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15 March 2023

INTEGRATED REPORTING ON GREENHOUSE GAS POLICIES AND MEASURES AND ON PROJECTIONS

under article 18 of Regulation (EU) No 2018/1999 of the European parliament and of the Council Decision on the Governance of the Energy Union and Climate Action

FINLAND

CONTENTS

1 INTRODUCTION

As a member of the European Union, Finland has reporting obligations regarding integrated reporting on greenhouse gas policies and measures and on projections under Article 18 of the Regulation (EU) 2018/1999 and articles 36, 37 and 38 of Commission implementing Regulation (EU) 2020/1208. By 15 March 2021, and every two years thereafter, Member States shall report to the Commission information on their national policies and measures or group of measures and their national projections of anthropogenic greenhouse gas emissions by sources and removals by sinks.

Finland's 2023 reporting on the policies and measures and projections comprises of following data and information submitted through the Commission´s online tool in the Reportnet 3 portal:

- this textual report (pdf file)
- information on implemented, adopted and planned policies and measures (PAM web form)
- national projections of greenhouse gas emissions (excel file)
- description of National Systems for Policies and Measures and Projections (PAM web form)
- Model Factsheet (excel file)
- other tables specified in Annex XXV in the Implementing Regulation (EU) 2020/1208.

From 2023, the Member States shall also report the progress of the other four dimensions of the Energy Union. That part of the integrated national energy and climate progress reporting is submitted through the ReportENER portal.

Information provided on greenhouse gas emissions and trends in this report is consistent with the information in Finland's greenhouse gas inventory submission on 14 April 2022[1]. Statistics Finland is responsible for greenhouse gas emissions inventory reporting. 2020 is used as reference year for the projections. The warming potential of different greenhouse gases is translated into carbon dioxide equivalents using global warming potential (GWP) factors according to the IPCC's Fifth Assessment Report (AR5).

End of July 2022 is the cut-off date between existing measures and additional measures. Climate and energy policies and measures that have been implemented or adopted by July 2022 are included in the "With Existing Measures" (WEM) projection. The "With Additional Measures" (WAM) projection includes in addition policies and measures that are planned but not implemented before 1 August 2022 provided that necessary information on the impact of the measure is available.

In Finland, the policies and measures to reduce greenhouse gas emissions as well as mitigation and adaptation objectives and actions are largely defined in national, governmental, regional and/or sectoral strategies, programmes and plans. The concrete climate and energy policy measures that are presented in the integrated reporting on greenhouse gas policies and measures and on projections, and discussed in more detail in this report, are largely based on Finland's latest National Climate and Energy Strategy,

[1] Finland's 2022 greenhouse gas inventory submission under the UNFCCC, https://unfccc.int/ghg-inventories-annex-i-parties/2022

the second Medium-term Climate Change Policy Plan and the Climate Plan for the Land Use Sector, all of which were finalized in 2022.

Chapter 2 provides information on implemented, adopted and planned policies and measures. Projected greenhouse gas emissions as well as sensitivity analysis of the projections are presented in Chapter 3. The methodology for preparing the projections is presented in Chapter 4. Information on updates of the Long-term strategy is presented in Chapter 5.

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2 POLICIES AND MEASURES

2.1 Background for the information provided

The policies and measures presented in this report to reduce greenhouse gas emissions stem from the common EU targets and targets set in Finland at the national level.

A carbon-neutral Finland by 2035 was set as the target in the Programme of Prime Minister Sanna Marin's Government (2019). The Climate Change Act has been revised accordingly and the key objective of the new Act is to ensure that Finland will achieve carbon neutrality by 2035 at the latest. New emissions reduction targets by 2030 and 2040 are also included in the Act and the previous emissions reduction target by 2050 is 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. In addition, the scope of the Act is extended to also cover the land use sector, and a target concerning the strengthening of carbon sinks is added.

The EU has set Finland a 2030 national target for reducing greenhouse gas emissions in the non-emissions trading sector by 50 per cent compared to 2005. At the same time, emissions from the land-use sector should be kept lower than the computational reduction in emissions from sinks.

The mitigation actions presented in this Reporting are based on the latest National Climate and Energy Strategy called "Carbon Neutral Finland 2035", the second Medium-term Climate Change Policy Plan and the Climate Plan for the Land Use Sector, all of which were finalized in 2022. The focus in the description of the mitigation actions is in the period starting from 2021.

The 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. 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.

The mitigation actions are presented separately for the "With Existing Measures" projection (WEM) and the "With Additional Measures (WAM)" projection (see Section 3.1). Policies and measures that have been implemented by July 2022 are included in the "With Existing Measures" (WEM) projection. The "With Additional Measures" (WAM) projection includes in addition policies and measures that are planned but not implemented before 1 August 2022. Finland does not provide a without measures (WOM) projection.

Finland reports a total of 132 individual or groups of policies and measures in the PAM web form in the Reportnet 3 portal. Beginning from this Reporting, the PAM web form includes also measures that concern other dimensions of the Energy Union than decarbonisation. 121 of the reported measures have a direct climate mitigation impact. 96 of these are fully or mainly implemented, nine adopted, one has expired, and 22 are planned. In comparison to the 2021 reporting there are a further 44 measures with decarbonisation impact 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 previous reporting. For road transport, for example, more single measures are reported in the PAM web form 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.

2.2 Mitigation actions and their effects

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 presented in detail in the PAM web form in the Reportnet 3 portal 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 PAM web form. 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 PAM web form, and the aggregated estimates are provided for the group of measures. The notation Partly IE, partly included elsewhere, is used in the web form 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 2.2.1 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 2.2.2 and 2.2.3.

2.2.1 Energy

Policies and measures in the WEM 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). 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 WEM 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 the PAM web form in the Reportnet 3 portal. Energy taxation and tax-related subsidies are described in Section 2.2.9.

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 1. 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.

Table 1. 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	35.3	41.8	25.3	19.6
of which energy	NA	29.6	37.3	21.5	16.0
industrial processes	NA	3.4	4.0	3.9	3.5
Non-ETS	NA	34.3	33.7	29.5	28.1
CO_2 emissions from domestic civil aviation	NA	0.3	0.2	0.2	0.1
Total	**71.4**	**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.

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.

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[2] 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.

[2] 416/2019

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[3]:

- 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

[3] https://www.climate2035.fi/

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 were 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 Act[4], 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.

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[4] 1429/2014

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[5] 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 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 so-

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

lar 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 joint target 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 differ-

ent 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 the Model Factsheet). 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 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 WEM projection for renewable energy in Finland is shown in Figure 1 and Table 2.

Figure 1. Historic development and WEM projection for renewable energy, TWh

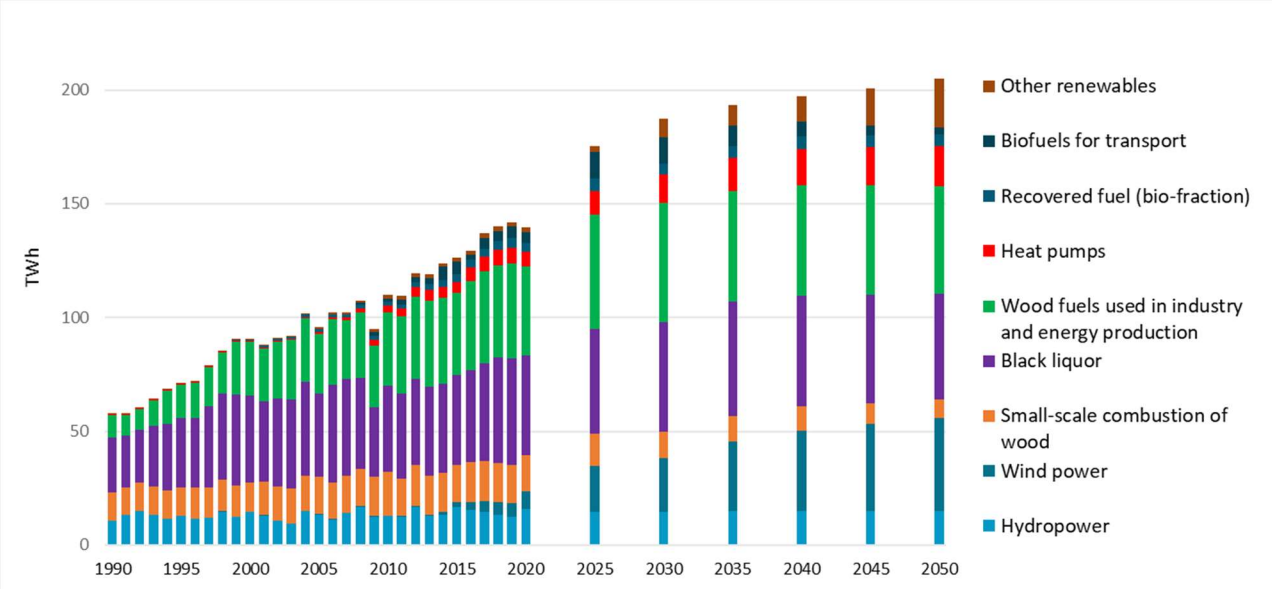


Table 2. Historic development and WEM projection for renewable energy, TWh

	Historical			WEM Projection					
	2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Black liquor	37.7	39.5	43.9	46	48	50	49	48	46
Wood fuels used in industry and energy production	32.3	36.2	39.1	50	52	49	48	48	47
Small-scale combustion of wood	19.2	16.2	15.7	14	12	11	10	9	8
Hydropower	12.7	16.6	15.7	15	15	15	15	15	15
Heat pumps	2.9	4.8	6.6	10	12	14	16	17	17
Wind power	0.3	2.3	7.9	20	23	31	36	38	41
Biofuels for transport	1.6	5.8	4.7	12	11	9	6	4	3
Recovered fuel (bio-fraction)	1.7	3.2	3.8	5	5	5	6	6	6
Other renewables	1.5	1.6	2.2	3	8	9	11	16	21
Total	**109.9**	**126.3**	**139.6**	**176**	**188**	**193**	**197**	**201**	**205**

