

**Government report on  
the National Energy and Climate Strategy for 2030**

(Unofficial translation)

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## **1 Key premises and objectives**

### **1.1 Introduction**

Finland's long-term objective is to be a carbon-neutral society. The report published by the Parliamentary Committee on Energy and Climate Issues in October 2014, "Energy and Climate Roadmap 2050", serves as a strategic level guide on the journey towards this target. The roadmap analysed the means of constructing a low-carbon society and achieving an 80–95 % reduction in greenhouse gas emissions from the 1990 level in Finland by 2050.

This National Energy and Climate Strategy outlines the concrete actions and objectives that will enable Finland to achieve the energy and climate targets specified in Prime Minister Sipilä's Government Programme and jointly adopted in the EU for 2030, and to systematically set the course for reaching the 2050 targets. Approximately three quarters of all greenhouse gas emissions in Finland come from energy production and consumption, including energy used for transport. Emissions are also produced in industrial processes, from the soil and livestock farming in agriculture and in the waste processing sector. Measures in all sectors are needed to achieve the targets. Energy sector measures are examined in terms of both the production and use of energy. Energy efficiency is at the centre in not only reducing the use of fossil fuels and the greenhouse gas emissions caused by them but also increasing the share of renewable energy.

The starting point of the strategy is to look at the energy and climate policy in different sectors comprehensively from the perspectives of emission reduction, energy policy, and growth and employment. The energy and climate policies should have a long time span and be in line with the Roadmap contained in the report of the Parliamentary Committee on Energy and Climate Issues. On the other hand, the policies should be sufficiently dynamic and flexible to allow for agile action in changing conditions. Technological development and the operating environment, including future EU regulation, are fraught with major uncertainties. The Government Programme specifically states that financial steering instruments must be compatible with EU guidelines and based on technology neutrality and ranking of economic priorities.

The energy and climate policy has three basic dimensions that must be constantly kept in balance when transitioning towards a carbon neutral society. The energy system must i) be cost-effective and enable the growth of the national economy and Finnish companies' competitiveness in the global market, ii) be sustainable from the perspective of greenhouse gas emissions and the environment, and iii) offer sufficient security of supply. The transformation of the energy system must be controlled and based on the existing system. Energy production and industrial investments have a long life cycle, and the replacement rate of buildings and even the vehicle fleet is slow. Theoretical calculations concerning an optimal energy production structure far in the future are useless if we do not also take into account the required investments, their funding needs, and the markets that should make the investments commercially profitable over time. Understanding this dynamics plays a key role in developing energy and climate policy that supports the preconditions for growth.

When formulating a national energy and climate strategy, it is essential to take into account the special features of our country, which include a cold climate, long transport distances, extensive energy-intensive industry, as well as domestic raw material resources, especially forest biomass. Naturally, the fact that Finland is part of the regional, European and even global energy market, cannot be forgotten when drafting policy measures. The purpose of this

strategy is to also outline the premises for exerting influence in the Nordic, European and international context.

## **1.2 Energy and Climate Roadmap 2050**

The Energy and Climate Roadmap <sup>1</sup> that was prepared by the Parliamentary Committee on Energy and Climate Issues appointed by Prime Minister Katainen's government serves as a strategic-level guide on the journey towards a carbon-neutral society.

An extensive research project titled 'Low Carbon Finland 2050 platform'<sup>2</sup> completed in cooperation with a number of research institutes was used as essential background material for preparing the Roadmap. Among other things, this project created four scenarios for low-carbon development paths until 2050. The assumptions made in the scenarios, especially regarding the development and acceptability of carbon capture and storage technologies, development of nuclear power capacity and sustainability criteria for wood-based biomass, have a crucial impact on the possibilities of reducing emissions.

The roadmap analysed the means for constructing a low-carbon society and achieving an 80–95 % reduction in greenhouse gas emissions from the 1990 level in Finland by 2050. It discusses energy production and energy systems, use of energy, agriculture and forestry and carbon sinks, the waste sector and multidisciplinary measures that cut across several sectors. The Roadmap states that the measures Finland must take in any case in order to reduce greenhouse gases emissions by 80–95 % are related to renewable energy, energy efficiency and cleantech solutions.

According to the Roadmap, issues that are important for Finland when transitioning into a carbon-neutral society include safeguarding the security of supply of energy under all conditions, profitable and emission-free forest biomass use, carbon sink calculation rules, replacing fossil transport fuels with bio-based fuels and securing the competitiveness of society. The building of a carbon-neutral society requires actions on all levels, and efforts must be made to reduce greenhouse gas emissions in all sectors, even if their possibilities of doing so vary.

Rather than selecting or proposing a delineated pathway towards 2050, the Roadmap examines different alternatives and their impacts on the cost-effectiveness of reducing emissions and the competitiveness of Finnish society.

## **1.3 Climate Change Act**

The Climate Change Act (609/2015) that entered into force in June 2015 established a framework for the long-term and cost-effective planning and monitoring of climate policy in Finland with the aim of reducing anthropogenic emissions of greenhouse gases into the atmosphere, mitigating climate change, and adapting to climate change through national

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<sup>1</sup> Energy and Climate Roadmap 2050. Report of the Parliamentary Committee on Energy and Climate Issues, 16 October 2014

<sup>2</sup> Low Carbon Finland 2050 -platform. Energiajärjestelmien kehityspolut kohti vähähiilistä yhteiskuntaa. Antti Lehtilä, Tiina Koljonen et al. Espoo 2014. VTT Technology 165. 91 p. <http://www.lowcarbonplatform.fi/>

actions. The Climate Change Act is a goal-oriented framework act which applies to state authorities but does not contain substantive legislation on different sectors.

The act contains a provision on a climate change policy planning system that includes a medium-term climate change policy plan adopted by the Government once every government term as well as a long-term climate change policy plan adopted at least once every ten years and a national adaptation plan for climate change. An annual climate change report shall be prepared every year.

The climate change policy plans are coordinated and put together by different ministries: the Ministry of Economic Affairs and Employment is responsible for the long-term climate change policy plan, the Ministry of Agriculture and Forestry for the national adaptation plan for climate change, and the Ministry of the Environment for the medium-term climate change policy plan. Each branch of administration prepares the section relevant to its mandate for the ministry responsible for coordinating the plan.

The act sets as the long-term target reducing greenhouse gas emissions by a minimum of 80 per cent by 2050 compared to 1990 levels. The fact that this target is specified in an act provides the Government with a clear guideline for preparing plans compliant with the Climate Change Act and a reference point for evaluating the results of the monitoring exercise. The long-term emission reduction target applies to all greenhouse gas emissions, while the medium-term climate policy plan only concerns the non-ETS sector.

The formulation of the medium-term climate change policy plan must be coordinated with the Government's energy and transport policy planning as necessary. The plan specifies the measures needed to achieve the climate policy objectives in different administrative branches. The Government shall monitor plan implementation and make decisions on any additional measures that may be required, and the plan must be adjusted on this basis.

The act gives the Parliament and the public better possibilities for participating in and influencing the planning of the Finnish climate change policy. The Government shall submit a report to the Parliament on the climate change policy plans it has formulated, and the annual climate change report to be included in the Government's annual report keeps the Parliament informed of the achievement of climate targets and the effectiveness of the measures introduced.

The inclusion and access to information of the general public will contribute to broad-based and high-quality preparation of decisions and thus the acceptability of climate policy decisions. The appointment of a Climate Panel referred to in the Climate Change Act in its current form will promote dialogue between policy-making and scientific knowledge. The purposes of the Climate Change Act also include enhancing and coordinating the activities of state authorities in planning measures that are aimed at mitigation of climate change and at the monitoring of the implementation of these measures.

#### **1.4 International system of climate conventions**

The UN Framework Convention on Climate Change that entered into force in 1994 contains decisions on key climate policies. The objective of this convention is to bring the greenhouse gas concentrations in the atmosphere down to a harmless level. The Framework Convention does not contain quantitative obligations.

In the more specific Kyoto Protocol to the UN Framework Convention, which entered into force in 2005, industrial countries undertook to reduce their CO<sub>2</sub> emissions. The Kyoto Protocol is the first legally binding instrument that has managed to reduce emissions internationally. The first commitment period under the Kyoto Protocol covered the years 2008–2012. Finland ratified the Kyoto Protocol together with the other European Union Member States in 2002. During the first commitment period, Finland set the target at keeping emissions at the 1990 level in compliance with the Protocol's calculation rules, and this was achieved successfully. The second commitment period of the Kyoto Protocol spans the years 2013–2020; the threshold for its entry into force has not yet been attained.

The Paris Agreement adopted by the Meeting of the Parties to the UN Climate Convention in December 2015 enhances global climate measures. The agreement entered into force on 4 November 2016, and it concerns the post-2020 period. So far, the agreement has been signed by 192 and ratified by 111 Parties, whose share of global emissions is 61 %. The objective of the Paris Agreement is holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. Additionally, the agreement aims to increase the states' ability to adapt to the adverse impacts of climate change and to make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development. In order to achieve this target, the Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, and to undertake rapid reductions thereafter, so as to achieve a balance between anthropogenic emissions and removals by sinks of greenhouse gases in the second half of this century.

The Paris Agreement does not oblige the Parties to aim for certain emission targets; instead, the Parties give their pledge in the agreement to prepare, communicate and maintain successive targets (nationally determined contributions) that they intend to achieve. As a rule, the nationally determined contributions extend till 2025 or 2030; new or updated contributions will be communicated by 2020 and then every five years.

The joint nationally determined contribution of the EU and its Member States is based on a decision adopted by the European Council in 2014 to reduce the EU's internal greenhouse gas emissions by a minimum of 40 % from their 1990 levels by 2030. The joint nationally determined contribution of the EU and its Member States does not predict what the level of the final nationally determined contribution to be communicated by 2020 will be, how it will be allocated to different Member States, or how it is to be achieved.

The Paris Agreement contains a progression principle, according to which the climate measures (in other words, the nationally determined contributions) must become more stringent and/or expand over time. Each successive nationally determined contribution must reflect the Party's highest possible ambition. A Party may at any time adjust its existing nationally determined contribution with a view to enhancing its level of ambition. The states may engage in cooperative approaches that involve the use of internationally transferred mitigation outcomes or various mechanisms. Such cooperation must, however, promote sustainable development and ensure environmental integrity and transparency and ensure the avoidance of double counting.

Global stocktakes will be carried out every five years to evaluate progress towards the objectives of the Paris Agreement. The first stocktake will be undertaken in 2023, with an interim stocktake in 2018. The outcome of the global stocktake shall inform Parties in updating their nationally determined contributions. The objectives communicated by the Parties so far will limit the increase in temperature to 2.7–3 °C above pre-industrial levels.

While they represent a significant improvement compared to previous development pathways, they are thus not adequate to achieve the objectives of the Paris Agreement.

## **1.5 Energy Union**

The European Union's energy policy is today developed under the umbrella of the Energy Union. The European Commission issued a Communication on the Energy Union in February 2015, in which the Commission outlined future actions related to energy issues that are within the Union's competence. They include energy security, a fully integrated European energy market, energy efficiency, decarbonising the economy and R&D. The internal energy market (of electricity and gas) and energy security are key contents of the Communication. As the most important action of the Energy Union, the Commission specifies the implementation of the current EU energy legislation, especially that of the 3rd Internal Energy Market Package.

In the context of the internal energy market, the Commission announced new initiatives that concern the retail market, the 15 % electricity interconnection target, European projects of Common Interest (PCIs), the roles and obligations of EU level actors (ENTSO-E/G, ACER), development of network codes, regional cooperation between Member States, examination of the market impacts of capacity mechanisms and renewables support schemes as well as energy price trends.

The crisis in Ukraine has sparked debate on the EU's energy security, especially regarding gas, as was the case previously in the context of the Russia-Ukraine gas crises in 2006 and 2009. Problems in gas deliveries through Ukraine affect Eastern Central European countries, in particular. In order to improve energy security, the Commission issued a proposal for a Security of Gas Supply Regulation, a proposal for a decision on establishing an information exchange mechanism with regard to intergovernmental agreements and non-binding instruments between Member States and third countries (the IGA decision) and a new LNG strategy in February 2016. The Commission also continues developing alternative gas supply routes.

The implementation of the EU 2030 Climate and Energy Package objectives described in section 1.6 is a key part of the Energy Union. In order to implement the indicative common EU target of improving energy efficiency by 27 %, the Commission seeks to reform the regulation on this sector. The building and transport sectors, in particular, have potential for improving energy efficiency.

To implement the binding EU level target of a 27 % share of renewable energy, the Commission intends to issue a renewable energy package before the end of 2016, in connection of which the sustainability of using biomass for energy and biofuels will also be examined.

The target of reducing emissions by 40 % will be implemented through a review of the ETS Directive and an Effort Sharing Decision, for which the Commission issued a proposal in summer 2016. In addition, a decision will be made on the role of land use, land-use change and forestry (LULUCF) sector in the emission reduction targets.

Additionally, the Commission is developing a governance model that has also been discussed in the context of monitoring the targets of the 2030 package. A separate proposal on this model will be issued in late 2016. The Commission monitors progress made with the Energy Union's objectives in annual reports submitted to the Council and the Parliament. National energy and climate plans and progress reports, for which the Commission is preparing models



in cooperation with the Member States, will be key parts of the governance model. The first draft for a national plan must be produced in 2017, with a finished plan to follow in 2018. The plans shall span the years 2021–2030 and contain a description of energy and climate policy that covers the five dimensions of the Energy Union. In time, the Commission will review and comment on the draft national plans.

## **1.6 European Union energy and climate policy 2020 and 2030**

The climate and energy policy objectives and measures adopted in the European Union have an extremely strong steering effect on the preparation and implementation of Finland's climate and energy policy.

The European Council agreed upon a 2020 climate and energy package in 2007, and the Commission issued the relevant legislative proposals in 2008. The 20–20–20 targets contained in the package are a 20 % cut in emissions, obtaining 20 % of EU energy from renewables, and a 20 % improvement in energy efficiency.

The EU's greenhouse gas emissions will be reduced through a one-sided commitment by at least 20 % of the 1990 level by 2020. The emission reductions will mainly be implemented through the emissions trading system. The emission reduction targets in the non-ETS sector, or the so-called effort sharing sector, were allocated to the Member States based on their GDP within a range of  $\pm 20$  %. Finland's binding target is to cut emissions by 16 % in the non-ETS sector. The share of renewable energy sources in the EU is to be increased from 8.5 % of the final energy consumption in 2005 to 20 % in 2020. This target was shared between the Member States; Finland's binding target is 38 %. At the same time, the EU intends to improve energy efficiency and thus achieve a 20 % reduction in energy consumption by 2020 from what it would be with no new measures. The energy efficiency target is indicative rather than binding.

### The climate and energy package

The new 2030 climate and energy framework of January 2014 contains the Commission's proposals for climate and energy targets for the post-2020 period. The European Council made a decision on the package in October 2014. Its only target that is directly binding to the Member States concerns reducing emission in the non-ETS sectors. However, the EU wishes to continue promoting renewable energy use and improving energy efficiency after 2020. Common EU targets were thus agreed upon for these areas. A binding EU level target, or at least a 27 % share of renewable energy consumption by 2030, was set. An indicative EU level target of at least 27 % was set for improvement in energy efficiency by 2030. The target for reducing greenhouse gas emissions is set to at least 40 % (compared to 1990 level) by 2030. The target for reducing emissions is 43 % in the ETS sector and 30 % in the non-ETS sectors compared to 2005.

On Finland's initiative, special consideration was given to the potential for cutting emissions in the transport sector. The European Council requested that the Commission examine means for promoting the consumption of renewable transport fuels among other things. This is important in order to secure a market for advanced biofuels produced in Finland.

The target of reducing emissions by at least 40 % is in keeping with the target of not exceeding a temperature increase of 2 degrees and with the emissions reduction pathway in the low-carbon economy roadmap proposed by the Commission in 2011.

The European Council also adopted rather detailed policy guidelines for updating the ETS Directive and the Effort Sharing Decision. In summer 2015, the Commission issued its proposal for revising the EU emissions trading system based on the European Council policies. In summer 2016, proposals were issued for reducing emissions in the effort sharing sector and for including the land use, land use change and forestry sector (LULUCF) in the EU's climate targets for 2030.

Provisions on the EU **emissions trading system** are contained in the ETS Directive. The system has been operational since 2005, and it covers the Member States as well as Iceland, Liechtenstein and Norway. The system underwent a significant overhaul in connection with the adoption of the climate and energy package in 2009. The emissions trading system applies to large industrial plants and power plants with capacity in excess of 20 MW. Aviation has been part of the system since the beginning of 2012. The system covers slightly less than one half of the EU's CO<sub>2</sub> emissions. Since 2013, an EU-wide emission cap has been set for the ETS sectors. The emission cap will be reduced annually in a linear fashion, so that by 2020, a 21 % reduction in emissions will have been achieved in the emissions trading sector compared to 2005. In 2015, the inclusion of the so-called market stability reserve in the emissions trading system was approved to reduce the system's vulnerability to disruptions. The market stability reserve will be introduced in 2019.

The Commission's proposal for reviewing the ETS Directive will mean reforms, especially in the free allocation of emission allowances and combat against carbon leakage. In addition, the funding mechanisms contained in the emissions trading system will be updated and clarified. Negotiations on the proposal for the directive are likely to be completed in late 2017 at the earliest.

The EU **Effort Sharing Decision** specifies binding targets for reducing emissions in the non-ETS sectors, excluding the LULUCF sector and international shipping. Key sectors covered by the Effort Sharing Decision are transport, building-specific heating, agriculture, waste management and industrial gases.

The Effort Sharing Decision establishes binding emission reduction targets for each Member State in the non-ETS sectors. Finland must achieve a 16 % reduction in emissions compared to 2005 by 2020. In addition to the binding target for 2020, a trajectory for cutting emissions has also been established for the years 2013–2020. Under the decision, emissions must be reduced annually following a linear trajectory. The Effort Sharing Decision contains flexibility mechanisms to help Member States achieve the targets.

In summer 2016, the Commission published its proposal for a new Effort Sharing Regulation 2021–2030. This proposal adopts the same approach as the Effort Sharing Decision 2013–2020. A binding target for cutting their emissions by 2030 is set for the Member States, which must be achieved following a linear trajectory. Different flexibility mechanisms may be used to achieve the target.

According to the Commission's proposal, Finland should achieve a 39 % cut in its emissions by 2030 compared to 2005. The target to be established for Finland is the second most stringent in the EU, as the highest national target is 40 %. The proposal allows Finland a one-off flexibility to access allowances from the EU ETS sector amounting to 2 percentage points. Member States have to give a binding notification to the Commission of the amount of this flexibility they will use by the end of 2019.

The Commission also proposes that Finland could access credits from the LULUCF sector amounting to 1.3 percentage points annually compared to the emissions level of the baseline year. However, such stringent conditions have been set for utilising this mechanism that the possibilities of accessing it appear rather uncertain, unless the proposal can be amended during further processing. Both, access to one-off allowances in the ETS sector and the use of LULUCF credits are new flexibility mechanisms. In addition, the current flexibility mechanisms, including the banking, borrowing and trading of allowances between Member States are in use. Banking and borrowing allow Member States to use any surplus allowances in later years and borrow limited amounts of allowances from the following year. Buying and selling means that the Member States can trade in allowances.

The Commission's proposal for a regulation is based on emission reduction targets expressed in percentage points. A delegated regulation will be issued at a later date on the Member States emission quotas in tonnes. According to the proposal, average emissions in 2016–2018 would be used to determine the linear trajectory.

Negotiations on the Commission's proposal for an Effort Sharing Regulation began in autumn 2016. It is not likely that this process will be completed before the beginning of 2018 at the earliest.

