Energy and Climate Roadmap 2050

Report of the Parliamentary Committee on Energy and Climate Issues on 16 October 2014

Publications of the Ministry of Employment and the Economy
Energy and the climate
50/2014

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Energy and Climate Roadmap 2050 –
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Finland's long-term objective is to be a carbon-neutral society. This objective will not be easy to reach, but it is nonetheless achievable. This challenge is particularly huge in the energy sector. Approximately 80% of all greenhouse gas emissions in Finland come from energy production and consumption, when energy used for transport is included. In addition to carbon-neutral society, Finland's energy policy focuses equally on safeguarding energy supplies under all conditions and maintaining and improving the nation's ability to compete on an international scale.

In order to ensure the broad-based consideration of energy and climate policies, increase shared understanding of the relevant issues on a national level, and improve both long-term and predictable policy-making, the parliamentary committee on energy and climate issues has prepared a roadmap for Finland. The roadmap extends to the year 2050 and will serve as a strategy guide on the journey towards achieving a carbon-neutral society. The parliamentary committee is served by two representatives from each parliamentary political party and the preparation of materials for consideration by the committee has been coordinated by a secretariat jointly convened by the Ministry for Employment and the Economy and the Ministry of the Environment. Each ministry has drafted estimates with regards to its respective remit.

The roadmap focuses particularly on energy production and energy systems/infrastructures, energy consumption, other sectors, and cross-sectoral activities. The roadmap is not intended to produce delineated pathways towards 2050; instead, work on the roadmap will consist of researching the alternatives for reducing carbon emissions and the impact of these alternatives on cost-effectiveness of emission reductions and competitiveness of the society. The strengths and weaknesses of Finland in these areas will also be assessed, as well as the opportunities and threats associated with various related situations. The parliamentary committee will make joint recommendations regarding the aforementioned aspects.

Concerted efforts must be made to reduce greenhouse gases in all sectors despite some sectors or areas of industry having lesser or greater potential to produce these emissions. For example, in order to meet the targets set for reducing emissions, the energy system must be changed virtually emission-free by 2050; however, many industrial emissions can only be significantly reduced if carbon capture and storage (CCS) technology can be effectively commercialised. In working towards the goal of reducing greenhouse gases by 80–95%, Finland must in any case increase the use of renewable energy sources – particularly domestic bioenergy – and capitalise on the potential of increasing energy efficiency and developing cleantech solutions in all areas of industry. Finland must also work hard to ensure adequate energy self-sufficiency and security of supply. Moreover, the Finnish state and its municipalities must comprehensively commit to reducing carbon emissions in all activities.

When striving to mitigate climate change it is important that all parties limit their emissions. Finland must take an active role in various fora towards negotiating and agreeing upon an effective international commitment to tackling climate-related issues. Such involvement can further level the global playing field and help preserve the key position of energy-intensive industry within the Finnish economy. Consequently, export opportunities for Finnish cleantech enterprises would also be increased.

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Foreword

Limiting the climate change that threatens the Earth requires strong measures from mankind. Finland is contributing to the effort, as Finland's long-term goal is a society that is carbon-neutral. This challenge is particularly great in the energy sector. Approximately 80% of all greenhouse gas emissions in Finland come from energy production and consumption, when energy used for transport is included.

In addition to the climate and environment, Finland's energy policy will equally concentrate on two other topics: taking care of the security of supply under all circumstances and supporting the society's competitiveness.

We have prepared an energy and climate roadmap covering the period until 2050 for Finland. The roadmap will serve as a strategic-level guide on the journey toward a carbon-neutral society.

The roadmap is not intended to produce delineated pathways towards 2050; instead, it will consist of researching the alternatives and their impact on cost-efficiency and the competitiveness of the society. The strengths and weaknesses of Finland in these areas will also be assessed, as well as the opportunities and threats associated with various related situations. To influence these, we present a number of comments and strategic suggestions.

Parliamentary Committee on Energy and Climate Issues

Jan Vapaavuori
Chairman, NCP

Marjo Matikainen-Kallström NCP	Lauri Ihalainen SDP	Sirpa Paatero SDP
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Oras Tynkkynen GF	Sauli Ahvenjärvi CD	Sari Palm CD

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Summary

Finland's long-term objective is to be a carbon-neutral society. This objective will not be easy to reach, but it is nonetheless achievable. This challenge is particularly great in the energy sector. Approximately 80% of all greenhouse gas emissions in Finland come from energy production and consumption, when energy used for transport is included.

The roadmap to 2050 serves as a strategic-level guide on the way toward a carbon-neutral society. The roadmap contains an analysis of the means for the construction of a low-carbon society and an 80–95% reduction in greenhouse gas emissions in Finland from the level of 1990 by 2050. The building of a carbon-neutral society requires activity on all levels.

The average global temperatures are estimated to rise by three to five degrees unless the emission trend is turned downward. Delaying the emission reductions will increase the probability of severe risks to ecosystems and communities. Efficient limiting of global warming requires fruitful international climate negotiations, effective climate agreements and ambitious emission reduction goals. Owing to the production structure of Finland's industry, the cost for the national economy of reducing greenhouse gases might be sizable, particularly if the key technologies regarding emission reductions do not progress as desired and the most important competitor countries outside of the EU do not commit to the reduction of greenhouse gases to the same extent. The cost of the emission reduction goal would mostly be associated with the increased price of energy production, raw materials used and transportation.

If a comprehensive international climate agreement can be reached, the cost for Finland would remain considerably lower. As a positive side to the tight climate goals, one can mention the development of new technology (cleantech) and its improved exportability, energy savings, reduced dependency on imported energy, the effect on air quality and the positive effects of the slowed climate change.

The measures that Finland must take in any case in order to reduce the emissions of greenhouse gases by 80–95% are related to renewable energy, energy efficiency and cleantech solutions. Finland must increase the share of renewable energy in both energy production and consumption. The maximal use of domestic bioenergy must be secured, and the use of biofuels must be increased as the source of energy for transportation. In addition, other renewable energy forms must be increased. The potential of energy efficiency and the cleantech sector must be utilised in all sectors.

Finland must, in all of the alternatives, see to the well-being and competitiveness of society and to the operating premises of industry. Reasonable prices of energy are crucial for energy-intensive industry. Likewise, Finland must invest in developing

and marketing new technology and keep this as a leading theme of industrial policy, as the new low-carbon technologies are the strongest-growing areas globally.

In Finland, the significance of energy is particularly great, and Finland must see to the security of the energy supply under all circumstances. Therefore, it is important to ensure that Finland has sufficient electricity production capacity to also guarantee the security of supply in exceptional conditions and secure the premises for market-based investments in the production of electricity in Finland.

Efforts must be made to reduce greenhouse gas emissions in all sectors, although the potential for this varies greatly between the sectors. For example, many industrial process emissions can only be significantly reduced if carbon capture and storage technology (CCS) becomes commercialised.

The energy system must be converted to a nearly emission-free state by 2050. At the same time, fossil fuels and peat must be almost entirely discontinued in the production of electricity and district heating unless the commercialisation of CCS enables their use. These will be replaced by sustainable, renewable fuels, primarily with forest biomass, whose profitability must be secured because its role is of the utmost importance. For Finland, it is essential that sustainably produced biomass continue to be deemed carbon-neutral in the EU and international climate negotiations.

Should the central biomass fuels not remain zero-emission or CCS not be commercialised, the 80–95% reduction of emissions cannot be reached in practice. In particular, the commercialisation of CCS is essential for reaching the emission reduction goal.

In Finland, forests serve as carbon sinks, i.e., they bind carbon-dioxide from the atmosphere as they grow. The extent of the carbon sink has varied between 30% and 60% of Finland's overall emissions, and the sink is estimated to grow in the coming decades. The position of the sinks in the coming emission reduction obligations will most likely be limited and their calculation rules are still open. Finland must aim at solutions in the carbon sink calculation rules that justly take into consideration the national circumstances and special features of heavily forested countries.

It is very difficult in agriculture to reach visible reduction, at least in the short term, without limiting the growth of the surface area of organic soil utilised for agriculture in or without reducing working on organic soil (i.e., affecting the food production yield/the production assortment). It is important to design and implement the agriculture's measures for limiting the climate change so that they do not jeopardise Finnish agriculture or global food security.

Currently, the most efficient way to reduce the emissions from transportation is to replace fossil fuels with bio-based fuels. Attempts should be made in Finland to do this to a significant extent with Finnish production, which would originate from forest and field biomass and waste, as well as various sidestreams. In order to secure the production premises for biofuels for transportation, Finnish demand for advanced biofuels must continue to be ensured by means of obligations, and the matter could be promoted also at the EU level.

The greenhouse emissions from transportation must also be reduced by using alternative propulsion systems and technologies. Outside urban areas, the promotion of new propulsion systems and technologies must be the principal climate measure with respect to transportation. In addition, it is necessary to promote a tighter, more unified community structure.

By the end of 2020, all new buildings must be nearly zero-energy houses. The significance of renovation construction will increase, and new, cost-efficient steering measures will be implemented where necessary to utilise energy-efficiency possibilities. The climate-tolerance of the built environment should be promoted holistically and rapidly. The utilisation and ease of implementation of smart technology is important.

Cost-efficient energy and material efficiency must be promoted with determination in various sectors. In addition, sustainable consumption and production-guiding means must be improved while supporting the municipalities in their low-carbon efforts.

When striving to combat climate change, it is important that all parties limit their emissions. Finland must take an active role in negotiating and agreeing upon an effective international commitment to tackling climate-related issues within various forums. Such involvement can further level the global playing field and help preserve the key position of energy-intensive industry within the Finnish economy. At the same time, the global need for low-carbon technologies would grow, opening up new export possibilities for Finnish cleantech businesses.

Table 1 presents the shares of different greenhouse gas emission sources as percentages of Finland's total greenhouse gas emissions in 2012. The shares of the total greenhouse gas emissions of different emission sources vary annually, which makes the table merely indicative in that respect, and it does not include emissions caused by solvents, for example.

Table 1. Shares of Finland's total greenhouse gas emissions by source in 2012.

Sector	Share of Finland's total greenhouse gas emissions in 2012 (%)	The most important measures for reducing the emissions	Further comments
Energy sector	78.0		
Energy industry *Electricity generation* *District heating production* *Oil refining* *Other*	33.5 *13.6* *15.2* *4.3* *0.5*	- Almost entirely covered by the emission trading scheme (excl. small heat plants) - Increase the use of renewable energy - The commercialisation of CCS would enable a significant reduction of emissions	
Domestic transportation *Passenger cars* *Trucks and vehicle combinations* *Other road traffic* *Other traffic (including air, railway and water transportation)*	20.8 *11.1* *4.5* *2.8* *2.4*	- Use of biofuels in transportation - Binding standards for car manufacturers (EU-level) - Urban design and transportation method changes that reduce the amount of transportation	- Sufficiency of Finnish renewable-energy raw material sources, also considering the energy requirements and use of raw materials of other sectors
Manufacturing industry and construction (includes the industry's own electricity and heat production)	13.7	- Almost entirely covered by the emission trading scheme	
Public, service and household sector (mostly building-specific heating)	4.5	- By the end of 2020, all new buildings must be nearly zero-energy houses (EU-level regulation) - Energy-efficiency in renovation building - Smart systems	
Agriculture and forestry and fishing (buildings and machines) Other fuel use (including the Defence Forces and evaporation)	2.5 2.9		
Industrial processes	8.8		
Metal industry Chemical industry Mineral products	3.7 1.5 1.9	- Almost entirely covered by the emission trading scheme - The commercialisation of CCS would enable significant emission reductions (79% of the industrial emissions are CO2 that could be captured with CCS)	- Industrial processes cause emissions whose significant reduction is almost impossible if CCS does not become commercialised
F-gases (fluorinated greenhouse gases)	1.6	- Measures conformant to EU's F-gas legislation	
Agriculture (other than energy-based GHG emissions)	9.4	- Utilisation of agricultural biomass and waste in energy production	- It is difficult to significantly limit the emissions without affecting the amount or assortment of production. - The agricultural climate policy should be expanded to cover solutions related to land use and the energy sector.
Soil Domestic animals' digestion Manure handling	5.7 2.5 1.1		
Waste sector	3.4	- Preventing the production of waste - Recycling waste - Utilising waste as energy	- The present measures will lead to an 85% emissions reduction by 2050 (cf. 1990)
Waste to waste sites Handling and composting waste water	2.9 0.5		

1 Central premises

1.1 Introduction

Finland's long-term objective is to be a carbon-neutral society. This challenge is particularly great in the energy sector. Approximately 80% of all greenhouse gas emissions in Finland come from energy production and consumption, when energy used for transport is included.

Reducing carbon-dioxide emissions would cause expenses for Finland if a comprehensive climate agreement cannot be reached. Owing to the production structure of Finland's industry, the cost for the national economy of reducing greenhouse gases might be sizable, particularly if the key technologies regarding emission reductions do not progress as desired and the most important competitor countries outside of the EU do not commit to the reduction of greenhouse gases to the same extent. The cost of the emission reduction goal would mostly be associated with the increased price of energy production, raw materials used and transportation.

The unequal rise of expenses between different countries would cause a risk of carbon leakage which, if realised, would mean that production would be moved to countries with lower cost levels. The rise of the expenses and the decrease of investments and production would have negative impact on Finland's industry and the national economy as a whole.

If a comprehensive international climate agreement can be reached, the cost for Finland would remain considerably lower. As a positive side of the tight climate goals, one can mention the development of new technology (cleantech) and its improved exportability, energy savings, reduced dependency on imported energy, the effect on the air quality and the positive effects of the slowed climate change.

Finland is highly dependent on energy and has a high consumption per capita in that respect. The high consumption of energy is partly attributable to a high standard of living, cold climate, a great need for public lighting, the significant share of energy-intensive industry in the national economy and long distances. Owing to the great significance of energy, Finland has traditionally placed great importance on its efficient use. In energy efficiency and the development of energy technology, we are among the leading countries globally in many areas. With respect to the national economy, it is significant that Finland's energy self-sufficiency is low, as for example all traditional fossil fuels are imported.

The energy policy of Finland and of the EU has three main focus areas: ensuring the security of supply under all conditions, supporting the competitiveness of the society and caring for the environment.

To ensure the broad-scale consideration of energy and climate policy, to increase national consensus and to strengthen long-term and predictable policy, Prime Minister Jyrki Katainen's government established a Parliamentary Committee on Energy and Climate Issues on 27 June 2013 with the task of preparing an energy and climate roadmap for Finland up to 2050. Representatives from all political parties represented in Parliament were invited to the Committee.

The roadmap to 2050 serves as a strategic-level guide on the path toward a carbon-neutral society, the long-term goal for Finland. Reaching the goal requires long-term and predictable energy and climate policy for enabling investments, reducing greenhouse gas emissions in all sectors, increasing energy efficiency and increasing the share of renewable energy. As different measures are needed in all sectors, the roadmap addresses them all.

The roadmap contains an analysis of the means for building a low-carbon society and achieving an 80–95% reduction in greenhouse gas emissions in Finland from their 1990 level by 2050 as part of the international effort to limit climate change.

The roadmap does not attempt to choose any single path to 2050; instead the aim is to explore various alternatives, identify prerequisites common to all of the paths and bring forward Finland's national strengths and limitations, which are of particularly great importance with respect to the greenhouse gas emission reduction goals. The alternatives focus on the cost-efficient reduction of greenhouse gas emissions along with the competitiveness of society, the promotion of clean technology and utilisation of its export potential, as well as the security of energy supply and national economy. In addition, Finland's goals and position with respect to European and broader international development are assessed.

International negotiations on limiting climate change and adapting to it

Fighting the climate change that threatens the world requires strong measures from mankind, the effects of which will be reflected on the entire society, especially the coming generations. The share of Finland and the EU of the global emissions is small and, in light of current development, even declining. Therefore, reaching a global climate agreement is of utmost importance in limiting climate change.

According to the Intergovernmental Panel on Climate Change (IPCC), air temperatures have risen globally 0.85 degrees Centigrade between the years 1880 and 2012. The parties to the United Nations Framework Convention on Climate Change have defined the goal so as to limit the warming of the climate to two degrees above the pre-industrial time. The IPCC estimates that, at the current growth rate, the average temperature may rise by over 4.5 degrees by the end of the century. The uncertainty in both directions is great, however.

Finland is negotiating in the UN climate negotiations (UNFCCC) as part of EU on the reduction of greenhouse gas emissions, the increase of carbon sinks, measures for adapting to climate change, the management of damage and loss caused by climate change and the related financial matters. The goal is to reach an agreement in December 2015 at the UN climate negotiations on an international climate convention applicable to the post-2020 period, which is to apply to all parties. The EU is preparing for these negotiations by agreeing on its own emission reduction goals for 2030 by October 2014.

Even if global climate change could successfully be limited to two degrees, the temperature in Finland is likely to rise more than this. Thus, Finland faces the challenge of adapting. Adapting refers to the adjustment or preparation of humans and nature to changes so as to minimise the damage and maximise the benefit. Finland prepared its first adaptation strategy already in 2005, and its update was completed in 2014.

Framework of the roadmap

The world is developing quickly and unpredictably. It can, however, be assumed that environmental and climate friendly technology develops at an accelerating pace, which should help solve problems. As a small and developed country, Finland can cope well amidst even unforeseeable changes if we work in a cost-efficient way and accept the new solutions.

Finland has outlined its goal as to reduce greenhouse gas emissions by 80–95% by 2050. However, it is possible that the reduction goal will have to be tightened even from this level. Building a carbon-neutral society requires actions at all levels: national, provincial, municipal, commercial and household. The activity of market actors and citizens in attaining a low-carbon state requires support from society as well as structural changes.

The new low-carbon technologies are currently the strongest-growing fields globally. The size of the global market is already approximately €1.6 trillion, representing around 6% of the world's GDP. Finland's cleantech sector grew by 15% in 2012. The transition to a low-carbon society and the use of clean technology open up considerable possibilities for Finland. Also the transition to more sustainable consumption opens new doors. In all alternatives, Finland must invest in the development and marketing of new technology and keep this as a focus point of industrial policy.

In all scenarios, Finland must see to its competitiveness. Reasonable energy prices are crucial for the energy-intensive industry, whose share of Finland's industrial production was 38% in 2012. The price of energy and cost-efficient improvement of energy use are also important for low-income households.

Increasing renewable energy and energy efficiency will increase the security of supply, but Finland continues to be dependent on imported fossil fuels. Finland is also dependent on electricity imports annually and particularly during peak consumption times. The security of supply aspects do not allow for any type of "creative destruction strategy"[1] in the energy sector. A better connection with common European systems will improve the security of supply. However, in the foreseeable future, Finland will continue to bear the main responsibility for its security of supply. Reducing energy imports will have a significant effect on the balance of trade.