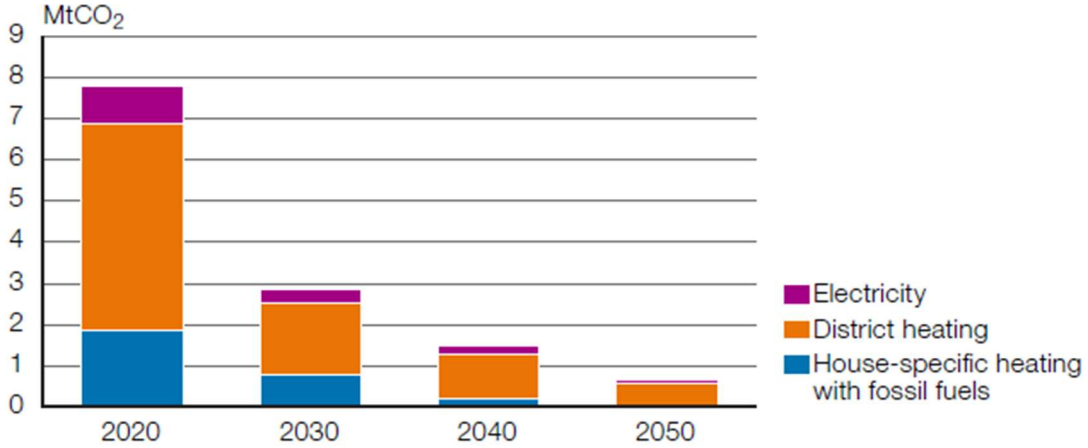
Renewable energy policies and measures for the transport sector are described in Section 2.2.2.

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 2 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.

Figure 2. Heating and cooling energy use CO_2 emissions (million tonnes CO_2)



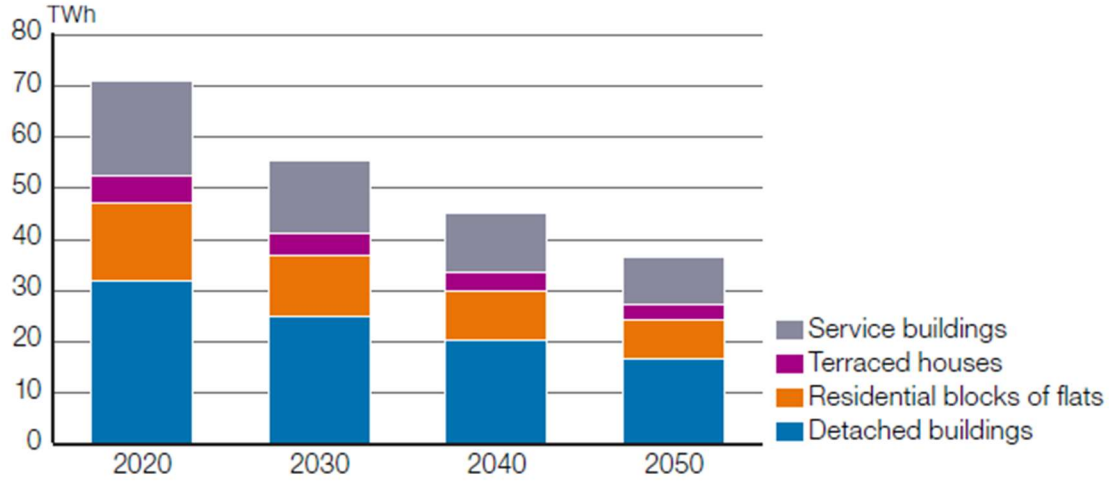
Source: Finland's renovation building strategy 2020–2050

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 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 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.

Figure 3. Heating and cooling use of buildings by building type, TWh



Source: Finland's renovation building strategy 2020–2050

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.

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 pro-

posed 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 WEM 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 the Model Factsheets) 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[6] in the Energy Efficiency Agreement scheme and Energy Efficiency Agreement for oil-heated buildings[7] 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.

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

[7] 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

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.

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.

2.2.2 Transport

Policies and measures in the WEM 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 Section 2.2.3, as they mainly concern international transport and bunker fuel emissions. In the WEM 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[8]. 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 WEM 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, HCT transport, and digitalisation in logistics, although they are not actual measures. The WEM 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.

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

Replacing fossil fuels with alternative transport fuels

The main measures under this theme included in the WEM 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[9] 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)[10]. 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)[10] 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 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. The obligation for 2023 is also temporarily lowered being now 13.5 per cent. The obligation on the annual minimum share of renewable fuels in transport is increased to 34 per cent in 2030. These amendments to the national Act on promoting the use of renewable fuels in transport came into force on 1 January 2023.

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[9] 446/2007

[10] (EU) 2018/2001

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 WEM 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[11] 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 WEM 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 WEM 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 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[12] 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[13] (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

[11] 446/2007

[12] 2009/443/EU

[13] 2019/631/EU, adopted in 2019 and applied since 1 January 2020

and a 31 per cent reduction from 2030.The WEM 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 (48.9 per cent) 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 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 amended Act on periodic support for the purchase of an alternative propulsion vehicle or conversion of a vehicle to alternative propulsion is effective between 1.1.2022 and 1.12.2024[14]. As of 2018, and currently until 31 March 2023, people who are either buying a new electric car or signing a long-term lease agreement for an electric car

[14] 1289/2021

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- or diesel-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.

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[15]. Appropriations for these purposes have been reserved in the central government budget, starting from 2018. In addition, vehicles' energy efficiency is promoted by the support designed for housing companies' charging point infrastructure.

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 vehicle.

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[16] 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[17] on the creation of an energy label for cars, as well as an information campaign for alternative power sources[18]. Motiva publishes information on sustainable choices along with a Choosing a Car website[19]. 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 period, the average CO_2 emissions (NEDC) of new cars decreased by 28 per

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[15] 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

[16] https://www.ilmastopaneeli.fi/autokalkulaattori/

[17] 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

[18] https://www.traficom.fi/fi/ajavaihtoehtoa (only in Finnish)

[19] https://www.motiva.fi/ratkaisut/kestava_liikenne_ja_liikkuminen/valitse_auto_viisaasti (in Finnish)

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 WEM 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[20] 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[21]. 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 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

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[20] 2019/1242/EU

[21] 839/2020

largest GHG emissions reduction in the WEM 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 WEM 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 WEM 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 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[22] 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

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

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 9.75 million for large urban areas (4 areas) and EUR 8.125 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.

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 0.9 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.[23]

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)[24]. 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

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

[24] 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

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[25]). 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 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[26] 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 WEM projection.

The incentivising of various procurers to invest in environmentally friendly vehicles has been promoted since the EC Clean Vehicles Directive[27](CVD) entered into force. The revised Clean Vehicles Directive[28] 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

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[25] 320/2017

[26] High Capacity Transport

[27] 2009/33/EC

[28] 2019/1161/EU

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[29], 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.

HCT transport and digitalisation in logistics will result in the largest greenhouse gas emissions reduction in the WEM projection under this theme. The WEM 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.

Policies and measures in the WAM projection

The PAM web form 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. The aim 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.[30] 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.

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[29] 740/2021

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

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[31]. 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 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.[32] 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.

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.

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[31] COM (2021) 645 final, page 4

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

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[33]. 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 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[34] 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[35] 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.

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

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

[35] The Finnish Transport and Communications Agency Traficom's impact assessment (1.7.2022).

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 funding levels for public transport after 2025 to 2032 will be further specified as part of the preparation and implementation of the Traffic12 plan.[36]

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.[37]

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.

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

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

2.2.3 International bunkers

Policies and measures in the WEM 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 implemen-tation 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 CO2 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 com-pared 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 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 CO2 emissions, fuel consumption, transport work and average energy effi-ciency. 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 (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 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 avia-tion CO_2 emissions by more than 17 million tonnes per year.

Based on the Roadmap for fossil-free transport described in Section 2.2.2 the Government made Resolutions on reducing greenhouse gas emissions from aviation, as well as maritime and inland waterway transport. According to the Government Resolution, 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 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 was submitted to the ICAO in 2021.

The Government Resolution 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, 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 mari-time 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). 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 was unanimously 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.