The share of **renewable energy** in the EU's final energy consumption shall be at least 27 % in 2030. The Commission is currently preparing a post-2020 renewable energy package that will comprise a reviewed RES Directive (REDII) for 2020–2030 and the EU's bioenergy sustainability policy. The REDII proposal is likely to contain a provision that obliges the Member States to set a target for renewable energy for 2030. The national energy and climate plan required by the governance model would, among other things, specify policy measures for achieving the target. On the basis of the national targets submitted by the Member States, the Commission would assess whether the EU will achieve the binding 27 % target. The REDII Directive may contain a fill in procedure to ensure that the 27 % target will be reached at the EU level. This procedure may include an obligation placed on some Member States to increase their targets or to procure/buy renewable energy units/statistical transfers from another Member State.

Similarly to the 2020 package, the target for **energy efficiency** was defined with reference to the Commission's estimate of future energy consumption dating back to 2007. The Commission originally proposed a 30 % target for energy efficiency, but the European Council decreased it to 27 %. At the same time, however, it was agreed that the Council will review the energy efficiency target before 2020, keeping in mind the projected 30 % level. The Member States can set more stringent national targets. The Commission is currently also preparing a proposal for reviewing the Energy Efficiency Directive. Its main objective is to implement the energy efficiency target of the 2030 climate and energy framework. The Commission is likely to propose a binding energy efficiency target of 30 % at the EU level. The obligations and actions under the directive will also be extended to the period 2020–2030. Rather than proposing actual new actions, the Commission is expected to specify the existing ones.

EU level renewable energy and energy efficiency targets will also not be allocated to Member States as national targets in the future, and progress will be monitored through the new governance model. This will provide Member States with flexibility in achieving the climate and energy package targets. While the governance model will to a great extent be based on the current programmes, it will strive for better coordination of reporting and planning. Under the governance model, the Member States will prepare national plans and report to the

Commission on progress made with their implementation. It is vital that, as stated in the Basic Treaty, the Member States will have full freedom to choose their energy sources also in the future.

The Commission will issue further legislative proposals related to the 2030 climate and energy framework before the end of 2016. The Commission is expected to issue a so-called winter package that contains reviews of the Renewable Energy Sources Directive (RES), the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED) as well as a proposal concerning the sustainability of biomass energy use and a related governance model. The package will also contain proposals for developing the internal market for electricity.

The Commission organised a stakeholder consultation on cutting transport sector emissions in summer 2015 and published a communication on "A European Strategy for Low-Emission Mobility" (COM(2016) 501 final). This strategy is part of the Commission's so-called summer package, the other elements of which comprise the aforementioned proposals for an Effort Sharing Regulation between the EU Member States and the LULUCF Regulation.

### **1.7 Energy targets of Prime Minister Sipilä's Government**

The strategic objectives of Prime Minister Sipilä's Government Programme, 'Finland, a Land of Solutions', includes bio economy and clean solutions. Five key projects fall under this heading, of which the one titled 'Towards carbon-free, clean and renewable energy cost-efficiently' contains the Government's energy and climate policies.

The energy policies of the key project 'Towards carbon-free, clean and renewable energy cost-efficiently' are as follows:

- The use of renewable energy will be increased in a sustainable way so that its share will rise to more than 50 per cent during the 2020s and the self-sufficiency in renewable energy to more than 55 per cent. This will be based, in particular, on the growth in the supply of bioenergy and other emission-free renewable energy. The greatest opportunities will be achieved in increasing the production and technology of liquid biofuels and biogas.
- Aid for lowering the costs of the increase in renewable energy that is compatible with the EU guidelines will be based on technology neutrality and ranking of economic priorities.
- Meeting the sustainability criteria for biomass and fair burden sharing in the EU and international climate negotiations will be secured.
- A compensation system for the indirect impacts of emissions trading on electricity prices will be introduced and financed by means of the revenue from emissions trading.
- Coal will no longer be used in energy production and the use of imported oil for the domestic needs will be cut by half during the 2020s.
- The share of renewable transport fuels will be raised to 40 per cent by 2030.

- Industrial activities in the sector and their exports will be supported in the financing of both innovation and exports.
- The public sector will be encouraged to introduce carbon-neutral energy solutions.
- Incentives will be provided for replacing imported oil in heating by emission-free, renewable alternatives.
- Use of horse manure in energy production must be allowed.
- The introduction of new technologies will be promoted by pilot projects in the cleantech sector.

Additional targets for the government term are that Finland has achieved the 2020 climate objectives already during the government term and that the adoption of low-emission energy sources will be encouraged through taxation.

The Government’s Ministerial working group on bioeconomy and clean solutions has specified three of the energy policies contained in the Government Programme as follows:

Government Programme wording	Specification
<p>“The use of renewable energy will be increased in a sustainable way so that its share will rise to more than 50 per cent during the 2020s and the self-sufficiency in renewable energy to more than 55 per cent.”</p>	<p>The share of renewable energy will be calculated based on the final energy consumption, similarly to the target for 2020 under the Renewable Energy Directive (2009/28/EC).</p> <p>The self-sufficiency target will also be calculated in terms of final energy consumption. In addition to renewable energy, peat, wastes and recycled fuels as well as reaction heat from the industry will be taken into consideration. Energy produced from imported chips will not be included in self-sufficiency of energy supply calculations.</p>
<p>“The share of renewable transport fuels will be raised to 40 per cent by 2030.”</p>	<p>The target for renewable transport fuels will be defined as stated in the Act on the promotion of the use of biofuels for transport (446/2007), however including electricity used for transport as referred to in the Renewable Energy Directive (2009/28/EC) and hydrogen produced from renewable energy sources in the target.</p> <ul style="list-style-type: none"> <li>• Renewable fuels mean biofuels, in other words liquid or gaseous fuels used in transport produced from biomass. The share of electricity will be calculated as stated in the</li> </ul>

	<p>aforementioned directive.</p> <ul style="list-style-type: none"> <li>• Biofuels produced from wastes or residues, or non-food cellulose or lignocellulose, will qualify for double credits towards meeting the target.</li> <li>• Their share will be calculated as a proportion of the total amount of motor petrol, diesel oil and biofuels delivered for distribution in Finland and the electricity used in road and rail transport.</li> </ul>
<p>“The use of imported oil for the domestic needs will be cut by half during the 2020s.”</p>	<p>The use of imported oil for the domestic needs refers to the total energy amount of fossil motor petrol, diesel, jet fuel, kerosine and heavy fuel oil delivered for consumption in Finland. Bunkering for the needs of international shipping and air traffic will not be included in this volume. Such products as bitumen, lubricants, refinery gases, liquid gas and petrol coke will also not be included.</p> <p>The reference year for reducing the use of imported oil will be 2005, or the year referred to in the Renewable Energy Directive (2009/28/EC) and the EU Effort Sharing Decision (406/2009/EC).</p>

## **2 Adequacy of current measures for reaching the targets**

A key tool in the strategy work was scenario calculations used to assess the future development of both greenhouse gases and energy production and consumption. Rather than predictions, the scenarios are projections extending into the future that are based on selected initial assumptions. Scenarios were prepared for both current policy measures (the so-called basic scenario) and the new measures outlined in the strategy (the so-called policy scenario).

The basic scenario is used to assess whether the measures on which decisions have already been made are sufficient to achieve the set energy and climate targets, or whether additional policy measures will be needed. By examining the scenarios, the scope of the required additional measures can be estimated, and the impacts of any new measures on other energy and climate targets can be determined.

The basic scenario includes energy and climate policy measures on which decisions were made before spring 2016. The most significant new measures since the Energy and Climate Strategy 2013 was completed are the new energy efficiency requirements of renovations as well as restrictions on landfilling biodegradable waste. Other key measures include the promotion of renewable energy use by means of taxation and other incentives, emissions trading, the obligation to distribute transport biofuels, energy efficiency agreement and audit activities, energy regulations applicable to new buildings, promotion of vehicle energy efficiency, promotion of public transport and a modal shift in transport, as well as the Rural Development Programme for Mainland Finland.

### **2.1 EU 2020 targets**

The Government's objective is to achieve the 2020 targets set for Finland by the EU before the end of the government term.

The share of renewable energy in final energy consumption has increased ahead of the target, and the minimum target of 38 % was already exceeded for the first time in 2014. The trend also looks positive in the future, and the share of renewables is expected to clearly exceed 40 % before the government term ends.

While the binding renewable energy target for the transport sector set by the EU is 10 %, Finland has decided on a higher national target of 20% by 2020. An obligation to distribute biofuels applies to sellers of road transport fuels, ensuring that this target will be met. The 10 % target was reached in 2014.

Linear trajectories have been established for the EU Member States concerning non-ETS greenhouse gas emissions for 2013–2020, which should not be exceeded. The binding target set for Finland is to reduce emissions by 16 % from their 2005 levels by 2020. In the first three years of this period, Finland's annual emissions have been below the targeted trajectory volumes. Warm weather and the country's poor economic standing have contributed to the low emissions. While the trend of decreasing emissions continues in the basic scenario, volumes below the trajectory cannot necessarily be achieved towards the end of the period without resorting to the so-called flexibility mechanisms. Taking the entire period in consideration, however, the basic scenario indicates that Finland could meet its obligations under the Effort Sharing Decision by means of domestic emissions cutting measures and by banking and borrowing allowances.

## **2.2 Reduction of greenhouse gas emissions by 2030**

Under the proposal issued by the Commission in July 2016, Finland's target in the effort-sharing sector is a 39 % reduction in emissions by 2030 compared to 2005.

In the basic scenario, greenhouse gas emissions in the non-ETS sector will keep declining throughout the 2020s, and in 2030, they will be some 8 % lower than in 2020 and 22 % lower than in 2005. The greatest reductions will concern fluorinated greenhouse gases, or F gases, which will be cut by 46 % over a decade. Methane emissions will be reduced by 15 %, non-ETS CO<sub>2</sub> emissions by 5 %, and nitrous oxide emissions by 2 %. The emissions trend in the basic scenario is nowhere near sufficient to achieve Finland's binding target for 2030.

In order to reach a 39 % reduction compared to emission levels in 2005, a reduction of some 6 Mt CO<sub>2</sub> eqv. would be required in addition to the emissions trend indicated in the basic scenario. Emission trends in the transport sector will play a key role for meeting the target, as over one third of the ETS sector emissions are today caused by the transport sector. In addition to increasing its emission cutting actions, a Member State may use so-called flexibility mechanisms, which include one-off flexibilities and purchasing allowances from other Member States, in order to achieve the set target.

## **2.3 Increasing renewable energy use**

In the basic scenario, the absolute volume of renewable energy will continue increasing beyond 2020. The greatest increase will be seen in the use of forest chips and waste liquors from forestry. Positive development in the forestry sector, including new investments, will increase the supply of sidestreams and forest chips. Heat pumps will also continue to increase in popularity. The increase in wind power production will slow down significantly compared to the development in the 2010s, as no aid for production will be available for new power stations. While the volume of solar electricity will increase many-fold, its annual production volumes in the basic scenario will remain below one TWh.

The increase in the final energy consumption will be curbed and remain at 315 TWh in the basic scenario. The share of renewable energy in the final energy consumption will thus grow further, albeit more slowly than in 2010–2015. The share of renewable energy in the basic scenario will be 42 % in 2020 and 47 % in 2030. This share will be 3 percentage points less than the Government's target for the late 2020s. A precondition for achieving this target is increasing the final renewable energy consumption by about 10 TWh while the total consumption remains unchanged. Similarly, a reduction in the final consumption of non-renewable energy by 20 TWh would also result in a 50 % share of renewable energy.

## **2.4 Increasing renewable energy use in transport**

In the basic scenario, it is presumed that the obligation to supply a minimum of 20 % biofuels will continue to apply to road transport fuel distributors throughout the 2020s. This figure includes double credits for advanced biofuels. Pursuant to the directive concerning biofuels' impact of indirect land-use change (the ILUC Directive), first-generation biofuels are eligible for credit up to no more than 7 % of the total fuel volume. In the basic scenario, the physical share of biofuels in the energy content of diesel oil and petrol thus is a maximum of 13.5 % in total. In 2030, the electricity consumption of electric vehicles will be 0.35 TWh and that of rail transport 0.75 TWh in the basic scenario. 42 % of the procured electricity will be produced from renewable energy sources in Finland.



When calculated as specified in the ILUC Directive, the use of renewable energy in transport will remain at 22 % in the 2020s according to the basic scenario, which only is slightly over one half of the 40 % target stated in the Government Programme.

## **2.5 Increasing energy self-sufficiency**

The increase in renewable energy use will improve Finland's self-sufficiency regarding energy supply. The self-sufficiency rate will be 4 to 5 percentage points higher than the share of renewable energy. The self-sufficiency rate in the basic scenario, as it is defined in Chapter 1, will be 51 % in 2030, or 4 percentage points less than the Government target.

## **2.6 Halving the use of imported oil for energy**

The phasing out of oil, which started in the early 2000s, will continue. The greatest volumes of oil products are used in transport, working machinery and the heating of buildings. In the basic scenario, the consumption of diesel oil, petrol, light and heavy fuel oil as well as jet fuel and aviation gasoline will total 68 TWh in 2020 and 62 TWh in 2030. The biocomponent in diesel oil and petrol will amount to 13.5 % of the energy volume, or about 5.5 TWh, throughout the 2020s. The volume of fossil oil will be 57 TWh in the basic scenario in 2030, exceeding the target for halving the use of imported oil, or 44 TWh, by over 12 TWh.

## **2.7 Phasing out coal in energy production**

In recent years, the volume of coal use has varied considerably from year to year, mainly depending on the demand for condensing power. The use of coal has declined in recent years, and some coal-fired power plants have been decommissioned. In the basic scenario, the use of coal will continue to decline significantly, even though it may not be phased out completely on market terms. Only one condensing power plant is expected to remain in operation in 2030. In combined heat and power production, coal would still be used to some extent, as it is a more competitive fuel than natural gas. In building-specific heat production, coal is used little. According to the basic scenario, coal use will account for 3–7 TWh of power and heat production in 2030, depending on the volume of condensing power production. The volume of condensing power production will be determined by the situation in the Nordic electricity market. Condensing and CHP plants are usually operational in winter as the demand for electricity peaks, and they are thus important from the perspective of the adequacy of power supply.

### 3 Energy and climate strategy policies

#### 3.1 Increasing renewable energy use and self-sufficiency in energy supply

Policies:

- Renewable energy use will be increased to account for over 50 % of the final energy consumption in the 2020s. The long-term goal is for the energy system to become carbon neutral and be heavily based on renewable energy sources. Policy measures looking to 2030 take into account not only cost-effectiveness but also longer term needs to change the energy system.
- The use of agricultural, societal and industrial waste and sidestreams in the production of heat and electricity as well as transport fuels will be promoted. This will also reduce environmental stress, promote a circular economy, and create reference sites for clean bioeconomy and circular economy solutions.
- Decentralised electricity and heat production based on renewable energy will be promoted. An effort will be made to increase decentralised small-scale production, mainly on market terms and through the current economic incentives. The interest of citizens, companies and the public sector in utilising renewable sources in the energy solutions of individual buildings will be encouraged through guidance by information and local reference sites. Changes in financial incentives for decentralised production, including investment aids, will be implemented with moderation and over a sufficiently long time interval, taking the reduction in the costs of decentralised production into account.
- Renewable energy investment subsidies will primarily be targeted at the commercialisation of new technologies and to the non-ETS sector, including plants producing advanced biofuels for transport, wider use of alternative transport power sources, and building-specific or other non-ETS electricity and heat production of companies and farms. The objective is that aid for different technologies will be phased out as a technology develops, the costs are reduced and competitiveness improves.
- Additional measures taken to increase the volume of renewable energy and improve energy efficiency will bring Finland's self-sufficiency in energy up to 55 % of final energy consumption by the end of the 2020s.

Global efforts to reduce greenhouse gas emissions will create demand for clean energy production and consumption solutions. In measures that promote renewable energy use, attention should also be paid to the creation of references and a domestic market for solutions based on renewable energy, resource efficiency and a flexible energy system, which are growing global sectors.

Forest biomass will be crucial for Finland as a raw material for renewable energy. The objective is that the majority of 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 not suitable as raw material for wood processing, or for which there is not enough

demand in this field. By means of different policy measures, this forest biomass will be channelled to replace imported fossil fuels in heating, CHP production and transport. The biomass must be sustainably produced, and its energy use must also meet any sustainability criteria set by the European Union.

The degree of self-sufficiency will be calculated in terms of final energy consumption. In addition to renewable energy, peat, wastes and recycled fuels as well as reaction heat from the industry will be taken into consideration. According to this definition, nuclear power produced in Finland is not included in the self-sufficiency target, unlike in international energy statistics.

### **3.2 Halving the use of imported oil for energy**

Policies:

- The main part of emission reduction measures in the ETS sector will comprise actions in the transport sector. These actions will directly reduce the energy use of oil. The proposed measures associated with building-specific heating and machinery will also reduce the use of oil for energy. These measures will halve the use of imported mineral-based oil for energy by the end of the 2020s compared to the reference level of 2005.

The use of imported oil for domestic needs refers to the total energy content in fossil motor petrol, diesel, jet fuel, kerosine and heavy fuel oil delivered for consumption in Finland. Bunkering for the needs of international shipping and air traffic is not included in these calculations. Such products as bitumen, lubricants, refinery gases, liquid gas and petrol coke are also not included. The reference year for reducing the use of imported oil is 2005, or the year referred to in the Renewable Energy Directive (2009/28/EC) and the EU Effort Sharing Decision (406/2009/EC).

### **3.3 Phasing out coal in energy production**

Policies:

- Finland will phase out the use of coal for energy by 2030. An effort will be made to strengthen EU steering instruments that reduce CO<sub>2</sub> emissions from energy production. In addition to the EU emissions trading system, coal use will be regulated by means of tax and aid schemes to ensure that domestic fuels will maintain their competitiveness in the combined production of electricity and district heat compared to coal.
- The starting point for the energy taxation of heat production will be the current consistent tax system. Any tax increases should emphasise the tax component based on CO<sub>2</sub> content.
- No new power plants can be built, or replacement investments made, that will be based on burning hard or brown coal. Once the existing plants based on pulverised fuel combustion have been decommissioned, coal will only be used as a backup fuel in exceptional situations.
- During the current government term, a proposal will be prepared for an act on the transition period following which the use of coal for energy will be phased out by

2030, taking into account aspects related to the continuity and security of energy supply and emergencies.

There has been a declining trend in the use of coal for energy for over 10 years, and the calculations of the basic scenario indicate that this trend will continue. In 2030, the share of coal is estimated to be some 1–2 % of the total energy consumption. In addition to the EU emissions trading system, this trend can be reinforced within the framework of the current tax system by focusing any increases in taxes related to heat production on the CO<sub>2</sub> component.

Coal will remain necessary as a fuel over the next few years, especially in combined heat and power (CHP) production. As it is easy to store and low in price coal may also be needed over a longer term to ensure security of supply. The production of forest chips, for example, depends on the wood market, and peat production especially on weather conditions. By using coal, security of supply can be safeguarded in situations where domestic fuels are not available in adequate quantities. When drafting new legislation, any questions of compensation for plant investments made by companies will be taken into account.

