehensive resilience through using the resources of society, communities and individuals and through new ways of combining these resources. Research is also needed to identify obstacles to adaptation, such as institutional path dependencies and social and cultural practices and to develop solutions to eliminate such obstacles.

- The Towards a Sustainable, Healthy and Climate-Neutral Food System (FOOD) (funding: estimated EUR 21.3 million, 2019 to 2025) programme seeks a solution for moving towards a sustainable, healthy and climate-neutral food system. Here, "food system" refers to the complex web of multilevel connections that tie together individuals, organisations, technology, and the environment, other production factors such as infrastructure, energy, fertilisers and pesticides, and biodiversity.

- The Climate Change and Humans (CLIMATE) (funding: estimated EUR 27.2 million, 2020 to 2026) programme seeks solutions to how people can make and implement their decisions related to mitigating or adapting to climate change, and how society can facilitate this decision making sustainably and equitably.

In addition, several ongoing Strategic Research Council (SRC) programmes (2018 to 2027) include research consortia relevant to climate change. These programmes encompass themes such as the sustainable use of resources by societies, communities and individuals, the halting of biodiversity loss with research-informed solutions, and steering social development. The recently finished Strategic Research Council (SRC) programmes (2015 to 2021) with similarly relevant research consortia included topics such as energy transition and renewable energy, the use of forest resources, the circular economy of non-renewable substances, resource-efficient food production, climate and resource scenarios in relation to security risks, urbanisation, and information requirements for decision making at various levels of society.

Box 8.5
Rescue and Resilience Funding also Boosted Green Research

The Rescue and Resilience Plan (RRP), including an RDI funding package, supported the green transition with EUR 192 million. Finland's RRP intended to accelerate green transition solutions to facilitate significant reductions in greenhouse gas emissions in Finland to support the national carbon neutrality target. This has also boosted green research. The green transition will require robust expertise and related investments and the design and delivery of key technologies for the low-carbon circular economy and the green transition through research, partnerships and corporate investment.

The plan also supports the green transition through investments of EUR 319 million in the decarbonisation of the energy sector, namely in energy transmission and distribution and in new energy technologies. Furthermore, EUR 156 million will be invested in low-carbon hydrogen, as well as in carbon capture, storage and recovery. In addition, the plan supports the low-carbon heating of buildings by providing funding of EUR 70 million for the replacement of oil boilers with low- or zero-carbon heating systems. Concerning green transport, EUR 40 million will be invested in supporting private and public charging points for electric cars and the gas charging and refuelling infrastructure. EUR 161 million is available for the most promising carbon-free energy investments.

Programmes of Business Finland

Business Finland (and its predecessor Tekes) has invested significantly in the long-term development of low-carbon solutions. Business Finland financed low-carbon energy solutions with an estimated EUR 2 billion between 2006 and 2019. Renewable energy sources and energy efficiency have been key targets. The adaptation to climate change has shifted from developing individual solutions to developing systemic and sustainable solutions.

Business Finland's programmes are important instruments for combating the effects of climate change and promoting carbon neutrality. The Smart Energy programme (EUR 151 million, 2017 to) supports internationalisation and exports. It catalyses and funds energy-related ecosystems and testbeds in

Finland and abroad. Focus segments are waste-to-value, bioenergy, biofuels, smart grids, district energy, hydrogen, power-to-X, and batteries. The Bio and Circular Economy programme (EUR 171 million thus far, 2019 to) supports the development of competitive bio- and circular economy solutions and ecosystems that offer solutions to global environmental challenges and offer potential for significant global markets. The Sustainable Manufacturing Finland programme (EUR 92 million, 2020 to) focuses on renewing business models and increasing productivity, while actively seeking solutions to the challenges of climate change. Although the programme covers manufacturing industries extensively, it emphasises machine tool industries, electronics and photonics, and companies in the industrial digital transformation industry. The aims of the Smart Mobility and Batteries from Finland programme (EUR 100 million, 2020 to) are mitigating climate change and finding flexible new mobility and logistics low-emission solutions. The programme helps Finnish companies benefit from business opportunities in transport, logistics, and mobility services and create a significant Finnish battery industry.

The mission concept is a new way of working for Business Finland. Missions aim to accelerate societal systemic changes and meet global challenges. Business Finland has launched two missions, Zero Carbon Future and Digital Native Finland. The Zero Carbon Future mission focuses on creating future wellbeing by increasing the global carbon handprint. The mission focuses on the energy transition and transport and mobility sectors. A significant amount of RRF funding (EU's Recovery and Resilience Facility) will be directed through Business Finland to projects related to the green transition.

Climate-change-related programmes by the ministries

Ministries channel their research funding to climate-change-related topics through the research and expert organisations in their administrative sector, such as Business Finland and others, whereas some, like the Ministry of Agriculture and Forestry and the Ministry of the Environment have also allocated funds through specific research and development programmes or calls.

Through its research and development activities, the Ministry of Agriculture and Forestry of Finland aims to proactively produce knowledge, expertise, and innovations to support decision making, promoting the competitiveness of economic activities and ensuring the sustainable use of renewable natural resources. In 2020, the ministry launched the "Catch the Carbon" package as part of the various additional measures for the land-use sector under the Government Programme. The aim of the "Catch the Carbon" package is to achieve an annual emission reduction of at least three million tonnes of carbon dioxide equivalent by 2035.

The Catch the Carbon package also includes a research and innovation programme, an information programme with projects that focus on strengthening the knowledge base for the future climate measures in the land-use sector, as well as more practical development projects. There are around 100 Catch the Carbon projects in 2022.

The research and innovation programme aims to produce new research information that anticipates changes in the operating environment, as well as solutions for climate action in the land-use sector and the sustainable use of renewable natural resources. It comprises 15 multidisciplinary projects that focus on the reduction of GHG emissions, strengthening carbon sinks and reservoirs, and thus strengthening climate change resilience in agriculture, forestry, and other types of land use. The research and innovation programme will continue until 2024. Its volume is EUR 15 million, and the main actors in the projects are universities (e.g. University of Helsinki, University of Oulu, University of Eastern Finland) and research institutes, particularly Natural Resources Institute Finland. Several universities of applied sciences and some companies are also involved as partners. The programme emphasises close stakeholder cooperation to ensure information is effectively transmitted to serve as the basis for decision making and practical actions.

In cooperation with Business Finland, the Ministry of the Environment has prepared a programme (EUR 40 million, 2021 to 2025) to support Finnish companies and other organisations in developing low-carbon solutions related to the built environment. The aim is also to promote adaptation to climate change. The Ministry aims at proactively producing knowledge through its research and development activities. The scope is to boost the development and dissemination of products, technologies, services and practices for the built environment that mitigate climate change, promote the renewal of economic structures, and enhance the competitiveness of Finnish companies based on sustainable solutions. Funding is made available through the European Union's Recovery and Resilience Facility (RRF).

Sitra, the Finnish Innovation Fund

Sitra is a future fund that collaborates with partners from different sectors to research, trial, and implement new ideas that shape the future. The aim is for Finland to be a pioneer in sustainable wellbeing. Sitra investigates, explores, and develops operating models in close cooperation with other organisations to support public administration. Sitra pursues ambitious climate and nature policies, the acceleration of a fair and competitive circular economy, and encouraging citizens to act on sustainability.

Sitra's work in promoting ambitious and cost-effective climate policy has addressed such questions as: what does a cost-effective emissions reduction pathway for Finland look like, and what kind of role could taxation, and more specifically, an environmental tax reform, play in reducing emissions and promoting economic growth and employment? From 2021 onwards, the work is also addressing the link between our economic system and nature, as well as finding solutions to halt biodiversity loss and mitigate climate change.

During the reporting period, Sitra has invested a total of approximately EUR 23.1 million in projects carried out as part of the Sustainability Solutions theme area, contributing to more than 300 projects. Sitra has also invested in several funds that promote climate change mitigation. These include a renewable energy infrastructure, energy efficiency in buildings, sustainable forestry, and new business models for a circular economy.

Foundations

Several Finnish foundations support environmental and climate research and actively participate in the mitigation of climate change. These foundations have placed considerable emphasis on the promotion of the interaction between environmental research and society. They also support open science through these measures. The Finnish Association of Finnish Foundations has established a "Climate and Environmental Measures of Foundations" website that includes examples of the operating models and tools implemented by the active foundations. Here is an indicative but incomplete list of the biggest Finnish foundations supporting climate and environmental research: the Finnish Cultural Foundation; the Jane and Aatos Erkko Foundation; the Swedish Cultural Foundation in Finland; the Kone Foundation; the Maj and Tor Nessling Foundation; the KAUTE Foundation; the Maa- ja Vesitekniikan Tuki Foundation; the Finnish Natural Resource Research Foundation; the Weisell Foundation; the Åbo Akademi University Foundation; the Tiina and Antti Herlin Foundation; and the Walter and Andrée de Nottbeck Foundation.

8.2.2 Climate process and climate system studies

The Finnish Meteorological Institute, FMI, has a staff of around 200 scientists working on climate change and related problems. Regarding climate process and climate system studies, the emphasis of the programme is on:

- Climate research and services (supplying climate data, studying atmospheric radiation, analysing extreme events, performing climate modelling and scenarios, conducting impact and adaptation studies, including socioeconomic aspects, and communicating climate change);

- Greenhouse gases (measuring greenhouse gas concentrations and fluxes and interpreting the measurements using modelling tools);

- Aerosols, clouds, trace gases and climate (measuring properties of aerosols, clouds, trace gases, and their interactions both in situ and remotely, modelling aerosol dynamics and aerosol-cloud interactions).

The aerosol climate research at the FMI focuses on two main areas: the climatic influences of anthropogenic aerosols in both polluted and pristine regions; and the role of natural boreal forest aerosols in clouds and the climate. The research relies on field measurements at selected sites in Finland and international hotspots, modelling, and laboratory work and satellite retrieval.

The FMI's greenhouse gas research focuses on the high-precision concentration of GHGs and the exchange fluxes between ecosystems and the atmosphere, most typically of forests, peatlands and agricultural soils. The FMI operates both types of measurements at the Pallas-Sodankylä GAW station and on Utö island in the Baltic Sea. There are also several flux measurement sites across Finland, including a subarctic site of Kaamanen peatland, with the world's longest CO_2 flux time series.

The universities of Helsinki, Tampere and Eastern Finland and the FMI constitute the Atmosphere and Climate Competence Center (ACCC), the Finnish Flagship that works to address climate change and air quality issues (see also Section 8.2.1).

Paleoclimatology

The paleoclimatological studies of Finnish universities and research institutes are primarily based on the abundant natural archives in Finland and polar areas and they contribute to international research programmes, e.g. to hemispheric and global scale reconstructions (see Box 8.6).

Box 8.6
Paleoclimatology Research in Finland

At the **Environmental Change Research Unit (ECRU), University of Helsinki,** the central research theme is the development and application of empirical, computational and modelling tools to detect global climatic and environmental changes and analyse their ecological and societal impacts. ECRU focuses on centennial- to millennial-scale climatic changes especially in Arctic environments. The research is largely based on proxies stored in natural archives (peatlands, lake and marine sediments, ice cores). Research themes include carbon cycling, past climate development, and extreme events, Arctic sea-ice history and past black carbon deposition, and past peatland, lake, and marine ecosystem dynamics.

At the **Geosciences Research Unit, University of Oulu,** the objectives are to produce important threshold values in geochemical and sedimentological proxy information on past climate warming events and related loss of ice in the Arctic in time scales from hundreds to hundreds of thousands of years. The dynamics of past ice sheets, the evolution of the landscape, and high-latitude oceans are studied with modern sedimentological techniques and laser scanning imageries. The Space Climate Research Unit of the University of Oulu studies the evolution (over a few hundred years) of the Sun and the effects of solar magnetic activity. The solar wind affects the Earth's atmosphere, especially at high latitudes. Studies are related to questions like how the atmosphere is influenced, and how relevant it is to climate change.

The Laboratory of Chronology (LC) of the Finnish Museum of Natural History analyses the isotopic and elemental compositions of samples from environmental archives. LC has led efforts to construct radiocarbon and stable isotope chronologies from Finnish subfossil materials for the late and mid Holocene. Furthermore, abrupt climatic and environmental anomalies are tracked down by multiproxy methodologies, and the interaction between nature and people is addressed.

Natural Resources Institute Finland (Luke) has constructed one of the longest tree-ring chronologies in the world (5634 BCE to 2021 CE), based on living trees and mega-fossils recovered from lake bottoms and lakesides. Tree-ring material and its carbon isotope data have been used for reconstructions of past summer temperatures, cloud cover changes, and ocean-atmospheric circulation variability after the last glaciation period in cooperation with LC. Paleoclimate data are used to analyse the impacts of natural forcing factors such as solar activity and explosive volcanism.

At the University of Turku, research in the RewarD project focuses on the melting rapidity of the Scandinavian Ice Sheet at the end of the last Ice Age and the formation of subglacial meltwater routes in Finland. The importance of the glacial dynamics is that such glacial landforms (murtoos and related subglacial drainage routes) have yet to be properly described and determined in glaciated terrains of the Northern Hemisphere. The results will increase our understanding of how current glaciers will behave in a warming climate.

8.2.3 Climatic modelling and prediction

In cooperation with the University of Helsinki, the FMI contributes to climate change research by using global climate models to study the physical and chemical processes of the Earth's climate system. Global climate modelling at the FMI focuses on the use and development of the European Community Earth system model, EC-Earth, as part of a Europewide consortium. The main responsibility of the FMI in the development of EC-Earth lies in improving the model's global aerosol scheme. With EC-Earth, the FMI contributed to the CMIP6 climate model intercomparison project, whose combined results were used as the basis for the latest climate change projections provided in the IPCC's sixth Assessment Report. While most of the climate model development is done for EC-Earth, other global climate models such as ECHAM-HAMMOZ, NorESM, and UVic are also used for research purposes.

For example, research projects aim to better understand the ongoing climate change in the polar regions, biosphere-aerosol-cloud feedbacks, radiative transfer in the atmosphere, and the applicability of negative emissions technologies in climate change mitigation. Single components of the Earth system models, such as the atmospheric component Open-IFS, land surface component LPJ-Guess, and ocean component NEMO of the full earth system model EC-Earth, are used and developed to address specific research goals such as ensemble predictions in weather forecasting, the role of global forests as a carbon sink, and sea-ice characteristics in the Baltic and Arctic Seas.

The FMI also develops and uses the regional climate models HARMONIE-CLIM for climate change studies in the Nordic countries. Regional climate modelling is used to produce data to evaluate the societal impacts of climate change in northern Europe, as well as to produce high-resolution projections of the changes in extreme weather-related hazards in the future.

The FMI also investigates aerosol-cloud interactions with a large eddy simulation model for aerosol-climate interactions, UCLALES-SALSA, which it has developed. The model has been used to develop new parameterisations for large scale models, improving the understanding of cloud microphysical processes and interpreting field observations.

The FMI uses and develops models (e.g. the JSBACH land surface model, the LDNDC ecosystem model, the PEcAn modelling and data assimilation platform) to study carbon sinks and sources in forests, peatlands, and agricultural lands under management and in a changing climate, as well as feedbacks between the land carbon cycle, nutrient availability, water cycle, and atmosphere. The FMI also produces information about global biospheric and anthropogenic greenhouse gas emissions in recent years by using atmospheric inverse modelling (Carbon Tracker Europe, CIF) with atmospheric GHG data from satellites and in situ measurements. The FMI participates in joint international GHG modelling efforts like the GCP (Global Carbon Project) which feed into IPCC work.

8.2.4 Research in support of the national greenhouse gas inventory

Research in support of the national greenhouse gas inventory has aimed to develop methodologies and emission factors or other parameters to improve the accuracy and reduce the uncertainties of the greenhouse gas inventory. This research has been largely funded by the Ministry of the Environment and the Ministry of Agriculture and Forestry. Funding has also been provided by various consortiums, including other ministries, national funding organisations such as the Academy of Finland, and the private sector.

In recent years, the focus of research in supporting the greenhouse gas inventory has been on developing and improving methods and national parameters for estimating carbon stock changes, in soils in particular, in the land-use, land-use change and forestry (LULUCF) and agriculture sectors. The Finnish Yasso model for estimating carbon stock changes in soils (developed by the European Forest Institute, the Finnish Environment Institute, Natural Resources Institute Finland (Luke) and the Finnish Meteorological Institute has been acknowledged internationally and is also used in inventory preparation in other countries. A recent example of Yasso model-related research that yielded an improvement in the estimate of the carbon stock changes in croplands is a project that studied the chemical composition of different soil amendments. Based on the results, the effect of cover crops is now included in the estimate of cropland CO_2 and N_2O emissions in the national greenhouse gas inventory.

Several research projects conducted by universities and research institutes have provided emission factors and research results to estimate CO_2, N_2O, and CH_4 emissions from organic soils and peat extraction. For example, the effects of paludiculture and continuous cover forestry are actively studied to facilitate the reporting of the potential GHG mitigation resulting from novel management options.

A development project on the Finnish normative manure system provided material to update the Nitrogen Mass Flow Model, which is used to calculate nitrous oxide emissions from manure management (the Finnish Environmental Institute and the Natural Resources Institute Finland). Furthermore, an ongoing project with the Finnish Environment Institute (SYKE) as the Finnish partner, funded by the Nordic Council of Ministers, aims to improve the F-gas inventories in the Nordic countries through joint comparison and verification of the emission estimation methodologies, emission factors, and other parameters and assumptions used in different countries.

Efforts to disseminate the results of the research have been made to support other countries in their inventory preparation efforts. In addition to publishing the results in internationals journals and experts' participation in the preparation of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, emission factors and parameters have been provided to the IPCC Emission Factor Database (EFDB), which is a key source of information for developing countries in particular.

8.2.5 Research on the impacts of climate change, adaptation, and mitigation

This sub-chapter mainly focuses on research performed since the publication of the Seventh National Communication. The text aims to provide an overview and the descriptions are not exhaustive. More information on the research activities is available at the websites of the research institutes and universities (see the list at the end of Chapter 8).

Many research institutes and universities carry out research on climate change impacts, adaptation and mitigation in Finland. Several research organisations have set up their own climate-change-related programmes or research units. Close cooperation among research organisations is a characteristic feature of Finnish research on climate change impacts, adaptation and mitigation.

National research programmes (see Section 8.2.1) have provided funding and common goals for the research.

Taking as an example the Academy of Finland's and the Strategic Research Council's funding for climate change related research which totalled in 2017 to 2021 more than EUR 175 million (see 8.2.1). The funding is allocated broadly; more than 30 organisations served as grant holders during the research period.

The Ministry of Agriculture and Forestry and the Ministry of the Environment were funding the Research Programme for Environmental impacts of agriculture (MATO) during 2016 to 2020. One of the aims of the MATO programme was to enhance adaptation and mitigation. The Ministry of Agriculture and Forestry also runs a development fund for agriculture and forestry that grants R&D funds for activities that benefit the agri-food sector across a broad front. The main focus is on research concerning the sustainable development of the profitability and competitiveness of livelihoods. The funded projects also include adaptation theme.

In research on climate change, natural sciences no longer dominate and economics, law, social sciences and humanities are increasingly contributing to the knowledge that is needed for tackling climate change in terms of mitigation or adaptation. For example, issues of justice and a fair transition to a resilient low carbon society as well as energy security have become important research topics.

An overall objective of the research on climate change is to be able to understand better complex interactions between a wide range of climate change impacts and adaptation and mitigation measures. Active research on possible measures to address climate change has emerged. The interactions between mitigation and adaptation actions are also increasingly recognised. Inter- and transdisciplinary approaches are more and more employed to deal with the complexity of the challenges. In addition, active participation of practitioners is required; for example, practitioners such as farmers contribute with important practical knowledge in the development of verification system for carbon sequestration in arable lands.

Climate change research is also closely connected to other themes, such as bioeconomy and circular economy, resilience, studies of societal transitions, energy research, transport research, consumer studies and also ecological research. Education and training of experts are an integral part of the research activities.

Research on climate change impacts and adaptation

Research on climate change impacts and adaptation has become a recognised topic in the Finnish R&D activities. Most of the research is based on project funding ranging from short-term studies to long-tem research projects. Finnish research organisations and researchers participate actively also in European research projects.

Key themes of the research include

- the impacts of climate change in different sectors and areas (for example, agriculture, forestry, health, buildings and other infrastructure, hydropower, ecosystems, the Arctic);
- scenario development, including the use and downscaling of global and European scenarios based on the Representative Concentration Pathways (RCP) and Shared Socioeconomic Pathways (SSP);
- risk assessments, including the analysis of exposure and vulnerability at a national, regional or local scale; analysis of the costs of inaction in the face of changing climate;
- adaptation and resilience, including the use of nature-based solutions for, for example, flood or storm water management;
- cross-border impacts of climate change and relevant policy responses.

The Ministry of Agriculture and Forestry has carried out a systematic review of past and ongoing research projects in Finland with a focus on adaptation to climate change in different sectors.[12] The research has provided a base for the updating of the National Adaptation Plan and for regional and local roadmaps and strategies for adaptation to climate change.

Research on climate change mitigation, including technologies

As with research on climate change impacts and adaptation, studies on mitigation, as well as analyses of mitigation policies are carried by many research organisations. Key themes include

- identifying, developing and assessing technological solutions for mitigating climate change in different sectors, including renewable energy production and power-to-X solutions;
- energy efficiency in different sectors (e.g. industry, buildings, transport), energy storage and demand-side management;
- socio-economic analyses of energy transitions, in particular the shift to low carbon futures and climate neutrality at different levels of governance and managing intermittent energy sources;

12 Ministry of Agriculture and Forestry (forthcoming) Report on the state of the research supporting adaptation to the climate change in 2021

– developing and analysing scenarios for emission reductions, including technological and economic modelling;

– examining ways to maintain and increase sinks, including carbon capture;

– developing, analysing and evaluating policy instruments for reaching energy and climate goals;

– the exploration of links between mitigation, resource efficiency and biodiversity conservation.

The overall goal is to strengthen the knowledge base for systemic transitions to a low carbon, resource efficient and resilient society. An increasing number of studies have assessed climate change problems from a transdisciplinary perspective and integrated socio-economic aspects. For example, the Strategic Research Council has funded large consortia, in which research institutes, universities and other actors, including the private sector, join forces in dealing with technology and energy disruptions and resource efficiency. Other broad inter- and transdisciplinary research efforts have addressed the mitigation of emissions from the land use sector and dealt with opportunities to increase sinks in forests and forestry and agriculture.

Funding from Business Finland plays an important role for technology developers who are seeking business opportunities in mitigation technologies. The EU's Integrated Life Projects have supported demonstration projects for upscaling. One example is the support for Carbon Neutral Municipalities and Regions (Canemure).

Some actors in the field of mitigation research and examples of their research are presented here below:

Research, development and innovation (RDI) in both Universities and Universities of Applied Sciences combine multidisciplinary expertise with the needs of co-operative partners and the society. New solutions are widely sought to help society and businesses in their sustainable renewal e.g. by supporting the transition towards a carbon-neutral society in all sectors.

Co-operation and co-creation with both companies and the public sector enhance also long lasting partnerships. Funding is provided by the European Social Fund (ESF), European Regional Development Fund (ERDF) as well as ministries' programmes and Business Finland in many cases, while the financing from the municipalities and companies plays a significant role too.

VTT Technical Research Centre of Finland Ltd (VTT) is conducting applied research in areas that are crucial to solve in order to reach a carbon neutral economy and society. These areas are carbon-neutral process industry, low-carbon and smart mobility, sustainable and smart built environment, sustainable food system, carbon neutral and flexible energy system, and hydrogen for future society.

Some examples on achievements include that VTT has established innovation ecosystems in smart energy and smart transportation, where companies, research actors, public sector and citizens can co-create and pilot new technologies and services. It has also led development in sustainable fuels, and their utilization in various forms of mobile and stationary applications. Research on alternative proteins with lower carbon footprint has resulted in four start-ups. VTT has also been working on development of a small modular nuclear reactor for residential heating. In addition, it has supported ministries to formulate medium and long term climate and energy scenarios and carried out assessment of impacts of national climate and energy policies and measures in collaboration with other research institutes.

The Finnish Environment Institute (SYKE) carries out research on climate change mitigation by analysing the economics and management of renewable intermittent energy sources, the legal base for low carbon transitions, the practices of low carbon consumption and business development, and by developing methods and processes for estimating and analysing consumption-based greenhouse gas emissions as a complement to area-based estimates that SYKE has produced for all municipalities in Finland. SYKE also carries out research on the security aspects of the energy transition.

The Natural Resources Institute Finland (Luke) has organized its research activities into four programmes, namely Profitable and responsible primary production, Circular bioeconomy, Climate smart carbon cycle and Adaptive and resilient bioeconomy. All of these have climate change mitigation and adaptation as an integral, inherent theme. Furthermore, The Natural Resources Institute Finland also has a programme for Statutory and expert services which is responsible for e.g. the greenhouse gas inventory for agriculture and land use, land-use change and forestry sectors.

Research on assessing, evaluating and monitoring climate action

Policies and other societal actions to strengthen mitigation and adaptation are regularly reported to the UNFCCC and the EU (Chapter 4), but, in addition dedicated research aims at creating more systematic and better quality controlled information on the contribution of policies to transformative societal change. Such assessments and evaluations of policies have in particular been initiated by the Strategic Research Council (SRC) and the dedicated Government's analysis, assessment and research activities (VNTEAS).
The latter have, for example, included research-based assessment of the Government's Climate and Energy Strategy and a research-based evaluation

of the national Climate Change Adaptation Plan 2015–2022[13]. These operational studies for policy development have been linked with more strategic research on climate and energy issues through studies focusing on technological disruption in energy. New projects under the SRC Climate Programme deepen the understanding further, for example by analysing the perceived legitimacy and fairness of current and potential policy instruments. They have evaluated current systems and also provided assessments of alternative future pathways.

Climate justice and just transition related research

Climate justice and just transition related research have been increasing in recent years. Currently the Climate Change Panel is in the process of creating a support tool to assess justice-aspects in climate policy. The Legitimacy 2035 research project assesses legitimacy issues in the context of climate legislation and policy. In addition, there are thematic research projects related to, for example, just and sustainable food system transition. Furthermore, Ministry of the Environment has made new type of research cooperation with research groups from the University of Turku: A specific Citizens' Jury on Climate Actions was convened to support the assessment of the legitimacy of the Government's Medium-term Climate Change Policy Plan and was run by the researchers. The Citizens' Jury on Climate Actions discussed 14 policy measures and assessed, that during the implementation of the measures factors such as income and geographical location should be taken into account. The Ministry of the Environment has cooperated also with other research groups in relation to use of new participatory methods, for example in participation of the youth[14].

8.3 Systematic observations

The routine surface and upper air weather observations made by the FMI are the primary source of atmospheric observations relevant to climate change, including atmospheric composition. The FMI also carries out physical marine observations.

SYKE conducts or coordinates climate-related observations of hydrology and the chemical and biological state of inland and marine waters, as well as of terrestrial biodiversity. Climate-related observations of forests, agricultural areas, and fisheries are made by the Natural Resources Institute, Luke. Several universities also have activities in this area. The data collected compiled by the Finnish Museum of Natural History (Luomus) provides data for understanding long-term changes in the biota.

13 KOKOSOPU project, Hilden et al. 2022, https://tietokayttoon.fi/julkaisu?pubid=42102

14 ALL-YOUTH (allyouthstn.fi)

Most of the systematic long-term observational activities depend on regular budgetary funding, but many important data series on biota (birds, insects) are collected by amateur observers. In addition, observations carried out as part of research projects are funded to a significant degree by external R&D funding. The total funding for systematic observations related to climate change is difficult to determine, because most of the observations are primarily made for other monitoring purposes (such as resource management), although the observations are also applicable to tracking climate change. Budgetary funding for some of these monitoring programmes has partly been reduced, and some data series may therefore suffer. There is also a need to invest in both virtual and physical infrastructure to ensure the maintenance and accessibility of the long-term data that prove important in understanding the gradual effects of climate change.

The sections below present the atmospheric, ocean, terrestrial and cryosphere observation systems. The observation systems covered are those providing climate observations, as well as other observations relevant for research on climate change impacts, adaptation, and mitigation.

8.3.1 Atmospheric observing systems

The FMI's meteorological observation network is comprised of 83 manual precipitation stations and 185 automatic weather stations (AWS), of which two include upper-air observations. AWSs offer a comprehensive set of parameters essential for climate studies (e.g. temperature, pressure, relative humidity, precipitation, wind, solar radiation). Observation records are mainly distributed as synoptic weather messages every ten minutes, and hourly via the Global Telecommunication System. The FMI has been responsible for the aviation weather observations of Finnish airports since 2012. A dual polarisation Doppler radar network provides comprehensive coverage of Finland, offering a wide range of climate and operative applications for society.

The FMI participates in the Global Climate Observing System (GCOS) Surface Network (GSN) with three stations. One station (Sodankylä) is also part of the GCOS Upper-Air Network and the GCOS Reference Upper-Air Network (GUAN and GRUAN). Since 2013, the FMI's datasets have been free for public use via an online service (see 8.1.1 and Box 8.1).

For example, Finnish climate observations have been included in the European Climate Assessment & Dataset (ECA&D), which is a European collection of reliable long-term climatic observations for climate change research. In addition, daily precipitation data are in use at the Global Precipitation Climatology Centre (GPCC).

The FMI has maintained a climatological database since 1959, including data from climatological normal values to near-real-time values for certain observations. In addition to the electrical data records, a significant amount of climatological data dating back nearly 200 years in time is still in paper format and being digitised.

The FMI is actively participating in the activities of the network of European Meteorological Services (EIG EUMETNET). The activities of the EUMETNET include observing systems, data processing, basic forecasting products, research and development, and training.

Finland is a participant in the Global Atmosphere Watch (GAW) programme of the World Meteorological Organization (WMO), the purpose of which is to observe greenhouse gas concentrations and the long-range transport of pollutants in the atmosphere. Greenhouse gas measurements are made available at the World Data Centre for Greenhouse Gases (WDCGG) at the Japan Meteorological Agency and other global and European data banks.

The FMI maintains a GAW station at Pallas-Sodankylä in Lapland, where greenhouse gas concentrations are measured on a mountaintop in a national park. Carbon dioxide, methane, nitrous oxide, ozone, air pollutants, and aerosols are measured continuously at the station. Continuous measurements of carbon dioxide started in 1996 and of methane in 2004.

Finland is participating in the Integrated Carbon Observation System (ICOS) (see also Sections 8.1.1 and 8.1.2), which is a European research infrastructure for quantifying and understanding the greenhouse gas balance of the European continent and adjacent regions. Both atmospheric concentrations and fluxes over different ecosystems are measured, with measurements taken over oceans and the Baltic Sea.

The mission of ICOS is:

- To provide the long-term atmospheric and flux observations required to understand the present state and predict the future behaviour of the global carbon cycle and greenhouse gas emissions.
- To monitor and assess the effectiveness of carbon sequestration or greenhouse gas emission reduction activities on global atmospheric composition levels, including the attribution of sources and sinks by region and sector.
- To set new standards for research instrumentation, measuring protocols, and data processing.

The ICOS Finland network maintains four atmospheric stations at Hyytiälä SMEAR II, Pallas, Puijo, and Utö which continuously measure the high-accuracy concentrations of carbon dioxide, methane, and carbon monoxide. Weekly sampling will include a broader selection of species similar to that of the GAW programme. The host institutes of ICOS Finland (the FMI, the University of Helsinki, the University of Eastern Finland) also maintain nine ICOS ecosystem stations that measure greenhouse gas fluxes above forest, wetland, lake, and urban environments. The Stations Measuring Ecosystem-Atmosphere Relationship (SMEAR) in the boreal climate zone support research on biosphere-aerosol-cloud-climate interactions and the biogeochemical cycles of carbon, nitrogen, sulphur, and water. Several SMEAR sites contribute to atmospheric and environmental research infrastructures such as ICOS, ACTRIS and eLTER, allowing synergistic data interpretation (see also 8.3.3). The national station network now consists of a total of 13 atmospheric and ecosystem stations that are part of ICOS. From 2022, Natural Resources Institute Finland and the University of Oulu have joined ICOS Finland and are preparing to add their flux stations to the ICOS network.

For ACTRIS, the Finnish site selection (called National Facilities) includes the FMI Pallas and Utö sites, the University of Helsinki INAR sites in Hyytiälä, Värriö, and Helsinki, and a University of Eastern Finland site in Puijo. In addition, the FMI operates overseas ACTRIS stations in Marambio (Antarctica) and Tiksi (Siberia). However, the Tiksi station is currently (2022) inactive. The ACTRIS sites contribute to aerosol, trace gas, and cloud in-situ observations, as well as to the cloud remote sensing components of ACTRIS.

Furthermore, the FMI is leading the preparation of part of the ACTRIS Data Centre (CloudDataNet). The University of Helsinki is contributing to ACTRIS central calibration facilities in aerosol in-situ and trace gases. The University of Helsinki and FMI are establishing the ACTRIS Head Office to provide effective access for a wide user community to resources and services to facilitate high-quality Earth System Research (see Section 8.1.2).

Additional climate-related observational activities carried out at the FMI are as follows:

- The FMI is responsible for national background air quality monitoring. The monitoring network consists of about twenty measurement stations. Most of the measurements are part of international monitoring and research programmes.

- Background air quality monitoring started at the beginning of the 1970s. Today, the measurements include major ions, polycyclic aromatic hydrocarbons (PAHs), heavy metals and mercury in the air and in precipitation, ozone, sulphur oxides, nitrogen oxides, volatile organic compounds, and fine particles.

- The FMI has also assisted in establishing and enhancing measurements of atmospheric composition at stations in India, China, South Africa, and on polar research cruises.

- The Integrated Monitoring programme, which is coordinated by the United Nations Economic Commission for Europe (UNECE), refers to the simultaneous measurements of the physical, chemical, and biological properties of an ecosystem over time and across compartments at the same location (stations in Kotinen and Hietajärvi). The objective of HELCOM (Baltic Marine Environment Protection Commission, or the "Helsinki Commission") is to protect the marine environment of the Baltic Sea (station at Hailuoto).

- The FMI also maintains a monitoring and warning system for tropospheric ozone concentrations in accordance with the European Union's Ozone Directive. Air quality issues in the EU are coordinated by the European Environment Agency and the European Topic Centre on Air Quality.

Finland is a member of the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). The FMI hosts the EUMETSAT's Satellite Application Facility on Ozone & Atmospheric Chemistry Monitoring, O3SAF.

8.3.2 Ocean observing systems

Finnish research institutes with significant marine components have started a national marine research infrastructure consortium (FINMARI) coordinated by the Finnish Environment Institute SYKE. The aim is to facilitate efficient international and national use of the marine infrastructure. This is done in close cooperation with other international and national infrastructures and ESFRIs[15] such as ICOS, EMBRC, and EURO-ARGO.

The infrastructure includes the research infrastructures of four Finnish research institutes and three university field stations. FINMARI is a distributed infrastructure, consisting of field stations, research vessels, laboratory facilities, FerryBoxes, gliders, fixed measurement platforms, and profiling buoys in the Northern Baltic Sea. FINMARI is listed as a nationally essential research infrastructure in the Finnish national infrastructure roadmap for 2021 to 2024. FINMARI is a hub for the ocean observing system in Finland and provides access to both the infrastructure and the data it produces.

SYKE participates in the joint Baltic Sea environmental monitoring programme (HELCOM COMBINE), which has produced long-term data on the state of the Baltic Sea since 1979. The operative state monitoring of offshore sea areas in the Gulfs of Bothnia and Finland, as well as the northern Baltic Proper is carried out by SYKE (chemical and biological parameters, contaminants) and the FMI (physical parameters). Monitoring is conducted at about 55 sampling stations during four annual cruises with R/V Aranda. Offshore monitoring is undertaken in cooperation with the Swedish Meteorological and Hydrological Institute (SMHI), and with Estonian and Russian research institutes. The monitoring of coastal waters is carried out by regional environmental authorities with SYKE. For example, the marine monitoring data serve the national implementation of the EU Marine Strategy Framework Directive and the Water

15 EU's European Strategy Forum on Research Infrastructures

Framework Directive and the work of HELCOM. The open data have also been utilised e.g. in evaluating the observed climate change effects in the Baltic Sea. Data are also delivered e.g. to the databases of the International Council for the Exploration of the Sea (ICES), the European Environment Agency (EEA), and EMODnet/ DG MARE.

SYKE also delivers near-real-time information from several million datapoints annually on the state of the Baltic Sea through the Alg@line, which serves research, the general public, the media and the authorities. Alg@line utilises the Ship-of-Opportunity (SOOP) monitoring system, which uses merchant ships as operating platforms on which measurements are taken using autonomous flow-through systems. The Algaline project is a pioneer in the field of unattended SOOP monitoring, forming a state-of-the-art environmental monitoring system ranging from data collection and assimilation to Internet applications and products.

The FMI is responsible for monitoring the physical properties of the Baltic Sea. The FMI's operational measurement network includes 14 tide gauges, five wave buoys, Argo floats (TS/O2) in four of the Baltic Sea basins, and several surface temperature buoys along the coast. Regular temperature and salinity soundings are also made in coastal monitoring stations. In addition to the abovementioned ICES, EEA, and EMODnet databases, operational measurements are also provided to the Copernicus Marine Service database.

The FMI also contributes to the global Argo programme by providing floats for the Nordic Seas in addition to the Baltic Sea via the Euro-Argo Research Infrastructure. For enhanced climate, marine, and ecosystem research in the Baltic Sea, the FMI has established with SYKE the Utö Atmospheric and Marine Research Station (part of FINMARI), which provides high time-resolution data on marine ecosystem atmosphere feedback processes and the carbon cycle.