2.2.4 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 WEM 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 Section 2.2.1. 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 WEM projection

The amount of emissions from F-gases (HFC, PFC, SF6) 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 SF6 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 SF6 in specific applications in which the consumed amount of SF6 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[38] and the directive related to HFC emissions from air conditioning systems in motor vehicles.[39] 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 EU market, bans on the

[38] 2014/517/EC

[39] 2006/40/EC

use of HFCs in certain applications and obligations related to leak checking and repairs, F-gas recovery and technician training.

The WEM 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 WEM 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 0.1 million tonnes CO_2 eq. in 2030.

2.2.5 Agriculture

Policies and measures in the WEM 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.[40] At programme level, Finland has defined evaluation and implementation plans to evaluate climate change issues[41].

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[42] 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[43], 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

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[40] 1305/2013/EU (rural development regulation)

[41] Yli-Viikari, A. (ed.) (2019) http://urn.fi/URN:ISBN:978-952-326-822-7

[42] Ministry of Agriculture and Forestry (2022) https://urn.fi/URN:ISBN:978-952-366-388-6

[43] Ministry of the Environment (2022) http://urn.fi/URN:ISBN:978-952-361-417-8

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[44]. 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.

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[45]. 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.

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

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[44] Maanavilja, L. et al. (2021) http://urn.fi/URN:ISBN:978-952-383-263-3

[45] Riipi, I. et al. (2021) http://urn.fi/URN:ISBN:978-952-380-241-4

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[46], 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[47] 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 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

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[46] Ministry of Agriculture and Forestry (2021) http://urn.fi/URN:ISBN:978-952-366-196-7

[47] https://mmm.fi/ravinteetkiertoon

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[48].

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[49]. Many of these measures are also mentioned in the WEM 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.

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 Finland's Eight National Communication, 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 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.

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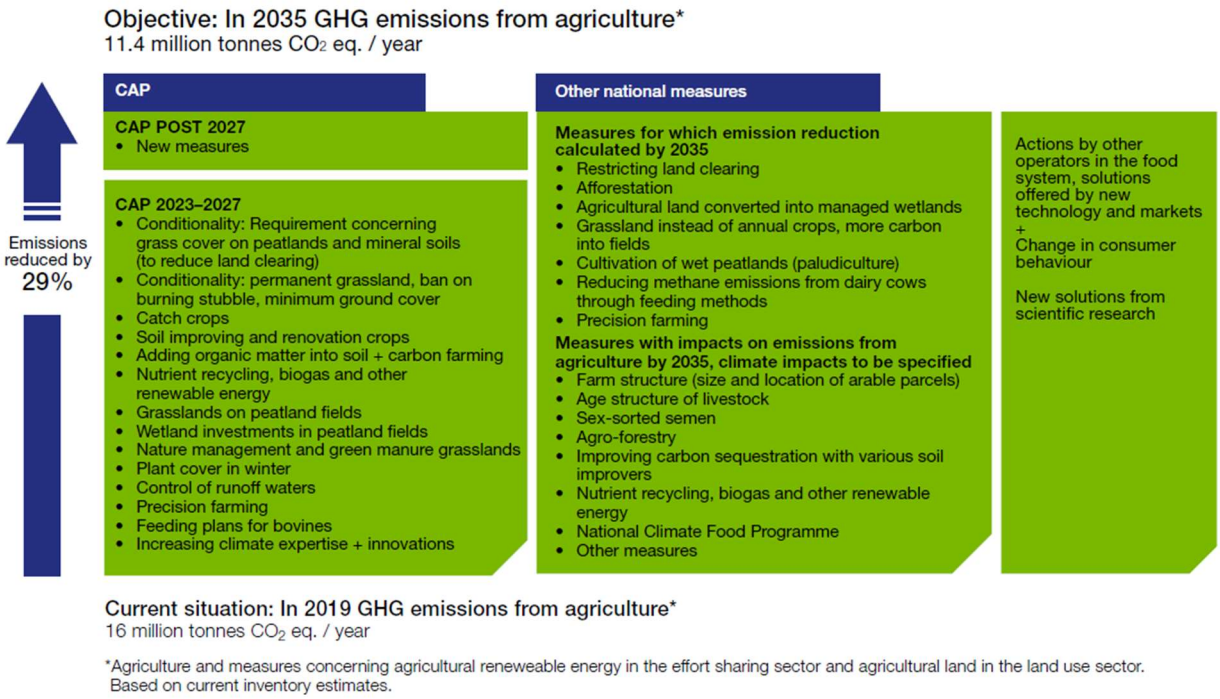
[48] Ministry of Agriculture and Forestry (2021) http://urn.fi/URN:ISBN:978-952-366-192-9

[49] Lehtonen (2022) https://mmm.fi/documents/1410837/1516663/HERO_selvitys_A4_2022.pdf/9fbf32ea-2a0b-3a4f-a0e8-b59c1e1b0995/HERO_selvitys_A4_2022.pdf?t=1650617552625

Figure 4. Potential measures to reach the 29 per cent emission reduction target for Finnish agriculture by 2035



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.[50] 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[51]. 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.

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[50] https://mmm.fi/en/climatefriendlyfoodprogramme

[51] Saarinen, M. et al. (2019) http://urn.fi/URN:ISBN:978-952-287-773-4

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[52] 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.

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.

2.2.6 Land use, land-use change and forestry

Policies and measures in the WEM projection

The LULUCF WEM projection is based on the Climate Plan for the Land Use Sector, which was adopted in 2022. The plan 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 3 and Table 4).

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 as 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[53]. The measures mentioned in the Climate Plan

[52] Ministry of the Environment (2022) http://urn.fi/URN:ISBN:978-952-361-417-8

[53] In line with the Government Decree 5/2021.

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 4).

The Climate Plan also aims to promote other goals of sustainable development, and it has reconciled with other plans, programmes and strategies. The Plan interface with the Climate and Energy Strategy, the Medium-Term Climate Change Policy Plan, the National Climate Change Adaptation Plan, the Biodiversity Strategy, the National Forest Strategy, the Finnish Bioeconomy Strategy, water resources management, and policies and programmes for agriculture (for agriculture see Chapter 2.2.5).

Table 3. 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
		Promoting markets and incentives related to carbon sequestration and storage and the reduction of emissions	Communication and interaction
			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
To promote afforestation: • Act on fixed-term support for afforestation • Afforestation of low-yield fields suitable for afforestation			Local and regional cooperation
		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. 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, AR5 GWP)

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	0.132	0.215
Paludiculture, groundwater level -30 cm	2030: 5,000 ha 2035: 10,000 ha	0.046	0.093
Paludiculture, groundwater level -5 – -10 cm	2030: 2,500 ha 2035: 5,000 ha	0.046	0.092
Managed wetlands	2030: 4,000 ha 2035: 7,500 ha	0.070	0.132
Perennial grasslands without tilling	2030: 40,000 ha 2035: 40,000 ha	0.081	0.081
Wetting of low-yield, thick peaty arable land into wetlands	2030: 10,000 ha 2035: 10,000 ha	0.175	0.175
Comprehensive planning of peatland forest management (avoidance of remedial ditching)	-	-	-
Comprehensive planning of peatland forest management (continuous cover forestry)	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		**1.98**	**3.09–3.29**

Finland's forest policy promotes sustainable forest management, and the policy measures include legislation, the National Forest Strategy (NFS), financial support, and extensive public forestry organisations. The NFS 2025 was reformed in 2022 (National Forest Strategy 2035) and the national Forest Council approved it on 14 December 2022. The WEM projection was prepared before the adoption, but some aspects of the new NFS are already included in it.

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 high-quality forest management can improve both the growth and the growing stock's resistance 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; ensuring forest regeneration and protectinghabitats and species biodiversity; a long-term programme of forest tree improvement to ensure good-quality seeds for 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[54] and the Forest Damages Prevention Act[55] 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. The relevance and functioning of both the Forest Act and the Forest Damages Prevention Act were reviewed recently.

Forests are 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 NFS, in line with the Climate Plan for the Land Use Sector and the National Energy and Climate Strategy, will help to achieve the target set by the directives on promoting the use of energy from renewable sources.[56] Global economic development will greatly influence the achievements of the NFS goals.

The national measures set out in the NFS 2025 aimed to secure the climate advantages provided by forests and ensure the availability of renewable raw materials. The strategy was implemented by ten strategic projects updated in 2019. The completely new projects added to the National Forest Strategy applied to climate sustainable forestry, international forest policy, and EU policies, as well as new products made from wood. More projects than before also included the diversification of forest management methods, the safeguarding of biodiversity, water protection and the diversification of business. Projects to be considered crosscutting included the improvement of the availability and usability of forest, nature and environmental data and the facilitation of their integration with other data sources. The crosscutting projects also included the aim to build common understanding and cooperation between various actors with pluralistic communication and interaction.

One of the objectives of the Government Programme (December 2019) is to halve the use of peat for energy by 2030. This aim is included in the WEM projection by allotting releasing areas for afforestation and other biomass production. Regarding agricultural soils, measures affecting CO_2 emissions and removals from croplands and grasslands are presented in Table 3.