### **3.4 Wood-based energy**

Policies:

- Energy taxation will provide an incentive for the primary use of forest chips and forest industry by-products in CHP production and building-specific heat production.
- When preparing for the EU programming period that starts in 2021, a review of the forestry sector incentive system will be conducted. As part of this exercise, the need for aid in the forestry sector after 2020 will also be assessed from the perspective of renewable energy targets.
- Taxation will be used to ensure that peat, while not being more competitive than forest chips or forest-industry by-products, will be more cost-effective than coal and other imported fossil fuels. The taxation of peat is a key steering instrument, especially in separate heat production.
- In addition to peat prices and taxation, the price of emission allowances will be a key factor influencing the respective competitiveness of fuels. 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. In the current situation, an aid scheme will be needed for the use of forest chips in CHP production.
- The operating aid scheme for forest chip electricity will promote the cost-effective use of forest chips and strengthen the forest chip delivery chain. The scheme will remain unchanged until the Commission's valid state aid approval expires. The necessity for and development of the aid scheme will be reviewed in 2018.
- The increased domestic production of advanced transport biofuels will also increase the use of forest industry by-products and forest chips. When developing policies, the availability of forest biomass and the value added in different uses will be taken into account.
- The volume and share of imported chip use will be monitored regularly. In terms of forest chip use as well as entrepreneurship and employment in its production chain,

the decisions to use either domestic or imported chips will essentially be made by the power companies.

- Energy produced from imported chips will not be included in the calculation of energy supply self-sufficiency.

The dispatching of peat, coal, natural gas and biomass (forest industry sidestreams, forest chips, sawdust, bark and other biomass) in energy production will be influenced by the prices of these fuels, taxes on fossil fuels and peat and the price of emission allowances.

At the current price levels of emission allowances, peat is competitive compared to coal. A significant increase in the tax rate on peat could undermine its competitiveness compared to coal, especially in coastal CHP plants.

In the production of building-specific heat, the price of emission allowances has a major impact on the competitiveness of forest chips. Forest chips are not competitive in this production type at the current tax rates on peat, current market prices of fuels and today's low emission allowance price. However, the prices of fuels and peat vary by region and by plant.

In non-ETS, building-specific heat production, peat is highly competitive. As a rule, forest chips cannot compete with peat in these applications, and sawdust and bark are also not necessarily competitive at the current tax rate on peat.

The competitiveness of forest chips compared to peat in CHP production will be ensured by an aid scheme for forest chip electricity production. The scheme will support electricity produced from fuel chips and hog fuel made from wood obtained directly from the forest. The aid level will be determined to ensure that forest chips will be more competitive than peat in CHP production. The aid level will change as indicated by the emission allowance price and the tax rate on peat. The objective of the aid scheme for forest chip electricity production will be not only increasing forest chip use in energy production but also ensuring that forest chip fractions that are more expensive to harvest will be collected and used.

Under the Commission's valid state aid approval, new plants can be approved for the aid scheme until the beginning of 2021. In the aid scheme for forest chip electricity production, the aid levels will be automatically reduced if the emission allowance price goes up clearly from its current level. The tax rate on peat will also have an essential impact on the aid level. If the emission allowance price is expected to remain low in the 2020s, the possibility of extending the validity of the aid scheme should be investigated. In that case, Finland must be prepared to make changes in the aid scheme in view of, in particular, the EU's State aid and bioenergy regulation in the post-2020 period.

Due to new forestry investments, the use of wood will increase significantly in Finland over the next few years. The operating aid scheme must not have the effect of channelling raw material suitable for the forestry sector and other wood processing industry to energy production. From 2019 on, this aid will be reduced by 40 % if forest chips are made from logs or pulpwood that would be suitable for industrial raw material.

Part of the aid for forest chip electricity production is targeted at energy produced with imported raw materials. In 2015, for example, 300,000 solid cubic metres of forest chips were imported, of which 80 % were used for CHP production and 20 % for building-specific heating. The aid paid to forest chip electricity in 2015 amounted to EUR 33 million, and an

estimated 5 % (EUR 1.65million) of this sum was granted to electricity produced from imported chips. Under EU legislation and WTO rules, the treatment of domestic and imported commodities must be non-discriminatory. However, it is justified to regularly monitor the volume of imported forest chips in the Finnish market. Electricity produced from these chips should not be included in domestic production when examining self-sufficiency.

The situation in the wood market, or the volume of regeneration cutting, thinning and forest management operations, has an essential impact on the availability of forest chips. The objective of the Government Programme and Finland's National Forest Strategy 2025 is to promote the availability of timber by diverse means. An effort has been made to encourage private forest owners to carry out forest management operations, including the management of seedling stands and young forests, by means of a financing system for sustainable forestry (Kemera). This has contributed to the availability of small-diameter energy wood, in particular. The current sustainable forestry financing system will be valid until 2020. When assessing the need to update the financing system, the requirement for forestry aids will be investigated, including support for managing young forests, also from the perspective of the post-2020 renewable energy targets.

### **3.5 Biogas production and use**

Policies:

- The production and use of biogas will increase, and growing Finnish business will emerge around it.
- Finland will influence the drafting of EU legislation and State aid rules in the EU's post-2020 programming period by promoting solutions that support biogas.
- National provisions and permit procedures will be clarified to promote the production and use of biogas.
- Support for biogas plants will continue to be available at least at the current levels as part of the aid schemes of the Ministry of Economic Affairs and Employment and the Ministry of Agriculture and Forestry.
- The wider use of gas-powered vehicles and machinery will be promoted.
- A better utilisation of the biogas potential of agricultural biomasses will be promoted.

The production and utilisation of biogas in Finland have typically grown by a few percentage points annually. The largest quantities of biogas are produced by plants built in connection with landfills, with joint digestion plants in the second and urban wastewater treatment plants in the third place. At the moment, biogas is mostly used for producing heat and electricity. While the biogas volumes used in transport are clearly lower, there has been a rapid increase in this area in recent years.

The majority of the biogas potential is associated with agricultural production. There has been wide interest in increasing biogas production on farms or from agricultural biomasses for some time.

While farms have plenty of biomasses suitable for biogas production, they have so far only been utilised to a minor extent, as yield/cost analyses have been unable to identify adequate

numbers of cost-effective applications. In addition, profitable concepts for costly plants have been hard to find. Achieving profitability is particularly difficult if costs are incurred for the raw material.

Typically, biogas production on farms has advantages that are not directly associated with energy economy, including more efficient nutrient recycling, cutting greenhouse gas emissions, improved hygiene and reduced odour nuisances. Circular economy related benefits are often in a key role.

The outlook for biogas use is the most promising in the transport sector and as fuel for machinery. A significant expansion of the distribution network of compressed gas (methane) is being planned. As a result, this network would go a long way towards meeting the EU requirements concerning a distribution network of alternative fuels. The biogas distribution network could also be complemented with small refuelling stations that could be established in connection with farms or biogas plants, for example, or on main routes.

The share of biogas in all gas used to refuel vehicles was some 40 % in 2015. At the beginning of 2016, there were some 2,200 vehicles powered by compressed gas in Finland. It is estimated that there will be some 3,600 gas-fuelled vehicles in 2020 and some 13,100 in 2030. Shipping may also offer completely new possibilities for using biogas, as international restrictions on sulphur and nitrogen emissions in this sector will accelerate the introduction of liquid methane in ships.

Biogas production is already supported in many ways today: by a tax exemption, a feed-in tariff for electricity produced from biogas, energy aid provided by the Ministry of Economic Affairs and Employment and business aid and farm investment subsidies granted by the Ministry of Agriculture and Forestry. Additional measures for promoting the production and use of biogas may consist of diverse elements. Biogas investments may be encouraged by developing national legislation and streamlining permit procedures. Influencing EU level measures and State aid guidelines is one way of promoting this end. These measures and rules, on the other hand, will determine the possibilities of influencing the trends of biogas production and use by direct changes in aid measures.

### **3.6 Support for electricity and heat production from renewable energy sources**

Policies:

- The preconditions for increasing renewable energy use and transitioning into a fully emission-free and carbon-neutral energy system over the long term include providing incentives for developing expertise and increasingly efficient solutions. It is justified to ensure that the national market offers an incentive to develop wind power and solar electricity projects among others, as investments associated with these energy forms are increasing strongly in the global context.
- The utilisation of the renewable energy potential in Finland for industrial-scale electricity production is one of the key questions in terms of long-term energy and climate objectives. The feed-in tariff system of wind power in its current form will be phased out as agreed. Instead, the aim will be at implementing future projects on commercial terms. To provide a transition period solution and to maintain Finnish project expertise, technology-neutral competitive tendering processes will be necessary, which means that aid for producing electricity will only be paid to the most cost-effective and competitive investments in renewable electricity production. The

objective is to increase the production capacity of renewable electricity in the early 2020s, taking the electricity system's development needs into account. In 2018–2020, production capacity totalling 2 TWh will be put out to tender. Consequently, those among a large number of potential projects that are the most inexpensive and that can be implemented optimally from the perspective of the public economy can be selected. The model for operating aid and the associated tendering process will be specified in greater detail as the government proposal on this issue is drafted. In the drafting and implementation of the operating aid scheme, societal impacts will be carefully considered, including impacts on businesses, the environment and human health. The Ministry of Economic Affairs and Employment will commission an independent and comprehensive report on the negative health and environmental impacts of wind power before the act on the operating aid scheme is drafted.

- The possibility of including small-scale CHP production projects relying on forest energy in the operating aid scheme will be investigated separately, taking into consideration the wood and fuel markets and the possibility of utilising sawdust and bark and ensuring that emissions in the effort sharing sector are not increased.
- Investment subsidies will be continued. Discretionary investment subsidies are particularly suitable for experimental projects related to new energy technologies. Many solutions in this sector will play a key role as electricity production increasingly relies on new energy sources, and the share of variable electricity generation grows. In addition, investment subsidies will also be necessary in the future for promoting minor industrial scale electricity production projects.
- In the sphere of small-scale electricity production, the current financial steering instruments will be preserved, including the electricity taxation model where annual production of less than 800 MWh for household use is exempt from electricity tax, and domestic help tax credit is available for the installation work.
- Granting investment support for investments in companies' small-scale production will continue to be justified in order to promote the development of the domestic market. The aid levels will be reduced with improving cost-effectiveness, and investment support will be phased out as projects are launched on commercial terms.
- The introduction of a system of centralised information exchange in the retail market for electricity in 2019 will enable new services and practices associated with electricity supply. As the centralised information exchange system is set up, the possibility of utilising small-scale production for units located in the same building more flexibly will be investigated.
- An increase in the share of renewable and low-emission district heating production will be promoted by means of energy taxation and operating aid for forest chip electricity. New technology investments that produce district heating from renewable energy sources will be supported if the risks and costs associated with the technology are high. Aid for non-ETS heat production investments of companies and farms in which renewable energy is utilised can be continued. The goal is phasing out support for conventional technologies.
- Small-scale electricity production and decentralised heat production in rural areas will be promoted by agricultural investment subsidies and business support under the Rural Development Programme for Mainland Finland.



- Considering the climatic conditions in Finland, an effort should be made to avoid negative impacts at the energy system level, including sharper spikes in electricity consumption in winter, when striving to increase the production of decentralised renewable energy. Both in building-specific heating and heat production for district heating networks, combinations of different forms of renewable energy production will be promoted that will cost-effectively complement each other in different seasons. Public support should not undermine the operating preconditions of the district heating infrastructure. Guidance by information aiming to increase the use of small-scale renewable energy in decentralised electricity production and heating (including solar power and heat solutions) will be enhanced by adequate financial resources to ensure that neutral and correct information is readily available.

The emissions trading system and the electricity market do not currently provide a sufficient incentive to invest in renewable energy. It is thus necessary to encourage the development and commercialisation of renewable energy production technologies, also by aid schemes. It has been estimated that this will create cost savings for the national economy over the long term.

The operating aid scheme for wind power stations (feed-in tariff system) in Finland has promoted the development of more cost-effective solutions and provided a strong incentive for project development. The estimated capacity of wind power projects with a completed permit process corresponds with approx. 6 TWh of annual production.

In order for Finland to bring the share of renewable energy up to 50 % in the 2020s and achieve a fully carbon-neutral energy system by 2050, active policy measures will be already required in the next few years to ensure that expertise will be available and development related to wind power projects, in particular, will continue, and that the most cost-effective projects waiting for an investment decision will be implemented. For this reason, it is necessary to introduce a operating aid scheme for renewable energy, with a tendering process to guarantee cost-effectiveness.

In addition to wind power projects, investment projects relying on other renewable energy sources could also participate in technology neutral tendering processes. The inclusion of small-scale CHP projects utilising forest energy in the operating aid scheme will need to be investigated separately. This investigation would take into consideration such aspects as the wood and fuel markets, the possibility of using sawdust and bark, and ensuring that emissions in the effort sharing sector are not increased.

The operating aid scheme would be a transition period solution, and the tendering processes would take place in 2018–2020. The projects selected for the scheme in the tendering processes would become productive in the early 2020s. At that time, the need for the aid scheme would be reassessed. The EU’s Renewable Energy Directive for the post-2020 period is in the process of being reviewed. The European Commission’s State aid guidelines for the post-2020 period are also being updated. While the Commission’s plans as to the contents of these guidelines have not been confirmed, it is necessary to prepare for changes that could be significant compared to the current situation.

Experimental projects related to new energy technologies (including the storage of energy, integration of variable generation in the electricity system and offshore wind power in Arctic conditions), in which new solutions are tested for the first time in the Finnish conditions, are often associated with significant technological and financial risks. However, taking such risks is essential to enable the later utilisation of new innovative solutions in industrial scale production and to renew the energy system towards achieving carbon neutrality.

Investment subsidies are best suited for promoting experimental projects related to new energy technologies. It will thus be necessary to continue the aid scheme for key energy projects in 2016–2018.

The greatest potential for small-scale production of solar power, in particular, is found in residential properties. Industrial, office, farm and different public sector buildings (including schools and hospitals) also have considerable potential for increasing solar electricity generation.

Solar electricity is the most cost-effective on sites where it replaces electricity purchased from the grid. Potential for small-scale wind power is associated especially with off-grid and particularly windy sites. However, with the current investment costs and low market price of electricity, the technical and economic potential of wind power is low.

The potential of small-scale hydroelectricity production is mostly based on projects aiming to modernise and improve the efficiency of disused and currently operational power plants. In agriculture, the potential lies especially in utilising biomass-based sidestreams of agriculture for CHP production and solar power. In the case of production forms based on biomass, however, it should be ensured that the energy is utilised where this can be done with the highest cost-efficiency. In particular, this means transport fuels and heat and electricity production to cover on-site consumption.

A new aid scheme for electricity production would be an excessively cumbersome procedure for minor industrial scale solar power, hydroelectric power and other renewable electricity projects, mainly because of the tendering process. Energy aid continues to be needed to promote projects of this type. The energy aid system has been in use for a long period, and it has been used to flexibly target investment subsidies to companies' energy efficiency and renewable energy products.

Decentralised energy production in rural areas can be promoted by funding under the Rural Development Programme for Mainland Finland 2014–2020 (the Rural Development Programme) for the investments of farms and rural SMEs as well as for more extensive rural innovation and development projects. For the part of energy production, the purpose of the aid is to promote the production of renewable energy on farms for their own consumption and to encourage enterprising related to renewable energy in rural areas.

As regards small-scale production, the procurement costs of solar power, in particular, have decreased significantly, and this trend is set to continue. The production of solar power may become profitable on market terms as soon as in the next few years. Before this, it will be important to preserve the current measures, or tax exemption of small-scale production, investment support, and domestic help credit for labour costs to ensure that the market and the installed capacity will continue growing.

The number of companies supplying equipment for small-scale production has gone up significantly in recent years, which has increased competition, improved the efficiency of operations and brought prices down. Significant non-economic factors can also be seen in the background of small-scale production and the increase of solar power production in particular. The deployment and better visibility of solar panels have speeded up the increase in the number of these systems in the relevant areas. Easy access to up-to-date, neutral and correct information must be ensured by means of the current steering instruments and guidance by information.

District heating is today the most common type of heating in Finland, available in almost all cities and urban centres. Approximately one half of the heating needs of residential and service buildings are met with district heating. The distribution of fuels used to produce district heating varies significantly from location to location. The emissions and renewability of district heating depend on how it is produced. The majority of district heating production is based on fossil fuels (in 2015, the share of natural gas was 20.3 % and the share of coal 21.4 %) and peat (15 % in 2015).

The target of the district heating sector, or reducing CO<sub>2</sub> emissions and increasing the share of renewable energy forms, will mainly be reached by increasing the share of wood-based fuels (32.6 % in 2015). In the future, new energy sources for district heating may also be introduced, including large heat pumps, low-grade residual heat, solar heat and industrial residual heat. Production modes that are completely new in Finland, including geothermal energy, may bring new possibilities for increasing the share of renewable energy in district heating production.

In the area of increasing decentralised renewable heat production, potential is offered by sites where direct electric heating and oil heating are used. Heating systems based on direct electric heating and oil or gas heating account for slightly more than 40 % of the built-up area.

Competition in the heating market is tougher and especially geothermal heat and various hybrid systems have become more common. Geothermal heat, in particular, has emerged as the greatest challenger to district heating in recent years. A significant proportion of changes in the heating method are carried out when a building is being renovated or investments are needed in the current system.

Wood heating is mostly used in rural municipalities and urban centres. The use of wood in heating low-rise buildings has remained more or less unchanged. While electric heating as the main heating system remains a popular choice in low-rise buildings, in newly constructed low-rise buildings it is selected as the heating method less often.

Solar heat is suitable for a complementary heating system in addition to the main system, as the energy obtained from the sun is mainly available in summer, and the system cannot produce the required amount of heat in wintertime. Solar heat is highly suitable for heating domestic water, the need for which does not vary significantly with the seasons. In low-rise buildings, in particular, the choice of heating method is increasingly influenced by other reasons besides the investment costs, including environmental questions, the impact of the heating system on the value of the property, or uncertainty concerning the price trends of centralised heat production.

### **3.7 Reducing greenhouse gas emissions**

Reducing greenhouse gas emissions in the effort sharing sector

The starting point for estimating the need to cut emissions in the effort sharing sector was the European Commission's effort sharing proposal. For Finland, this means achieving an emission level of approx. 20 Mt by 2030. The national basic scenario indicates that the current measures will lead to a level of approx. 26 Mt by 2030. The need to reduce emissions will follow a linear trajectory in the period 2021–2030, reaching the level of approx. 6 Mt in 2030. At the beginning of this period, the annual need to cut emissions is considerably lower, however.

The EU's current Effort Sharing Decision and the new proposal for an Effort Sharing Regulation contain the possibility of using so-called flexibilities. The one-off flexibility mechanism included in the proposal for a regulation (proposed volume 2 percentage points) would be advantageous for Finland and set Finland's binding target at 37 %. In volumes, a flexibility of 2 percentage points would mean emissions amounting to approx. 0.7 Mt at the annual level.

Initial estimates indicate that the planned emission reduction measures and the one-off flexibility mechanism together are not sufficient to cover the estimated need to cut emissions. Finland should also be prepared to use other types of flexibility mechanisms to stay on the linear trajectory towards reducing emissions. Preparation for using the flexibilities is also necessary from the perspective of risk management: the effectiveness of emission reduction measures is always associated with uncertainties. Of other flexibility mechanisms, banking and borrowing allowances and buying allowances from other Member States can also be considered. A separate detailed plan for flexibility mechanism use will be drafted later.

Policies:

- In non-ETS sectors (transport, agriculture, building-specific heating, waste management, use of fluorated greenhouse gases, machinery use), the emission reduction measures defined in the medium-term policy plan will be implemented to reach the target for 2030.
- Finland will be prepared to use the one-off flexibility mechanism referred to in the Effort Sharing Regulation.
- A separate detailed plan for flexibility mechanism use which accounts for the emission reduction target will be prepared in the course of further drafting.
- An obligation to blend light fuel oil used in machinery with a 10 % share of bioliquids will be introduced.
- Work to support the climate solutions of municipalities and regions will be developed, for instance by implementing experimental and cooperation projects.
- Steering methods used in the areas of housing, mobility and nutrition will be developed further, and consumers will be empowered to take action that reduces greenhouse gas emissions caused by consumption.
- The efforts to identify new, cost-effective emission reduction measures will be continued, while a plan for the use of effort sharing sector flexibility mechanisms in the period 2021–2030 is prepared, taking the results of negotiations that concern the pending EU legislative proposals (the Effort Sharing Regulation and the LULUCF Regulation) into consideration. Finland will prepare to expand and increase the efficiency of emission reduction measures towards the end of the period.