8.3.3 Terrestrial observing systems

In the following, the terrestrial observing systems in Finland also includes a description of inland waters and hydrology. The observing systems of greenhouse gas measurements over different terrestrial ecosystems and of the interaction of terrestrial ecosystems and atmosphere are described in Section 8.3.1 above.

SYKE is the national centre coordinating and supervising the monitoring of the water resources, hydrological cycle, and chemical and biological state, including data management, quality control, and the assessment of the chemical and ecological quality of inland waters. Many hydrological data series are unique for their temporal duration (longer than 100 years), particularly those related to the freezing and break-up of rivers and lakes and the water levels of some large lakes.

Flood forecasting at SYKE is based on the Watershed Simulation and Forecasting System. Its main component is a model that simulates the entire hydrological cycle and water balance in catchment areas. The forecasts are made several times a day from more than 500 water-level and discharge observation points and are available on the webpage providing national information about the water situation in Finland (vesi.fi). Simulated hydrological data with more than 20 variables from 1962 to the present are available from the system's user interface. The modelling system is used extensively in research projects on climate change impacts in hydrological cycle and water resources in Finland. The climate-change-related data and simulations are produced on demand, and some information and maps are also available on the national webpages, vesi.fi and ilmasto-opas.fi. The hydrological simulation system also includes a nutrient simulation model (VEMALA), which can be used to simulate extensive water quality data, including source apportionment. The loading projections can be provided for historical periods, as well as for the future climate change scenarios on demand.

The water quality data acquired and hosted by SYKE cover the country and important watersheds, as well as special small-scale watersheds for baseline monitoring. All data are subject to systematic quality control, including the use of standardised methods for analysis.

Finland reports terrestrial climate observations to several international databases. For example, runoff data are reported to the Global Runoff Data Centre in Germany and the Nordic Runoff Data Centre in Sweden. Finland has reported lake water temperatures to a global project coordinated by the University of Nebraska.

SYKE also carries out monitoring using data from Earth Observation (EO) satellites[16]. These include water quality and temperature in the Baltic Sea, snow extent, and lake ice, which are currently monitored operationally (i.e. products are generated when new data become available, in practice, almost every day for the moderate resolution satellites such as Sentinel 3). For inland lakes, the operating methods are under development. Land cover, land-use, and phenology products are generated more slowly: one per year for every six years[17]. Land and cryosphere products are SYKE's contribution to the EU's Copernicus services. Operational processing of EO data is carried out in cooperation with the Finnish Meteorological Institute at the National Satellite Data Centre.

In addition to inland water observations, the monitoring of terrestrial ecosystems aids the detection of changes induced by climate change. Integrated monitoring has indeed become an important approach in environmental

16 www.syke.fi/earthobservation

17 For details, see (https://www.syke.fi/en-US/Open_information/Open_web_services/EO_web_map_services).

sciences. At SYKE, the multidisciplinary International Cooperative Programme on Integrated Monitoring (UNECE ICP IM) is one of the activities established under the Convention on Long-range Transboundary Air Pollution (CLRTAP) to develop the necessary international cooperation for assessing pollutant effects and emission reductions. The key aim is to quantify the integrated effects of air pollution and climate change on the environment through monitoring, modelling, and scientific review using data from catchments or plots in natural or semi-natural forested areas with minimal disturbance. SYKE further participates in the UNECE ICP Waters and ICP Modelling & Mapping (ICP M&M) activities, which also cover the monitoring and assessment of climate change effects.

The Finnish Long-Term Socio-Ecological network (LTER Finland) is coordinated by the University of Helsinki and brings together the Finnish research sites and scientists conducting research on long-term socio-ecological processes and problems in a coordinated Finnish research infrastructure. The LTER also belongs to the Europe-LTER and international LTER (ILTER) networks. LTER Finland currently consists of nine highly instrumented sites/research platforms, representing the main ecosystems (marine, terrestrial, lake, subarctic, urban) in Finland, which provide a national infrastructure for long-term site-based ecosystem and biodiversity research in Finland, including climate change impacts.

Currently, about 60 national monitoring schemes or projects provide data concerning biodiversity in Finland. This monitoring work involves three research institutes: the Finnish Museum of Natural History; Natural Resources Institute Finland Luke; and SYKE. This work includes collecting information on the changes taking place in ecosystems and habitats, species and species communities, and genes and genotypes. Monitoring data dealing with changes in biodiversity and habitats are compiled on a website. SYKE organises national butterfly (since 1999) and moth (since 1993) monitoring schemes, providing information about the effects of climate change on species occurrences. SYKE is also coordinating the research infrastructure project FinBIF (Finnish Biodiversity Information Facility).

Monitoring of disease vectors and zoonoses that can be connected to climate change is performed by the Finnish Food Authority and the Finnish Institute for Health and Welfare.

Luke performs national forest inventories (NFIs), which produce reliable information on the land use, forest resources, growth, condition and biodiversity of forests. NFIs are based on statistical sampling. The most recent NFI was undertaken between 2014 and 2018 and the 13th NFI is ongoing (2019 to 2023). Twelve NFIs have been completed since the 1920s, providing internationally unique time series on the development of land use and forest resources.

Luke participates in UNECE ICP Forests Level II intensive monitoring, which is the key for providing an insight into causes affecting the condition of forest ecosystems and the effects of various stress factors, including climate change. The results are reported annually. The forest damage advisory service at Luke is responsible for monitoring forest pests and diseases and the damage they cause. The service supports the decision making of forest owners and administrators by answering enquiries and producing diagnoses and prognoses about forest pests and diseases. Luke also collects information on the phenology of tree and forest berries. The extent of climatic warming can thus be assessed based on the time series for the bud burst of different tree species.

Finland is a member in the Sustaining Arctic Observing Networks (SAON) and the vice-chair currently comes from Finland. The SAON was established on the initiative of the Arctic Council and the International Arctic Science Committee (IASC). The purpose of the SAON is to support and strengthen the development of multinational engagement for sustained and coordinated pan-Arctic observing and data sharing. The SAON has two committees: the Arctic Data Committee and the Committee on Observations and Networks. The vision of the SAON is to sustain a comprehensive observing system for the Arctic and that users should have access to free, open and high-quality data that will realise pan-Arctic and global value-added services and provide societal benefits. The EUR 15 million Arctic Passion EU project with parallel actions in the US and Canada are supporting strongly SAON to facilitate the ROADS process[18] with a key goal to establish Shared Arctic Variables (SAV) to broaden observation practitioners to local and indigenous communities. Ongoing projects also include an atmospheric observations initiative and participation in the EU PolarNet project for the optimisation of existing monitoring and modelling programmes. The prime Finnish site in SAON is the Pallas Supersite[19], which is a versatile research infrastructure for monitoring and studying the atmosphere, ecosystems and their interactions.

The surveillance system of invasive alien species has been developed to collect and record data on the occurrence of invasive alien species, estimate how their populations have increased or shifted location, and measure the effectiveness of the management measures. The work in mostly done by integrating new elements into the existing inventories and monitoring systems. Citizens can also report their observations of alien species to an internet portal[20], which includes geospatial information.

8.3.4 Cryosphere observing systems

Except for sea ice monitoring, the cryosphere observing system in Finland is organised as part of the hydrological monitoring system. Monitored cryosphere

18 https://helda.helsinki.fi/handle/10138/341820

19 https://en.ilmatieteenlaitos.fi/pallas-atmosphere-ecosystem-supersite

20 https://vieraslajit.fi/

variables include snow water equivalent, ice cover duration and thickness in lakes and rivers, and seasonal soil frost thickness. This monitoring programme is coordinated by SYKE. Data storage and data quality control, as well as making data available to the public, are done on SYKE's premises. All monitoring data can be accessed through the webpage providing the national information of the water situation in Finland[21]. Field measurements are carried out by the local authorities or citizen observers. The monitoring network consists of more than 200 cryosphere monitoring stations where data are collected fortnightly or more frequently during the winter, and the stations are spread all over Finland. Earth Observation (EO) satellite products are used to operationally monitor snow extent and lake ice. The international data availability will be developed in the Arctic PASSION project ("Pan-Arctic Observing System of Systems: Implementing Observations for Societal Needs"), in which the FMI and SYKE are partners. Cryospheric data are also reported to the National Snow and Ice Data Center (NSIDC) in the United States.

Based on satellite observations and ground measurements, the FMI has developed methodology to reliably estimate the amount of annual snow mass and changes in snow cover in the Northern Hemisphere[22]. These accurate data, starting in 1980, are a significant improvement to the Essential Climate Variables of the WMO's Global Climate Observing System.

Sea ice monitoring in the Baltic Sea is carried out by the FMI, which has about 20 people observing ice along the Finnish coastline. They observe the ice situation visually and measure the thickness of the ice weekly, providing pointwise in-situ information. The data are available from the FMI. To cover the whole Baltic Sea, the most important source for ice observations is satellites. They provide information on the ice extent and type, concentration, ice ridges and leads, for example. Both in-situ and satellite measurements provide an input to model the structure, thermodynamics and drift of sea ice. The FMI also provides a long time series of the maximum annual extent of ice cover in the Baltic Sea that starts in the winter of 1720/1721.

8.3.5 Support for developing countries in strengthening systematic observations

Climate change and the intensification of extreme weather phenomena will increase the demand for development projects, especially in countries that lack the capacity to develop the required systematic observations themselves. The strengthening of atmospheric and terrestrial observing systems provides basic information for adaptation to changes in climate and environmental conditions.

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21 https://www.vesi.fi/

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Finland finances the Systematic Observations Financing Facility (SOFF), launched in 2022, that supports Least Developed Countries (LDC) and Small Island Developing States (SIDS) to generate and exchange basic surface-based observational data critical for improved weather forecasts and climate services. Finland also finances the Climate Risk and Early Warning Systems (CREWS) initiative that funds Least Developed Countries (LDC) and Small Island Developing States (SIDS) for risk informed early warning systems. Furthermore, many other organizations and funds that Finland finances, such as the Adaptation Fund, Green Climate Fund and Nordic Development Fund, implement projects that strengthen the capacities of developing countries to assess climate risks, develop early warning systems and take anticipatory action.

Projects that support the development of observation systems and are funded by the Finnish Government are described in Section 8.4. The research institutes SYKE, Luke, GTK, and FMI provide expertise in the planning and implementation of projects, including work to improve monitoring systems and their use in climate change adaptation. The FMI also leads and provides expertise to projects funded by the World Bank, the Asian Development Bank and the EU.

8.4 Capacity building in developing countries

As it has for many years, Finland continues to finance and operate extensive capacity building programmes around the world concerning climate observations, research and higher education relevant to climate change mitigation and adaptation, meteorology, and the sustainable management of forests, water and other natural resources.

The programmes have increased the endogenous capacities and capabilities of developing countries to tackle these issues through improved technological means and human resources. Thanks to the momentum of the cooperation and higher visibility through the programmes, this has also led to increased national funding and support. Furthermore, the programmes have identified opportunities for and supported actions to overcome barriers to the free and open international exchange of data and information. From 2017 to 2021, more than 70 institutions in 25 developing countries have benefitted from capacity building provided by their Finnish counterparts.

The main instruments to support capacity building in developing countries are the Institutional Cooperation Instrument (ICI), the Higher Education Institutions Institutional Cooperation Instrument (HEI-ICI), and the Academy Programme for Development Research (DEVELOP). Furthermore, many other development cooperation programmes, funded through bilateral cooperation or through multilateral channels, include elements to increase the endogenous capacities of partners in developing countries.

In transboundary water cooperation, critical for climate change adaption, Finland has supported the drafting of the UNECE Water Convention handbook on the effective, equitable and sustainable transboundary water allocation intended for global use, and a review of solutions and investments in the water-food-energy-ecosystems nexus in transboundary basins. Finland has also played an active role in developing international water diplomacy activities in collaboration with partners, including UNICEF and the OSCE, emphasising the potential of water cooperation in conflict prevention and in confidence-building measures. The Finnish approach builds on joint analyses, training and mentoring, bringing together technical water expertise with peace mediation.

The Institutional Cooperation Instrument (ICI) supports projects between public sector institutions. The projects respond to the capacity development needs of the public sector institutions of developing countries with the expertise available in Finnish governmental authorities and agencies. The objective of the projects is to strengthen the capacities and knowledge of the institutions and their staff. The projects are funded by the Ministry for Foreign Affairs and implemented by Finnish public sector institutions with their corresponding counterpart institutions in developing countries. Between 2017 and 2021, four Finnish public sector agencies have provided climate-related capacity building through ICI projects.

The Finnish Meteorological Institute (FMI) is among the world's leading national hydrometeorological institutes and has provided capacity-building and technical assistance to national meteorological and hydrological services (NMHS) to develop weather, climate, and early warning services through development cooperation projects worldwide. It has implemented the following ICI projects since 2017:

– Improving the Adaptation to Climate Change by Enhancing Weather and Climate Services in Kenya, Rwanda, and Tanzania. Partners: Kenya Meteorological Department, Rwanda Meteorology Agency, Rwanda Environmental Management Authority, and Tanzania Meteorology Authority. 2022, ongoing

– Capacity Building in the Field of Meteorology, FMI-Uzhydromet Meteorology Project. Partner: Centre of Hydrometeorological Service of the Republic of Uzbekistan (Uzhydromet). 2022, ongoing

– Meteorology cooperation in Ukraine, UHMC-FMI Meteorology Project. Partner: Ukrainian Hydrometeorological Center (UHMC). 2022, ongoing

– Improving the Adaptation to Climate Change by Enhancing Weather and Climate Services in Sudan. Partner: Sudan Meteorological Authority. 2020, ongoing

- Promoting the Modernisation of Hydrometeorological Services in Vietnam. Partner: Meteorological and Hydrological Administration of Viet Nam. 2019, ongoing

- Finnish-Nepalese Project for Improved Capability of the Government of Nepal to Respond to the Increased Risks Related to the Weather-related Natural Disasters Caused by Climate Change. Partner: Department of Meteorology and Hydrology (DHM). 2018, ongoing

- Capacity Building in the Field of Meteorology, Finnish-Kyrgyzstan Meteorology Project. Partner: The Agency on hydrometeorology under the State Committee on Ecology and Climate of the Kyrgyz Republic (Kyrgyzhydromet). 2018 to 2021

- Capacity Building in the Field of Meteorology, Finnish-Tajikistan Meteorology Project. Partner: The Agency on Hydrometeorology of the Committee of Environment Protection under the Government of the Republic of Tajikistan (Tajikhydromet). 2017 to 2021

- Promoting Adaptation to Climate Change by Reducing Weather and Climate-Related Losses through Improved Services in Sudan and South Sudan. Partners: Sudan Meteorological Authority (SMA) and South Sudan Meteorological Department (SSMD). 2016 to 2019.

Natural Resources Institute Finland (Luke) is a research and expert organisation with expertise in renewable natural resources and sustainable food production. It has implemented the following ICI projects since 2017:

- Institutionalising National Forest Monitoring in Myanmar. Partners: Myanmar Forest Research Institute and University of Forestry, Yezin. 2017 to 2021

- Implementation support of results and data of the first National Forest Resources Monitoring and Assessment at regional and local level in Tanzania. Partners: Tanzania Forest Services (TFS), Tanzanian Forest Research Institute (TAFORI) and Sokoine Agricultural University (SUA). 2016 to 2020

- Capacity building on novel approaches in sustainable management of forest and wood resources in Mozambique. Partners: Agrarian Research Institute of Mozambique (IIAM) and the Faculty of Agronomy and Forest Engineering of Eduardo Mondlane University (UEM-FAEF). 2016 to 2020.

The Geological Survey of Finland (GTK) is a geoscience research agency operating under the Ministry of Economic Affairs and Employment, specialising in the assessment and sustainable use of geological resources. It has been implementing the following climate-related ICI projects since 2017:

- Strengthening the Mastering of Natural Resources for National Welfare in Tajikistan. Partner: Main Department of Geology under the Government of the Republic of Tajikistan (MDG). 2022, ongoing

- Strengthening the Mastering of Natural Resources for National Welfare in Uzbekistan. Partner: State Committee of the Republic of Uzbekistan on Geology and Mineral Resources (GOSCOMGEOLOGY). 2022, ongoing

- Strengthening the Mastering of Natural Resources for National Welfare in the Kyrgyz Republic. Partner: State Committee of Industry, Energy and Subsoil Use of the Kyrgyz Republic (SCIESU). 2020, ongoing

- Managed Aquifer Recharge to Ensure Sustainable Groundwater Availability and Quality under Ongoing Climate Change and Fast Economic Development in Vietnam. Partners: The Sub-Institute of HydroMeteorology and Climate Change (SIHYMECC) and the Center for Water Resources Warning and Forecast (CEWAFO). 2018, ongoing.

The Finnish Environment Institute (SYKE) is a multidisciplinary research and expert institute, committed to solving society's most burning issues that have an impact on the environment. It has implemented the following ICI projects since 2017:

- Building Capacity of the Kyrgyz Republic on assessing the environmentally sustainable development of the Lake Son Kul. Partner: State Agency of Environmental Protection and Forestry of the Kyrgyz Republic (SAEPF). 2016 to 2018

- Marine Spatial Data Infrastructure (MSDI), Integrated Coastal Zone Management (ICZM) and Maritime Spatial Planning (MSP) in Zanzibar. Partner: Department of Urban and Rural Planning (DoURP) of Zanzibar. 2016 to 2018

- Formation of decision-making system aimed at ecological and economic development of Issyk-Kul lake's territory, based on the results of environmental monitoring. Partner: State Agency of Environmental Protection and Forestry of the Kyrgyz Republic (SAEPF). 2014 to 2018.

The Higher Education Institutions Institutional Cooperation Instrument (HEI-ICI) supports collaborative projects between higher education institutions, with the objective of strengthening the provision of higher education and developing the subject-specific, methodological, educational, and administrative capacities of the participating institutions in developing countries. The programme is funded by the Ministry for Foreign Affairs and administered by the Finnish National Agency for Education.

The ongoing climate-related HEI-ICI programmes during the funding period between 2020 and 2024 are:

- Strengthening Climate Change Education for Sustainable Development in Myanmar and Vietnam (CLIDEV). The partner institutions are the University of Helsinki and Laurea University of Applied Sciences in Finland, Yezin Agricultural University and the University of Forestry and Environmental Sciences in Myanmar, and Hue University and the Vietnam National University of Forestry in Vietnam. The associate partners are the Food and Agricultural Organization of the United Nations Regional Office, the Joint IUFRO-IFSA task force on Forest Education and the Center for People and Forests (RECOFTC).

- Problem-based-learning bioeconomy entrepreneurship and capacity building programme in Africa (PBL-BioAfrica). The partner institutions are the Häme University of Applied Sciences and Aalto University in Finland, Egerton University, the University of Nairobi, and South Eastern Kenya University in Kenya, Mulungushi University, and the University of Zambia in Zambia. The associate partners are the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), the Finnish University Partnership for International Development (UniPID), the Accelerated Growth for SMEs in Zambia Programme (AGS), as well as local associate partners in Kenya and Zambia.

During the funding period between 2017 and 2020, the following climate related HEI-ICI programmes were implemented:

- Promoting education and research on energy-efficient lighting and renewable energy for sustainable development (EARLI). The partner institutions are Aalto University in Finland, the University of Dar es Salaam (UDS) in Tanzania, Eduardo Mondlane University (UEM) in Mozambique, and Addis Abeba University (AAU) in Ethiopia. The affiliate partners are the Fundo de Energia (FUNAE), Electricidade de Moçambique (EDM), Empresa Nacional de Parques e Ciência e Tecnologia and Empresa Publica – ENPCT in Mozambique, and the Ethiopian Energy Authority in Ethiopia.

- Capacity Building in Fisheries and Aquaculture Education in the Kyrgyz Republic (FishEDU). The partner institutions are the University of Eastern Finland and the Kyrgyz National Agrarian University in the Kyrgyz Republic. The affiliate partners are the UN World Food Programme (Kyrgyz Republic Country Office), the UN Food and Agriculture Organization (Kyrgyz Republic Country Office), the Regional Central Asian and Caucasus Fisheries and Aquaculture Commission, the Department of Fisheries at the Ministry of Agriculture of the Kyrgyz Republic, and Aqua Service Ltd. in the Kyrgyz Republic, as well as Natural Resources Institute Finland, Stimulator Ltd., and Raisioagro Ltd. in Finland.

- Geospatial and ICT Capacities in Tanzanian Higher Education Institutions (Geo-ICT). The partner institutions are the University of Turku in Finland, the University of Dar es Salaam (UDSM), Ardhi University (ARU), the State University of Sansibar (SUZA), and Sokoine University of Agriculture (SUA) in Tanzania.

- Partnership for Forestry Higher Education Cooperation in Mekong Region (PARFORM). The partner institutions are the Viikki Tropical Research Institute (VITRI) of the University of Helsinki in Finland, Savannakhet University (SKU), the National University of Laos (NUoL) and Souphanouvong University (SU) in Laos, the University of Forestry in Yezin, Myanmar, and Kasetsart University (KUFF) in Thailand.

- Native Crops for Innovative and Sustainable Food Futures in Peru and Colombia (PECOLO). The partner institutions are the Finland Futures Research Centre and the Functional Foods Forum and Department of Biochemistry at the University of Turku in Finland, Universidad El Bosque in Colombia, and Universidad Agraria La Molina in Peru.

- Sustainable Management of Natural Resources in Mozambique (SuMNatuRe). The partner institutions are the University of Jyväskylä in Finland and the Eduardo Mondlane University and Zambeze University in Mozambique, as well as the University of Eastern Finland as an affiliate partner.

- Improving capacity, quality, and access of Geoinformatics Teaching, Research and Daily Application in Taita Taveta County, Kenya (TAITAGIS). The partner institutions are the Department of Geosciences and Geography at the University of Helsinki in Finland and the Taita Taveta University (TTU) in Kenya.

The Academy Programme for Development Research (DEVELOP) is funded by the Academy of Finland and the Ministry for Foreign Affairs of Finland. It provides funding to multidisciplinary, problem-based research that targets global development issues, helps boost development and capacities in developing countries and makes good use of Finnish knowledge and expertise in the field. The programme's themes are based on Finland's development policy objectives and the Agenda 2030/Sustainable Development Goals. The programme provides funding for four-year research projects.

The ongoing climate-related research programmes under DEVELOP from 2018 to 2022 are:

- Water and vulnerability in fragile societies (WATVUL). The partner institutions are the University of Helsinki and Aalto University in Finland, the Royal University of Phnom Penh and the Cambodian Institute for Technology (ITC) in Cambodia, the University of Gadjah Mada in Indonesia, and Centro de Investigaciones y Estudios Superiores en Antropología Social (CIECAS) and Colegio de la Frontera Sur (ECOSUR) in Mexico.

– Environmental sensing of ecosystem services for developing climate smart landscape framework to improve food security in East Africa (SMARTLAND). The partner institutions are the University of Helsinki in Finland, Taita Taveta University, Jomo Kenyatta University of Agriculture and Technology, the Kenya Forest Research Institute, the Kenya Wildlife Service, the Kenya Forest Service, the Ministry of Agriculture of Kenya, Duke University, the Swedish University of Agricultural Sciences, and the International Livestock Research Institute.

– Sustainable Livelihoods and Politics at the Margins: Environmental Displacement in South Asia. The partner institutions are the University of Helsinki in Finland and Shahjalal University of Science and Technology, Sylhet, in Bangladesh.

– Cuban Energy Transformation, Integration of Renewable Intermittent Sources in the Power Systems (IRIS). The partner institutions are the University of Turku and Tampere University in Finland, Universidad de Oriente, Santiago de Cuba Instituto Superior Politécnico Jose Antonio Echeverria, the Technical University of Havana, CUJAE CUBAENERGIA, and Centro de Investigacion de Energia Solar (CIES) in Cuba.

– Superior Grain Safety with Designed Mycotoxin Binding Properties (POWERGRAIN). The partner institutions are the University of Helsinki, the Department of Food and Nutrition Science (FAN) in Finland, and IRSAT DTA (Institut de Recherche en Sciences Appliquées et Technologies) in Burkina Faso.

Literature and internet links

Aalto University ice tank, https://www.aalto.fi/en/research-and-learning-infrastructures/aalto-ice-and-wave-tank

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Algaline, https://www.finmari-infrastructure.fi/ferrybox/

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Business Finland, https://www.businessfinland.fi/en

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Environmental monitoring at the Finnish Environment Institute (SYKE) and the environment administration, including National environment monitoring strategy & development program MONITOR 2020 http://www.syke.fi/en-US/Research__Development/Production_of_environmental_information

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The Finnish Association of Finnish Foundations: Climate and Environmental Measures of Foundations https://saatiotrahastot.fi/en/climate-and-environment/

Finnish Climate Change Panel, www.ilmastopaneeli.fi

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The Finnish Institute for Health and Welfare, https://thl.fi/en/web/thlfi-en

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IPCC Emission Factor Data Base, http://www.ipcc-nggip.iges.or.jp/EFDB/main.php

Natural Resources Institute Finland (Luke), http://www.luke.fi

Nordic Working Group for Climate and Air (NKL), https://www.norden.org/en/noak

Open data - The portal "avoindata" (open data). Direct links to available open data sources throughout Finland, including research institutes, national authorities, regional councils and municipalities
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Photo: IStock.com

9

Education, training and public awareness

This chapter describes how climate change is included in the education system of Finland from basic education to universities. This is followed by a portrayal of international training activities, including the training of experts from developing countries. Finally, raising public awareness is discussed. The roles of ministries, local authorities, other public bodies, non-governmental organisations, and other relevant stakeholders are explained. Several climate change or energy saving campaigns are also presented.

9 Education, training and public awareness

9.1 General policy

Climate change is incorporated in the Government's education and public awareness policies and practices. These policies and practices are under continuous development. Climate change issues are included in basic education and upper secondary level education as overarching values and as part of sustainable development education. Climate-change-related topics are also addressed by both universities and universities of applied sciences (Section 9.2).

The National Energy and Climate Strategy (2016) states that citizens should be provided with up-to-date information on all aspects of the Government's climate and energy policy. Information, guidance, best practices and tools are provided to help consumers make climate friendly choices in their everyday lives (Section 9.4). For example, international training activities are carried out by higher education institutions, and capacity building activities are also carried out as part of development cooperation (Section 9.3).

The national Medium-term Climate Change Policy Plan, in accordance with the Climate Change Act, is approved by each Finnish Government, most recently in 2017. The Government is scheduled to submit the next Medium-term Climate Change Policy Plan report to Parliament in 2022. The plan will mention the raising of education levels and advanced training in various sectors to support citizens in reducing their carbon footprints.

The Ministry of Education and Culture drafted a policy document in 2020 for the sustainable development of its administrative sector. The policy document guides the activities of the administrative sector on a sustainable basis. Education, research, culture, youth, and sport policies can contribute to all the UN 2030 Agenda for Sustainable Development goals. For example, it entails equal cultural rights, high-quality early childhood education, the raising of skills and education levels, lifelong learning, access to information, cultural rights, and wellbeing and inclusion. Overall, the activities of the Ministry of Education and Culture's administrative sector promote cultural change, which is a prerequisite for the realisation of comprehensive sustainable development.

The Government approved a strategic programme to promote the circular economy in 2021. It sets out objectives for the use of natural resources and measures by which a society based on a carbon neutral circular economy will provide a sustainable foundation for our economy in 2035. The programme highlights that knowledge, education, and continuous learning are requirements for a prosperous circular economy, as well as for solutions to the climate change challenges.

Under the Glasgow work programme on Action for Climate Empowerment (ACE), launched at the Conference of Parties serving as the meeting of the Parties to the Paris Agreement (Third session, CMA3) in 2021, the Parties are encouraged to engage all stakeholders (e.g. local governments, non-governmental organisations (NGOs), intergovernmental organisations (IGOs), business, and industry) in education, training, public awareness, public participation, public access to information, and international cooperation (= six elements of ACE) on climate change, reflecting the elements of Article 6 of the Convention. ACE serves as a framework for country-driven actions, giving the Parties flexibility in implementing and taking national circumstances and priorities and initiatives into account, while building long-term capacity and expertise in developed and developing countries for implementing ACE, including by promoting strong domestic enabling environments.

The activities this chapter describes include Finland's efforts to implement ACE. In particular, the activities of local governments are described in Section 9.4.3 and the activities of NGOs in Section 9.4.5. At the end of this chapter, there are short descriptions and Internet links to the projects, networks, and campaigns being carried out by various stakeholders.

9.2 Education

9.2.1 Education policy

All children in Finland receive compulsory basic education (comprehensive school) between the ages of seven and 16. All six-year-olds participate in pre-primary education. Having completed comprehensive school education, all students gain an upper secondary qualification. The minimum school leaving age was raised to 18 in 2021. Students continue to general (duration three to four years) or vocational upper secondary education and training (duration two to four years). The completion of upper secondary education gives students the eligibility to continue to higher education (Figure 9.1).

Higher education is offered by universities and universities of applied sciences (UAS). Both sectors have their own profiles. Universities emphasise scientific research and instruction. UASs, also known as polytechnics, adopt a more practical approach. A network of 14 universities and 23 UASs covers the whole country.

At the universities, students first complete the bachelor's degree, after which they may pursue the higher master's degree. As a rule, students are admitted to study for the higher degree. The target time for completing a master's degree is generally five years. Universities also arrange separate master's degree programmes with separate student selections, for which the entry requirement is a bachelor's degree or corresponding studies. At the universities, students can also study for scientific or arts postgraduate degrees, which are the licentiate and the doctorate degrees.

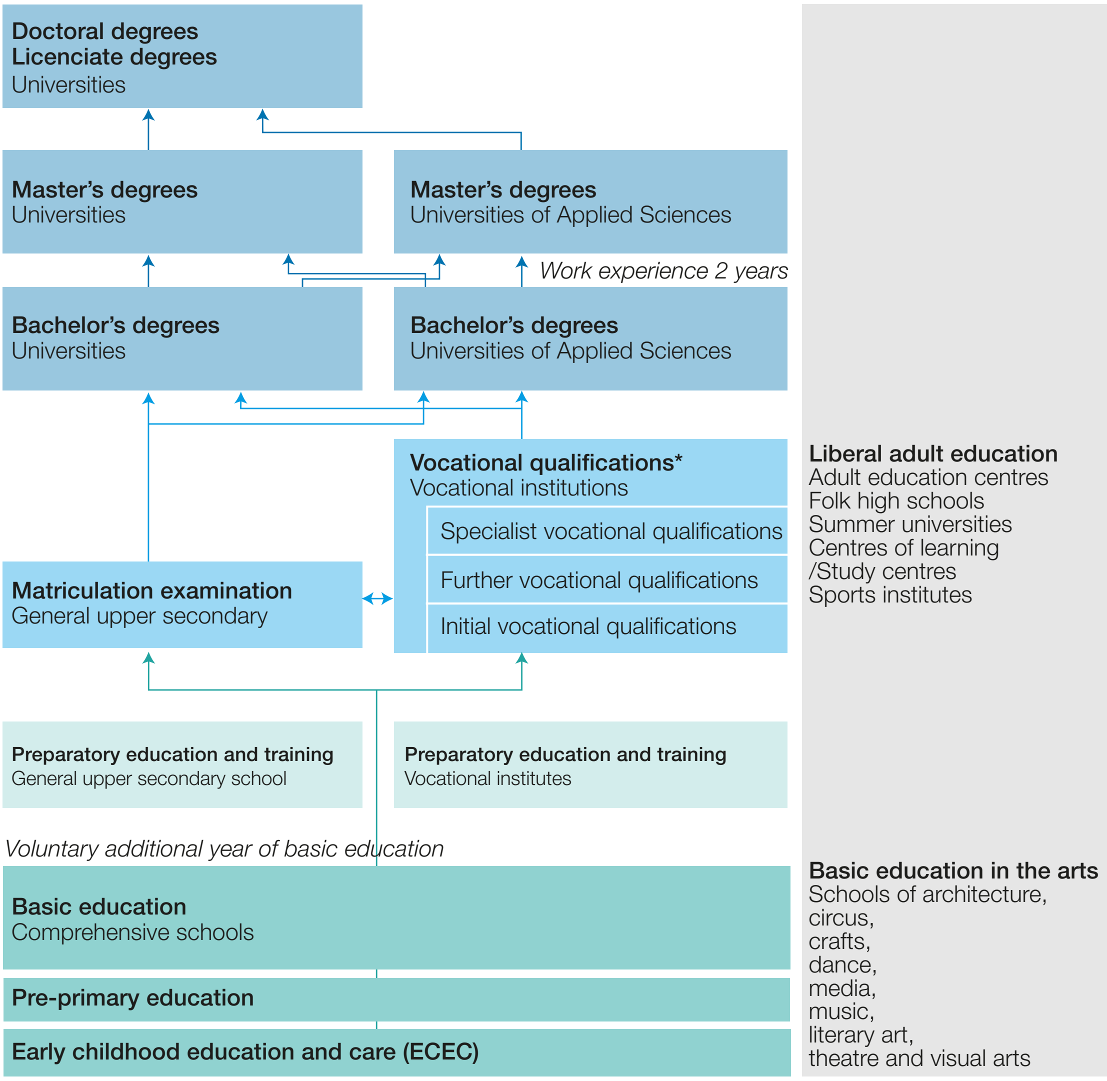
It takes approximately three to four years of full-time study to complete a UAS degree. Degree studies provide a higher education qualification and practical professional skills. Twenty-five thousand students were enrolled in universities in 2020. UASs admitted 40,000 students in 2020.

Educational institutions organise education and training intended for adults at all levels. Adult education comprises education and training leading to a degree or certificate, liberal adult education, and staff development, and other training provided or purchased by employers, as well as labour market training, which is mainly targeted at unemployed people. Efforts have been made to make the provision as flexible as possible to enable adults to study and work at the same time.

One of the basic principles of Finnish education is that citizens have equal access to high-quality education and training. Education is free at all levels, from pre-primary to higher education (degree education). Tuition fees are charged for citizens of non-EU/EEA countries in university and UAS programmes given in a foreign language. All schools in Finland are connected to the Internet.

All municipalities have at least one free public library, and there were more than 750 public libraries in 2018. About 70 per cent of Finns use libraries, which is the highest share among EU countries. The circulation of daily newspapers has decreased by 20 per cent in the last decade (355 per 1,000 adults in 2011). At the same time, the use of electronic media has grown rapidly.

Figure 9.1
Education system in Finland



* Also available as apprenticeship training by training agreement.

9.2.2 Education on sustainable development and climate change in the national curricula

Climate change issues are included in the education given on sustainable development in Finland's compulsory basic education system. Many school subjects deal with sustainable development and climate change, and they are also dealt with as a cross-curricular theme. Teachers decide the context and manner in which issues are taught. Teaching should form a systematic learning path, one that progresses through the grades.

The National Core Curriculum for Basic Education entered into force in 2014. With this curriculum, sustainability is not only one cross-curricular theme supported by some of the values in the value basis. Instead, it is the overarching task of basic education and is strongly embedded in all elements of the core curriculum. The new core curriculum, with its focus on promoting a sustainable lifestyle, represents a holistic approach to sustainability. This approach covers all dimensions of sustainability, as well as students' and the school community's developing competences and their safety and wellbeing. Sustainability is also one of the seven transversal competences in the curriculum. Climate change is especially involved in the subject level in geography and biology.

The importance of ecological sustainability and climate change should not remain abstract when handled from the global to the local level. The Finnish national core curriculum steers ecological sustainability, showing that sustainability issues play a significant role in the curriculum, and that ecological sustainability is expressed in many subjects and in some schools in the school's operating culture.

The new National Core Curriculum for Upper Secondary Schools (2019) also highlights several sustainability and climate issues. Students (aged 16 to 19) should be familiar with the main aspects of the ecological, economic, social, and cultural dimensions of sustainable development and be able and willing to act in support of sustainable development in their own lives. Climate change is especially involved at the subject level in geography and biology.

Vocational education is guided by national qualification requirements for different fields (161 qualifications). In the 2018 vocational education reform, sustainable development was included in the common parts of vocational upper secondary requirements as a compulsory component. In addition, sustainable development and environmental issues have been integrated into the foundations of professional qualifications as competence requirements and skills requirements for each profession. In some areas, environmentally conscious activities are cross-cutting. For example, agriculture, forestry, and natural sciences are based on the wellbeing and sustainability of nature. The circular economy is an important theme e.g. in the construction sector and in the textile and fashion sector, while the social and health sector adaptation to climate change is a required competence. A new optional module, Climate responsibility, will be included in all vocational upper secondary qualifications in the autumn of 2022. In addition, further vocational qualifications and specialist vocational qualifications offer the opportunity to specialise in resource efficiency and environmental education, for example.

Education also aims for transversal and lifelong learning competences. These competences refer to an entity consisting of knowledge, skills, values, attitudes, and will, and they all are required for learning about sustainability and climate responsibility. To make these more consistent and coherent and part of the learning and operating culture, the Finnish National Agency for Education has launched projects to promote sustainability, climate responsibility, and the green transition in education from early childhood to secondary education.

The main aims of the Sustainable Development Certification of Educational Establishments (see links at the end of chapter) are

- To develop the quality of teaching, the learning environment, and the operations of educational establishments,
- To implement education for sustainable development in teaching and the school culture through a comprehensive approach.

Supporting programmes and materials

Free and open websites have been published for teachers and educators working on different levels of educational system. These websites present sustainability and climate change from the perspective of subject teaching at school or school culture and offer photo material, assignments, and general information on sustainability and climate change and sustainability education. For example, the Finnish National Agency for Education unveiled the 'Sustainable future' website in 2021. It provides information and support on the various dimensions of sustainability, and how to carry out their training activities for guidance and professionals in education and training, from primary schools to secondary and liberal arts education.
https://www.oph.fi/fi/kestava-tulevaisuus

The Teacher's Climate Guide (openilmasto-opas.fi) was launched in 2016, and it serves teachers working in secondary and upper secondary schools. The Class Teacher's Climate Guide (luokanopenilmasto-opas.fi) followed in 2019 and is intended for primary school teachers. It offers information about climate change and climate education, and practical ideas about how to process climate change with primary school children aged between seven and 12. In 2021, the Early Childhood Educator's Climate Guide was published (vakanilmasto-opas.fi), the contents of which are quite similar to the Class Teacher's Climate Guide, but for use in the context of early childhood education. The guides have been produced by experienced environmental educators in cooperation with organisations working in the field. The work has been funded by foundations and partly by the state environmental administration.