Increasing renewable energy is in the interest of the Finns, and we can do it in a more cost-efficient way than many other countries. Forest biomass will be a central source of renewable energy on the way to 2050 but solar and wind energy in particular, as well as geothermal energy, can be utilised much more than at present. The cost-efficient increase of building-specific small scale generation is also important in all alternatives.

With global warming, it is also estimated that the heating need will decrease while the need for cooling will increase. The production of hydroelectric power is expected to grow and the flow conditions affecting production will change. The extremes of weather will challenge the durability of the electric networks.

Cost-efficient operations are important in all alternatives. In market economy, the possibility of the state to influence development should be limited to a variety of steering measures (standards, taxes, subsidies) but the investments should remain as much the task of the market actors as possible.

In an uncertain world where we face ever-increasing challenges, consistent policies are essential, though certain flexibility is required when the need for modifications arises. The policy definitions of the Parliamentary Committee on Energy and Climate Issues influences how Finland will attain its low-carbon goal in the coming decades and create a stable operating environment for the various actors of society.

1.2 Recent changes in the energy sector

The rapid growth of shale gas production in the United States has produced a change in the global energy market in just a few years. Thanks to its low price, shale gas has replaced coal in energy production, and therefore the United States has managed to lower both the price of energy and the emissions. On the other hand, the United States has also improved energy efficiency and invested in renewable energy. The lowered price of coal, in turn, has increased its use in Europe, seeing as the price of the emission allowance has been low.

The production of natural gas liquids obtained as a by-product of unconventional oil and natural gas production is also rapidly growing. The International Energy Agency, IEA, estimates that the oil production peak will not occur by 2035 (although the production of conventional oil apparently peaked at the end of the last decade). The discussion on the commonly agreed model of the continuous increase of price of fossil fuels, which is the basis of the energy policy, has already started. It is estimated

1 Because of the security of supply, the energy system cannot be reformed to such an extent that the supply of energy is compromised when shifting toward a low-carbon energy system.

that fossil fuels will retain their competitiveness in the coming decades but regional and fuel-specific differences are great. In the basic scenario, the IEA is estimating that the consumption of fossil fuels will increase by 24% between 2011 and 2035. Their share of the world's total energy, however, will decrease from 82% to 76%.

The energy and climate objectives set in Europe for 2020 have strongly increased the production of renewable energy, which has partly decreased the cost of renewable energy technologies and created new jobs. The growth, however, has significantly been based on public subsidies, which consumers will pay directly in their energy bill or indirectly in the state budget. In some countries, the cost of the subsidies has grown unforeseeably high and they have been cut. The subsidies have also partly been lowered because the renewably energy technology has become more competitive than before.

The subsidy mechanisms have also decreased the wholesale price of electricity, which has weakened the profitability of traditional power plants capable of electricity production adjustment. The need for the balacing of the electric system grows, however, because of the intermittency of wind and solar energy production. To secure adjustment-capable electricity production capacity, several countries (such as Germany, France and the United Kingdom) are preparing to put into motion various capacity mechanisms, i.e., granting subsidies to traditional power plants.

On the Nordic market, the price of electricity has also clearly decreased and, based on studies, will remain low at least far into the 2020s. It is difficult to build any new electricity production capacity in Finland that would be competitive against the Norwegian and Swedish hydroelectric power.

In the long term, bioenergy will have an important role in the EU and in Finland in particular. The potential of using bioenergy will greatly be affected by the level of the price of emission allowances, what requirements will be set for the sustainability of bioenergy production and whether it will retain its carbon-neutral status in emission trading.

The prices of emission allowances have plummeted in the EU because of the poor economic situation, use of flexible mechanisms and the significant surplus of emission allowances caused by the subsidised renewable energy forms, and emission trading does not guide investments to low-carbon solutions as was expected in the past. Attempts have been made in the EU to rectify problems involved with emission trading by backloading the sale of emission allowances and by proposing the implementation of a reserve mechanism.

The great potential of energy efficiency has been acknowledged globally, and the EU enacted an ambitious Energy Efficiency Directive in 2012. According to the International Energy Agency IEA's assessment, if the goal is to limit global warming by 2 degrees during this century in a cost-efficient way, energy efficiency must play a central role and the improvement of energy efficiency must globally reduce the consumption of energy by one-third to one half by 2050.

The implementation of carbon capture and storage technology (CCS) has not progressed according to earlier estimates. On the other hand, the development of electric cars and energy-efficient construction technology has been rapid.

The International Energy Agency IEA estimates in its main scenario that the production of nuclear power will grow by 67% between 2011 and 2035. In Europe, the situation is divided: there are countries that are discontinuing nuclear power or keeping it at the existing level, and there are those increasing their use of this energy.

1.3 Key background material

The roadmap uses the Low Carbon Finland 2050 platform research project (later, the Low Carbon Finland project) as key background material. The preparation was done by the VTT Technical Research Centre of Finland, Geological Survey of Finland, Finnish Forest Research Institute and Government Institute for Economic Research. The project produced scenarios on alternative development paths for a low-carbon society up to 2050.

The Low Carbon Finland project formed four alternatives low-carbon scenarios.

1. Growth
2. Stagnation
3. Save
4. Change

In the Growth scenario, the economy of Finland and the rest of the world is stable and grows quickly. The industrial structure shifts toward products and concepts of higher additional value. The development and adoption of new technologies and services is quick, the community structure becomes more condensed and smart solutions are broadly used in both living and in the transportation. As a counterpart for the Growth scenario, in the Stagnation scenario the premise is blocked economic areas, such as trade barriers between regions, which also means slower technological development than in the other low-carbon scenarios. In the Stagnation scenario, no global climate agreement will be reached, either, wherefore it can be considered a risk scenario.

In the Save scenario, the EU will aim to implement the saving goals with a hastened timetable, i.e., the 80% reduction goal would be attained already in 2040. In this scenario, investments are made particularly in energy and resource efficiency but development is slower with respect to new technologies than in the Growth scenario. The Change scenario represents the alternative of radical change where both technological development and society's structural changes occur very quickly. In this final scenario, the premise is that people's values and attitudes lay the premise for change in both Finland and globally.

In addition to these, two other scenarios were calculated where the economic structures would remain close to present development. One of these scenarios is Baseline, which adheres to the premises of the updated Energy and Climate Strategy (2013) until 2025 and trend-like development thereafter. The set emission goals will not be attained in the Baseline scenario. It is a basic scenario that indicates the magnitude of additional measures that should be implemented in addition to the present ones. In addition to the Baseline scenario, a Base -80% scenario was calculated, where the economic development and structure would be the same as in the Baseline scenario but the emissions would be pushed to the target levels.

In all scenarios with the exception of Baseline, Finland and the rest of the EU will implement the 80% reduction goal of greenhouse gas emissions by 2050. The global climate agreement will be reached in scenarios other than stagnation and baseline.

In all scenarios, the emission goals set will only be reached if technological development is as assumed in the scenarios. In particular, the assumption of the development and acceptability of carbon capture and storage technologies (CCS), the development of nuclear power capacity and the sustainability criteria for wood-based biomass will significantly influence the capacity and cost of emission reductions. The key assumption regarding emission reductions is CCS technology. With respect to national economy expenses, the Stagnation scenario stands out as the worse alternative, where the EU countries will implement the emission goals even if no global climate agreement is reached.

In all of the scenarios, the use of wood-based biomass in energy production and production of second generation refined bioproducts will grow considerably. The significance of energy wood is high with respect to Finland's emission reduction goals even in the shorter term, when it comes to reducing the emissions from transportation. The threat is, however, the attribution of sustainability criteria to wood-based biomass such that not all sustainably produced wood-biomass would continue to be considered carbon neutral but some emission factor would be assigned to it.

1.4 Sources of greenhouse gas emissions

In 2008–2012, Finland's average greenhouse gas emissions were 4% lower than in 1990. Between 1990 and 2012, however, Finland's GDP grew by 48%, which indicates a significant decoupling of economic growth from emissions.

In the same four year period, the average greenhouse gas emissions amounted to a total of 68 million CO_2 tonnes without the LULUCF sector (land use, land use change and forestry), and Figure 1 presents the significance of the various sectors. Finland's current emission reduction goals have been divided into the emission trading sector and the emissions not covered by it (non-emission trading sector) whose emission development is presented in figures 2 and 3.

Figure 1. Finland's greenhouse gas emissions in 2012 without the LULUCF sector (land use, land use change and forestry sector). Figure: Statistics Finland

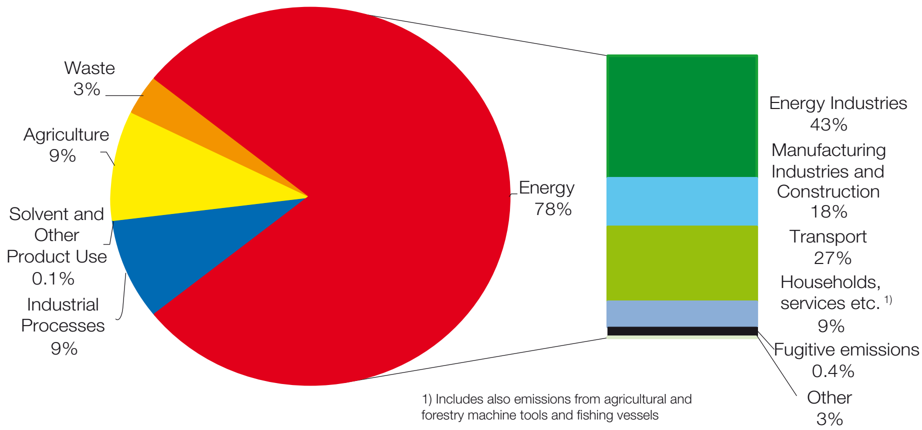
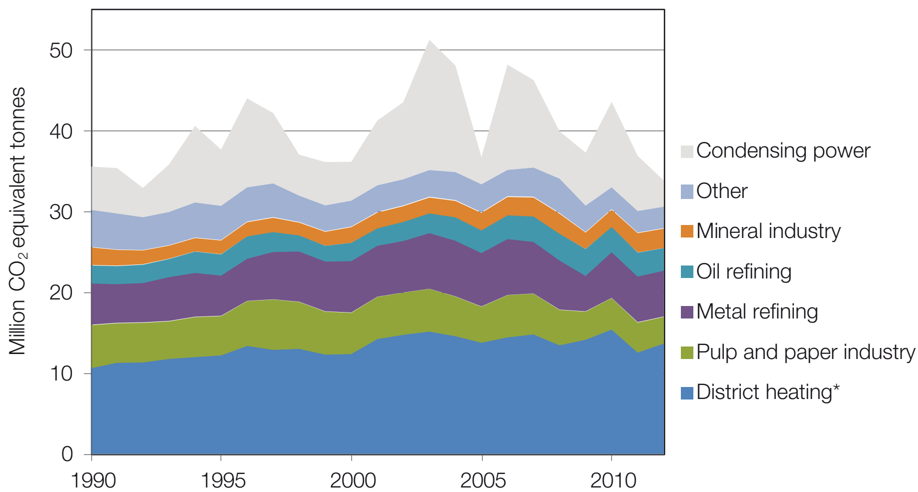
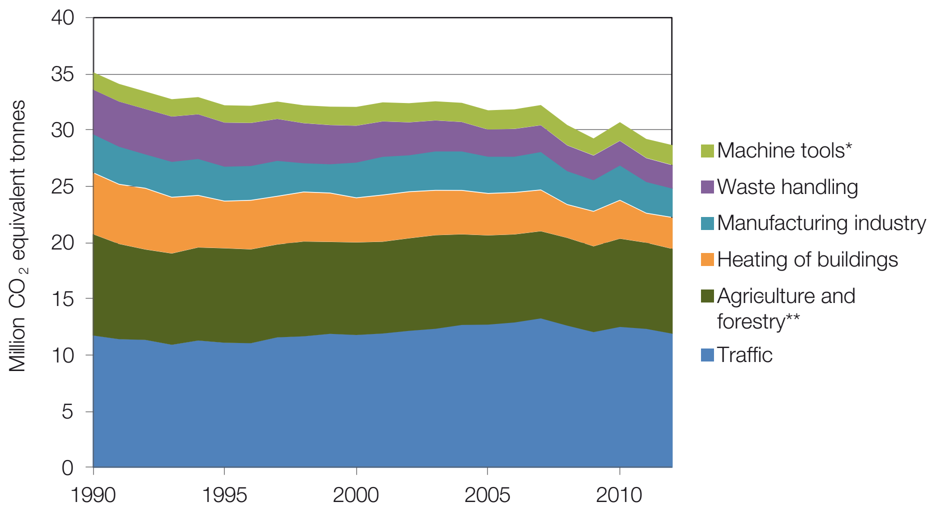


Figure 2. Emission trading sector's greenhouse gas emissions in Finland (source: the MEE)



* emissions from combined district heating and power production and separate district heating production

Figure 3. Non-emission trading sector's greenhouse gas emissions in Finland (source: the MEE)



* other than agriculture and forestry machine tools

** including energy use in buildings and machine tools

1.5 The emission trading system and the use of flexible mechanisms in reducing emissions

Finland's greenhouse gas emission reduction goals are connected to EU's reduction goals. The European Council has set the goal to reduce EU's greenhouse gases by 80–95% from the 1990 level by 2050. The European Commission adopted a communication in 2011 on the transition to a low-carbon economy in 2050. According to the low-carbon roadmap, emissions can be reduced cost-efficiently in the EU by 40% by 2030, 60% by 2040 and 80% by 2050 with measures internal to the EU.

In January 2014, the commission released its proposal for the 2030 framework for climate and energy policies. The Commission proposes that the 2030 reduction goal with European measures be 40% lower than the 1990 level. In addition, the Commission states that if international climate negotiations reveal a need for increasing ambitions, this could take place by allowing the use of international (external to EU) emission reduction units in a later stage. The European Council will make policy definitions on the EU's emission reduction goal by October 2014.

Emission trading sector

As of the beginning of 2013, industries covered by the EU's emission trading sector (electricity production, energy-intensive industry, the majority of district heating in Finland and aviation) no longer have a national emission reduction goal but, instead, an emission cap covering the entire EU's emission trading sector (the total amount of emission allowances), i.e., a reduction goal. The emission trading system ensures that EU's reduction goal will be implemented because emission trading facilities and aviation must always cover their emissions with emission allowances.

Companies covered by emission trading can reduce their emissions or purchase emission allowances from the market if the price of the emission allowance is lower than their own reduction measures. With respect to the reductions in the EU and globally, it is not worth setting a separate, binding national emissions reduction goal for the emission trading sector, as the purpose of emission trading is to implement the emission reductions in the EU where it is most economical.

Emissions not covered by the emission trading system

Member-state-specific reduction goals for 2020 have been set for emissions not covered by the emission trading system (transportation, agriculture, building-specific heating etc.) in the EU's effort sharing decision. Most likely goals specific to member states will also be set for the post-2020 period.

At present, member states can also use emission reductions implemented either in another EU country or outside of the EU for covering their own reduction obligation. The justification for the use is mostly cost-efficiency: emission reductions implemented elsewhere may be significantly cheaper than reductions in the country with the obligation.[2] It is likely that at least "flexibility" within the EU (the possibility to purchase emission allowances from other member states) will also be available after 2020. The possibility of using emission reductions implemented outside of the EU depends on EU's bilateral agreements and the outcome of the international climate negotiations.

According to the Commission's communication on the 2020–2030 framework for climate and energy policies, EU's emission trading sector's reduction goal for 2030 would be 43% compared to 2005 and the non-emission-trading sector's reduction goal would be 30% compared to 2005.

2 The Kyoto Protocol flexibility mechanisms, i.e., joint implementation (JI) and clean development mechanism (CDM).

2 Energy production and energy system

2.1 Self-sufficiency regarding energy and electricity supply

The degree of energy self-sufficiency is measured by putting domestic energy sources as primary energy in proportion to the total energy consumption. In Finland, nuclear power has traditionally been counted as imported energy. According to the calculation method conformant to this practice, the degree of energy self-sufficiency was 31% on average during 2000–2009 but has risen clearly since. In 2010–2013, the degree of self-sufficiency was 35% on average. In international practice (e.g., Eurostat and IEA), nuclear power is counted as domestic energy. According to this calculation method, the degree of self-sufficiency in 2000–2009 was 48% on average, while it was 53% in 2010–2013.

In all of the Low Carbon Finland project scenarios, which forecast the situation up to 2050, energy self-sufficiency will improve. According to the Finnish calculation method, the degree of self-sufficiency will vary between 45% and 65% in the different scenarios, while the same figure according to international practice would be 70–80% in 2050. The scenarios assume that the carbon capture and storage technologies will at least somewhat become ripe for market owing to which the use of natural gas and coal is possible to an extent in all scenarios. This impacts Finland's self-sufficiency level within each scenario.

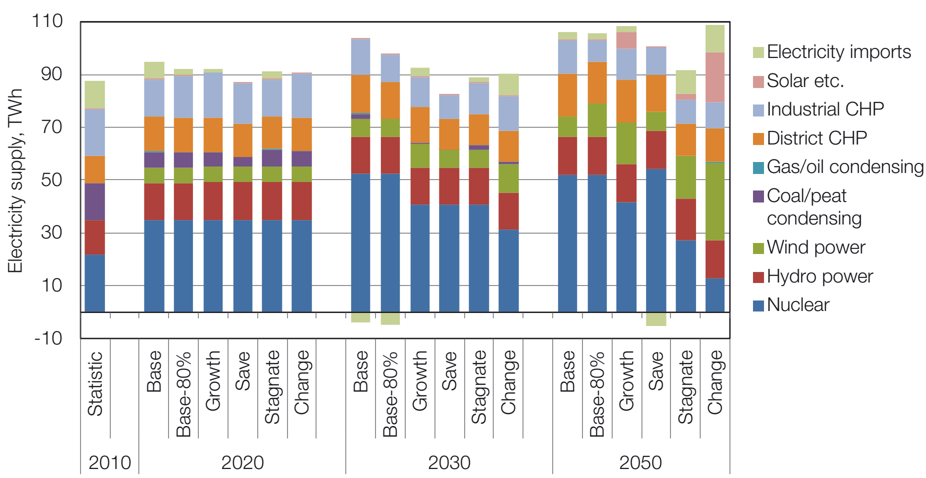
Self-sufficiency in electricity supply

All Low Carbon Finland scenarios heavily invest in the increase of renewable energy and the improvement of energy efficiency. This supports the goal to increase self-sufficiency in electricity production (electricity produced in Finland compared to the total consumption of electricity). The self-sufficiency of electricity supply increases from the present in all scenarios. In the Save scenario, Finland would be a net exporter of electricity in 2050 during a normal year while, in the Growth scenario, the annual level of electricity import would be very minor. In the Stagnate and Change scenarios, electricity imports would amount to approximately 10% of electricity supply.