The Climate Change Act that entered into force in summer 2015 sets the long-term target for reducing greenhouse gas emissions at a minimum of 80 % by 2050 compared to 1990 levels. Enshrining this target in the act provides the Government with clear guidelines for preparing the plans referred to in the Climate Change Act and a reference value for evaluating monitoring results. The long-term emission reduction target applies to all greenhouse gas emissions, while the medium-term climate policy plan only concerns the non-ETS sector.

The drafting of the medium-term climate change policy plan began in autumn 2015 and is to be completed in early 2017. In practice, the climate change policy plan has been prepared simultaneously with the Energy and Climate Strategy. The climate change policy plan specifies the emission reduction target for 2030 in the effort sharing sector and the measures used to achieve it.

The medium-term policy plan is to a great extent based on sector-specific plans that concern the possibilities and costs of cutting emissions. In other words, these efforts are based on a bottom-up process, where sector-specific plans are prepared first (transport, agriculture, heating of buildings, waste management, fluorinated greenhouse gases or F gases, machinery). The policy plan also examines cross-cutting themes, including the role of municipalities' climate actions, consumers' significance in climate policy and links between air protection and climate measures. The primary focus of these efforts will be emission trends up to 2030. This is consistent with the interpretation of the concept 'medium term' as it was defined in the rationale of the Climate Change Act and also compatible with the time horizon applied in EU climate policies.

The sector-specific plans look at both historical trends in emissions and future scenarios up to 2030. The scenarios analyse the adequacy of current measures and the methods that could be used to achieve greater cuts in emissions. Proposals for new policy measures by which the required cuts in emissions can be reached are at the core of the plans.

The sector-specific plans are combined to lay the foundation for the medium-term policy. The objective is that the proposed measures would cover a major part of the current need to reduce emissions. While particular attention is to be paid to cost-effectiveness when selecting the measures, other criteria will also be examined.

Final touches were being put on the sector-specific plans in autumn 2016. At this stage, emission reduction measures amounting to some 4–5 Mt at the 2030 level had been identified as a total for the sectors scrutinised so far. In the sections below, the sector-specific measures are discussed in detail:

## Transport

The transport sector accounts for approx. 40 % of effort sharing sector emissions and thus plays a key role in achieving the emission reduction target. Emission reduction possibilities in the transport sector have been investigated thoroughly in recent years in several reports that have looked at the emission reduction potential, costs and other impacts of various measures. Emission reduction measures can be divided into three categories: transport system level changes, improvements in vehicle energy efficiency and increased use of renewable fuels.

The emission reduction impact achieved through improving the transport system's energy efficiency could be approx. 1 Mt a year. The emission reduction impact achieved through improving the energy efficiency of vehicles could be approx. 0.6 Mt a year. In practice, this will be realised by reducing the vehicles' emissions per kilometre. By replacing fossil fuels with renewable power sources, an annual reduction of 1–2 Mt in emissions could be achieved. The exact range of these figures depends on the blending ratio aimed for.

On the basis of the aforementioned estimates, the total emission reductions in the transport sector could amount to 2.6–3.6 Mt in 2030. For a more detailed discussion of transport sector measures, see section 3.8.

## Agriculture

In agriculture, greenhouse gas emissions originate from decentralised biological sources, which make their mitigation more challenging than in many other sectors.

The possibilities of achieving cost-effective emission reductions in effort sharing sector are rather limited in agriculture. Measures that are purely related with the agricultural sector are difficult to find. The impacts of emission reduction measures related with the soil, in particular, are allocated also to the so-called LULUCF sector. The most effective measures aiming to reduce greenhouse gas emissions from agriculture in Finland are related with organic soils. Emissions from energy used in agriculture as well as emission from machinery and building-specific heating are accounted in other sectors.

The measures used to reduce greenhouse gas emissions in the agriculture should be compatible with the EU's Common Agricultural Policy and its aid schemes as well as the EU State aid rules. Agricultural policy falls within the jurisdiction of common EU policies, and EU funding should be available for improving the efficiency of the measures, as they concern attaining common targets. Finland should thus influence EU level measures, ensuring that possibilities are created for resorting to national measures in which regional special features can be better accounted for. The aim should be at creating development-oriented rather than restrictive measures.

In the sector-specific plan for agriculture, there is a particular emphasis on measures to reduce emissions from organic soils, as well as on measures aiming to replace fossil fuels used in agriculture by biogas. The total impact of the measures proposed in the sector-specific plan is estimated 0.5 Mt a year.

## Building-specific heating, waste management and F gases

Reductions in emissions from building-specific heating could be achieved by both continuous improvement of energy efficiency in line with the new Höylä agreement and by increasing the proportion of renewable energy. An obligation to blend light fuel oil used for heating with a 10 % share of bioliquids will be introduced. Improving the combustion technology for small-scale burning of wood will reduce emissions, especially the emissions of black coal that warms the climate.

Emissions from waste management in the effort sharing sector can be reduced further by including waste incineration in the emissions trading sector, better enforcement of the prohibition on landfilling organic waste, and more effective collection of landfill gas.

Cuts in the emissions of industrial gases with powerful effects on warming the climate, or F gases, are currently strongly based on EU legislation. In the national context, the emissions can to some extent be reduced further through public procurement and by means of education and information activities.

The measures related to building-specific heating, waste management and reducing F gas emissions could in total achieve an annual cut in emissions of approx. 0.9 Mt by 2030.

## Machinery

Greenhouse gas emissions from machinery have remained more or less unchanged in recent years. The current EU regulation on machinery engines concerns conventional air pollution rather than energy efficiency or CO<sub>2</sub> emissions.

For the part of light fuel oil used in machinery, a 10 % blending obligation with bioliquids will be introduced. Extending regulation to energy efficiency and CO<sub>2</sub> emissions would direct the product development of EU manufacturers in the machinery sector and guarantee a declining trend in emissions as the machinery fleet is replaced. The deployment of innovative technical solutions related to energy consumption could thus be promoted. From 2017 on, the type approvals of machinery engines will also enable the use of biogas in tractor engines, which will contribute to cuts in emissions.

The role of municipalities, regions and consumption in reaching the emissions target

The municipalities have a crucial role in attaining the emissions targets in the effort sharing sector. The municipalities' decisions related to land use, transport and services, business policy, energy issues and procurement have an impact on greenhouse gas emissions. Sustainable public procurement both supports cutting emissions and offers possibilities for developing the domestic market.

Both municipalities and regions have been active in preparing climate strategies, especially in 2009–2012. There are almost 40 municipalities in Finland that are climate policy pioneers. They have committed to significant emission reduction targets that are more stringent than the national and EU targets. In many Finnish pioneering municipalities, climate targets have been linked to economic and employment targets.

Housing, mobility and food have maintained their position in Finland as the most central sources of greenhouse gas emissions from consumption. They cause approximately 75 % of consumption-driven emissions produced in Finland. Public steering has been developed within the scope of a Programme to Promote Sustainable Consumption and Production. In energy issues, for example, indications of consumers assuming a more active role can be seen, which should be supported by guidance. Sustainable choices should be enabled by sets of steering instruments, including economic steering, experimentation and campaigns.

### **3.8 Transport sector measures**

- Over the long term, transitioning into a transport system with extremely low emissions. By 2030, reducing traffic emissions by some 50 % compared to the situation in 2005. Focusing the emission reducing measures on road transport, which presents the greatest potential for emission reductions.

Transport plays a key part in achieving Finland's national climate targets, as it produces some 40 % of the Finnish greenhouse gas emissions in the effort-sharing sector. The role of the transport sector in reducing emissions will also be highlighted as reducing emissions will be even more difficult in other sectors (including agriculture). The transport sector is thus preparing to cut its emissions by up to 50 % by 2030.

Some 90 % of emissions from domestic transport are produced by road transport. Approximately 58 % of road traffic emissions are produced by cars, 37 % by vans and trucks, and the remainder by buses, motorbikes etc. The share of railway traffic in emissions is about one per cent, the share of aviation some two percent and the share of waterborne traffic some four per cent.

The fastest way to reduce greenhouse gas emissions from transport is replacing current transport fuels with renewable ones, or fuels or power sources with lower emissions.

Over the longer term, however, increasing the share of alternative transport fuels will not be adequate as the only method of reducing traffic emissions. The annual energy volumes consumed by transport are so great that covering the entire energy requirement by renewable raw materials is not possible. Measures that reduce energy consumption are thus also needed.

The energy efficiency of the transport system can be improved by such measures as developing new transport services, influencing choices of travel and transport modes and utilising intelligent transport methods. On the other hand, the energy efficiency of vehicles can be improved inter alia by developing engine technology, reducing vehicle weights and introducing completely new technologies (including electricity).

#### Improving the energy-efficiency of the transport system

- In the transport sector, the current self-service market will be replaced by a service market. By promoting the “Mobility as a Service” model, the aim is to reduce the number of solo car journeys and to halt the increase in the transport performance of cars in urban areas regardless of a growing population.
- Implementing a legislative reform related to the transport market (the Transport Code).
- Coordinating transport and land-use as well as promoting the conditions for walking, cycling and public transport, especially in urban areas. The target is at a 30 % increase in the number of journeys taken by walking and cycling by 2030. Also preparing for changing mobility habits through land use planning and parking norms.
- Examining the possibilities of influencing transport performances and choices of transport modes through customer fees charged by transport network company LIVE and LIVE’s investments. Decisions on LIVE will be made separately once the requisite reports have been completed.
- Promoting the automation of transport and different remote practices.
- Significantly improving the energy efficiency of transport by developing the operating methods.

Promoting the Mobility as a Service model is a promising alternative for improving the energy efficiency of the transport system. MaaS encourages a more environmentally friendly mode of transport distribution by making public transport more attractive, combining innovative first and last kilometre solutions and promoting services based on the sharing economy. Logistics services for companies will also improve and become more efficient.

In practice, generation of new service models and the revolution of the transport market will be promoted by reforming and relaxing the current legislation on the transport market. The provisions will be collected in a coherent Transport Code that 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 will be encouraged. Open data, better utilisation of data resources and the opening of payment interfaces will create preconditions for both new



business ideas and the development of those operating models of transport that receive public support, including public transport.

The foundation for an energy efficient transport system is laid by a well-functioning urban structure. Both the organisation of public transport and the promotion of walking and cycling need to be supported by a concise urban structure and careful coordination of transport and land use. It must be possible to develop the infrastructure for modes of transport that provide an alternative for cars in cooperation with the central and local government. At the same time, it must be ensured that services are also available close by, without the need for a car journey. Developing public transport with an open mind and promoting walking and cycling will improve not only the energy efficiency of transport but also the smooth running of traffic, transport safety and air quality in cities.

Up till now, it has been very difficult for the central government to participate in municipalities' projects aiming to promote walking, cycling or public transport. The Ministry of Transport and Communications is currently working on a project aiming to establish LIVE, a transport network company. The project examines a model where tasks related to the management, development and maintenance of state transport routes would be transferred to LIVE, a state enterprise to be established, that would mainly be funded by customer fees. In the future, customer needs would set the direction for the development of the transport network and traffic volumes, as the customers' choices would affect the company's service offering and investments. The aim of the LIVE project is to investigate and formulate a proposal for the required legislative amendments and other measures so that the reform could be implemented from the beginning of 2018, if a separate decision is made to go ahead.

The energy efficiency of goods transport and logistics will be improved by means of digitalisation and the Mobility as a Service model as well as by transport companies' own actions and the customers' active role. The dimensions and weights approved for use in heavy-duty transport in Finland, which are greater than those permitted in Central Europe, will also be fully utilised.

### Improving the energy-efficiency of vehicles

- Influencing the drafting of EU legislation applicable to car manufactures so that the specific consumption and emissions of new cars and vans will be reduced by approximately 30 % from their 2020 levels by 2030.
- Participating in the preparation and introduction of the corresponding threshold values for heavy-duty vehicles in the EU.
- Speeding up the replacement rate of the vehicle fleet in Finland considerably. Investigating the possibilities of reducing the current taxes on vehicle purchases as regards vehicles with lower emissions. Decisions on transport network company LIVE will be made separately once the requisite reports have been completed.
- The precise methods for promoting the replacement of the vehicle fleet and the wider spread of new technologies will depend on such issues as whether or not the transport network company LIVE will be established. It is possible that the wider uptake of lower-emission vehicles needs to be promoted by a new form of fixed-term risk subsidy, the estimated annual amount of which would be EUR 25 million over the next few years.

The EU has adopted binding threshold values for the average CO<sub>2</sub> emissions of cars and vans sold in the EU. The Commission is currently working on updating these values and setting more stringent targets for 2030. The threshold values planned for both cars and vans are so low that they cannot be achieved without a considerable increase in electric solutions in the vehicle fleet. The Commission is also working on setting similar threshold values for the manufacturers of heavy goods vehicles. The more stringent threshold values set for vehicle manufacturers will help EU Member States (including Finland) achieve their national targets for reducing emissions.

In Finland, an effort has been made to promote the purchases of lower-emission cars by means of car taxation. The Finnish car tax is staggered on the basis of the car's specific emissions (CO<sub>2</sub>/km). The current taxation model together with the threshold values applicable to EU vehicle manufacturers have resulted in a considerable decrease in the specific emissions of new cars sold in Finland since 2008. The taxation model has not, however, proven an adequate incentive to bring new technologies (such as electric or gas-powered vehicles) onto the roads. The proportion of electric vehicles and other alternative technologies in new vehicles sold remains only about one per cent.

The car tax increases the purchasing price of cars in Finland. Compared to other European countries, Finnish motorists drive older cars on average. The average age of Finnish cars has increased since 2008. In 2015, it was approximately 11.7 years. Also, the average age of cars that are scrapped has increased year by year; in 2015 it was over 20 years, while the EU average was some 15 years. The replacement rate of the Finnish car fleet has in recent years been slow, on average only once every 20 years.

## Replacing oil-based fossil fuels with renewable and/or low emission alternatives

- The physical share of biofuel energy content in all fuels sold for road transport will be increased to 30 % cent by 2030<sup>3</sup>.
- In order to stabilise the operating environment and to secure new investments, the continuity of the biofuel market across the EU must be ensured. The possibilities of creating a joint Nordic biofuel market should also be examined.
- The distribution station network for new fuels (including gas and hydrogen) and the network of recharging points needed for electric vehicles will mainly be built on market terms in Finland. In addition, cost-effective ways of promoting the expansion of the network of recharging points for electric vehicles and refuelling points for gas-powered vehicles will be assessed, taking into consideration the recommendations of the working group on distribution infrastructure that examined this question.
- However, the central government must ensure that the share of new technologies in the vehicle fleet can be brought up to a level that is adequate for creating a well-functioning market. The goal for Finland is to have a minimum of 250,000 electric vehicles in total (fully electric vehicles, hydrogen-powered vehicles and rechargeable hybrids) and a minimum of 50,000 gas-fuelled vehicles in 2030.

A transition from conventional fossil oil based fuels to other alternatives has already begun in Finland. The most popular alternative fuels currently are liquid biofuels (ethanol and renewable diesel). The total blending ratio of biofuels made from renewable raw materials in petrol and diesel for road transport is currently over 10 %, and this ratio is constantly increasing. Natural gas and biogas are used to some extent as road transport fuels in Finland, and natural gas is also used in shipping. Electricity has been the most important power source for rail traffic for some time, and it is now also emerging as an important power source for road transport.

As far as known at the moment, meeting the entire energy needs of transport with a single alternative power source or fuel will not be possible. The suitability of various alternative power sources for different modes of transport also differs. In aviation, liquid biofuels currently appear to be the only realistic alternative to fossil oil. The number of options for shipping, heavy-duty vehicles and cars is increasing. The largest number of alternatives is available for cars, which can run on all of the aforementioned power sources. The potential for reducing emissions is also the greatest for cars.

Advanced biofuels are a quick solution for reducing our dependence on oil and emissions from transport. By using biofuels made from domestic raw materials, we can reduce our dependence on crude oil and the cost of buying crude oil in our trade balance of energy. The use of liquid biofuels will not require changes in our current distribution infrastructure (drop-in fuels), or the changes are minor (high-blend ethanol etc.) Advanced biofuels can also be

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<sup>3</sup> According to the calculation method currently used in the European Union, this means an approximate share of 53 %. In this double credit method, the energy content of biofuels produced from wastes and residues, non-food cellulose and lignocellulose is multiplied by two. The target set in the Government Programme of Prime Minister Sipilä, or a 40 % share of renewable transport fuels, is based on the double credit calculation method.

used in those modes of transport where the use of such power sources as electricity is not currently considered possible. Biofuels are particularly important for trucks and long-distance buses as well as for aviation. At the same time, it must be ensured that the logistics costs of our export industry remain reasonable from the perspective of our competitiveness. Biofuels are also highly suitable for stockpiling when preparing for crises concerning security of supply and for emergencies.

Electric vehicles currently represent the only technology that significantly reduces not only greenhouse gas emissions but also energy consumption in transport. The efficiency of an electric vehicle with batteries is 50-70 %, whereas this figure for a vehicle with an internal combustion engine is less than 25 % at best. The specific CO<sub>2</sub> emissions of Finnish electricity production are already very low, and will be further decreased as a result of the emissions trading, and the increase in emissions brought about by electric motoring will thus be relatively small in the emissions trading sector in Finland. Using electricity as a transport power source will not result in significant needs to increase the electricity production capacity insofar as the recharging of electric vehicles mainly takes place during off-peak times of electricity consumption (at night). In the future, smart recharging will make it possible to control the recharging times of batteries, thus creating significant potential for demand response in the electricity market.

In addition to electricity, hydrogen is the only energy carrier that enables completely carbon free transport, provided that no fossil energy has been used to produce the hydrogen. The objectives of increasing the fleet of gas-fuelled vehicles include both promoting nutrient recycling and achieving considerable CO<sub>2</sub> emission reductions in the effort-sharing sector. The carbon dioxide emissions of natural gas are within the same range as those of diesel but lower than emissions from petrol. Replacing petrol with natural gas in transport will reduce CO<sub>2</sub> emissions by some 25 %. An even greater emissions reduction can be achieved by using biogas. The raw materials of renewable gas are usually domestic, and decentralised production fosters employment at the local level.

### **3.9 Built environment**

A significant share of Finland's greenhouse gas emissions are produced in built environments. Buildings account for some 38 % of the final energy consumption. Climate change mitigation measures associated with the built environment comprise land use decisions, energy-efficient new construction and renovations, building maintenance, material efficiency and the utilisation and promotion of renewable energy. Decisions that concern land use and construction will have impacts extending far into the future, as infrastructures are slow to change.

The objective of the Land Use and Building Act is to ensure that the use of land and water areas and building activities create preconditions for a good living environment and promote ecologically, economically, socially and culturally sustainable development. National land use objectives are part of the land use planning system referred to in the Land Use and Building Act.

Policies:

The energy efficiency requirements in new construction will be set and maintained at a cost-optimal level. The production of solar power and solar heat and preconditions for deploying intelligent systems and introducing flexibility in the demand for electricity in new buildings will be promoted. EU level minimum requirements for the energy efficiency of building

products will be promoted, and if necessary, national minimum requirements will be set for construction products.

- Energy efficiency will be improved, and renewable energy use will be promoted in the existing building stock.
- An obligation of blending light fuel oil used in heating with a 10 % share of bioliquids will be introduced. The implementation of voluntary energy efficiency agreements will be continued and developed. Guidance by information will be provided on energy-efficient building use and a good indoor climate.
- Energy efficiency in renovations will be improved.

The energy efficiency requirements for renovations will be set and maintained at a cost-optimal level. Any financial incentives to renovations should be sustained, predictable and targeted.