The OKKA Foundation for Teaching, Education and Personal Development maintains the national Sustainable Development Certification of Educational Establishments. The certification system was established in 2004, and it is applicable to comprehensive and upper secondary schools, vocational institutions, liberal adult education, basic education in the arts, NGOs, and children's cultural centres. The certification system is based on the indicators for a sustainable future, which enable an educational organisation to evaluate how its teaching, operating culture, and management support future-oriented change agency. The indicators and supporting materials can be used to develop an organisation's activities and a sustainable development programme without a certification target. By March 2022, the OKKA Foundation has awarded the sustainability certificate to a total of 111 organisations.

Eco-Schools, the world's largest sustainable schools programme, has been run in Finland under the name Vihreä lippu (Green Flag) for more than 20 years. Currently, more than 350 schools and kindergartens are registered in the programme in Finland. Eco-Schools empowers children to drive change and improve their environmental awareness through the simple Seven-Step framework to achieve the international Eco-Schools Green Flag award. Eco-Schools develops pupils' skills, raises environmental awareness, improves the school environment, and creates financial savings. The Foundation for Environmental Education Finland coordinates the programme in Finland and supports the participants with nine thematic materials. Climate change was included in the themes in 2019.

Many projects, networks, campaigns, or competitions in and between schools support the teaching of sustainable development and climate change; they give pupils an opportunity to use their knowledge and provide teachers with opportunities for in-service training. Environment Online – ENO, RCE Espoo (Regional Centre of Expertise on Education for Sustainable Development), and Finland's Science Education Centre LUMA are examples of such projects (see also Boxes 9.1 and 9.2). More information and examples can be found at the end of this chapter. Many different public service organisations have funded NGOs to visit schools as climate ambassadors and to discuss climate change and ways to curb it. This programme has been actively pursued in the present decade, with good results.

The transdisciplinary URGENT project (2019 to 2023), funded by the Academy of Finland and coordinated by the Finnish Environment Institute, studies how to bring urban and regional planning together with formal education. The "Urban and regional planning with the young generation – collective and intergenerational learning encouraging sustainability transformations" project explores how education for sustainable development can create innovative and scalable transformative pathways to more sustainable societies. The project is establishing a dialogue between schools and planning institutions and is empowering the learning of students, teachers, planners, and researchers. The project co-develops sustainable education and planning and analyses the impact of these new practices in eliciting the progress towards sustainability and sustainability transformation in society at large.

The Just Food programme has developed sustainable school meals with municipalities and schools, involving school students in the planning of climate friendly meals. The programme established a school meal plan with a six-week rotation, that halves the climate impact of school meals compared to regular meal plans. Pupils are seen as the climate friendly food consumers of the future, and their opinions need to be carefully considered. Sustainable culinarians of the future can be guided towards better options with small changes – for example, serving vegetarian options in the same manner as meals containing meat.

Box 9.1

Science Education Centre Luma and National Luma Network

Finland's Science Education Centre LUMA is an umbrella organisation coordinated by the Faculty of Science of the University of Helsinki to bring schools, universities, and industries together. LUMA coordinates cooperation between schools, universities, business, and industry in Finland. It aims to promote meaningful and relevant learning and study and teaching of natural sciences, mathematics, computer science, and technology. A national LUMA network has also been established. LUMA celebrated its tenth anniversary in 2013. Supporting lifelong learning for children and young people centres on activity clubs, summer camps, and the Ksenonit virtual club, Science Day, and the webzine Luova for young people. The activities aim to deliver positive experiences for children and young people in the LUMA subjects. At the same time, natural interaction with the scientific community at the university is fostered. The centre organises a large number of science clubs and camps each year. The international Millennium Youth Camp has been organised annually since 2010. Subject teachers' and primary education teachers' lifelong learning is supported via workshops, summer courses, and an annual LUMA Science Fair. The Nordic Nord Start Climate Change Competition was held by the Finnish Ministry of Education and Culture in the autumn of 2021. The competition was part of Finland's presidency of the Nordic Council of Ministers in 2021 and was organised in cooperation with the LUMA Centre Finland's StarT programme. The competition aimed to gather children, young people, and adults to brainstorm concrete ways of combating climate change.

Box 9.2

Climate Change and Sustainability Education Development Project

The Finnish National Agency for Education is coordinating the Climate Change and Sustainability Education Development project (2021 to 2023). The aim is to provide organisers of early childhood, basic, and secondary education with more focused and integrated support for their environmental sustainability work. The project is based on the basics of the early childhood education plan and basic and secondary degree education curricula and qualifications. Environmental sustainability education is a component of education that supports the lifelong learning process for the sustainable values, knowledge, skills, and practices of individuals or communities. The project will also support the change in the operating culture of primary and secondary schools towards a more ecologically sustainable lifestyle and strengthen knowledge on climate change mitigation. As part of this larger development project entity, the project for the development of sustainable development and the green transition in vocational education and training is being implemented. The main task is to draw up a sustainability and green transition roadmap for vocational education and training in Finland.

9.2.3 Climate change in higher education and climate change training

Universities provide climate change education as part of different degree programmes, including environmental studies, environmental technology, chemistry, chemical technology, and energy technology. Some universities also offer postgraduate studies in climate change. Teaching related to climate change is closely tied to the research in this field.

UASs offer higher education related to climate change in their degree requirements and master's degree programmes, including in environmental engineering, energy engineering, and sustainable development.

Climate University

Climate University is a network of 18 higher education institutions in Finland that develops and fosters climate and sustainability education in higher education. The network has published a set of nine open online courses on climate change, sustainability, the circular economy, sustainability leadership, systems thinking, climate communication, statistical tools, and climate solutions. The teacher network provides peer support to lecturers teaching these topics. Climate University collaborates with the Una Europa European Universities Initiative to provide courses for larger international audiences. Climate University is coordinated by the University of Helsinki.
https://climateuniversity.fi/

Climate.now

Climate.now is a multidisciplinary study and teaching module on the basics of climate change. It contains written material, video lectures and interviews, assignments, tests, and a guide for teachers that will help anyone familiarise themselves with the basics of climate change. You can complete the study module independently or as part of your higher education studies. The scope of the whole module is five credits. In addition to teachers and students, the material can be used by companies, other organisations, and the media. Climate.now is part of the Climate University courses and is currently in the curricula of 11 higher education institutions in Finland.
https://www.climatenow.fi/

ClimComp (Academy of Finland)

Learning the competences of effective climate change mitigation and adaptation in the education system (ClimComp) is a research project funded by the Academy of Science Finland between 2021 and 2024. In this study, the competences society requires to efficiently mitigate and adapt to climate change, and how these competences are learned and taught throughout the education system, are studied in collaboration with climate and education scientists from the University of Helsinki and the Finnish Meteorological Institute.

INAR International education activities

INAR participates in and coordinates several European Union projects and nationally funded projects to educate experts, teachers, and university students about climate competences. INAR has been especially active in ERASMUS projects with several Eastern European countries. However, due to the situation in Ukraine, all education collaboration with Russian and Belarus is currently on hold. Another active field of international education collaboration is carried out with universities in China, Cyprus, Iceland and Sweden.

Further information

https://www.atm.helsinki.fi/peex/index.php/portfolio-items/projects-subprograms/?portfolioCats=35

- Multilevel Local, Nation- and Regionwide Education and Training in Climate Services, Climate Change Adaptation and Mitigation (ClimEd; Erasmus+ Programme for Capacity Building in the Field of Higher Education Action)
- Pan-Eurasian EXperiment – Finnish–Russian Earth System Research Network (PEEX-FRESReN)
- Pan-Eurasian EXperiment – Academic Challenge (PEEX-AC, Finnish National Agency for Education; FIRST+, Finnish–Russian Student and Teacher Mobility Programme)
- Modernisation of Doctoral Education in Science and Improvement Teaching Methodologies (MODEST; Erasmus+ Capacity Building in the Field of Higher Education Programme).

Climate issues are also included in the sustainable development teaching given as part of teacher education, which in Finland is a university-level programme for all teachers throughout the education system. Nevertheless, only a fraction of the country's teachers outside the natural sciences has adequate pedagogical expertise in sustainable development and climate change. Various activities to advance sustainable development exist.

Universities, UASs, and several training institutes provide continuing education programmes and vocational training in climate change and related issues, e.g. energy efficiency and environmental technology, for individuals and companies.

9.3 International training activities

Many higher education and research institutions in Finland provide international training and cooperate with research and higher education institutions, as well as governmental institutions in developing countries to support institutional development. Some examples are presented below.

Policies to promote internationalisation in Finnish higher education and research (2017 to 2025) are in the process of being implemented. A Team Finland Knowledge Network has been set up, and the team specialists are now in their duty stations. Other parts of the implementation process will be monitored and developed under the steering processes of higher education institutions and scientific institutions, as well as in the International Forum, which will include participation by various university networks and other stakeholders. The higher education institutions are expected to utilise their research and expertise to solve global problems and consolidate the knowledge base in developing countries. All eligible students, regardless of their nationality, can apply for the higher education degree programmes. Around 20 per cent of degree programmes in higher education institutions are international degree programmes, with English as the teaching language. In 2019, the share of international students in UASs was 6.6 per cent. In universities, it was 6.9 per cent.

Six out of 12 master's degree programmes at the University of Eastern Finland's (UEF) Faculty of Science and Forestry directly target the sustainable use of natural resources and climate change mitigation. During the last decade, these programmes, run in partnerships with European, North American, Russian, Chinese, Brazilian, and Ghanaian universities, have trained more than 100 experts, representing more than 50 nationalities. Furthermore, the UEF Faculty of Science and Forestry trains international climate change specialists in its doctoral programmes in forest sciences and in the biology of environmental change. Furthermore, postgraduate training in Arctic biogeochemistry is part of the Nordic Center of Excellence's "Impacts of a changing cryosphere: Depicting ecosystem-climate feedbacks from permafrost, snow and ice (DEFROST)" network.

The training of experts from developing countries in managing forests and other natural resources is an integral part of the agricultural and forest science programmes at the University of Helsinki. One example is the Viikki Tropical Resources Institute (VITRI), which is part of the Faculty of Agriculture and Forestry; the institute has maintained a strong focus on rehabilitating degraded natural and human-made production systems, including agroforestry systems, and on the various products and services provided by these systems across the different ecological zones in Asia, Africa, and Latin America. More than half the doctoral students come from developing countries such as Sudan, Thailand, and China.

The Sustainable Global Technologies (SGT) programme is a multidisciplinary educational programme at the Aalto University School of Engineering. The SGT programme aims to increase awareness, education, and research in the fields of sustainability, development, and technology. It offers a special module in Sustainable Global Technologies at Aalto University. The SGT programme is an example of a UN Habitat Partner University Initiative;

it is also collaborating with the United Nations Environment Programme (UNEP). Aalto University is also one of the partnering universities in the Environomical Pathways for Sustainable Energy Services (SELECT) master's degree programme. SELECT is part of the Erasmus Mundus Programme, an EU-funded cooperation and mobility programme that aims to enhance the quality of European higher education and to promote dialogue and understanding between people and cultures through cooperation with third countries. SELECT will be extended to include a doctoral programme as well.

Training activities in developing countries are also implemented through development cooperation financed by the Ministry for Foreign Affairs. The main financing instruments are the Institutional Cooperation Instrument (ICI), Higher Education Institutions Institutional Cooperation Instrument (HEI-ICI) and the Academy Programme for Development Research (DEVELOP). Details about these instruments, as well as lists of projects funded between 2017 and 2021, are provided in Chapter 8.4 (Capacity building in developing countries).

At the University of Eastern Finland (UEF), the Faculty of Science and Forestry coordinates and participates in various education and research projects that target capacity building in the areas of sustainable forest use and environmental studies. Currently, projects are being carried out in West Africa (Sierra Leone and Burkina Faso), Venezuela, Ghana, Uganda, India, and Kenya. These projects deal with bioenergy issues and carbon sequestration and focus on strengthening climate expertise through curriculum development at local universities, for example. VITRI is an active participant in the development of the forestry sector in Sudan, Kenya, Ethiopia, Thailand, Indonesia, and Laos.

The Finnish Meteorological Institute (FMI) has coordinated several development cooperation projects funded by various development funding institutes such as the World Bank, Asian Development Bank and the Ministry for Foreign Affairs of Finland (MFA). Many of these projects are funded using the Institutional Cooperation Instrument (ICI) of MFA, which enables close cooperation with partner institutes focusing especially on human capacity building. The projects the FMI coordinates always include a strong training component, and the subjects of the training typically include adaptation to climate change. For example, capacity building has covered adapting to the changes in the intensity and frequency of extreme weather events that require the extensive development of early warning services. The sectors, in addition to the partner institutes, that benefit from the training include traffic, agriculture, health, and energy production. The FMI also trains researchers from other countries, either on site in their own countries (for example, in Africa and Central Asia) or in Finland. More information on climate-change-related capacity building projects being carried out in developing countries is presented in Section 8.4.

The Nordic office of the Energy and Resources Institute (TERI, India) was established in 2012 at the UEF to promote collaborative activities between organisations in the Nordic region and India on issues related to sustainable forestry, the bioeconomy and renewable energy. The TERI Nordic office provides a platform in which academic and business communities can interact with each other in joint research collaboration and the transfer of technological expertise.

Finland participates actively in EU initiatives which promote international cooperation in exchanging and developing good practices in the fight against climate change. In the EU Programme for Education, Training, Youth and Sport (Erasmus+), an important priority is "Environment and fight against climate change", which has been the focus of many international projects and mobilities implemented within the Programme with Finnish coordination. For example, the whole school approach, education for sustainable development in general and the training of real estate energy efficiency has been developed in international cooperation.

Finnish higher education institutions participate actively in Erasmus+ Capacity Building in Higher Education projects supporting the development of higher education in countries outside Europe. The CBHE projects support the relevance, quality, modernisation and resilience of higher education in the partner countries and promote the general priorities of the European Commission, such as the Green Deal, digitalisation, sustainable growth, peace and security.

A new strategic partnership programme is the Digital climate change curriculum for architectural education: methods towards carbon neutrality, implemented by University of Tampere.

Finland has participated actively in the quest for ways to decrease the carbon footprint of the Erasmus+ Programme, using the Account, Reduce and Compensate principle. Between 2019 and 2021, the Finnish National Agency for Erasmus+ coordinated an international Working Group with representatives of the European Commission and some other National Agencies of Erasmus+. Its main purpose was to account for the carbon footprint of the whole programme and analyse various compensation scenarios. Moreover, proposals and recommendations were made to steer the choice of transport means to decrease the share of flights, including actions related to programme design and management, as well as awareness raising. The result is available in the publication: Feasibility study on compensation scenarios for the new and greener Erasmus+ programme 2021–2027.

9.4 Public awareness

According to the Finnish Climate Barometer 2019 survey, Finns wished to see solutions to the climate crisis in the priority themes of the next Government term and Finland's Presidency of the Council of the EU in 2019. Growing numbers of Finns have also changed their own behaviour to mitigate climate change.

Four out of five Finns consider that urgent action is required to mitigate climate change. The future Government should introduce even more policy measures to effectively mitigate climate change than people thought before the previous general elections (an increase in the share of respondents from 52 per cent in 2015 to 70 per cent in 2019). Seventy-five per cent of the respondents want the EU to serve as an example in climate change mitigation, independent of how this may affect the EU's competitiveness, and two out of three Finns consider that Finland should be a trailblazer in the introduction of new solutions that help reduce emissions. Concerning general elections, 44 per cent of Finns would vote for a candidate active in climate change mitigation.

Three out of four consider that one of the principles applied in taxation should be that those who cause emissions also pay for them, which means taxation can be reduced elsewhere. Almost half of Finns think taxes on fossil fuels and meat and milk products should be increased. As many as a third of Finns would be prepared to ban the sale of new petrol- and diesel-powered passenger vehicles in 2030.

The concern about the impacts of climate change is already reflected in everyday choices. In 2015, only 29 per cent of respondents reported that they had changed their own behaviour because of climate change; in 2019, the percentage was 41 per cent.

More than half of Finns have reduced electricity consumption, and almost half the population are buying less for climate reasons. About a third have calculated their own carbon footprint, and a quarter intend to compensate for the emissions they are causing in the next few years. Well over half the respondents wish to have more information about climate change and advice in making climate-smart choices.

The media coverage of climate change has been extensive in Finland. Partly as a result of the media debate, the general public considers some issues serious environmental problems; some risks are amplified, while others are attenuated. Peaks in climate coverage have been caused by international policy negotiations such as the Paris Climate Change Conference in 2015 and mild winters. Other contributing factors have included the release of EU and government policies on emissions reductions, releases of major scientific reviews, expressions of concern by key actors, and the related debate on energy policy.

As an example of public awareness and information regarding climate policy actions: the Finland's Eighth National Communication under the United Nations Framework Convention on Climate Change was released to an open public opinion in 2022. A similar procedure was carried out with the previous national communication.

Box 9.3
The Year of Research-Based Knowledge 2021 in Finland

The Year of Research-Based Knowledge was a joint initiative organised by the Ministry of Education and Culture, the Academy of Finland and the Federation of Finnish Learned Societies. Its aim was to make research-based knowledge even more visible and accessible and to intensify the collaboration between organisations working with research-based knowledge.

The theme year gathered actions and events in a programme that gave a comprehensive view of research-based knowledge and its role in the wellbeing of individuals and functioning of society, for example.

There were around 440 separate actions and events under the umbrella of the Year of Research-Based Knowledge. Dozens of the actions and events were directly related to climatic issues or environmental matters.

The Year of Research-Based Knowledge increased the visibility of various sources of knowledge, including statistics, reports and analyses, as well as highlighting the fundamental nature of knowledge, where knowledge is updated as new research results emerge.

The theme year was aimed at everyone living in Finland, as well as decision makers and business and industry. A specific aim was to provide children and young people with creativity, inspiration and hope for the future.

How was the programme built?

The programme of the Year of Research-Based Knowledge consisted of actions and events produced by network partners.

Any organisation, association, or group working with research-based knowledge could apply to become part of the programme with their event, act, campaign, exhibition, artwork, intervention, or development project.

The theme year's coordination provided the network partners with a collaboration platform to increase national visibility and enable new partnerships.

The partners implemented the year's objectives alongside their own goals and raised awareness of the year and its programme among their stakeholders.

The theme year's coordination, communication and collaboration contributed to implementing resources more efficiently and increasing the visibility and accessibility of the events and actions at local and national level.

9.4.1 Climate change communication

Communications on climate change are handled by many different organisations. Cooperation is therefore needed to ensure actions are well coordinated. Since 2010, the Ministry of the Environment has had the official responsibility for coordinating the cooperation on climate change communications. The steering group for climate change communications was appointed for its fourth term in 2022. The steering group is composed of all relevant ministries (the Ministry of Agriculture and Forestry, the Ministry of the Environment, the Ministry of Economic Affairs and Employment, the Ministry for Foreign Affairs, the Prime Minister's Office, and the Ministry of Finance), research organisations (the Finnish Environment Institute SYKE, the Finnish Meteorological Institute FMI, the VTT Technical Research Centre of Finland, and Natural Resources Institute Finland Luke), regional organisations (Centres for Economic Development, Transport and the Environment, and the Association of Finnish Local and Regional Authorities), the Finnish National Agency for Education, Business Finland, the Finnish Innovation Fund Sitra, Motiva (see Section 9.4.2) and Demos Helsinki. In recent years, the composition of the steering group has been expanded as the number of organisations in which climate issues have become prominent, and cross-cutting themes in communications continue to grow. The aim of the cooperation is not only to coordinate climate- and energy-related communication but also to carry out common communication projects and share best practices and expertise. The cooperation makes it possible to consider climate change communications from a wider perspective than that of each individual organisation.

In 2019 the steering group conducted a Climate Barometer: the group designed a survey on Finnish citizens' views concerning climate change issues. It was conducted by KantarTNS before the last parliamentary elections. Some key results are presented above in Section 9.4. The results were widely covered in the media, and they have since often been referred to in different kinds of presentations, publications and the media. The previous Climate Barometer was conducted in 2015.

The various organisations in the group have organised national events in connection with publication of various IPCC reports that have been open to all. The group has communicated on the content of the IPCC reports through various channels, including press releases, blogs, infographics and social media (see an example in Figure 9.2). The reports have been widely noted in both traditional and social media. The work on raising public awareness of the IPCC assessment reports has been rewarded by the Institute of the Languages of Finland as an exemplary work to make climate change and related Government policies more understandable and interesting for the general public. Infographics produced from each IPCC report can be freely used by anyone. In August 2020, the messages of the IPCC 1.5-degree report were widely covered in the Finnish media. An open event was organised and streamed nationwide, connecting the report's core messages to national and international climate policy. To help media and stakeholders spread the report's messages, its infographics were published. They can be freely used by anyone.

The steering group on climate change communications participated in producing the content for a country brand narrative about Finland as a climate actor, prepared by the Ministry for Foreign Affairs with other ministries and stakeholders in 2021. The group also participated in the production of a slideshow that presents practical examples of Finnish climate actions. The material is intended for both climate change communications and discussions of climate actions as part of official duties.

At the end of 2021, the Ministry for Foreign Affairs published the "Until We Act" communications concept and an associated website, based on the country brand narrative about Finland as a climate actor and the related slideshow. The steering group on climate change communications also participated in designing the concept and website.

The aim of the cooperation is not only to coordinate climate- and energy-related communication but also to accomplish common communication projects and share best practices and expertise. The cooperation makes it possible to consider climate change communication from a wider perspective than that of each individual organisation.

Encouraging the public to participate in the planning of Finland's climate policies continued in 2016 with an open online platform, energiajailmasto.fi, on which anyone, regardless of their background, could comment on the planned climate strategies and measures of emissions reduction.

Nominated by the Finnish Ministry of the Environment for the first time at the end of 2011, the interdisciplinary and independent Climate Change Panel of researchers and academicians aims to enhance communication between science and politics in issues related to climate change (see Section 4.2.2 for the role of the panel in policymaking and Box 8.2 for its research activities). The Finnish Climate Change Panel has actively participated in the public debate by releasing statements, organising discussions, developing consumer tools to support climate-friendly decision making (see Box 9.4), and interacting with the media, decision makers and other stakeholders.

The Finnish Innovation Fund Sitra's work on promoting sustainable lifestyles with practical suggestions for positive changes, a lifestyle test, surveys, development programmes and information compiled on the environmental impacts of everyday life has led to the creation of a multinational EU-funded PSLifestyle project, which will develop an online service for European citizens with personalised and culturally relevant suggestions through which people can build their own sustainable good life plans based on their carbon footprint.

Box 9.4

Cost and Emissions Calculator for Cars

The Cost and Emissions Calculator for Cars ("Autokalkulaattori" in Finnish) is an online calculation tool. The tool was developed by the Finnish Climate Change Panel and the Finnish Environment Institute. It helps consumers choose which type of car to buy, based on lifecycle emissions and costs. The tool calculates cumulative greenhouse gas emissions and adds up purchasing and running costs over a car's lifetime. The purpose of this tool is to help compare both costs and emissions at the same time to help consumers make an informed decision.

The emissions and cost calculations are based on default settings based on information from car manufacturers, best available scientific knowledge and the user's own estimation of kilometres driven per year. The user can adjust all the settings. For example, the default setting for the emissions factor for electricity is the average emissions factor for the Finnish grid, but it can be altered if the source of electricity is known. The results of the calculation are shown in graphs and charts, which adjust in real time when elements of the calculations are changed, and up to six different car scenarios can be compared at the same time.

Many of the Government organisations provide training for various stakeholders, both independently and through the Steering Group for Climate Communications. For example, the Finnish Meteorological Institute has organised annual training about climate change for journalists since 2006. In 2020 and 2021, the training was organised virtually, enabling even wider participation of journalists from anywhere in Finland. To date, around 500 journalists have already participated in the training. The participants are journalists covering a wide range of subjects such as the environment, politics, economics, and technology.

One result of the cooperation between various organisations is the national web portal on climate change, Climateguide.fi, which was launched in 2011. The main language of the portal is Finnish, but much of the information is also available in Swedish and English. The website provides scientific background information on various aspects of climate change, as well as a tangible means for mitigation and adaptation. Climateguide.fi features web articles, checklists, observational and modelled data, mapping tools, interactive visualisations, videos and learning assignments. The website raises awareness about climate change and its implications for Finland and supports society and citizens in mitigating climate change and adapting to it. It also serves as a platform through which key Finnish research institutions and projects can disseminate their information in a user-friendly way. Climateguide.fi is especially targeted at the general public and decision makers and experts in various sectors, students and teachers, and the media. The FMI, SYKE, and Luke share responsibility for the content of the web portal, as well as for updating and further developing it. There are also plans for more research institutions to join.

The national IPCC working group coordinates and presents Finnish standpoints in the IPCC reports. It aims to raise awareness about the IPCC's work in Finland and the Finnish contribution to it. The communications department of the FMI is responsible for communications about the IPCC's activities and works in close cooperation with the communications department of the Ministry of the Environment. The most important channels are press releases and conferences, seminars for decision makers, and training programmes for journalists. These are put together in cooperation with the Finnish scientific community.

The Climate Policy Round Table was launched in February 2020, and it met for the first time in May 2020. Due to the Covid-19 pandemic, the start of the Round Table was delayed and meetings are held remotely for the most part. The Round Table discusses key Government initiatives and legislative proposals aimed at carbon neutrality, as well as roadmaps, especially from the perspective of a fair transition.

The purpose of the Round Table is to create a common understanding of how Finland can make a just transition to a carbon neutral society by 2035, and the discussion of the Round Table has been fruitful for this purpose. A good overview of different opinions of several sectors of society has been gained from the discussions about a carbon neutral society, which can be utilised in official preparation, as well as policymaking. The material of the meeting is distributed to the Government servants who are responsible for the issue discussed, and the outcomes of the meeting are presented to the Ministerial Working Group on Climate and Energy Policy.

The Prime Minister chairs the Round Table. In her absence, the Minister of the Environment and Climate Change usually chairs the meeting. All the Vice Chairs usually participate in the meetings as well. The selection of the members was decided by the Ministry of the Environment in close cooperation with the Prime Minister's Office. The Prime Minister's Office officially conducted the process of appointing the members. The Round Table consists of four Vice Chairs, 20 members, and three Representatives of Expert Bodies.

The starting point for setting up the Round Table was that it would be a high-level confidential discussion forum. The Round Table is therefore limited to a certain number of persons and entities. The Round Table uses the Chatham House Rule, which supports a confidential atmosphere (e.g. direct quotations from another member's speech are not allowed in communication). The selection was made to ensure the Round Table represented various actors or sectors of society. From a regional and social perspective, the composition of the Round Table recognises the active role of young people in climate issues. One of the Vice Chairs represents the Finnish National Youth Council, Allianssi, and one of the members represents the Agenda 2030 Youth Group. The Round Table also includes representatives of the Sámi Parliament and municipalities, who will play an important role in achieving Finland's climate neutrality target by 2035.

Preparations are made in cooperation with Special Advisers to the Ministers (e.g. meetings, workplans, etc.). The youth representative and the representative of industry are involved in planning the meetings and developing the general work of the Round Table with the Secretariat.

Finland has also had a national Citizens' Jury on Climate Action. The national Citizens' Jury contributed to the assessment of the fairness of the climate actions. The Jury formulated a considered public opinion on 14 different climate measures related to food, housing and transport. The outcomes of the Jury were introduced to the Round Table's meeting in May 2021.

The results of the Jury were handled by the Working Group for Medium-Term Climate Change Policy Plan. The working group consists of Government officials from several ministries.

The statement of the Jury has been documented as part of the Medium-Term Climate Change Policy Plan. From the point of acceptability, the Jury's and other key initiatives that have emerged from the consultations (e.g. Sámi and youth consultations) are presented in the plan, and it is explained how they have been taken into account.

The final report about the Citizens' Jury was completed at the end of June 2021. The main findings of the Citizens' Jury included that the new Climate Policy Plan should consider the economic impact of the actions on individuals and different socioeconomic segments, as well as regional equality. The Jury also hoped that it would be possible to live and take part in everyday activities everywhere in Finland in future. In the general observations, the Jury also highlighted the allocation of tax revenues in public administration and municipalities to climate-friendly traffic, housing, and food, as well as the importance of steering by information so that all citizens have an adequate knowledge of the impacts of climate actions and e.g. different types of allowances and deductions.

In addition, the Ministry of the Environment has been testing several methods and innovations to engage in reforms to the Climate Act, utilising a human-rights based inclusive approach to consultation and working with a range of external partners. Methods include an online survey in six languages (English, Swedish, Finnish and three Sámi languages); consultations in different cities with the public; consultations with stakeholders (e.g. municipalities, legal experts); consultations with young people in schooltime via the all-Youth project; dialogues with journalists; online discussions using the Timeout platform, meetings with climate activists in small groups; hearings; and workshops with Sámi youth in Finnish and Sámi. In October 2020, human rights-related discussions were planned through the BIBU research project.

The implications of climate change have a particularly strong influence on Arctic regions and indigenous peoples such as the Sámi. The Government has therefore also officially negotiated with the Sámi Parliament in relation to the Climate Act. Language rights have been protected in the negotiations. There have also been online consultations in the three Sámi languages.

The Ministry of the Environment is preparing a climate mid-term plan for 2035. In the online questionnaire related to the climate plan, there was a total of more than 18,000 participants between January and February 2021. The aim was to ask what climate policy measures citizens found fair and just. The main findings included that citizens preferred climate measures that included financial incentives and information support.

Youth consultations

The Agenda 2030 Youth Group was established in the spring of 2017 under the Finnish National Commission on Sustainable Development led by the Prime Minister. The Agenda Youth Group has two aims: to serve as an advocate for the goals and participate in the national planning and implementation of the Sustainable Development Goals. The Finnish Agenda 2030 Youth Group is composed of less than 20 people aged between 15 and 28 from all over Finland and with a variety of backgrounds.

The Youth Group is invited to various stakeholder meetings in the ministries, and it attends workshops, discussions, and events on sustainable development. The members serve as advocates and participate in the dialogue and debate on the goals in national contexts. For example, the group has organised a panel session for presidential candidates on climate change and a youth climate summit in March 2019, which involved 500 young people. As a part of their summit, they prepared a declaration on climate change, which was sent to Members of Parliament.

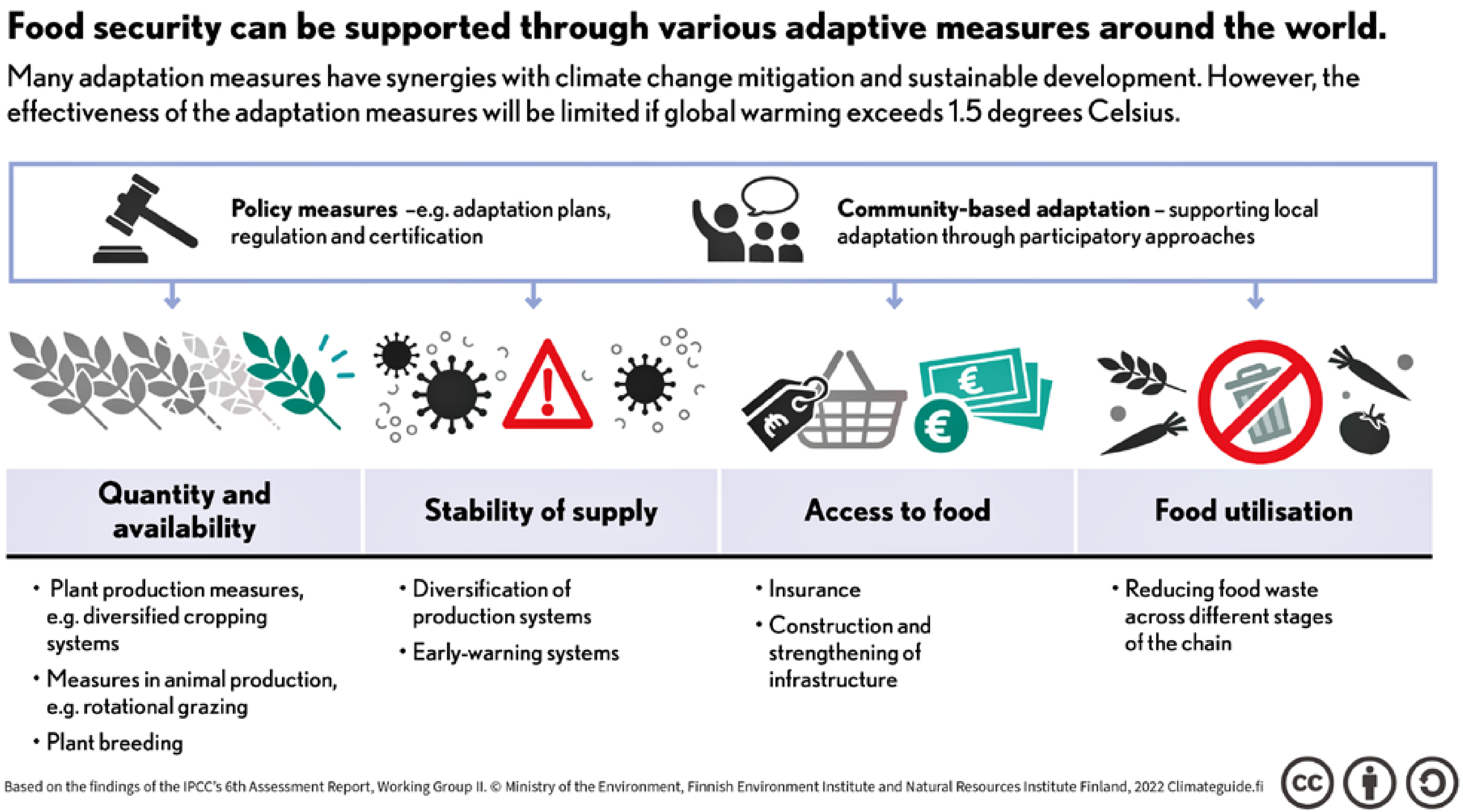
Finland has also supported the World Summit of Students for Climate, which has strengthened the participation of young people in several countries and created a considerable amount of new carbon sinks. The World Summit of Students for Climate took place between 29 May and 5 June 2019 in Finland. The summit was initiated and organised by ENO Schoolnet in cooperation with the cities of Helsinki and Joensuu, the municipality of Liperi, the Ministry of the Environment, and the Ministries of Agriculture and Forestry, of Education and Culture and for Foreign Affairs. One hundred and thirty-five students and 100 teachers from 70 countries were involved. The students discussed climate change and forests based on their preliminary assignment, and they committed to start planting trees (tree planting and tree adopting schools). They voted on the actions they could take as students and created the Climate Action Plan 2019–25. Teachers had workshops in the field of education, the natural sciences and the circular economy, for example. The ultimate goal is to tie three million tonnes of carbon dioxide by 2025. The summit was endorsed by the President of the Republic of Finland, Sauli Niinistö.

Finland has also funded the 2020 Earth School platform (UNEP and Ted-Ed), which includes an extensive amount of environmental education materials. Several Finnish environmental educators were involved in creating content.

There have also been separate consultations for young people between 2020 and 2021 in cooperation with researchers and NGOs. Youth Climate and Nature Summit was held in Finland in October 2021, gathering hundreds of youth to discuss climate action.

In addition, children and young people themselves have been active in many forms. One of the most visible is the rap group Biolapset, which includes children between the ages of eight and 14. They have sung for the climate at various public events.

Figure 9.2
Food security can be supported through various adaptive measures around the world – an example of the infographics made based on the results of the IPCC's Sixth Assessment Report and published in the Finnish climate change portal Climateguide.fi.



9.4.2 Raising awareness about energy efficiency

Communications on energy efficiency is mainly the responsibility of two ministries, the Ministry of Economic Affairs and Employment and the Ministry of the Environment, and of other Government bodies, research institutes, and state-owned organisations, e.g. Motiva. Motiva is a fully state-owned sustainable development company that encourages the efficient and sustainable use of energy and materials. Motiva provides information, solutions, and services to public administrations, businesses, municipalities, and consumers to enable them to make resource-efficient, effective, and sustainable choices. Motiva contributes to energy education through specific projects and campaigns in schools and enhances the energy competence development of professionals in various sectors through online training materials. Motiva also coordinates several communications and awareness-raising activities.

Energy Awareness Week

Motiva has successfully run the National Energy Awareness Week and the specific energy awareness week for primary schools since 1996. The theme week in October has become an established annual event, during which companies, municipalities, schools, and other organisations and households concentrate on undertaking energy actions and promoting the sustainable use of energy – voluntarily. The week offers a great opportunity to act on and to communicate about mitigating climate change, promote energy efficiency, and make sustainable choices.

Motiva provides Energy Awareness Week participants with tools, tips, informative materials, and support for communications. Motiva communicates on the theme week and participants' actions through its communication channels, especially on social media. The campaign reaches hundreds of thousands of Finns every year. Energy Awareness Week is supported by the Finnish Energy Authority.

The rational use of energy and materials and understanding their meaning are an important civic skill that is good to teach children from an early age. Along with increased awareness and positive attitude changes, one of the main objectives of the Energy Awareness Week for Schools is simply to encourage pupils to act on their knowledge. The theme week also aims to spread energy efficiency information and activities to homes. The Energy Agent Adventure is a competition for school children, where classes compete for two weeks to see who succeeds in doing the most tasks that save energy in school and at home. The top five classes win prizes. Local energy companies and municipalities support the schools by sponsoring the Hey, everything is working! material package and Children's Energy Books for schools. Tens of thousands of children learn about energy during the theme week every year.