Finland is part of the Nordic and European electricity market, where power plants are used based on commercial agreements. Attaining total self-sufficiency in electricity supply would require that Finland have sufficient domestic production capacity with lower variable production cost than the other countries. The Nordic countries, however, already have plenty of hydroelectric and wind power along with low variable production costs. Reaching the goal will therefore require significant production subsidies whose acceptability is difficult from the perspective of the EU internal market and state subsidy legislation.

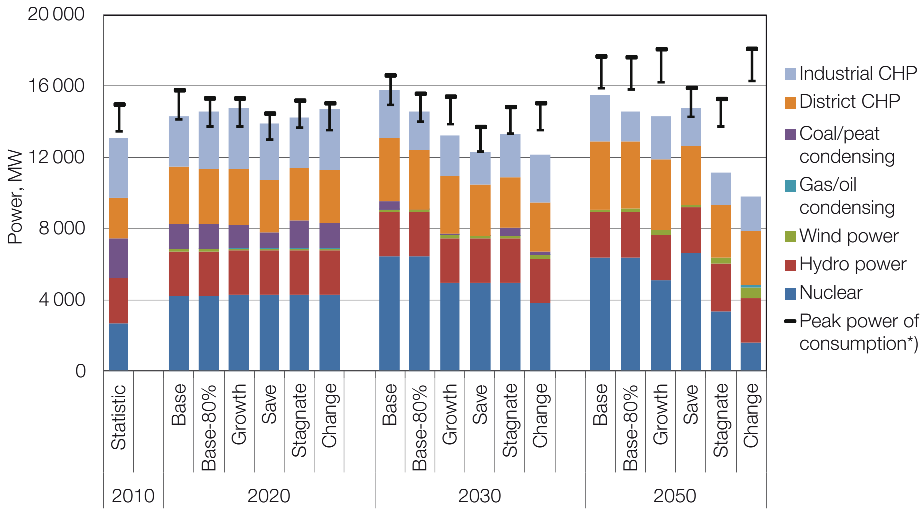
The studied scenarios, however, differ significantly with respect to the structure of electricity supply in 2050 (Figure 4). The assumption in the Change scenario is a major technological breakthrough owing to which the share of wind and solar power would be considerably high. These production forms would cover 44% (48 TWh) of electricity consumption. Only one large nuclear power plant unit production would remain. Also in the Growth scenario, the share of wind and solar power would be significant, i.e., approximately one-fifth. In the Save and Stagnate scenarios, solar power would not become commonplace but the building of wind power would proceed according to the currently set goals (Save) or even considerably further (Stagnate).

Figure 4. Structure of electricity supply in the Low Carbon Finland scenarios, TWh



The supply of electricity must be consider not only from the perspective of production and consumption balances (indicated in terawatt-hours, TWh) but also from the perspective of production capacity and power (indicated in megawatts, MW). Figure 5 presents the electricity generation capacity, corresponding to the production and consumption scenarios, which can be used during peak load, and an assessment of the peak load. The assessments correspond to the assumptions used by Statistics Finland for different production forms. With respect to consumption, the figure presents the ratio of peak load to the annual consumption of electricity as a variation range. At the top of the variation range, the ratio of the peak power to average power corresponds to today's ratio while at the bottom of the range, the ratio is 10% lower. The assumption of the decreasing ratio is justified as 2050 approaches, as fluctuations in electricity price will increase demand response while the storage of energy will correspondingly enable a better power balance.

Figure 5. The capacity available during peak consumption in the Low Carbon Finland scenarios, and the peak consumption power, MW



*) At the top of the variation range, the ratio of the peak power to the average power corresponds to today's ratio. At the bottom of the variation range, this is 10% lower.

Although demand response and storages were to reduce the need for production capacity, import dependency from the perspective of sufficiency of capacity would rise in all scenarios compared to the present state, with the exception of the Save scenario. The great proportion of wind and solar power, particularly in the Change scenario, is problematic, as their production during the peak load is uncertain or low. During the next ten years, power dependency during peak consumption will not be a significant problem if the operation of the electricity market is not compromised and the transmission connections between Finland and the neighbouring countries are sufficient. If Finland expects to attain its self-sufficiency goal from the perspective of capacity sufficiency, sufficient capacity must be ensured also with variable capacity mechanisms (section 2.2). If major electricity users and retailers were obliged to obtain power corresponding to their procurement using their own capacity or agreements, this would cause significant additional expenses.

It is justifiable to set the self-sufficiency goal for Finnish electricity production capacity at the annual level. This means that Finland could produce its annual demand of electricity but, depending on the Nordic hydroelectric and wind power situation as well as seasonal or other factors affecting the market price of electricity, electricity will be imported to or exported from Finland.

2.2 Electricity market

Operation of the electricity market

Finland is part of the Nordic electricity wholesale market, which includes the Nordic and Baltic countries. Electricity trading is based on the trading of electric energy, and separate compensation is not paid for electric power i.e., the provision of production capacity on the market. Approximately 70% of the electricity wholesale trade is done in the Nord Pool Spot electricity exchange. On the Elspot market, the market area's system price and regional prices will be set for the next day by an auction based on the purchase and sales offers of electricity producers, distributors, retailers and major end users. The regional prices will differ from the system price if the electricity transmission capacity limits the transmission between regions. The electricity exchange's spot price will be used generally as a reference price for other electricity trading. The Nordic electricity market is being integrated with the pan-European market.

In Nord Pool Spot, electricity is traded on the Elspot market and also the Elbas market where the parties of the electricity market can specify their electricity procurement within the day all the way to the beginning of the hour preceding the hour of use. The parties of the electricity market are responsible for their electricity balance, i.e., they must ensure that the producer will deliver the promised electricity amount and that the user and retailer of the electricity will acquire the amount of electricity they use or resell. Finland's transmission system operator Fingrid is responsible for the country's electricity balance during the usage hour by conducting electricity adjustment trade. The electricity balances of all parties to the electricity market are settled after the hour of use and deviations will be debited and credited with the electricity trade balance.

The main grid transmission and distribution of electricity are natural monopolies whose operation and pricing is supervised in Finland by the Energy Authority. It is the grid operators' obligation to transmit electricity, connect the customers to their grid and develop the operation of their grid without discrimination and at reasonable price. The transmission system operator Fingrid bears a so-called system responsibility. For the maintenance of the balance (frequency) between consumption and production, Fingrid will carry out the abovementioned adjustment trading, maintain a sufficient amount of so-called spinning reserve (frequency-controlled normal operation reserve and frequency-controlled disturbances reserve). The entire power system is sized so that it can tolerate any single fault, i.e., the faulting of a line or power plant without the system crashing.

On the retail market of electricity, the users may freely choose their electricity supplier. There are approximately 75 retail sellers of electricity in Finland.

Benefit of the common electricity market

Finland's strong transmission connections with the neighbouring countries enable a liquid and competitive wholesale electricity market. At the same time, the diversity of the different Nordic countries' electricity production structures can be used efficiently. Norway's electricity production is almost entirely hydroelectric power, which amounts to about half in Sweden with a bit more than one-third being nuclear power. In Denmark, approximately half of the production is thermal power based on coal and natural gas. Finland's production is distributed more evenly between thermal power, nuclear power and hydroelectric power. In a good water year, the Nordic market can utilise hydroelectric power to reduce expenses and carbon dioxide emissions. Correspondingly, in dry years, the thermal power from Finland and Denmark will guarantee the sufficiency of electric energy on the market.

The common electricity market also enables joint utilisation of the electric system's reserves and the adjustment between electricity production and consumption with hydroelectric power. Even if each country were to have sufficient production capacity for meeting the peak demand for electricity, the Nordic electricity systems are technically interdependent. For example, without connections with the neighbouring countries, the largest plant in Finland's electricity system could be at most 500 MW.

Electricity system's balancing: production adjustment, demand response, storages and transmission connections abroad

Since it is not yet possible to store significant amounts of electricity, electricity production must continuously correspond to the use of electricity. This requires adjustment capacity and flexibility from electricity production and/or demand. In the future, the increase of intermittent production, i.e., wind and solar power and large base-load plants will decrease the production and proportional share of the traditional condensing power. The shortened operating time of condensing power plants has already led to the shutdown of the Inkoo power plant units, for example. The discontinuing of condensing power reduces the adjustment capacity of the electricity production system.

The economic depression, subsidy-based investments made on the European and Nordic electricity markets in renewable energy and the low cost of emission allowances have kept the wholesale price of electricity low. The wholesale price is expected to remain low in the coming years as well. The prices of electricity forwards rated at Nasdaq OMX Oslo ASA (the electricity derivatives exchange in Oslo) maintain the current price level until 2018. This has made market-based investments in electricity production more difficult. Investments in the combined production district heating and power are also threatened, as the profitability of the additional investment required for electricity production is poor because of the low price of electricity.

Because of the change of the production structure of electricity, the demand response for electricity must increase. Demand response refers to the reaction of electricity demand to the price of electricity. At present, electricity consumption does not vary much with price except for the loads of heavy industry. The development of smart grids and meters will also enable demand response for medium-sized companies and even residences. In Finland, approximately 98% of the electricity consumption sites are equipped with a smart meter that registers consumption by the hour. In the future, load control can be used in the real-time power adjustment of the power system. Electricity sellers are running experiments where the electricity consumption of residential consumers can be controlled according to principles agreed on in advance in exchange for compensation.

Currently, electricity can mostly be stored using pump power, where water is pumped to a head-pond when cost is low and then produced when the cost rises. Research is currently ongoing on the storage of "extra" electricity into methane (power-to-gas), where electricity could be produced from methane during peak demand. Correspondingly, electricity could be used to produce hydrogen or methanol, which would be suitable as traffic fuel. Over a longer period, it should also be possible to store energy on a broader scale in batteries. As electric cars become more commonplace and the technology develops, it should be possible to also use the car batteries as storage.

The development of both demand response and electricity storage and their profitability require that the variation of the market price of electricity be passed on to the users of the energy at the hourly level. The increase of variable production will increase the price variation significantly in the future.

The flexibility of the electricity system can also be improved by seeing to the strength of the main electric grid and sufficient connections with the neighbouring countries.

Capacity mechanisms

Because of the challenges caused by variable production and lack of market-based investments, many countries are considering various support measures for ensuring sufficient electricity production capacity in their systems. In some of the countries, particularly the UK, production capacity is becoming obsolete and requires rapid investments. Therefore, capacity-based subsidies are considered for traditional support forms as well. The measures are generally referred to as capacity mechanisms.

Capacity mechanisms naturally distort competition on the electricity market, particularly in cross-border trading if the support measures vary in different countries. A good example of this is the capacity fee implemented in Russia in 2011, after which the import of electricity to Finland plummeted. In the U.S., the implementation of a capacity mechanism in one market area has typically also led to other market areas connected to this area being forced to implement a comparable mechanism.

Capacity mechanism can be implemented in a variety of ways. The strategic reserves used in Finland, Sweden and Norway ensure that the electricity system continues to have near-obsolete production capacity at its disposal. The producers will keep the capacity on standby based on bidding. The capacity will be invoked only if the market cannot find a balanced price. The cost of the system is rather low.

In actual market-wide capacity mechanisms, the capacity of a power plant is a product parallel to the electrical energy. In the simplest form, the producers of electricity are paid administrative capacity fees based on the production capacity. Such a system is in use in Greece and Ireland, for example. The typical additional cost is approximately 10–20% of the market price of electricity.

The price of the capacity may also be based on a separate capacity market. In centralised capacity auctioning, an independent authority determines the necessary capacity for the coming years and the price is determined based on producer bids. The producers are obliged to deliver the capacity offered and a significant penalty will result from the failure to meet the obligation. In a distributed capacity obligation system, major end users and retailers determine the capacity they themselves need, and the obligation can be fulfilled with own capacity in addition to certificates purchased from producers. Both capacity market models can also be implemented with reliability options, which are financial instruments.

The implementation of the capacity mechanisms is being considered by at least Germany, France, the UK and Italy. In particular, France and the United Kingdom have strongly developed capacity mechanisms and will most likely also implement them.

SWOT analysis

Finland's strengths	Finland's weaknesses
• Finland is part of the competed wholesale electricity market in the Nordic countries • Benefits of the joint operation of hydro and thermal power dominated electricity systems • Reliable operation of main grid and strong connections with neighbouring countries • Diversified production structure of electricity • Great share of combined heat and power production	• Dependence on import during peak load
Opportunities for Finland	**Threats for Finland**
• Nordic hydroelectric power resources ease the increase of variable renewable production • Technology and business expertise based on smart grids and meters	• Poor premise for market-based investments at the current wholesale electricity price • Replacement investments for combined heat and power production can be compromised • European plans on capacity mechanisms may threaten the operation of the common market • Because of the above reasons, Finland's electricity production may also become dependent on subsidies

2.3 Bioenergy

Current situation

In 2012, almost one fourth of Finland's total consumption of energy (92 TWh)[3] was produced with wood fuels. The majority of our wood-based energy is produced from forestry's sidestreams, i.e., black lye, bark, sawdust and other production sidestreams (56 TWh). These fuels are also mostly used for the energy needs of the industry. In addition to production sidestreams, the use of forest chips, i.e., felling waste, small-diameter poles and stubs in energy production (15 TWh) has significantly increased in recent years. Forest chips have particularly replaced the use of peat. The small-scale use of wood, i.e., the use of logs and forest chips in residential houses, cottages and farms, is also considerable (18 TWh).

The agriculture's biomasses were used in 2012 in Finnish energy production for an estimated 1–2 TWh. With respect to the use of agricultural biomasses, various waste and sidestreams have been on the increase.

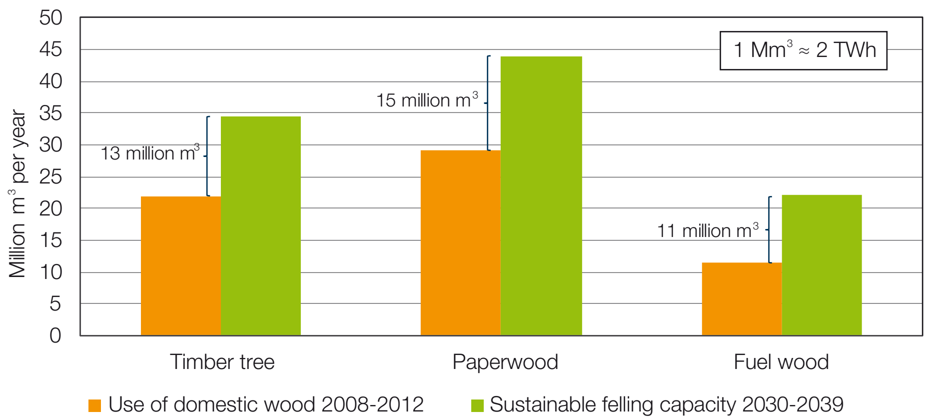
Finland's goal is to increase the share of renewable energy of the end consumption of energy to 38% by 2020, where biomasses and forest biomasses in particular play a central role. The most significant growth objective has been set for forest chips (25 TWh share of electricity and heat production in 2020). The quantitative goals set for the use of forest chips will increase as the climate policy goals become tighter.

Use of bioenergy in the future

Finland's forests have the potential to more than double the use of forest chips from the current level if the availability of the chips is considered from the perspective of the development of Finland's forest resources and the largest sustainable felling levels (Figure 6).

3 All energy quantities (TWh) in section 2.3 refer to the energy content of the fuel, i.e., the primary energy.

Figure 6. Domestic use of log, pulp and energy wood in 2008–2012, sustainable felling capacity with respect to wood production and economic aspects in 2030–2039 and their difference. The greatest sustainable felling capacity has been calculated using Finnish Forest Research Institute's MELA model.



The Finnish Forest Research Institute has estimated that if forests were to be felled according to the greatest sustainable felling capacity with respect to wood production and economy, the accrual of energy wood in the coming decades would be approximately 22 million cubic metres (44 TWh) annually. If the residential use of wood remains steady, it will be possible to add almost 11 million cubic metres (22 TWh) to the energy sector's use of forest chips. Part of this forest chips volume is felling residue and stubs harvested in connection with plant cutting. Thus, reaching this harvest volume requires not only the forest-owners' readiness to see the potential for energy wood but also an increased wood use by the forestry industry that refines timber trees. At present, the utilisation level of our forests with respect to the greatest sustainable fellings is approximately 70%. If the forestry industry's production volume were to remain at the current level, the annual harvesting capacity of forest chips would be approximately 36 TWh in the coming decades without compromising the supply of pulpwood to the industry.

Table 2 presents the usage volumes of biomass by target and wood type in the different Low Carbon Finland scenarios for the years 2030 and 2050. As the distribution of the use of biomass between different targets and wood types varies by scenario, the figures presented in the table cannot be directly added together. In addition, the production at bio-refineries also uses sawdust and bark to some extent, which has not been included in the figures of the table.

Table 2. The use of forest chips and pulpwood in electricity and heat production and in producing liquid biofuels, TWh (the figures for 2030 and 2050 according to the Low Carbon Finland scenarios)

	2012	2030	2050
Use by target:			
Electricity and heat production	15.3	29 – 34	29 – 32
Manufacture of liquid biofuels	0	7 – 19	21 – 33
Total (TWh)	**15.3**	**37 – 53**	**52 – 65**
Use by wood type:			
Stubs	2.2	4 – 6	2 – 9
Branches, heads etc.	5.2	11 – 12	11 – 14
Small-dimensioned wood, does not include firewood	7.2	18 – 24	20 – 25
Pulpwood	0.7	0 – 10	12 – 27
Total (TWh)	**15.3**	**34 – 49**	**52 – 63**

For 2012, the pulpwood column includes sturdy bole tree, which refers to timber tree that was not accepted as industrial raw material. In the present statistics, pulpwood is not presented separately but as part of small-dimensioned wood. The section on use by wood type contains only Finnish wood. The future pulpwood estimate also includes the potential energy use of sawmill chips.
Small-dimensioned wood refers to wood with a small diameter, which is usually harvested from seeding stands and young thinning stands being reconditioned. In energy and price statistics, small-dimensioned wood is divided into delimbed trunks and non-delimbed whole trees.

In the impact assessments of the EU's 2030 energy and climate package, the target estimate of the so-called non-emission-trading sector would require considerable amounts of biofuels for use in transport and machine tools. Therefore, an amount of forest chips near the top value, 19 TWh, presented on table 2 for 2030 would be required for manufacturing biofuels.

After 2030, the usage volumes of energy wood estimated in the scenario cannot be covered with traditional forest chips made from small-dimensioned wood and harvesting residue, especially if the use of the wood in industry does not increase from the present level. The additional need can be covered by using pulpwood suitable as the raw material for the paper industry or by importing energy wood from abroad. Finland's timber balance and sustainable felling possibilities per se enable the wood usage volumes estimated in the scenarios.