- The carbon footprint of construction materials and products will be reduced.

An effective link will be established between construction sector regulation and greenhouse gas emissions produced in the manufacturing of construction materials and products. As a first step, a roadmap on this issue will be prepared; in which measures required to develop steering related to the carbon footprint of materials will be specified. Procurement instructions related to this objective will be issued for public construction projects.

- Promoting wood construction

The storage of carbon bound in the Finnish forests will be increased by promoting the use of timber in construction, taking the long-term sink effect thus achieved into account.

- The material efficiency of construction will be improved

The circular economy will be reinforced in construction by improving the sorting and recycling of building waste produced in new construction and renovations and by creating an effective recycling market for demolition materials and products. Industrial symbiotic relations between building construction and other industrial sectors will be improved.

#### Land use policies

- The effectiveness of land use and mobility in urban subregions will be promoted by developing legislation and the land use planning system, by updating the national land use objectives, and through agreements between the central government and municipalities. Transport infrastructure implementation will be linked to land use planning and construction with the aim of reducing emissions.
- In growing urban subregions, new construction will primarily be directed to areas with existing services and public transport. Outside growing urban centres, land use steering will be developed taking into account the need to develop areas, new trends of the natural resources economy and the strive for local energy production. Rural centres and villages will be strengthened to safeguard the local availability of services.

By means of urban structure development measures, emission reductions amounting to 0.4 Mt CO<sub>2</sub> a year can be achieved by 2030 compared to the basic scenario. The most significant solutions that concern cutting emissions are associated with sustainable urban development: urban structure and effective functioning of urban subregions, coordination of land use and transport, creating 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 of 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.

- In land use planning and construction and when making efforts to develop the steering of these sectors, preparation is made for utilising solar power.
- In land use planning, Finland will prepare to utilise extensively the country's wind power potential. In order to minimise the negative impacts of wind power plants, an effort will primarily be made to centralised wind power construction in large units at a sufficient distance from permanent housing.

Preconditions for increasing wind power production include coordinating wind power construction with land use in the surrounding areas, giving sufficient consideration for negative impacts and ensuring local acceptability. In order to promote planning, the Land Use and Building Act contains specific provisions on local master plans that apply to wind power construction directly. Rapid progress has been made in recent years in land use planning for wind power construction. Finland will prepare for the installation and construction of solar panels and solar collectors by means of an amendment to the Land Use and Building Act, which will harmonise and streamline the permit procedure so that permit consideration would only be required in case of those solar panels or collectors that have significant impacts on the townscape or the environment.

### **3.10 Distribution obligation and supply of biofuels for road transport**

Policies:

- In road, transport, the share of biofuels in the energy consumption measured as the physical share of the energy content will be increased from the 13.5% laid down in the current legislation on the biofuel distribution obligation to 30% by 2030<sup>4</sup>. The increase in transport biofuel use will be examined as a whole together with the blending obligation applicable to the light fuel oil used in machinery and heating.
- The starting point is that any additional demand will be covered by advanced biofuels produced in Finland. Based on estimates of transport energy consumption, the required total volume of biofuels and bioliquids replacing light fuel oil would be in the range of 1,100,000 toe/a (12.8 TWh/a), and the need for additional production capacity would be 600,000 toe/a (7 TWh/a) by 2030. The additional production could be based on several different technologies, and the raw materials would mainly consist of different wastes and residues as well as lignocellulose from forestry and forest industry. The biofuel production could be partly based on imported raw materials.

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<sup>4</sup> Applying EU rules on so-called double credits, this share will be increased from 20 % to about 53 %.

- Biofuels with the largest production volumes, which would account for some 80% of the production, would consist of so-called drop-in biofuels, or renewable diesel and biopetrol. These fuels can be used in the existing fleet without restrictions, and no new distribution infrastructure need be constructed for them. To complement them, bioethanol and biogas (biomethane) will be produced.
- The investment costs of the targeted volume of domestic production are estimated to be around EUR 1.5 billion.
- The increase in the demand and thus supply of road transport biofuels will be ensured also in the future by means of an obligation to distribute liquid biofuels imposed on fuel distributors, combined with fuel taxation of the current type. Many production technologies are only in the process of being developed, and due to the technology risks related to their demonstration, risk support is needed to encourage investments in them. The annual need for this risk support is estimated at EUR 40–50 million over the next few years. An effort will be made to obtain some of this through EU funding instruments.
- At the EU level, policies that promote the creation of a market for advanced biofuels must be continued.

The studies produced indicate that the most advantageous option for alternative transport power sources in terms of the national economy would be replacing fossil fuels with drop-in biofuels produced in Finland. This way, investments and employment can be encouraged, and preconditions for technology exports can be created. All other sources of alternative energy have restrictions related to the vehicle fleet, among other things, which may not have been solved by 2030. While advanced biofuels will be the most important energy form to replace fossil fuels in the next decade, it is obvious and, over the long term, essential that other new power sources, including electricity and hydrogen, will also gain a foothold.

In terms of Finland's policies and objectives concerning biofuels, it is vital that policies promoting the biofuel market will also be continued across the EU. An individual national market would hardly be a sufficient incentive for the industry to develop and invest in new biofuel technologies.

The need to increase biofuel production relies on several raw materials, some of which may be imported. While the demand for domestic wood-based raw material<sup>3</sup> also depends on the selected technologies, it is estimated to be in the range of 3–4 million m<sup>3</sup>.

The analysis shows that potential investment possibilities exceed the proposed 600 kt.

Decisions on investment subsidies for biorefineries, similarly to appropriations for other aid types, will be made later in the central government budget, taking the Government Fiscal Plan into account.

### **3.11 Policy on sinks**

Policies:

- Finland will actively exert influence on the proposed EU LULUCF Regulation and its accounting rules to ensure that (i) increasing, sustainable and diverse use of the forests will be possible, (ii) the accounting rules will reflect the actual sinks and emissions,

and (iii) a limited amount of the sink units also from forests could be used to meet the effort sharing sector target in 2021–2030.

- The sustainable management and use of forests, including forest conservation, will be ensured by (i) implementing the measures of the National Forest Strategy, (ii) maintaining a good forest health, and (iii) reinforcing the growth and carbon capture capacity of the forests over the long term.
- The possibilities for afforestation in treeless areas will be investigated (including implementation methods, costs and impacts).
- Measures for reducing deforestation, especially in connection with urban and transport sector construction (including through land use planning) and as a result of clearing land for cultivation will be specified and implemented.
- Techniques for measuring carbon sequestration and storage in arable land and cultivation methods that help to increase the carbon sink will be developed. A pilot project that aims to increase the carbon sink of farms will be launched.
- The impacts of the greening payments, cross-compliance conditions and environment payments of the EU's Common Agricultural Policy on soil carbon stocks in Finland will be examined, and proposals on how farmers can be encouraged to improve soil condition, including building up the soil carbon stocks and reducing the speed at which the carbon stocks are depleted, will be prepared in connection with the CAP reform.

The Land Use, Land-Use Change and Forestry (LULUCF) sector covers land use categories and their respective changes (forest land, cropland, grassland, wetland, settlements and other land use) as well as their greenhouse gas emissions and removals, or sinks. The climate impacts of the land use sector are significant globally and especially in Finland.

The forests are the largest sink in the land use sector Finland. The size of the forest carbon sink, i.e. the quantity of carbon dioxide that is sequestered as the forests grow and released in harvesting, has varied between some 20–50 million tonnes of carbon dioxide equivalent (Mt CO<sub>2</sub> eqv.) in 1990–2013. Annually, the net sink of the Finnish forests has corresponded to 30–60 % of Finland's total emissions.

The objectives of forest management and use were set in the National Forest Strategy 2025. The goal is to increase the use of wood for different products and energy up to 80 million cubic metres of stemwood annually. This objective means that the carbon sink of forests will remain at the level of 13–20 Mt CO<sub>2</sub> eqv., with an increase towards the end of the period 2021–2030. Active forest management and use will also maintain the forests' health and ability to grow, which is a basic precondition for their capacity to sequester carbon. Finland is the most forested country in the EU, and preliminary estimates indicate that the potential for afforestation is limited.

Agricultural land, or cropland and grassland, are a net source of greenhouse gas emissions in Finland (over 7.5 Mt CO<sub>2</sub> eqv. annually), and the carbon stock in Finnish croplands has decreased on average. By means of good cultivation practices, the decrease of the carbon stock may be slowed down and, in some cases, the carbon stock may even be replenished by increasing carbon input into soil. The greatest potential for reducing emissions is in peatlands, and the greatest potential for increasing the carbon stock in mineral soils.



Measures implemented under the Rural Development Programme for Mainland Finland currently seek to slow down the decrease of soil carbon as well as to increase the soil carbon stock. These measures include investments in controlled subsurface drainage, perennial grassland (in other words, environment management grasslands) and plant cover on arable land in winter. Direct aid, fully funded by the EU under the European agricultural policy, is now associated with agri-environmental requirements and 30 % of direct payments have been linked to greening payments. Farmers must comply with three greening measures on their eligible hectares. Greening payment measures that affect the soil include the requirements of perennial grassland, diversification of cultivation and partly also ecological focus areas. Additional measures under CAP cross-compliance conditions with an impact on the soil are the prohibition of burning stubble and the requirement of plant cover in fallow land. A number of research projects related to the carbon sinks of agricultural land and the impact of these measures are currently under way.

The most significant source of emissions in the land use sector is associated with clearing forest for other land use purposes, mainly as a result of urban construction and clearing land for cultivation. The annual emissions from these sources are approx. 3.5 Mt CO<sub>2</sub> eqv.

In July 2016, the European Commission published its proposal for a Land Use, Land Use Change and Forestry (LULUCF) Regulation, which integrates this sector in the EU climate and energy framework. The proposal is closely linked with the proposal for an Effort Sharing Regulation issued at the same time. The LULUCF proposal set binding targets for the Member States concerning sinks and emissions as well as formulating detailed accounting rules up till 2030. Finland is extremely displeased with the accounting rules proposed by the Commission, as they may lead to a situation where a country such as Finland with the land use sector as an actual net sink may be imposed an accounted additional burden. Under this proposal, a reference level for the carbon sink of forests would be set for 2021–2030. As wood use increases, the carbon sink in the managed forest land will decrease, and the focus in climate change mitigation will shift towards replacing fossil raw materials with renewable ones, including wood.

### **3.12 Electricity and gas markets**

Electricity market development

Policies:

- Well-functioning regional and European electricity markets and sufficiently strong cross-border connections are the most efficient and cost-effective way of guaranteeing competitive electricity prices and security of supply. To ensure the targeting of investments at capacity that makes sense for the system as a whole, the price signals in short-term markets must also genuinely reflect the demand and supply of electricity. In order to activate consumers, consumer prices of electricity should be more responsive to wholesale price fluctuations.
- The operation of the electricity market will be developed from the perspectives of regional and European markets. The new alternating current connection planned between Northern Finland and Northern Sweden is a key project for securing sufficient transmission lines. The aim is to have the new 800 MW transmission line between Finland and Sweden included in the EU's PCI list in 2017.

- Work aiming to create preconditions for a common Nordic electricity market will be continued.
- Flexibility in consumption and production and active participation in the electricity market through smart solutions will be promoted, and the country's pioneering position in the development of intelligent networks will be maintained. Intelligent network development will play a key role in strengthening the consumers' role, integrating renewable electricity production in the electricity system, improving security of supply and creating new business models. Flexibility of demand plays an essential part in energy efficiency.
- A target for the security of supply in electricity associated with the adequacy of electric power will be defined.
- The power reserve system will be preserved and developed towards greater flexibility. It will be justified to increase the power reserve subjected to a tendering process by the Energy Authority from the current 299 MW to some 600 MW.
- A government bill on a data hub will be drafted and debated in the Parliament during the spring session 2017.
- The prerequisites for CHP production will be maintained as part of an energy-efficient and low-emission energy system with a high degree of security of supply.
- The cybersecurity of the electricity system will be ensured.
- Attaining the security of supply target set for distribution networks, a good security of supply level of the grid, and replacement investments will be secured.

Finland is part of the regional Nordic and Baltic electricity market, and in a broader context, part of the European common market. A large electricity market is the best way of reaching competitive electricity prices and security of supply. This will be the basic premise for developing the functioning of the electricity market.

The market model to be adopted in the future is being widely debated in Europe and in the Nordic countries. There is no reason to alter the existing market model based on electric power trading in the Nordic countries, at least not over the short term. On the other hand, sufficient time should be allowed for a broad-based discussion on the future market model. Mechanisms are being drafted in such countries as the UK, France and Italy where the payment for electric energy would also include a fee for the electric power, or a producer would be under an obligation to maintain the required power. The European Commission will issue a proposal concerning electricity market development before the end of 2016.

The common electricity market is undergoing a transition where the electricity production system is becoming more decentralised and the importance of variable renewable energy, including wind and solar power, is increasing. At the same time, the condensing power capacity that can be regulated is declining. The increased need for regulation during different times of the day due to variable production will require increased flexibility in electricity consumption and production, and active participation of consumers in the market through smart solutions. The means for increasing the required flexibility include electricity storage, the electricity system and other energy systems, including electric transport, the district heat system and the gas market. In order to enable investments that create more flexibility and for

many other reasons, it is important that the price signals generated in the electricity market, and also in the daily and regulating power markets, are genuine and sufficiently strong.

Intelligent electricity networks will work as a service platform in the transition towards a more decentralised and carbon-neutral electricity system. They will give the customers better possibilities for participating in the electricity market, improve security of supply and cost-effectively create new business opportunities for companies. In September 2016, the Ministry of Economic Affairs and Employment appointed a broad-based working group to prepare concrete actions through which intelligent networks could serve the customers' possibilities of participating actively in the electricity market and help maintain the general security of supply.

Major end users of electricity already participate actively in the market, and the new measures will thus focus on the utilisation of the growing decentralised resources, in particular. The preconditions for this include modifications in the terms of connecting to the grid that aim to support market participation, development of measuring requirements, gathering of information on decentralised production and developing the infrastructure for directing demand. The tariff structures of both electricity sales and system operators should be developed to strengthen price signals. Measurement and balancing principles will also be created for electricity storage, and the open questions of energy taxation will be addressed.

The data hub prepared by Fingrid will enable more efficient and consistent data communications, which will be essential for future electricity markets. In order for the data hub to be implemented, legislative amendments will be required urgently, or in the next few months. They will be later complemented with the necessary sets of data protection rules. The increase in variable production will also influence seasonal differences in maintaining the balance of power in the demand for and production of electricity. At the times of peak demand when the winter temperatures plummet, little wind power and no solar power is produced. Consequently, CHP production and hydroelectric power that can be regulated obtained from the Nordic market through sufficiently strong transmission connections will be key methods for ensuring the security of supply. The objective is to have the next power transmission connection between Finland and Sweden included in the EU's PCI list (Projects of Common Interest) and to build this connection as fast as possible. In November 2016, the transmission system operators in Finland and Sweden agreed upon preparations for building a new 800 MW power transmission connection.

To ensure the adequacy of power, the existing power reserve system should be maintained and developed towards greater flexibility. Both power stations and flexibility of demand can be used to create a power reserve. Increasing the power reserve subjected to a tendering process by the Energy Authority from the current 299 MW to some 600 MW would be justified.

In addition to balancing the adequacy of electric power as well as demand and supply, the reliability of transmission and distribution networks influence the security of supply. In international comparisons, the security of supply of transmission networks in Finland is excellent. At the same time, however, Finland must prepare for new threats, especially those related to cybersecurity. A good level of cybersecurity also plays a key role in the preparation of the centralised information system and data hub to be developed for electricity trade. The attainment of the security of supply targets set for the electricity distribution networks and adequate replacement investments that support target achievement must be secured.

A significant part of Finland's increasingly carbon-neutral energy production will continue to rely on nuclear power, also in the future. The question of extending the life cycle of the

currently operational nuclear power units will become topical towards the end of the 2020s at the latest. Teollisuuden Voima's Olkiluoto 3 unit, which is under construction, will considerably improve the country's self-sufficiency in electricity production. A decision on the construction licence of Fennovoima's Hanhikivi nuclear power stations is due in 2018.

#### Gas market development

##### Policies:

- The construction of the Balticconnector gas pipe between Finland and Estonia will enable the opening and renewal of the gas market. As this investment is completed, the exemption from the Internal Market in Natural Gas Directive will be dropped, and the gas market will be fully open for competition from the beginning of 2020. In the new natural gas market act, price regulation of piped gas will be dropped, and gas marketplaces and internal market rules will be introduced. The objective is to create a regional gas market in Finland and the Baltic countries.
- Gasum's transmission network and gas sales will be unbundled.

The creation of a gas market will provide preconditions for continuing the use of gas as an industrial raw material, for energy purposes and as an alternative transport fuel alike. The use of gas for energy will be important, especially during the transition towards a carbon-neutral energy system. The gas infrastructure will enable the utilisation of biogas and, later, synthetic gas. Over a longer term, the gas market can also be utilised as a flexibility mechanism for the electricity system (the so-called power-to-gas solution).

### 3.13 Energy efficiency

The efficient and economical use of energy and natural resources in general will support the achievement of all targets of the energy and climate strategy in practice. Meeting the common EU energy efficiency target, or increasing the efficiency of energy use by 20 % compared to the situation without new efficiency measures by 2020, and also the so far unspecified increase of 27–30 % in energy efficiency by 2030, will require both common EU measures, including setting energy requirements compliant with the Ecodesign Directive for all new devices and groups of devices, and strong national inputs in energy efficiency measures by all Member States.

The design and usability of the entire energy system and infrastructures that use energy must be improved in order to increase energy efficiency. This will promote optimising energy consumption, cutting emissions and securing the supply of energy for citizens and businesses. By utilising more readily accessible and accurate measurement and monitoring data, the variations and costs arising from fluctuations in energy production and demand can be balanced out. Increased measurement data and methods developed for its management will also create preconditions for new energy efficiency products and measures.

##### Policies:

- Energy efficiency will be more strongly promoted at the level of the entire energy system as regards electricity, heat and transport alike. Electricity market development, for example by increasing the flexibility of demand and supply, will have an important role. Preserving the preconditions for CHP production will also be an essential part of system level energy efficiency.

- The extensive use of tried and tested energy efficiency measures will be continued and intensified in all sectors. Increasing attention will be paid to activating consumers and small companies to take energy efficiency measures.
- Finland will seek to influence new energy efficiency provisions drafted within the EU to ensure that the indicators and assessment criteria contained in them would genuinely target improving energy efficiency.
- Consumers will be offered more energy advice, and their participation will be encouraged.
- The provision of comprehensive and timely energy advice based on cooperation and replication of good practices will be ensured together with local and regional actors.
- In efforts to encourage the citizens' participation in energy use planning and creating demand flexibility, new technologies will be used to gather smaller consumer groups into groups of an adequate size.

Energy efficiency agreements in different sectors will offer a good platform for large and medium enterprises to improve their energy efficiency. They are not suitable for small enterprises, which have no in-house energy sector expertise and often no knowledge of how they could use energy more efficiently. Practical and easy-to-introduce methods for monitoring and improving a company's energy use will be needed. Management of energy use can also be provided as an outsourced service.

- Energy efficiency will be improved in the process industry and the energy sector on the basis of energy audits.

It became necessary to drop the energy audit grant for large companies that served as a good incentive for concluding energy efficiency agreements, as the grant procedure was replaced by the mandatory and less extensive energy efficiency audits required under the Energy Efficiency Directives. The two-phase audit system for the process industry brought good results and encouraged companies to invest in the targets recognised and analysed in the audits. As follow-up for mandatory energy efficiency audits, a new procedure will be developed in which the cost-effective energy efficiency potential of the process industry and energy production, and CHP production in particular, will be established using the latest measurement technologies and analysed drawing on the best expertise.