Advice and guidance to consumers on sustainable choices

The nationwide consumer energy advice service provides information and ideas on how to save energy, the environment, and the climate at home. The target group of the advice is consumers, housing associations, municipalities, and small and medium-sized enterprises (SMEs). The core of the activity is to provide high-quality and reliable information and tools to support their energy decisions. Regional energy advisers in all Finnish provinces provide unbiased and free information about how to increase energy efficiency and use of renewable energy through online energy advice on Facebook @ Asiaaenergiasta, by email, and through the Energy Advice Phone Service.

Motiva coordinates the consumer energy advice efforts by providing advisers with supportive services such as a website and Facebook page, training webinars, tools, marketing, and promotional and networking support. The network of regional advisers meets annually to exchange experiences and best practices and for training. The work is supported by a broad-based advisory steering group chaired by the Energy Authority. The Finnish Energy Authority funds the activities.
https://www.motiva.fi/koti_ja_asuminen/kuluttajien_energianeuvonta

Mobility management

The Finnish Transport Agency Traficom supports the development of smart mobility through annual state grants for mobility management, which are intended for municipalities, local authorities, and non-profit organisations. Grants can be applied for a variety of projects that aim to influence people's travel choices and strengthen sustainable mobility habits, either through the provision of information or service experiments. In 2022, 35 projects were awarded grants totalling around EUR 1.21 million. Traficom also supports the European Mobility Week in Finland, which activates municipalities and other actors to spread information on sustainable mobility and involve citizens through various activities.
https://www.liikkujanviikko.fi

Advice on home renovation

The advice network on the renovation of buildings, managed by the Ministry of the Environment, gives advice to homeowners, tenants, housing associations, and real estate managers. The network provides advice and online tools, for example, for finding professional service providers and the proper recycling of construction materials. A key focus of the advice is to improve the energy efficiency of the building when it is renovated. The advice is free of charge. The ministry arranges an annual renovation advice networking event for exchanging experiences, best practices, and common challenges, and for networking.
https://www.ymparisto.fi/fi-fi/rakentaminen/korjaustieto/korjausneuvonta

Home repair advice for the elderly over 65

The Finnish Association for the Welfare of Older People has regional home repair experts who provide home repair advice for the elderly, e.g. by helping veterans and older people to assess and plan home renovation and apply for repair allowances. If necessary, they also help in finding contractors to carry out the repairs. The repair advice is provided free of charge. A free phone service is available on weekdays.
https://vtkl.fi/toiminta/korjausneuvonta

Photovoltaics for homes

Photovoltaics for homes (Aurinkosähköä kotiin) is an annual nationwide campaign (March to September) whose aim is to increase Finns' knowledge of photovoltaics and its suitability for houses and housing associations, and to provide information on procurement costs and service providers through an online comparison service. The campaign website provides reliable and unbiased information on photovoltaics and its procurement.

The service enables homeowners and housing companies to compare and procure PV systems between preapproved offers by different PV system providers. The service provides an online tool for bidding. The service provides: 1) advice on solar energy – the benefits of solar electricity; information on systems; a calculator for sizing; step-by-step instructions for procurement; 2) preapproved offers from PV system providers; 3) a tool for bidding for single family houses and housing companies, incl. small businesses. A national service since 2018, operated by Motiva, supported by the Energy Authority.
https://www.aurinkosahkoakotiin.fi

9.4.3 Local activities

In Finland many municipalities have a climate strategy or are in the process of preparing one. These municipalities have incorporated climate change mitigation into their practices (see Section 4.2.5).

The municipalities play a decisive role as intermediators of information regarding attitudes towards climate issues and enabling changes in people's lifestyles. Many municipalities are committed to reducing their greenhouse gas emissions and encouraging citizens to contribute to combating climate change.

Carbon Neutral Municipalities Network

The Towards Carbon Neutral Municipalities (Hinku) network brings together municipalities, businesses, citizens, and experts to create and carry out solutions to reduce greenhouse gas emissions. The municipalities involved are committed to reducing greenhouse gas emissions more extensively and rapidly than EU targets require. The network aims to create solutions that have economic and social benefits, as well as environmental advantages. There are now more than

80 Hinku municipalities and five Hinku regions in the network. The Hinku municipalities are home to 2.2 million inhabitants, covering about 40 per cent of the Finnish population. The municipalities in the network are committed to an 80 per cent reduction in greenhouse gas emissions from 2007 levels by 2030. The tools offered to the partners are based on research and aim to deliver scientific knowledge and expertise to practise and excel in forming a climate-smart Finland. The tools include carbon footprint calculators and the sharing of best practices. The results are encouraging: climate emissions in Hinku municipalities decreased between 2007 and 2020 by 36 per cent. The Hinku network is coordinated by the Finnish Environment Institute SYKE.
https://www.hiilineutraalisuomi.fi/en-US/Hinku

Finnish Sustainable Communities Network

Another indication of the determination at the local level is the FISU network – Finnish Sustainable Communities. FISU municipalities form a group of forerunner communities committed to becoming carbon neutral and waste-free, as well as curbing overconsumption by 2050. The municipality, businesses and other local operators build a common vision and roadmap to achieving these goals. They identify new ways of working and cooperation. The idea is to strengthen the municipal and regional economy, create jobs and promote sustainable wellbeing. The network is coordinated by the Finnish Environment Institute SYKE and Motiva, which together form a service centre in support of the FISU municipalities. The service centre conveys topical information and competence to the municipalities and other interest groups and promotes the FISU network in the national media and in events related to the theme of best practice in pioneering, provides reliable information on new opportunities and develops practices in a peer-to-peer network.
https://www.fisunetwork.fi/en-US

Climate Information Advisory Service

The Climate Information (Ilmastoinfo) advisory service, delivered by the Helsinki Region Environmental Services Authority (HSY), advises residents and housing associations in the Helsinki metropolitan area. The advisory service help in a wide range of energy issues; matters related to the use of equipment and properties, energy renovations of buildings, or on the transition to renewable energy. Climate Information runs housing company energy expert training courses focusing on the basics of a housing company's energy consumption and energy efficiency, also as online training at https://koutsi.hsy.fi/. The advisory services are free of charge.
https://www.hsy.fi/ilmastoinfo/

Industrial Symbiosis in Finland

FISS (the Finnish Industrial Symbiosis System) is a concrete tool for promoting the circular economy. FISS is a collaborative approach that helps companies

and other actors make better use of resources and generate new business. The FISS model is based on the active promotion of symbiosis, i.e. facilitation and co-development. The goal is also to increase the value added of materials and create new competitive products and services. FISS aims to promote new business opportunities, the reuse of waste, and reducing the use of natural resources. The goal is also to advance the implementation of a waste hierarchy. FISS activities promote the resource efficiency of various actors in the regions and can be seen as an important tool in regional development and the economy. Motiva coordinates FISS at a national level, and the identification and promotion of symbioses is done at a regional level, where regional organisers work with companies and help them.
http://www.industrialsymbiosis.fi/

Active and Sustainable Journey to School

Active Journey to School (Fiksusti kouluun) is a programme to promote more sustainable and active school journeys to reduce traffic-related emissions and promote physical activity on the way to school. The programme aims for better traffic safety, an enhanced and sustainable physical activity culture in schools and teaching, support for strategies, and operating models for active and sustainable journeys to school. The programme offers information and advice for the planning and implementation of smarter journeys to school. The programme has been running since 2018. Fiksusti kouluun is a joint programme of the LIKES Research Centre for Physical Activity and Health, the Network of Finnish Cycling Municipalities (Pyöräilykuntien verkosto), and Motiva to promote sustainability and physical activity in school journeys. It works in cooperation with the Schools on the Move programme. The programme is funded by the Ministry of Education and Culture and the Finnish Transport and Communications Agency Traficom.
https://fiksustikouluun.fi

Sustainable Commuting to Work

The Sustainable Commuting to Work (Fiksusti töihin) website provides facts and tips for more sustainable commuting to work, as well as for transitions during the workday. Road transport creates a significant part of greenhouse gas emissions and other environmentally harmful emissions such as small particles and hydrocarbons. More sustainable commuting is part of workplace responsibility. Everyone can also reduce emissions on their own commute. Sustainable mobility and commuting cover several options: walking and cycling whenever possible; the use of public transport for longer commutes; choosing electric and gas cars when driving is essential; and diverse mobility, wellbeing, and climate-friendly choices. The website provides information on sustainable commuting and mobility, tips for employers on how to encourage employees to commute in a sustainable way, tips for employees for better wellbeing through smart commuting, examples, and best practices. The project also provides

webinars and events, materials, and publications and newsletters. The project is funded by the Finnish Transport and Communications Agency's Traficom and Moving Adult programme. The project is coordinated by Motiva.
https://www.fiksustitoihin.fi/

9.4.4 National Policy Implementation Activities

Energy Efficiency Agreements

Finland is one of the few European countries where voluntary means like the voluntary Energy Efficiency Agreement scheme, have proven to work and yield profits. Energy savings and energy efficiency have been improved through agreements drawn between the Government and industrial/municipal associations since the 1990s. Energy efficiency agreements are an important part of Finland's energy and climate strategy and are the primary means of promoting energy efficiency in Finland. The agreements implement and monitor the implementation of the energy efficiency obligations set by the EU Energy Efficiency Directive. A wide range of companies in the industrial, energy, and service sectors, as well as municipalities, have entered into agreements. Their energy consumption covers about 60 per cent of Finland's total energy consumption. The current contract period is valid until 2025.

Energy efficiency agreements have proved their effectiveness. The measures implemented by the nearly 600 companies and 112 municipalities and associations of municipalities that joined the voluntary energy efficiency agreements between 2017 and 2020 improved their energy use by a total of about 8.9 terawatt hours per year at the end of 2020. The savings realised correspond to the annual energy consumption of almost 450,000 electrically heated detached houses. The annual savings achieved in 2020 correspond to about 2.5 per cent of Finland's total energy consumption in 2020.

The companies and municipalities that have joined the agreement invested a total of approximately EUR 764 million in energy efficiency between 2017 and 2020. Over the four years, the organisations that have joined the agreement have taken a total of almost 15,000 individual energy efficiency measures. The measures implemented between 2017 and 2020 reduced the total annual CO_2 emissions of the companies and entities that joined the agreements by approximately 2 million tonnes and their annual energy costs by more than EUR 350 million. Between 2017 and 2020, the Ministry of Employment and the Economy supported the energy efficiency investments of companies and entities that have entered into agreements in the business, municipal, and real estate sectors with a total of EUR 77.6 million. Support has been provided for 764 projects that would not otherwise have taken place. The agreement scheme is managed by Motiva, commissioned by the Energy Authority.
https://energiatehokkuussopimukset2017-2025.fi/en/

Energy Performance Certificate Advice Service

The Energy Performance Certificate (EPC) is a tool for comparing and improving the energy efficiency of buildings in sales and rental situations. The energy performance certificate was introduced in Finland in 2008 in all new construction, and in sales and rental situations of large buildings and new detached houses in 2009. Motiva provides information about and examples of energy performance certificates, organises webinars for qualified energy certificate issuers, and an advice service on energy performance certificates to homeowners, housing companies, and other interested stakeholders. The advice service covers a weekly phone service and an email service, and a FAQ listing. The law on the energy certification of buildings implements the EU's Energy Performance of Buildings Directive (EPBD). The energy performance certificate makes it possible to compare buildings based on their properties. As of 1 June 2013, an energy performance certificate is also required in connection with the sale and rental of an old detached house. The energy performance certificate is valid until it is replaced by a new one, but for a maximum of ten years from the date of issue. The Housing Finance and Development Centre (ARA) maintains a register of qualified energy certificate issuers. Motiva Oy provides information and an advice service on issues related to energy performance certificates, commissioned by the Ministry of the Environment, which is responsible for the content of and general guidance on the law.
https://www.motiva.fi/energiatodistus

Wood Construction Advisory Service

The Public Wood Construction Advisory service provides municipalities with free expert advice on wood construction issues. The aim of the advice service is to increase the use of wood in public sector construction by increasing the knowledge and interest in wood construction in municipalities and strengthening cooperation between different actors. The carbon footprint of wood construction is significantly smaller than other building materials when a building's entire lifecycle, from the manufacture of building materials to construction, use, and recycling, is considered. Motiva runs the Public Wood Advisory Service, which is part of a two-year project covering a hands-on advisory service, free Wood Academy online trainings, regional events, and working groups focusing on the joint development of public wood construction. The project is funded by the Ministry of the Environment as part of the Wood Construction Programme (2016 to 2022).
https://www.motiva.fi/puurakentaminen

Sitoumus2050.fi platform

Sitoumus2050 is a unique concept that communicates Agenda 2030 goals and gives cities, companies, and citizens a concrete way to take action in reaching targets. The idea of the Sitoumus2050.fi platform is to encourage organisations and citizens to set measurable sustainability targets, make public commitments, and report regularly on their progress. The service is maintained by the Commission for Sustainable Development, and all commitments are accepted, published, and followed by the Commission. Organisations themselves can decide which sustainability goals are meaningful for them, and which actions are relevant when trying to reach their targets.

Commitments typically have targets for reducing greenhouse gas emissions, reaching carbon neutrality, or other environmental goals. Social sustainability goals are also popular. For citizens, the Sitoumus2050 platform provides a lifestyle test which allows you to count your personal carbon footprint. After taking the test, one can also publish one's own sustainable development commitment.

All information on the site is public, so anyone can check what kind of goals a certain company has set and read about how they have proceeded in their reports. So far more than 1,000 organisations have published their sustainable development commitments on the site, and more than 100,000 citizens have taken the lifestyle test and received an estimation of their lifestyle's carbon footprint, and how they could reduce it.
https://sitoumus2050.fi/en_US/kestavatelamantavat#/

Green Deal Agreements

Green Deal is a voluntary agreement between the state and the business community. Agreements can also be concluded with the public sector. Green Deal agreements are used to find solutions to climate challenges, reduce the loss of biodiversity and the over-consumption of natural resources, and promote a circular economy in Finland. Green Deal agreements bring together those who have a key role to play in bringing about the desired change.

The agreements may contribute to better implementation of the legislation or complement the law. For example, the objectives set in the agreements may be stricter than in the law, or certain objectives may be achieved without further regulation. Green Deals and the commitments made under them are part of Society's Commitment to Sustainable Development, introduced by the Finnish National Commission on Sustainable Development. The Parties undertake to set ambitious and achievable targets for environmental and social impacts. Green Deal agreements seek results that can be achieved relatively quickly, the follow-up of which is agreed in the agreement. The agreements aim to bring added value compared to the current situation by jointly seeking new solutions and approaches to address the selected challenges. The agreements specify the measures to be taken by the parties to the agreement and the undertakings to which they are committed to achieve the agreed objectives.

Examples of Green Deals: Plastic bag Green Deal (2016 to 2025), Green Deal in the construction equipment industry (2019 to 2025); Green Deal on sustainable dismantling (2020 to 2025); Emission-free construction sites

– Green Deal on sustainable procurement (2020 to 2030); Construction plastics Green Deal (2020 to 2027)[1].
https://sitoumus2050.fi/en/tietoa-green-dealista#/

Construction Plastics Online Training Package

The circular economy in construction is advancing on many fronts, but there is still room for improvement in plastics recycling. The construction sector is one of the industries that use the most plastics, but separate collection of the plastic fraction in the construction value chain is not yet commonplace. One major reason is the lack of expertise on construction sites and throughout the supply chain. The training package focuses on the film plastic used for packaging and protection, which accumulates most in terms of volume. The training package is related to the implementation of the voluntary Construction Plastics Green Deal (2020 to 2027). The Green Deal aims to increase the separate collection, reuse, and recycling of film plastics. The Construction Plastics online training is aimed at the entire construction industry supply chain. The free, self-study, and open-to-all training package is suitable for clients and implementers of construction projects and contracts, the product industry, the trade sector, and construction equipment rental companies. The training provides supervisors and management with additional information and skills for guidance. Motiva has produced the training package and maintains the online training platform commissioned by the Ministry of the Environment.
https://www.motiva.fi/ajankohtaista/koulutukset/rakentamisen_muovit_-koulutuskokonaisuus (about the training course)
http://www.motiva-verkkokurssit.fi (online course)

Low-Emission Work Machines Online Training Package

Many of the machines used on construction sites are still powered by internal combustion engines and emit a significant amount of CO_2 and local emissions. Switching to low-emission machines and using them properly will help reduce the carbon footprint of construction and traffic emissions. In addition to reducing greenhouse gas emissions, the goal of online training is to reduce local emissions that are harmful to health, such as particulate matter, carbon monoxide and nitrogen dioxide, and noise. The training package is commissioned by the Ministry of the Environment and is part of the implementation of both the Green Deal in the Construction Equipment Industry and the Low Emissions Construction Sites Green Deal. The agreements aim to reduce emissions through voluntary action. The Low-Emission Work Machines training package is open to everyone, focusing on ways to reduce emissions from machinery from the perspective of the machine user, contractor, and builder. The training is free of charge, and the material adapted for short-term studies is ideal for both self-study and teaching

1 https://www.youtube.com/watch?v=LX_1SmA18lw&t=10s

material. Motiva has produced the training package and maintains the online training platform commissioned by the Ministry of the Environment.
http://www.motiva.fi/tyokoneala (about the training course)
http://www.motiva-verkkokurssit.fi (online course)

Materials Marketplace

This national marketplace for materials is for the professional exchange of waste and production by-products of companies and organisations. The Materials Marketplace can also be used to search for and provide related services such as waste management and expert services. The key objective of the Materials Marketplace is to promote the recovery of waste and by-products and the circular economy by providing a meeting place for operators and users of recycled materials. The aim of the Materials Marketplace is to make the material flows generated in Finland more visible in one place, so that new ways of utilisation emerge around them, and the materials end up being increasingly utilised. Such a recycling market is the key to increasing the value of recycled materials. Recycled materials should be considered valuable raw materials to keep them in circulation for as long as possible. The Marketplace originates from the renewal of the Finnish Waste Act (2020), according to which a possessor of waste must first search for a market-based waste management service on the platform before it is possible to ask for municipal waste management in accordance with the secondary liability of a municipality. The use of the Materials Marketplace is free of charge and open to industry players. Motiva operates the Marketplace, which is commissioned by the Ministry of the Environment.
http://www.materiaalitori.fi

KEINO Competence Centre

KEINO is a network-based Competence Centre for Sustainable and Innovative Public Procurement in Finland. The main objectives of the operation are: to increase the number of innovative and sustainable procurements in Finland; to make public procurement recognised and actively used as a management tool; and to ensure contract entities openly disseminate information on their own experiences and learn from one another. The KEINO Competence Centre aims to provide opportunities for collaboration and networking between procurement professionals and public actors involved in procurement, as well as businesses. The members responsible for the operation and co-development are Motiva, the Association of Finnish Local and Regional Authorities, the VTT Technical Research Centre of Finland Ltd, Business Finland, the Finnish Environment Institute SYKE, and Hansel Ltd. The first six are now still part of the consortium and are responsible for the operation and co-development of the centre.

The KEINO Competence Centre is part of the implementation of the Finnish Government Programme, and its operations are steered and funded by the

Ministry of Economic Affairs and Employment. KEINO supports and helps Finnish public contracting authorities with the development of sustainable and innovative procurement. Motiva is the coordinator of KEINO and responsible for the centre's services.
https://www.hankintakeino.fi/en

Place of Experiment

Place of Experiment is a digital platform for concrete experiments, launched in 2017 to improve an experimental culture in Finland in the Government's "Kokeileva Suomi" (Finland of Experiments) key project. Place of Experiment aims to find innovative solutions for the development of society and services. It also seeks to promote individual initiative and entrepreneurship and to strengthen regional and local decision making and cooperation. The Finnish model combines measures to facilitate experimenting with grassroots innovations based on the Government agenda.

Along with managing the platform and serving the experimenters community, Motiva manages thematic calls for experiments of short-term experiments (four to five months) funded by ministries and other stakeholders looking for new and innovative solutions to current practical challenges. Examples of thematic calls for experiments: Circular Economy (2017, 2019); AI (2018); Municipal Climate Solutions (2020); Responsible Food Services (2021); Preserving Biodiversity of the Finnish Archipelago Sea (2021).
https://www.kokeilunpaikka.fi/en

9.4.5 Activities and campaigns of the NGOs

A growing number of NGOs have climate-related activities. For example, the World Wide Fund for Nature (WWF Finland), the Finnish Association for Nature Conservation (Suomen Luonnonsuojeluliitto), Finn Church Aid (Kirkon ulkomaanapu), the Finnish Red Cross, Youth Academy, Fingo, and the Guides and Scouts of Finland (Suomen Partiolaiset) keep the issue constantly on the agenda and offer people opportunities to participate.

The Nature League (Luonto-Liitto in Finnish), established in 1943, is a nationwide non-governmental nature and environmental protection organisation for children and young people. The Nature League arranges environmental education for children and young people in the form of afternoon clubs and nature camps. It also provides opportunities to take action in thematic action groups. One of the action groups deals with the climate theme.

WWF Finland has participated in the worldwide Earth Hour movement since 2007. The event is held annually, encouraging individuals, communities, households, and businesses to turn off their non-essential electric lights for one hour, from 8:30 to 9:30 p.m. towards the end of March, as a symbol of their commitment to the planet. Schools are also invited to participate, and some material and ideas are provided especially for them. WWF Finland also runs the Green Office, which is an environment management system for offices. For young people, WWF Finland provides an opportunity to take part in climate work in WWF Youth groups (WWF Nuoret) in the three biggest cities in Finland. WWF Youth groups organise campaigns and events and encourage other young people to take action. They focus especially on sustainable food.

EKOenergy is a non-profit ecolabel and promotes sustainable energy choices globally. The label is developed and managed by the Finnish Association for Nature Conservation, and EKOenergy-labelled energy is currently being used in 60+ countries. The EKOenergy label helps consumers find out and communicate about using climate friendly and environmentally sustainable energy. The label also works as a fundraising tool for renewable energy projects in developing countries. By using the label, renewable energy consumers make an additional positive impact. More than 40 projects were financed between 2018 and 2021. In 2020, UN DESA (UN Department of Economic and Social Affairs) included EKOenergy as one of the 16 good practices for SDG (Sustainable Development Goals) implementation, and in 2021, EKOenergy's commitment to promote renewable energy was accepted under the UN Energy Compacts programme.

Alongside the well-established NGOs, new NGOs, movements and loosely organised groups have emerged to require climate action and find solutions. For example, many of these groups bring together certain age groups or occupations and the use of the arts (concerts, music videos, exhibitions) or strongly highlight some consequences of climate change. More intense non-violent forms of action have also been introduced: civil disobedience practised by Extinction Rebellion Finland (Elokapina) has stimulated discussion about climate change, climate policy and acceptable forms of climate action.

Ilmastotoiminta.fi gathers information on the different possibilities of climate and environmental activities today at one address, so more and more people can find the most suitable form of climate action. The site provides information on various organisations and movements that carry out climate and environmental activities, as well as tools for planning and implementing climate activities. The site was launched and is maintained by two private individuals with experience of climate communication, environmental action, and research.

Some new groups and movements

Fridays for Future is a worldwide youth-led movement in which many young people in Finland have also joined since 2018. It has succeeded in bringing up young people's views and concerns. Climate strikes by Fridays for Future have been organised in many towns, and the society has been forced to consider whether it is acceptable to miss school lessons while taking part in social activities like climate action. In turn, adults have set up Climate Parents (Ilmastovanhemmat ry), which is active in insisting that decision makers consider the coming generation when deciding on climate issues. Climate Parents has been followed by Climate Grandparents (llmastoisovanhemmat ry) and a group called Activist Grannies (Aktivistimummot).

Protect Our Winters Finland Ry (POW) was established in 2014, and it combines especially those who like or work with winter sports. Well-known ambassadors like snowboarder Enni Rukajärvi have drawn attention to POW and its cause. In turn, Save Pond Hockey is uniting the global hockey community against climate change. It co-organises Save Pond Hockey Tournaments around the world and donates profits to projects tackling the climate crisis. Like POW, Save Pond Hockey has utilised ambassadors: among the more than 3,500 players who have joined the tournaments so far are the Stanley Cup champions, Olympic medallists, celebrities and the President of Finland.

Joint campaigns

NGOs and movements have also combined to conduct climate-change or energy-related campaigns, some of which have received broad publicity. For example, Birdlife Finland, Fingo, Greenpeace Finland, Coal-free Finland (Hiilivapaa Suomi), the Nature League (Luonto-Liitto), the Finnish Friends of the Earth, Natur och Miljö, Protect Our Winters (POW), the Finnish Association for Nature Conservation (Suomen Luonnonsuojeluliitto), and WWF Finland ran a campaign called “Irreplaceable” (Korvaamaton) to remind politicians and voters of the importance and urgency of climate action. The campaign targeted the parliamentary elections in 2019.

Coal-free Finland (Hiilivapaa Suomi) is a longer-term campaign at a municipality and city level to shut down coal plants in municipalities across Finland, in which citizens have decided to take action against the use of coal. The campaign is working in collaboration with the Finnish Friends of the Earth, the Finnish Nature League, Changemaker, Climate Parents, 350 Finland, Fingo, UN Youth of Finland, Europe Beyond Coal, and Save Pond Hockey and is run by volunteers from a variety of backgrounds. The campaign’s methods include lobbying and advocacy, participating in public debate, and awareness raising among citizens and stakeholders.

NGOs supporting climate education

Many NGOs also play an important role in supporting teachers and youth workers in climate education. They provide materials, visit schools, and arrange in-service training, mostly with the financial support of state actors, foundations, and even companies.

FEE Finland (the Finnish Foundation for Environmental Education) enhances a sustainable way of life through environmental education. FEE Finland is part of an international FEE (Foundation for Environmental Education) network, which consists of 73 member countries. FEE Finland coordinates the Green Key programme in Finland and enhances environmental education collaboration.

A non-profit organisation, Development Centre Opinkirjo, established in 1947, produces and offers training and teaching materials for teachers. Climate has been one of its themes for a few years now. Ilmastokirjo – Climate Spectrum provides material for teachers and students but also connects schoolchildren and other actors in society by facilitating a QA service and organising meetings on climate issues.
https://ilmastokirjo.fi/

9.5 Short descriptions and Internet links of some projects, networks, and campaigns

Climateguide.fi

The Climateguide.fi website provides information about climate change, its impacts, adaptation, and mitigation. The website's aim is to be a national, publicly available digital service about climate change and to provide up-to-date, independent, and reliable information about climate change based on research and other verified data. It also aims to support decision making, risk management, climate communication, and learning. The website is also available in Finnish (Ilmasto-opas.fi) and in Swedish (Klimatguiden.fi). The website and its main content are maintained by the Finnish Meteorological Institute (FMI), the Finnish Environment Institute (SYKE), and Natural Resources Institute Finland (Luke).
https://www.climateguide.fi

Kysyilmastosta.fi

In the KysyIlmastosta.fi web service, anyone can ask questions about the climate, climate change and its impacts, the behaviour of the climate system itself, or anything related to the climate. The web service will find researchers and experts to answer the questions. Users can also vote for questions they find interesting and important, and the service prioritises the most popular topics when seeking expert answers. In addition, new research is created from the questions submitted. The research is designed in collaboration with users and scientists, and research questions are approached with real-world research tools (such as climate models). The scientific process and the research results are then illustrated on the website, which is provided by the Finnish Meteorological Institute (FMI) and the Institute for Atmospheric and Earth

System Research (INAR) of the University of Helsinki. The service is available in Finnish and English.
https://www.kysyilmastosta.fi/en/

Ilmastokatsaus

The Finnish Meteorological Institute (FMI) publishes a monthly climate bulletin in Finnish (Ilmastokatsaus) and a yearly climate bulletin (Ilmastovuosikatsaus). Both online digital magazines are in Finnish and cover weather and climate issues, with articles about weather conditions in Finland and weather events worldwide, weather and greenhouse gas statistics, and changes in Arctic sea ice. The monthly bulletin also has English summaries of weather events. The magazine's target audience are from the fields of research and education, as well as members of the general public who are interested in the present climate, weather, and climate change. The FMI climate bulletin magazine also features a supplement called Research Letters, which is published twice a year in English, and it features short peer-reviewed papers about the climate, climate change, extreme weather and climate services.
https://ilmastokatsaus.fi

Climate Diet

The Climate Diet is a calculator, developed by the Finnish Environmental Institute, which helps consumers calculate their carbon footprint. It also gives advice on how to reduce it and presents the results compared to average Finns. The calculator considers different fields of life from housing to travel, food consumption, shopping habits and household waste management. Since its update in 2019, the calculator has attracted 119,000 visitors to calculate their carbon footprint, meaning approximately 34,000 calculations per year.
https://ilmastodieetti.ymparisto.fi

Climate.now

Climate.now is a multidisciplinary study and teaching module on the basics of climate change. It contains written material, video lectures and interviews, assignments, tests, and a guide for teachers that will help anyone familiarise themselves with the basics of climate change. You can complete the study module independently or as part of your higher education studies. In addition to teachers and students, the material can be used by companies, other organisations and media.
https://www.climatenow.fi/

Teacher's Climate Guide

The Teacher's Climate Guide is a free and open climate education package for subject teachers working in secondary schools and high schools. It explains climate change in the context of each school subject, and provides exercises and

visual material. It also contains tips for multidisciplinary climate education, tips for integrating climate change in education and activities at the primary level, and basic information about climate change and climate education. The English version is for international use and aimed at teachers around the world.
https://teachers-climate-guide.fi

University of Eastern Finland (UEF) – United Nations Environment Programme (UNEP) Course on Multilateral Environmental Agreements

The UEF-UNEP Course on Multilateral Environmental Agreements (MEAs) is a high-profile two-week course on MEAs, international environmental lawmaking, and diplomacy. It is organised annually in cooperation between the University of Eastern Finland and UNEP, with a changing course venue and theme each year.

The aim of the course is to equip present and future negotiators of multilateral environmental agreements with the information and experiences of others in the area of international environmental lawmaking to improve the impact and implementation of these key treaties.

The course is intended for experienced Government officials engaged in international environmental negotiations. Other stakeholders such as representatives of NGOs and the private sector, researchers and academics in the field of international environmental law are also eligible. Starting from 2004, the course has had a total of 399 participants from 121 different countries.
https://sites.uef.fi/cceel/uef-unep/

Teachers’ Climate Change Forum

University of Helsinki Science Education (a part of national LUMA Centre Finland) and Institute for Atmospheric and Earth System Research (INAR) have organised international Teachers’ Climate Change Forum 2022 (TCCF) for continuous professional development program of teachers in all levels of education. The conference deals with climate science, climate education and the connection between these two domains. There is also online material provided for teachers; material provides teachers at different levels of education the latest research related to climate change, and supports teachers in building their own expertise and self-efficacy to teach climate change.

The Teachers’ Climate Change Forum is a virtual forum organised by LUMA Centre Finland. At the forum, teachers interested in climate change education can share their practical experience and learn from each other. The Director of the LUMA Centre Finland chairs the forum.
https://www.helsinki.fi/en/science-education-and-academic-outreach/teachers/teachers-climate-change-forum

Towards Carbon Neutral Municipalities and Regions (Canemure)

Canemure, the Towards Carbon Neutral Municipalities and Regions -project implements practical measures for climate change mitigation during a six year period, from 2018 to 2024. Alongside practical climate action, the project will build capacity, create cooperation networks and spread good practices throughout Finland. The Canemure consortium consists of 21 partners: cities and municipal organisations, research institutions and companies. https://www.syke.fi/en-US/Research__Development/Research_and_development_projects/Projects/Towards_Carbon_Neutral_Municipalities_and_Regions_CANEMURE/Towards_Carbon_Neutral_Municipalities_an(50659)

KUJA and KUJA2 projects on the continuity management of municipalities and local and regional authorities

The objective of the KUJA project, "The continuity management of municipalities" (2014 to 2016), was to develop the capacity of local actors to ensure disruption-free functioning in all situations, including during weather- and climate-change-related disruptions. The tools produced during the project support the development of preparedness and continuity management, as well as the protection of citizens' wellbeing. With the KUJA2 project, "The continuity management of local and regional authorities" (2017 to 2019), the scope was widened to include provinces. Provinces play an important role in the coordination of regional preparedness after the major health, social services and regional government reform in 2019. KUJA2 aimed to strengthen the interconnectedness of municipalities, regional authorities, and their key stakeholders and to promote a shared understanding of preparedness. Both projects have been implemented in cooperation between the Association of Finnish Local and Regional Authorities and the Finnish National Emergency Supply Agency.

Climate resilience tools by Tapio

Climate resilience tools for the public and private sectors were released at the end of 2016, compiled by Tapio Consulting Services and funded by the Ministry of Agriculture and Forestry. These tools include a variety of good practices, guides, and measures used by public and private sector actors to implement measures in the different aspects of climate resilience. The concept also presents good examples of how to secure climate resilience, and how to assess it.

Citizens Climate Pledge

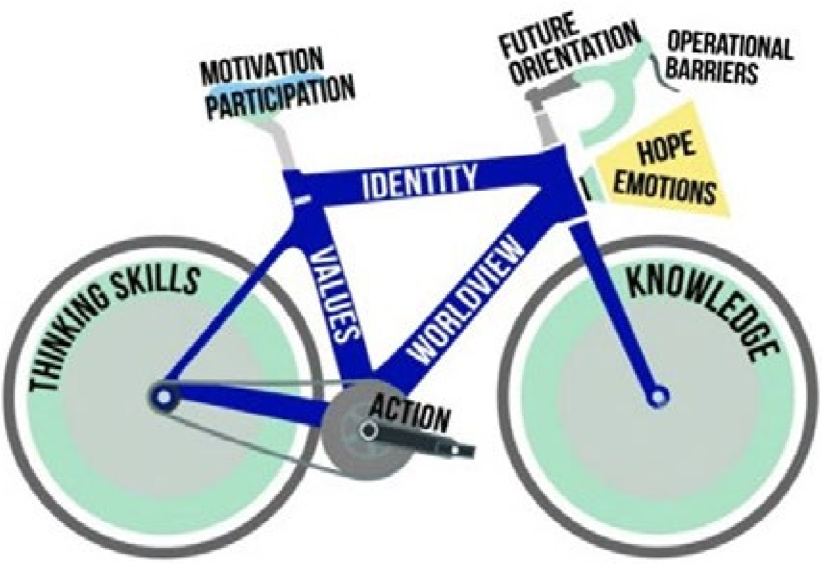
Citizens Climate Pledge is an NGO-led initiative that encourages individual citizens to announce their personal commitment to halve their carbon footprint within ten years. Launched in 2015 in Finland, Citizens Climate

Pledge aims to bring citizens into the centre of the societal transition to low-carbon development. Today, the initiative has more than 2,500 signatories, including the present and two former Presidents of Finland, the leaders of Finland's largest corporations, musicians, artists, and top athletes. Citizens Climate Pledge became global in 2016, when the Finnish initiators launched the international version with UNFCCC. It is now possible for any global citizen to commit to join a global movement of action on climate change. https://climatepledge.global/

Bicycle Model on Climate Change Education

Four Finnish researchers introduced their holistic model of climate change education in 2017 (Figure 9.3). The model is presented as a bicycle, because both climate change education and a bicycle are entities that require all their parts to function together. The idea of being in motion is also a common feature. The model has been well adopted by practitioners, because it helps analyse and plan education on the wicked problem of climate change. It has also been further developed at least by The Association of Finnish Children's Cultural Centers and in Early Childhood Educator's Climate Guide. https://www.sirene.fi/blog/bicycle-model-on-climate-change-education/

Figure 9.3
Bicycle model on climate change education



MAPPA.fi

The MAPPA service is an environmental education "search engine", which already includes more than 1,600 materials for learning outside and teaching sustainable lifestyles. It serves as an open and common place for more than 300 organisations that produce material for teachers and other educators. Educators themselves can also add their good materials to the service so that they can be used by others as well. For example, the user can search for materials by age group, subject, or the type of the situation in which the material is required. There are also "thematic backpacks" in which materials have been collected that together form a useful set like "Food Materials" or "A Perspective of Hope in Climate Education".

MAPPA was first published in 2013 and has since grown to be a significant service that helps teachers find ideas and materials and producers to get more visibility for their work. MAPPA has been developed further, and it now includes a common calendar of events in the field and presents supporting services that are available for teachers around the country. MAPPA was established and is maintained by the Finnish Association of Nature and Environment Schools and was initially funded by the Ministry of the Environment and later the Ministry of Education, Partioaitta, and the Otto A. Malm Foundation.
https://mappa.fi

Educators' Climate Front

Climate Front in a community that helps professionals in various fields to act together to mitigate climate change. The idea is to help people use their expertise in climate work while helping the professions cooperate. One can join the Climate Front as an individual or as an organisation. Teachers and Educators are currently one of the six professions in the Front. The others are psychologists, doctors, engineers, IT workers, and artists.
https://ilmastorintama.fi/

Climate Thoughts – Guide to Climate Education in Youth Work

Youth Academy published a Guide to Climate Education in Youth Work in 2020. The guide gives youth workers more insight into meeting young people's climate feelings and discussing and taking action on climate issues. The guide helps the youth worker to better encourage and support young people to take part in climate discussions, activities, and influences in their daily lives.
https://www.nuortenakatemia.fi/wp-content/uploads/2020/12/ilmastoajatuksia_opas-nuorten-ilmastokasvatukseen-2020.pdf

Literature

Glasgow work programme on Action for Climate Empowerment (2021) UNFCCC (CMA) 2021 https://unfccc.int/sites/default/files/resource/cop26_auv_3b_Glasgow_WP.pdf

Government report on the National Energy and Climate Strategy for 2030 (2017) Publications of the Ministry of Economic Affairs and Employment of Finland 12/2017. http://urn.fi/URN:ISBN:978-952-327-199-9

Strategic programme to promote a circular economy https://ym.fi/documents/1410903/42733297/Government+resolution+on+the+Strategic+Programme+for+Circular+Economy+8.4.2021.pdf/309aa929-a36f-d565-99f8-fa565050e22e/Government+resolution+on+the+Strategic+Programme+for+Circular+Economy+8.4.2021.pdf?t=1619432219261

The Finnish Education System https://okm.fi/en/education-system

National Core Curriculum for General Upper Secondary Education 2019, Finnish National Board of Education 2021, Regulations and guidelines 2019/2c.