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[54] 1093/1996 (amendment 1085/2013)

[55] 1087/2013 (amendment 1168/2021)

[56] 2001/77/EC and 2009/28/EC

Policies and measures in the WAM projection

A WAM projection is not given for the LULUCF sector, because there are no additional measures targeted specifically at the LULUCF sector. However, some of the additional 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 section 2.2.5 under “Policies and measures in the WAM projection”.

2.2.7 Waste management and waste tax

Policies and measures in the WEM 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[57]; the Decree on Waste[58]; the Government Decree on Landfills[59]; and the Government Decree on Packaging and Packaging Waste[60]. 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[61] and the Decree on Waste[62] 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[63] is also intended to increase recycling.

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[57] 646/2011

[58] 978/2021

[59] 331/2013

[60] 1029/2021

[61] 646/2011

[62] 978/2021

[63] 1029/2021

The restrictions on the landfilling of biodegradable municipal solid and other organic wastes have been made stricter. The Decree on Landfills[64] 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 accordance with the schedule and numerical targets given in the directive on the landfill of waste[65]. 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.

2.2.8 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[66] 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

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[64] 331/2013

[65] 1999/31/EC

[66] 132/1999

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 structure but on complex processes that include lifestyle changes, as well as economic conditions and development.

2.2.9 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.[67] 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 5. 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.[68] 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

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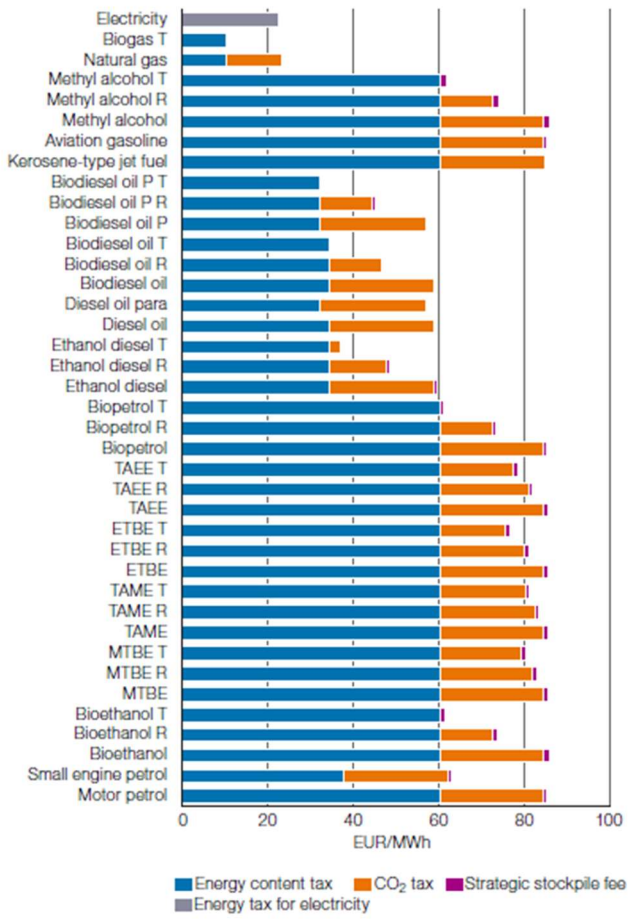
[67] 1260/1996 and 1472/1994

[68] 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.

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.

Figure 5. Energy tax rates of fuels used in transport in 2022

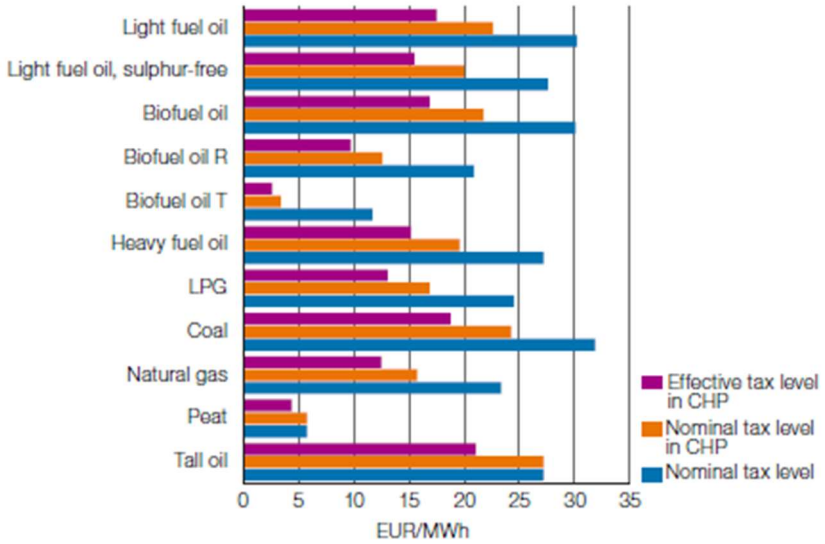


As the energy content tax on diesel is lower than the environmental criteria of the tax require, and there are no other environmental or other grounds for favouring diesel cars, diesel-powered cars are subject to the tax on driving power as part of annual vehicle tax. It complements fuel taxation and 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.[69]

[69] 1281/2003

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 6. 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.[70]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.[71]

Figure 6. Energy tax rates for fuels used for heating, as well as in power plants and mobile machinery in 2022



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.[72]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, for-

[70] 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.

[71] 603/2006 https://finlex.fi/fi/laki/ajantasa/2006/20060603

[72] 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.

estry, 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.

In the WEM 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.

3 PROJECTIONS

3.1 Overview of WEM 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). Climate and energy policies and measures that have been implemented or adopted by July 2022 are as far as possible included in the "With Existing Measures" (WEM) 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 WEM and WAM projections, including estimated impacts on greenhouse gas emissions, are presented in more detail in Chapter 2. The original time horizon of current projections is mid-term and targeted to the years 2030-2035. The latest amendment to the Regulation (EU) 2018/1999 requires, however, emission forecasts for a sequence of six future years ending with 0 or 5, immediately following the reporting year (i.e. 2050 for this reporting). The projection figures for 2040-2050 are approximate for two reasons. Firstly, the long time horizon includes large uncertainties with respect to, among others, technology development and deployment. Secondly, some sectoral projections and figures have simply been extrapolated to 2050 when the original projections have been too short. The extended time horizon also increases the relevance of technical CO_2 sinks like carbon capture and storage (CCS) and bioenergy with carbon capture and storage (BECCS). Therefore, CCS and BECCS are included in the reporting for the first time, despite the uncertainties in their potential and deployment pace.

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 WEM projections from previous years. This is done in Section 3.4.

Most of the measures included in the WAM projection of the 2021 Reporting have been implemented and are now part of the WEM projection. The most significant implemented new policy measures affecting future emissions compared to the previous reporting are a group of energy and transport related taxation measures, measures promoting emissions-free and energy-efficient road transport, a speed up of hard

coal energy use phase out, promotion of biogas, measures for energy efficiency and phase out of oil and gas heating in buildings, public procurement criteria for F-gases and several new measures in the agricultural, forestry and land-use sectors, including the Catch-the-Carbon research and innovation programme and the Climate Food programme.

The "With Additional Measures" projection (WAM) includes only a few measures additional to the WEM 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 WEM 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 2.

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.

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[73], 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 macroeconomic projections are described in the report "Macroeconomic scenarios: Carbon neutral Finland 2035 – measures and impacts of climate and energy policies"[74].

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 WEM projection for the LULUCF sector were prepared (see Section 3.2.2). Thus, the estimates of carbon removals in the LULUCF sector will be re-evaluated in future.

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

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[73] Millaista osaamista Suomi tarvitsee 2040? What kind of expertise will Finland need in 2040? (in Finnish). PTT Reports 269. https://www.ptt.fi/julkaisut/millaista-osaamista-suomi-tarvitsee-vuonna-2040/

[74] 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

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)[75]. 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.

Table 5 shows a summary of the main assumptions of the WEM projection for 2020 to 2035. The numerical values for key variables and assumptions are presented in the Parameter excel-file in Reportnet 3.

Table 5. Assumptions of the WEM 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

[75] 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

3.2 'With Existing Measures' projection

3.2.1 Total effects

Total emissions in the WEM projection for 1990 to 2050 are shown in Figure 7 (total emissions without the LULUCF sector) and Table 6 (without and with the LULUCF sector). In Figure 7 CO_2 captured with CCS technology is deducted from the CO_2 emission figures and the pillars show the net CO_2 emissions. CCS volumes for the different years are presented in Table 6.

Compared with the 1990 base year, the total greenhouse gas emissions without LULUCF are projected to be 63 per cent lower in 2030, and 70 per cent lower in 2035 (including effect of CCS). The corresponding figures for CO_2 emissions are 67 and 75 per cent. CH_4 emissions are expected to continue to decline steadily, being 57 per cent lower in 2030 and 61 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 7. Greenhouse gas emissions without LULUCF, with indirect CO_2 and CCS, by gas according to the latest greenhouse gas emission inventory (1990 to 2020) and the WEM projection (up to 2050), million tonnes CO_2 eq.