#### About the energy efficiency target

As a result of the proposed policies, the consumption of primary energy would be some 418 TWh and the final energy consumption would be some 314 TWh in 2030 (based on the scenario calculations). Measuring energy efficiency by the energy consumption in a country level (primary or final energy consumption) does not always reveal the actual improvements in the efficiency of energy use. Industrial and service sector production may expand, especially through serving other countries (biorefineries, data centres), while being energy efficient.

The EU has measured energy efficiency in 2020 and 2030 by primary energy consumption. Instead of primary energy, or at the very least in addition to it, some other indicator of energy efficiency should be developed, as a low-emission energy system mainly based on renewables does not automatically lead into a reduction in the overall energy consumption. Finland,

together with the EU and the IEA, should continue to improve the measurement and monitoring of energy efficiency, for example by sector-specific examinations.

### **3.14 Adaptation to climate change**

Policies:

- The implementation of the National Climate Change Adaptation Plan 2022 will be strengthened further. In particular:
  - a) Further enhance the management of climate change risks for example by (i) determining the significance of the global, regional and local impacts and risks of climate change (ii) targeting measures cost-effectively at the most significant impacts, and (iii) assessing the financial impacts and effectiveness of the adaptation measures.
  - b) Investigate the possibilities of adapting to climate change impacts that are more severe than expected and supporting different sectors in preparing for them. The indirect impacts of global climate change on Finland will be monitored.
  - c) Encourage local and regional actors to take adaptation and preparation measures, especially by disseminating information and sharing experiences. The responsibilities for adaptation and preparation will be clarified further.

In addition to mitigation emissions, climate change adaptation is an important part of the climate policy framework. The temperature is estimated to rise by the end of this century with 2.3–6 degrees C in Finland compared to the period 1986–2005, depending on the global development of greenhouse gas emissions. As the climate becomes warmer, both the natural environment and society will be exposed to exceptionally rapid changes as extreme weather events and water conditions become more widespread.

The government resolution on a National Climate Change Adaptation Plan 2022 was adopted in 2014. The aim of this plan is that Finnish society has the capacity to manage the risks associated with climate change and adapt to changes in the climate. Climate change adaptation will be carried out most cost-effectively by integration adaptation as a part of the normal planning and decision-making processes in different sectors. The objective is that the actors will have access to the necessary climate change assessment and management methods and research and development work, communication and education and training have enhanced the adaptive capacity of society, developed innovative solutions and improved citizens' awareness on climate change adaptation. The EU adaptation strategy is being implemented nationally through the Climate Change Adaptation Plan.

### **3.15 Energy technology and innovations**

Policies:

- Energy technology and innovations may serve as a significant driver of economic growth. Finland will continue to make major investments in developing new technologies and commercialising innovations, in particular to speed up the introduction of clean and smart energy systems and the associated products and

services, and more extensively resource-wise solutions that are based on user needs and required by communities.

- Full use will be made of the international Mission Innovation cooperation to promote the networking of Finnish cleantech companies and research institutes of the field and creating partnerships. For this purpose, a clean energy ecosystem will be organised as part of the growth programme (a cooperation network for actors) based on a strong public-private partnership.

The energy sector is undergoing a powerful transformation, which is associated with immense business potential, also for Finnish companies. New business activities may create new jobs and exports, and thus well-being for Finland. While promoting sustainable, reliable and cost-effective energy business in Finland, we can also create new growth and export business for Finnish companies. The transformation of energy systems has been launched globally, and Finland has every opportunity to be a pioneer in this area.

The Paris Climate Agreement has been estimated to improve the global competitive position of the European industry and to secure industrial jobs, also in Finland. The scope of this agreement opens up great growth potential for cleantech companies, including good opportunities for Finnish businesses in this sector.

Constant renewal is expected in the energy sector, which is reflected especially in many system level developments. Improving the reliability of the electricity networks will be necessary in our highly electricity-dependent society. When fossil fuels are phased out, the subsidised increase in weather-dependent electricity production, or wind and solar power, in the electricity market will have a massive impact on the entire system. Uncoordinated production, on the other hand, will create challenges related to price trends in the electricity market and thus the profitability of other power plants. Managing the power balance in the face of strong fluctuations in uncoordinated production will be another major challenge.

In October 2016, Finland joined the Mission Innovation (MI) project published in connection with the Paris climate summit, in which 20 countries with a leading role in energy use and energy technologies undertook to double their R&D investments in clean energy over five years. At the same time, a significant group of international capital investors committed to funding the deployment and scaling of innovations developed within the MI. This is another important channel for participating in the global transformation for Finnish companies. Simultaneously with Mission Innovation, a private sector initiative called Breakthrough Energy Coalition (BEC) was published in Paris. The Coalition is committed to providing funding with a higher risk tolerance for innovation projects from Mission Innovation countries. In total, 28 private investors from 10 different countries are involved in this initiative.

The transforming energy system will create new business opportunities while changing the existing ones. Not all consumers wish to be active participants, and this may also give rise to service business of a completely new type. The consumer's role will be emphasised in production and storage of electricity. Flexibility of demand will make the consumer a key actor, no longer just a customer. However, not all consumers wish to become service providers or even assume a particularly active role. New, comprehensive service concepts will thus be created where the customers may, for example, be sold an energy service which includes energy supply, the management of a micro-grid and electricity storage, and follow-up of consumption. R&D&I funding will also be allocated to the development of these new business models.

Five years ago, Finnish Funding Agency for Innovation Tekes made large investments in SHOK programmes (Strategic Centres for Science, Technology and Innovation). Of the energy and environmental sector programmes, SGEM (Smart Grid and Energy Markets) has produced significant competence that can be utilised in the development of intelligent electricity networks and smart control. The FLEXe programme (Flexible Energy Systems) initiated an examination of the requirements for a flexible energy system. Companies will take the lead in utilising the programme's research findings. A project due for completion in 2016 is investigating the building of an intelligent and flexible energy system in the Åland Islands. For experimentation and development purposes, cooperation networks (ecosystems) are to be established where the parties produce added value in the form of products, services and information in close interaction, both for each other and customers outside the ecosystem.



## **4 Energy and climate strategy impact assessments**

### **4.1 Target achievement**

#### EU 2020 targets

Even with the current measures, the share of renewable energy in final energy consumption will clearly exceed 40 % before the end of the government term, and new measures will thus not be needed in order to meet the EU 2020 targets or the associated Government Programme targets. The new measures proposed in the strategy will mainly increase the share of renewable energy in the next decade.

In terms of non-ETS greenhouse gas emissions, it appears that taking into consideration emissions produced during the entire period, or the years 2013–2020, Finland would meet its binding targets under the Effort Sharing Decision by means of domestic emission reduction measures and by banking and borrowing annual emission allowances.

#### Reduction of greenhouse gas emissions by 2030

The proposal issued by the Commission in July 2016 that concerns a 39 % reduction in emissions by 2030 compared to 2005 is challenging and will require a considerable number of additional measures. This strategy outlines the most central new measures by which Finland aims to achieve the target. The medium-term climate policy plan to be issued in spring 2017 will specify and complement the measures needed to achieve this target.

The emission reductions that must be achieved by 2030 amount to approximately 5 Mt CO<sub>2</sub> eqv. compared to the basic scenario if Finland resorts to the one-off flexibility mechanism to reduce the required cuts in emissions. Transport sector energy efficiency measures together with the obligation to distribute biofuels will take care of the greatest cuts in emissions. The second most important action that will influence target achievement will be the inclusion of waste incineration in the emissions trading sector. It is also proposed that emissions will be cut by an obligation to distribute light fuel oil blended with a 10 % share of bioliquids, restricting nitrous oxide emissions from organic soils, and measures that concern F gas emissions. In addition, a number of smaller measures and possible new actions has been identified whose cost-effectiveness, practicability and impacts will be assessed when drafting the climate policy plan. At least some of these additional measures will be needed to enable Finland to achieve the emission reductions required in the effort sharing sector. The most cost-effective additional measures and the range of emission reductions achieved by them as indicated by the modelling exercise carried out by VTT Technical Research Centre of Finland are described in section 4.4.

#### Increasing renewable energy use and self-sufficiency in energy supply

The proposed policy measures will significantly increase the volume of renewable energy and the self-sufficiency of energy supply in the next decade. The higher distribution obligations of biofuels and bioliquids will help replace fossil oil products and increase renewable energy use by some 7 TWh by 2030. While the biofuel manufacturing process will increase the final energy consumption, as the energy used by biorefineries is mainly renewable, biofuel production itself will increase the share of renewable energy in Finland's final energy consumption. Aid for industrial-scale electricity production will increase wind power production and other renewable electricity generation by a total of 2 TWh. Promoting the use

of gas-powered vehicles together with other measures to encourage biogas use and production will increase the use and production of biogas to some extent.

As an estimate, the share of renewable energy in final energy consumption will reach some 50 % in 2030. The Government's target for the end of 2020s can be reached by means of the proposed measures.

As a result of the new policy measures, Finland's self-sufficiency in energy supply would rise to approx. 55 % of final energy consumption in 2030. The exact share will depend on the proportion of forest chips and biofuels that will ultimately be imported. In other words, the strategic policies will implement the government's self-sufficiency target.

#### Increasing renewable energy use in transport

Transport sector energy efficiency measures, an increased obligation to distribute biofuels, and increasing the number of electric vehicles to 250,000 and the number of gas-powered vehicles to 50,000 will bring the share of renewable energy use in transport up to over 50 %, which clearly exceeds the 40 % target set out in the Government Programme.

#### Halving the use of imported oil for energy

The volume of imported fossil oil in the basic scenario is 57 TWh in 2030, which exceeds the target for halving the use of imported oil, or 44 TWh, by more than 12 TWh. Transport sector energy efficiency measures together with the increased obligation to distribute biofuels will reduce the use of fossil oil by an estimated 10 TWh by 2030. Blending light fuel oil with bioliquids will replace some 1.5 TWh of oil in 2030.

The proposed policy measures will more or less achieve the target for halving the use of imported oil. The impacts of emission reduction measures to be specified later in connection with the formulation of the climate policy plan will also be assessed in terms of the target for reducing imported oil use.

#### Phasing out coal in energy production

The calculations in the basic scenario indicate that the use of coal for energy will keep declining. The policies of the strategy will speed up this development and ensure that the use of coal for energy will have been phased out by 2030, taking into account the perspectives associated with the security of supply in energy, emergency supply and exceptional situations.

## **4.2 Impacts on wood use and carbon sinks**

### Wood fuels

The majority of wood fuels are obtained as by-products from the sidestreams of wood processing, including black liquor, bark and sawdust. Wood-based raw materials will also be used for producing transport biofuels. As set out in section 3.4, the objective is that the majority of forest-based energy will continue to be produced on market terms from the sidestreams of forestry and other wood-processing industry. By means of various policy measures, forest-based biomass will be channelled to replace fossil fuels in heating, CHP production and the manufacture of transport biofuels and other bioliquids.

The basic scenario of the energy and climate strategy (WEM) indicates that in 2030, 48 TWh of energy would be produced from the waste liquors of wood-processing industry and 66 TWh from solid wood fuels. As regards forest chips, the basic scenario estimates that in 2030, 29 TWh of electricity and heat would be produced from forest chips. This would correspond to some 14.5 million m<sup>3</sup> of forest chips. Based on the studies and calculations prepared for the policy scenario (WAM), it has been estimated that the demand for wood biomass in the manufacture of transport biofuels will be in the range of 3–4 million m<sup>3</sup>. Based on the estimates given above, the overall use of forest chips in the production of electricity, heat and various liquid biofuels in 2030 is expected to amount in total to 14–18 million m<sup>3</sup>/year. In impact assessments prepared for the Energy and Climate Strategy, the total use of forest chips in 2020–2030 was put at 13.5, 15 and 17 million m<sup>3</sup>. No significant changes are expected to take place in the use of forest chips and traditional firewood in households and on farms.

#### Estimates concerning the development of the carbon sink of forests and biodiversity

Natural Resources Institute Finland assessed the expected development in the greenhouse gas balance of forests including soil based on three roundwood removal scenarios. In these scenarios, the annual roundwood removal figures were approximately between 73 million m<sup>3</sup> and 79 million m<sup>3</sup>, and in the scenario based on the greatest removals of roundwood that would be sustainable in terms of wood production, 89 million m<sup>3</sup>. During the last ten-year period, the corresponding roundwood removal volume was on average 60.6 million m<sup>3</sup>, and in 2015, 68 million m<sup>3</sup>. In other words, the volume of roundwood removal would increase from the current figures in all the calculated scenarios. The scenarios did not account for the possible impacts of climate change on forest growth over the period of scrutiny, as these values are associated with significant uncertainties. It is likely that climate change will spur forest growth but also increase the occurrence of different types of forest damage, which will reduce forest growth.

The Energy and Climate Strategy is based on a roundwood removal scenario in which the annual total removal of roundwood was estimated to grow to 79 million m<sup>3</sup>/a year by 2035. In this case, the removal of roundwood would almost reach the target level of 80 million m<sup>3</sup>/year set in the National Forest Strategy for 2025. Similarly, the Energy and Climate Strategy is consistent with the Government target of increasing annual wood use by 15 million cubic metres from the current values. In the calculations, three different figures for the volume of forest chips were examined, or 13.5, 15 and 17 million m<sup>3</sup> annually.

The difference between the carbon dioxide that is captured from the atmosphere and stored as forest growth and the carbon dioxide released in connection with fellings, or the carbon sink of forests, has varied between approx. 20–50 million tonnes in 1990–2013 in carbon dioxide equivalent (Mt CO<sub>2</sub> eqv.). Annually, the net sink of the Finnish forests has corresponded to 30–60 % of Finland's total emissions. The carbon sink of Finnish forests according to the greenhouse gas inventory was 26 Mt CO<sub>2</sub> eqv. in 2013. If the fellings of roundwood were increased to 79 million m<sup>3</sup>/year and forest chip use would amount to 15 million m<sup>3</sup> annually, the carbon sink would be reduced to 13.5 Mt CO<sub>2</sub> eqv. by 2030. The reference level set for Finland for the period 2013–2020 (approx. 20 Mt CO<sub>2</sub> eqv./year) would be achieved again relatively soon, or in 2035–2044.

In addition to the carbon sink impacts, the Natural Resources Centre Finland and the Finnish Environment Institute have also assessed impacts on biodiversity on the basis of the scenarios. They scrutinised the biodiversity impacts on key structural features of the forests, which include the structure of the standing crop, the age structure of forests and the volume of deadwood. A central conclusion of the scenario exercise was that fellings of roundwood can

be increased to 79 million m<sup>3</sup>/annually while also safeguarding forest biodiversity. A precondition for this is a more intensive use of the existing nature management methods for biodiversity enhancement in commercial forests. They include saving more dead trees in fellings, promoting the conservation of old-growth forests and sites of high natural value, avoiding harvesting on valuable natural sites, leaving more large living trees standing in regeneration fellings and burning for environment management purposes.

If the removal of roundwood increased up to the greatest sustainable level in terms of wood production, which would be 89 million m<sup>3</sup> annually, the forests would only represent a very small sink by the middle of the period 2015–2024. The sink would turn into an emission in the years 2025–2034, only to revert to a minor sink towards the end of the period 2035–2044. In this case, further measures would also be required to safeguard biodiversity.

In addition to the impacts on carbon sinks and biodiversity based on roundwood removal and volumes of forest chip use, Natural Resources Institute Finland has also evaluated the total technical and economic potential of forest chips. Forests are no longer grown and felled for energy use in Finland, and thus the potential for forest chips depends on the extent of final fellings and forest management operations.

Natural Resources Institute Finland has estimated the technical harvesting potential of crown mass at 11.6 million m<sup>3</sup> and that of stumps at 12.0 million m<sup>3</sup> annually if the felling volumes of timber reached the greatest level sustainable in terms of timber production. The availability of crown mass and stumps has significant links to the volume of final fellings. The estimates of the potential in small-diameter trees are 6.2–8.3 million m<sup>3</sup>, depending on the harvesting technique. Harvesting may refer to the harvesting of delimbed or whole trees, or combined harvesting of energy wood and timber.

In addition to national estimates, Natural Resources Institute Finland has also examined the sufficiency of forest chips in regional terms. The results indicate that the greatest volumes in proportion to the potential for harvesting crown mass, stumps and small-diameter trees exist on the southern coast and on the Bothnian Bay coast. The greatest unused forest chip potential is found in Central and Eastern Finland and in Kainuu.

#### **4.3 Impacts on central government finances**

Issues related to funding needs will be processed and the relevant decisions will be made within the central government spending limits in the General Government Fiscal Plan, coordinated with other expenditure needs of the public economy. Table 1 shows a compilation of funding related to the Energy and Climate Policy for 2017–2020 in the budget for 2017 and the General Government Fiscal Plan for 2017–2020.

**Table 1: Funding under the current General Government Fiscal Plan**

Appropriation	EUR million				
	2017	2018	2019	2020	2021–2030 Total
<u>Ministry of Economic Affairs and Employment</u>					
Investment subsidies for renewable energy and new energy technology (32.60.45.)	40	40			
Operating aid for electricity from renewable energy sources (item 32.60.44)	245	305	305	245	1,340
<u>Ministry of Agriculture and Forestry</u>					
<u>Rural Development Programme:</u>					
Certain agri-environment payment measures					
Balanced use of nutrients 1)	103.2	103.2	103.2	103.2	
Incorporation of slurry into fields 1)	7.4	7.4	7.4	7.4	
Control of runoff waters 1)	6.0	6.0	6.0	6.0	
Environment management grasslands 1)	35.4	35.4	35.4	35.4	
Wetland management 1)	0.5	0.5	0.5	0.5	
Advice 1)	4.0	4.0	4.0	4.0	
Renewable energy investments	9.0	9.0	9.0	9.0	
<b>TOTAL appropriations (national funding)</b>	<b>385</b>	<b>445</b>	<b>405</b>	<b>345</b>	<b>1,340</b>

1) Contains 42 % of EU co-funding

Budget authority	EUR million				
	2017	2018	2019	2020	2021–2030
<u>Ministry of Economic Affairs and Employment</u>					
Energy aid (32.60.40.)	35	35	35	35	
<b>TOTAL budget authority</b>	<b>35</b>	<b>35</b>	<b>35</b>	<b>35</b>	<b>0</b>

**Table 2: Estimate of new funding needs arising from the proposed measures**

Appropriation	EUR million				
	2017	2018	2019	2020	2021–2030 Total
<b>Ministry of the Environment</b>					
Piloting of digital mobility services (Ministry of the Environment + Ministry of Transport and Communications)	0.5	0.5	0.5	0.5	
Market experiments related to low-carbon business and service platforms (e.g. former railway stations as hubs)	2.5	2.5	2.5	2.5	
Guidance by information in wood construction		2	2	2	
<b>Ministry of Agriculture and Forestry</b>					
Additional needs of R&D related to sink policy measures	0.75				
<b>Ministry of Economic Affairs and Employment</b>					
Operating aid for renewable electricity (new aid scheme based on a tendering process)				13	265
<b>Ministry of Transport and Communications</b>					
Promoting energy-efficient vehicles (electricity and gas)		25	25	25	25
<b>TOTAL appropriations</b>	<b>4</b>	<b>30</b>	<b>30</b>	<b>43</b>	<b>290</b>
Budget authority	EUR million				
	2017	2018	2019	2020	2021–2030
<b>Ministry of Economic Affairs and Employment</b>					
Energy aid (32.60.40.)		5	5	5	400
Major new energy technology products (incl. biorefineries)			60	60	240
<b>TOTAL budget authority</b>	<b>0</b>	<b>5</b>	<b>65</b>	<b>65</b>	<b>640</b>

Table 2 provides initial estimates of the completely new funding needs arising from the new measures proposed in this document in 2017–2020 and 2021–2030. A significant part of strategy implementation costs would be realised after 2020.