National Core Curriculum for Basic Education 2014, Finnish National Board of Education 2014, Publications 2016/5.

eRequirements service for qualification requirements for the vocational qualifications https://eperusteet.opintopolku.fi/#/en

Policies to promote internationalisation in Finnish higher education and research 2017–2025 https://okm.fi/en/international-strategy-for-higher-education-and-research

The Climate Barometer 2019, Ministry of the Environment Press release 18-03-2019. https://www.ymparisto.fi/en-US/Maps_and_statistics/Climate_Barometer_2019_Finns_wish_to_hav(49671)

Sustainable development policy of the Ministry of Education and Culture and its administrative branch - Valto (valtioneuvosto.fi)

Internet links

Climateguide.fi web portal, https://www.climateguide.fi

Ilmastokatsaus (climate bulletin, in Finnish) https://www.ilmastokatsaus.fi/

Kysyilmastosta.fi (ask about climate) web service https://www.kysyilmastosta.fi/en/

Climate University https://climateuniversity.fi/

Climate.now https://www.climatenow.fi

Ilmastoinfo (Climateinfo, in Finnish), https://www.hsy.fi/ilmastoinfo/

Energy Awareness Week
https://www.motiva.fi/en/public_sector/training_and_communication_in_the_improvement_of_energy_efficiency

Finnish University Partnership for International Development (UniPID),
https://www.unipid.fi/

The Higher Education Institutions Institutional Cooperation Instrument Programme (HEI ICI)
https://www.oph.fi/en/programmes/hei-ici-programme

Hinku network – Towards Carbon Neutral Municipalities,
https://www.hiilineutraalisuomi.fi/en-US/Hinku

Motiva, a state-owned company promoting the sustainable use of energy and materials,
https://www.motiva.fi/en

National IPCC working group (in Finnish),
https://www.ilmatieteenlaitos.fi/suomen-ipcc-tyoryhma

The Finnish Climate Change Panel
https://www.ilmastopaneeli.fi/en/

LUMA Centre Finland (science education network of Finnish universities)
https://www.luma.fi/en/

Sustainable development certification of educational establishments,
https://koulujaymparisto.fi/in-english/

Teacher's Climate Guide
https://teachers-climate-guide.fi/

Luokanopen ilmasto-opas (Class Teacher's Climate Guide, in Finnish)
https://luokanopenilmasto-opas.fi

Varhaiskasvatuksen ilmasto-opas (Early Childhood Educator's Climate Guide, in Finnish)
http://vakanilmasto-opas.fi

The Association of Finnish Local and Regional Authorities
https://www.localfinland.fi/

Abbreviations

ΔT	temperature change
°C	degree Celsius
°N	degrees north
AAU	assigned amount unit
AAU	Addis Abeba University
ACCC	Atmosphere and Climate Competence Center
ACE	Action for Climate Empowerment
ACTRIS	Aerosols, Clouds and Trace Gases Research Infrastructure
ADAPT	Adaptation and Resilience for Sustainable Growth
AFIR	Alternative Fuels Infrastructure
AFRY	an engineering, design, and advisory services company
AGE	applied general equilibrium
AGS	Accelerated Growth for small and medium-sized enterprises in Zambia Programme
ALIISA	a road transport model to calculate the impact of policies and measures on the longer-term trend in greenhouse gas emissions
AMAP	Arctic Monitoring and Assessment Programme
AR	afforestation and reforestation
AR6	the IPCC Sixth Assessment Report
ARA	Housing Finance and Development Centre of Finland
ARD	afforestation (A), reforestation (R) and deforestation (D)
ARKTIKO	The Arctic Academy Programme
ARU	Ardhi University
AWS	automatic weather station
BC	Black Carbon
BCE	before common era
BEAC	Barents Euro-Arctic Council
BECCS	bioenergy with carbon capture and storage
Biodiversa	European Biodiversity Partnership
CAEP	ICAO Committee on Aviation Environmental Protection
Canemure	Towards Carbon Neutral Municipalities and Regions, an EU Life project
CAP	Common Agricultural Policy
CBHE	Capacity Building in Higher Education
CBSS	Council of the Baltic Sea States
CCS	Carbon Capture and Storage
CCSU	Carbon capture, utilisation and storage
CDM	Clean Development Mechanism

CE	common era
CER	certified emission reduction unit
CEWAFO	Center for Water Resources Warning and Forecast
CH_4	methane
CHP	combined heat and power
CIECAS	Centro de Investigaciones y Estudios Superiores en Antropología Social
CIES	Centro de Investigacion de Energia Solar
CIF	Carbon Tracker Europe
CII	carbon intensity indicator
CLC	Climate Leadership Coalition
CLIDEV	Strengthening Climate Change Education for Sustainable Development in Myanmar and Vietnam
CLIHE	Climate Change and Health research programme
CLIMATE	Climate Change and Humans programme
CLRTAP	Convention on Long-range Transboundary Air Pollution
cm	centimetre
CMA3	the 3rd session of the Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement
CMIP5	Coupled Model Intercomparison Project Phase 5
CMIP6	Coupled Model Intercomparison Project Phase 6
CMP	Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CO_2 eq.	carbon dioxide equivalent
CORINAIR	a programme to establish an inventory of emissions of air pollutants in Europe
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CP	commitment period
CREWS	Climate Risk and Early Warning Systems
CRF	Common Reporting Format
CTF	Common Tabular Formats
CVD	Clean Vehicles Directive
D	deforestation
DCS	Data Collection System
DEFROST	Depicting ecosystem-climate feedbacks from permafrost, snow and ice network
DES	Data Exchange Standards
DEVELOP	Academy Programme for Development Research

DG MARE	Directorate-General for Maritime Affairs and Fisheries
DHM	Department of Meteorology and Hydrology
DoURP	Department of Urban and Rural Planning of Zanzibar
Dremfia	a dynamic regional sector model of Finnish agriculture
DRR	Disaster Risk Reduction
e.g.	exempli gratia
EARLI	energy-efficient lighting and renewable energy for sustainable development
EC	European Commission
ECA&D	European Climate Assessment & Dataset
EC-Earth	European Community Earth system model
ECEC	Early childhood education and care
ECHAM-HAMMOZ	a 3-dimensional chemistry climate model jointly developed by Max Planck Institute for Meteorology, Hamburg, Jülich Research Center, Swiss Federal Institute of Technology Zurich, Center for Climate Systems Modeling, University of Oxford, Finnish Meteorological Institute
ECOSUR	Colegio de la Frontera Sur
ECRU	Environmental Change Research Unit
EDM	Electricidade de Moçambique
EEA	European Economic Area
EEA	European Environment Agency
EED	Energy Efficiency Directive
EEDI	Energy Efficiency Design Index
EEP	Energy and Environment Partnership
EEX	European Energy Exchange
EEXI	Energy Efficiency Existing Ship Index
EFDB	The Emission Factor Database
EIA	environmental impact assessment
EIG EUMETNET	Network of European Meteorological Services
EKOREM	a calculation model for energy use of building stock developed by the unit of Construction Management and Economics at Tampere University of Technology and Technical Research Centre of Finland
ELIISA	the newest transport scenario model which can produce scenarios of the development of vehicle fleet and its energy consumption and greenhouse gas emissions
eLTER	Long-Term Ecosystem Research
ELY Centre	regional Centre for Economic Development, Transport and the Environment
EMBRC	European Marine Biological Resource Centre

EMEP	European Monitoring and Evaluation Programme
EMODnet	European Marine Observation and Data Network
ENO	Environment Online
ENPCT	Empresa Nacional de Parques e Ciência e Tecnologia and Empresa Publica
EO	Earth Observation
EPA	Environmental Protection Agency
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
E-PRTR	European Pollutant Release and Transfer Register
ERANET	European Research Area Networks
ERASMUS	European Region Action Scheme for the Mobility of University Students
ERDF	European Regional Development Fund
ERU	emission reduction unit
ESD	Effort Sharing Decision
ESF	European Social Fund
ESFRI	EU's European Strategy Forum on Research Infrastructures
esp.	especially
et al.	et alia, and others
ETBE	ethyl tertiary-butyl ether
etc.	et cetera, and other things
ETLA	The Research Institute of the Finnish Economy
ETS	Emissions Trading System
ETSAP TIAM	a bottom-up, technology-rich model that covers 28 regions and depicts a technologically detailed supply side of the energy system, from primary energy supply over conversion to final energy demand
EU	European Union
EU ETS	EU Emissions Trading System
EU-27	European Union of 27 member states
EUMETSAT	The European Organisation for the Exploitation of Meteorological Satellites
EUR	euro
EURO-ARGO	European Research Infrastructure Consortium for Observing the Ocean, which is the European contribution to the international Argo programme for ocean monitoring
EUROCONTROL	European Organisation for the Safety of Air Navigation
EURO-CORDEX	Coordinated Downscaling Experiment – European Domain

FACCE JPI	Agriculture, Food Security and Climate Change, Joint Programming Initiative
FAN	Department of Food and Nutrition Science in Finland
FAO	Food and Agriculture Organization
FAQ	frequently asked questions
FFFSR	Friends of Fossil Fuel Subsidy Reform
F gases	fluorinated greenhouse gases (HFCs, PFCs, SF_6 and NF_3)
FINAGE	a dynamic, applied general equilibrium model of the Finnish economy
Finavia	Finnish Civil Aviation Administration
FinBIF	Finnish Biodiversity Information Facility
FinELib	consortium of Finnish universities, research institutions and public libraries which promotes availability of e-resources and open publishing
FINMARI	The Finnish Marine Research Infrastructure
Finnfund	The national Development Finance Institution of Finland
FINSCAPES	Finnish Scenarios for Climate Change Research – Addressing Policies, Regions and Integrated Systems
FIRST	Finnish-Russian Student and Teacher Exchange Programme
FishEDU	Capacity Building in Fisheries and Aquaculture Education in the Kyrgyz Republic
FISS	Finnish Industrial Symbiosis System
FISU	Finnish Sustainable Communities
FM	forest management
FMI	Finnish Meteorological Institute
FMRL	Forest Management Reference Level
FOOD	Towards a Sustainable, Healthy and Climate-Neutral Food System programme
FSC	Forest Stewardship Council
FSRU	Floating Storage Regasification Unit
FTIA	Finnish Transport Infrastructure Agency
FuelEU Maritime	a legislative proposal part of the EU's proposed Fit for 55 package directed to decarbonise international shipping
FUNAE	Fundo de Energia
g	gramme
GAW	Global Atmosphere Watch
GCF	Green Climate Fund
GCOS	Global Climate Observing System
GCP	Global Carbon Project
GCV	gross calorific value

GDP	gross domestic product
GEF	Global Environment Facility
Geo-ICT	Geospatial and ICT Capacities in Tanzanian Higher Education Institutions
GHG	greenhouse gas
GIPL	Gas Interconnection Poland–Lithuania
GJ	gigajoule
GNI	gross national income
GOSCOMGEOLOGY	State Committee of the Republic of Uzbekistan on Geology and Mineral Resources
GPCC	The Global Precipitation Climatology Centre
GRUAN	GCOS Reference Upper-Air Network
GSN	Surface Network
GTK	The Geological Survey of Finland
GUAN	GCOS Upper-Air Network
GW	gigawatt
GWh	gigawatt hour
GWP	global warming potential
ha	hectare
HARMONIE-CLIM	regional climate models for climate studies in Nordic countries, developed by the Finnish Meteorological Institute
HC	hydrocarbons
HCT	High Capacity Transport
HDD	heating degree days
HEI-ICI	Higher Education Institutions Institutional Cooperation Instrument
HELCOM	Baltic Marine Environment Protection Commission or the "Helsinki Commission"
HELCOM COMBINE	the joint Baltic Sea environmental monitoring programme
Helmi	a programme that aims to strengthen biodiversity led by the Ministry of the Environment
HFC	hydrofluorocarbon
HIISI	"Carbon neutral Finland 2035 – measures and impacts of the climate and energy policies" project
Hinku	Towards Carbon Neutral Municipalities
HLM-LTAG	High-Level Meeting on the Feasibility of a Long-Term Aspirational Goal for International Aviation CO_2 Emissions Reductions

HSY	Helsinki Region Environmental Services Authority
HWP	harvested wood products
i.e.	id est, other words
IAM	integrated assessment model
IASC	International Arctic Science Committee
ICAO	International Civil Aviation Organisation
ICES	International Council for the Exploration of the Sea
ICI	Institutional Cooperation Instrument
ICOS	Integrated Carbon Observation System
ICP M&M	International Cooperative Programme on the Modelling & Mapping
ICT	information and communication technology
ICT	Cambodian Institute for Technology
ICZM	Integrated Coastal Zone Management
IE	included elsewhere
IEA ETSAP TIMES	The TIMES model generator developed as part of the IEA-ETSAP (Energy Technology Systems Analysis Program of the International Energy Agency), an international community which uses long term energy scenarios to conduct energy and environmental analyses
IFC	International Finance Corporation
IFI	International Financial Institution
IGO	intergovernmental organizations
IIAM	Agrarian Research Institute of Mozambique
ILTER	International Long-Term Socio-Ecological network
IMO	International Maritime Organization
IMP	Illustrative Mitigation Pathway
IMPAKTI	a calculation tool for emission mitigation impact of measures promoting the use of renewable energy
INAR	Institute for Atmospheric and Earth System Research
incl.	including
INSPIRE	Infrastructure for Spatial Information in the European Community
IPCC	Intergovernmental Panel on Climate Change
IRIS	Integration of Renewable Intermittent Sources in the Power Systems
IRSAT DTA	Institut de Recherche en Sciences Appliquées et Technologies
IT	information technology
ITL	Independent Transaction Log
JI	Joint Implementation

JPI	Joint Programming Initiative
JPI Climate	Connecting Climate Knowledge for Europe, Joint Programming Initiative
JSBACH	Jena Scheme for Biosphere-Atmosphere Coupling in Hamburg – the land component of the atmospheric component ECHAM and part of the Max Planck Institute Earth System Model
KantarTNS	Global market research and market information company
KAUTE	A foundation which supports research in economics and technical sciences and the dissemination of research results
KEINO	Competence center for Sustainable and Innovative public procurement
kg	kilogramme
km	kilometre
km^2	square kilometre
KOKOSOPU	Implementation of the National Policy on Climate Change Adaption project
KP LULUCF	Land Use, Land Use Change and Forestry activities under the Kyoto Protocol
kt	kilotonne
KUFF	Kasetsart University
KUITTI	Assessment of the Cost of Inaction Regarding Climate Change project
KUJA	“The continuity management of municipalities” project (2017 to 2019)
KUJA2	“The continuity management of local and regional authorities” project (2014 to 2016)
LC	The Laboratory of Chronology
LDC	least developed countries
LDCF	Least Developed Countries Fund
LDNDC	ecosystem model developed by the Finnish Meteorological Institute
LEAP-Agri	Long-Term EU-Africa Research and Innovation Partnership on Food and Nutrition Security and Sustainable Agriculture
LEAP-RE	Long-Term Joint European Union - African Union Research and Innovation Partnership on Renewable Energy
LHV	Lower Heating Value
LIISA	a road traffic sub-model to the LIPASTO calculation system
LIKES	Research Centre for Physical Activity and Health

LIPASTO	a calculation system for transport exhaust emissions and energy use in Finland
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LPJ-Guess	Lund–Potsdam–Jena General Ecosystem Simulator – a process-based dynamic vegetation-terrestrial ecosystem model designed for regional or global studies
LTAG	long-term global aspirational goal
LTER Finland	Finnish Long-Term Socio-Ecological network
LTRS	long-term renovation strategy
LTS	long-term strategy
Luke	Natural Resource Institute Finland
LULUCF	Land Use, Land Use Change and Forestry
LUMA	Finland's Science Education Centre
Luomu 2.0	National organic farming programme
Luomus	Finnish Museum of Natural History
m	metre
m/s	metre per second
m^2	square metre
m^3	cubic metre
MaaS	Mobility-as-a-Service
MAL	land use, housing and transport
MAPPA	The central Material Bank and search service for environmental and sustainability education and outdoor learning in Finland
MARPOL	International Convention for the Prevention of Pollution from Ships
MATO	Research Programme for Environmental impacts of agriculture
MCCF	Multilateral Carbon Credit Fund
MDB	Multilateral development banks
MDG	Main Department of Geology under the Government of the Republic of Tajikistan
MEA	Multilateral Environmental Agreements
MEAE	Ministry of Economic Affairs and Employment
MEERI	a water-borne traffic sub-model to the LIPASTO calculation system
MELA	a forest decision support system tool generated for Finnish conditions
MELA2012/2016	the 2012/2016 version of a forest decision support system tool generated for Finnish conditions
MEPC	Marine Environment Protection Committee

METSO	Forest Biodiversity Programme for Southern Finland
MEUR	million euros
MFA	Ministry for Foreign Affairs
MJ	megajoule
mm	millimeter
MODEST	Modernization of Doctoral Education in Science and Improvement Teaching Methodologies
MONASH	a large-scale economic model originally developed at Victoria University, Australia
Motiva	state owned sustainable development company in Finland
MRV	monitoring, reporting and verification
MSDI	Marine Spatial Data Infrastructure
MSP	Maritime Spatial Planning
MSR	Market Stability Reserve
Mt	million tonnes
MTBE	methyl tertiary-butyl ether
MW	megawatt
MWh	megawatt hour
N_2O	nitrous oxide
NA	not available
na	not assessed
NAP	National Adaption Plan
NAS	national climate adaption strategy
NC7	Finland's Seventh National Communication under the United Nations Framework Convention on Climate Change
NC8	Finland's Eighth National Communication under the United Nations Framework Convention on Climate Change
NCV	net calorific value
NDC	Nationally Determined Contribution
NECP	National Energy and Climate Plan
NECPR	National Energy and Climate Plan Progress Report
NEDC	New European Driving Cycle
NEFCO	Nordic Environmental Financing Corporation
NEMO	Nucleus for European Modelling of the Ocean, ocean component of the earth system model
NF_3	nitrogen trifluoride
NFI	National Forest Inventory
NFI12	National Forest Inventory 2014 to 2018
NFP	National Forest Programme Facility

NFS	National Forest Strategy
NGO	non-governmental organization
NKL	Nordic Working Group for Climate and Air
NMHS	National Meteorological and Hydrological Services
N Model	Nitrogen Model, a simulation model of cropping systems to track nitrogen as it cycles between stocks
NMVOC	Non-Methane Volatile Organic Compounds
NOAK	Nordic Working Group for Global Climate Negotiations
NorESM	Norwegian Earth System Model
NO_X	nitrogen oxides
NSIDC	National Snow and Ice Data Center
NUoL	National University of Laos
O3SAF	Satellite Application Facility on Ozone & Atmospheric Chemistry Monitoring
OA	open access
ODA	official development assistance
ODS	ozone-depleting substances
OECD	Organisation for Economic Cooperation and Development
OECD DAC	OECD Development Assistance Committee
OECD DAC CRS	OECD Development Assistance Committee's Creditor Reporting System
OKKA	Foundation for Teaching, Education and Personal Development
Open-IFS	Open Integrated Forecasting System
OSCE	Organization for Security and Co-operation in Europe
P	paraffinic diesel
PAHs	polycyclic aromatic hydrocarbons
PAM	post-authorisation measures
PaMs	Policies and Measures
PARFORM	Partnership for Forestry Higher Education Cooperation in Mekong Region
PBL-BioAfrica	Problem-based-learning bioeconomy entrepreneurship and capacity building programme in Africa
PCF	Prototype Carbon Fund
PEcAn	Predictive Ecophysiological Carbon Flux Analyzer - modelling and data assimilation platform
PECOLO	Native Crops for Innovative and Sustainable Food Futures in Peru and Colombia
PEEX-AC	Pan-Eurasian EXperiment – Academic Challenge
PEEX-FRESReN	Pan-Eurasian EXperiment – Finnish-Russian Earth System Research Network

PEFC	Programme for the Endorsement of Forest Certification
PFC	perfluorocarbons
PITKO	Long-Term Development of Total Emissions project
PJ	petajoule
PM	particles
PMI	Partnership for Market Implementation
PMR	Partnership for Market Readiness
POLIREM	calculation model for energy use of building stock
POW	Protect Our Winters
POWERGRAIN	Superior Grain Safety with Designed Mycotoxin Binding Properties research programme
PSLifestyle project	an EU Green Deal project to create a tool European citizens can use to build Positive and Sustainable Lifestyles
PSO	Public Service Obligations
PTT	Pellervo Economic Research Institute
PV	photovoltaic system
QA	quality assurance
QC	quality control
R	Biofuel that meets the sustainability criteria decreed in the act on biofuels and bioliquids (393/2013).
R&D	research and development
RAILI	a railway traffic emission sub-model of LIPASTO calculation system
RC	Regional Council
RCE	Regional Centre of Expertise on Education for Sustainable Development
RCP	Representative Concentration Pathway
RDI	research, development and innovation
RECOFTC	Joint IUFRO-IFSA task force on Forest Education and the Center for People and Forests
RED II	EU's Renewable Energy Directive
REF	recovered fuels
ReFuel EU	Aviation a legislative proposal part of the EU'S proposed Fit for 55 package for sustainable air transport
RMU	Removal Units under the Kyoto Protocol, given from net removals from land use, land-use change and forestry activities
ROADS	Roadmap for Arctic Observing and Data Systems
RRF	Recovery and Resilience Facility
RRP	Recovery and Resilience Plan

RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
SAEPF	State Agency of Environmental Protection and Forestry of the Kyrgyz Republic
SAF	sustainable aviation fuel
SAON	Sustaining Arctic Observing Networks
SCIESU	State Committee of Industry, Energy and Subsoil Use of the Kyrgyz Republic
SDGs	Sustainable Development Goals
SEF	standard electronic format
SELECT	Environomical Pathways for Sustainable Energy Services master's degree programme
SF_6	sulphur hexafluoride
SF-GTM	a forest sector model
SGT	Sustainable Global Technologies
SIDS	Small Island Developing States
SIHYMECC	The Sub-Institute of HydroMeteorology and Climate Change
Sitra	Finnish Innovation Fund
SKU	Savannakhet University
SMA	Sudan Meteorological Authority
SMARTLAND	Environmental sensing of ecosystem services for developing climate smart landscape framework to improve food security in East Africa
SmartMet	Meteorological data visualization and automated forecast production system
SMEAR	Stations Measuring Ecosystem-Atmosphere Relationship
SMEs	small and medium-sized enterprises
SMHI	Swedish Meteorological and Hydrological Institute
SO_2	sulphur oxide
SOFF	Systematic Observations Financing Facility
Sofi	Science Advice Initiative of Finland
SOOP	Ship-of-Opportunity monitoring system
SOTKA	a project part of the Helmi habitats programme to improve the status of waterfowl populations
SPA	Shared Climate Policy Assumption
SRC	Strategic Research Council
SSMD	South Sudan Meteorological Department
SSP	Shared Sosioeconomic Pathway
STI	science, technology and innovation
SU	Souphanouvong University

SUA	Sokoine Agricultural University
SuMNatuRe	Sustainable Management of Natural Resources in Mozambique
SUOMI	“Climate change adaption: regional aspects and policy instruments” project
SUZA	State University of Sansibar
SWDS	solid waste disposal site
SYKE	Finnish Environment Institute
T	Biofuel that is produced of waste or residues, or inedible cellulose material or lignocellulose.
t	tonne
TAEE	tert-Amyl ethyl ether
TAFORI	Tanzanian Forest Research Institute
TAITAGIS	Geoinformatics Teaching, Research and Daily Application in Taita Taveta County, Kenya
TAME	tert-Amyl methyl ether
TCCF	Teachers’ Climate Change Forum
TED-Ed	TED’s youth and education initiative
Tekes	Finnish Funding Agency for Technology and Innovation
TEM	Ministry of Economic Affairs and Employment of Finland
TERI	Energy and Resources Institute
TFS	Tanzania Forest Services
TGF	Testing Ground Facility
THL	Finnish Institute for Health and Welfare
TIMES-VTT	an energy system model, which is based on the IEA-ETSAP TIMES energy system modeling framework and the global ETSAP-TIAM model
TJ	terajoule
TPES	total primary energy supply
Traffic12	National Transport System Plan
Traficom	Finnish Transport and Communications Agency
TTU	Taita Taveta University
TWh	terawatt hour
TYKO	a calculation model for non-road mobile machinery
UAS	university of applied science
UCLALES-SALSA	Large-Eddy Simulation Code and the Sectional Aerosol module for Large-Scale Applications – large eddy simulation model for aerosol-climate interactions
UDSM	University of Dar es Salaam
UEF	University of Eastern Finland
UEM	Eduardo Mondlane University

UEM-FAEF	Faculty of Agronomy and Forest Engineering of Eduardo Mondlane University
UHMC	Ukrainian Hydrometeorological Center
UHMC-FMI	Meteorology Project Meteorology cooperation in Ukraine
UK	United Kingdom of Great Britain and Northern Ireland
UN	United Nations
UN DESA	United Nations Department of Economic and Social Affairs
UNCTAD	United Nations Conference on Trade and Development
UNECE	United Nations Economic Commission for Europe
UNECE ICP	UNECE International Cooperative Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UniPID	Finnish University Partnership for International Development
URGENT	"Urban and regional planning with the young generation – collective and intergenerational learning encouraging sustainability transformations" project
USD	United States dollar
U-value	the thermal transmittance of a material
UVic	University of Victoria
VATTAGE	a dynamic, applied general equilibrium model of the Finnish economy
VITRI	Viikki Tropical Resources Institute
VNTEAS	Government's Joint Analysis, Assessment and Research Activities
VR	Finnish State Railways
VTT	Technical Research Centre of Finland
WAM	With Additional Measures
WASH	Water, Sanitation and Hygiene
WATVUL	Water and Vulnerability in Fragile Societies
WCRP	World Climate Research Programme
WDCGG	World Data Centre for Greenhouse Gases
WEM	With Existing Measures
WGE	Working Group on Environment
WLTP	Worldwide Harmonized Light Vehicle Test Procedure
WM	With Measures
Wm^{-2}	watt per square metre
WMO	World Meteorological Organization
WOM	Without Measures

WTO	World Trade Organization
WWF	Worldwide Fund for Nature
Yasso07	A model of the cycling of organic carbon in soil
YKR	Community Structure Monitoring
YLVA	Compliance Monitoring Data System, a tool for processing and monitoring environmental permits in Finland

Annex 1

SUMMARY 1.A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
(Sheet 1 of 3)

Inventory 2020
Submission 2022 v6
FINLAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	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	17504.84	206.70	22.63	975.87	1.72	NO	0.00	NO	98.18	315.91	84.41	23.17
1. Energy	33509.96	10.26	1.75						94.61	311.16	37.87	15.17
A. Fuel combustion Reference approach(2)	33514.01											
Sectoral approach(2)	33433.62	9.40	1.75						94.56	311.14	31.21	15.16
1. Energy industries	12867.90	1.17	0.78						20.49	21.44	1.14	7.58
2. Manufacturing industries and construction	6079.17	0.82	0.47						28.17	35.23	1.65	3.99
3. Transport	10345.40	0.49	0.29						30.93	52.84	6.19	0.11
4. Other sectors	3201.53	6.80	0.20						12.96	200.40	22.09	3.13
5. Other	939.62	0.12	0.02						2.00	1.23	0.16	0.36
B. Fugitive emissions from fuels	76.34	0.87	0.00						0.05	0.02	6.65	0.01
1. Solid fuels	NO	NO	NO						NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	76.34	0.87	0.00						0.05	0.02	6.65	0.01
C. CO_2 Transport and storage	NO,IE,NA											
2. Industrial processes and product use	3883.45	0.05	0.82	975.87	1.72	NO	0.00	NO	1.36	0.19	30.77	8.00
A. Mineral industry	946.52								0.06	NO	NO	0.00
B. Chemical industry	1049.67	0.05	0.76	NO	NO	NO	NO	NO	0.79	NO	2.16	4.12
C. Metal industry	1756.77	0.00	NO				NO		0.37	0.17	0.28	2.80
D. Non-energy products from fuels and solvent use	130.50	0.01	0.00						0.13	0.03	24.00	0.13
E. Electronic industry				NO,IE	NO,IE	NO	NO,IE	NO				
F. Product uses as substitutes for ODS				971.44	0.78							
G. Other product manufacture and use			0.05		NO,IE		0.00					
H. Other[3]	NO	NO	NO	4.43	0.93		0.00		0.00	NO	4.33	0.95
3. Agriculture	202.52	101.03	12.88						2.15	2.35	15.67	NO
A. Enteric fermentation		83.14										
B. Manure management		17.82	0.91								12.37	
C. Rice cultivation		NO									NO,NA	
D. Agricultural soils		NE,NO	11.97						2.09	NE	3.19	
E. Prescribed burning of savannas		NO	NO						NO	NO	NO	
F. Field burning of agricultural residues		0.07	0.00						0.06	2.35	0.11	
G. Liming	200.96											
H. Urea application	1.56											
I. Other carbon-contining fertilizers	NA											
J. Other	NO	NO	NO						NO	NO	NO	NO
4. Land use, land-use change and forestry [4]	-20091.08	30.63	6.79						0.06	2.21	NE	NE
A. Forest land [4]	-30351.27	27.76	6.36						0.06	2.19	NE	
B. Cropland [4]	8042.35	IE,NA	0.02						NE,IE	NE,IE	NE	
C. Grassland [4]	767.41	0.00	0.00						0.00	0.02	NE	
D. Wetlands [4]	2034.79	2.86	0.33						NE,NA	NE,NA	NE	
E. Settlements [4]	712.38	NE,NA	0.07						NE,NA	NE,NA	NE	
F. Other land [4]	NO,NA	NA	NA						NA	NA	NE	
G. Harvested wood products	-1296.74											
H. Other [4]	NA	NA	NA						NA	NA	NE	NE
5. Waste	NO,NE,IE	64.73	0.40						NO,NE,IE	NO,NE,IE	0.10	NO,NE,IE
A. Solid waste disposal [5]	NO	55.40							NO	NO	0.07	
B. Biological treatment of solid waste [5]		2.86	0.15						NO	NO	NO	
C. Incineration and open burning of waste [5]	NO,NE,IE	NO,NE,IE	NO,NE,IE						NE,IE	NE,IE	NE,IE	NE,IE
D. Wastewater treatment and discharge		6.47	0.25						NO	NO	0.03	
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	1848.98	0.09	0.05						21.36	3.19	0.83	0.85
Aviation	869.13	0.00	0.02						4.22	0.82	0.09	0.23
Navigation	979.85	0.08	0.02						17.14	2.37	0.74	0.62
Multilateral operations	NO	NO	NO						NO	NO	NO	NO
CO_2 emissions from biomass	39632.96											
CO_2 captured	101.51											
Long-term storage of C in waste disposal sites	54646.56											
Indirect N_2O			0.46									
Indirect CO_2	65.95											

[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. Data on disaggregated emissions of HFCs and PFCs are to be provided in table 2(II) of this common reporting format.
[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
(Sheet 1 of 1)

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)]	17504.84	5167.55	6744.06	975.87	1.72	19.13	NO	NO	30413.18
1. Energy	33509.96	256.60	522.94						34289.50
A. Fuel combustion (sectoral approach)	33433.62	234.91	522.28						34190.82
1. Energy industries	12867.90	29.33	232.53						13129.76
2. Manufacturing industries and construction	6079.17	20.44	138.62						6238.23
3. Transport	10345.40	12.15	85.88						10443.43
4. Other sectors	3201.53	170.11	58.59						3430.23
5. Other	939.62	2.89	6.66						949.17
B. Fugitive emissions from fuels	76.34	21.69	0.66						98.68
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	76.34	21.69	0.66						98.68
C. CO_2 transport and storage	NO,IE,NA								NO,IE,NA
2. Industrial processes and product use	3883.45	1.25	243.05	975.87	1.72	19.13	NO	NO	5124.48
A. Mineral industry	946.52								946.52
B. Chemical industry	1049.67	1.13	226.53	NO	NO	NO	NO	NO	1277.33
C. Metal industry	1756.77	0.00	NO			NO			1756.77
D. Non-energy products from fuels and solvent use	130.50	0.13	0.76						131.39
E. Electronic Industry				NO,IE	NO,IE	NO,IE	NO	NO	NO,IE
F. Product uses as ODS substitutes				971.44	0.78				972.22
G. Other product manufacture and use			15.76		NO,IE	13.96			29.72
H. Other	NO	NO	NO	4.43	0.93	5.17			10.54
3. Agriculture	202.52	2525.80	3837.63						6565.95
A. Enteric fermentation		2078.48							2078.48
B. Manure management		445.60	270.27						715.87
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NO	3566.83						3566.83
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		1.72	0.53						2.25
G. Liming	200.96								200.96
H. Urea application	1.56								1.56
I. Other carbon-containing fertilizers	NA								NA
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	-20091.08	765.67	2022.30						-17303.12
A. Forest land	-30351.27	694.03	1894.22						-27763.02
B. Cropland	8042.35	IE,NA	7.21						8049.56
C. Grassland	767.41	0.02	0.65						768.08
D. Wetlands	2034.79	71.62	98.22						2204.63
E. Settlements	712.38	NE,NA	20.26						732.65
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-1296.74								-1296.74
H. Other	NA	NA	NA						NA
5. Waste	NO,NE,IE	1618.22	118.14						1736.37
A. Solid waste disposal	NO	1385.01							1385.01
B. Biological treatment of solid waste		71.56	43.35						114.92
C. Incineration and open burning of waste	NO,NE,IE	NO,NE,IE	NO,NE,IE						NO,NE,IE
D. Waste water treatment and discharge		161.65	74.79						236.43
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	1848.98	2.19	13.93						1865.09
Aviation	869.13	0.11	7.08						876.32
Navigation	979.85	2.07	6.85						988.78
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	39632.96								39632.96
CO_2 captured	101.51								101.51
Long-term storage of C in waste disposal sites	54646.56								54646.56
Indirect N_2O			137.29						
Indirect CO_2 [(3)]	65.95								
Total CO_2 equivalent emissions without land use, land-use change and forestry									47716.30
Total CO_2 equivalent emissions with land use, land-use change and forestry									30413.18
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									47782.25
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									30479.13