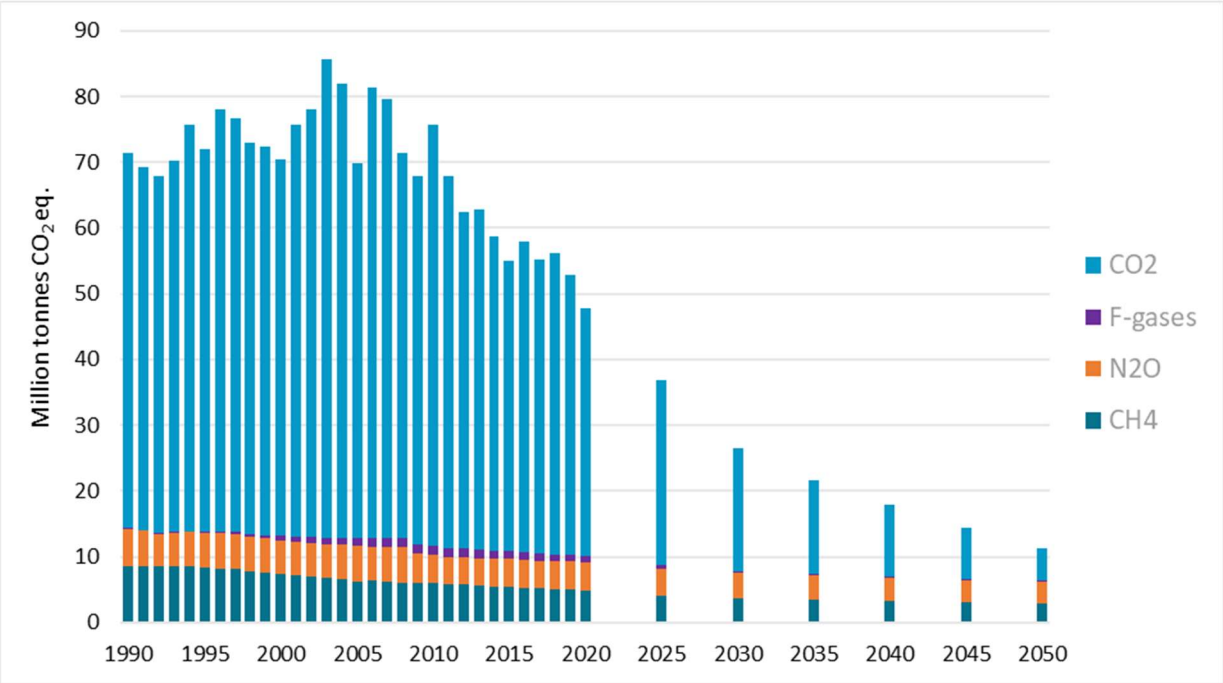


Table 6. Greenhouse gas emissions according to the most recent inventory data (1990 to 2020) and the WEM projection (2025 to 2050), kilotonnes CO_2 eq.

	GHG emissions and removals								
	Historical				WEM projection				
	1990	2005	2010	2020	2025	2030	2035	2040	2050
Sector									
1. Energy (excl. CCS&BECCS)	53 420	53 721	60 201	34 262	24 737	17 580	14 495	12 707	10 849
2. Industrial processes and product use	5 216	6 553	6 096	5 068	5 346	4 211	3 069	3 317	3 907
3. Agriculture	7 391	6 422	6 537	6 444	5 784	5 540	5 341	5 127	4 800
4. Land use, land-use change and forestry	-13 494	-20 585	-21 827	-17 437	-23 012	-20 925	-22 658	-20 451	NE
5. Waste	5 208	3 121	2 839	1 917	1 522	1 265	1 077	934	732
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO
Indirect CO_2 emissions	166	88	70	66	40	31	25	22	20
CCS, BECCS	0	0	0	0	-500	-2 200	-2 350	-4 200	-9 000
Gas									
CO_2 emissions without net CO_2 from LULUCF[1]	57 081	57 135	64 151	37 662	28 150	18 576	14 333	10 998	4 969
CO_2 emissions with net CO_2 from LULUCF[1]	39 976	33 308	39 361	17 571	2 474	-5 058	-11 071	-12 183	NE
CH_4 emissions without CH_4 from LULUCF	8 610	6 253	5 992	4 930	4 056	3 677	3 399	3 187	2 852
CH_4 emissions with CH_4 from LULUCF	10 325	7 602	7 084	5 788	4 947	4 625	4 391	4 172	NE
N_2O emissions without N_2O from LULUCF	5 657	5 367	4 254	4 199	4 031	3 842	3 714	3 565	3 373
N_2O emissions with N_2O from LULUCF	7 553	7 260	6 125	5 996	5 805	5 603	5 467	5 310	NE
HFCs	0	1 123	1 321	946	663	301	178	121	73
PFCs	0	4	3	2	1	1	1	1	1
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	54	23	22	20	28	29	32	35	41
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (without LULUCF, with indirect CO_2)	**71 402**	**69 905**	**75 743**	**47 758**	**36 929**	**26 425**	**21 656**	**17 908**	**11 308**
Total (with LULUCF, with indirect CO_2)	**57 908**	**49 320**	**53 916**	**30 321**	**13 918**	**5 500**	**-1 002**	**-2 543**	**NE**

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 8 and Table 7. 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. If all CCS and BECCS is reported in the ETS sector, CCS and BECCS brings the ETS net emissions to negative values around 2045 in the WEM projection.

The emissions from the non-ETS sector have decreased steadily since 2005, and the decrease is expected to continue. In the WEM 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 8. 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 WEM projection (until 2050). The development of the total emissions without the LULUCF sector is also presented. Dashed lines include the effect from CCS.

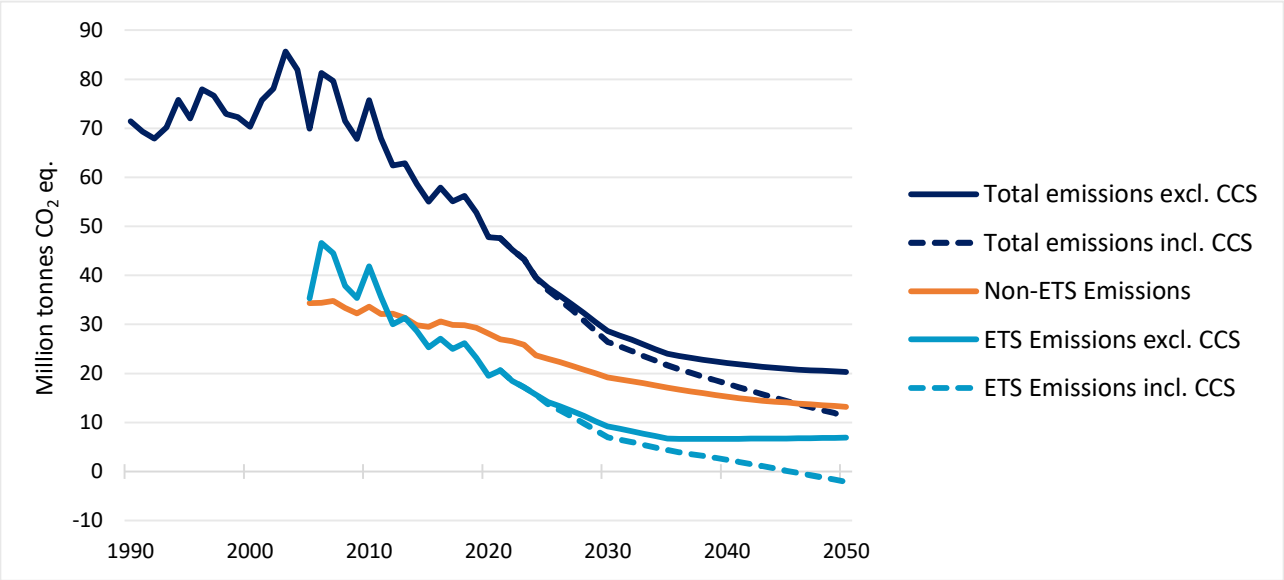


Table 7. Historical (2005 to 2020) and projected (2025 to 2050) greenhouse gas emissions (incl. CCS) in the Non-ETS and ETS sector and civil aviation based on the latest greenhouse gas inventory and the WEM projection, respectively

	Historical			WEM Projection				
	2005	**2010**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
	million tonnes CO_2 eq.			million tonnes CO_2 eq.				
Non-ETS	34.3	33.7	28.1	23.0	19.2	17.1	15.3	13.2
ETS	35.3	41.8	19.6	13.7	7.0	4.4	2.4	-2.1
Civil aviation, CO_2	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.2
Total emissions	**69.9**	**75.7**	**47.8**	**36.9**	**26.4**	**21.7**	**17.9**	**11.3**

The development of total emissions regarding the number of inhabitants, primary energy use, and economic development is presented in Table 8. All indicators show a steady downward trend that continues in the WEM projection. Today, the emissions are decoupled from both the GDP growth and energy use development and decline steadily.