The most important new funding needs arise from subsidising renewable energy. It is proposed that the current energy aid scheme be continued after 2020, and a general increase of EUR 5 million is proposed in the relevant budget authority. The Government Programme contains an agreement on a support programme for key energy projects in 2016–2018. It is proposed that this support programme be continued in 2019–2023, with an annual budget authority of EUR 60 million. Under this support programme, experimental new energy technology projects with significant technological and economic risks would be funded. Implementing projects of this type is vital in order to realise investments in innovative solutions in Finland. Some of the funding would be used on biofuel production projects.

Operating aid for renewable energy based on a tendering process would be introduced as a transition period solution. In 2018–2020, a tendering process that concerns electricity production capacity amounting to a total of 2 TWh would be organised. Based on assumptions concerning the price of electricity used in the strategy, the required central government appropriations would be some EUR 13 million in 2020 and some EUR 265 million in total in 2021–2030.

New steering instruments will be needed to achieve the strategy's target of having at minimum 250,000 electric vehicles and 50,000 gas-powered vehicles in Finland by 2030. Many technologies and infrastructure systems related to alternative transport power sources are still undergoing development. Due to the technology risks associated with them, risk support is needed to promote the wider use of alternative power sources. The annual need for this support in 2018–2021 is estimated at some EUR 25 million.

Table 3 shows an estimate produced by the Ministry of Transport and Communications and the Ministry of Economic Affairs and Employment of the impacts that the proposed measures will have on reducing central government income in 2017–2020 and 2021–2030.

**Table 3: Estimate by the Ministry of Transport and Communications and the Ministry of Economic Affairs and Employment of the proposed measures' impacts that reduce central government's tax revenue**

	EUR million				
	2017	2018	2019	2020	2021–2030
<b>Reduction in central government revenue</b>					<b>Total</b>
Tax revenue from transport fuels					543
Revenue from car tax		2	4	6	540
Revenue from vehicle tax					23
Tax revenue from light fuel oil					143
Emission allowance trading revenue lost because of one-off flexibility					160
<b>Total reduction in tax revenue</b>	<b>0</b>	<b>2</b>	<b>4</b>	<b>6</b>	<b>1,409</b>

The most significant impacts that will reduce the central government income in the transport sector will be due to the proliferation of low-emission vehicles and the slower increase of transport performances. At the current rates of energy taxation, the tax revenue would be reduced by EUR 543 for the part of transport fuels and by EUR 540 for the part of car tax in 2021–2030. The yields from vehicle tax would only be reduced by EUR 23 million in the same period, as this reduction will be compensated for by an increase in the accrual of the power source component of the vehicle tax.

The replacement of 10 % of light fuel oil in heating and machinery with bioliquids will reduce tax revenue by EUR 160 million at the current rates of energy tax in 2021–2030.

Utilising a one-off flexibility mechanism of 2 percentage points will reduce the central government's trading income by an estimated EUR 160 million with the price assumptions used in the strategy.

#### **4.4 Impacts on the Finnish energy system and non-ETS greenhouse gas emissions**

VTT has assessed the impacts of the energy and climate policy measures on Finland's energy system and, in a broader context, energy economy in a project of the Government's analysis, assessment and research activities titled Keiju (Sustainable energy and climate policy and the role of renewables in Finland). The global TIMES-VTT energy system model was used to calculate the scenarios. This model contains a more accurate description of the Finnish, Swedish, Norwegian and Danish energy systems and data on other countries aggregated to form larger areas. Additionally, the model describes the trade in all energy commodities, which also enables the preparation of calculated impact assessments of self-sufficiency in energy supply.



The impact assessment set out, first of all, to examine how Finland could cost-effectively meet the EU's ETS sector target for reducing greenhouse gas emissions. Another focal point were assessments of how the measures taken under the Energy and Climate Strategy would influence Finland's energy system: the impacts on the structure of energy production, energy use in different final energy consumption sectors and cost-effectively cutting greenhouse gas emissions, also taking into account the trading of emission allowances in the EU area. The WAM scenario contains the new measures set out in the strategy through which Finland aims to attain the emission reduction target. The requisite additional measures were optimised using the TIMES-VTT model on the basis of their cost-effectiveness. The additional measures will be outlined in the medium-term climate policy plan to be adopted in 2017.

#### Initial assumptions of the WEM and WAM scenarios

The input data and initial assumptions of the With Existing Measures (WEM) scenario that contains the current policy measures are in line with the background assumptions of the energy and climate strategy baseline scenario published on 15 June 2016. The With Additional Measures (WAM) scenario is based on the following assumptions:

- The blending obligation of road transport fuels will be 30 %, which will be implemented in 2030 by following a linear trajectory from the 2020 target level.
- The obligation to blend light fuel oil for machinery and heating of buildings with bioliquids will be 10 % in 2030.
- The production capacity of new sustainable biorefinery products will be 600 ktoe in 2030, of which 300 ktoe will come from wood-based raw materials, and 300 ktoe will be produced from bio-based wastes and other bio raw materials.
- Aid for wind power production will be continued, ensuring that in 2021–2024, 2 TWh of new wind power capacity will be deployed in productive use.
- The energy efficiency of the transport system will be improved in both passenger and goods transport. The number of electric vehicles will be a minimum of 250,000 and the number of gas-powered vehicles 50,000 in 2030.
- It is assumed that 2 percentage points of the emission reduction target can be covered by ETS sector flexibility mechanisms in 2030.
- Inclusion of waste incineration emissions in the ETS sector. More efficient enforcement of the landfill ban and collection of landfill gases offer further potential for reducing emissions.
- In farming, the emission reduction potential of organic soils will be over 0.3 Mt by 2030. Additionally, there is significant potential for increasing biogas production, or at minimum 1 TWh.
- More efficient collection and reduction of F gases offer further potential for cutting emissions.

#### Meeting of Government Programme targets

For data on meeting key Government Programme targets related to the energy system, see Table 4. In the examination of the energy system, the target for reducing ETS sector emissions, or 37 %, was set as a fixed limit in the modelling, and it will thus be achieved exactly. Rather than modelling the other targets directly, their achievement in the WAM scenario is an outcome that the model produced on the basis of all other input data.

The results indicate that the target for reducing oil consumption, or 50 % from the 2005 level, will be achieved more or less as planned in the WAM scenario, in which a calculated reduction of some 50 % will be realised. The 50 % target set for the share of renewable energy will also be narrowly achieved. The calculations indicate that the assumptions that concern investments in wind power would appear to influence target achievement; in other words, if the assumed operating aid for additional wind power capacity of 2 TWh is excluded from the model, the target for renewable energy will not be attained in the calculations. On the other hand, the target concerning the share of domestic energy that is related to self-sufficiency, or 55 % of final energy consumption, will be exceeded according to the modelling results. Phasing out coal use in energy production will be achieved, apart from minor condensing power production during periods of peak consumption in winter.

**Table 4. Achievement of key Government Programme targets in the WAM scenario**

Target	Target level 2030	Implementation in WAM scenario
Reduction in ETS sector emissions	39% (from 2005 levels)	39% (presuming that 2 percentage points are achieved through flexibility mechanisms)
Reduction in oil consumption	50% (from 2005 level)	Approximately 50%
Increase in the share of renewable energy in final energy consumption	50%	50%
Increase in the share of domestic energy in final energy consumption	55%	56%
Reduction in the use of coal for energy production	0–2.5 TWh (as fuel)	2.2 TWh

If we presume that 2 percentage points of the 39 % reduction target in the ETS sector can be covered by resorting to flexibility mechanisms, the remaining net reduction target of 37 % will, according to VTT's estimates, correspond to emissions of 21.2 Mt CO<sub>2</sub> equivalent in 2030. Similarly, if the ETS sector emissions in the WEM scenario are 25.8 Mt in 2030, the need for additional reductions in the WAM scenario are approx. 4.6 Mt. According to the results, these additional reductions are divided as follows:

**Table 5 Realisation of additional measures to reduce emissions in the WAM scenario**

Additional measure	Impact in 2030
Improvement in transport system energy efficiency	0.7 Mt
Increase in the blending obligation of motor fuels to 30%	2.1 Mt
Introduction of a blending obligation for machinery	0.2 Mt
Introduction of a blending obligation for heating oil	0.4 Mt
Restriction of emissions from organic soils in agriculture	0.3 Mt
More efficient capture of F gases and criteria for refrigerants	0.2 Mt
Inclusion of waste incineration in the ETS sector	0.6 Mt
More efficient enforcement of the landfill ban and landfill gas collection	0.1 Mt

#### 4.5 Impacts on the national economy

The Paris Climate Agreement gives a boost to global markets in the so-called cleantech sectors and thus opens fairer opportunities for the Finnish industry as other countries have also given commitments to cut their emissions. The impacts of the Paris Agreement are included in the basic scenario of the strategy.

VTT has assessed the impacts of the energy and climate policy measures on the Finnish national economy in a project of the Government's analysis, assessment and research

activities titled Keiju (Sustainable energy and climate policy and the role of renewables in Finland), in which the national economy is described through a calculated balance model. The balance model describes the economy from the perspective of decisions made by households, companies and the public sector. The impact assessment of the measures implemented in the With Additional Measures scenario (WAM) compares the impacts of the new policy measures to the With Existing Measures scenario (WEM), in which the future is analysed in terms of our current ideas of the development in the global market and the domestic economy. The WEM scenario takes into consideration policy decisions that have already been made. The most important ones of these are the pension reform which will ameliorate the looming shortage of labour, especially in the 2020s, as well as the social contract that will already promote competitiveness and preconditions for economic growth in the next few years. In addition, the impacts of the pending social and health care reform on the need for labour and the public economy were anticipated in the assessment.

Key assumptions in the WAM scenario's assessment of impacts on the national economy include the following:

- The energy system will follow the WAM scenario assessed using the TIMES-VTT model
- Biofuel production will follow the estimate produced using the TIMES-VTT model
- Transport sector development will stay in line with the estimate produced by the Ministry of Transport and Communications on transport performance and vehicle fleet trends
- Financial steering will have no net effect on the budget

In the WAM scenario, reductions in greenhouse gas emissions will mainly be achieved by means of energy system and ETS sector measures. The impacts of emissions trading were already taken into account in the WEM scenario. However, the structure of both the production and consumption change in the WAM scenario, which will have an impact on the budgetary position of the public sector. In addition, the support required by biorefineries will increase public expenditure, while the growing share of biofuels and a transport performance that will increase more slowly than in the WEM scenario will reduce the fuel tax accrual. It was assumed that budget neutrality will be achieved by a small increase in commodity tax (for example, through value added taxation).

In addition to the impacts associated with central government finances, increasing the share of biofuels by means of the distribution obligation will also push transport costs up, as the price of renewable diesel is higher by some 33 cents/l than the price of fossil fuels. As an estimate, this would mean that with a blending ratio of 30 %, diesel users will incur an annual additional cost of EUR 210 million compared to the current prices. Similarly, replacing light fuel oil with a bioliquid in heating and machinery will increase the users' costs. A blending ratio of 10 % in light fuel oil will increase the fuel oil price by some 6 cents/l, or 8 %. If the oil consumption of an oil-heated low-rise building is 3,000 l a year, the annual cost impacts will be approx. EUR 180. As regards machinery, the cost increase ensuing from the blending obligation would primarily affect businesses and agriculture. In proportion, the increase in fuel oil costs will be approx. 8 %, or similar to the cost increase of oil heating. The absolute effects will, however, depend on company size and machinery use. Petrol is also used to some extent in machinery.

For the impacts of the WAM scenario on the national economy, see Table 6. The domestic product will be approx. 0.6 % smaller in 2030 than what is shown in the WEM scenario. This impact will be caused by lower private consumption and investments than in the WEM scenario and a slowing down of foreign trade. The impact on the domestic product will mostly be created by a decline in exports, which will reflect the impacts of the measure on the domestic cost level. On the other hand, imports will also decline, which will increase the domestic product.

**Table 6. Impacts on the national economy (difference between the WAM and WEM scenarios) in 2030**

	Change compared to the WEM scenario, percent	Impact on the domestic product Compared to the WEM scenario, percent
Domestic product	-0.59	
Private consumption	-0.40	-0.23
Investments	-0.85	-0.10
Public consumption	0.00	0.00
Exports	-1.75	-0.76
Imports	-1.33	0.49

While the change in employment in the national economy as a whole is put at -0.15 %, it is expected that primary production and energy supply sectors will preserve their current employment levels at minimum.

More employment will be created especially in the production of biofuels and bioenergy. The increase in the biorefining of forest raw materials (300 ktoe) will increase employment by 2,000 person-years. In other biorefining sectors, the increase (300 ktoe) is estimated to be 150 person-years.

It is expected that the 2 TWh increase in wind power capacity will create 400 person-years' worth of employment.

As coal use is phased out, chip and pellet boilers and heat pumps will create new heat production, but the quantitative impact on employment in these sectors is difficult to estimate.

#### **4.6 Environmental impact assessment of the Energy and Climate Strategy (plans and programmes of public authorities)**

If the policies of the Energy and Climate Strategy are implemented, they will have both positive and negative impacts referred to in the Act on the impact assessment of plans and programmes of public authorities on the environment and society. Positive impacts mean consequences that promote the achievement of the set societal objectives, whereas negative impacts mean consequences that hamper the achievement of objectives other than the climate targets. In addition to greenhouse gas emissions, the impacts of the policies will affect such areas as air pollution, human health, natural resources use, biodiversity, carbon sinks of forests, water systems and human living conditions. Some of these impacts will be felt outside the Finnish borders.

Observations show that the average temperature of the Earth has increased by approximately one degree over the last one hundred years. Major variations have been recorded between different years and decades, but all of the warmest years have occurred since 1997. A new global temperature record was made in 2014, only to be exceeded in 2015. Preliminary data

indicates that 2016 was even warmer. The impacts of climate change can already be observed globally as extreme weather phenomena and their consequences. The Paris Climate Agreement approaches climate change mitigation in a new way through undertakings given by all signatories. In order to inspire international trust, the impacts of mitigation measures should be assessed in all countries as thoroughly and transparently as possible, both in terms of reducing greenhouse gas emissions and other impacts. This will also help to manage any side effects. The impacts of the Climate and Energy Strategy have thus been diversely assessed in research projects launched by the Prime Minister's Office. The results of these projects informed the preparation of the strategy.

Cuts in greenhouse gas emissions in line with the strategy will be achieved, in particular, by replacing fossil fuel use in different sectors with renewable energy and electricity and by reduced and more efficient energy use. However, all infrastructure and power generation related construction as well as the manufacturing and use of biofuels, heat pumps and electric vehicles are associated with the consumption of materials and energy, which may contribute to reducing the environmental benefits achieved.

It is estimated that while the quantity of air impurities will be reduced as a consequence of the policies proposed in the strategy, health risks associated with them will continue to be significant. Emissions from the high stacks of power plants have a minor impact on today's air quality. Policies seeking to reduce transport performances or increase the number of electric and gas-powered vehicles play the most significant role in reducing air impurities, as they cut the emissions of nitrogen oxides and fine particles. The impact on air quality in cities will ultimately also depend on trends in vehicle performance and their geographical distribution.

Small-scale burning of wood in fireplaces is a key question for air quality. Small-scale burning is a source of small particles that cause negative health impacts, as well as black coal and methane that warm the climate. While the strategy's policies will not significantly change the current status of small-scale burning, these emissions can be influenced by means of technical standards, innovations, education and instructions issued by municipalities among other things.

Policies seeking to promote the increase of renewable energy place particular emphasis on bioenergy used in transport, buildings and machinery. Approximately one half of the increase in bioenergy will be based on the use of wood-based raw materials, which are obtained from both forest industry sidestreams and forest chips. The strategy's basic scenario predicts that timber harvesting will increase from its current level. The harvesting volumes will determine the development of carbon sinks. For a more detailed discussion of the carbon sink impact of forests, see section 4.2. However, the significance of the sink impact for meeting the EU 2030 target will depend on the details of the calculation rules to be agreed upon within the EU. Additionally, forestry operations will affect the albedo of forests and the volume of volatile compounds that contribute to cloud formation. The climate impacts of these factors remain relatively little known.

In addition to climate impacts, a significant increase in wood use compared to the current level may undermine forest biodiversity and cause harmful impacts on water bodies. The impacts will strongly depend on the extent to which the fellings and the harvesting of stumps and felling residues will increase as a result of increased wood use. Stress on water systems is mainly caused by fellings, fertilisation and ditch reconditioning.

The scrutiny of biodiversity impacts focused on key structural features of the forests, which include the structure of the standing crop, the age structure of forests and the volume of

deadwood. The key conclusion of the scenario examination is that the harvesting of roundwood can be increased to some 73–80 million m<sup>3</sup>/year from today's levels without causing significant adverse effects on the current status of forest biodiversity. A precondition for this is a more intensive use of the existing methods for biodiversity promotion. They include saving more dead trees in fellings, promoting the conservation of old-growth forests and sites of high natural value, avoiding harvesting on valuable natural sites, leaving more large live trees standing in regeneration fellings and burning for environment management purposes.

In farming, increasing grass cover on organic soils will reduce CO<sub>2</sub> emissions from the degradation of peat and also the leaching of nitrogen into water systems. While the carbon sink can be increased by reforestation of fields, reforestation also reduces habitat for open area species and changes the landscape. Increasing biogas production from biowaste will enable avoidance of emissions from degradation and nutrient recycling, which reduces emissions by restricting the need to manufacture new fertilisers. In farming, biogas production may indirectly reduce land clearing and the consequent emissions into air and water bodies.

The increased use of renewable energy sources, especially wind power stations and solar panels, will reduce air pollution but increase the use of rare materials and create pressures to open mines in which these materials may be obtained. However, solar panels are evolving rapidly, and in the future, more common raw materials may be used for manufacturing them. The increase in renewable energy will be likely to improve employment and thus human well-being in areas targeted by investments, construction and raw material acquisition. However, the impacts on the national economy will depend on such factors as how the measures will affect other domestic investments and technology industry imports as well as the use of flexibility mechanisms for meeting the binding emission targets.

Regulation of construction and land use will have a direct impact on living conditions. There is a great need for renovations that improve energy efficiency, especially in older building stock. While some of the current indoor air problems may be solved as these renovations are implemented, it is necessary to ensure the repairs do not create new indoor air quality risks.

The strategy's policies will create better preconditions for developing public transport, cycling and walking and reducing the transport performances of private cars. This will have positive impacts on health and comfort. Electric vehicles will reduce noise and air pollution. Reduced transport performances, on the other hand, will cut street dust emissions, and journeys taken by cycling and walking will increase the population's physical activity, bringing diverse health benefits. At the same time, attention should be paid to the fact that the implementation of these policies may locally increase pressures on green spaces or exposure to noise and air pollution in areas with a highly compact urban structure. The significance of the impacts will to a great extent be determined by the planning and practical implementation of the measures and general technical development.

The targets for reducing greenhouse gas emissions by 2030 and beyond are so demanding that climate change mitigation measures will have major impacts on people's general living conditions. Some of the measures will encourage innovations, which may offer new business opportunities and jobs. The consumer's position may also change.

While technological progress may enable energy savings without the consumers taking on an active role, many of the policies require a new type of agency of the citizens in changing



living conditions. The Transport Code (HE 161/2016 vp), for example, may bring about significant changes in the way transport services are provided and used. The sharing economy also entails a major sociocultural change. Various population groups may be in very different positions in terms of how easy it is for them to participate in the sharing economy or how efficiently they can use the new services. The policies combined with other national and international developments may also have a direct impact on the living conditions. Income gaps, for example, may become more significant if there is a major increase in energy prices and energy-saving investments are costly.