(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

(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

TABLE 10 EMISSION TRENDS
GHG CO_2 eq emissions

(Sheet 1 of 6)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	(kt CO_2 eq)															
Total (net emissions)[2]	57574.51	57574.51	42613.04	47070.89	49271.75	61608.75	58439.40	57322.86	60715.37	58235.52	56860.41	55082.15	58860.57	60035.81	66798.11	61995.83
1. Energy	53442.15	53442.15	52115.25	51508.25	53447.21	58781.02	55274.94	61028.91	59448.90	56133.59	55514.28	53709.68	59154.01	61753.88	69369.55	65481.66
A. Fuel combustion (sectoral approach)	53318.59	53318.59	51963.04	51331.85	53205.79	58621.03	55106.94	60869.15	59263.35	55985.29	55391.88	53588.03	59022.73	61627.69	69243.13	65363.37
1. Energy industries	18969.25	18969.25	18787.99	18607.58	21353.52	26343.19	24031.16	29781.90	27397.20	24148.96	23601.80	22141.40	27575.76	30393.22	37470.55	33405.88
2. Manufacturing industries and construction	13374.91	13374.91	12867.07	12351.73	12438.40	12773.87	12168.39	12031.56	12309.70	11943.50	11904.01	11934.04	11487.97	11177.27	11569.03	11645.01
3. Transport	12095.17	12095.17	11724.94	11637.32	11174.09	11521.49	11318.31	11312.46	11864.81	11985.78	12191.61	12078.40	12185.37	12367.02	12554.59	12897.29
4. Other sectors	7740.51	7740.51	7577.89	7669.09	7255.74	6743.81	6258.49	6357.45	6366.29	6462.58	6375.94	6016.72	6255.23	6210.36	6116.54	6017.99
5. Other	1138.74	1138.74	1005.15	1066.12	984.04	1238.67	1330.58	1385.78	1325.35	1444.46	1318.52	1417.47	1518.40	1479.83	1532.41	1397.20
B. Fugitive emissions from fuels	123.56	123.56	152.21	176.41	241.42	159.99	168.00	159.76	185.55	148.30	122.40	121.65	131.28	126.19	126.42	118.29
1. Solid fuels	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	123.56	123.56	152.21	176.41	241.42	159.99	168.00	159.76	185.55	148.30	122.40	121.65	131.28	126.19	126.42	118.29
C. CO_2 transport and storage	NO,NA	NO,NA	NA,NO	NA,NO	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA
2. Industrial Processes	5397.60	5397.60	4993.89	4704.42	4734.26	5009.54	5063.70	5308.80	5613.44	5645.17	5807.93	5988.41	6056.49	6095.18	6441.06	6795.54
A. Mineral industry	1218.22	1218.22	1050.07	952.06	857.51	898.40	873.72	913.96	943.13	955.98	1030.01	1080.45	1084.49	1084.31	1127.58	1189.36
B. Chemical industry	1866.46	1866.46	1676.77	1493.00	1499.83	1621.12	1673.44	1674.61	1653.55	1574.32	1547.14	1581.36	1520.23	1592.77	1663.07	1766.90
C. Metal industry	1976.07	1976.07	1987.05	1991.26	2113.32	2121.91	2076.30	2198.67	2414.58	2419.66	2448.48	2389.23	2440.13	2318.35	2480.87	2576.16
D. Non-energy products from fuels and solvent use	219.66	219.66	175.06	177.58	178.72	197.60	187.31	167.61	152.16	147.60	141.58	137.87	144.11	143.48	118.13	111.01
E. Electronic industry	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NE,NO,IE	NO,IE
F. Product uses as ODS substitutes	0.01	0.01	0.02	0.04	0.25	81.69	150.92	234.69	334.60	443.69	538.92	717.57	788.18	882.14	978.28	1082.39
G. Other product manufacture and use	109.48	109.48	97.01	82.65	78.49	81.18	91.13	85.73	81.96	79.25	79.30	62.21	59.12	55.19	51.44	50.58
H. Other	7.70	7.70	7.91	7.83	6.14	7.63	10.88	33.54	33.46	24.68	22.50	19.73	20.24	18.95	21.69	19.13
3. Agriculture	7506.86	7506.86	7095.97	6562.53	6848.55	6888.92	6697.81	6797.03	6898.61	6687.49	6622.19	6614.85	6594.35	6640.85	6515.16	6496.66
A. Enteric fermentation	2420.59	2420.59	2332.71	2252.21	2273.07	2278.66	2145.53	2153.96	2187.33	2134.90	2098.69	2108.79	2089.97	2114.61	2092.97	2074.66
B. Manure management	651.05	651.05	617.07	613.61	624.57	646.19	644.31	664.30	694.00	675.22	663.50	661.34	668.88	684.96	703.37	705.98
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	3783.81	3783.81	3684.96	3394.20	3474.01	3487.26	3494.34	3497.27	3521.90	3422.26	3403.87	3490.27	3412.51	3390.81	3412.84	3436.00
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	4.02	4.02	3.67	3.03	3.77	3.62	3.35	3.66	3.60	2.70	2.52	3.60	3.14	3.25	3.04	3.00
G. Liming	642.01	642.01	455.16	296.88	472.14	472.49	409.67	477.26	490.96	451.61	452.82	350.01	418.92	446.22	301.90	275.91
H. Urea application	5.39	5.39	2.40	2.60	0.99	0.69	0.60	0.58	0.83	0.80	0.79	0.85	0.93	1.00	1.05	1.11
I. Other carbon-containing fertilizers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
J. Other	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]	-13441.26	-13441.26	-26316.08	-20440.90	-20489.45	-13738.00	-13193.06	-20302.86	-15609.71	-14397.06	-15148.44	-15047.94	-16601.98	-17858.40	-18731.66	-19827.76
A. Forest land	-19203.92	-19203.92	-33664.45	-27566.78	-25567.12	-17702.93	-17539.83	-26459.00	-19991.35	-18547.65	-20069.15	-19810.95	-23921.01	-24730.32	-25276.88	-26436.73
B. Cropland	5395.68	5395.68	5122.30	5116.89	5419.79	5647.30	5645.92	6571.64	7276.75	7158.02	7289.32	7436.03	7189.19	7100.69	7363.08	7615.50
C. Grassland	1019.72	1019.72	999.49	965.52	955.11	926.37	906.42	881.82	888.03	860.89	848.75	838.68	855.88	835.40	830.83	883.11
D. Wetlands	1450.56	1450.56	1429.94	1616.00	1562.52	1777.46	1647.28	1699.11	1775.21	1582.05	1990.03	1796.06	2008.12	2044.09	1962.63	1885.26
E. Settlements	846.68	846.68	883.05	922.04	985.38	1042.03	1050.04	1117.51	1221.64	1274.84	1275.44	1297.33	1467.84	1440.05	1484.56	1623.94
F. Other land	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
G. Harvested wood products	-2951.60	-2951.60	-1087.97	-1496.07	-3846.57	-5429.62	-4904.21	-4115.24	-6781.32	-6726.55	-6484.23	-6606.56	-4203.54	-4549.95	-5097.62	-5400.65
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Waste	4669.16	4669.16	4724.01	4736.60	4731.18	4667.27	4596.02	4490.98	4364.13	4166.32	4064.46	3817.15	3657.70	3404.29	3204.00	3049.73
A. Solid waste disposal	4327.75	4327.75	4384.59	4400.82	4391.98	4326.01	4245.11	4133.90	4015.74	3816.88	3713.44	3463.44	3303.25	3047.68	2839.96	2678.79
B. Biological treatment of solid waste	44.10	44.10	49.52	55.56	59.79	64.01	72.98	82.38	83.08	88.14	93.22	97.91	102.95	107.96	112.05	116.52
C. Incineration and open burning of waste	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
D. Waste water treatment and discharge	297.30	297.30	289.90	280.21	279.41	277.25	277.92	274.70	265.31	261.31	257.79	255.80	251.50	248.66	251.99	254.42
E. Other	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
Memo items:																
International bunkers	2865.77	2865.77	2718.49	3071.51	2535.64	2189.13	1973.33	2178.76	2315.62	2705.25	2890.69	3139.02	2949.77	3175.36	3196.74	2956.31
Aviation	1016.07	1016.07	956.13	845.24	794.30	836.26	904.44	968.22	1005.94	1030.67	1103.18	1072.15	1099.06	1086.52	1122.81	1292.89
Navigation	1849.70	1849.70	1762.36	2226.27	1741.34	1352.87	1068.90	1210.55	1309.68	1674.58	1787.51	2066.86	1850.72	2088.84	2073.93	1663.42
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	18306.86	18306.86	17982.73	17676.41	20981.71	21773.40	22206.28	22368.06	25388.93	26184.30	27544.04	27918.78	27238.97	29325.13	30112.74	31687.89
CO_2 captured	NO	NO	NO,NA	NO,NA	0.86	20.07	54.15	73.54	106.08	127.95	156.47	183.44	175.68	176.47	186.21	212.73
Long-term storage of C in waste disposal sites	37785.27	37785.27	39123.77	40334.09	41438.78	42456.86	43405.85	44279.05	45103.92	45860.11	46554.49	47266.63	47943.58	48569.52	49175.57	49760.89
Indirect N_2O	421.61	421.61	410.34	400.01	405.80	406.51	375.80	382.50	374.69	354.72	348.14	332.12	336.75	331.83	343.43	324.09
Indirect CO_2 [3]	166.34	166.34	155.75	149.69	143.32	142.74	133.48	119.37	118.25	115.07	110.57	108.29	107.95	98.27	98.11	95.22
Total CO_2 equivalent emissions without land use, land-use change and forestry	71015.77	71015.77	68929.12	67511.80	69761.20	75346.75	71632.46	77625.72	76325.08	72632.58	72008.86	70130.08	75462.55	77894.21	85529.77	81823.59
Total CO_2 equivalent emissions with land use, land-use change and forestry	57574.51	57574.51	42613.04	47070.89	49271.75	61608.75	58439.40	57322.86	60715.37	58235.52	56860.41	55082.15	58860.57	60035.81	66798.11	61995.83
Total CO_2 equivalent emissions, including indirect CO2, without land use, land-use change and forestry	71182.11	71182.11	69084.87	67661.48	69904.52	75489.50	71765.94	77745.08	76443.33	72747.65	72119.42	70238.38	75570.50	77992.48	85627.88	81918.81
Total CO_2 equivalent emissions, including indirect CO2, with land use, land-use change and forestry	57740.85	57740.85	42768.79	47220.58	49415.07	61751.50	58572.88	57442.23	60833.62	58350.59	56970.98	55190.44	58968.52	60134.08	66896.22	62091.05

Note: All footnotes for this table are given at the end of the table on sheet 6.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2005	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)	49355.98	55285.03	62659.70	51512.97	34496.08	53891.83	45868.80	37700.56	44389.11	37686.07	36209.25	40212.49	38775.65	48732.29	39145.10	30413.18	-47.18
1. Energy	53743.15	64816.83	62843.62	54501.77	52626.35	60230.38	52784.34	47495.42	48106.83	44257.70	40601.59	43345.94	40910.31	42071.54	38922.22	34289.50	-35.84
A. Fuel combustion (sectoral approach)	53599.71	64695.79	62705.40	54349.08	52498.92	60088.22	52656.60	47352.12	47987.36	44140.92	40455.29	43207.71	40731.93	41950.57	38830.20	34190.82	-35.87
1. Energy industries	22150.12	33016.35	31034.45	24514.99	25600.17	30954.39	24943.96	20853.12	22171.88	20953.12	17780.26	19,159.55	17,514.59	18,676.85	16,248.84	13,129.76	-30.78
2. Manufacturing industries and construction	11365.94	11630.36	11468.81	10921.89	8732.00	10042.19	9640.52	8424.06	8393.77	7067.92	6754.81	6,821.02	6,663.57	6,807.39	6,591.16	6,238.23	-53.36
3. Transport	12876.49	13039.33	13394.58	12751.32	12179.38	12674.31	12496.86	12188.59	11966.24	10844.11	10852.51	12,064.25	11,462.51	11,658.34	11,249.40	10,443.43	-13.66
4. Other sectors	5705.08	5596.00	5458.85	4966.46	4882.45	5209.48	4539.46	4824.55	4429.47	4313.12	4075.56	4,191.19	4,045.54	3,865.38	3,775.95	3,430.23	-55.68
5. Other	1502.08	1413.74	1348.71	1194.43	1104.92	1207.84	1035.80	1061.81	1025.98	962.65	992.15	971.70	1,045.72	942.61	964.86	949.17	-16.65
B. Fugitive emissions from fuels	143.44	121.04	138.22	152.68	127.43	142.16	127.74	143.30	119.47	116.78	146.30	138.23	178.38	120.98	92.03	98.68	-20.13
1. Solid fuels	NO	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	143.44	121.04	138.22	152.68	127.43	142.16	127.74	143.30	119.47	116.78	146.30	138.23	178.38	120.98	92.03	98.68	-20.13
C. CO_2 transport and storage	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	0.00
2. Industrial Processes	6765.15	7001.22	7456.58	7696.77	6041.15	6159.40	6102.37	5931.68	5798.54	5556.26	5703.80	5911.62	5736.85	5736.57	5394.61	5124.48	-5.06
A. Mineral industry	1176.13	1270.12	1294.88	1227.14	909.18	1167.01	1256.53	1120.15	1061.36	1032.18	966.05	1,083.92	1,134.50	1,060.57	971.54	946.52	-22.30
B. Chemical industry	1849.75	1756.34	2126.81	2337.81	1590.91	1018.72	950.03	995.96	1120.83	973.54	1161.63	1,249.17	1,370.27	1,310.92	1,343.87	1,277.33	-31.56
C. Metal industry	2403.84	2472.70	2494.91	2553.51	1968.86	2438.85	2383.28	2290.91	2094.75	2070.08	2150.41	2,196.61	1,928.17	2,096.30	1,874.97	1,756.77	-11.10
D. Non-energy products from fuels and solvent use	103.15	114.55	131.46	126.84	131.33	115.17	112.96	116.93	126.73	114.98	139.42	145.58	141.48	159.11	155.03	131.39	-40.19
E. Electronic industry	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	0.00
F. Product uses as ODS substitutes	1160.06	1313.89	1347.07	1379.28	1382.20	1360.94	1341.02	1350.12	1331.12	1297.75	1235.15	1,177.06	1,107.42	1,061.94	1,008.43	972.22	9208858.27
G. Other product manufacture and use	57.04	51.26	49.25	47.07	38.72	42.29	41.23	40.19	37.48	37.85	34.93	35.95	38.16	35.73	31.47	29.72	-72.86
H. Other	15.18	22.35	12.21	25.13	19.94	16.42	17.32	17.42	26.28	29.87	16.20	23.33	16.85	11.99	9.30	10.54	36.93
3. Agriculture	6529.05	6501.57	6480.63	6604.88	6566.88	6650.75	6473.62	6445.56	6526.04	6573.31	6573.72	6655.41	6550.95	6497.09	6624.45	6565.95	-12.53
A. Enteric fermentation	2057.71	2063.59	2045.28	2030.94	2050.62	2094.62	2070.60	2051.60	2055.11	2087.64	2115.10	2,104.27	2,095.62	2,078.21	2,070.33	2,078.48	-14.13
B. Manure management	724.09	720.92	726.56	707.21	734.14	746.58	727.75	738.35	732.85	747.45	756.79	755.88	741.18	736.11	732.07	715.87	9.96
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
D. Agricultural soils	3453.31	3392.42	3428.66	3537.37	3439.68	3528.70	3470.98	3450.19	3429.85	3511.68	3517.54	3,524.56	3,513.22	3,469.21	3,619.22	3,566.83	-5.73
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
F. Field burning of agricultural residues	2.95	2.63	2.88	2.80	2.72	1.85	2.17	2.13	2.87	2.62	2.44	2.34	2.45	1.80	2.65	2.25	-43.96
G. Liming	289.86	320.64	275.46	325.01	338.26	277.41	199.54	201.61	304.38	222.21	179.75	265.58	196.65	210.28	198.03	200.96	-68.70
H. Urea application	1.14	1.38	1.78	1.54	1.45	1.58	2.58	1.68	0.98	1.71	2.11	2.79	1.83	1.48	2.15	1.56	-71.07
I. Other carbon-containing fertilizers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
J. Other	NO	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)	-20493.52	-25921.89	-16906.02	-19953.34	-33298.52	-21710.64	-21966.83	-24589.54	-18335.19	-20860.31	-18761.62	-17655.65	-16280.42	-7392.83	-13589.55	-17303.12	28.73
A. Forest land	-30667.65	-33592.69	-23138.05	-30463.29	-47161.71	-31969.10	-32096.70	-35160.86	-28046.82	-29699.88	-27428.63	-25,758.50	-23,310.14	-14,555.16	-21,886.72	-27,763.02	44.57
B. Cropland	7492.71	7616.46	7237.58	7547.23	7430.86	7617.34	7522.41	7736.53	7441.46	7409.94	7377.52	7,891.11	7,618.92	7,813.71	7,910.35	8,049.56	49.19
C. Grassland	911.26	920.47	917.75	907.59	858.00	820.88	764.22	761.47	761.05	745.52	759.23	765.97	763.48	769.13	780.92	768.08	-24.68
D. Wetlands	2104.77	2373.17	2061.63	2206.89	2333.47	2324.54	2253.62	2113.26	2327.77	2206.50	2145.25	2,161.63	2,161.82	2,291.98	2,198.24	2,204.63	51.98
E. Settlements	1634.73	1521.76	1622.96	1631.69	1593.35	1689.18	1758.55	1632.82	1546.46	1502.53	1292.02	1,100.19	981.18	867.09	786.42	732.65	-13.47
F. Other land	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.00
G. Harvested wood products	-1971.20	-4762.91	-5609.74	-1785.25	1645.65	-2195.41	-2170.92	-1674.81	-2367.20	-3027.00	-2909.11	-3,818.13	-4,497.73	-4,581.51	-3,380.64	-1,296.74	-56.07
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
5. Waste	2812.15	2887.30	2784.89	2662.89	2560.23	2561.95	2475.30	2417.44	2292.89	2159.10	2091.76	1955.17	1857.96	1819.92	1793.38	1736.37	-62.81
A. Solid waste disposal	2430.51	2501.54	2385.94	2273.21	2180.73	2168.93	2076.47	2035.58	1915.52	1784.02	1730.66	1,607.46	1,508.95	1,467.24	1,425.68	1,385.01	-68.00
B. Biological treatment of solid waste	130.60	134.65	147.00	138.00	138.47	143.63	145.98	127.30	129.74	128.53	112.85	101.02	103.93	109.24	127.91	114.92	160.57
C. Incineration and open burning of waste	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	NE,NO,IE	NE,NO,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	0.00
D. Waste water treatment and discharge	251.04	251.11	251.95	251.68	241.03	249.39	252.84	254.56	247.64	246.56	248.24	246.70	245.08	243.44	239.79	236.43	-20.47
E. Other	NO	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	NO	0.00
Memo items:																	
International bunkers	2930.24	3251.01	3141.12	3094.65	2371.07	2328.46	2588.65	2255.62	2337.24	2208.32	2906.22	2878.00	3219.19	3428.71	3650.17	1865.09	-34.92
Aviation	1300.90	1446.49	1669.31	1806.91	1583.12	1667.22	1972.84	1904.19	1965.37	1936.65	1979.32	1,983.90	2,114.79	2,408.03	2,595.43	876.32	-13.75
Navigation	1629.34	1804.53	1471.81	1287.75	787.95	661.24	615.81	351.43	371.87	271.67	926.90	894.09	1,104.40	1,020.68	1,054.74	988.78	-46.54
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass	30010.40	32929.69	31883.67	32420.79	29358.97	34664.11	34316.21	36004.20	37054.64	38014.13	37209.27	38,464.35	40,417.95	41,593.16	42,271.70	39,632.96	116.49
CO_2 captured	183.55	211.96	234.04	213.52	185.06	197.80	180.14	147.21	145.59	149.72	139.09	138.45	133.42	134.99	124.28	101.51	100.00
Long-term storage of C in waste disposal sites	50358.07	50989.94	51587.80	52125.20	52579.06	53039.63	53469.66	53841.76	54128.68	54328.91	54482.33	54,533.66	54,561.75	54,595.03	54,623.27	54,646.56	44.62
Indirect N_2O	283.17	305.86	289.72	264.68	240.99	253.05	230.80	218.19	213.13	201.64	185.86	179.52	173.83	168.03	158.16	137.29	-67.44
Indirect CO_2 (3)	88.10	88.91	88.60	79.61	71.19	69.88	67.66	62.02	59.74	56.19	54.94	55.30	53.38	53.62	53.37	65.95	-60.35
Total CO_2 equivalent emissions without land use, land-use change and forestry	69849.50	81206.92	79565.73	71466.31	67794.61	75602.47	67835.63	62290.10	62724.31	58546.37	54970.87	57868.14	55056.07	56125.12	52734.65	47716.30	-32.81
Total CO_2 equivalent emissions with land use, land-use change and forestry	49355.98	55285.03	62659.70	51512.97	34496.08	53891.83	45868.80	37700.56	44389.11	37686.07	36209.25	40212.49	38775.65	48732.29	39145.10	30413.18	-47.18
Total CO_2 equivalent emissions, including indirect CO2, without land use, land-use change and forestry	69937.60	81295.83	79654.33	71545.92	67865.80	75672.35	67903.29	62352.12	62784.05	58602.57	55025.81	57923.44	55109.45	56178.74	52788.02	47782.25	-32.87
Total CO_2 equivalent emissions, including indirect CO2, with land use, land-use change and forestry	49444.08	55373.94	62748.30	51592.58	34567.27	53961.71	45936.45	37762.58	44448.85	37742.26	36264.19	40267.79	38829.03	48785.91	39198.47	30479.13	-47.21

TABLE 10 EMISSION TRENDS

CO_2

(Sheet 2 of 6)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[(1)]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	(kt)															
1. Energy	52584.73	52584.73	51230.84	50610.24	52504.63	57806.18	54306.99	60013.26	58436.80	55128.78	54547.58	52784.64	58150.46	60743.02	68318.40	64460.62
A. Fuel combustion (sectoral approach)	52473.23	52473.23	51127.38	50500.39	52347.74	57739.75	54232.40	59948.50	58333.58	55064.84	54492.43	52726.16	58097.51	60681.51	68262.38	64405.59
1. Energy industries	18843.01	18843.01	18651.29	18460.42	21185.15	26149.66	23833.72	29548.82	27165.10	23917.16	23378.08	21924.67	27306.91	30081.30	37117.91	33074.21
2. Manufacturing industries and construction	13192.36	13192.36	12696.96	12194.18	12262.27	12591.98	11989.02	11849.42	12110.28	11750.11	11704.88	11732.69	11294.12	10993.62	11383.89	11452.51
3. Transport	11821.46	11821.46	11454.17	11371.83	10916.49	11272.09	11076.35	11077.53	11638.06	11771.32	11988.70	11890.46	12006.78	12201.27	12401.36	12754.26
4. Other sectors	7489.95	7489.95	7330.36	7418.44	7009.54	6499.63	6016.13	6100.91	6107.96	6196.16	6115.64	5774.79	5985.97	5939.85	5841.74	5741.51
5. Other	1126.45	1126.45	994.59	1055.52	974.29	1226.39	1317.18	1371.82	1312.18	1430.09	1305.13	1403.55	1503.72	1465.47	1517.48	1383.09
B. Fugitive emissions from fuels	111.49	111.49	103.46	109.84	156.89	66.43	74.60	64.76	103.22	63.94	55.15	58.48	52.96	61.50	56.02	55.04
1. Solid fuels	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	111.49	111.49	103.46	109.84	156.89	66.43	74.60	64.76	103.22	63.94	55.15	58.48	52.96	61.50	56.02	55.04
C. CO_2 transport and storage	NO,NA	NO,NA	NA,NO	NA,NO	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA
2. Industrial processes	3682.21	3682.21	3500.36	3355.35	3335.61	3453.30	3398.25	3541.97	3767.58	3770.28	3865.72	3874.43	3943.42	3850.74	4032.98	4201.46
A. Mineral industry	1218.22	1218.22	1050.07	952.06	857.51	898.40	873.72	913.96	943.13	955.98	1030.01	1080.45	1084.49	1084.31	1127.58	1189.36
B. Chemical industry	270.23	270.23	289.75	236.06	187.65	237.13	262.62	263.23	259.06	248.36	246.91	268.12	275.97	305.84	307.38	325.82
C. Metal industry	1976.06	1976.06	1987.05	1991.26	2113.32	2121.91	2076.29	2198.67	2414.58	2419.66	2448.48	2389.22	2440.13	2318.34	2480.87	2576.16
D. Non-energy products from fuels and solvent use	217.69	217.69	173.49	175.98	177.13	195.86	185.62	166.10	150.81	146.29	140.32	136.64	142.84	142.24	117.16	110.12
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	NO
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	647.40	647.40	457.56	299.47	473.13	473.18	410.27	477.83	491.79	452.41	453.60	350.85	419.85	447.22	302.95	277.02
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	642.01	642.01	455.16	296.88	472.14	472.49	409.67	477.26	490.96	451.61	452.82	350.01	418.92	446.22	301.90	275.91
H. Urea application	5.39	5.39	2.40	2.60	0.99	0.69	0.60	0.58	0.83	0.80	0.79	0.85	0.93	1.00	1.05	1.11
I. Other carbon-containing fertilizers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
J. Other	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)]	-17105.00	-17105.00	-29960.28	-24067.01	-24097.31	-17341.72	-16780.55	-23878.07	-19176.45	-17949.16	-18673.32	-18543.75	-20073.04	-21295.23	-22133.40	-23195.08
A. Forest land	-22730.92	-22730.92	-37170.72	-31052.27	-29031.83	-21160.68	-20977.67	-29881.42	-23401.94	-21941.11	-23431.75	-23142.00	-27224.01	-27997.94	-28507.80	-29630.69
B. Cropland	5389.04	5389.04	5116.04	5110.90	5414.01	5641.69	5640.44	6566.24	7271.36	7152.54	7283.69	7430.16	7182.96	7094.04	7356.04	7608.20
C. Grassland	1019.08	1019.08	998.85	964.86	954.44	925.68	905.73	881.13	887.28	860.27	847.99	838.00	855.17	834.64	829.96	882.27
D. Wetlands	1334.64	1334.64	1312.39	1495.45	1439.47	1651.39	1517.65	1566.52	1639.65	1444.27	1849.25	1653.62	1863.45	1899.13	1817.24	1738.55
E. Settlements	834.76	834.76	871.13	910.12	973.16	1029.81	1037.52	1104.69	1208.52	1261.43	1261.73	1283.03	1452.94	1424.85	1468.77	1607.25
F. Other land	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
G. Harvested wood products	-2951.60	-2951.60	-1087.97	-1496.07	-3846.57	-5429.62	-4904.21	-4115.24	-6781.32	-6726.55	-6484.23	-6606.56	-4203.54	-4549.95	-5097.62	-5400.65
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Waste	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
A. Solid waste disposal	NO	NO	NO	NO	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	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
D. Waste water treatment and discharge																
E. Other	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
Memo items:																
International bunkers	2839.72	2839.72	2693.75	3043.24	2512.50	2169.38	1955.73	2159.25	2294.79	2680.68	2863.84	3110.16	2922.80	3146.74	3167.94	2931.02
Aviation	1007.73	1007.73	948.28	838.29	787.76	829.37	896.99	960.24	997.65	1022.15	1094.07	1063.28	1089.98	1077.56	1113.56	1282.23
Navigation	1832.00	1832.00	1745.48	2204.95	1724.74	1340.01	1058.74	1199.00	1297.14	1658.53	1769.77	2046.88	1832.82	2069.18	2054.38	1648.79
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	18306.86	18306.86	17982.73	17676.41	20981.71	21773.40	22206.28	22368.06	25388.93	26184.30	27544.04	27918.78	27238.97	29325.13	30112.74	31687.89
CO_2 captured	NO	NO	NO,NA	NO,NA	0.86	20.07	54.15	73.54	106.08	127.95	156.47	183.44	175.68	176.47	186.21	212.73
Long-term storage of C in waste disposal sites	37785.27	37785.27	39123.77	40334.09	41438.78	42456.86	43405.85	44279.05	45103.92	45860.11	46554.49	47266.63	47943.58	48569.52	49175.57	49760.89
Indirect N_2O																
Indirect CO_2 [(3)]	166.34	166.34	155.75	149.69	143.32	142.74	133.48	119.37	118.25	115.07	110.57	108.29	107.95	98.27	98.11	95.22
Total CO_2 equivalent emissions without land use, land-use change and forestry	56914.34	56914.34	55188.76	54265.06	56313.37	61732.67	58115.52	64033.06	62696.17	59351.46	58866.90	57009.92	62513.74	65040.97	72654.32	68939.11
Total CO_2 equivalent emissions with land use, land-use change and forestry	39809.33	39809.33	25228.48	30198.05	32216.05	44390.95	41334.97	40154.98	43519.72	41402.31	40193.58	38466.17	42440.70	43745.74	50520.93	45744.04
Total CO_2 equivalent emissions, including indirect CO2, without land use, land-use change and forestry	57080.68	57080.68	55344.51	54414.74	56456.69	61875.41	58248.99	64152.42	62814.42	59466.54	58977.47	57118.21	62621.69	65139.24	72752.44	69034.33
Total CO_2 equivalent emissions, including indirect CO2, with land use, land-use change and forestry	39975.68	39975.68	25384.23	30347.74	32359.38	44533.69	41468.45	40274.35	43637.97	41517.38	40304.15	38574.46	42548.65	43844.01	50619.04	45839.26

Note: All footnotes for this table are given at the end of the table on sheet 6.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2005	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	52788.93	63820.57	61861.04	53570.00	51730.77	59225.38	51863.98	46580.50	47208.17	43388.13	39761.14	42458.66	40040.31	41172.70	38043.49	33509.96	-36.27
A. Fuel combustion (sectoral approach)	52718.51	63762.35	61780.13	53472.87	51656.05	59128.97	51776.18	46478.69	47129.02	43304.40	39652.62	42354.55	39893.72	41081.92	37978.35	33433.62	-36.28
1. Energy industries	21878.94	32667.32	30689.53	24193.79	25292.10	30576.34	24595.57	20531.92	21849.11	20652.79	17505.54	18,867.86	17,234.26	18,365.95	15,948.60	12,867.90	-31.71
2. Manufacturing industries and construction	11186.18	11456.79	11301.67	10762.17	8597.45	9890.89	9490.85	8273.99	8241.51	6916.10	6594.96	6,648.62	6,490.54	6,628.49	6,415.02	6,079.17	-53.92
3. Transport	12742.69	12913.82	13274.43	12641.42	12075.66	12570.63	12395.50	12091.16	11869.19	10746.37	10754.99	11,965.99	11,364.48	11,558.71	11,149.29	10,345.40	-12.49
4. Other sectors	5423.54	5324.34	5179.12	4692.68	4596.57	4894.81	4268.82	4530.51	4153.32	4035.79	3814.39	3,909.66	3,768.88	3,595.76	3,510.15	3,201.53	-57.26
5. Other	1487.15	1400.08	1335.38	1182.81	1094.28	1196.29	1025.44	1051.11	1015.89	953.36	982.74	962.42	1,035.55	933.02	955.28	939.62	-16.59
B. Fugitive emissions from fuels	70.42	58.22	80.91	97.13	74.71	96.41	87.79	101.81	79.15	83.73	108.52	104.11	146.59	90.79	65.14	76.34	-31.53
1. Solid fuels	NO	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	70.42	58.22	80.91	97.13	74.71	96.41	87.79	101.81	79.15	83.73	108.52	104.11	146.59	90.79	65.14	76.34	-31.53
C. CO_2 transport and storage	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	NO,IE,NA	0.00
2. Industrial processes	3967.39	4228.10	4621.55	4724.44	3834.59	4576.39	4571.08	4361.89	4190.22	3983.78	4156.10	4454.84	4339.00	4412.00	4138.17	3883.45	5.47
A. Mineral industry	1176.13	1270.12	1294.88	1227.14	909.18	1167.01	1256.53	1120.15	1061.36	1032.18	966.05	1,083.92	1,134.50	1,060.57	971.54	946.52	-22.30
B. Chemical industry	285.08	371.63	701.34	817.90	826.22	856.19	819.13	834.78	908.34	767.36	901.25	1,029.78	1,135.87	1,097.17	1,137.74	1,049.67	288.43
C. Metal industry	2403.84	2472.70	2494.91	2553.51	1968.86	2438.84	2383.27	2290.91	2094.75	2070.08	2150.41	2,196.61	1,928.17	2,096.30	1,874.96	1,756.77	-11.10
D. Non-energy products from fuels and solvent use	102.34	113.66	130.43	125.89	130.33	114.35	112.13	116.05	125.76	114.17	138.39	144.52	140.46	157.97	153.93	130.50	-40.05
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				
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
3. Agriculture	291.00	322.02	277.24	326.56	339.72	278.99	202.12	203.29	305.36	223.92	181.86	268.37	198.49	211.76	200.18	202.52	-68.72
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	289.86	320.64	275.46	325.01	338.26	277.41	199.54	201.61	304.38	222.21	179.75	265.58	196.65	210.28	198.03	200.96	-68.70
H. Urea application	1.14	1.38	1.78	1.54	1.45	1.58	2.58	1.68	0.98	1.71	2.11	2.79	1.83	1.48	2.15	1.56	-71.07
I. Other carbon-containing fertilizers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
J. Other	NO	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]	-23827.01	-29228.77	-20178.38	-23174.43	-36445.38	-24789.67	-24978.84	-27548.37	-21248.54	-23726.95	-21578.50	-20427.96	-19063.33	-10178.78	-16375.28	-20091.08	17.46
A. Forest land	-33825.34	-36721.24	-26228.47	-33498.06	-50117.90	-34852.98	-34911.03	-37919.61	-30758.32	-32363.12	-30041.19	-28,326.62	-25,889.67	-17,138.46	-24,470.34	-30,351.27	33.52
B. Cropland	7485.29	7609.01	7230.28	7540.05	7423.62	7609.74	7514.48	7728.36	7433.11	7401.48	7369.03	7,882.65	7,610.64	7,805.69	7,902.70	8,042.35	49.24
C. Grassland	910.40	919.59	916.82	906.67	857.02	819.91	763.27	760.58	760.15	744.61	758.43	765.20	762.70	768.39	780.20	767.41	-24.70
D. Wetlands	1956.40	2223.18	1908.54	2049.85	2172.84	2160.46	2087.96	1946.05	2159.32	2036.91	1974.97	1,991.11	1,991.61	2,121.48	2,027.25	2,034.79	52.46
E. Settlements	1617.45	1503.59	1604.19	1612.32	1573.39	1668.61	1737.39	1611.06	1524.40	1480.18	1269.37	1,077.84	959.13	845.63	765.56	712.38	-14.66
F. Other land	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.00
G. Harvested wood products	-1971.20	-4762.91	-5609.74	-1785.25	1645.65	-2195.41	-2170.92	-1674.81	-2367.20	-3027.00	-2909.11	-3,818.13	-4,497.73	-4,581.51	-3,380.64	-1,296.74	-56.07
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
5. Waste	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	NE,NO,IE	NE,NO,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	0.00
A. Solid waste disposal	NO	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	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	NE,NO,IE	NE,NO,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	0.00
D. Waste water treatment and discharge																	
E. Other	NO	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	NO	0.00
Memo items:																	
International bunkers	2904.33	3222.45	3113.74	3068.06	2350.84	2308.67	2566.82	2236.80	2317.71	2189.95	2881.63	2853.66	3191.80	3399.73	3619.36	1848.98	-34.89
Aviation	1290.19	1434.60	1655.60	1792.08	1570.10	1653.51	1956.64	1888.55	1949.24	1920.76	1963.08	1,967.62	2,097.42	2,388.26	2,574.14	869.13	-13.75
Navigation	1614.15	1787.86	1458.13	1275.98	780.74	655.16	610.18	348.25	368.47	269.19	918.55	886.04	1,094.37	1,011.47	1,045.22	979.85	-46.51
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass	30010.40	32929.69	31883.67	32420.79	29358.97	34664.11	34316.21	36004.20	37054.64	38014.13	37209.27	38,464.35	40,417.95	41,593.16	42,271.70	39,632.96	116.49
CO_2 captured		211.96	234.04	213.52	185.06	197.80	180.14	147.21	145.59	149.72	139.09	138.45	133.42	134.99	124.28	101.51	100.00
Long-term storage of C in waste disposal sites	50358.07	50989.94	51587.80	52125.20	52579.06	53039.63	53469.66	53841.76	54128.68	54328.91	54482.33	54,533.66	54,561.75	54,595.03	54,623.27	54,646.56	44.62
Indirect N_2O																	
Indirect CO_2 [3]	88.10	88.91	88.60	79.61	71.19	69.88	67.66	62.02	59.74	56.19	54.94	55.30	53.38	53.62	53.37	65.95	-60.35
Total CO_2 equivalent emissions without land use, land-use change and forestry	57047.32	68370.69	66759.84	58621.00	55905.07	64080.76	56637.17	51145.69	51703.75	47595.83	44099.10	47181.86	44577.80	45796.46	42381.84	37595.93	-33.94
Total CO_2 equivalent emissions with land use, land-use change and forestry	33220.31	39141.92	46581.46	35446.57	19459.69	39291.09	31658.33	23597.32	30455.22	23868.88	22520.59	26753.90	25514.46	35617.68	26006.56	17504.84	-56.03
Total CO_2 equivalent emissions, including indirect CO2, without land use, land-use change and forestry	57135.42	68459.60	66848.43	58700.61	55976.26	64150.63	56704.83	51207.71	51763.49	47652.02	44154.03	47237.16	44631.17	45850.08	42435.21	37661.88	-34.02
Total CO_2 equivalent emissions, including indirect CO2, with land use, land-use change and forestry	33308.41	39230.82	46670.05	35526.18	19530.88	39360.97	31725.98	23659.34	30514.95	23925.07	22575.53	26809.20	25567.84	35671.30	26059.93	17570.80	-56.05