Table 8. Greenhouse gas emission intensity based on the latest greenhouse gas inventory for 2010 to 2020 and the WEM projection for 2025 to 2050

	Historical			WEM projection				
	2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
Emissions per capita, tonnes CO_2 eq. / capita	14.09	10.03	8.63	6.64	4.74	3.89	3.24	2.09
Emissions per GDP, kg CO_2 eq. / EUR	0.36	0.26	0.21	0.15	0.10	0.08	0.06	0.03
Emissions per primary energy, tonnes CO_2 eq. / MWh	0.19	0.15	0.13	0.09	0.07	0.06	0.05	0.03

3.2.2 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 WEM 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 WEM 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) can reduce emissions even further. In the WEM projection CCS investments are expected from 2025, whereas BECCS is deployed ten years later. CCS is assumed to be used in the petrochemical industry and is in the GHG projection file included in the figures for CRF category 1.A.1.b Petroleum Refining. Blue hydrogen production and CRF category 2.B could also be a possible alternative for CCS. BECCS suits in particular in connection with forest industry processes and manufacturing of biofuels. The emissions reduction impact of BECCS is in this reporting included in CRF category 1.A.2 Manufacturing Industries and Construction. In the WEM projection the total emissions reduction impact of CCS and BECCS is 2.2 million tonnes CO_2 eq. in 2030 and after that, it approximately doubles every ten years reaching 9 million tonnes CO_2 eq. in 2050. 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 (including CCS, excluding transport) in the WEM projection are presented in Table 9. 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 9. Historical (1990 to 2020) and projected (2025 to 2050) greenhouse gas emissions from the energy sector (including CCS, excluding transport) based on the latest inventory and the WEM projection respectively

	Historical				WEM projection				
	1990	**2005**	**2010**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
	million tonnes CO_2 eq.				million tonnes CO_2 eq.				
Total emissions	**41.3**	**40.9**	**47.5**	**23.8**	**16.1**	**8.7**	**6.6**	**4.1**	**-1.3**
CO_2	40.8	40.0	46.7	23.2	15.4	8.1	6.1	3.6	-1.7
CH_4	0.2	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2
N_2O	0.3	0.4	0.5	0.4	0.4	0.3	0.3	0.3	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 WEM 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 WEM 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 WEM 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 WEM 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 WEM 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 WEM 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 now included in the WEM projection is the increase of remote work. Remote work is a new phenomenon created by the Covid-19 pandemic . 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 WEM projection.

According to the WEM 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[76] setting stricter CO_2 emission standards for cars and light commercial vehicles will contribute to a significant reduction in the WEM 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 6.2 million tonnes from 2005 to 2030 (Table 10).

Table 10. Historical (1990 to 2020) and projected (2025 to 2050) greenhouse gas emissions from transport based on the latest greenhouse gas inventory and the WEM projection, respectively

	Historical				WEM Projection				
	1990	**2005**	**2010**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
	million tonnes CO_2 eq.				million tonnes CO_2 eq.				
Total emissions	**12.1**	**12.9**	**12.7**	**10.4**	**8.2**	**6.7**	**5.5**	**4.4**	**3.1**
CO_2	11.8	12.7	12.6	10.3	8.1	6.6	5.4	4.3	3.1
CH_4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0

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[77], 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

[76] 2019/631/EU, adopted in 2019 and applied since 1 January 2020

[77] EUROCONTROL Aviation Outlook 2050. Main Report April 2022; https://www.eurocontrol.int/sites/default/files/2022-04/eurocontrol-aviation-outlook-2050-main-report.pdf

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 11.

These projected emissions of marine and aviation bunkers do not as such consider the impact of the measures presented in Section 2.2.3, which aim to improve energy efficiency and increase the use of alternative fuels.

Table 11. Historical (1990 to 2020) and projected (2025 to 2050) greenhouse gas emissions from international bunkers based on the latest greenhouse gas inventory and the WEM projection, respectively

	Historical				WEM Projection				
	1990	**2005**	**2010**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
	million tonnes CO_2 eq.				million tonnes CO_2 eq.				
Total emissions	**2.9**	**2.9**	**2.3**	**1.9**	**2.9**	**3.2**	**3.5**	**NE**	**NE**
Aviation	1.0	1.3	1.7	0.9	1.8	1.9	2.1	NE	NE
Navigation	1.8	1.6	0.7	1.0	1.1	1.3	1.4	NE	NE

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 WEM 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 WEM 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 WEM 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 WEM 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 WEM projection for F-gases includes the impacts of the EU regulation on F-gases[78] and the EC directive related to emissions from air-conditioning systems in motor vehicles[79]. 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 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 WEM projection. Historical and projected greenhouse gas emissions from industrial processes and other product use are presented by gas in Table 12.

Table 12. Historical (1990 to 2020) and projected (2025 to 2050) greenhouse gas emissions from industrial processes and other product use based on the latest greenhouse gas inventory and the WEM projection, respectively

	Historical				WEM Projection				
	1990	**2005**	**2010**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
	million tonnes CO_2 eq.				million tonnes CO_2 eq.				
Total emissions	**5.2**	**6.6**	**6.1**	**5.1**	**5.3**	**4.2**	**3.1**	**3.3**	**3.9**
CO_2	3.7	4.0	4.6	3.9	4.4	3.6	2.6	2.9	3.4
CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N_2O	1.5	1.4	0.2	0.2	0.2	0.2	0.3	0.3	0.4
F-gases	0.1	1.1	1.3	1.0	0.7	0.3	0.2	0.2	0.1

[78] 2014/517/EU

[79] 2006/40/EC

Agriculture

In recent years, changes in the emissions from agriculture have been small. The projections were updated in 2022. In the WEM projection, the total emissions from the agricultural sector are expected to decrease[80]. 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 13).

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 13.

Table 13. Historical (1990 to 2020) and projected (2025 to 2050) greenhouse gas emissions from agriculture based on the latest greenhouse gas inventory and the WEM projection, respectively

	Historical				WEM Projection				
	1990	**2005**	**2010**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
	million tonnes CO_2 eq.				million tonnes CO_2 eq.				
Total emissions	**7.4**	**6.4**	**6.5**	**6.4**	**5.8**	**5.5**	**5.3**	**5.1**	**4.8**
CO_2	0.6	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
CH_4	3.1	2.8	2.9	2.8	2.3	2.3	2.2	2.1	2.0
N_2O	3.6	3.3	3.4	3.4	3.2	3.1	3.0	2.8	2.6

LULUCF

The WEM projection includes the measures introduced in the Climate Plan for the Land Use Sector, more specifically the measures for which the effects on emissions and removals were possible to assess (Ollila et al. 2022). The measures in the Plan are mainly focused on agricultural lands and forests. The background for the projection is the HIISI-WEM scenario (Maanavilja et al. 2021), which is reformed with these additional measures. In the WEM projection, the HIISI-WEM scenario is applied for wetlands and settlements. The WEM projection starts in 2021 and extends to 2040.

[80] Miettinen, A. et al. (2022) http://urn.fi/URN:ISBN:978-952-380-500-2

Table 14. Historical (1990 to 2020) and projected (2025 to 2050) greenhouse gas emissions and removals from the LULUCF sector based on the latest greenhouse gas inventory and the WEM projection respectively

	Historical				WEM Projection				
	1990	**2005**	**2010**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
	million tonnes CO_2 eq.				million tonnes CO_2 eq.				
Total emissions and removals	**-13.5**	**-20.6**	**-21.8**	**-17.4**	**-23.0**	**-20.9**	**-22.7**	**-20.5**	**NE**
CO_2	-17.1	-23.8	-24.8	-20.1	-25.7	-23.6	-25.4	-23.2	NE
CH_4	1.7	1.3	1.1	0.9	0.9	0.9	1.0	1.0	NE
N_2O	1.9	1.9	1.9	1.8	1.8	1.8	1.8	1.7	NE

The LULUCF sector as a whole is projected to be a net sink in the WEM projection (Table 14). In 2035, the net sink is estimated to be −22.7 million tonnes of carbon dioxide equivalent. The net sink is projected 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 out in the Climate Plan for the Land Use Sector.

In the WEM 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 (e.g. deforestation) 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.

To some extent, the projections for the agricultural sector and the LULUCF sector include 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 WEM projection for agriculture. The LULUCF sector projection therefore produces slightly higher emissions reductions for cropland and grassland than using the measures and parameters of the agriculture WEM projection.

In the forests, the roundwood removals increase up to 79 million cubic metres (including the use of wood for bioenergy) in the period 2026 to 2035, and the estimated carbon sink of forests (including trees and soil) will be approximately at the level of −28.1 million tonnes of CO_2 eq. per annum by 2035. The modelled volume of roundwood removals is based on the estimated development of the Finnish forest industry (Maanavilja et al. 2021). 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.

According to the greenhouse gas inventory, the LULUCF sector has been a net sink in Finland during the years 1990–2020, though the net sink has varied greatly annually. The most recent preliminary greenhouse gas inventory results show that in 2021, the LULUCF sector was a net source of emissions for the first time. The main reason for the sector turning from a net sink to a net source in 2021 is that the carbon sink of forests decreased considerably due to increased felling removals, decreased growth of growing stock and changes in applied methodology. A new method was adopted for calculating the CO_2 emissions from drained forest peatlands. The projections for the LULUCF sector were estimated in early 2022, which means

the old method for estimating the CO_2 emissions from drained forest peatlands was used, and that the projections are now inconsistent with the most recent inventory results. New scenarios, which take into account the new method, will be prepared in 2023–2024.