Farms can produce more energy for both their own purposes and for sale. Energy production at farms can be planned as part of value chains where, for example, food production residue and waste are utilised as energy and nutrition by means of bio-gasification, for example. The potential of agricultural biomass suitable for energy use is estimated at 11–21 TWh (Hannu Mikkola's dissertation from 2012). The availability and energy use of agricultural biomasses are influenced by a variety of factors, such as the food and energy market situation, oil prices, weather, production sustainability and prices obtained from the energy raw material.

Questions related to bioenergy

In statistical terms, Finland's forest resources provide good potential for increasing the use of biomasses in energy production. With the target volumes for 2020, forest chips used for energy will mostly originate from forestry and regeneration cutting by-products. Also non-wood-based biomass (for example, field biomass, manure, waste) has potential as the energy source of the future.

Increasing the use of forest chips in multi-fuel power plants is a cost-efficient way of increasing the use of renewable energy in the generation of power and heat. The use of biomass is efficient in Finland thanks to the combined heat and power production. It is also energy-efficient to use biomass in separate heat boilers.

It is also possible to reduce the agriculture's environmental load and greenhouse gas emissions by developing the agriculture's energy solutions.

The emission factor of biomass in emission trading and greenhouse gas inventory is presently zero, which means that increasing the energy use of biomass is an effective way of reaching the greenhouse gas goals.

The energy use of biomass will promote employment and regional policy goals and increase the security of supply. Expertise related to the energy use of biomass will also create possibilities for technology export. Finland has strong bioenergy expertise, for example related to boiler technologies, biorefineries, gasification and biomass procurement chains.

The promotion of the energy use of biofuel and biomass has given rise to concerns of the sustainability of bioenergy, such as compromised food production, adverse effects on the diversity of nature, effects on the soil's carbon and nutrition balances and the effect on the atmosphere's carbon dioxide content.

Scientific discussion is ongoing regarding the climate neutrality of using biomass for energy (particularly the short-term effect of burning stubs and tree trunks), which may at some point also affect international and/or EU-level emission calculations. The topic is closely related to the handling of sinks at the international and EU levels as well.

Finland's forestry industry, wood-refining industry and the integrated bioenergy production are not typical in the EU. It is particularly important for a member state like Finland to exercise its influence on matters in advance so that EU-level policy frameworks and legislation will not jeopardise the operating prerequisites for sustainable bioenergy production.

Increasing the production of bioenergy to a level that would require other than forestry and felling by-products to be used for energy production will lead to discussions on the use of forest resources, sinks and the climate-neutrality of using biomass for energy.

The largest harvest potential for forest chips is located in eastern Finland but the use is expected to grow the strongest in south-western and southern Finland, so it can be estimated that the transportation distances will grow. The cost pressure will increase if the transportation distances grow with increasing chip volumes and harvesting will have to be extended to smaller harvesting sites with lower yields.

SWOT analysis

Finland's strengths	Finland's weaknesses
• From the perspective of sustainable felling capacity, there are no obstacles to the strong increase of the energy use of domestic biomass • Cost-efficiency of forest chips • Efficiency of biomass energy use in forestry, CHP plants and heat boilers • Expertise related to the energy use of biomass (boiler technology, biofuel technology, procurement chains, distributed production) • Domestic biomass will reduce the import of fossil fuels	• Deviation from "mainstream" EU; Finland's forestry industry, wood-refining industry and the integrated bioenergy production are not typical in the EU • The possibility of the state to finance the implementation or use of biomasses to a broader extent and the unpredictability of the EU's state subsidy policies • Economic non-profitability of first thinning and the management work of a young forest
Opportunities for Finland	**Threats for Finland**
• Export of cleantech technology • Building of new types of resource-efficient value chains and the profitability and environmental benefits obtained from them • Developing distributed production as part of the energy policy	• Global development related to the sustainability and carbon-neutrality of biomass, particularly the change of international and EU-level greenhouse gas emission calculation rules • Impact of policy changes on the demand for advanced traffic biofuels and on the profitability of investments • The position of biomass and its use in the international climate policy is yet to be organised • The capacity of the forestry industry will not grow, which will limit the level of wood harvesting • Poor profitability of new CHP plants • Difference between the regional supply and demand of forest biomasses • Effect of the broad-scale use of forest biomass on nature diversity

2.4 Other renewable sources of energy

Hydroelectric power

Hydroelectric power's share of electricity production varies in Finland annually between 10% and 20% depending on the water situation. The production of hydroelectric power will grow only with increased power of the existing plants and increased small-scale hydroelectric power and rain assuming that the restrictions in the Rapids Protection Act and the Water Act are maintained. The production power of hydroelectric power plants best suited for power adjustment cannot significantly be increased by modernisation in Finland. With respect to hydroelectric power, the goal is to increase production by approximately 0.5 TWh to 14 TWh by 2020.

According to the Low Carbon Finland scenarios, the production of hydroelectric power could be an estimated 15–16 TWh in 2050.

Wind power

Finland has significant potential for the construction of coastal and offshore wind power and the industrial expertise and capacity for the needs of the wind power industry.

In 2013, approximately 0.8 TWh of electricity was produced in Finland with wind power, amounting to approximately 0.9% of consumption. Finland's goal is to increase the production of wind power to 6 TWh in 2020 and 9 TWh in 2025. The production of wind power is currently subsidised with a feed-in tariff system. With respect to land wind power, the level of the production subsidy is sufficient. However, a demonstration project of offshore wind power is financed with an additional investment subsidy. New plants are included in the subsidy programme until 2020 or until the 2,500 MW capacity (annual production 6 TWh) is met. It is not yet possible to estimate the need for the subsidy programme after 2020. The subsidy system, if any, must meet the EU's state subsidy system criteria, and excess subsidies must not be paid.

According to the Low Carbon Finland scenarios, the production of wind power could be 7–29 TWh in 2050. The production of wind power would be at most three times the amount of the 2025 goal. Here, building offshore wind power has crucial significance. Increasing offshore wind power will require considerable state subsidising. Although offshore wind power will not be profitable in the near future, it may have significant technology export potential.

The significant increase of wind power will continue to require the development of various administrative permit processes. The construction of wind power will most likely be concentrated in larger wind farms. Provincial and municipal zoning for wind power construction is currently very active in the entire country. Despite the zoning, the implementation of wind power is still slow or even prevented by many other limiting factors. Increasing the production of wind power will require adapting the construction of wind power to the surrounding land use, a sufficient consideration of adverse effects and securing local acceptability as well as smoother administrative procedures.

It has been estimated that offshore wind power will increase its share of all wind power projects in Europe, which will provide new growth possibilities for cleantech business in energy and the marine industry, for example in the erecting, operation and maintenance of offshore turbines and the laying down of sea cables. Research carried out in Finland on arctic wind power technology may give special expertise to Finnish companies that could create a competitive advantage for the turbine market for cold winter conditions.

Small-scale electricity production

Small-scale electricity production commonly refers to solar power, small-scale hydroelectric power, small-scale wind power and small CHP (combined heat and power production) that covers, for example, part of the energy requirement for a residence or space. One important prerequisite for small-scale electricity production is easy connectivity to the grid. Another significant prerequisite is the possibility to sell excess electricity. At times, surplus electricity which could be sold on the electricity market could be generated. Electricity may be fed to the grid only if it has a buyer. Temporal variation with respect to the producer's own consumption is typical of small-scale electricity generation.

It is estimated that the small-scale production of electricity will increase. By promoting small-scale production, it would be possible to support local solutions and increase the use of renewable energy. Small-scale production increases the consumers' awareness of their own energy consumption and promotes activeness in energy-efficiency and saving. Small-scale production may have a significant impact in the future as a factor improving the energy self-sufficiency of residential and business buildings and farms and, during seasons favourable for solar power, as a factor that decreases the national electricity production need. The promotion of small-scale generation will also create a lead market for Finnish companies operating in the sector. Finland has first-class expertise, especially in smart-grid solutions related to small-scale generation. Their export potential could be significantly promoted through domestic lead markets.

Solar power

Finland has sufficient solar radiation for producing solar power. Southern Finland does not essentially differ from northern Germany with respect to conditions. The production of solar electricity and heat is still low in Finland. With respect to electricity, the production is emphasised in sites external to the electricity grid (cottages, base stations) while larger units focus on demonstration equipment.

The price of solar cells has decreased significantly in recent years. The amount of solar electricity will increase in Finland to replace purchased electricity. In Finland, the consumer is free of the electricity tax for their own consumption if the production takes place in a production facility of less than 50 kVA. According to IEA estimates, the production cost of solar electricity will decrease to a competitive level in the consumers' own use under market conditions after 2020, and the market will grow.

In the future, solar electricity is likely to be produced in a variety of ways. Concentrated solar power plants (CSP) heat up a medium with solar rays, and the technology's benefits include different size categories and the storage of solar energy. Solar power can also be increased as part of distributed energy production, typically as systems integrated to buildings.

According to the Low Carbon Finland scenarios, the production of solar electricity could be 0.2–18 TWh in 2050. With variable renewable electricity's share of the overall electricity production constantly on the rise, more adjustment capacity is required in the electricity system.

Solar heat

Solar heat is used mainly to supplement other forms of heating. In particular the new construction regulations guide builders to increase the use of renewable sources of energy. Solar heat is best suited to sites with a need for heat during summer. In new office buildings, the building's heat acquisition and possible production of solar heat can be equal at the annual level. Solar heat is most often used as an auxiliary heating system for buildings, for example for heating domestic hot water. The pricing of the surplus heat has a significant impact on the profitability, as the cost of solar heat production is still considerably higher than the energy cost of district heating.

Heat pumps

Ground source heat pumps utilise solar energy absorbed by the ground or a body of water. A heat well drilled into the bedrock is currently the most common means of utilising ground source heat. A ground-source heat pump uses electricity, the amount of which corresponds to approximately one third of the amount of renewable energy (heat) extracted from the ground. Outdoor pumps are either air-air or air-water heat pumps. An air-source heat pump can supplement other forms of heating and is also suitable for cooling residences during summer months.

SWOT analysis

Finland's strengths	Finland's weaknesses
• Technology expertise (e.g., ICT, wind power components, development of solar panels) • Open electricity market and broadly adopted smart electricity meters • Good wind power potential and plentiful light during the summer • Areas reserved in zoning for significant wind power construction	• The current strong need for subsidies of solar and wind power • The production of solar power is the greatest when the consumption of electricity is the lowest and the production of electricity otherwise low-emission • Insufficient number of demonstration projects in Finland (offshore wind power and solar electricity) • Strong oppositions in wind power construction and its local acceptability • Low resources of the environmental administration and municipalities in controlling wind power construction
Opportunities for Finland	**Threats for Finland**
• Utilisation of the entire process chain of offshore wind power (arctic expertise, offshore erecting, operation and maintenance and the required equipment) • Technology competence (arctic competence, ICT, smart hybrid solutions, storage of electricity, demand response, cooling with solar energy) • Energy and resource-efficient living environment • The consumer's possibility for an active role as a small-scale producer on the market • Increasing self-sufficiency in the production of electricity	• Increased need for adjustment power because of increased production of variable power and increased dependence on imports during peak consumption • The state subsidies apply largely to technology imports • The increase of wind power production will not succeed if the adverse effects caused by wind power plants are not sufficiently taken into account and minimised efficiently

2.5 Fossil fuels and peat

The use of fossil fuels is the largest source of greenhouse gas emissions both in Finland and globally. Their share of the global energy consumption is approximately 82%. In the main estimate of the International Energy Agency (IEA), the share will decrease to 76% by 2035 but the use will increase by 24% because of increased total consumption of energy.

IEA has also presented a development path where there is a probability of slightly under 50% that global warming will be limited to two degrees. In it, the share of fossil fuels will decrease to 64% and the use will be reduced by 11% by 2035.

Carbon capture and storage

The carbon dioxide generated in large power plants and industrial plants can be captured with carbon capture and storage technology (CCS). The capturing systems in particular, however, are expensive and consume plenty of energy. In order for a new power plant to capture approximately 90% of the carbon dioxide produced, the cost of building the plant would increase by an estimated 30–80% and the efficiency would decrease by 7–14 percentage points.

The captured carbon dioxide would be pre-processed and transported in liquid form to the storage site by either pipes or ships. In Finland's case, this would principally mean ships. Carbon dioxide can be stored in geological formations, for example, such as depleted gas and oil fields. Scientists are also researching other technologies for binding carbon.

CCS is still in the development stage, and its challenges include expensive technology along with the uncertainties and responsibilities involved with long-term storage. At present, it is difficult to assess when it will be possible for CCS to be deployed for broad-scale commercial use.

CCS can attain emission reductions in otherwise challenging sectors, such as industrial process emissions. Combined with the utilisation of bioenergy, CCS also enables negative emissions, which may be needed when seeking emission-neutrality and compensating emissions in particularly challenging sectors.

Industrial process emissions

Many industrial processes utilise raw materials whose use generates greenhouse gas emissions. These industrial process emissions amounted to approximately 5.6 million carbon dioxide equivalent tonnes in 2011, i.e., approximately 8 percent of Finland's total emissions.

The key greenhouse gas released in industrial processes is carbon dioxide. It is generated when manufacturing steel, concrete or glass, for example, and its share of industrial process emissions was 78% in 2011. Reducing industrial process emissions with current technology is difficult, in many cases virtually impossible. If the above CCS process were to become commercialised, carbon dioxide emissions could be reduced, particularly in the manufacture of iron and steel.

F-gases, i.e., fluorinated greenhouse gases, are also important, as their share of the industrial process emissions amounts to 20%. Their emissions grew tenfold between 1990 and 2011, as F-gases have been used to replace ozone-destroying compounds in cooling and refrigeration devices, for example. Measures conformant to the EU's new F-gas regulation can significantly reduce F-gases. The regulation limits the amount of F-gases introduced on the market in the EU to 21% of their 2009–2012 level by 2030. In addition, leakage prevention and gas recovery when products and devices are decommissioned are improved. It is still necessary to assess whether there is need for implementing financial control mechanisms at the national level.

Use of fossil fuels and peat in Finland

In Finland, the share of fossil fuels and peat of the total consumption of energy has ranged from 46% to 53% in recent years (including transport fuels). In 2012, oil's share of the total energy consumption was 24%, while the corresponding figure was 9% for coal, 8% for natural gas and 5% for peat.

In order for Finland to reach at least the 80% greenhouse gas emission reduction goal by 2050, the energy system must be changed almost entirely emission-free. At the same time, fossil fuels must be almost entirely discontinued in the production of electricity and district heating unless the commercialisation of CCS enables their use.

The Low Carbon Finland project also conducted a sensitivity analysis to analyse a scenario where CCS does not become commercialised. Thus, based on the results, the set goal of 80% reduction can almost be reached but, when approaching the target, the cost will be very high. The commercialisation of CCS is therefore essential for attaining the 80–95% emission reduction goal in an economically feasible way.

Special characteristics of fuels

Burning peat will produce greenhouse gas emissions, so using it for energy must be discontinued in the long run in order to attain the emission reduction goal, unless the commercialisation of CCS enables its use. Peat is, however, a Finnish fuel, the use of which creates jobs, strengthens the balance of trade and improves energy self-sufficiency and the security of the energy supply. In addition, Finland's existing power plant boilers usually cannot, for technical reasons, handle pure biomass as fuel, while peat is suitable as a mixed fuel parallel to biomass. When burned as a mixed fuel parallel to biomass, peat has technical benefits related to the alkalis of biomass.

Because of the benefits of peat, it is important to ensure that it will be discontinued only after first discontinuing fossil fuels. Peat extraction must still be developed toward environmentally conscious production.

Natural gas is suitable for many purposes: it can be used in energy production and industry and as fuel for road and sea transport. In addition, the manufacture of biofuels requires hydrogen produced from natural gas. Natural gas can be used for limiting climate change, as the carbon dioxide emissions from burning the gas are approximately 40% lower than from burning coal and approximately 25% lower than from fossil fuels used in transport. For natural gas, it is important to ensure that the life cycle emission balance is good and that the investments do not result in a commitment to the use of fossil gas in energy production in the long run.

The use of natural gas is further favoured by the retaining of infrastructure, as the existing gas pipes can be used directly for transporting biogases and bio-based synthetic natural gas (bio-SNG). The liquefied natural gas (LNG) terminals currently planned would provide more options for procuring natural gas, enable the gas market to be opened and reduce the supply and price risk caused by a single supplier. In the future, gas may also be suitable as a new type of energy storage; if the production of wind or solar power clearly exceeds the demand for electricity, the excess could be converted to gas (the power to gas technology). At present, the method is expensive.

As with other fossil fuels and peat, natural gas can only be used in energy production with CCS in the long run in order to attain the emission goals. In any case, natural gas is suitable as fuel during the transition period toward clean technologies.

For the past 30 years, the total consumption of oil in Finland has ranged on both sides of 100 TWh when the refineries' own consumption is included. The use of oil tonnes sold in Finland in 2013 was divided as follows: transport 53%, raw materials and lubricants 18%, energy production 12%, agriculture and forestry and construction 10% and building heating 7%.

The transport sector will be discussed in more detail in section 3.1, and the buildings' oil heating systems will be discontinued over time even with current measures. Oil used in energy production and as raw material can be replaced by other fuels up to a certain point. Oil used in agricultural and forestry machine tools can be replaced with bio-based fuels.

SWOT analysis

Finland's strengths	Finland's weaknesses
• None of the fossil fuels or peat is in a dominant position • During the transition period, peat will improve the degree of energy self-sufficiency and security of supply, strengthening the balance of trade and creating jobs • In electricity and heat production, fossil fuels and peat can largely be replaced with biomass • Over time, oil heating systems in buildings will become discontinued, even by simply continuing the current measures	• The industry's process emissions cannot be significantly reduced without CCS or production cuts • Coal in particular is inexpensive and in abundant supply. Therefore it is challenging to replace it
Opportunities for Finland	**Threats for Finland**
• If CCS becomes commercialised, it will enable significant emission reductions in industry and large power plants • LNG reduces Finland's dependence on Russian gas and improves the security of supply • The existing gas network directly allows for transporting biogas and bio-SNG • The number of jobs in the cleantech sector, as well as its export possibilities may increase when the use of fossil fuels is reduced • Bio-CCS would enable the production of negative emissions	• CCS will not become commercialised. This would partly increase the need for using domestic biomass, which, however, may be limited by the acceptability of the energy use of biomass (see section 2.3) • The continuously decreasing price of fossil fuels and the low price of emission allowances do not support the discontinuation of fossil fuels

3 Use of energy

3.1 Transport

Transport emission trend

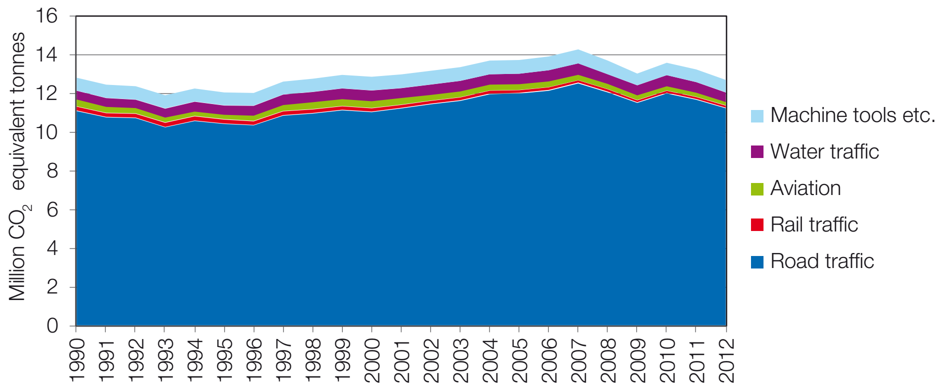
In 2012, the Finnish transport greenhouse gas emissions amounted to approximately 13 million carbon dioxide equivalent tonnes. This equals approximately one-fifth of all of Finland's greenhouse gas emissions and approximately 40% of the non-emission-trading sector's emissions. According to the national energy and climate strategy, transport emissions in Finland could be 11 million tonnes in 2020 (a 15% decrease compared to 2005) and, upon the implementation of the EU's climate package for 2030, perhaps only 8–9 million tonnes in 2030 (up to 35–40% emission reduction).