TABLE 10 EMISSION TRENDS

CH_4

(Sheet 3 of 6)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	(kt)															
1. Energy	12.65	12.65	13.86	14.48	15.06	15.43	15.39	15.85	15.31	15.38	14.26	13.26	14.71	14.20	14.58	14.17
A. Fuel combustion (sectoral approach)	12.21	12.21	11.96	11.86	11.75	11.72	11.68	12.08	12.06	12.03	11.59	10.76	11.60	11.64	11.79	11.66
1. Energy industries	0.39	0.39	0.41	0.43	0.48	0.58	0.62	0.73	0.77	0.78	0.76	0.74	0.92	1.15	1.33	1.23
2. Manufacturing industries and construction	0.63	0.63	0.61	0.59	0.68	0.70	0.72	0.70	0.74	0.71	0.72	0.74	0.70	0.68	0.70	0.71
3. Transport	4.50	4.50	4.29	4.14	3.95	3.70	3.50	3.36	3.20	2.92	2.66	2.37	2.19	1.96	1.72	1.59
4. Other sectors	6.53	6.53	6.52	6.59	6.55	6.62	6.69	7.14	7.21	7.46	7.29	6.76	7.64	7.70	7.88	7.97
5. Other	0.15	0.15	0.12	0.11	0.10	0.13	0.15	0.16	0.15	0.17	0.15	0.16	0.16	0.16	0.17	0.17
B. Fugitive emissions from fuels	0.44	0.44	1.91	2.62	3.32	3.71	3.70	3.77	3.25	3.35	2.67	2.50	3.11	2.56	2.79	2.51
1. Solid fuels	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	0.44	0.44	1.91	2.62	3.32	3.71	3.70	3.77	3.25	3.35	2.67	2.50	3.11	2.56	2.79	2.51
C. CO_2 transport and storage																
2. Industrial processes	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.19	0.28	0.14	0.23	0.11	0.13	0.17	0.12	0.11
A. Mineral industry																
B. Chemical industry	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.28	0.13	0.23	0.10	0.12	0.17	0.11	0.10
C. Metal industry	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. Non-energy products from fuels and solvent use	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. 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
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	111.66	111.66	107.55	104.40	105.67	106.65	101.58	102.50	104.71	102.11	100.43	100.85	100.48	102.05	101.80	101.28
A. Enteric fermentation	96.82	96.82	93.31	90.09	90.92	91.15	85.82	86.16	87.49	85.40	83.95	84.35	83.60	84.58	83.72	82.99
B. Manure management	14.72	14.72	14.13	14.22	14.63	15.39	15.66	16.23	17.11	16.63	16.40	16.38	16.78	17.37	17.99	18.21
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	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
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	0.12	0.12	0.11	0.09	0.12	0.11	0.10	0.11	0.11	0.08	0.08	0.11	0.10	0.10	0.09	0.09
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
4. Land use, land-use change and forestry	61.27	61.27	60.57	59.98	59.29	58.69	58.03	57.37	56.73	56.03	54.97	53.83	52.76	51.62	50.45	49.30
A. Forest land	59.42	59.42	58.68	58.04	57.29	56.63	55.91	55.19	54.50	53.74	52.64	51.46	50.35	49.20	48.01	46.81
B. Cropland	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,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
D. Wetlands	1.85	1.85	1.89	1.95	2.00	2.06	2.11	2.17	2.23	2.28	2.33	2.37	2.41	2.42	2.44	2.49
E. Settlements	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA
F. Other land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
G. Harvested wood products																
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Waste	182.98	182.98	185.16	185.71	185.48	182.94	179.86	175.57	170.59	162.60	158.45	148.44	142.03	131.91	123.68	117.31
A. Solid waste disposal	173.11	173.11	175.38	176.03	175.68	173.04	169.80	165.36	160.63	152.68	148.54	138.54	132.13	121.91	113.60	107.15
B. Biological treatment of solid waste	1.03	1.03	1.16	1.30	1.40	1.49	1.70	1.93	1.95	2.06	2.18	2.29	2.41	2.54	2.63	2.73
C. Incineration and open burning of waste	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
D. Waste water treatment and discharge	8.84	8.84	8.62	8.38	8.40	8.40	8.35	8.28	8.01	7.86	7.73	7.61	7.48	7.46	7.45	7.42
E. Other	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
Total CH_4 emissions without CH_4 from LULUCF	307.49	307.49	306.76	304.79	306.41	305.22	297.03	294.12	290.89	280.23	273.36	262.65	257.35	248.34	240.18	232.87
Total CH_4 emissions with CH_4 from LULUCF	368.76	368.76	367.33	364.77	365.69	363.90	355.06	351.48	347.63	336.25	328.33	316.48	310.11	299.96	290.63	282.16
Memo items:																
International bunkers	0.14	0.14	0.14	0.17	0.13	0.10	0.08	0.09	0.10	0.13	0.14	0.16	0.15	0.16	0.16	0.13
Aviation	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
Navigation	0.14	0.14	0.13	0.16	0.13	0.10	0.07	0.09	0.09	0.12	0.14	0.15	0.14	0.16	0.16	0.12
Multilateral operations	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 sheet 6.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2005	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	14.43	13.81	13.70	13.28	13.31	14.16	12.52	13.19	12.58	12.38	11.96	12.54	12.34	12.18	11.87	10.26	-18.84
A. Fuel combustion (sectoral approach)	11.54	11.32	11.44	11.10	11.24	12.37	10.96	11.58	11.02	11.09	10.50	11.22	11.13	11.01	10.82	9.40	-23.05
1. Energy industries	1.01	1.19	1.09	1.06	1.01	1.17	1.07	1.03	1.04	1.04	0.95	1.08	1.12	1.24	1.22	1.17	198.94
2. Manufacturing industries and construction	0.66	0.71	0.70	0.67	0.58	0.74	0.83	0.82	0.84	0.88	0.87	0.87	0.89	0.89	0.85	0.82	28.76
3. Transport	1.48	1.36	1.27	1.07	0.97	0.91	0.82	0.74	0.71	0.68	0.65	0.60	0.56	0.53	0.50	0.49	-89.21
4. Other sectors	8.22	7.91	8.23	8.16	8.56	9.42	8.12	8.84	8.32	8.39	7.93	8.57	8.44	8.24	8.13	6.80	4.17
5. Other	0.17	0.15	0.15	0.13	0.12	0.13	0.13	0.13	0.12	0.11	0.11	0.10	0.12	0.12	0.11	0.12	-21.50
B. Fugitive emissions from fuels	2.89	2.49	2.26	2.18	2.08	1.79	1.56	1.61	1.57	1.28	1.46	1.32	1.21	1.17	1.05	0.87	99.33
1. Solid fuels	NO	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	2.89	2.49	2.26	2.18	2.08	1.79	1.56	1.61	1.57	1.28	1.46	1.32	1.21	1.17	1.05	0.87	99.33
C. CO_2 transport and storage																	
2. Industrial processes	0.10	0.09	0.16	0.10	0.10	0.10	0.05	0.06	0.06	0.05	0.08	0.05	0.15	0.10	0.04	0.05	-74.31
A. Mineral industry																	
B. Chemical industry	0.10	0.09	0.16	0.10	0.10	0.10	0.05	0.05	0.06	0.05	0.07	0.04	0.15	0.10	0.04	0.05	-75.54
C. Metal industry	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	56.42
D. Non-energy products from fuels and solvent use	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	-54.77
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				
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
3. Agriculture	101.25	101.30	100.69	99.41	100.67	102.54	100.87	100.24	100.34	102.00	103.33	102.94	102.21	101.37	101.02	101.03	-9.52
A. Enteric fermentation	82.31	82.54	81.81	81.24	82.02	83.78	82.82	82.06	82.20	83.51	84.60	84.17	83.82	83.13	82.81	83.14	-14.13
B. Manure management	18.86	18.67	18.79	18.09	18.56	18.70	17.98	18.11	18.04	18.41	18.65	18.69	18.32	18.18	18.13	17.82	21.10
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
D. Agricultural soils	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	0.00
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
F. Field burning of agricultural residues	0.09	0.08	0.09	0.09	0.08	0.06	0.07	0.07	0.09	0.08	0.07	0.07	0.07	0.06	0.08	0.07	-43.96
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	0.00
4. Land use, land-use change and forestry	48.19	47.07	45.92	43.63	41.32	39.01	36.71	35.46	34.26	33.06	31.84	30.60	30.59	30.61	30.61	30.63	-50.01
A. Forest land	45.66	44.52	43.32	40.96	38.59	36.22	33.90	32.64	31.42	30.20	28.95	27.72	27.72	27.73	27.70	27.76	-53.28
B. Cropland	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,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	0.00	0.00	-68.02
D. Wetlands	2.52	2.55	2.60	2.67	2.73	2.78	2.80	2.82	2.84	2.85	2.89	2.88	2.87	2.88	2.90	2.86	55.13
E. Settlements	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	0.00
F. Other land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
G. Harvested wood products																	
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
5. Waste	107.54	110.49	106.15	101.33	97.40	97.21	93.69	91.56	86.70	81.37	78.91	73.62	69.73	68.11	66.78	64.73	-64.62
A. Solid waste disposal	97.22	100.06	95.44	90.93	87.23	86.76	83.06	81.42	76.62	71.36	69.23	64.30	60.36	58.69	57.03	55.40	-68.00
B. Biological treatment of solid waste	3.06	3.17	3.47	3.26	3.28	3.42	3.49	3.06	3.12	3.10	2.76	2.50	2.59	2.71	3.14	2.86	177.91
C. Incineration and open burning of waste	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	NE,NO,IE	NE,NO,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	0.00
D. Waste water treatment and discharge	7.25	7.26	7.24	7.14	6.89	7.03	7.14	7.08	6.96	6.91	6.93	6.82	6.79	6.71	6.61	6.47	-26.85
E. Other	NO	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	NO	0.00
Total CH_4 emissions without CH_4 from LULUCF	223.32	225.69	220.70	214.12	211.48	214.00	207.13	205.04	199.69	195.80	194.28	189.15	184.44	181.76	179.71	176.08	-42.74
Total CH_4 emissions with CH_4 from LULUCF	271.51	272.76	266.62	257.75	252.81	253.01	243.84	240.50	233.95	228.85	226.12	219.75	215.03	212.37	210.32	206.70	-43.95
Memo items:																	
International bunkers	0.13	0.15	0.12	0.11	0.07	0.06	0.06	0.04	0.04	0.03	0.09	0.09	0.11	0.10	0.10	0.09	-38.05
Aviation	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	0.00	-18.18
Navigation	0.12	0.14	0.11	0.10	0.06	0.05	0.05	0.03	0.03	0.02	0.08	0.08	0.10	0.09	0.09	0.08	-38.86
Multilateral operations	NO	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)																	

TABLE 10 EMISSION TRENDS
N_2O
(Sheet 4 of 6)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	(kt)															
1. Energy	1.82	1.82	1.80	1.80	1.90	1.98	1.96	2.08	2.11	2.08	2.05	1.99	2.13	2.20	2.30	2.24
A. Fuel combustion (sectoral approach)	1.81	1.81	1.80	1.79	1.89	1.97	1.95	2.08	2.11	2.08	2.05	1.99	2.13	2.20	2.30	2.24
1. Energy industries	0.39	0.39	0.42	0.46	0.52	0.60	0.61	0.72	0.71	0.71	0.69	0.67	0.83	0.95	1.07	1.01
2. Manufacturing industries and	0.56	0.56	0.52	0.48	0.53	0.55	0.54	0.55	0.61	0.59	0.61	0.61	0.59	0.56	0.56	0.59
3. Transport	0.54	0.54	0.55	0.54	0.53	0.53	0.52	0.51	0.49	0.47	0.46	0.43	0.42	0.39	0.37	0.35
4. Other sectors	0.29	0.29	0.28	0.29	0.28	0.26	0.25	0.26	0.26	0.27	0.26	0.24	0.26	0.26	0.26	0.26
5. Other	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.04	0.03
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and natural gas and other emissions	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. CO_2 transport and storage																
2. Industrial processes	5.56	5.56	4.86	4.42	4.61	4.85	4.94	4.94	4.88	4.66	4.56	4.59	4.34	4.47	4.69	4.97
A. Mineral industry																
B. Chemical industry	5.34	5.34	4.64	4.20	4.39	4.63	4.72	4.72	4.66	4.44	4.34	4.40	4.17	4.30	4.54	4.83
C. Metal industry	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	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Electronic industry																
F. Product uses as ODS substitutes																
G. Other product manufacture and use	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.18	0.17	0.16	0.15	0.14
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	13.65	13.65	13.25	12.26	12.53	12.58	12.58	12.61	12.71	12.36	12.27	12.56	12.29	12.22	12.31	12.37
A. Enteric fermentation																
B. Manure management	0.95	0.95	0.89	0.87	0.87	0.88	0.85	0.87	0.89	0.87	0.85	0.84	0.84	0.84	0.85	0.84
C. Rice cultivation																
D. Agricultural soils	12.70	12.70	12.37	11.39	11.66	11.70	11.73	11.74	11.82	11.48	11.42	11.71	11.45	11.38	11.45	11.53
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	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
G. Liming																
H. Urea application																
I. Other carbon containing fertlizers																
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry	7.15	7.15	7.15	7.14	7.13	7.17	7.17	7.18	7.21	7.22	7.22	7.22	7.22	7.20	7.18	7.16
A. Forest land	6.85	6.85	6.84	6.83	6.82	6.85	6.85	6.85	6.87	6.88	6.87	6.86	6.86	6.84	6.81	6.79
B. Cropland	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
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
D. Wetlands	0.23	0.23	0.24	0.24	0.25	0.25	0.26	0.26	0.27	0.27	0.28	0.28	0.28	0.28	0.28	0.28
E. Settlements	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06
F. Other land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
G. Harvested wood products																
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Waste	0.32	0.32	0.32	0.31	0.32	0.31	0.33	0.34	0.33	0.34	0.35	0.36	0.36	0.36	0.38	0.39
A. Solid waste disposal																
B. Biological treatment of solid waste	0.06	0.06	0.07	0.08	0.08	0.09	0.10	0.11	0.12	0.12	0.13	0.14	0.14	0.15	0.16	0.16
C. Incineration and open burning of waste	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
D. Waste water treatment and discharge	0.26	0.26	0.25	0.24	0.23	0.23	0.23	0.23	0.22	0.22	0.22	0.22	0.22	0.21	0.22	0.23
E. Other	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
Total direct N_2O emissions without N_2O from LULUCF	21.35	21.35	20.24	18.80	19.35	19.72	19.81	19.97	20.04	19.44	19.23	19.49	19.13	19.25	19.67	19.98
Total direct N_2O emissions with N_2O from LULUCF	28.50	28.50	27.39	25.93	26.49	26.89	26.98	27.15	27.25	26.66	26.45	26.71	26.35	26.45	26.86	27.14
Memo items:																
International bunkers	0.08	0.08	0.07	0.08	0.07	0.06	0.05	0.06	0.06	0.07	0.08	0.08	0.08	0.08	0.08	0.07
Aviation	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
Navigation	0.05	0.05	0.05	0.06	0.05	0.04	0.03	0.03	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.04
Multilateral operations	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	1.41	1.41	1.38	1.34	1.36	1.36	1.26	1.28	1.26	1.19	1.17	1.11	1.13	1.11	1.15	1.09
Indirect CO_2 [3]																

Note: All footnotes for this table are given at the end of the table on sheet 6.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	(kt)																%
. Energy	1.99	2.18	2.15	2.01	1.89	2.18	2.04	1.96	1.96	1.88	1.82	1.93	1.88	1.99	1.95	1.75	-3.39
A. Fuel combustion (sectoral approach)	1.99	2.18	2.15	2.01	1.89	2.18	2.03	1.96	1.96	1.88	1.81	1.92	1.88	1.99	1.95	1.75	-3.30
1. Energy industries	0.83	1.07	1.07	0.99	0.95	1.17	1.08	0.99	1.00	0.92	0.84	0.89	0.85	0.94	0.91	0.78	99.72
2. Manufacturing industries and construction	0.55	0.52	0.50	0.48	0.40	0.45	0.43	0.43	0.44	0.44	0.46	0.51	0.51	0.53	0.52	0.47	-16.84
3. Transport	0.33	0.31	0.30	0.28	0.27	0.27	0.27	0.26	0.27	0.27	0.27	0.28	0.28	0.29	0.29	0.29	-46.69
4. Other sectors	0.25	0.25	0.25	0.23	0.24	0.27	0.23	0.24	0.23	0.23	0.21	0.23	0.22	0.21	0.21	0.20	-32.86
5. Other	0.04	0.03	0.03	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	-22.63
B. Fugitive emissions from fuels	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	0.00	0.00	0.00	-44.65
1. Solid fuels	NO	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	-44.65
C. CO_2 transport and storage																	
. Industrial processes	5.41	4.79	4.91	5.22	2.66	0.65	0.54	0.64	0.80	0.78	0.95	0.82	0.86	0.79	0.75	0.82	-85.34
A. Mineral industry																	
B. Chemical industry	5.24	4.64	4.77	5.09	2.56	0.54	0.44	0.54	0.71	0.69	0.87	0.73	0.77	0.71	0.69	0.76	-85.77
C. Metal industry	NO	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	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	-54.79
E. Electronic industry																	
F. Product uses as ODS substitutes																	
G. Other product manufacture and use	0.16	0.14	0.13	0.13	0.10	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.09	0.08	0.06	0.05	-75.56
H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
. Agriculture	12.44	12.24	12.37	12.73	12.45	12.78	12.58	12.54	12.46	12.75	12.78	12.80	12.74	12.59	13.08	12.88	-5.66
A. Enteric fermentation																	
B. Manure management	0.85	0.85	0.86	0.86	0.91	0.94	0.93	0.96	0.95	0.96	0.97	0.97	0.95	0.94	0.94	0.91	-4.53
C. Rice cultivation																	
D. Agricultural soils	11.59	11.38	11.51	11.87	11.54	11.84	11.65	11.58	11.51	11.78	11.80	11.83	11.79	11.64	12.15	11.97	-5.73
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
F. Field burning of agricultural residues	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	-43.96
G. Liming																	
H. Urea application																	
I. Other carbon containing fertlizers																	
J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
. Land use, land-use change and forestry	7.14	7.15	7.13	7.15	7.09	7.06	7.03	6.95	6.90	6.85	6.78	6.74	6.77	6.78	6.78	6.79	-5.14
A. Forest land	6.77	6.76	6.74	6.75	6.68	6.64	6.60	6.52	6.46	6.40	6.34	6.29	6.33	6.34	6.35	6.36	-7.21
B. Cropland	0.02	0.03	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	8.52
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	12.09
D. Wetlands	0.29	0.29	0.30	0.30	0.31	0.32	0.32	0.32	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	40.81
E. Settlements	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.07	0.07	0.07	0.07	70.00
F. Other land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
G. Harvested wood products																	
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
. Waste	0.42	0.42	0.44	0.43	0.42	0.44	0.45	0.43	0.42	0.42	0.40	0.38	0.38	0.39	0.42	0.40	24.78
A. Solid waste disposal																	
B. Biological treatment of solid waste	0.18	0.19	0.20	0.19	0.19	0.20	0.20	0.17	0.17	0.17	0.15	0.13	0.13	0.14	0.17	0.15	136.24
C. Incineration and open burning of waste	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	NE,NO,IE	NE,NO,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	NO,NE,IE	0.00
D. Waste water treatment and discharge	0.23	0.23	0.24	0.25	0.23	0.25	0.25	0.26	0.25	0.25	0.25	0.26	0.25	0.25	0.25	0.25	-2.02
E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
otal direct N_2O emissions without N_2O from LULUCF	20.25	19.63	19.87	20.40	17.42	16.05	15.61	15.57	15.64	15.83	15.95	15.93	15.87	15.76	16.20	15.84	-25.78
otal direct N_2O emissions with N_2O from LULUCF	27.40	26.78	26.99	27.55	24.51	23.11	22.64	22.53	22.54	22.68	22.73	22.66	22.65	22.55	22.98	22.63	-20.60
lemo items:																	
nternational bunkers	0.08	0.08	0.08	0.08	0.06	0.06	0.07	0.06	0.06	0.06	0.08	0.07	0.08	0.09	0.09	0.05	-38.14
viation	0.04	0.04	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.07	0.02	-13.73
lavigation	0.04	0.04	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.02	0.02	-52.14
lultilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
O_2 emissions from biomass																	
O_2 captured																	
ong-term storage of C in waste disposal sites																	
ndirect N_2O	0.95	1.03	0.97	0.89	0.81	0.85	0.77	0.73	0.72	0.68	0.62	0.60	0.58	0.56	0.53	0.46	-67.44
ndirect CO_2 (3)																	

TABLE 10 EMISSION TRENDS
HFCs, PFCs, SF_6, and NF_3
(Sheet 5 of 6)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	(kt)															
Emissions of HFCs and PFCs - (kt CO_2 equivalent)	0.23	0.23	0.27	0.33	0.58	82.07	151.35	235.19	335.30	444.36	545.32	718.67	790.27	883.86	982.21	1085.58
Emissions of HFCs - (kt CO_2 equivalent)	0.02	0.02	0.03	0.05	0.20	81.24	149.81	233.44	333.48	442.45	540.28	715.47	786.49	880.92	978.99	1082.62
HFC-23	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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
HFC-41	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
HFC-125	NO	NO	NO	NO	NO	0.01	0.01	0.02	0.03	0.03	0.04	0.05	0.06	0.07	0.08	0.08
HFC-134	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-134a	NO	NO	NO	NO	0.00	0.01	0.02	0.03	0.06	0.10	0.12	0.19	0.15	0.16	0.23	0.26
HFC-143	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-143a	NO	NO	NO	NO	NO	0.01	0.02	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.08	0.09
HFC-152	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.02	0.03	0.00	0.00	0.04	0.03
HFC-161	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	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
HFC-236cb	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
HFC-236fa	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
HFC-245fa	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,IE	NO,IE	NO,IE	NO,IE	NO,IE
Unspecified mix of HFCs[4] - (kt CO_2 equivalent)	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.15	0.04	2.69	0.27	66.61	75.57	2.65	2.43
Emissions of PFCs - (kt CO_2 equivalent)	0.21	0.21	0.24	0.28	0.38	0.83	1.54	1.75	1.82	1.91	5.04	3.21	3.78	2.94	3.21	2.96
CF_4	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
C_2F_6	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
C_3F_8	NO,IE	NO,IE	NO,IE	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
C_4F_{10}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
$c\text{-}C_4F_8$	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
C_5F_{12}	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
$C_{10}F_{18}$	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
Unspecified mix of PFCs[4] - (kt CO_2 equivalent)	0.21	0.21	0.24	0.27	0.31	0.36	0.42	0.48	0.55	0.63	3.71	0.84	0.96	0.96	1.27	0.77
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
Emissions of SF_6 - (kt CO_2 equivalent)	52.48	52.48	40.16	25.67	19.75	23.86	36.98	54.16	50.11	38.62	30.76	26.06	25.53	25.34	25.57	23.84
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	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,NE	NO
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO,NE	NO

Note: All footnotes for this table are given at the end of the table on sheet 6.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2005	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)	1161.86	1316.95	1349.17	1386.83	1385.11	1365.80	1345.03	1355.14	1336.72	1304.23	1240.65	1182.29	1112.19	1066.84	1013.24	977.59	428657.84
Emissions of HFCs - (kt CO_2 equivalent)	1158.20	1313.00	1346.14	1384.07	1381.91	1363.18	1342.06	1351.43	1332.24	1300.21	1239.19	1180.82	1110.57	1065.13	1011.33	975.87	4658371.96
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	0.00	100.00
HFC-32	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	0.03	0.03	0.04	100.00
HFC-41	NO	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,IE	NO,IE	NO,IE	NO,IE	NO,IE	0.00
HFC-125	0.09	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	100.00
HFC-134	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-134a	0.28	0.31	0.32	0.34	0.34	0.32	0.30	0.30	0.30	0.28	0.25	0.23	0.22	0.19	0.18	0.17	100.00
HFC-143	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-143a	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	100.00
HFC-152	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-152a	0.03	0.04	0.04	0.03	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	22604.47
HFC-161	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-227ea	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	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	NO	0.00
HFC-236ea	NO	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	NO	0.00
HFC-245ca	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-245fa	NO	NO	NO,IE	NO,IE	NO,IE	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-365mfc	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	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)	0.63	1.76	2.54	8.68	3.04	10.54	10.48	12.42	7.22	6.79	5.06	4.59	3.96	3.98	3.69	4.43	42565.00
Emissions of PFCs - (kt CO_2 equivalent)	3.66	3.96	3.03	2.75	3.20	2.62	2.97	3.71	4.48	4.03	1.46	1.48	1.61	1.71	1.90	1.72	729.42
CF_4	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	0.00
C_2F_6	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
C_3F_8	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	100.00
C_4F_{10}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
$c\text{-}C_4F_8$	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	0.00
C_5F_{12}	NO	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	NO	0.00
$C_{10}F_{18}$	NO	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	NO	0.00
Unspecified mix of PFCs[4] - (kt CO_2 equivalent)	1.17	1.31	0.65	0.61	1.32	0.94	1.46	1.85	2.91	2.73	0.43	0.65	0.80	0.92	1.12	0.93	351.40
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	0.00
Emissions of SF_6 - (kt CO_2 equivalent)	22.19	27.56	19.17	26.66	26.71	21.79	23.67	22.16	30.70	34.25	21.56	29.50	24.44	20.03	18.21	19.13	-63.55
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	0.00	-63.55
Emissions of NF_3 - (kt CO_2 equivalent)	NO	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	NO	0.00

TABLE 10 EMISSION TRENDS SUMMARY
(Sheet 6 of 6)

GREENHOUSE GAS EMISSIONS	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (kt)															
CO_2 emissions without net CO_2 from LULUCF	56914.34	56914.34	55188.76	54265.06	56313.37	61732.67	58115.52	64033.06	62696.17	59351.46	58866.90	57009.92	62513.74	65040.97	72654.32	68939.11
CO_2 emissions with net CO_2 from LULUCF	39809.33	39809.33	25228.48	30198.05	32216.05	44390.95	41334.97	40154.98	43519.72	41402.31	40193.58	38466.17	42440.70	43745.74	50520.93	45744.04
CH_4 emissions without CH_4 from LULUCF	7687.13	7687.13	7669.11	7619.71	7660.18	7630.42	7425.68	7352.88	7272.35	7005.66	6834.10	6566.27	6433.66	6208.46	6004.62	5821.63
CH_4 emissions with CH_4 from LULUCF	9218.93	9218.93	9183.37	9119.31	9142.34	9097.62	8876.41	8787.03	8690.64	8406.32	8208.35	7911.99	7752.75	7498.92	7265.81	7054.05
N_2O emissions without N_2O from LULUCF	6361.59	6361.59	6030.81	5601.03	5767.32	5877.73	5902.93	5950.43	5971.14	5792.47	5731.79	5809.16	5699.36	5735.59	5863.05	5953.43
N_2O emissions with N_2O from LULUCF	8493.53	8493.53	8160.76	7727.53	7893.02	8014.25	8039.69	8091.50	8119.60	7943.91	7882.41	7959.25	7851.33	7881.95	8003.60	8088.32
HFCs	0.02	0.02	0.03	0.05	0.20	81.24	149.81	233.44	333.48	442.45	540.28	715.47	786.49	880.92	978.99	1082.62
PFCs	0.21	0.21	0.24	0.28	0.38	0.83	1.54	1.75	1.82	1.91	5.04	3.21	3.78	2.94	3.21	2.96
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	52.48	52.48	40.16	25.67	19.75	23.86	36.98	54.16	50.11	38.62	30.76	26.06	25.53	25.34	25.57	23.84
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO,NE	NO
Total (without LULUCF)	71015.77	71015.77	68929.12	67511.80	69761.20	75346.75	71632.46	77625.72	76325.08	72632.58	72008.86	70130.08	75462.55	77894.21	85529.77	81823.59
Total (with LULUCF)	57574.51	57574.51	42613.04	47070.89	49271.75	61608.75	58439.40	57322.86	60715.37	58235.52	56860.41	55082.15	58860.57	60035.81	66798.11	61995.83
Total (without LULUCF, with indirect)	71182.11	71182.11	69084.87	67661.48	69904.52	75489.50	71765.94	77745.08	76443.33	72747.65	72119.42	70238.38	75570.50	77992.48	85627.88	81918.81
Total (with LULUCF, with indirect)	57740.85	57740.85	42768.79	47220.58	49415.07	61751.50	58572.88	57442.23	60833.62	58350.59	56970.98	55190.44	58968.52	60134.08	66896.22	62091.05

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (kt)															
1. Energy	53442.15	53442.15	52115.25	51508.25	53447.21	58781.02	55274.94	61028.91	59448.90	56133.59	55514.28	53709.68	59154.01	61753.88	69369.55	65481.66
2. Industrial processes and product use	5397.60	5397.60	4993.89	4704.42	4734.26	5009.54	5063.70	5308.80	5613.44	5645.17	5807.93	5988.41	6056.49	6095.18	6441.06	6795.54
3. Agriculture	7506.86	7506.86	7095.97	6562.53	6848.55	6888.92	6697.81	6797.03	6898.61	6687.49	6622.19	6614.85	6594.35	6640.85	6515.16	6496.66
4. Land use, land-use change and forestry[5]	-13441.26	-13441.26	-26316.08	-20440.90	-20489.45	-13738.00	-13193.06	-20302.86	-15609.71	-14397.06	-15148.44	-15047.94	-16601.98	-17858.40	-18731.66	-19827.76
5. Waste	4669.16	4669.16	4724.01	4736.60	4731.18	4667.27	4596.02	4490.98	4364.13	4166.32	4064.46	3817.15	3657.70	3404.29	3204.00	3049.73
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)[5]	57574.51	57574.51	42613.04	47070.89	49271.75	61608.75	58439.40	57322.86	60715.37	58235.52	56860.41	55082.15	58860.57	60035.81	66798.11	61995.83

(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
(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 CO2 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
(5) Includes net CO_2, CH_4 and N_2O from LULUCF.

GREENHOUSE GAS EMISSIONS	2005	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	57047.32	68370.69	66759.84	58621.00	55905.07	64080.76	56637.17	51145.69	51703.75	47595.83	44099.10	47181.86	44577.80	45796.46	42381.84	37595.93	-33.94
CO_2 emissions with net CO_2 from LULUCF	33220.31	39141.92	46581.46	35446.57	19459.69	39291.09	31658.33	23597.32	30455.22	23868.88	22520.59	26753.90	25514.46	35617.68	26006.56	17504.84	-56.03
CH_4 emissions without CH_4 from LULUCF	5583.07	5642.24	5517.38	5353.01	5287.11	5350.01	5178.33	5126.06	4992.14	4894.91	4857.05	4728.64	4611.02	4543.92	4492.79	4401.88	-42.74
CH_4 emissions with CH_4 from LULUCF	6787.71	6819.00	6665.41	6443.86	6320.23	6325.21	6096.01	6012.52	5848.64	5721.31	5653.03	5493.74	5375.85	5309.28	5257.92	5167.55	-43.95
N_2O emissions without N_2O from LULUCF	6035.07	5849.47	5920.16	6078.81	5190.60	4784.12	4651.43	4641.06	4661.00	4717.15	4752.52	4745.85	4730.62	4697.87	4828.58	4721.77	-25.78
N_2O emissions with N_2O from LULUCF	8163.92	7979.60	8044.49	8209.06	7304.34	6887.95	6745.76	6713.42	6717.84	6757.39	6773.41	6753.06	6748.71	6718.46	6849.18	6744.06	-20.60
HFCs	1158.20	1313.00	1346.14	1384.07	1381.91	1363.18	1342.06	1351.43	1332.24	1300.21	1239.19	1180.82	1110.57	1065.13	1011.33	975.87	4658371.96
PFCs	3.66	3.96	3.03	2.75	3.20	2.62	2.97	3.71	4.48	4.03	1.46	1.48	1.61	1.71	1.90	1.72	729.42
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
SF_6	22.19	27.56	19.17	26.66	26.71	21.79	23.67	22.16	30.70	34.25	21.56	29.50	24.44	20.03	18.21	19.13	-63.55
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Total (without LULUCF)	69849.50	81206.92	79565.73	71466.31	67794.61	75602.47	67835.63	62290.10	62724.31	58546.37	54970.87	57868.14	55056.07	56125.12	52734.65	47716.30	-32.81
Total (with LULUCF)	49355.98	55285.03	62659.70	51512.97	34496.08	53891.83	45868.80	37700.56	44389.11	37686.07	36209.25	40212.49	38775.65	48732.29	39145.10	30413.18	-47.18
Total (without LULUCF, with indirect)	69937.60	81295.83	79654.33	71545.92	67865.80	75672.35	67903.29	62352.12	62784.05	58602.57	55025.81	57923.44	55109.45	56178.74	52788.02	47782.25	-32.87
Total (with LULUCF, with indirect)	49444.08	55373.94	62748.30	51592.58	34567.27	53961.71	45936.45	37762.58	44448.85	37742.26	36264.19	40267.79	38829.03	48785.91	39198.47	30479.13	-47.21

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2005	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	53743.15	64816.83	62843.62	54501.77	52626.35	60230.38	52784.34	47495.42	48106.83	44257.70	40601.59	43345.94	40910.31	42071.54	38922.22	34289.50	-35.84
2. Industrial processes and product use	6765.15	7001.22	7456.58	7696.77	6041.15	6159.40	6102.37	5931.68	5798.54	5556.26	5703.80	5911.62	5736.85	5736.57	5394.61	5124.48	-5.06
3. Agriculture	6529.05	6501.57	6480.63	6604.88	6566.88	6650.75	6473.62	6445.56	6526.04	6573.31	6573.72	6655.41	6550.95	6497.09	6624.45	6565.95	-12.53
4. Land use, land-use change and forestry[5]	-20493.52	-25921.89	-16906.02	-19953.34	-33298.52	-21710.64	-21966.83	-24589.54	-18335.19	-20860.31	-18761.62	-17655.65	-16280.42	-7392.83	-13589.55	-17303.12	28.73
5. Waste	2812.15	2887.30	2784.89	2662.89	2560.23	2561.95	2475.30	2417.44	2292.89	2159.10	2091.76	1955.17	1857.96	1819.92	1793.38	1736.37	-62.81
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Total (including LULUCF)[5]	49355.98	55285.03	62659.70	51512.97	34496.08	53891.83	45868.80	37700.56	44389.11	37686.07	36209.25	40212.49	38775.65	48732.29	39145.10	30413.18	-47.18

Documentation box:
• Parties should provide detailed explanations on emissions trends in chapter 2: Trends in Greenhouse Gas Emissions and, as appropriate, in the corresponding Chapters 3 - 8 of the national inventory report (NIR). Use this documentation box to provide references to relevant
• Use the documentation box to provide explanations if potential emissions are reported.

Documentation box	
	1.A.3.b: CO2, CH4 and N2O emissions and fuel consumption of all fuels in crf categories 1A3bii-1A3biv are included in 1A3bi. 1.A.3.e: CO2, CH4 and N2O emissions and fuel consumptions from category 1A3e is reported in 1A5a due to confidentiality 1.A.5.b: CO2, CH4 and N2O emissions and fuel consumptions of all fuels from category 1A5b is reported in 1A5a due to confidentiality. 1.AB: IE explanations: NGL incl. in crude oil, other kerosene inlc. in jet kerosene, lubricants incl. in other oil, petroleum coke incl. in other oil, refinery feedstock incl. in crude oil, anthracite incl. in bituminous coal, LNG imports and stock change in Natural gas. Production in Other Fossil Fuels/Waste equals to total waste combustion in order to get actual apparent consumption. 1.AC: For further details on discrepancies more than 2% between RA and SA see NIR Chapter 3.2.1 1.AD: Empty cells in row 'Reported under' should be NA and missing due to CRF Reporter programming.. LPG and other oil are used mainly for plastics production. 1.AD Liquefied Petroleum Gas: LPG used for plastics production 1.AD Other Oil: Other oil used mainly for plastics production 1.B.2: Subsector 1.B.2d includes CO2 emissions from distribution in town gas in 1990 to 1993. NMVOC emissions from gasoline evaporation from road transport (1.B.2d) can be seen in Table 1s2. 2.: Confidential data of F gases is reported as IE due to aggregation problems if notation key C is used. CRF tables are not fully consistent with the NIR tables concerning method and emission factor information of F gases. CRF Reporter is programmed in a way that method and emission factor information changes automatically to NA for subcategories, with no emissions data (notation keys IE or C are used in the respective cells in the CRF tables). The NIR includes the correct method and emission factor information for these subcategories. 2.D.1: Lubricant use (2.D.1) includes 2-stroke oil since full time series of activity data to allocate these emissions to energy subsectors is not available (see NIR chapter 3.2.3). 2.E: Confidential data of F gases is reported as IE due to aggregation problems if notation key C is used. 2.H.3 2.H.3 Other (please spe: Under Category 2.H.3 Grouped confidential data of halocarbons and SF6, following sources and emissions of F gases have been grouped due to confidentiality: HFC-23 from semiconductor manufacturing, HFC-152a from foam blowing in 2015 and 2016, HFC-227ea and HFC-365mfc from foam blowing in 2000 to 2006, HFC-125, HFC-134a and HFC-227ea from Fire protection, HFC-245fa and HFC-43-10mee from aerosols, CF4, C2F6 c-C4F8 and C3F8 (1990 to 2006, 2014 and 2016) from semiconductor manufacturing, SF6 from magnesium die casting, semiconductor manufacturing, shoes (until 2007) and research 3.A.4 Reindeer Reindeer: for fur animal method& EF: see NIR 5.2.2.3 and 2006 IPCC Guidelines, Vol. 4-2, Section 10.2.4. 3.B.2.4 Reindeer Reindeer: 3.D.1.2.c: N input from potato cell sap and meat and bone meal on agricultural lands 4.G.D Activity Data: 5.B.1.a: Activity data in wet tons 5.B.1.b Industrial solid waste: Activity data in wet tons 5.B.2.a: Activity data in wet tons. CH4 flared and CH4 for energy are not reported because T1 method is utilized instead of default method and the implied emission factor would become misleading. 5.B.2.b Industrial solid waste: Activity data in wet tons. CH4 for energy recovery is not reported because T1 method which does not utilize recovery data would give misleading information on implied emission factors. 5.B.2.b Industrial sludge: CH4 for energy recovery is not reported because T1 method which does not utilize recovery data would give misleading information on implied emission factors. 5.B.2.b Municipal sludge: CH4 for energy recovery is not reported because T1 method which does not utilize recovery data would give misleading information on implied emission factors. 5.C: Open burning of waste in solid waste disposal sites does not occur in Finland. Open burning of waste in households is an insignificant source. Waste incineration to energy is reported in Energy sector. 5.C.1.2.a: Open burning of waste in solid waste disposal sites does not occur in Finland. Waste incineration to energy is reported in the Energy sector. 5.D.1: CH4 for energy recovery is not reported because country specific method which does not utilize recovery data would give misleading information on implied emission factors. 5.D.2: CH4 for energy recovery is not reported because country specific method which does not utilize recovery data would give misleading information on implied emission factors.

Annex 2

CTF Tables for financial, technological and capacity-building support 7(2019), 7(2020), 7(a)_2019, 7(a)_2020, 7(b)_2019, 7(b)_2020, 8 and 9

Provision of public financial support: summary information in 2019[a]

Allocation channels	Year									
	European euro - EUR					USD[b]				
	Core/ general[c, 1]	Climate-specific[d, 2]				Core/ general[c, 1]	Climate-specific[d, 2]			
		Mitigation	Adaptation	Cross-cutting[e]	Other[f]		Mitigation	Adaptation	Cross-cutting[e]	Other[f]
Total contributions through multilateral channels:	236,475,496.00	46,957,400.00		64,767,716.00		264,721,250.30	52,566,214.00		72,503,877.50	
Multilateral climate change funds[g]	80,337,000.00	46,957,400.00		28,550,000.00		89,932,832.00	52,566,214.00		31,960,147.00	
Other multilateral climate change funds[h]	53,400,000.00	46,000,000.00		6,400,000.00		59,778,349.00	51,494,458.00		7,164,446.00	
Multilateral financial institutions, including regional development banks	93,737,307.00			20,947,538.00		104,933,735.00			23,449,610.00	
Specialized United Nations bodies	62,401,189.00			15,270,178.00		69,854,683.30			17,094,120.50	
Total contributions through bilateral, regional and other channels		10,466,544.00	1,932,239.00	22,113,688.00			11,716,716.00	2,163,034.00	24,755,050.00	
Total	236,475,496.00	57,423,944.00	1,932,239.00	86,881,404.00		264,721,250.30	64,282,930.00	2,163,034.00	97,258,927.50	

Note: Explanation of numerical footnotes is provided in the documentation box after tables 7, 7(a) and 7(b).