Projection for LULUCF accounting categories as specified in the Regulation (EU) 2018/841

Projections of LULUCF accounting categories under the Regulation (EU) 2018/841 were compiled from the WEM projection. Projections were compiled for the period 2021–2025 and, where applicable, for the period 2026–2030. Accounting of managed forest land for the second commitment period will not be possible until the final forest reference level is available. CH_4 and N_2O emissions from drainage of organic soils and direct N_2O emissions from nitrogen mineralization were allocated into correct accounting categories. Direct N_2O emissions from forest fertilization, CH_4 and N_2O emissions from controlled burning and wildfires on forest land, and emissions and removals from harvested wood products were allocated into managed forest land. The new method implemented in the greenhouse gas inventory for the 2023 submission was not applied in the projection.

The sum of accounted emissions and removals are projected to be -5.5 million tonnes of CO_2 eq. in the period 2021–2025 (Table 15). Greenhouse gas inventory data of the 2022 submission were used to calculate the average annual emissions and removals for managed cropland and managed grassland in the base period 2005–2009. These were 5.8 million tonnes of CO_2 eq. for managed cropland and 0.7 million tonnes of CO_2 eq. for managed grassland. The forest reference level for managed forest land is -29.4 million tonnes of CO_2 eq. for the period 2021–2025 (Annex to Commission delegated regulation (EU) 2021/268[81]). Finland has chosen not to include managed wetlands in the scope of its first commitment period.

Table 15. Projected emissions and removals from 2021 to 2025 by LULUCF accounting categories

Accounting category	Scenario	Total cumulative emissions/removals (million tonnes CO_2 eq.) 2021–2025
Afforested land	WEM	-0.4
Deforested land	WEM	12.9
Managed cropland	WEM	0.9
Managed grassland	WEM	-0.4
Managed forest land, including harvested wood products	WEM	-18.5
Managed wetland	WEM	Not selected

[81] Commission delegated Regulation (EU) 2021/268 of the 28 October 2020 amending Annex IV to Regulation (EU) 2018/841 of the European Parliament and of the Council as regards the forest reference levels to be applied by the Member States for the period 2021-2025.

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 WEM projection (Table 16). The main reason for this reduction is the implementation of the Landfill Directive[82] and national legislation[83] 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 16. Historical (1990 to 2020) and projected (2025 to 2050) greenhouse gas emissions from the waste sector based on the latest greenhouse gas inventory and the WEM projection respectively (waste incineration not included)

	Historical				WEM Projection				
	1990	**2005**	**2010**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
	million tonnes CO_2 eq.				million tonnes CO_2 eq.				
Total emissions	**5.2**	**3.1**	**2.8**	**1.9**	**1.5**	**1.3**	**1.1**	**0.9**	**0.7**
CH_4	5.1	3.0	2.7	1.8	1.4	1.2	1.0	0.8	0.6
N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Indirect CO_2 emissions

The WEM 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.

[82] Landfill Directive 99/31/EC

[83] Government decree on Landfills (331/2013)

3.3 'With Additional Measures' projection

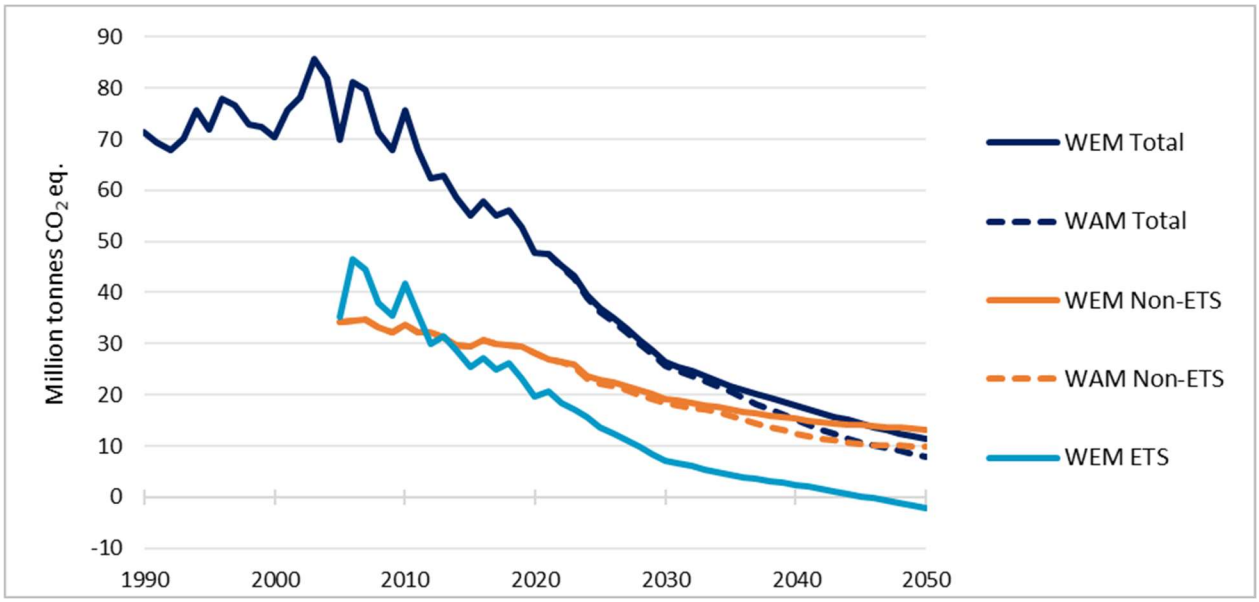
The WAM projection presented in this chapter includes measures already decided at a governmental level and described in Chapter 2. There are planned measures for the transport sector, machinery, F-gases, agriculture, and the waste sector.

With a few exceptions, all the planned measures described in Chapter 2 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 9. Solid lines portray the WEM 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 9. Greenhouse gas emissions in EU ETS and non-ETS sectors in the WAM projection (dashed lines) compared to the WEM projection (solid lines) in 2021 to 2050 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 WEM 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 17). The emissions in the ETS sector remain the same as in the WEM projection.

Table 17. Historical (2005 to 2020) and projected (2025 to 2050) greenhouse gas emissions (incl. CCS) 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**	**2040**	**2050**
	million tonnes CO_2 eq.			million tonnes CO_2 eq.				
Non-ETS	34.3	33.7	28.1	22.2	18.5	16.0	12.5	9.9
ETS	35.3	41.8	19.6	13.7	7.0	4.4	2.4	-2.1
Civil aviation, CO_2	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.2
Total emissions	**69.9**	**75.7**	**47.8**	**36.1**	**25.7**	**20.5**	**15.1**	**8.0**

Table 18 presents a summary of the WAM projection emissions and the difference between them and the emissions levels in the WEM projection.

Table 18. Greenhouse gas emissions (incl. CCS, without LULUCF) on a gas-by-gas basis for the WAM projection and the difference between them and the WEM projection between 2025 and 2050, 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**	**2040**	**2050**
	million tonnes CO_2 eq.						
CO_2	64.2	37.7	27.7	18.2	13.5	8.7	2.2
CH_4	6.0	4.9	4.0	3.6	3.3	3.0	2.5
N_2O	4.3	4.2	3.9	3.7	3.6	3.4	3.2
F-gases	1.3	1.0	0.6	0.2	0.1	0.1	0.1
Total	**75.7**	**47.8**	**36.1**	**25.7**	**20.5**	**15.1**	**8.0**
Difference to WEM			**-0.8**	**-0.7**	**-1.1**	**-2.8**	**-3.4**

When the different emission sectors are examined, the sectoral WAM projections do not differ from the WEM 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 WEM 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 WEM 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 WEM 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 WEM projection.

The current F-gas measures in the WEM 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 0.1 million tonnes CO_2 eq. in 2030.

The WAM projection of agriculture[84] 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.

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 WEM 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 14).

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[84] Miettinen, A. et al. (2022) http://urn.fi/URN:ISBN:978-952-380-500-2

For the LULUCF sector, the WAM projection does not differ from the WEM projection. Hence, the above-mentioned 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 WEM 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 WEM projection.

3.4 Assessment of aggregate effect of policies and measures

The aggregated estimates for the greenhouse gas reduction impacts of individual WEM policies and measures presented in Chapter 2 are 26 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 (WEM 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 from the data in the PAM web form is shown in Table 19.