In the long term, the EU has set a 60% emission reduction goal for transport (Finland's emissions at most 5 million tonnes in 2050). A reduction of approximately 80% is calculated for domestic traffic in Finland's foresight report on climate and energy policy (2009), in which case transport's remaining emissions will decrease to 1–3 million tonnes in the 2050 scenarios.

Approximately 90% of domestic transport emissions are produced in road traffic, as shown in figure 7. Approximately 60% of the road traffic emissions are caused by passenger cars, 35% by vans and trucks and the rest by buses, motorcycles etc. Rail transport amounts to approximately 1% of the emissions, air traffic 2% and sea traffic 4%.

The emissions of international traffic are not, for the time being, included in the scope of international agreements and are therefore not covered by the official greenhouse gas emission inventory. The need for energy for international traffic, however, must be taken into consideration in, for example, situations where part of the transport energy consumption is covered by domestic renewable energy.

Figure 7. Greenhouse gas emissions from domestic transport (and machine tools included in the transport sector) 1990–2012 (source: Statistics Finland)



The emissions of road traffic have traditionally increased as the economy grows and transport performances rise. Correspondingly, these emissions have decreased when the economy shrinks and performances plummet. In recent years, these cause and effects seem less connected. The decrease of emissions depends, therefore, on factors other than just a change in transport performance, such as the increased use of renewable energy in traffic and the increasingly smaller specific emissions of new passenger cars.

Renewable energy in transport

The use of renewable energy is promoted in the EU by a common, binding goal set for all member states according to which the share of renewable energy in transport energy consumption must be increased to 10% by 2020. In Finland, the goal has been doubled with the so-called Distribution Obligation Act. According to the law, fuel distributors must supply at least 6% of biofuels for consumption in 2011–2014. After this, the distribution obligation will increase steadily and reach 20% in 2020.

Transport biofuels, as well as electricity-powered transport, are considered zero-emission in the transport sector in greenhouse gas inventory, i.e., the emissions caused by their production will be counted as greenhouse gas emissions in the sectors that produce them. Transport's energy consumption will differ from transport's greenhouse gas emissions in the future. The energy consumption may even increase while the emissions (in the transport sector) will decrease.

Average emissions from passenger cars

According to the EU's binding CO2 limits that apply to car manufacturers, the average emissions of new passenger cars may be at most 130 g/km in 2015. In 2020, the emissions may be at most 95 g/km. For vans, the goal is to push emissions to the 175 g/km level by 2017 and 147 g/km by 2020. In order to limit emissions this drastically, car manufacturers must also implement so-called new technologies in manufacturing, such as electric cars.

The average CO_2 emissions of new cars decreased in Finland in 2007–2012 by approximately 24%, partly because of the EU limit values and partly because of the domestic car and vehicle tax, the rate of which depends on the CO_2 emissions. Not enough new cars and new technologies, in particular (electric, gas and flexifuel cars), were sold to meet the goals. The low sales stall the reaching of the emission reduction targets and could threaten the goals in the non-emission trading sector if transport performances start growing again once the economic situation changes. The working group on future forms of propulsion in transport of the Ministry of Transport and Communications issued a report in 2013 presenting several detailed goals, for example passenger car traffic should be almost zero-emission in 2050.

Need for other measures

The implementation of renewable energy and increasingly low-emission technology in transport is a central means of reducing the greenhouse gas emissions of transport. However, other means are also needed in the long run. The energy amounts consumed by transport, including international transport, are so large that the sources of renewable energy raw materials cannot satisfy the entire transport sector's biofuel raw material needs, considering the need for energy in other sectors of society. In addition, (traditional) biofuel can only be mixed with gasoline to a certain extent because of the technical limitations of the present car pool, whereby the slowness of the renewal of the car pool imposes its own limitations to the use of these biofuels.

It should also be noted that renewable energy and low-emission technology will not solve other traffic problems, such as traffic congestion on main routes or the problem of arranging for parking when town space is limited.

In urban traffic and inter-town traffic, greenhouse gas emissions and energy consumption can be reduced by influencing the distribution of the form of transportation and transport performance, particularly in towns. Public transport's share of moving Finns is presently around 8% while walking and bicycling amount to approximately 30%. At best, the shares of walking, bicycling and public transport in certain urban travels could reach well above 50%, which means that there is plenty of space for improvement.

Promoting public transport, walking and bicycling would also decrease other harmful environmental effects of traffic, such as exhaust fume emissions and noise harmful to heath, improve the smoothness and safety of traffic and promote national health because of increased physical exercise. Influencing the distribution of varied transport means and transport performance is cost-efficient in towns in particular.

SWOT analysis

Finland's strengths	Finland's weaknesses
• Advanced traffic infrastructure covering the entire country • Good raw material base for promoting the use of biofuels and other renewable energy and the genuine commitment of actors in the field to promoting the matter • Solid expertise in the fields of smart traffic and other new traffic services that utilise information technology	• Distributed community structure and concentration of services, which increases moving by private cars • Economic incentives that increase private driving • Concentration of cargo transports on rubber tyres
Opportunities for Finland	**Threats for Finland**
• Possibilities for exporting transport biofuels • Export possibilities for new traffic services (e.g., smart traffic services)	• Failure to meet the emission reductions or increased import of biofuels if the planned biorefineries are not implemented • Continuous increase of energy consumption by transport • Continuous growth of traffic and congestion of urban traffic and other problems of the traffic system if the transport climate policy concentrates only on promoting the use of biofuels

3.2 Built environment

Climate change limiting measures related to the built environment comprise land use, energy-efficiency in both new and renovated constructions, the maintenance of buildings and the utilisation of renewable energy. Decisions that involve land use and construction have a far-reaching impact because the infrastructure changes slowly. A significant part of energy consumption takes place in the built environment

Land use planning

The most significant solutions related to the reduction of emissions in zoning are related to the urban structure and functionality of communities, the internal structure of the parts of town, combining land use and traffic, creating premises for the production of renewable energy and enabling a lifestyle where carbon dioxide emissions are low. In urban regions, these require services within walking distance, good public transport services and a lightweight traffic network, a vital and functioning city centre and good accessibility of recreation and green spaces. Practical solutions for decreasing emissions may vary significantly in different parts of the country.

The growth of urban regions and the dispersion of the community structure have resulted in, for example, longer journeys to work and services, and the increased use of private cars. This has particularly been strengthened by scattered construction in fringe areas of urban regions and zoning policies that heavily rely on passenger cars.

A prerequisite for public transport is sufficient regional efficiency. In a scattered community structure, it is not cost-efficient to arrange for public transport nor will it further the emission goals. The distances are often also too large to be travelled on bicycle or on foot.

The zoning and building of new areas almost always produces greater carbon dioxide emissions than supplementary construction. The implementation of new residential areas also has an impact with respect to carbon sinks and emissions calculation. With respect to the efficient utilisation of the infrastructure and minimising maintenance costs, supplementary construction is usually a far better option than building a new residential area.

Construction and buildings

By the end of 2020, all new buildings must be nearly zero energy buildings. With respect to renovation construction, the level of energy efficiency has significantly been improved with the building code that entered into force in 2013. The significance of renovation construction will increase, and new, cost-efficient steering measures will be implemented where necessary to utilise energy-efficiency possibilities.

The share of renewable energy will continue to be increased. In recent years, renewable energy's share of the energy produced by building-specific heating systems has amounted to approximately 60%. The share of building-specific heating systems, in turn, of the heating energy for buildings has been approximately 40%. The remaining 60% has been covered by district heating and electricity, where renewable energy has also been used.

With respect to buildings, the method of energy production and the source of energy will be emphasised in the future along with the choices of the building users. The field has a continuous need for information guidance and development measures. Proactive maintenance and the renovation of buildings and the built environment that take the characteristics of the buildings into account would promote the goals of sustainable development.

SWOT analysis

Finland's strengths	Finland's weaknesses
General • Networking; a small country enables efficient collaboration between different actors • Utilisation of renewable energy • Functioning systems and structures • District heating in broad-scale and efficient use • CHP plants Community structure, living environment, traffic • High-quality technology competence • Solid existing infrastructure Construction and buildings • Control of the energy efficiency of construction and measures already taken • Reasonably good energy efficiency of the buildings	General • The population's age structure and economic situation limit the willingness to invest • Scattered population, long distances and challenging climate conditions Community structure, living environment, traffic • Price of living in the Helsinki region, people moving to the surrounding municipalities and commute long distances • Land use policy that varies from one urban region to another and is partly poor • Small passenger potential of public transport resulting from the scattered community structure • Lengthened commuting distances • The polarisation of the discussion regarding the community structure into a town-countryside confrontation although the necessary means and their significance are different in towns and in the countryside Construction and buildings • High cost of residences, particularly in the Helsinki region • The great building pool will adapt to changes slowly • Building pool unused because of increasing regional inequality
Opportunities for Finland	**Threats for Finland**
Community structure, living environment, traffic • Utilisation of the existing infrastructure • Controlled supplementary construction of the present, loose urban structure • Increasing the quality of the living environment in supplementary construction and high-quality living environment as a competitive factor • Possibilities for changes in the way people get around: improving the premises for public transport and active moving (bicycling and walking) particularly in towns • Energy and resource-efficient living environment • Development of land policy Construction and buildings • High-quality expertise in energy issues • Utilisation of planned building management and lifespan management • Utilisation of the possibilities in renovation construction • Utilisation and promotion of smart technology	Community structure, living environment, traffic • The impact of the accelerating structural change of businesses on regional construction and mobility of workforce • The efficiency of land use policy cannot be improved • Conflicts between different societal goals and steering mechanisms, which are perceived as unfair • Scattered community structure of urban regions • Increased need for transport by passenger cars • Decreased competitiveness of public transport • Deterioration of the existing infrastructure Construction and buildings • Quality issues in construction • Lifecycle management shortcomings • Impact of regulation of the construction industry on the price of construction

3.3 Energy-intensive industry

Finnish manufacturing industry is traditionally very energy-intensive (forest, paper, metal and chemical industries), and these industries still form a large part of the volume of the national industry.

The backbone of the forest industry's production is plentiful forest resources and northern coniferous wood, whose raw material produces paper and cardboard and provides a competitive advantage. In the steel industry, Finland has a globally unique, effective logistics and raw-material based production chain for stainless steel manufacturing.

The relative significance of energy-intensive industries has decreased in recent years but they continue to be a central part of Finland's economy. In 2012, these industries represented one-third of export revenues and more than 40% of total exports; they directly employed 75,000 people and, through the cumulative effect, indirectly created jobs for a great deal more. The significance of the forest industry and metal refining is further enhanced when considering Finland's trade balance. In both industries, the majority of the production is exported and, particularly with the forest industry, a significant portion of the raw materials used for production is domestic. Fields from the manufacturing industry or comparable fields that use a significant amount of energy and are clearly growing are the mining and chemical industries and datacentres.

Energy procurement of the energy-intensive industry

Energy is a significant production factor and a big expense in the forest, metal and chemical industries. Therefore, the use and procurement of energy has been arranged as efficiently as possible. Energy-efficiency in both consumption and procurement results in a competitive advantage. In particular, the procurement of electricity by heavy industry differs in Finland compared to most of its competitors by the large proportion of the industry's own production. Forest companies produce almost half of the electricity they need in their own combined heat and power plants (CHP) where the key fuels are their own wood-based sidestreams and waste. In addition, the companies own such large interests in water and nuclear power plants (the so-called Mankala principle) that some of them are net sellers of electricity. The forest industry's electricity procurement is largely based on zero-emission sources of energy. In the future, the energy intensity of the forest industry's production will decrease considerably, as the production share of new products, such as biofuels and bioliquids and biofibre materials will increase.

Attempts have been made in Finland to limit the increasing cost of energy in the same way as in the competing countries, i.e., an energy tax that is lower than in other sectors. The manufacturing industry has an electricity tax rate that is lower than in the service business or for households, in addition to which energy-intensive industry also receives an energy tax break. With this method, the tax burden can be kept reasonable in the most energy-intensive industries.

Energy as a production expense

Finland's energy-intensive industry's share of the national product is larger and the energy intensity higher than in other EU countries on average. In 2012, the energy-intensive industry's share of the added value of the factory industry was approximately one-third. The availability and cost of energy have a significant impact on the operating premises, export competitiveness, trade balance and economic growth of the energy-intensive industry. In particular, it is important for investors in industries that use plenty of energy to be relatively certain about the long-term evolution of price of energy.

According to a study by Pellervo Economic Research PTT, an internationally level playing field is a prerequisite for the success of Finnish industry. The competitiveness is affected not only by resources but also by technology, competence and infrastructure.

International climate negotiations and the risk of carbon leakage

For Finland, it is particularly important that all future international climate solutions minimise the risk that the production and investments of the energy-intensive industry could move to countries where the climate policy does not produce a cost burden similar to the homeland (so-called carbon leakage). The Commission has, for example, assessed the risk of carbon leakage related to the operation of energy-intensive industry in connection with the preparation of the 2030 framework for energy and climate policies.

If international climate negotiations do not reach a comprehensive global agreement on the reduction of emissions or if the corresponding cost burden is not imposed in key competing countries on industry, the way it is in the EU, the competitiveness of the industry must be protected by continuing and developing the current measures for alleviating the risk of carbon leakage in ways that do not weaken the incentive to reduce the emissions. Reaching a solid climate agreement is, however, the most efficient solution for preventing carbon leakage.

If various compensation mechanisms must be continued to prevent carbon leakage, such as free initial distribution of emissions allowances and the compensation of indirect expenses of emission trading, an EU-wide mechanism should exist in order to apply them. National solutions can position different EU member states unequally depending on the amount of compensation. At least Germany, Spain, the Netherlands and, among non-EU-countries, Norway already now compensate the indirect cost of emission trading to the industry.

The use of various flexible mechanisms at both EU and international levels must also be considered once it becomes clear what shape the global climate agreement will take.

The future position of the energy-intensive industry in Finland

It is a benefit for Finland and for global climate policy goals that efficient and modern energy-intensive industries remain in Finland also in the future. Energy-intensive industry in Finland continuously develops its operations and processes, and products whose manufacture requires plenty of energy are, thus, manufactured responsibly and with energy efficiency, taking greenhouse gas emissions into consideration.

In order to diversify and balance the industrial structure, Finland has compelling reasons to invest in the growth of cleantech both in the energy-intensive industry and in other areas as well. Investments in cleantech will also produce solutions to global climate challenges.

SWOT analysis

Finland's strengths	Finland's weaknesses
• Finland has its own supply of raw material for the forestry indust, particularly long-fibre wood, which not all countries have • The forest industry is largely based on the use of renewable energy • The price of energy in Finland is still competitive in comparison with other European countries • The industry already works with relatively good energy efficiency in Finland • Finland has plenty of expertise in process industry	• The structure of Finland's industry is energy-intensive, whereby changes in the price of energy may have a larger impact on the national economy than in many other countries • The structure of Finnish industry exposes it to the carbon leakage risk • The manufacturing industry has great regional significance, which means that the impact of discontinued production cannot easily be compensated for
Opportunities for Finland	**Threats for Finland**
• The development and growth of the bioeconomy (e.g., biofuels) enable the development of new products using existing production facilities • Collaboration and synergies between cleantech and the energy-intensive industry	• The international climate agreement cannot be reached • The carbon leakage will become a reality, and new jobs in cleantech require different expertise than lost factory jobs

3.4 Energy efficiency

Efficient use of energy and saving it are the key premises of the energy and climate policy. Cost-efficiency and other needs of the society must be matched with the promotion of energy efficiency. With respect to energy efficiency, Finland is at a good level in many ways but retaining that state and improving it will require continuous investment and development.

Energy efficiency refers to measures that utilise energy in an efficient way, thus using less energy than before. Energy saving, in turn, refers to entirely giving up an activity that requires energy or settling for less, which reduces the need for energy.

Energy efficiency measures are typically divided in two areas. Most of the measures are related to technology and technical solutions, such as the consumption of a car, the efficiency of electric devices and the insulation of a building. The other area involves the consumer's own actions and choices.

Most of the savings attained with energy efficiency are reached with technology and technical solutions. These changes often take time because of the large volume of structures and equipment and their slow renewal. New and more energy-efficient solutions are often initially more expensive than the older technology, when it comes to the cost of investment, but with more commonplace use and development of the technology, the prices usually come down.

Energy efficiency related to activities and choices is always important, whether the technology and structures in use be modern or older and more energy-consuming. Energy efficiency related to actions and choices does not usually require direct investments but, on the other hand, the saving potential is usually not reached.

Steering mechanisms for energy efficiency are controlled by standards (e.g., building codes, emission limits on new cars), voluntary agreements, economic steering and communication and education. Finland employs all of these methods. In particular, voluntary energy efficiency agreements and audits have a long history and have produced good experiences. Finland's energy efficiency activities have been praised in international assessments by the EU and IEA for their diversity and market orientation.

Identifying and proving energy efficiency is not as simple as merely assessing emissions or the amount of renewable energy. The results must be compared to the projections for development without energy efficiency measures.

Energy efficiency must apply to all energy, including electricity. Replacing other forms of energy with electricity may result in a total consumption of energy that is lower than in the original. As a general rule, domestic and global future projections and scenarios involve a significant increase of electricity's share of the total energy. Increasing energy efficiency must also be central in the use of electricity.

Energy efficiency is a goal worth striving for but it should not be measured by the total energy consumption or by the end-use of energy at the EU or member state levels. Setting an energy efficiency goal for the evolution of the total consumption or end use of energy would be problematic for Finland, as artificial limitations might have to be imposed on production and consumption. Measuring energy efficiency per capita and GDP unit involves the same problem, as it does not indicate the reason for the high energy consumption.