Abbreviation: USD = United States dollars.

[a] Parties should fill in a separate table for each year, namely 2015 and 2016, where 2018 is the reporting year.

[b] Parties should provide an explanation of the methodology used for currency exchange for the information provided in tables 7, 7(a) and 7(b) in the documentation box.

[c] This refers to support to multilateral institutions that Parties cannot specify as being climate-specific.

[d] Parties should explain in their biennial reports how they define funds as being climate-specific.

[e] This refers to funding for activities that are cross-cutting across mitigation and adaptation.

[f] Please specify.

[g] Multilateral climate change funds listed in paragraph 17(a) of the "UNFCCC biennial reporting guidelines for developed country Parties" in decision 2/CP.17.

[h] Other multilateral climate change funds as referred in paragraph 17(b) of the "UNFCCC biennial reporting guidelines for developed country Parties" in decision 2/CP.17.

Custom Footnotes

Documentation Box:

1: Core/general
Overall/unearmarked support to a given organization
2: Climate-specific
Share of Finnish core/general funding that is directed to mitigation and/or adaptation (= the share Finland reports as climate finance)
3: Status
Finland reports only disbursed amounts of climate finance
4: Funding source
Finland's climate finance is part of its official development assistance (ODA) flows, as defined by OECD/DAC.
5: Financial instrument
Finland reports financial instrument as defined by OECD/DAC.
6: Type of support
Mitigation and Adaptation based on OECD Rio markers, cross-cutting when support covers both mitigation and adaptation.
7: Sector
As defined by OECD/DAC.
Each Party shall provide an indication of what new and additional financial resources they have provided, and clarify how they have determined that such resources are new and additional. Please provide this information in relation to table 7(a) and (b).
In 2020 Finland's public climate finance to developing countries totaled EUR 131 million, which compared to 147 million in 2019, 47 million in 2018, 119 million in 2017 and 43 million in 2016 continues on a growing track. Climate finance is part of Finland's official ODA budget. The total ODA budget was EUR 1122 million in 2020, EUR 1010 million in 2019 and EUR 833 million in 2018. Out of the total ODA, the share of climate finance was 6% in 2018, 15 % in 2019, and 12 % in 2020. Even though there was a slight drop in 2020, climate finance is on a growing trajectory. Furthermore, when taking into account the planned figures until 2025, the current government has been able to grow climate finance 80 % compared to the previous government (2015-2018).

Table 7 FIN_BR5_v0.1

Provision of public financial support: summary information in 2020[a]

Allocation channels	*Year*									
	European euro - EUR					*USD[b]*				
	Core/ general[c, 1]	*Climate-specific[d, 2]*				*Core/ general[c, 1]*	*Climate-specific[d, 2]*			
		Mitigation	*Adaptation*	*Cross-cutting[e]*	*Other[f]*		*Mitigation*	*Adaptation*	*Cross-cutting[e]*	*Other[f]*
Total contributions through multilateral channels:	186,194,338.00	900,000.00	7,300,000.00	84,164,149.00		212,187,276.00	1,025,641.00	8,319,087.00	95,913,557.50	
Multilateral climate change funds[g]	51,050,000.00		7,000,000.00	37,498,000.00		58,176,636.00		7,977,207.00	42,732,762.00	
Other multilateral climate change funds[h]	8,900,000.00			8,900,000.00		10,142,450.00			10,142,450.00	
Multilateral financial institutions, including regional development banks	113,006,046.00	900,000.00		41,224,734.00		128,781,817.00	1,025,641.00		46,979,753.00	
Specialized United Nations bodies	22,138,292.00		300,000.00	5,441,415.00		25,228,823.00		341,880.00	6,201,042.50	
Total contributions through bilateral, regional and other channels		26,990,313.00	4,000,476.00	9,358,605.00			30,758,192.00	4,558,947.00	10,665,078.00	
Total	186,194,338.00	27,890,313.00	11,300,476.00	93,522,754.00		212,187,276.00	31,783,833.00	12,878,034.00	106,578,635.50	

Note: Explanation of numerical footnotes is provided in the documentation box after tables 7, 7(a) and 7(b).

Abbreviation: USD = United States dollars.

[a] Parties should fill in a separate table for each year, namely 2015 and 2016, where 2018 is the reporting year.

[b] Parties should provide an explanation of the methodology used for currency exchange for the information provided in tables 7, 7(a) and 7(b) in the documentation box.

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[f] Please specify.

[g] Multilateral climate change funds listed in paragraph 17(a) of the “UNFCCC biennial reporting guidelines for developed country Parties” in decision 2/CP.17.

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Provision of public financial support: contribution through multilateral channels in 2019[a]

Donor funding	Total amount				Status[b, 3]	Funding source[f, 4]	Financial instrument[f, 5]	Type of support[f, g, 6]	Sector[c, f, 7]
	Core/general[d, 1]		Climate-specific[e, 2]						
	European euro - EUR	USD	European euro - EUR	USD					
Total contributions through multilateral channels (1)	236,475,496.00	264,721,250.30	111,725,116.00	125,070,091.50					
Multilateral climate change funds	80,337,000.00	89,932,832.00	75,507,400.00	84,526,361.00					
1. Global Environment Facility	4,787,000.00	5,358,782.00	957,400.00	1,071,756.00	Disbursed	Oda	Grant	Mitigation	Cross-cutting
2. Least Developed Countries Fund									
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund	22,150,000.00	24,795,701.00	22,150,000.00	24,795,701.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
6. UNFCCC Trust Fund for Supplementary Activities									
7. Other multilateral climate change funds	53,400,000.00	59,778,349.00	52,400,000.00	58,658,904.00					
Finland-IFC Blended Finance for Climate Program	46,000,000.00	51,494,458.00	46,000,000.00	51,494,458.00	Disbursed	Oda	Equity	Mitigation	Cross-cutting
Other multilateral climate change funds (2)	7,400,000.00	8,283,891.00	6,400,000.00	7,164,446.00	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Multilateral financial institutions, including regional development banks	93,737,307.00	104,933,735.00	20,947,538.00	23,449,610.00					
1. World Bank	62,590,000.00	70,066,047.00	10,030,400.00	11,228,478.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
2. International Finance Corporation									
3. African Development Bank	28,647,307.00	32,069,077.00	9,167,138.00	10,262,104.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
4. Asian Development Bank	2,500,000.00	2,798,611.00	1,750,000.00	1,959,028.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
5. European Bank for Reconstruction and Development									
6. Inter-American Development Bank									
7. Other									
Specialized United Nations bodies	62,401,189.00	69,854,683.30	15,270,178.00	17,094,120.50					
1. United Nations Development Programme									
2. United Nations Environment Programme	1,500,000.00	1,679,167.00	300,000.00	335,833.00					
Total	1,500,000.00	1,679,167.00	300,000.00	335,833.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
3. Other	60,901,189.00	68,175,516.30	14,970,178.00	16,758,287.50					
Food and Agricultural Organization	700,000.00	783,611.30	560,000.00	626,889.10	Disbursed	Oda	Grant	Cross-cutting	Forestry
International Fund for Agricultural Development	52,000,000.00	58,211,127.00	13,000,000.00	14,552,782.00	Disbursed	Oda	Other (Grant, Concessional Loan)	Cross-cutting	Agriculture
United Nations Children's Fund	5,300,000.00	5,933,057.00	630,000.00	705,250.20	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
United Nations International Strategy for Disaster Reduction	1,000,000.00	1,119,445.00	100,000.00	111,944.50	Disbursed	Oda	Grant	Cross-cutting	Not Applicable
Other multilateral	1,901,189.00	2,128,276.00	680,178.00	761,421.70	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting

Abbreviations: ODA = official development assistance, OOF = other official flows, USD = United States dollars.

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[f] Please specify.

[g] This refers to funding for activities that are cross-cutting across mitigation and adaptation.

Custom Footnotes

(1) Domestic currency is EUR. 1 USD = EUR 0.8933 (2019), 1 USD = EUR 0.8775 (2020)

(2) Other multilateral climate change funds (2019): Includes disbursement of 0.5 million EUR/ 0.5 million EUR climate specific, NEFCO, recipient country Ukraine

(3) Other multilateral climate change funds (2020): Includes disbursement of 0.5 million EUR / 0.5 million EUR climate specific, NEFCO, recipient country Ukraine

(4) European Bank for Reconstruction and Development (2020): Includes disbursement of 1 million EUR / 0.9 million EUR climate specific, ERBD, partly recipient country Ukraine

Provision of public financial support: contribution through multilateral channels in 2020[a]

Donor funding	Total amount: Core/general[d, 1] European euro - EUR	Core/general USD	Climate-specific[e, 2] European euro - EUR	Climate-specific USD	Status[b, 3]	Funding source[f, 4]	Financial instrument[f, 5]	Type of support[f, g, 6]	Sector[c, f, 7]
Total contributions through multilateral channels	186,194,338.00	212,187,276.00	92,364,149.00	105,258,285.50					
Multilateral climate change funds	51,050,000.00	58,176,636.00	44,498,000.00	50,709,969.00					
1. Global Environment Facility	8,190,000.00	9,333,333.00	1,638,000.00	1,866,666.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
2. Least Developed Countries Fund	7,000,000.00	7,977,207.00	7,000,000.00	7,977,207.00	Disbursed	Oda	Grant	Adaptation	Cross-cutting
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund	26,960,000.00	30,723,646.00	26,960,000.00	30,723,646.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
6. UNFCCC Trust Fund for Supplementary Activities									
7. Other multilateral climate change funds	8,900,000.00	10,142,450.00	8,900,000.00	10,142,450.00					
Other multilateral climate change funds (3)	8,900,000.00	10,142,450.00	8,900,000.00	10,142,450.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
Multilateral financial institutions, including regional development banks	113,006,046.00	128,781,817.00	42,124,734.00	48,005,394.00					
1. World Bank	57,980,000.00	66,074,074.00	9,456,800.00	10,776,980.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
2. International Finance Corporation	740,000.00	843,304.00	740,000.00	843,304.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
3. African Development Bank	25,806,046.00	29,408,599.00	8,297,934.00	9,456,335.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
4. Asian Development Bank	22,500,000.00	25,641,025.00	17,750,000.00	20,227,920.00	Disbursed	Oda	Other (Grant, Equity)	Cross-cutting	Cross-cutting
5. European Bank for Reconstruction and Development (4)	1,000,000.00	1,139,601.00	900,000.00	1,025,641.00	Disbursed	Oda	Grant	Mitigation	Cross-cutting
6. Inter-American Development Bank									
7. Other	4,980,000.00	5,675,214.00	4,980,000.00	5,675,214.00					
7. Other - Total	4,980,000.00	5,675,214.00	4,980,000.00	5,675,214.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
Specialized United Nations bodies	22,138,292.00	25,228,823.00	5,741,415.00	6,542,922.50					
1. United Nations Development Programme	1,000,000.00	1,139,601.00	300,000.00	341,880.00					
Total	1,000,000.00	1,139,601.00	300,000.00	341,880.00	Disbursed	Oda	Grant	Adaptation	Cross-cutting
2. United Nations Environment Programme	5,500,000.00	6,267,806.00	1,100,000.00	1,253,561.00					
Total	5,500,000.00	6,267,806.00	1,100,000.00	1,253,561.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
3. Other	15,638,292.00	17,821,416.00	4,341,415.00	4,947,481.50					
Food and Agricultural Organization	2,350,000.00	2,678,063.00	1,632,500.00	1,860,399.00	Disbursed	Oda	Grant	Cross-cutting	Forestry
International Fund for Agricultural Development	3,500,000.00	3,988,604.00	875,000.00	997,151.00	Disbursed	Oda	Grant	Cross-cutting	Agriculture
United Nations Children's Fund	5,800,000.00	6,609,687.00	980,000.00	1,116,809.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting
United Nations International Strategy for Disaster Reduction	2,000,000.00	2,279,202.00	200,000.00	227,920.20	Disbursed	Oda	Grant	Cross-cutting	Not Applicable
Other multilateral	1,988,292.00	2,265,860.00	653,915.00	745,202.30	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting

Abbreviations: ODA = official development assistance, OOF = other official flows, USD = United States dollars.

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[b] Parties should explain, in their biennial reports, the methodologies used to specify the funds as disbursed and committed. Parties will provide the information for as many status categories as appropriate in the following order of priority: disbursed and committed.

[c] Parties may select several applicable sectors. Parties may report sectoral distribution, as applicable, under “Other”.

[d] This refers to support to multilateral institutions that Parties cannot specify as being climate-specific.

[e] Parties should explain in their biennial reports how they define funds as being climate-specific.

[f] Please specify.

[g] This refers to funding for activities that are cross-cutting across mitigation and adaptation.

Custom Footnotes

(1) Domestic currency is EUR. 1 USD = EUR 0.8933 (2019), 1 USD = EUR 0.8775 (2020)

(2) Other multilateral climate change funds (2019): Includes disbursement of 0.5 million EUR/ 0.5 million EUR climate specific, NEFCO, recipient country Ukraine

(3) Other multilateral climate change funds (2020): Includes disbursement of 0.5 million EUR / 0.5 million EUR climate specific, NEFCO, recipient country Ukraine

(4) European Bank for Reconstruction and Development (2020): Includes disbursement of 1 million EUR / 0.9 million EUR climate specific, ERBD, partly recipient country Ukraine

Table 7(b)

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Provision of public financial support: contribution through bilateral, regional and other channels in 2019[a]

Recipient country/ region/project/programme[b]	*Total amount*		*Status[c, 3]*	*Funding source[g, 4]*	*Financial instrument[g, 5]*	*Type of support[g, h, 6]*	*Sector[d, g, 7]*	*Additional information[e]*
	Climate-specific[f, 2]							
	European euro - EUR	*USD*						
Total contributions through bilateral, regional and other channels (1) (2)	34,512,471.00	38,634,800.00						
Sierra Leone / ODA equity through Finnfund	9,889,722.00	11,070,997.00	Disbursed		Equity	Cross-cutting	Other (capacity Building)	
Serbia / ODA equity through Finnfund	7,904,000.00	8,848,091.00	Disbursed		Equity	Mitigation	Energy	
Nepal / ODA equity through Finnfund	1,672,740.00	1,872,540.00	Disbursed		Equity	Cross-cutting	Energy	
Asia, regional / Energy and Environment Partnership Programme with the Mekong Region	1,658,030.00	1,856,072.00	Disbursed		Grant	Mitigation	Energy	
Viet Nam / Uppgrading the Rainfall Storm and Lightening Detection Capabilities of National Hydro-Meteorogical Service	1,456,458.00	1,630,424.00	Disbursed		Other (Interest Subsidy)	Adaptation	Other (capacity Building)	
Tanzania / Forestry and Value Chains Development FORVAC	987,680.00	1,105,653.00	Disbursed		Grant	Cross-cutting	Forestry	
Africa / Africa, regional / ODA equity through Finnfund	904,514.00	1,012,553.00	Disbursed		Equity	Mitigation	Other (capacity Building)	
Africa / Africa, regional / ODA equity through Finnfund	841,324.00	941,815.00	Disbursed	Oda	Equity	Cross-cutting	Forestry	
Nepal / Rural Village Water Resources Management Project (III phase)	767,068.00	858,690.00	Disbursed		Grant	Cross-cutting	Water And Sanitation	
Honduras / HN/Rural Electrification project ESSE-FN-2008	475,781.00	532,610.00	Disbursed		Other (Interest Subsidy)	Adaptation	Energy	
Asia, regional / ODA equity through Finnfund	427,154.00	478,175.00	Disbursed		Equity	Cross-cutting	Forestry	
/ Other bilateral climate change related programs	7,528,000.00	8,427,180.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting	

Abbreviations: ODA = official development assistance, OOF = other official flows; USD = United States dollars.

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[b] Parties should report, to the extent possible, on details contained in this table.

[c] Parties should explain, in their biennial reports, the methodologies used to specify the funds as disbursed and committed.
Parties will provide the information for as many status categories as appropriate in the following order of priority: disbursed and committed.

[d] Parties may select several applicable sectors. Parties may report sectoral distribution, as applicable, under “Other”.

[e] Parties should report, as appropriate, on project details and the implementing agency.

[f] Parties should explain in their biennial reports how they define funds as being climate-specific.

[g] Please specify.

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Custom Footnotes

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(2) Domestic currency is EUR. 1 USD = EUR 0.8933 (2019), 1 USD = EUR 0.8775 (2020)

Table 7(b) FIN_BR5_v0.1

Provision of public financial support: contribution through bilateral, regional and other channels in 2020[a]

Recipient country/ region/project/programme[b]	*Total amount*		*Status[c, 3]*	*Funding source[g, 4]*	*Financial instrument[g, 5]*	*Type of support[g, h, 6]*	*Sector[d, g, 7]*	*Additional information[e]*
	Climate-specific[f, 2]							
	European euro - EUR	*USD*						
Total contributions through bilateral, regional and other channels	40,349,394.00	45,982,217.00						
Africa / Africa, regional / Finnfund	19,289,605.00	21,982,456.00	Disbursed	Oda	Equity	Mitigation	Other (capacity Building)	
Africa / Africa, regional / Finnfund	6,009,967.00	6,848,965.00	Disbursed	Oda	Equity	Mitigation	Forestry	
Asia, regional / Finnfund	1,188,380.00	1,354,280.00	Disbursed		Equity	Adaptation	Other (capacity Building)	
Myanmar / Finnfund	1,169,864.00	1,333,178.00	Disbursed		Equity	Adaptation	Other (capacity Building)	
India / Finnfund	1,000,000.00	1,139,601.00	Disbursed		Equity	Mitigation	Energy/transport	
Tanzania / The Ministry of Finance and Economic Affairs of Tanzania	931,662.00	1,061,724.00	Disbursed		Grant	Cross-cutting	Forestry	
Ethiopia / Recipient Government	760,000.00	866,096.00	Disbursed		Grant	Adaptation	Water And Sanitation	
Nepal / Other implementers	716,168.00	816,146.00	Disbursed		Grant	Cross-cutting	Water And Sanitation	
Developing countries, unspecified / Finnfund	690,741.00	787,170.00	Disbursed		Equity	Mitigation	Other (capacity Building)	
Tanzania / Other implementers	530,303.00	604,334.00	Disbursed		Grant	Cross-cutting	Forestry	
Africa / Africa, regional / Finnfund	381,498.00	434,756.00	Disbursed	Oda	Equity	Cross-cutting	Forestry	
Zambia / Other implementers	334,466.00	381,157.00	Disbursed		Grant	Cross-cutting	Agriculture	
Honduras / Other implementers	326,754.00	372,370.00	Disbursed		Other (Interest Subsidy)	Adaptation	Energy	
Viet Nam / Recipient Government	279,555.00	318,581.00	Disbursed		Other (Interest Subsidy)	Adaptation	Other (capacity Building)	
Ethiopia / F.a: Towards Resilient Communities	275,923.00	314,442.00	Disbursed		Grant	Adaptation	Water And Sanitation	
/ Other bilateral climate change related programs	6,464,508.00	7,366,961.00	Disbursed	Oda	Grant	Cross-cutting	Cross-cutting	

Abbreviations: ODA = official development assistance, OOF = other official flows; USD = United States dollars.

[a] Parties should fill in a separate table for each year, namely 2015 and 2016, where 2018 is the reporting year.

[b] Parties should report, to the extent possible, on details contained in this table.

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[d] Parties may select several applicable sectors. Parties may report sectoral distribution, as applicable, under "Other".

[e] Parties should report, as appropriate, on project details and the implementing agency.

[f] Parties should explain in their biennial reports how they define funds as being climate-specific.

[g] Please specify.

[h] This refers to funding for activities that are cross-cutting across mitigation and adaptation.

Custom Footnotes

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Provision of technology development and transfer support[a,b]

Recipient country and/or region	*Targeted area*	*Measures and activities related to technology transfer*	*Sector*[c]	*Source of the funding for technology transfer*	*Activities undertaken by*	*Status*	*Additional information*[d]
All regions: LDC, LIC & LMIC countries	Mitigation	Bilateral blended finance trust fund that invests equity and provides concessional loans to private sector climate mitigation projects that would not take place without slightly softer financial terms. Investments are targeted at LDC, LIC & LMIC countries. Technology providers and implementers of the project typically from elsewhere, bringing to these countries technology that is not there yet.	Energy	Public	Private	Implemented	Finland-IFC Blended Finance Climate Program, which channels government funds for equity, mezzanine and loan based investments for private sector renewable energy and energy efficiency projects. Some projects are implementation, while others are still planned.
All regions: mainly LDC, LIC & LMIC countries	Mitigation and Adaptation	Finland's national DFI is tasked to target minimum 50% of its annual new investments in climate mitigation and adaptation projects. Investments are mainly targeted at LDC, LIC & LMIC countries. Technology providers and implementers of the project typically from elsewhere, bringing to these countries technology that is not there yet.	Energy, Transport, Agriculture, Other (Forestry)	Public	Private	Implemented	Finnfund's climate investments are government funds used for equity, mezzanine and loan based investments to renewable energy, energy efficiency, forestry, agriculture, and transport sector projects. Activities ongoing, ie. Some projects implemented, others planned.
Viet Nam	Adaptation	Upgrade of the weather radar observation network, establishment of lightning detection network, installation and commissioning of the meteorological data visualization and automated forecast production system Smartmet which is an open source software developed by the Finnish Meteorological Institute (FMI).	Other (Meteorology)	Public	Private and Public	Implemented	The technology is provided by the Vaisala corporation, world's leading company for weather observation technology and products. The transfer of technology has been accompanied by comprehensive capacity building by the FMI.
ODA countries in Africa and Asia	Adaptation	Installation and/or commissioning of the meteorological data visualization and automated forecast production system SmartMet which is an open source software developed by the Finnish Meteorological Institute (FMI).	Other (Meteorology)	Public	Public	Implemented	The transfer of technology has been a part of the capacity building projects implemented by the FMI. Please see Table 9 as well Section 8.4 for the list of projects. Some projects on-going, some completed
ODA countries in Asia and the Pacific	Mitigation and Adaptation	Equity investments to start-ups and growth companies that create new technology and/or transfer new types of technological solutions to ODA recipient countries in Asia and the Pacific. 80% of the investments are done for climate tech (mitigation and adaptation)	Energy	Public	Private	Planned	Originally government funds, used for equity investments for start-up and growth companies through the ADB Ventures Investment Fund 1, in sectors such as renewable energy, energy efficiency, other cleantech and climatetech.

[a] To be reported to the extent possible.

[b] The tables should include measures and activities since the last national communication or biennial report.

[c] Parties may report sectoral disaggregation, as appropriate.

[d] Additional information may include, for example, funding for technology development and transfer provided, a short description of the measure or activity and co-financing arrangements.

Custom Footnotes

Provision of capacity-building support[a]

Recipient country/region	*Targeted area*	*Programme or project title*	*Description of programme or project* [b,c]
Sudan and South Sudan	Adaptation	Promoting Adaptation to Climate Change by Reducing Weather and Climate-Related Losses through Improved Services in Sudan and South Sudan	Institutional cooperation between the Finnish Meteorological Institute (FMI) and Sudan Meteorological Authority (SMA) and South Sudan Meteorological Department (SSMD)
Kyrgyzstan	Adaptation	Capacity Building in the Field of Meteorology, Finnish-Kyrgyzstan Meteorology Project	Institutional cooperation between the Finnish Meteorological Institute (FMI) and The Agency on hydrometeorology under the State Committee on Ecology and Climate of the Kyrgyz Republic (Kyrgyzhydromet)
Tajikistan	Adaptation	Capacity Building in the Field of Meteorology, Finnish-Tajikistan Meteorology Project	Institutional cooperation between the Finnish Meteorological Institute (FMI) and The Agency on Hydrometeorology of the Committee of Environment Protection under the Government of the Republic of Tajikistan (Tajikhydromet)
Nepal	Adaptation	Finnish-Nepalese Project for Improved Capability of the Government of Nepal to Respond to the Increased Risks Related to the Weather-related Natural Disasters Caused by Climate Change	Institutional cooperation between the Finnish Meteorological Institute (FMI) and Department of Meteorology and Hydrology (DHM) in Nepal
Viet Nam	Adaptation	Managed Aquifer Recharge to Ensure Sustainable Groundwater Availability and Quality under Ongoing Climate Change and Fast Economic Development in Vietnam	Institutional cooperation between the Geological Survey of Finland (GTK) and The Sub-Institute of HydroMeteorology and Climate Change (SIHYMECC) and the Center for Water Resources Warning and Forecast (CEWAFO)
Mozambique	Multiple Areas	Capacity building on novel approaches in sustainable management of forest and wood resources in Mozambique	Institutional cooperation between the Natural Resources Institute Finland (LUKE) and the Agrarian Research Institute of Mozambique (IIAM), Agrarian Research Institute of Mozambique (IIAM) and the Faculty of Agronomy and Forest Engineering of Eduardo Mondlane University (UEM-FAEF)
Viet Nam	Adaptation	Promoting the Modernisation of Hydrometeorological Services in Vietnam	Institutional cooperation between the Finnish Meteorological Institute (FMI) and Meteorological and Hydrological Administration of Viet Nam
Sudan	Adaptation	Improving the Adaptation to Climate Change by Enhancing Weather and Climate Services in	Institutional cooperation between the Finnish Meteorological Institute (FMI) and the Sudan Meteorological Authority

[a] To be reported to the extent possible.

[b] Each Party included in Annex II to the Convention shall provide information, to the extent possible, on how it has provided capacity-building support that responds to the existing and emerging capacity-building needs identified by Parties not included in Annex I to the Convention in the areas of mitigation, adaptation and technology development and

[c] Additional information may be provided on, for example, the measure or activity and co-financing arrangements.

Custom Footnotes

Complete list of projects in Chapter 8.4 of Finland's NC8. Please note that the Chapter 8.4. lists projects from 2017 to 2021.

Annex 3
Summary of reporting of the Supplementary information under Article 7, paragraph 2, of the Kyoto Protocol in the NC8

Information reported under Article 7, paragraph 2	NC8 section
National system in accordance with Article 5, paragraph 1	3.3
National registry	3.4
Supplementarity relating to the mechanisms pursuant to Article 6, 12 and 17	5.7
Policies and measures in accordance with Article 2	4, 7 and 8
Domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures	3.3, 3.4, 4.1 – 4.3
Information under Article 10	
Art 10a	3.3, 8.2.4
Art 10b	4.4, 4.5, 6.6 and 6.4
Art 10c	7.6
Art 10d	4.9, 8.3, 8.4
Art 10e	6.7, 8.3, 8.4, 9.3 and 9.4.
Financial resources	7

Annex 4

Recommendation in FCCC/IDR.7/FIN	Finland's Response in NC8	Where in NC8
The ERT recommends that Finland provide in its next NC information regarding factors and activities [in the projections of GHG emission] for all sectors, including the assumptions for the forest industry and the renewable energy that it produces, to allow readers to gain a better understanding of the development trend by sector.	Finland has improved the transparency of reporting by providing information on factors and activities in the projections of greenhouse gas emissions for all sectors.	Sections 5.8.2

Working Groups

Chapters 4 and 5

Bettina Lemström (Chair)	Ministry of Economic Affairs and Employment
Petri Hirvonen (Coordinator)	Ministry of Economic Affairs and Employment
Sini Niinistö (Coordinator)	Statistics Finland
Lotta Heikkonen Milja Keskinen Birgitta Vainio-Mattila Johanna Vanhatalo	Ministry of Agriculture and Forestry
Pia Kotro Outi Vilen	Ministry of Economic Affairs and Employment
Magnus Cederlöf Antti Irjala Pekka Kalliomäki Jyrki Kauppinen Eeva Nurmi Hanne Siikavirta Riikka Siljander Kai Skoglund Juha-Pekka Maijala Olli-Pekka Pietiläinen	Ministry of the Environment
Tuomas Laiho	Ministry of Finance
Tommi Forsberg Mikael Hilden Tarja Häkkinen Janne Pesu Jouko Petäjä Sara-Tuuli Siiskonen	Finnish Environment Institute (SYKE)
Torsti Alhava Katja Lohko-Soner	Finnish Transport and Communications Agency Traficom
Lea Gynther Ulla Suomi	Motiva
Heikki Lehtonen Antti Miettinen Tarja Tuomainen	Natural Resources Institute Finland (Luke)

Chapter 6

Kirsi Mäkinen (Chair)	Ministry of Agriculture and Forestry
Sini Niinistö (Coordinator)	Statistics Finland
Lauri Ahopelto	Ministry of Agriculture and Forestry
Karoliina Pilli-Sihvola	Ministry of Agriculture and Forestry
Jaana Avolahti	Ministry of Economic Affairs and Employment
Heta-Elena Heiskanen Antti Irjala Kaarle Kupiainen Juha-Pekka Maijala	Ministry of the Environment
Saana Ahonen	Ministry for Foreign Affairs
Jari Honkanen Jussi Korhonen	Ministry of the Interior

Saara Jääskeläinen Noomi Saarinen	Ministry of Transport and Communications
Jussi Karhunen	Finance Finland
Johan Munck af Rosenschöld	Finnish Environment Institute (SYKE)
Virpi Kollanus Päivi Meriläinen	Finnish Institute for Health and Welfare
Sanna Luhtala Heikki Tuomenvirta	Finnish Meteorological Institute (FMI)
Markus Melin Pirjo Peltonen-Sainio	Natural Resources Institute Finland (Luke)
Marketta Hyvärinen Soile Knuuti	Finnish Transport Infrastructure Agency

Chapter 7

Saana Ahonen Outi Myatt-Hirvonen	Ministry for Foreign Affairs

Chapter 8

Heta-Elena Heiskanen (Chair)	Ministry of the Environment
Sini Niinistö (Coordinator)	Statistics Finland
Paavo-Petri Ahonen	Ministry of Education and Culture
Mikael Hilden	Finnish Environment Institute (SYKE)
Kaarle Kupiainen	Ministry of the Environment
Sanna Luhtala	Finnish Meteorological Institute (FMI)
Juha-Pekka Maijala	Ministry of the Environment
Outi Myatt-Hirvonen	Ministry for Foreign Affairs
Mikko Peltonen	Ministry of Agriculture and Forestry
Marjaana Suorsa	Ministry of Agriculture and Forestry
Pilvi Toppinen	Academy of Finland
Heikki Tuomenvirta	Finnish Meteorological Institute (FMI)

Chapter 9

Paavo-Petri Ahonen (Chair)	Ministry of Education and Culture
Pia Forsell (Coordinator)	Statistics Finland
Kirsi-Maaria Forssell	Motiva
Heta-Elena Heiskanen	Ministry of the Environment
Katja Hilska-Keinänen	Finnish Environment Institute (SYKE)
Virpi Komulainen	Ministry of the Environment
Laura Kotila	Ministry of the Environment
Anne Liimatainen	Finnish National Agency for Education
Sanna Luhtala	Finnish Meteorological Institute (FMI)
Irmeli Mikkonen	Motiva
Kirsi Norros	Finnish Environment Institute (SYKE)
Heikki Tuomenvirta	Finnish Meteorological Institute (FMI)
Tanja Tuulinen	Center for Economic Development, Transport and the Environment

Members of the working groups contributed also to the chapters outside the focus of their own working group.

Contributors

In addition to members of the Committee for Preparing the Eight National Communication and working groups, following experts participated in the preparation of the national communication:

Alho, Jussi, Academy of Finland
Auranen, Eija, Business Finland
Auvinen, Veli, Ministry of Finance Finland
Carter, Tim, Finnish Environment Institute
Eerikäinen, Matti, Finnish Meteorological Institute
Espo, Juha, Statistics Finland
Forsius, Martin, Finnish Environment Institute
Forström, Laura, Academy of Finland
Fronzek, Stefan, Finnish Environment Institute
Frey, Anna, Finnish Meteorological Institute
Grönfors, Kari, Statistics Finland
Gummerus-Rautiainen, Päivi, Ministry of the Environment
Haakana, Markus, Natural Resources Institute Finland
Hakala, Jasper, Ministry for Foreign Affairs
Hakapää, Jyrki, Academy of Finland
Hassinen, Anu, Ministry for Foreign Affairs
Heiskanen, Anna-Stiina, Finnish Environment Institute
Helama, Samuli, Natural Resources Institute Finland
Helminen, Ville, Finnish Environment Institute
Herronen, Vilma, Statistics Finland
Honkatukia, Outi, Ministry of the Environment
Huttunen, Marika, Ministry of Agriculture and Forestry
Hyvärinen, Antti-Pekka, Finnish Meteorological Institute
Ihantola, Maija, The Finnish Association of Nature and Environment Schools
Jaakkola, Minttu, Nessling Foundation
Jalonen, Pauliina, Association of Finnish Municipalities
Jokinen, Pauli, Finnish Meteorological Institute
Jorri, Eeva-Liisa, Ministry of Agriculture and Forestry
Järvinen, Joel, Ministry of Agriculture and Forestry
Kallasvuo, Meri, Natural Resources Institute Finland
Karjalainen, Heli, Business Finland
Kaukolehto, Marjut, Academy of Finland
Keränen, Inka, Ministry of the Environment
Kokkonen, Matti, Statistics Finland
Koponen, Virpi, Business Finland
Korhonen, Marja-Riitta, Ministry of the Environment
Kuusisto, Tapio, Statistics Finland
Lanki, Timo, Finnish Institute for Health and Welfare (THL), University of Eastern Finland (UEF)
Lahtinen, Sami, Statistics Finland
Lappalainen, Hanna, Institute for Atmospheric and Earth System Research (INAR), University of Helsinki
Lehtiniemi, Maiju, Finnish Environment Institute
Lehtonen, Ilari, Finnish Meteorological Institute
Leino, Irene, Ministry for Foreign Affairs
Leskinen, Paula, Academy of Finland
Lindh, Päivi, Statistics Finland
Lohila, Annalea, Finnish Meteorological Institute
Luomaniemi, Virve, Statistics Finland
Lång, Kristiina, Natural Resources Institute Finland
Maljanen, Ville, Statistics Finland
Markkanen, Johanna, VTT Technical Research Centre of Finland
Mero, Petri, Finance Finland
Mikkelä, Ari, Business Finland
Mikkonen, Tuija, Ministry of the Environment

Niemivuo-Lahti, Johanna, Ministry of Agriculture and Forestry
Niininen, Minna, Statistics Finland
Nordberg, Juhana, Statistics Finland
Nummelin, Marjo, Ministry of the Environment
Ojala, Antti, University of Turku
Paananen, Antti, Energy Authority
Parry, Maaria, Helsinki Region Environmental Services Authority
Partala, Anneli, Natural Resources Institute Finland
Peltoniemi, Ismo, Academy of Finland
Perrels, Adriaan, Finnish Meteorological Institute
Petäjä, Tuukka, University of Helsinki
Pirkola, Kaisa, Ministry of Agriculture and Forestry
Pirttioja, Nina, Finnish Environment Institute
Pritsi, Kati, Finnish Environment Institute
Pynnönen, Esa, Ministry of the Environment
Raijas, Meri, Statistics Finland
Rantanen, Mika, Finnish Meteorological Institute
Rapo, Markus, Statistics Finland
Redsven, Mona, Finance Finland
Rehunen, Antti, Finnish Environment Institute
Riuttanen, Laura, Institute for Atmospheric and Earth System Research (INAR), University of Helsinki
Romakkaniemi, Sami, Finnish Meteorological Institute
Ronkainen, Mika, Statistics Finland
Roos, Jaana, Academy of Finland
Rouhiainen, Virve, Statistics Finland
Ruosteenoja, Kimmo, Finnish Meteorological Institute
Ryynänen, Kaisa, Finnish Meteorological Institute
Saren, Helena, Business Finland
Sevon, Tiina, Statistics Finland
Silfver, Tarja, Natural Resources Institute Finland
Sirviö, Tapani, Ministry of Agriculture and Forestry
Sjöstedt, Tuula, Sitra
Sojamo, Suvi, Finnish Environment Institute
Sorvali, Jaana, Natural Resources Institute Finland
Strahlendorff, Mikko, Finnish Meteorological Institute
Strand, Kari, University of Oulu
Suni, Tanja, Ministry of the Environment
Taajamaa, Laura, Academy of Finland
The Self-Government Body of the Sámi
Tirkkonen, Juhani, Ministry for Foreign Affairs
Torniainen,Tatu, Ministry of Agriculture and Forestry
Tulonen, Eetu, Ministry for Foreign Affairs
Tuomi, Laura, Finnish Meteorological Institute
Törnroos, Tea, Finnish Environment Institute
Uitto, Paula, Energy Authority
Uusikivi, Jari, Finnish Environment Institute
Uutela, Marko, Academy of Finland
Vanholm, Steven, Finnish Association for Nature Conservation
Veijalainen, Noora, Finnish Environment Institute
Vikfors, Sofia, Natural Resources Institute Finland
Virtanen, Katriina, Pirkanmaa Centre for Economic Development, Transport and the Environment
Virtanen, Tia-Maria, Ministry of Agriculture and Forestry
Voutilainen, Venla, Finance Finland
Weaver, Sally, University of Helsinki, the Finnish Climate Change Panel
Weckström, Jan B., University of Helsinki
Ylikangas, Mikko, Academy of Finland

Ympäristöministeriö
Miljöministeriet
Ministry of the Environment

Statistics Finland

Ministry of the Environment
PO Box 35,
FI-00023 GOVERNMENT,
FINLAND

Statistics Finland
PO Box 3C,
FI-00022 Statistics Finland,
FINLAND

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