The Energy and Climate Strategy consists of a number of policies with interlinking impacts. Strategy implementation will also have dynamic impacts, as a result of which new solutions for climate change mitigation will emerge. These will have further environmental impacts, both positive and negative ones. By recognising and accounting for the links between various environmental impacts, synergy benefits may be achieved in reducing harmful impacts. We must also take into consideration the fact that the general (global) economic development and, among other things, aid policies related to different energy production methods, will modify the challenges and pressures that affect climate change mitigation. The entire course of the development may change rapidly, which increases the uncertainty of impact assessments. For this reason, it is essential to monitor the development of the anticipated (and as yet unanticipated) impacts to gain a better understanding of the observed development and identify areas in which amending or specifying the policies is justified. A precondition for this will be systematic data collection on policy implementation and regular evaluation of the consequences.

#### **4.7 Strategy monitoring and reporting**

The monitoring of and reporting on energy and climate issues as a whole, is an extensive area. It comprises a number of separate data collections repeated at different frequencies, production of assessments and the forwarding of results. A broad range of central government agencies and expert institutes participate in the reporting.

The achievement of the targets and implementation of the measures outlined in energy and climate strategies are monitored through both national and international reporting exercises. The reporting requires a great deal of stocktaking and follow-up. This work is divided between several research institutes and agencies. While the monitoring mechanisms are EU and UN led, reporting is also carried out for national needs. Climate policy reporting concerns the actual trends in greenhouse gas emissions as well as estimates of future development (projections) and policy measures. Reporting covers both implemented policy measures and ones on which decisions and plans exist, as well as evaluations of their impacts. Both ex-ante and ex-post evaluations of the impacts are carried out. The measures seeking to promote renewable energy are monitored in the EU through progress reports, and energy efficiency measures are reported on in connection with the national energy efficiency action plans. The monitoring reports and the associated data tables are public and can be accessed on the websites of the EU and UN climate agreement.

The reports to be produced are based on different EU directives and the Monitoring Mechanism Regulation (525/2013), reports required under the UN Climate Agreement, and information submitted to the Parliament, for example in the Government's Annual Report. Reports are also submitted to international organisations in which Finland is a member, including the International Energy Agency IEA, Organisation for Economic Co-operation and Development OECD, and the International Renewable Energy Agency IRENA.

The Climate Panel, which supports dialogue between science and policy and builds up policy-makers' climate awareness, has produced a report on the monitoring of the energy and climate strategy<sup>5</sup>. Among other things, the report examines the different actors' roles in the drafting and monitoring of the Energy and Climate Strategy and assesses the development of reporting.

The latest reporting requirements in the energy and climate sector were imposed by the Climate Change Act of 2015. This act contains provisions on climate policy plans on which the Government will issue a report to the Parliament. The Government's annual climate change reports also inform the Parliament on the achievement of climate targets and the impact of the measures taken. The first annual climate change report will be issued in 2018.

The European Commission is developing reporting as part of monitoring the achievement of Energy Union targets. The Commission is planning to streamline the current reporting practices. New issues on which reports shall be submitted are also being planned by the Commission. The reform prepared by the Commission would apply to the post-2021 period.

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<sup>5</sup> Energia- ja ilmastostrategian seuranta – raportoinnin systematiikka ja tiedon käytettävyys. Marja Järvelä, Eija Syrjämäki et. al. Finnish Climate Panel Report 1/2016 (edited in September 2016).

## **5 Examination of an energy system based on 100 % renewable energy sources**

Finland's long-term objective is to be a carbon-neutral society. The Parliamentary Committee on Energy and Climate Issues prepared an Energy and Climate Roadmap 2050 for Finland. Rather than producing delineated pathways towards 2050, the roadmap researched different alternatives and their impacts.

In connection with preparing the Energy and Climate Strategy that is the subject of this document, an energy system based on 100 % renewable sources was examined. This examination drew on earlier investigations, on-going research and expert discussions (including an expert workshop organised by the Climate Leadership Council, Greenpeace, Sitra and Demos Helsinki on 10 October 2016). The goal has been to identify the possibilities and challenges of using 100 % renewable energy sources in different sectors and at the energy system level. The outlook for different energy technologies and new energy solutions (including renewable energy sources) and the business opportunities created by them have, among other documents, been discussed in a Tekes report on the outlook for energy technology and new energy solutions.

Many examinations spanning a longer term that have been produced so far focus on reducing greenhouse gas emissions. In addition to renewable energy, means for reducing greenhouse gas emissions cited in these documents include nuclear energy and combining CO<sub>2</sub> capture and storage technologies with fossil fuel use.

A significant increase in wind and solar power plays a key role in a discussion focusing on 100 % renewable energy sources. The fast development of renewable energy technologies, including wind and solar power technologies, and their improved competitiveness compared to other alternatives, create potential for transitioning into to an energy system based on 100 % renewable energy sources. Over time, this development will change energy systems and markets. It is thus necessary to consider how the Finnish energy system and business life can preserve their competitiveness and capitalise on this transformation by offering solutions to the global market.

The increase in the share of variable production will create challenges for the electricity sector, the resolution of which will inevitably necessitate energy system level solutions. These challenges are accentuated by the Finnish climatic conditions. For this reason, too, nuclear power will be a necessary solution during an extended transition period in the electricity sector. Nuclear power investments made today can still be utilised decades later.

A precondition for increasing the use of renewable energy in heating is that fossil fuels, which are currently to a great extent used for district heating production, will be replaced by renewable energy sources. When increasing bioenergy use, the demand for biomass for uses other than energy production should be accounted for. District heating can also be produced with electricity. New technologies, including geothermal energy, will bring additional potential for increasing the share of renewable energy sources in district heating production. Building-specific heat production may rely on wood-based fuels, heat pumps, biogas, solar heat and different hybrid solutions.

In Finland, attention should be paid to the fact that heat consumption peaks coincide with other peaks in hourly demand for electricity. Increased use of electricity in centralised and decentralised heat production may exacerbate the electricity consumption peaks in winter and add to the challenge related to security of supply. Bioenergy use, especially in the winter

season, offers solutions to these challenges that are suited for the Finnish conditions. Advanced biofuels and electric vehicles offer potential for increasing renewable energy use in the transport sector. Over a longer term, air traffic and shipping as well as heavy goods transport, in which fewer other options for increasing renewable energy use are available, will probably be emphasised in biofuel use. The increase in biofuel use will also be restricted by the demand for biomass in other applications. Some of the biofuels or their raw materials may be imported. The proliferation of electric vehicles will be influenced by the fleet replacement rate as well as technology and infrastructure development.

The increase in the share of renewable energy in electricity production will also push up the share of renewable energy in the industry, which is a highly significant electricity consumer in Finland. The share of renewable energy used by the industry can also be increased by replacing fossil fuels with renewable energy sources in heat production. The industry also produces process emissions, and in practice, technological solutions based on the use of energy sources other than renewable ones will be required to reduce these emissions. Carbon dioxide capture and storage is an example of such solutions. When discussing the possibilities of increasing the use of renewable energy sources in the industrial sector, it is vital to also take into account the international competitiveness of the industry and long-term preconditions for growth.

In the future, different energy use sectors will be increasingly integrated and operating in mutual interaction. To achieve the flexibility needed by the electricity system, flexibility of demand will be needed in the industry, the heating sector and other electricity consumption. The transport sector where electricity and, over the longer term, also hydrogen are becoming more prevalent as power sources, as well as the district heating sector, can also be utilised for storing energy. Other elements that increase the flexibility and security of the energy sector will additionally be needed. New solutions, including Power to X technologies that are being developed may bring new possibilities of using renewable energy. In addition to new solutions, the existing systems also need to be utilised and reinforced. System level energy and resource efficiency will be stressed more than ever.

The challenges and possibilities are different in different countries. District heating infrastructure and CHP production are examples of an existing system that offers a country such as Finland a possibility of responding to challenges associated with the transition into an energy system based on 100 % renewable energy sources. Seasonal storage of energy is an example of challenges that require solutions suitable for a country such as Finland. Solutions developed in other countries may be poorly suited for the Finnish conditions and/or extremely costly. In particular, the challenges related to variable and weather-dependent production are completely different in Finland than, for example, in Southern Europe, where the peak consumption of electricity coincides with the hottest season. Whether or not apt solutions can be found to the challenges of seasonal variations in Finland and other Nordic countries will to a great extent determine the competitiveness of the energy system and energy market over the longer term.

Heat and electricity production based on bioenergy and transport biofuels are also available during the periods of peak consumption in winter. The use of biomass for energy should, above all, be based on the utilisation of sidestreams from the industry, wastes and residues. In forestry operations and timber harvesting, wood material suitable for energy use is also generated that is not fit for use as a raw material for wood processing, or for which there is not enough demand.

The Energy and Climate Strategy policies will enable a continuous increase in the share of renewable energies, also in the post-2030 period, and thus to a great extent be compatible with the strive for a carbon-neutral society that increasingly relies on renewable energy sources use over the long term.

Several drivers of change will influence the future development of the energy system, one of which is the rapid development of renewable energy technologies. The development of renewable energy technologies as an element in the wider energy system development should be monitored and evaluated as part of strategy implementation. Thus the rate and direction of the change can be examined, as well as the challenges and opportunities arising from it for Finland.

## **Appendix 1: Outlook and possibilities for energy technology development in 2030–2050**

On request of the Ministry of Economic Affairs and Employment, Tekes prepared a report on the outlook for energy technology development and new energy solutions by 2030 to be used as background material for the preparation of the national Climate and Energy Strategy.

The energy sector is undergoing a powerful transformation, which is associated with immense business potential, also for Finnish companies. New business activities may create new jobs and exports, and thus well-being for Finland. The transformation of energy systems has been launched globally, and Finland has every opportunity to be a pioneer in this area.

Key drivers of change are associated with technology development, decentralised and renewable energy production, digitalisation, urbanisation and the consumer's more important role. These changes operate in a strong interaction, which makes future development particularly difficult to predict. Energy production will no longer be the most significant business area in the future, as the energy sector will increasingly turn into a service business. The role of digitality will increase, and IoT technology development (IoT, Internet of Things) will generate new business models.

The future energy system will be flexible and intelligent. In addition to directing energy production, energy consumption may also be managed and coordinated as indicated by the current production situation. Hybrid systems that combine different forms of production will become more widespread. Flexibility of demand will change the role of the consumer. An active consumer will simultaneously consume, produce and store energy. Digitalisation and the Industrial Internet will help improve the efficiency of energy use everywhere. Energy efficiency is a cost-effective way of reducing greenhouse gas emissions, and the circular economy mentality will further increase the efficiency of resources use.

A changing, flexible energy system will also create new business models and, in particular, new service business that was not previously possible. The development of the blockchain technology and its expansion into the industry and the energy sector will transform the character of the entire business. Global investments in clean energy broke all records in 2015, reaching a total of USD 329 billion. An important reason for this increase in investments is a significant drop in solar and wind power technology prices.

It has been predicted that the use of fossil fuels, especially coal, will decline significantly after 2020. There will be a considerable drop in the use of oil for heating due to such reasons as a strong increase in geothermal heat use. In the transport sector, on the other hand, reducing oil use will require further actions and investments in such areas as biofuels and electrification. Natural gas is considered a so-called bridging technology that can also replace oil in transport, as the changes this would require in the vehicle fleet are minor. Natural gas use will also enable increasing utilisation of biogas.

Globally, bioenergy is the most important source of renewable energy, and its production will expand in a near future. Biofuels, and especially transport biofuels, will also keep increasing after 2030, but as the electrification of transport will make headway at the same time, we should be prepared for the possibility that biofuels will also be a bridging product before electrification. The increase in the share of bioenergy use in electricity production is likely to remain minor in the future. Many stakeholders (IEA, IRENA) predict that the share of

bioenergy in renewable energy production will remain predominant, however, or at 50–60 % until at least 2030.

The Nordic countries have for a long time been pioneers regarding the electricity market. For example, a joint market has made it possible to level out fluctuations in Danish wind power production with hydroelectric power produced in Norway and Sweden. The Nordic countries have also shown that cutting emissions has not had a negative impact on the economy. The increasingly European market may change this situation. The use of hydroelectric power as a regulating power within the Nordic countries may decline if power can be obtained at a better price from Central Europe. This will bring pressures to increase electricity prices in the Nordic countries and hamper the management of renewable production.

The Nordic heating market amounts to some 240 TWh, of which district heating accounts for 43 %. There has been a significant drop in the use of fossil fuels in heat production in recent years. By 2030, carbon-neutral heat production will be possible as the energy efficiency of buildings improves, wood-based pyrolysis oil is commercialised, and biogas production and use increase. Heat pumps will continue to increase in popularity, and the utilisation of solar heat together with developing heat storages will become more common.

When renewable energy production increases, the power balance of the electricity system will be more difficult to maintain as weather-dependent solar and wind power assume a more dominating position in the energy palette. There will be an obvious need for flexibility in production and consumption. This, indeed, is a key goal in developing an intelligent electricity network. Flexibility of demand will change the role of the consumer. An active consumer will simultaneously consume, produce and store energy. The advancing technology will make it easy for the consumers to monitor their electricity consumption and to integrate their production and storage capacity with the system. Smart solutions in distribution network management, flexibility of demand solutions and advanced transmission technologies will play key roles in this.

#### Outlook for technology development

High-quality and internationally appreciated research in the further development of **solar technology** is conducted in Finland. Solar panels are also manufactured in Finland. However, Finnish companies will find larger markets in power electronics, automation and intelligent control systems. **Solar heating or cooling** remain little used. Different hybrid energy systems, in which the heat requirement is met with several mutually supportive energy sources, are also highly suitable for heat production. In a hybrid system solar heat can, depending on the site, be combined with a heat pump, a fireplace with a back boiler, bioenergy, oil and/or district heating among other things.

It is expected that **wind power production** will increase globally from 400 GW in 2015 to over 1,800 GW in 2030, and a significant growth is predicted for land-based wind power. Small-scale wind power is making slow progress due to a lack of competitive technology and the increased popularity of solar panels in low-rise buildings.

It is estimated that the share of **sustainable bioenergy** will be about one half of all renewable energy in 2030. Carbon-neutral transport will initially be achieved by using biofuels. Promoting the deployment of biofuels in heavy goods vehicles will be important. Sustainability will be a key factor, and international trade will grow. The raw material base of bioenergy will expand and increasingly rely on wastes, which will also encourage biogas use.

Various **hybrid solutions**, both in electricity and heat production, will increase as micro networks and flexibility of demand becomes more common. New solutions for long-term storage may be found in combinations of solar and bioenergy solutions, in particular. A great deal of research is being conducted on this area in Finland.

**Wave energy** is an example of a field where Finnish technology and companies are on the global leading edge without a domestic market. Wave energy is expected to be commercialised after 2020. The first more extensive sites will be off-shore wind farms, where wave energy production may benefit from shared network connections.

Immense possibilities are seen in **geothermal energy**. It offers renewable and plentiful energy that is relatively clean in environmental terms. Drilling methods have undergone strong development, which is likely to enable the use of geothermal energy also in Finland. The district heating network in Paris already has eight heat plants based on geothermal heat. Geothermal electricity production plants are being built in France and Germany, and some of these plants already operate in the United States.

**Improving energy efficiency** is the most cost-effective way of reducing CO<sub>2</sub> emissions. A good example of this is the wider spread of LED lighting. The energy efficiency of new buildings is improving constantly. Zero-energy houses are already being built, and in the future, there will be plus-energy houses. Consumers' energy-efficient choices are highly important. In the future, the energy system of an intelligent home can be used to control the electric devices, energy production and storage, and electricity trade of the household.

**Intelligent transport** will also increase service business, and the **MaaS (Mobility as a Service)** model will promote more efficient energy use. In its most simple form, MaaS means that travellers have easy access to the services they need, from door to door with a single payment and ticket. Different modes of transport work seamlessly together, and a plan can be changed even in the middle of the journey as information can be communicated smoothly if the mode of transport changes. Intelligent transport is now looking to the new Transport Code that strives to renew and develop the entire transport sector as digitalisation advances.

Digitalisation and IoT will make for more efficient **energy efficiency solutions in the industry**. Analysing big data and the progress of automation will make it possible to consider energy efficiency across the entire process and to control the process with efficiency in mind. Energy efficiency in the industry is not only associated with equipment and components but also with efficient utilisation of sidestreams.

In Finland, **combined heat and power production (CHP)** has been a centralised and efficient way of producing electricity and heat, and in recent years, also **cooling**. The low price of electricity and the reduced need for heating in new buildings have undermined the profitability of CHP production. Few new investments have been made in recent years. Using CHP production from biofuels as a regulating power is being studied in Finland and elsewhere in Europe.

**Carbon dioxide capture and storage from combustion gases** plays an important role in achieving the climate targets globally. CO<sub>2</sub> is already being captured and stored in a few demonstration projects, but this technology has not yet been applied to power plants on a commercial scale. Particular challenges to it include the large volumes of CO<sub>2</sub> to be captured, uncertainties and responsibility issues related to long-term storage of CO<sub>2</sub>, and the high cost of the technology. For this reason, the development of technologies related to **carbon dioxide recovery** as part of the circular economy has been started.



The **circular economy** improves the efficiency of resource and material use, ensuring that raw materials and their value are preserved in the cycle. Material losses and waste production are minimised. According to Sitra's calculations, the circular economy would offer Finland potential for added value amounting to EUR 1.5–2.5 billion. Several research and development projects are on-going around the circular economy.

The markets are increasingly showing interest in solutions that reduce the use of non-renewable and fossil raw materials. Solutions are sought in **bioeconomy** and new, biomass-based products and services. Bioeconomy comprises a lot more than just bioenergy and biofuels. Wood-based fibre can be processed into high-value chemicals, for example for the needs of the pharmaceutical and chemical industries. Nutrient cycling is another example of the business opportunities offered by the bioeconomy. Circular economy practices and digitalisation create possibilities for bioeconomy that link different sectors and business areas. A precondition for attaining the climate targets is developing new industrial processes, and the role of energy technologies as part of bioeconomy and circular economy can be seen to grow.

#### Business opportunities

Finland is a pioneering country in the field of intelligent electricity networks and gauges, bioenergy, biofuels and energy-efficient electricity use, which is based on long-term research and development. It can be predicted that plenty of new business will emerge around the flexible energy system.

Power electronics represents top expertise from Finland. Distribution networks will feature power electronics and intelligent properties. Finland could also offer expertise for turnkey system deliveries, but a large operator would be required to ensure competitiveness in the global market.

Virtualisation, on the other hand, is associated with technology that enables the simulation of reality. In the flexible energy system of the future, virtual power plants may have a key role in controlling such aspects as decentralised production, storage and consumption.

The flexible energy system of the future, in which the consumer plays an essential and significant role, will also create a need for different security technologies. The importance of cybersecurity will be highlighted, bringing new business opportunities.

Decentralised energy production contributes to creating export opportunities for Finnish technology and expertise. The greatest growth is expected in the fields of wind power, solar energy, biomass boilers and small-scale CHP technology. In these, Finland's areas of strength are wind power components, biofuels and biotechnologies as well as gas-fuelled engines and power plants. Potential export sectors also include turbine generators for small-scale and mini hydroelectricity installations and technological and system expertise in solar energy and fuels cells.

Growth can be achieved by integrating evolving service companies on the leading edge of digitalisation in the industrial ecosystem. Courage to open up the conventional value chains for operators and activities of a new type is needed. Above all, this will improve the profitability of growth companies that are the drivers of change and enable the more conventional prime movers of the economy to conquer new growth markets.

In the cleantech sector, the share of companies with a strong growth orientation is clearly larger than in the national SME sector as a whole. Investments in diverse and international

expertise of a high quality, is vital. If Finland wishes to be successful in the changing and toughening international competition in the energy sector, R&D&I investments should be increased in pace with the growing inputs of many other countries. The commitment to Mission Innovation requires Finland to double the funding for cleantech research and development by 2020. Supporting pilot and demonstration projects is also crucial for the success of Finnish companies.