Further investments must be made in analysing and dismantling obstacles for energy efficiency. In particular, investments must be made to increase the profitability of energy efficiency investments compared to alternative investment possibilities.

Energy efficiency can and must be promoted in all energy use. The industry's energy efficiency is already at a good level but there is always need for even more cost-efficient energy efficiency. The payback periods of many energy efficiency measures remain relatively short and the emission reductions attained with them are considerably more beneficial for the national economy than emission reductions in many other ways. In addition, improving material efficiency will also save energy.

The energy efficiency of households, traffic and services, as well as agriculture combine improved device energy efficiency, consumer choices and usage habits. In these areas, continuous communication and education play a significant role in addition to technology. EU-wide eco-planning and energy labelling measures are important for the energy efficiency of devices, as they impose efficiency requirements for devices and encourage the consumers to choose the most energy-efficient ones.

SWOT analysis

Finland's strengths	Finland's weaknesses
• Functional, market-based energy efficiency system with long history; energy audits and energy efficiency agreements and their reporting and follow-up • CHP well utilised in industry and district heating on a market-oriented basis	• The attitude toward new steering mechanisms and business models and their development is often conservative • The voluntary nature of many measures enables freeriding for some • At small energy consumption sites, services and households are not always sufficient incentive for improving the energy efficiency
Opportunities for Finland	**Threats for Finland**
• Possibility for exporting competence, cleantech (incl. improved industrial process efficiency) • High energy consumption serves as an incentive for energy efficiency	• It is difficult to understand that high energy consumption in Finland does not always equal energy inefficiency • Difficult to find a just and functioning energy efficiency meter • With scarce financial resources, the improvement of energy efficiency will often be the first to be compromised

4 Other sectors

4.1 Agriculture and forestry and carbon sinks

Forests and policy measures

Finnish forests are managed and used in a sustainable way in many respects, and a strategic goal is keeping the forests in active, sustainable and versatile use. Diversified forest management and use promote adaptation to climate change and manages the forests' carbon balance.

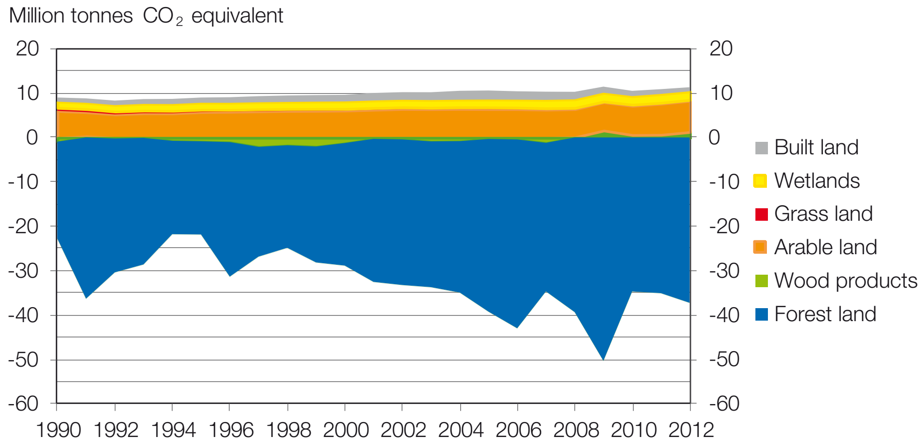
Forests often produce many benefits once it is ensured that no degradation of ecosystems takes place. Forests can be utilised in limiting climate change in three ways:

- Use of wood as a replacement for raw materials (wooden products and bioeconomy products, bioenergy)
- Carbon sink that binds carbon dioxide. Retaining the carbon sink requires that the growing stock be renewed
- Carbon storage (growing stock, wooden products and soil)

Carbon sink refers to a process where forests bind carbon dioxide from the atmosphere as they grow. In Finland, forests serve as carbon sinks whose volume has ranged between 30% and 60% of Finland's total emissions from 1990–2012. The sinks and emissions of agriculture and forestry are not only affected by the conversion of forested areas into built land or field but also, for example, by annual variations and natural destruction, which varies from year to year.

In international climate obligations, forests and agricultural land's carbon dioxide emissions are part of the separate LULUCF sector (land use, land use change and forestry). In the LULUCF sector, different land classes are both sources of greenhouse gas gases and their sinks, and this is presented in figure 8 for 1990–2012.

Figure 8. Greenhouse gas emissions and removal in the land use, land use change and forestry (LULUCF) sector from 1990–2012 (million tonnes of CO2 equivalent, emissions as positive and removal as negative figures). Source: Finland's greenhouse gas emissions 1990–2012, Reviews of Statistics Finland 2014/1.



The status of forests and sinks in international and EU-level emission reduction obligations will probably continue to be limited even in the future. It is possible that forest sinks will still be taken into consideration based on computational, not biological, sink[4] after 2020. The status of agriculture in the emission reduction obligations also remains open.

Emission and sink forecast for forests

Finland's forests are currently growing strong and the carbon sink of the growing stock in the forests is on the rise as well. Active management and use of the forests maintain the forests' ability to grow and bind carbon dioxide. The level and structure of the harvesting of wood is the most significant factor with respect to the development of the forest sink.

According to estimates, the wood reserve and carbon sink will continue to grow. In the Low Carbon Finland project's scenarios, the growing stock's sink will approximately double by 2050. Thus, the wood resources will enable a significant increase of the use of wood compared to the present level, including its use for energy.

Agriculture and policy measures

Agriculture-based emissions amount to approximately 20% of Finland's total emissions. The greenhouse gas emissions of the agricultural sector are reported

4 Computational sink means that instead of the factual biological sink, the obligation is based for example on the volume of the sink during base year or another predicted sink volume.

according to the United Nations Framework Convention on Climate Change in three sectors:

1. Agricultural sector: emissions from production animals, manure and soil (9% of Finland's total emissions in 2012). The emissions have decreased by 13% since 1990.
2. LULUCF sector: arable land emissions from soil and liming. The emissions have increased by approximately 7% since 1990.
3. Energy sector: energy use in agriculture.

The reduction of agricultural emissions has been affected particularly by the structural change that has taken place in agriculture: the farm sizes have increased and the number of domestic animals has decreased. In addition, reduced fertiliser use and improved efficiency of manure handling methods have contributed to the emission reduction.

It is difficult and expensive to significantly reduce emissions in the agricultural sector. The climate policy's treatment of agriculture should be broadened to cover land use solutions in particular, as it is relatively inexpensive to reduce the CO_2 emissions of soil. It is also important to consider whether agricultural production, the use of agricultural production inputs, the farms' own energy production and consumption should also be reviewed and compiled into statistics as a single entity at the national level. This would make the efforts of farmers more transparent and increase the motivation to reduce greenhouse gas emissions. The climate measures related to agriculture is also controlled by the EU's common agriculture policy. Limiting climate change and adapting to it is one of the goals of the 2014–2020 rural development programme.

Emissions of the agriculture sector

It is estimated that emissions from the agriculture sector will remain close to the present level until 2035. The growth of the surface area of organic soil continues but to a lesser extent than at the beginning of the 2000s. The best and most implementable means for reducing emissions in agriculture are measures that also generate benefits other than only emission reductions.

It is very difficult in agriculture to reach visible reduction, at least in the short term, without limiting the growth of the surface area of organic soil utilised for agriculture or without reducing work on organic soil (i.e., affecting the food production yield/the production assortment). If consumption habits do not become more vegetable-based in Finland, reducing agricultural production in Finland will not reduce greenhouse gas emissions globally (cf. carbon leakage).

It may be sensible to also inspect agricultural production at the national level using production-specific emissions (emissions/litre of milk or kilogram of corn), which can be reduced using several methods. In addition, it is already necessary for agriculture to prepare for climate change, where new technology and research is needed.

Soil emissions in the LULUCF sector

The emissions related to the soil of the arable land reported in the LULUCF sector will likely grow without special reduction measures. The emissions of organic soil form the greatest part of the total emissions and are most increased by the growth of the surface area of organic arable land.

As a result of climate change, it is estimated that the possibility for producing protein feed in Finland will grow. This will reduce the need for imported protein and, consequently, the pressure for change in land use and deforestation particularly in Latin America, which is where the majority of protein fodder is currently imported.

SWOT analysis

Finland's strengths	**Finland's weaknesses**
• Sustainable forestry and increasing forest resources • High-quality competence, technology and research and working infrastructure • Educated and skilled producers and their willingness to use new technology • Finnish consumers want to buy Finnish food • Broad agricultural compensation system for environmental protection enables reduction of emissions	• Large share of organic soil of the arable land in part of Finland • Deforestation, i.e., converting forest land to community building and farming • Shortcomings in matching the goals and measures of various policies • Low productivity caused by severe climate
Opportunities for Finland	**Threats for Finland**
• Sustainable and diversified utilisation of growing forest resources and using them to limit climate change • Export of wood-based products and technologies • Potential of agricultural biomasses, waste and sidestreams in the production of energy and nutrition • Possibilities offered by the reduction of food wastage • New technological solutions brought about by research to increase agricultural productivity • Extended growth season resulting from climate change • Farms as the producers of renewable energy and energy efficiency at farms	• The versatile utilisation of forests is limited by policy mechanisms • Increase of extreme weather phenomena and occurrence of new plant enemies and animal diseases • Lack of policy coherence in EU and international level legislation • Uncertainties at EU and international level regarding the calculation rules of the LULUCF sector and the role of agriculture after 2020 • Failure to keep arable land in growing condition and the resulting increase of emissions • Expensiveness and poor suitability to Finnish conditions of existing technology

4.2 Reducing the amount of waste and waste-based greenhouse gas emissions

In the waste sector, the 80–95% reduction of greenhouse gas emissions can be attained with the present waste management improvement measures. Because of their effect, the greenhouse gas emissions in the waste sector will decrease to approximately 0.6 million CO_2 equivalent tonnes by 2050 (an 85% decrease from the 1990 emissions (approximately 4.0 million CO_2 equivalent tonnes)). The estimate does not take into consideration the carbon dioxide emission generated by using waste as fuel for energy production, which is counted as part of the energy sector's emissions.

In 2011, Finland produced 95 million tonnes of waste. The majority is mineral waste from the excavation industry, such as soil and rock material waste, of which the annual production is 77 million tonnes. The second largest type is wood waste, with a total of 11 million tonnes. The wood waste streams originate mostly from the forest and wood industry and construction. Of all waste, approximately 54% ended up at waste sites, 36% in recycling and 10% in burning. If mineral waste is excluded from the assessment, the corresponding figures are 10%, 35% and 51%. Municipal waste's share of all waste is approximately 3%, and there has been a strong reduction in deposits at waste sites.

Reducing the waste site depositing of waste and increasing the utilisation of waste will reduce the greenhouse gas emission in the waste sector and increase the utilisation of waste not suitable for material use in energy production. In the coming years, waste site depositing of biodegradable and other organic waste will be discontinued and the recycling of municipal waste and utilisation of construction and demolishing waste as material will be increased.

In accordance with the principles regarding European circular economy and resource efficiency, a low-waste recycling society will be approached in the long term. As the share of recycling and material utilisation increases, the amount of waste utilised as energy will gradually decrease. There is a sufficient and suitable, geographically balanced plant capacity as part of the rest of the energy sector for the utilisation of waste as energy.

SWOT analysis

Finland's strengths	**Finland's weaknesses**
• Recent rapid development of waste management in Finland has resulted in a dynamic, growing waste industry • Competence in the energy use of waste for producing heat, electricity and transportation fuel as well as biogas is high • Adopting the principles of circular economy presents a challenge for developing new waste industry processes, raw material use of waste from material flows and utilisation of renewable energy sources • The energy utilisation level of waste wood is high • A modern and stable set of standards supports the implementation of the change	• Finland is not one of the leading experts of waste management and recycling • The desired cleantech exports have not emerged in the waste sector • Insufficient Finnish investments in new environmental protection technology that exceeds the minimum environmental protection requirements and lack of risk capital • The revolution of waste management and the resulting, opposing understandings of actors in the field. • The recycling economy cannot be made as efficient in a country with low population density as it can in a country with a higher density
Opportunities for Finland	**Threats for Finland**
• In the long run, there is a need to shift from waste policy and regulation to material policy and material lifecycle utilisation management • The energy potential of waste from agriculture and forestry can be efficiently and profitably used in such a way as to attain net environmental and health benefits • Transportation emissions can be reduced by replacing fossil fuels with Finnish, waste-based transportation fuels • The utilisation of wood waste not suitable for recycling as energy is a sensible option	• The development of demand for recycling products is uncertain • Impurities in the waste materials recycled can have an accumulated effect on new products • The low or negative price of waste may make it more difficult to develop business and may restrict competition and the emergence of innovation • Some of the wood waste is "stained" or damaged and cannot be utilised as material or such use is not desirable • The municipalities' economic interests may be a hindrance for the development of a competitive operating environment

5 Multi-disciplinary measures

5.1 Promoting the cleantech sector

The cleantech business, which is based on energy and environmental technology, is one of the areas of focus of Finland's industrial policy. Cleantech refers to products, services and processes that promote the sustainable use of natural resources and reduce emissions to the environment. While cleantech brings solutions to global environmental challenges, such as contamination of the environment, climate change and sufficiency of resources, it improves industrial and service competitiveness through the efficient use of materials and energy. Solutions related to renewable energy and energy efficiency are a very important part of the cleantech business, though it also involves mineral, bioeconomy and water management areas.

Finland is one of the leading cleantech countries in the world. The total turnover of Finnish cleantech companies in 2012 amounted to €25 billion, marking growth of 15% from the previous year. Finland's strengths in the cleantech business include the resource efficiency of industrial processes, i.e., the efficiency of energy, material and water use, as well as bioenergy and biobased products.

Fighting climate change creates huge cleantech markets

The International Energy Agency IEA has estimated that limiting climate change to an increase of 2 degrees requires an average of one trillion dollars in additional annual investments in new cleantech solutions until 2050. The emergence of such a large market will allow Finland's economy to be strengthened if we can develop cleantech solutions that are successful on the market. Already at present, energy industry solutions alone worth several billion euros each year are being exported from Finland, and the export has grown rapidly in the 2000s.

Cleantech solutions enable the cost-efficient reduction of emissions

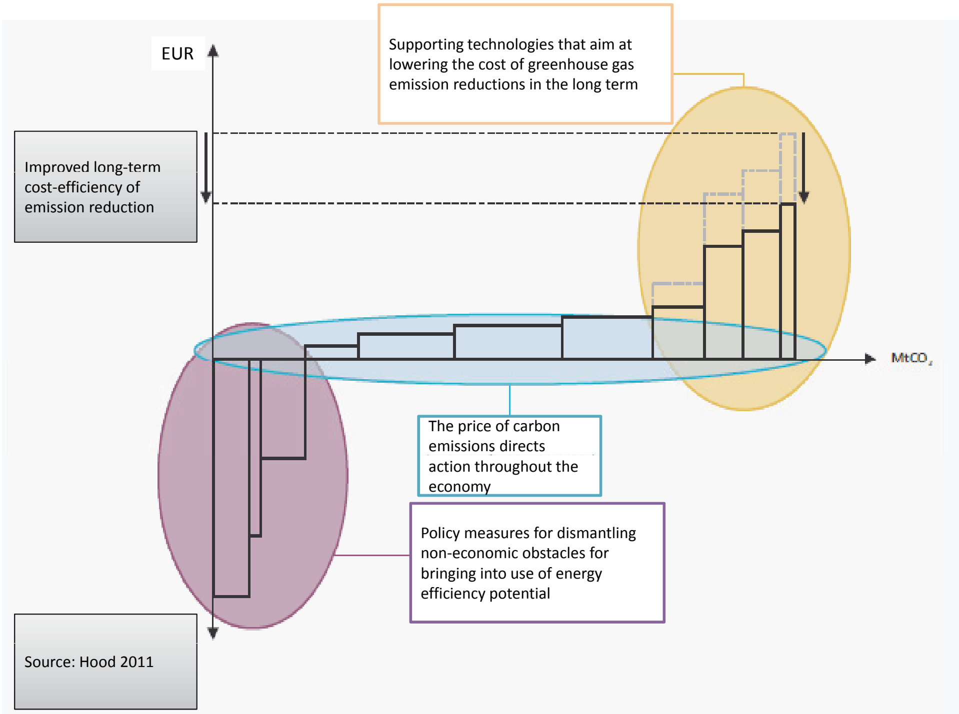
Attaining the climate and other goals set will require a more widespread use of cleantech solutions in Finland than at present. It is important to secure the operating premises for the cleantech solutions already in place and to develop and implement new cleantech innovations over a longer period of time.

Develop the premises of cleantech business in Finland and enable the increase of exports

The premises for cleantech business can be developed by removing obstacles to commercialisation, developing steering measures that are economic and aim at increasing competence and by creating new operating models for promoting the export of cleantech solutions.

The policy means for promoting the cleantech solutions that will move us towards the low-carbon society in 2050 are presented in figure 9.

Figure 9. Policy measures for promoting cleantech technologies. The horizontal axis reflects the emission reduction potential of the measures and the vertical axis their expense. (Source: Nordic energy technology perspectives, IEA and the Nordic Council of Ministers, 2013)



Promoting the implementation of cleantech will require measures that strengthen the market-based premises for implementing new cleantech solutions and remove administrative obstacles and those related to official regulations. Obstacles that are administrative and based on rules may significantly slow down the implementation of new solutions. A flexible operating environment that takes market changes into account in a flexible way on the home market is very important for Finnish cleantech companies.

Global measures for limiting carbon dioxide emissions create markets for cleantech solutions. Finnish cleantech companies can participate in solving the global climate challenge in Finland as well as around the world in co-operation with their customers. Finland's active measures in the homeland for promoting the market entry of cleantech solutions and developing new operating models for the promotion of exports will increase cleantech exports in the future.

SWOT analysis

Finland's strengths	Finland's weaknesses
• Significant R&D investments in cleantech • Good competitiveness in several cleantech technologies, such as the bio and energy technology sectors • Collaboration to remove obstacles related to administration and rules • Several globally active companies in the cleantech sector	• The commercialisation of new technology solutions often faces administrative challenges • Financing risky first demonstrations and commercial projects is challenging • Finland's competitiveness in certain energy-technology sectors with great global potential could be stronger (e.g., solar and wind power) • Small size of the home market
Opportunities for Finland	**Threats for Finland**
• A flexible operating environment enables the implementation of new solutions • Seamless collaboration between public and private sector in the development of new solutions, from research to first demonstrations • Developing the products of cleantech companies into competitive ones in order to take advantage of changes to the global energy systems • Internationally active cleantech companies will significantly benefit from the obligations of the global climate agreements on different countries • Develop the collaboration of the state and the companies in promoting exports	• Administrative processes become more complex and prevent the implementation of new cleantech solutions • The financing possibilities for developing and demonstrating new technologies decrease • The global change of the energy system is oriented to solutions where Finnish companies do not have a strategic competitive advantage • International climate negotiations end in a state of uncertainty or the solutions created are problematic for Finnish cleantech companies • The energy use of biomass is significantly limited in Finland or globally

5.2 Sustainable consumption and production

The attaining of the climate goals is significantly affected by consumption and the change of consumption behaviour. To influence these, steering measures are needed where the connections of consumption and lifestyles with the surrounding technologies, living environments and services, for example, are taken into account. As with energy production, increasing pressure for change will open up the possibility for the emergence of new cleantech solutions.