Table 19. The total i.e. aggregate effect of the policies and measures (PaMs) calculated based on the estimated impact of PaMs 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

(Mt CO_2 eq.)	Total emissions in 2020 [1]	Total effects of PaMs			
		2020	**2025**	**2030**	**2035**
WEM measures	47.8	26.2	44.5	52.2	54.8
WAM measures [2]		0.0	0.2	0.8	0.9

1 Without LULUCF

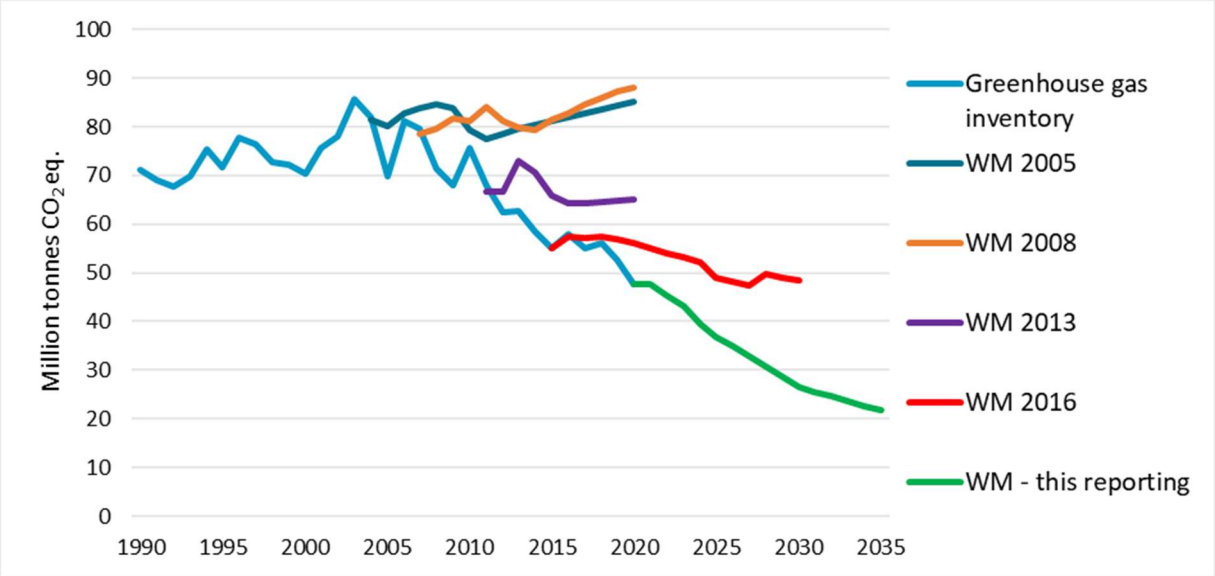
2 In addition to the total effect of PaMs included in the WEM projection

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 WEM projections from earlier reporting rounds. Figure 10 shows Finland's greenhouse gas emissions in the WEM 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 WEM 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 10. Greenhouse gas emissions according to the most recent inventory for 1990 to 2020 and in the WEM projections of the climate and energy strategies published in 2005, 2008, 2013 and 2016 until 2020 and 2030 respectively, and the WEM projection of this reporting



The main difference between the projections shown in Figure 10 is that most measures from previous WAM projections have been implemented since the previous reporting and are therefore included in the following WEM projections. The biofuel quota obligation in road transport is one of the measures with the greatest impact. Another significant difference since the WEM 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 reporting.

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 WEM projection of this reporting points clearly downwards.

For comparison purposes, the WEM 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 65 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 53 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 79 million tonnes CO_2 eq. in 2030 for a WOM projection.

3.5 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 WEM 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 WEM projection, even though some product groups already decrease (e.g. paper manufacturing) in the base case WEM. 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 WEM 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 WEM assumptions. No dynamic effects were considered.

The results of the sensitivity analyses are presented in Table 20 below. The overall effect of a lower economic growth (WEM −) results in a steadily decreasing final energy consumption in contrast with higher economic growth (WEM +), which steadily increases the energy use in the period from 2021 to 2030. In turn, in the base case WEM projection, the final energy consumption is almost flat.

In 2030, the gross final energy consumption would be only 279 TWh in the low growth case, but 301 TWh in the high growth case compared to 289 TWh in the base case WEM. The corresponding figures for primary energy consumption are 358 TWh (WEM −), 383 TWh (WEM +), and 370 TWh (base case WEM). The relative impact of economic growth is slightly higher on final energy consumption than on primary energy. The greenhouse gas emissions in 2030 differ in both cases in total by 0.8 to 0.9 million tonnes of CO_2 eq. from the emissions in the base case WEM projection. Most of the emissions increase and reduction respectively would take place in the ETS sector, with only 0.2 million tonnes of CO_2 eq. reduction in the non-ETS sector.

Table 20. Main results for the sensitivity analysis on how the economic growth rate affects the overall energy balance and greenhouse gas emission

	Unit	2020	2030			2035		
			WEM	WEM+	WEM -	WEM	WEM+	WEM -
GHG emissions								
Total excl. LULUCF	million tonnes CO_2 eq.	47.8	26.4	27.3	25.6	21.7	22.7	20.8
Total ETS	million tonnes CO_2 eq.	19.6	7.0	7.7	6.4	4.4	5.1	3.7
Total non-ETS	million tonnes CO_2 eq.	28.1	19.2	19.4	19.1	17.1	17.4	16.9
Primary energy consumption	TWh	355	370	383	358	364	384	346
Gross final energy consumption	TWh	285	289	301	279	286	303	270

WEM +, projection with higher economic growth than the WEM projection

WEM -, projection with lower economic growth than the WEM projection

4 METHODOLOGY

4.1 Approach and responsibilities

The reported WEM- 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)[85] 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 WEM 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 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.

4.2 Assumptions underlying calculations

A summary of key variables and assumptions is presented in Table 21. Specific sectoral and category-specific data are given in "*Table 3: Reporting on parameters/variables for projections*" that is submitted through the Reportnet 3 portal. A detailed description of assumptions and key variables can also be found in Finland's Eight National Communication, Section 5.8.

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[85] Koljonen, T. et al. (2021) https://urn.fi/URN:ISBN:978-952-383-257-2

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 below and described in more detail in Section 2.2.9. 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 in 2020 before the current energy crisis in Europe.

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 Appendix 1. The individual shares are assumed to remain constant for each branch over time in the projections.

Table 21. Key variables and assumptions used in the projections analysis for 1990 to 2050

	Unit	Historical				Projected				
		1990	2005	2010	2020	2025	2030	2035	2040	2050
Population	Million inhabitants	5	5.26	5.38	5.53	5.56	5.57	5.56	5.53	5.42
Gross Domestic Product	Billion EUR, 2020 prices	142	203	212	225	241	258	278	296	333
Coal wholesale price	EUR/GJ LHV, 2020 prices for history, 2022 prices for the future	NA*	5	5	10	3	3	3	3	4
Crude oil wholesale price	EUR/GJ LHV, 2020 prices for history, 2022 prices for the future	NA*	9	9	9	12	14	15	16	17
Natural gas wholesale price	EUR/GJ LHV, 2020 prices for history, 2022 prices for the future	NA*	6	9	13	6	6	7	8	10
Emission allowance price	EUR/t nominal prices	NO	23	14	25	25	30	35	40	50
Tax components: **										
Electricity, tax category I	cent/kWh, 2020 prices for history, 2022 prices for the future	NA*	NA*	0.98	2.24	2.24	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*	0.28	0.69	0.05	0.05	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*	7.63	10.33	10.33	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*	53.00	53.00	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 for history, 2022 prices for the future	NA*	NA*	NA*	58.72	60.52	60.52	60.52	60.52	60.52
Carbon dioxide component***	EUR/t lifetime CO2 emissions, 2020 prices for history, 2022 prices for the future	NA*	NA*	NA*	62.00	77.00	77.00	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.

***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

4.3 Description of models and methods

A fairly large number of models are applied for the preparation of the greenhouse gas emission projections and for impact assessment of policy measures. These are described in the Model factsheet file in the Reportnet 3 portal and in detail in Finland's Eight National Communication, Section 5.8.3.

A detailed description of methodologies and the process for collection and use of data is available in Finland's National System for Policies and Measures and Projections in Reportnet 3.

5 UPDATES OF THE LONG-TERM STRATEGY

In 2020, Finland submitted its Long-Term Strategy to the EU in accordance with the Implementing Regulation Act 2018/1999. The strategy includes Finland's latest national climate target, which is to achieve carbon neutrality by 2035. The Long-Term Strategy has not been updated since 2020.

For the assessment of the contribution of reported policies and measures applied in Finland to the achievement of Finland's long-term strategy, information is given in the reporting portal Reportnet 3 under the data flow of National greenhouse gas policies and measures - Reporting year 2023. Examples of policies that have been estimated to have a significant contribution, either absolutely or relatively, are the EU ETS, phasing out coal in energy production, promoting wind power, promoting new energy technology, implementing ecodesign and labelling, energy efficiency agreements, building regulations and standards, biofuel distribution obligation, CO_2 emission performance standards for vehicles, F-gas regulations and promotion of sustainable management and use of forest. Not all the reported policies have, however, contribution to the achievement of Finland's long-term strategy and in some cases contribution has been estimated to be weak or it is difficult to quantify. Example of policies which contribution is difficult to estimate are for example energy taxation, information campaigns, advice service and programmes increasing knowledge and promoting for example innovations.

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PROJECTED EU ETS AND NON-ETS SHARES OF GHG EMISSIONS

The split is based on GHG inventory data for the years 2018-2020.

CO_2 emissions	EU ETS %	Non-ETS %
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	91
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, 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
Carbon capture and storage (CCS and BECCS)	100	0
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