In 2012, the greenhouse gas emissions of the non-emission-trading sector amounted to a bit over a half of Finland's total emissions: 31.5 million CO_2 equivalent tonnes. The impact of consumption on greenhouse gas emissions is difficult to assess in detail, as private and public consumption also have an indirect impact on the emissions of the emission trading sector and, on the other hand, the emissions of the non-emission trading sector are not entirely caused by consumption.

The KUILU research project[5] has estimated that greenhouse gas emissions from living, private traffic and food lifecycles can be reduced by 4.5 million tonnes annually by 2020. On the other hand, according to other forecasts[6] greenhouse gas emissions

5 Finnish Environment Institute SYKE, National Consumer Research Centre, Finnish Meteorological Institute and Government Institute for Economic Research
6 Kotitalouksien hiilijalanjäljen skenaario vuoteen 2020. I. Mäenpää, 2011

caused by consumption will not necessarily decrease if the structure of consumption does not change and new, low-carbon innovations are not implemented.

At present, the community structure, energy and traffic systems or steering measures do not support sustainable solutions and choices in the best possible way. The steering measures are also partly conflicting, overlapping or insufficient. Neither is the premise in the design of the steering mechanisms always the consideration of wholes or different goals at the same time.

In consumer behaviour, the greatest emission reduction potential is in living and traffic. In living, the most significant emission reduction possibilities are related particularly to energy renovation but also the use of renewable energy in heating, heat and electricity savings and energy-efficient devices. In traffic, the emissions would most efficiently be cut by reducing transport performance and the use of lower-emission technology. In the food chain, the material and energy efficiency of the food system should be improved. Developing responsibility in the food chain, making public kitchens resource-wise, reducing food wastage and increasing consumer guidance are all effective measures in this regard.

On the other hand, increased efficiency alone will not be sufficient. Various control mechanisms (ecological product design, energy and environment labels, carbon-dioxide-connected vehicle taxation, construction regulations) have been used to improve the energy and material efficiency of individual products and services. Increased consumption may counteract some of the efficiency benefits. In order to reduce emissions, changes in consumption habits and new solutions from businesses and service providers are also needed.

It is also important to influence consumption because the manufacture of imported goods and raw materials will generate greenhouse gas emissions although they are not shown in Finland's emission balance.

The public sector as an enabler

The municipalities' role in limiting climate change is great. With their decisions and community planning, the municipalities affect energy production, the community structure and the need for traffic, for example. In order to produce services, the public sector spends approximately 20% of its budget on public procurement each year.

The Council of State's decision in principle on "the promotion of sustainable environment and energy solutions (cleantech solutions) in public procurement" sets goals for public-sector procurement. It significantly commits the state and the municipalities to promoting energy, environment and cleantech solutions. In the Council of State's decision in principle, the areas of focus are waste management, transportation solutions, energy production, public food services and the energy efficiency of buildings. The government promotes the implementation of procurements by setting an example, creating incentives, activating pioneer municipalities and establishing an information service that supports cleantech solutions.

Financial steering measures are critical to building a low-carbon society. Central steering mechanisms include various subsidies and taxes. Many subsidies that promote the competitiveness of businesses or employment can also be deemed to have adverse environmental effects. The majority of the problematic subsidies are in the transportation sector.

Subsidies in the transportation sector are particularly problematic for climate, as they can guide moving and choice of residence location in an increasingly car-dependent direction. In addition, the transportation sector is excluded from emission trading (except for aviation), where EU member states have the primary responsibility for emission reduction measures. On the other hand, transportation subsidies aimed at sparsely populated areas counteract the harm caused by Finland's conditions and long distances. It is important in transportation control to develop operating models and technologies for sparsely populated areas that allow people to run errands and guarantee services.

The design of choices and the creation of solutions also require expertise, understanding of the technology and financing. In particular, construction, renovation and making energy choices require impartial auditing expertise, solution models and means for assembling the saving or investment projects of individual households into broad and interesting wholes. Such measures are slowed by the lack of incentive financing systems (e.g., energy subsidies, ESCO energy saving models for residential housing companies).

Create technology and innovation together

Digitalisation breaks down barriers. IT applications already enable real-time monitoring and reporting of energy consumption. The consumers can also produce energy for the grid (distributed energy). In the future, smart sensors and home devices will increasingly enable planning everyday life in a way that reduces movement and the use of energy. E-commerce and 3D printing of objects change the structures of commerce and industry and may also cause negative climate and environmental effects in the form of increased energy consumption.

It is also necessary to extend services and develop them in a direction more sustainable for people and the environment. In the future, we will most likely have an increasing number of services produced by consumers for one another (car sharing, carpooling, reusing and rental of goods), which will produce new business possibilities for companies. Active consumers will also devise new solutions and product ideas together with companies. The consumers may also play a greater role in the production of food, and it is worthwhile to promote the new types of consumer-producer and partnership agricultural models.

The global value of the sharing economy[7] in 2013 was approximately €3 billion. It is difficult to fully assess the emission and resource efficiency benefits of the

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7 Business of citizens' activity that seeks to enhance the use of goods and services, for example by lending, renting, etc.

sharing economy. At best, the various forms of sharing will considerably increase the utilisation rate of premises, vehicles and goods and thus reduce the need for producing and maintaining extra capacity (e.g., heated, under-utilised spaces). At present, the development of the sharing economy is hindered by many legislative and taxation ambiguities.

SWOT analysis

Finland's strengths	**Finland's weaknesses**
• The technological competence and infrastructure (e.g., IT, electric grid, transportation) are good in Finland • Competence, product development culture and knowledge basis for audits and development (eco-product development) • The Finnish tradition of participation and a good level of information • Positive attitudes and atmosphere	• Rebound outside of the emission trading, i.e., (1) decreased emissions for individual products but increased greenhouse gas emissions because of increased consumption, (2) money saved from energy expenses is not routed to sustainable investments • According to studies, the mere increase of information on sustainable choices is not sufficient, and no expert services are available for households on renovation construction and energy choices, for example • The existing technology that supports low-carbon goals is not implemented
Opportunities for Finland	**Threats for Finland**
• Measures by the public sector and the example it sets, for example in public procurement, create demand for sustainable solutions and can serve as reference • Consumer demand may create a market for cleantech in the consumer sector • Development of technology, including digitalisation • Increasing responsibility in the food system and decreasing food wastage • In renovation construction, the need for heating energy would be decreased by 20–30% if buildings are renovated to the level corresponding to the standards of 2010 by 2050	• Inaction—it is not worthwhile for us to do anything because the big decisions will be made elsewhere, particularly in larger countries • Inaction—Finland takes action but other countries, particularly the larger ones, do not. This decreases competitiveness • Not identifying the consumer's possibility of influencing, whereby steering measures are not taken, either • The single-solution model, i.e., either "green consumption" or "technology makes the difference." Neither alone is enough but both hardware and reason are needed • Increased regional and social inequality

5.3 Strengthening local and regional climate work

Municipalities will increasingly need to respond to the challenges of the low-carbon and energy and resource efficient society. Urbanisation and changes in the industrial structure create the need for new moves. In particular, choices made in larger towns will significantly influence national emission development. Sustainable public procurement and encouraging businesses to develop sustainable environment and energy solutions are part of a municipality's climate work. Preparing for climate change and risk management is important to municipalities.

Have the municipalities' climate initiatives support the low-carbon goal

According to a study by the Association of Finnish Local and Regional Authorities, more than 40% of the municipalities in Finland carried out systematic climate work in 2012, and all municipalities of more than 50,000 residents participate in the work. The municipalities' climate initiatives are developed to correspond to the needs of different types of municipalities.

The association's climate campaign has attracted more than 50 municipalities to set goals for emission reduction. Sixteen *Toward carbon-neutrality (HINKU)* municipalities are committed to reducing their greenhouse gas emissions by 80% by 2030. The expanding HINKU forum supports the municipalities' climate work, distributes information on the best practices in limiting climate change and creates demand for environmentally friendly products and services. In the EU-wide *Town leaders' initiative*, the goal of the largest towns in Finland is to reduce their CO_2 emissions by 20–30% by 2020. Six largest towns in Finland have formed a town leaders' climate network that implements initiatives and best practices between large towns. Three of these towns also aim to be carbon-neutral by 2050.

Increasing the practical aspect or ambition may increase the attractiveness of climate work in municipalities and companies. Networking supports learning and initiatives for identifying cost-efficient emission reduction measures. Different sizes and types of municipalities benefit from the networks in their own ways. The municipalities also spar with one another and are committed to goals, measures and monitoring of results.

Climate initiatives have increased the municipalities' commitment to climate goals. Best practices have spread with them and businesses and municipal residents have participated in the activities.

Not all municipalities, however, are working on the environment yet. Including the climate aspect in the municipality's strategic work and strong commitment of the management has been implemented in relatively few municipalities. The knowledge basis needed for designing measures in climate work also requires strengthening.

Climate and energy solutions as part of the municipal strategy

The challenge for the municipalities is to include emission reduction measures in their residents' everyday life and well-being. The significance of the commitment of municipal management and key clerks is emphasised in the municipalities' climate work. With climate and energy policy matters part of the municipality's management and decision-making, the matters are naturally present in the municipality's own activities and when dealing with other actors in the area.

Several municipalities have carried out development on energy and climate issues. External funding has often been received for the projects. New operating methods have been created, for example in promoting environmental businesses; quality control of new constructions; control of improved energy use efficiency; zoning that promotes low-carbon goals; and joint procurement measures. Pioneer municipalities attempt to spread practices that have been deemed effective nationwide.

Up-to-date and comprehensive information basis to support local climate work

The costs and benefits caused by the reduction of climate emissions spread across many fields. Thus, an overall image of the effect of the measures is needed to support decision-making. For example, reducing greenhouse gas emissions from traffic may also reduce traffic jams, improve the quality of air and enable health-promoting lightweight traffic.

For the time being, the observed time periods of municipal emission development are rather short and monitoring has not been consistent. The impact assessments of local climate and energy policies are rather limited at present. Producing assessments that include costs and benefits supports the preparation of operation method and investment plans.

Impact assessments could be prepared with a more long-term approach than presently by strengthening expert work, which would also support extending the activities to new municipalities. Sufficient consistence and comparability must be invested in when developing statistics. Other practical background information is also needed in municipalities. This is developed in the online service climateguide.fi.

The HINKU project has shown that rather limited resources can significantly expedite the containment of climate change at the municipal level in such a way that the economic and social benefits of the activities are irrefutable while new types of growth outlooks can be created for the industry of the area. In addition, the image of municipalities and businesses benefits as they profile leaders in the energy and climate fields. With the expansion of the work, it has also drawn international interest. Correspondingly, Finnish municipalities can also learn from the experience of other countries, and networking should be promoted.

Almost all provinces have prepared their regional climate strategies. The spark for this has definitely been the 2008 climate and energy strategy and perceiving the climate strategy as part of the provincial federations' task of regional development. Each strategy looks like the province it was made in and emphasises the region's possibilities for confronting the climate challenge. A regional climate strategy can be particularly significant for small municipalities that do not have their own resources for this work. The policy definitions in the strategies are often rather generic, and therefore their implementation progresses variably. Practical action programmes with clear responsibilities would support the practical work.

SWOT analysis

Finland's strengths	Finland's weaknesses
• The municipalities have tasks and expertise, for example in planning land use and traffic, waste management, procurement, energy consumption and production. These measures can significantly influence the emission development • The broad-scale nature of the municipalities' duties supports a holistic approach to the management of energy and climate issues • The municipalities have active connections and collaboration possibilities with the residents • The municipalities' climate networks form commitments and give sparring assistance	• The cost, payback periods and benefits of emission reduction measures are still rather poorly known in the municipalities • The availability of expert support limits the strengthening of the knowledge basis and systematic climate work in many municipalities • Collaboration between the various sectors of a municipality is somewhat limited, which limits the efforts to identify common benefits and the discussion on cost effect • Approximately half of the municipalities do not yet carry out systematic climate work
Opportunities for Finland	**Threats for Finland**
• Large and growing urban regions have a key role but also small towns and the rural areas have possibilities • The municipalities' sustainable procurement can speed up the growth of cleantech companies • The benefits from improving the efficiency of municipal energy use benefit the municipality's own economy • Involving the municipality's residents increases the decision-makers' awareness of the acceptability of the measures • With their actions, municipalities can enable climate-wise sustainable actions of the residents, for example in moving, living and waste management • Sufficient expert support will ensure a solid information basis	• Climate and energy issues do not receive sufficient attention in the change of the municipal field • The total effect, including sidestream benefits, of climate measures are not identified • Decisions are based on insufficient analyses • If the national climate policy does not identify municipal-level possibilities, the national support for the municipalities' climate work will remain weak

5.4 Adapting to climate change

The first sub-report of the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC) confirms the understanding that climate change caused by human action is underway (IPCC, 2013[8]). Impact on natural and human systems resulting from climate change is manifested on all continents and sea areas. The effect of recent weather extremes, such as heat waves and floods, indicate that some ecosystems and several human systems are vulnerable to the current climate fluctuations.[9]

8 IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

9 IPCC, 2014. Summary for Policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability.

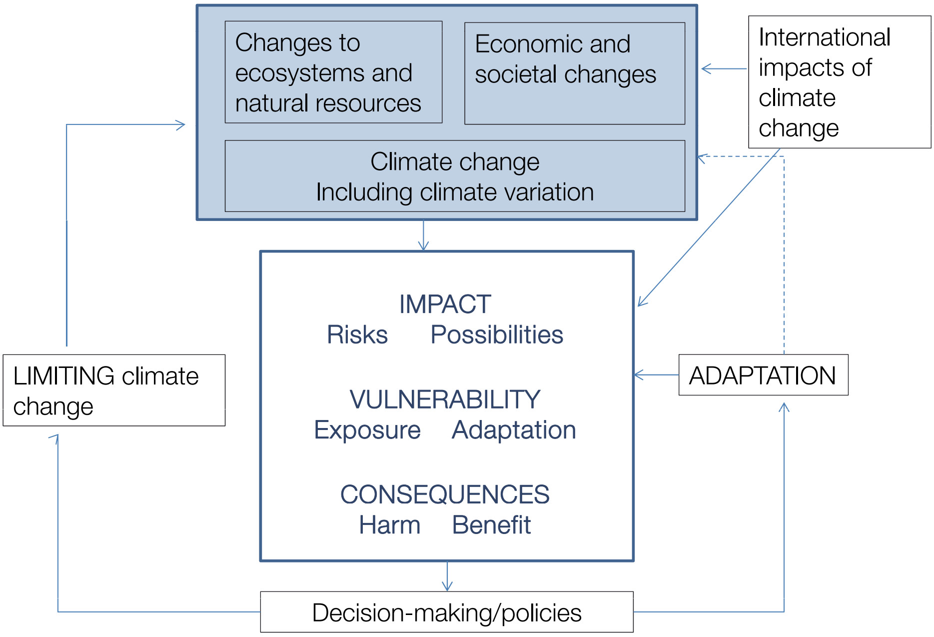
Adaptation is inevitable even if it were possible to reduce the global emission volume of greenhouse gases in the near future. This is because the change of the gaseous atmosphere that already has taken place will probably still lead to global warming of approximately one degree.

According to recent estimates, if emissions continue at the present rate, the planet's average temperature will rise by three to five degrees by the end of the century compared to the period 1986–2005. Further warming will increase the probability of severe and irreversible changes. In Finland, the increase of temperature is estimated to be 1.5–2 times greater than the international rise. With the average temperature, also the 24h highs and lows, precipitation, snow cover, the thermal growth season and other indicators on the climate will also change.

The time span of the change is very important. In the short term, adapting to various weather and water extremes will be particularly emphasised. For example, it is sensible to prepare for heavy rains, floods, drought and heat waves already based on the current experiences. It is estimated that weather extremes will become more commonplace with a warmer climate, although at present in individual weather situations it is not possible to clearly distinguish the contribution of climate change from the natural variation. In the long-term outlook, adapting to the effects of changes caused by the average change of the climate and risk management are emphasised. For example, in community design or forestry, the situation must be anticipated decades ahead.

Industries, living, transportation and other societal functions have adapted to local and regional climates. However, even in the present climate, weather extremes, such as storms and heavy rains, have already increased anomalies in the functionality of society, for example in the transmission of electricity and supply of water. The ability to adapt to climate and other changes is strengthened by society's general stability, a sustainable and well-managed built environment and other infrastructure, solid economy, functioning administration, a high education level and services maintained by society. In infrastructure maintenance, preparations should be made for problems already caused by the present weather extremes. The framework for adapting to climate change is presented in figure 10.

Figure 10. Framework for climate change adaptation.



The most important means of reducing the impact of climate change and the resulting risks is to limit greenhouse gas emissions at a global level. Adapting to climate change has a close connection with the success of limiting climate change internationally: the goal of climate change limiting is to minimise climate change, while adaptation seeks to solve problems caused by the change.

Despite global emission reduction measures, the emissions are growing globally and changes will take place in the climate system. Adapting to climate change must be commenced sufficiently early. In particularly, long-term investments with a long-term effect, securing functions important to the society and risk management require correctly timed and targeted measures.

Although climate change will be particularly rapid in northern areas such as Finland and Finland is a large country dependent on natural resources, the Finnish society has relatively good premise for adapting to the changes to come. This, however, requires active adaptation and ensuring the foundations for societal, economic and social development.

The committee's comments

The committee presents the following comments:

1. *Finland is committed to the European Union's goal of reducing greenhouse gas emissions by 80–95% of the 1990 level by 2050, which is possible to attain in Finland but very challenging. To reach the goal, significant measures are required in all sectors of society, especially in energy production and consumption, transportation, construction and living, and in agriculture and forestry.*
2. *As 80% of the greenhouse gas emissions are currently caused by the production and use of energy (including the energy used by vehicles), reaching the goal requires that the energy system be modified to an almost emission-free state.*
3. *Parallel to the climate aspect, the central goals of the energy policy are connected to securing well-being, competitiveness and a secure energy supply. These goals set the framework for how the required emission reduction goals can be reasonably implemented with respect to the overall interest of the society.*
4. *The international goal is to limit the increase of the planet's temperature to at most two degrees centigrade. This goal, as well as caring for Finland's relative competitiveness and securing the operating prerequisites for energy-intensive industry, requires that greenhouse gas emissions be significantly reduced at a global level. It is important that Finland exercise its influence in various forums for the implementation of significant emission reductions in all countries based both on international treaties and spontaneous actions.*
5. *Despite the fact that the EU is developing an internal market for energy, Finland must see to sufficient energy self-sufficiency and to the security of supply in an unstable world. Increasing Finland's energy self-sufficiency, in particular by increasing the use of renewable energy and improving energy efficiency, will also have a positive impact on the balance of trade.*
6. *The share of electricity in the end-consumption of energy will increase, whereby it is important to pay close attention to the security of the electricity supply. In electricity production, self-sufficiency and the security of supply are divergent. In addition to Finland's own electricity production capacity, the security of supply is improved by the Nordic joint market, the expanding European internal market and the increasing international transfer connections. Therefore, it is justifiable to set the Finnish electricity production's self-sufficiency goal so that the country would be able to be self-sufficient in electricity production at the annual level.*
7. *Finland has the conditions necessary for increasing emission-free, Finnish renewable energy in a way sustainable for the environment. At the same time, increasing the renewable energy sources benefits the national economy and*

employment as well as the vitality of the regions and the countryside. The position of forest biomass in Finland as a source of renewable energy is of primary and decisive importance. This is the result of measurable resources, cost-efficiency, the ability to replace fossil fuels and developing new ways of use. Renewable energy sources must be promoted primarily according to their order of cost efficiency.

8. *Energy efficiency can help fulfil all key goals of the energy policy while it is a basic prerequisite for the goal of attaining a low-carbon society. Energy efficiency must be improved in all functions of the society. New, smart technologies play a central role here. Intelligent systems and increasing the demand response for energy are essential success factors.*

9. *The state and the municipalities must holistically commit themselves to promoting low-carbon economy in all of their activities, for example by developing smart, built environments, improving their procurement praxes, promoting various experiments and pilot and demonstration projects and by creating premises for people in their everyday lives to make climate-favouring and sustainable choices.*

10. *The global effort for stopping climate change opens enormous business opportunities in the areas of cleantech and bioeconomy, which Finland must utilise to the fullest. Finland must aim to be an international pioneer in both cleantech and bioeconomy.*

11. *The journey to a low-carbon society is long and the challenge is immense. At present, it is impossible to accurately predict the structure of a low-carbon society in 2050. The energy policy also involves many uncertain factors, for example with respect to international and technological developments. The greatest foreseeable technological uncertainty involves the commercialisation of carbon capture and storage (CCS). The national energy and climate policy must be consistent and committed while inevitable intermediate stages must be accepted, as well as decision-making that adapts to the changes of the operating environment. Finland's traditional strength is the diversity of its energy system, the nurturing of which will also reduce vulnerability in the future and increase the possibility to work flexibly as conditions change.*

12. *Despite the significant uncertainty factors and the necessity for flexibility and adaptation, it is reasonable to set certain goals that fundamentally guide the coming policy. By 2050, Finland can, with determined energy-efficiency and energy saving measures, significantly reduce the end-consumption of energy, at best clearly below 250 TWh without compromising the national competitiveness. Our energy self-sufficiency can be increased to 50–60% or, including nuclear power produced in Finland, to 80%. The renewable energy's share of the total energy consumption can be increased to 50–60%.*

13. *With respect to certain areas essential to the whole, the committee presents the following as comments of higher degree of detail:*

General

a. *Finland must aim to secure the functionality of the EU's emission trade system in order to cost-efficiently reach the emission reduction goals. It is not feasible to impose a separate, binding national reduction goal for the emission trading sector; instead, European regulations should be followed. It must be possible to use emission reductions implemented outside of Finland, in accordance with EU and international decisions, to supplement the meeting of the reduction goal in sectors not covered by the emission trading.*

Energy production and energy system

b. *It is feasible for Finland to support the development of the Nordic and European electricity markets in order to increase the security of supply and cost-efficiency, to increase competition on the electricity market and to reduce emissions. At the same time, it is important to ensure that Finland has sufficient electricity production capacity for exceptional conditions and the premises for making market-based investments in the production of electricity. In particular, Finland must retain the competitiveness of combined heat and power production. The distributed small-scale production of electricity must be promoted. It is also important to develop electricity networks with high operating reliability, the possibility to utilise energy storages and promote demand response, for example by means of smart electricity networks and meters.*

c. *To attain significantly higher utilisation levels of bioenergy, the biomass used has to be produced in a sustainable way and be carbon-neutral in its energy use. Proving the sustainability of the use of wood must be included in the regulations and systems that prove the sustainability of forestry. For Finland, the core matter is that sustainably produced biomass will continue to be deemed carbon-neutral in the EU and international climate negotiations. The increasing energy use of forest biomass must be implemented without jeopardising the utilisation of energy sources with higher added value in the renewing bioeconomy. On the other hand, a successful forestry industry is a prerequisite for a significant increase in the energy use of wood.*

d. *Coal must be completely discontinued in energy production as soon as possible in a cost-efficient way that does not compromise the security of supply, unless the commercialisation of carbon capture and storage (CCS) changes the overall setting.*

e. *The use of natural gas must be secured during the period of transition toward lower-emission technologies. Burning natural gas produces fewer greenhouse gas emissions than burning coal or oil. The use of natural gas is justified because of its suitability to a variety of purposes and because it maintains the infrastructure for the transfer and use of biogas and bio-based synthetic natural gas. At the same* *time, it must be ensured that the lifespan emission balance of natural gas and all other fossil fuels is good.*

f. *Peat is a Finnish fuel, the use of which creates jobs, strengthens the balance of trade and improves energy self-sufficiency and the security of the energy supply. In addition, peat is suitable as a mixed fuel parallel to biomass, which is needed by the current power plant boilers in Finland. Burning peat releases greenhouse gas emissions, whereby its long-term energy use without carbon capture and storage (CCS) is not aligned with the emission reduction goal. The commercialisation of CCS and/or the emission trading system may, however, enable the future use of peat if it is economically feasible. Due to the benefits of peat, in order to reduce greenhouse gas emissions the use of other fossil fuels should be reduced first.*

Transportation

g. *For Finland, a good solution is to replace fossil transportation fuels with advanced bio-based fuels. The raw materials to use must be primarily Finnish forest and field biomass, waste and industrial sidestreams. Finland must support increased demand for biofuels with national and EU-level goals and obligations.*

h. *Transportation's energy efficiency must be improved by favouring public and lightweight traffic and, in cargo transports, railway and water transports. The promotion of new propulsions and technologies is important. In practice, the entire transportation system must be made very low-emission in the long term.*

Agriculture and forestry and carbon sinks

i. *It is important to design and implement the agriculture's measures for limiting the climate change so that they do not jeopardise security of supply, Finnish agriculture or global food security. Therefore, the primary goal in agriculture must be reducing the net emissions compared to the unit produced and striving for the overall consideration of the activities at the farm level. Attempts must be made to broaden the perspective of climate policy applicable to agriculture so as to cover not only agricultural production but also land use, land-use change and forestry (LULUCF) and the energy use at farms.*

j. *In the forestry sector, it is essential for Finland to aim for solutions in the calculation rules of carbon sinks that justly take into consideration the carbon binding and emissions caused by forests and forestry; secure the sustainable management and use of the forest and its ecosystem services; and encourage the use of renewable natural resources instead of non-renewable ones.*

Built environment and energy efficiency

k. *For Finland, it is appropriate to promote the cohesion of urban structure and an enhanced zoning of urban areas. The limiting climate change must be considered in the assessment of the impact of plans and programmes and in the drafting of regulations.*

l. *The energy-efficiency agreement system and audit activities must be retained in a key position in energy-efficiency activities. The significance of renovation construction will increase, and new, cost-efficient steering measures must be implemented for utilising the possibilities of energy efficiency.*

Cleantech and bioeconomy

m. *The global need for cleantech and bioeconomy solutions opens up large commercial possibilities for Finland, and therefore these areas must be kept at the core of the industrial policy. With this, it is also important to promote the research and development work for new cleantech and bioeconomy solutions, as well as their demonstration and piloting and commercialisation. Likewise, the possibility for adopting new solutions, for example through steering measures related to financing and by creating export promotion and financing models, must be implemented.*

Sustainable consumption and production and regional climate work

n. *Finland must provide financial support for choices that reduce emissions. It is feasible to renew taxation policies related to going to work and traffic by shifting transportation taxation from the purchase of vehicles to their use.*

o. *To support the municipalities' low-carbon plans and work, the information base needed in the municipal sector must be improved. The state must thus strengthen the research, development and expert support offered to the municipalities. EU's regional development funding is worth utilising in the promotion of regional low-carbon goals.*

p. *The public sector must change its services and procurements to increasingly resource-wise and innovation-encouraging ones, thus promoting environmentally sound and energy-smart solutions.*

Waste sector

q. *Finland must reduce the carbon footprint of the waste material flow by adhering to the priorities of waste management (prevention of the accrual of waste, preparation for reuse, recycling, energy use and other utilisation, waste site).*

Adapting to climate change

r. *It is feasible to set the goal of adapting to climate change so that Finnish society will have the ability to address the risks related to climate change and adapt to the changes of the climate.*

Appendix 1

Preparation of the roadmap

The roadmap has been prepared under the direction of the Parliamentary Committee on Energy and Climate Issues. The Committee has had two representatives from each party represented in Parliament, and the material preparation has been co-ordinated by the Committee's secretariat. Each ministry has drafted estimates with regards to its respective.

The head of the Committee's secretariat has been Director-General Esa Härmälä of the Ministry of Employment and the Economy and the secretaries' Environment Counsellor Merja Turunen of the Ministry of the Environment and Senior Specialist Sami Rinne of the Ministry of Employment and the Economy (as of 1 April 2014, Chief Counsellor Markku Kinnunen of the Ministry of Employment and the Economy). The secretariat's work has been contributed to particularly by Industrial Counsellor Petteri Kuuva and Senior Adviser Mikko Paloneva of the Ministry of Employment and the Economy.

The central background material for the preparation has been the joint study Low Carbon Finland 2050 platform by Geological Survey of Finland, the Finnish Forest Research Institute, the Government Institute for Economic Research and VTT Technical Research Centre of Finland. It assesses strategic natural resources and creates scenarios of alternative development paths up to 2050.

The roadmap work has aimed at broad and versatile public debate. The work was started at the Finlandia Hall with a seminar that was broadcast live on the web. The premises and progress of the work is also communicated on the Tiekartta 2050 site, which also publishes the presentations held at the meetings of the Parliamentary Committee on Energy and Climate Issues and information on the views of citizens and interest groups.

All parties interested in the matter had the chance to present their ideas in the Otakantaa.fi discussion arranged in the summer of 2013 or of commenting on the expert documents of the Tiekartta 2050 blog. In May 2014, an online survey on the reduction of greenhouse gas emissions and the citizens' capacity for energy and climate saving measures was carried out.

The Parliamentary Committee has also heard the views of various interest groups to support its work. The Ministry of Employment and the Economy, which co-ordinates the preparation, has heard the thoughts of regional and local actors and the financial sector's views on energy efficiency, cleantech and low-carbon issues. In addition, a live seminar broadcast online was arranged in June 2014 where the interest groups could comment on the preliminary thoughts of the Parliamentary Committee and send their comments to the Parliamentary Committee.

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Energia- ja ilmastotiekartta 2050
Parlamentaarisen energia- ja ilmastokomitean mietintö 16. päivänä lokakuuta 2014

Tiivistelmä | Referat | Abstract

Suomen pitkän aikavälin tavoitteena on hiilineutraali yhteiskunta. Tavoitteen saavuttaminen on mahdollista mutta haastavaa. Haaste on suuri erityisesti energia-alalle, sillä Suomen kasvihuonekaasupäästöistä noin 80 % syntyy energian tuotannosta ja kulutuksesta, kun siihen lasketaan mukaan liikenteen käyttämä energia. Suomessa kiinnitetään energiapolitiikassa yhtä lailla huomiota toimitusvarmuudesta huolehtimiseen kaikissa olosuhteissa sekä yhteiskunnan kilpailukyvyn tukemiseen.

Energia- ja ilmastopolitiikan laajapohjaisen tarkastelun varmistamiseksi, kansallisen yhteisymmärryksen lisäämiseksi sekä pitkäjännitteisen ja ennustettavan politiikan vahvistamiseksi parlamentaarinen energia- ja ilmastokomitea on valmistellut Suomelle vuoteen 2050 ulottuvan tiekartan, joka toimii strategisen tason ohjeena matkalla kohti hiilineutraalia yhteiskuntaa. Parlamentaarisessa komiteassa on ollut kaksi jäsentä kaikista eduskuntapuolueista, ja materiaalivalmistelua on koordinoinut työ- ja elinkeinoministeriön sekä ympäristöministeriön muodostama sihteeristö. Kukin ministeriö on valmistellut oman substanssialueensa arvioita.

Tiekartassa käsitellään erityisesti energian tuotantoa ja energiajärjestelmää, energian kulutusta, muita sektoreita sekä poikkileikkaavia toimia. Tiekartassa ei valita mitään yksittäistä polkua vuoteen 2050 asti, vaan tutkitaan eri vaihtoehtoja päästövähennystoimiksi sekä niiden vaikutuksia päästöjen vähentämisen kustannustehokkuuteen ja yhteiskunnan kilpailukykyyn. Lisäksi arvioidaan Suomen vahvuuksia ja heikkouksia sekä eri tilanteisiin liittyviä mahdollisuuksia ja uhkia. Näihin vaikuttamiseksi parlamentaarinen komitea esittää joukon kannanottoja.

Kasvihuonekaasuja on pyrittävä vähentämään kaikilla sektoreilla, joskin sektoreiden potentiaalit ovat hyvin erilaiset. Päästövähennystavoitteen saavuttamiseksi esimerkiksi energiajärjestelmä on muutettava lähes päästöttömäksi vuoteen 2050 mennessä, mutta monia teollisuuden prosessipäästöjä voidaan vähentää merkittävästi vain, jos hiilidioksidin talteenotto ja varastointiteknologia (CCS) kaupallistuu. Kasvihuonekaasupäästöjen vähentämiseksi 80–95 %:lla Suomen on joka tapauksessa lisättävä uusiutuvan energian – erityisesti kotimaisen bioenergian – käyttöä ja hyödynnettävä kaikilla sektoreilla energiatehokkuuden ja cleantech-toimialan potentiaali. Suomen on myös huolehdittava riittävästä energian omavaraisuudesta ja huoltovarmuudesta. Lisäksi valtion ja kuntien tulee kaikessa toiminnassaan kokonaisvaltaisesti sitoutua vähähiilitalouden edistämiseen.

Ilmastonmuutoksen hillitsemiseksi on tärkeää, että kaikki osapuolet rajoittavat päästöjään. Suomen tulee vaikuttaa eri foorumeilla voimakkaasti kansainvälisten ilmastoneuvotteluiden tuloksellisuuteen ja ilmastosopimuksen syntymiseen. Tämä myös tasoittaisi globaalia pelikenttää ja mahdollistaisi Suomen säilyttää energiaintensiivinen teollisuus keskeisenä osana teollisuuttaan. Samalla avautuisi uusia vientimahdollisuuksia suomalaisille cleantech-alan yrityksille.

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Energi- och klimatfärdplan 2050

Parlamentariska energi- och klimatkommitténs betänkande den 16. oktober 2014

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Finlands långsiktiga mål är ett koldioxidneutralt samhälle. Det är möjligt att uppnå målet, men det är en utmaning. Utmaningen är stor i synnerhet inom energisektorn, eftersom cirka 80 procent av växthusgasutsläppen i Finland härstammar från produktion och förbrukning av energi när man räknar med den energi som förbrukas i trafiken. Inom energipolitiken i Finland fästs lika stor uppmärksamhet vid att trygga leveranssäkerheten under alla förhållanden som vid att stödja samhällets konkurrenskraft.

För att säkerställa en bredbasig granskning av energi- och klimatpolitiken, öka det nationella samförståndet samt stärka en långsiktig och förutsägbar politik har den parlamentariska energi- och klimatkommittén berett en energi- och klimatfärdplan för Finland som sträcker sig fram till år 2050. Färdplanen fungerar som en strategisk anvisning på vägen mot ett koldioxidneutralt samhälle. Den parlamentariska kommittén har bestått av två medlemmar från varje riksdagsparti och materialberedningen har samordnats av ett sekretariat bildat av arbets- och näringsministeriet och miljöministeriet. Varje ministerium har berett bedömningar inom sitt substansområde.

I färdplanen behandlas i synnerhet energiproduktionen och energisystemet, energiförbrukningen, övriga sektorer samt gränsöverskridande funktioner. I färdplanen utstakas ingen enskild stig mot år 2050, utan färdplanen undersöker olika alternativ för utsläppsminskningsåtgärder och deras inverkan på utsläppsminskningens kostnadseffektivitet och samhällets konkurrenskraft. Dessutom bedöms Finlands styrkor och svagheter samt möjligheter och hot förknippade med olika situationer. För att påverka dessa presenterar parlamentariska kommittén ett antal ställningstaganden.

Man ska sträva efter att minska växthusgaserna inom alla sektorer, även om sektorerna har väldigt olika potential. För att utsläppsminskningsmålen ska uppnås måste exempelvis energisystemet göras nästintill utsläppsfritt före år 2050, men många av processutsläppen inom industrin kan minskas i betydande omfattning endast om teknologin för avskiljning och lagring av koldioxid (CCS) kommersialiseras. För att minska växthusgasutsläppen med 80–95 procent måste Finland i varje fall öka användningen av förnybar energi – i synnerhet inhemsk bioenergi – och utnyttja energieffektivitetens och cleantech-branschens potential inom alla sektorer. Finland måste också se till att självförsörjningsgraden för energi och försörjningsberedskapen är tillräcklig. Dessutom ska staten och kommunerna i all sin verksamhet på ett heltäckande sätt förbinda sig till att främja en koldioxidsnål ekonomi.

För att stävja klimatförändringen är det viktigt att alla parter begränsar sina utsläpp. Finland ska i olika forum kraftfullt påverka de internationella klimatförhandlingarnas resultat och uppkomsten av ett klimatavtal. Detta skulle även göra den globala spelplanen jämnare och göra det möjligt för Finland att bevara en energiintensiv industri som en central del av landets industri. Samtidigt skulle nya exportmöjligheter öppna sig för finländska cleantech-företag.

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Energy and Climate Roadmap 2050

Report of the Parliamentary Committee on Energy and Climate Issues on 16 October 2014

The report has been prepared by the Parliamentary Committee on Energy and Climate Issues and comprises a roadmap and an appendix. The roadmap describes key issues for Finland's energy and climate policies, which are related to Finland's long-term goal to become a carbon-neutral society and to security of supply and the society's competitiveness. With respect to central questions, the roadmap assesses Finland's strengths and weaknesses as well as the opportunities and threats for Finland. The Parliamentary Committee presents a number of statements and policy definitions to influence these.

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